TWENTY-FIFTH ANNUAL REPORT

OF THE

Kentucky Agricultural Experiment Station

OF THE

STATE UNIVERSITY

LEXINGTON, KY.

FOR THE YEAR 1912

MELVILLE AMASA SCOVELL

IN MEMORIAM

STATE UNIVERSITY PRESS
LEXINGTON, KY.

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MELVILLE AMASA SCOVELL.

Letter of Transmittal.

To His Excellency,

HON. JAMES B. MCCREARY,

Governor of Kentucky.

Sir:—

Under the authority of the Board of Control of the Kentucky Agricultural Experiment Station, and in accordance with an act of Congress, approved March 2, 1887, and entitled "An Act to establish Agricultural Experiment Stations in connection with the Agricultural Colleges established in the several States under the provision of an act approved July 2, 1862, and under the acts supplementary thereto," and of the act of the Legislature of the State of Kentucky, approved February 20, 1888, and entitled "An Act to accept the provisions of an Act passed by the Congress of the United States, approved March 2, 1887, for the establishment and maintenance of Agricultural Experiment Stations in connection with Agricultural Colleges established by the several States and Territories under an Act of Congress, approved July 2, 1862," I herewith submit the Twenty-fifth Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,

JOSEPH H. KASTLE, *Director.*

Lexington, Ky., Feb. 1, 1913.

State University

LEXINGTON, KY.

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Kentucky Agricultural Experiment Station.

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E. S. GOOD, Head of Animal Husbandry Division. (Beef Cattle, Sheep and Swine.)
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H. R NISWONGER, Assistant in Nursery Inspection, Division of Entomology and Botany.
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W. D. NICHOLLS, Dairy Husbandry, Stock Feeds.
J. S. McHARGUE, Assistant Chemist, Chemical Division.
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J. H. CARMODY, Extension Work, Horticulture.
J. J. HOOPER, Head of Animal Husbandry Division. (Dairy Cattle, Horses and Poultry.)
G. H. NOYES, Consulting Meteorologist.
R. L. PONTIUS, Veterinary Science, Animal Husbandry Division.
B. F. SCHERFFIUS, Tobacco Expert, U. S. Department of Agriculture.
A. J. REED, Dairy Expert, U. S. Department of Agriculture.

Address

KENTUCKY AGRICULTURAL EXPERIMENT STATION,

LEXINGTON, KENTUCKY.

THE KENTUCKY AGRICULTURAL EXPERIMENT STATION

In account with the United States Appropriations:

	Hatch Fund.	Adams Fund.
Receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1912, under Acts of Congress, approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund	$15,000.00	$15,000.00
Expenditures:		
By salaries	13,497.51	14,353.59
Postage and Stationery	366.74	9.00
Freight and Express	198.82	----------
Heat, Light, Water and Power	292.09	----------
Chemical and Laboratory Supplies	----------	122.97
Seeds, Plants and Sundry Supplies	129.85	5.00
Library	413.49	----------
Furniture and Fixtures	26.34	----------
Scientific Apparatus and Specimens	----------	349.77
Live Stock	----------	18.00
Traveling Expenses	44.95	63.67
Contingent Expenses	25.00	70.00
Buildings and Land	5.21	8.00
	$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Kentucky Agricultural Experiment Station for the fiscal year ended June 30, 1912; that we have found the same well kept and classified as above; that

the balance brought forward from the preceding year was nothing on the Hatch Fund and nothing on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000.00 under the Act of Congress of March 2, 1887, and $15,000.00 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000.00 and $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving balances of nothing and nothing.

And we further certify that the expenditures have been solely for the purpose set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) C. B. NICHOLS,
(SEAL) H. S. BARKER,
Auditors.

Attest: W. T. LAFFERTY, Business Agt., Custodian.

ANNUAL REPORT

OF THE

Kentucky Agricultural Experiment Station

FOR THE YEAR 1912

REPORT OF THE DIRECTOR.

The year 1912 has been an eventful one in the history of the Kentucky Agricultural Experiment Station, partly by reason of the passage of an act of the General Assembly, approved March 11, 1912, whereby the resources of the Experiment Station were increased by an appropriation of fifty thousand dollars per annum, and partly by reason of the untimely death of the Director, Dr. M. A. Scovell, on the fifteenth of August, 1912. Immediately following the death of Dr. Scovell, Dr. A. M. Peter, Chief Chemist of the Experiment Station, was appointed Acting Director. In this capacity he served until October 26, 1912, on which date Dr. Joseph H. Kastle, Head of the Department of Chemical Research in the Experiment Station was elected Dean of the College of Agriculture of the State University and Director of the Kentucky Agricultural Experiment Station. It has been the aim both of Drs. Peter and Kastle, at least for the time being, to carry on the work of the Experiment Station as nearly as possible in conformity with Dr. Scovell's original plans.

Among the items of general interest concerning the work of the Experiment Station for the year 1912, may be enumerated the following:

With the object of providing further revenues for the maintenance of the Experiment Station and for the carrying on of various lines of experimental work in agriculture, the General Assembly at its regular session in 1912, appropriated to the Experiment Station the sum of fifty thousand dollars per annum.

Section 1 of this act reads as follows:

"That there is hereby appropriated to the Agricultural Experiment Station of the State University, Lexington, Kentucky, for the current fiscal year and for each succeeding year thereafter, fifty thousand dollars ($50,000) for the purpose of making field experiments in the several sections of the State in order to ascertain by chemical and physical examination of our soils and by direct experiments in laboratory and fields what crops and treatment are best suited to each, whether the present methods are tending to best results and whether to the preservation or reduction of fertility, and what rotation and treatment will be most effective in retaining productive capacities of the soils of the various sections of the State; to discover and demonstrate the best methods of orchard treatment, the culture and marketing of fruits and vegetables and the most effective remedies for insects and diseases of fruits and vegetables, and to make a systematic study of plant breeding and development by means of crossing and selection of new and improved varieties of fruits and vegetables; to enable said Station to conduct investigations calculated to develop the beef, pork and mutton producing interests of the State, and especially to devise and conduct feeding experiments intended to demonstrate the most successful combination of stock foods, and to discover, if possible, the most economical and successful methods of maintaining animals and fitting them for the market, for pathological investigations, and to investigate live stock conditions both at home and abroad, in so far as they affect market values; to enable the said Station to conduct investigations for the purpose of developing the dairy interests of the State, and including feeding experiments for production

of milk and butter, and the rearing of calves, and the study of contagious diseases for the purpose of finding remedies therefor; to enable the said Station to conduct investigations for the purpose of developing the horse interests of the State, including the best methods of feeding and breeding, the study of diseases, and thorough scientific investigations for the benefit of the horse industry of the State; for the advancement of the poultry interests of the State, including experiments in breeding for egg production and methods best adapted for hatching and raising of chicks and feeding experiments and other investigations tending to the economical production of poultry and eggs; for providing the necessary equipment and paying the expenses of the extension work of said Experiment Station in order to bring the scientific knowledge already obtained, and that hereafter obtained, in the lines of agriculture and home economics, direct to the farm and home by means of personal visitation, correspondence, co-operative demonstrations and experiments and the solution of local problems by Station experts visiting the locality and studying the problems on the farm; towards the maintenance of said Station, and for the purpose of enlarging the hog cholera serum plant now at said Station and for the production of hog cholera serum and virus in large quantities for the benefit of the farmers of the State. Said serum and virus to be furnished the farmers of the State at partial cost of production, and not to exceed one cent per cubic centimeter and to be distributed through such channels as the director of the said Experiment Station may deem advisable for the protection of the swine interests of the State."

While the funds accruing to the Experiment Station under this act which was approved March 11, 1912, did not immediately become available, there has been a consistent effort on the part of all concerned to conform to the original spirit and intent of the act appropriating these additional funds, which has already resulted in the betterment of certain of the agricultural interests of the State and a good beginning has been made in several of the lines of work contemplated under this act. Thus, as elsewhere pointed out in this report, steps have been taken by the Board of Control of the Experi-

ment Station looking to the establishment of a number of experimental fields in different parts of the State and during the past year, one such field has been definitely established at Lone Oak in McCracken County. The soil survey of Webster County has been completed and the results published in Bulletin 162 and, as indicated in the report of the chemical work of the Experiment Station, one hundred and seventy-three soils have been analyzed in the chemical laboratory of the Experiment Station during the past year, and also sixty specimens of limestone for agricultural purposes. On the various experimental fields which it is our purpose to establish throughout the State, it is proposed to study those systems of crop rotation best adapted to the particular soil type for the development and maintenance of permanent soil fertility. A portion of the Experiment Station farm has been definitely set apart for horticultural experiments. During the past year, an extensive survey of the dairy farms of the State has been conducted by Messrs. Hooper and Nicholls, the usual high standards of milk production have been maintained throughout the past year and valuable experiments have been conducted on the rearing of calves by hand. Studies have been made on contagious abortion in cows and a simple diagnostic test for this disease devised. Experiments on poultry raising and increased egg production have been carried on at the Experiment Station farm. The Department of Agricultural Extension has been greatly strengthened and every reasonable effort is being made to bring the valuable results of Experiment Station work directly home to the man on the farm. As pointed out elsewhere in this report, one-fifth of the State appropriation for 1912 has been definitely set apart by the Board of Control of the Experiment Station for the erection and equipment of a new and

larger laboratory for the production of hog cholera serum and virus. In other words no pains have been spared to carry out the provisions of the State act and every branch of station work has been quickened and strengthened as the result of these efforts.

NEW BUILDINGS. In the autumn of 1911, contracts were let for the erection of a new addition to the Experiment Station building, and work on this new addition was begun during the late autumn and early winter of 1911. Work on this building was continued through the year 1912. On June 25, 1912, contracts were let for the construction of an animal house on Graham Avenue, Lexington, Kentucky. Work on this building was begun at once and actively prosecuted during the remainder of the year 1912.

On November 18th, a contract was let to the Congleton Lumber Company of Lexington, for the erection of a new hog cholera serum laboratory on the Experiment Station farm. Work on this building was begun at once, but owing to the extreme cold weather, the progress of the work was seriously interfered with. Funds were also appropriated by the Board of Control for the erection of a new tobacco barn on the Experiment Station farm.

EXPERIMENTAL FIELDS. In compliance with the provisions of the General Assembly, approved March 11, 1912, steps were taken by Acting Director Peter and the Board of Control looking to the location of a number of experimental fields in various parts of the State, and Professor Roberts, Head of the Division of Agronomy, was directed to proceed to the extreme western part of the State with the object of locating such a field in the neighborhood of Paducah, Kentucky, and on October 31, 1912, an experimental field was located at Lone Oak in McCracken County.



ANIMAL HOUSE.

ADDITIONS TO THE STAFF OF THE EXPERIMENT STATION. The Act of the General Assembly approved March 11, 1912, appropriating the sum of fifty thousand dollars annually to the Experiment Station contemplated not only the establishment and maintenance of a number of experimental fields in different parts of the State for the study of the various soil types represented in the State, together with the crops best adapted to each, but also experimental investigations in horticulture, feeding experiments with beef cattle, sheep and swine, methods of dairying, investigations looking to the development of the horse and poultry interests of the State, and the general maintenance of the Experiment Station. In compliance with the provisions of this act, therefore, it has been found necessary to extend our work considerably in a number of directions. Accordingly, the work in animal husbandry in the Experiment Station has been divided into two divisons, namely, (1) Beef cattle, sheep and swine, in charge of Professor Good and (2) Horses, dairy cattle and poultry in charge of Professor Hooper. The latter has been made a member of the Station Staff.

Within the period included in this report, Mr. T. R. Bryant was made Professor of Agricultural Extension Work and arrangements were made for the appointment of a person to take charge of extension work in Home Economics and also for the appointment of assistants in animal husbandry, horticulture and chemical research. A plot of ground of considerable size on the Experiment Station farm, was definitely set apart for the horticultural work under Professor Mathews.

Within the year 1912, the following appointments to the

Experiment Station Staff have been made by the Board of Control:

T. R. Bryant made Professor of Extension Work, June 28, 1912.

Dr. A. M. Peter appointed Acting Director of the Experiment Station, August 16, 1912.

Dr. Joseph H. Kastle appointed Dean of the College of Agriculture and Director of the Experiment Station, Oct. 26, 1912.

Prof. E. S. Good to have charge of one Division of Animal Husbandry, (Beef Cattle, Sheep and Swine) October 31, 1912.

Prof. J. J. Hooper made a member of the Staff of the Experiment Station, to have charge of the second Division of Animal Husbandry (Horses, Dairy Cattle and Poultry) October 31, 1912.

Walter Scheppelman appointed Bakery Expert, Pure Food and Drugs Division, October 31, 1912.

Dr. R. L. Pontius appointed Field Expert in Administration of Hog Cholera Serum, October 31, 1912.

J. S. McHargue appointed Assistant Chemist, October 31, 1912.

G. Harold Noyes appointed Consulting Meterologist of the Experiment Station, October 31, 1912.

W. H. Moore appointed Night Watchman of Station Building, November 4, 1912.

Satisfactory progress has been made in all lines of Experiment Station work during the year 1912, and a number of very important investigations have been completed. Among the latter may be mentioned the following:

A study of the insects in certain localities of the State in which pellagra is present, with the view of determining, if possible, the part played by stinging and biting insects in the spread of this infection, by Professor Harrison Garman.

A study of parturient paresis (milk fever) and eclampsia by Drs. Healy and Kastle, in which the analogy is shown between these two diseases and in which it is proven that they are due to toxic substances elaborated in the udder and the breast at or about the time of parturition.

A soil survey of Webster County made in cooperation with the Kentucky Geological Survey and Chemical Division of the Experiment Station.

A study of the catalpas and their allies by Professor Harrison Garman.

A study of the etiology of infectious abortion in cows and mares by Professor E. S. Good.

The diagnosis of infectious abortion in dairy cattle by Dr. F. M. Surface.

Studies on the cultivation of corn and soy beans by Professors Roberts and Kinney of the Division of Agronomy.

A general summary of the work of the several divisions of the Experiment Station is given in the following under the respective divisions.

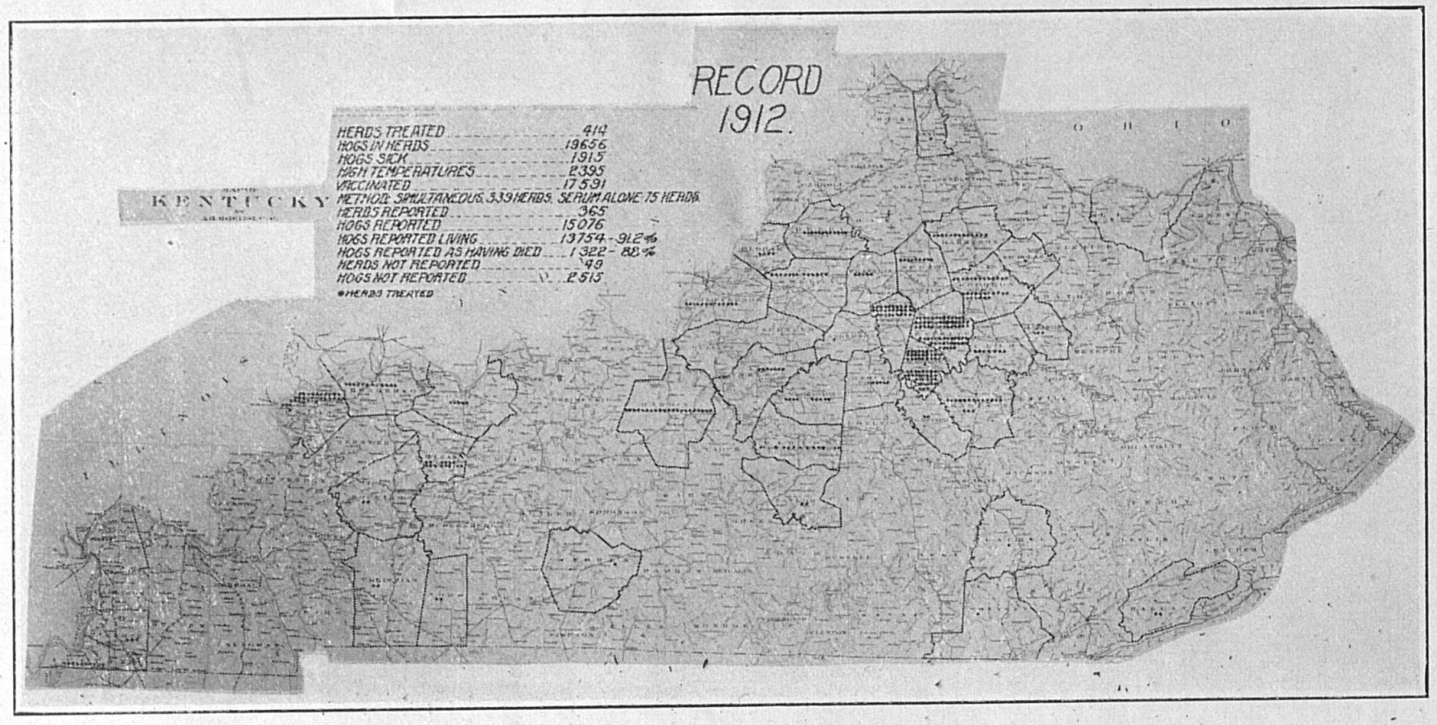
AGRONOMY. The work of this department during the past year, has included studies on the following important field crops, namely, corn, wheat, oats, barley, tobacco, alfalfa, sweet clover and soy beans, including variety tests, time and manner of seeding, cultural methods, harvesting, curing, and threshing, and the use of lime and fertilizers. A permanent soil experiment field was laid out on the Experiment Station farm in 1911, having for its object to test the efficiency of various systems of cropping and methods of soil treatment. Similar fields have been laid out at Burnside, Pulaski County, and at London, Laurel County. On the London field, the yield of corn was increased from 14 bushels per acre in 1911 to 39 bushels per acre in 1912, through the

use of phosphate and lime. Sites for experimental fields have been selected in Graves, McCracken, Logan and Muhlenberg Counties.

Experiments in soiling versus pasturing dairy cattle have been conducted in this department during the past year. The tobacco investigations have been conducted as heretofore in co-operation with the Bureau of Plant Industry, United States Department of Agriculture, under the guidance of Mr. Benjamin F. Scherffius. This work has included variety tests, the effect of fertilizers on yield and quality, the distribution of limited amounts of seed of purebred varieties of burley tobacco and the cleaning of tobacco seed free of charge to farmers and tobacco growers in the State.

ANIMAL HUSBANDRY. The work of this division has grown to such an extent during recent years that it has been found necessary to divide it into two subdivisions. Professor E. S. Good has had charge of the work on beef cattle, sheep and swine, and Professor J. J. Hooper of horses, dairy cattle and poultry. Important investigations have been carried on during the past year on infectious abortion in cows and mares. Infectious abortion in the cow has been found to be due to the Bang bacillus and a simple blood test for the diagnosis of this disease in the cow has been devised by Dr. Surface.

Anti-Hog Cholera Serum. An important part of the work of this division of animal husbandry has been the production of anti-hog cholera serum and the vaccination of hogs against hog cholera. This disease is the most serious menace to successful hog raising in Kentucky, at the present time. It has been estimated that the annual loss to the swine interests of the State, resulting from this disease, amounts to one and one-half millions of dollars. Realizing the enormity of this loss,



MAP SHOWING THE WORK OF HOG CHOLERA ERADICATION FOR 1912.
(Each dot represents a herd of hogs treated.)

the General Assembly in 1910 appropriated to the Experiment Station, the sum of two thousand dollars for the erection and equipment of a small laboratory for the production and distribution of anti-hog cholera serum. The first output of serum from this laboratory was made in April, 1911, and from this time on, until quite recently, the demand for serum has far exceeded the supply. Realizing the inadequacy of this small laboratory and of our limited equipment for the production of serum, further provision to this end was made by the General Assembly in the State Act approved March 11, 1912, in which the increased production of hog cholera serum and virus and the enlargement of the serum plant at the Experiment Station were enumerated among the other provisions of this Act. Accordingly, on September 17, 1912, the Board of Control of the Experiment Station appropriated out of the funds accruing under the State Act of 1912, the sum of ten thousand dollars for the erection and equipment of a new serum laboratory, and on November 18, 1912, competitive bids were received and opened for the construction of a new laboratory and the contract for the erection thereof was let to the Congleton Lumber Company, at a cost of $10,640, the laboratory to be completed by April 1, 1913. Work on the new laboratory was begun at once and the work actively prosecuted. Despite our inadequate equipment, 1,036,435 cubic centimeters of serum were produced at the Experiment Station during the year 1912. Four hundred and fourteen herds of hogs, containing 19,656 hogs were inoculated with serum furnished by the Experiment Station with a saving of 91.2 per cent of all hogs treated with serum, and within this period, the work of hog cholera vaccination was carried on in thirty-nine counties of the State. The map facing this page shows the work of hog cholera vaccination

accomplished during the year 1912, each dot representing a herd of hogs receiving the serum treatment.

Important studies have been carried on in the feeding of calves and the summer feeding of dairy cows. The model dairy on the Experiment Station farm, under the direction of Mr. John W. Nutter, has set a high standard for dairymen in Kentucky. At the International Dairy Show in Milwaukee, the Experiment Station milk was awarded fourth prize and cream from the Experiment Station, second prize, and at the National Dairy Show in Chicago, our cream was likewise awarded second prize in competition with a number of State Universities and eighty-two dairymen.

During the past summer, Professors Hooper and Nicholls made an exhaustive dairy farm survey of Kentucky, and a large amount of valuable data were collected on the practices followed by successful dairymen throughout the State. A large number of advanced registry tests have been conducted by this department. Information has been furnished to farmers and dairymen relative to the construction of silos, the remodeling of dairy barns, the rotation of crops best adapted to milk production and in every way this department has demonstrated its increasing usefulness to the farmers of the State.

In the poultry yards on the Experiment Station farm, five breeds of chickens are being studied and feeding experiments with chickens are now under way.

CHEMISTRY. The work of the Chemical Division during the calendar year 1912 has included the analysis of 369 specimens of various materials of which 173 were soils, 75 mineral and potable waters, 60 limestones, 7 phosphate rock, 11 coals, and 43 miscellaneous materials. In addition to the above, a large number of ores, rocks, minerals and other materials



JERSEY COWS, EXPERIMENT STATION FARM.

were examined qualitatively and reported without being entered regularly on the laboratory register. In addition to the analytical work of this division, a number of determinations have been made of the rate of solution of limestones of different degrees of fineness in dilute acids, with the view of determining just what grade of ground limestone was best suited for agricultural purposes. In cooperation with the Association of Official Agricultural Chemists, considerable work has been done in this division on methods for the analysis of insecticides, water and soil analysis, the latter involving a comparison of the methods employed in determining soil acidity. This work has been largely in the hands of Mr. Averitt who has devised a very rapid and satisfactory volumetric method for the analysis of lime-sulphur solutions which find considerable practical application as an insecticide and fungicide. The work of this division has also included the examination of a number of samples of cured tobacco for arsenic, lead and copper with the object of determining whether any noteworthy amounts of these poisonous substances, which are used in spraying tobacco for the tobacco worm, remain on or in the leaf after curing. The results of the analyses made in this division during the year, of mineral and potable waters from various sections of the State are appended as a separate section of this report.

ENTOMOLOGY AND BOTANY. In this division, the nursery inspection work has been continued, the total number of plants of all sorts inspected amounting to 4,400,150. The time required for this work was considerably greater than that required in previous years, owing to the large number of nurseries found to be infected with San Jose scale. The work of seed testing has also been continued, 493 samples having been examined for purity and 521 samples for germ-

inating power, making a total of 1,014. Improvements have been made in the method employed in testing the germinating power of bluegrass seed. Bacteriological examinations of 67 waters have been made in this division. The cooperative work with the United States Department of Agriculture on plant breeding and variety tests and the study of forage plants have also been continued. Altogether 332 experimental plots have been given over to this work on the Experiment Station farm, 56 to rotation systems, 79 to grasses and forage crops, 18 to spraying tests on tobacco, 38 to the study of the corn-ear worm, 17 to miscellaneous observations and 124 to variety tests, including corn 9.5, soy beans, 32.5 cowpeas 31, hemp 17, wheat 34. The investigations carried on by this division during the past year have included an exhaustive study of the corn-ear worm, a study of the nodule-forming bacteria of leguminous plants and of the molds of corn, especially in in their possible significance as the toxic agents in forage poisoning, a disease which has become increasingly prevalent among live stock in Kentucky and the western states during recent years. The scientific work of the Division of Entomology and Botany has also included the study of stinging flies, especially in their possible relation to pellagra.

EXTENSION. The work of agricultural extension as at present carried on in the Experiment Station, dates from the reorganization of the College of Agriculture in 1910. During the past year, this branch of our work has assumed more definite shape than heretofore. During the year, Mr. Thomson R. Bryant was made Professor of Agricultural Extension and two new men added to the department, one in agronomy and one in horticulture. Considerable aid has also been furnished by the other departments of the Experiment Station, looking to better and more efficient extension service. Farm

schools have been held in eleven counties of the State, with a total attendance of about 800 persons. An outgrowth of this work has been the organization of clover and alfalfa clubs in a number of localities.

Farmers' Week. Beginning the first Monday in January and continuing for one week a series of conventions was held at the College. These meetings and exhibits go to make up what is known as Farmers' Week. The annual meetings of the State Swine Breeders' Association, the Kentucky Dairy Cattle Club, the Kentucky Beef Cattle Breeders' Association, the Sheep Breeders' Association, the Horse Breeders' Association, the State Horticultural Society and the Kentucky Corn Growers' Association, were held at the University at this time. A dairy exhibit and dairy school and a corn school were held throughout the week, and also the State Corn Show. Each year increasing interest is shown in Farmers' Week. Men of national reputation were secured to deliver the principal addresses.

Educational exhibits have been made by the Department of Agricultural Extension at the State Fair, the National Corn Show and the Blue Grass Fair, and for the past three years, a model dairy has been operated at the State Fair which has attracted a great deal of attention and which has done much to stimulate cleanly and sanitary dairying in various parts of the State.

In cooperation with the United States Department of Agriculture, county agents have been placed in Madison and Henderson Counties. Their mission will be to instruct the farmers in the respective counties in which they are located in better and improved methods of farming. In cooperation with the State Department of Agriculture, a farm boys' encampment was held at the State Fair. On the basis of competitive examinations, 110 boys were selected

from 90 counties of the State. Transportation to and from the fair, together with board and lodging on the fair grounds and the privilege of all of the fair exhibits were given to these boys free of charge. During the morning hours, these boys received instruction in the various phases of agriculture, the afternoon being spent in a study of the various exhibits at the fair.

Among the new features of cooperative agricultural extension work carried on in the State during the past year, may be mentioned the agricultural special train which, beginning the 24th of March and continuing over twenty-nine days, was run over the seven principal railroads of the State. This train made one hundred and eight stops in various localities within the State and reached at least seventy thousand persons. The train was abundantly equipped with exhibits and illustrative material, showing the best and most recent agricultural practices. At each stop, instruction was given to those present by lectures and demonstrations, and a vast amount of agricultural literature was distributed.

As a regular part of the work of the extension department, a number of circulars have been published during the year on timely agricultural topics and a regular series of press bulletins emanating from this department has been published in two hundred and seventy-five newspapers in the State. These newspaper articles have served a very useful purpose in bringing directly to the farmer the valuable results of Experiment Station work.

COMMERCIAL FEEDING STUFFS. During the year, 1378 different brands of feeding stuffs were registered, representing over five hundred firms. About two and one-half million tags have been issued, estimated to represent over



BARN FOR THE FIRE-CURING OF TOBACCO, EXPERIMENT STATICN FARM.

one hundred and eleven thousand tons of commercial feeding stuffs sold in the State, and a business of over three and one-half million dollars. Seven hundred and five inspectors' samples have been analyzed both chemically and microscopically, and 152 manufacturers' and dealers' samples for registration purposes, making a total of 857. Seven violations have been reported for prosecution during the year which resulted in conviction in each case.

Two new materials, peat and bastol meal, have been offered to the trade in Kentucky and have been refused for registration, for the reason that the department feels that they are not of sufficient value as a feeding stuff to merit recognition, and should not, therefore, be classified as a feeding stuff.

Peat is an accumulation of more or less spongy, decaying vegetable matter, intermediate in character and properties between fresh vegetable material and coal, produced under various conditions of climate and topography, and found either in swampy locations or in damp, foggy regions. It is used for fuel and is manufactured into blankets, carpets, rugs, wadding, paper, carboard, etc., and peat gas for power purposes.

It is claimed that peat is being used extensively in the European countries as a feeding stuff, but from a nutritive standpoint, it appears to have no merit. It is also claimed that it is a good absorbent and dryer and that it possesses many corrective properties of bad effects caused by the use of other materials in feeding stuffs.

A sample of this material gave the following numbers on analysis: Protein 17.5 per cent, fat 0.82 per cent, ash 27.4 per cent, water 9.05 per cent. It is the opinion of the department, after making as thorough investigation as is pos-

sible at this time, that this material is inert or practically so, and has no place among commercial feeding stuffs.

Bastol meal consists of finely ground wood which has been subjected to the action of sulphurous acid and steam under pressure. Molasses is then mixed with this material and it is sold on the market as Bastol Meal. This department has made no analysis of this material, but from a report of the State Chemist of Indiana, the product contains 2.2 per cent crude protein, 0.4 per cent crude fat, 31.6 per cent crude fiber, and 52.6 per cent nitrogen free-extract.

The consumers of this State are cautioned to consider carefully the food value of these materials and likewise of other materials of like character, before purchasing them as feeding stuffs.

During the year, practically every town in the State, where commercial feeding stuffs are sold or are likely to be sold, has been visited from time to time by our inspectors for the purpose of securing samples for examination and for the purpose of determining whether the feeds offered for sale are properly labeled and the requirements of the law complied with. The results of our analyses and examinations have been reported to the manufactures and dealers of commercial feeding stuffs and to the consumers from whom the samples were taken.

The results of our inspection show conclusively that the purpose of the law is being accomplished. It is evident that there is a very general understanding in the trade, both wholesale and retail, relative to the requirements of the law regulating the sale of feeding stuffs and a very evident desire on their part to conform with the requirements of the law. The consumer likewise is becoming educated in the

subject of feeds and feeding, and is now purchasing his feeds on the basis of their actual feeding value.

The percentage of adulteration is steadily decreasing and a higher class of goods in general is the result. However, the unusual demand and the high prices of feeding stuffs during 1912 offered a great temptation to unscrupulous manufacturers and dealers. It was found also that a number of mixed feeds contained a large per cent of sand. Whether the sand was added intentionally or found its way into these feeds through the use of sweepings and screenings, the fact remains that such materials should not be in feeding stuffs in appreciable quantities.

On account of the unusual demand and the amount of feeding stuffs consumed in the State, every section of the State where feeding stuffs are sold had to be visited constantly in order to guard against adulterated, misbranded and inferior feeds. Special attention has been given to the use of screenings in feeding stuffs and a number of samples were analyzed. It was found that under the head of "Grain Screenings," "Recleaned Miscellaneous Field Seeds" and "Cleaned Grain Screenings," all sorts of weed seeds were being used in feeds sold in Kentucky. The use of such feeds, high in foreign weed seeds, tends to the introduction of many undesirable and noxious plants. These weed seeds, unless ground up or subjected to high temperature, will germinate under ordinary conditions and grow, thus stocking the farms of the State with weeds. Some of the molasses feeds and chicken feeds were found to contain unusual amounts of these weed seeds. A number of shipments of cottonseed meal coming into the State during the year have been of low grade, and this particular class of goods necessarily had to receive a good deal of attention. A

close inspection has been made and the same policy has been carried out as heretofore, in aiding both the manufacturer and consumer in the conservation of feeding materials and their economical use, and the dissemination of useful information along this line.

The division has also been interested in the adoption of a list of definitions of standard feeding materials. Such a list of definitions has been adopted by the Association of Feed Control Officials of the United States, and has been published to the Kentucky trade for guidance in the business in this State.

FERTILIZERS. During the year 1912, 672 brands of fertilizers have been registered by 54 firms, and in addition to the analyses of samples submitted by manufacturers, 405 samples of fertilizers collected by our inspectors or sent in by farmers have been analyzed in the fertilizer laboratory. The results of these analyses have been published in Bulletin 168. 2,075,988 tags were issued during the year, and 1,006,568 stamps of various denominations, ranging from 100 to 200 pounds.

PURE FOOD AND DRUGS. Within the period included in this report, analyses have been made in the laboratories of this division of 3003 samples of foods and food products and 698 samples of drugs and drug preparations of various sorts, in addition to which bacteriological examinations have been made of 1767 samples of various materials, such as milk and cream, water, tomato pulps and catsups, the contents of bakery and grocery bread boxes, etc., etc., making a grand total of 5468 samples analyzed or examined in the pure food and drug laboratories during the year 1912. Of the 2532 official samples of foods and food products, 550 were found to be adulterated, and of the 581 official samples of

JERSEY CALVES, EXPERIMENT STATION DAIRY.

drugs and drug preparations, 264 were found to be adulterated.

During the year 1912, 182 prosecutions have been brought against manufacturers and dealers on the basis of these findings. Up to date, these have resulted in 93 fines, 4 assessments of costs only, dismissals 6, verdicts of not guilty 9, still pending 13. In certain instances, a number of indictments were brought against the same firm or individual, which explains the difference between the total number of prosecutions and court findings.

During the past year, the inspectors and field force of the Pure Food and Drug Division have made careful inspections of grocery stores, drug stores, dairies, slaughter-houses and cold storage plants in practically every section of the State. Besides the regular inspection and examination of food and drug samples and reports to the State Attorneys thereon, this department has directed special attention towards the following subjects: Slaughter-house investigations, including plans for the establishment and control of the municipal abattoir; the sanitary inspection of grocery stores and the proper labeling of retail packages to show adulteration after the product has been taken by the grocer out of properly labeled wholesale packages; sanitary inspection of bakeries and the examination of materials employed in baking; sanitary inspection of dairies, and a bacteriological survey of the State's milk supply, including not only examination of the product from the dairies and milk depots, but also of samples taken from the market and in cooperation with city health departments; the examination of bleached flour; the examination of dried fruits and sausage for sulphites; the analysis of rice to determine coating and polishing; an inspection of cold storage ware-

houses; the analysis of veterinary supplies, physicians' prescriptions, pharmaceuticals, remedies and liniments intended both for man and animals; the collection of patent medicine labels and the correction of misstatements as to the medicinal value of such preparations.

HORTICULTURE. In the past, this important line of work has been seriously hampered through lack of space on the Experiment Station farm and through lack of assistance for the proper carrying on of the work. However, another beginning has been made in this important branch of Experiment Station work. Small plots of strawberries, raspberries, currants and other small fruits, have been planted and a larger area set out in grapes, which previous experience has shown give favorable returns both on our blue grass soils and elsewhere in the State. An old orchard on the Experiment Station farm is being rejuvenated and again brought under proper cultivation.

RESEARCH. The federal acts known as the Hatch Act and the Adams Act, and also the State Act, approved March 11, 1912, make provision for original investigations in the various branches of agriculture as a regular part of the work of the Experiment Station. Among the various investigations carried on in the Experiment Station within the period covered by this report may be mentioned the following:

The etiology of infectious abortion in cows and mares and the diagnosis of infectious abortion in cattle by means of the agglutination and complement fixation tests; a study of forage poisoning or the so-called cerebro-spinal meningitis in horses, cattle and mules; a continuation of the study of the corn-ear worm and of the nodule-producing bacteria of leguminous plants; botanical studies on the weeds and poison-

ous plants of Kentucky, including observations on their distribution, identification and possible eradication; studies on the composition of the ash of the sap, leaves and young stems of the wild grape vine (Vitis cordifolia); the occurrence and distribution of barium in plants and its possible significance in the growth of vegetation. Our researches have also included the study of calcium salts in their relation to the onset of labor and the relation of calcium to anaphylaxis; asymmetric color resemblances in certain animals; simplification and standardization of the methods of water analysis, and a volumetric method for the analysis of lime-sulphur solutions.

Bulletins.

No.

159. A Preliminary Study of Kentucky Localities in which Pellagra is Prevalent, having Reference to the Condition of the Corn Crop and to the Possible Presence of an Insect or other Agent by which the Disease Spreads. H. Garman.

160. Parturient Paresis (Milk Fever) and Eclampsia; and the Internal Secretion of the Mammae as a Factor in the Onset of Labor. Daniel J. Healy and Joseph H. Kastle.

161. Soy Beans. George Roberts and E. J. Kinney.

162. The Soils of Webster County. A. M. Peter and S. C. Jones.

163. Corn Production. George Roberts and E. J. Kinney.

164. The Catalpas and their Allies. H. Garman.

165. Investigations of the Etiology of Infectious Abortion of Cows and Mares. Edwin S. Good.

166. The Diagnosis of Infectious Abortion in Cattle. Frank M. Surface.

167. Forage Poisoning or so-called Cerebro-Spinal Meningitis in Horses, Cattle and Mules. Robert Graham.

168. Commercial Fertilizers. Joseph H. Kastle and H. E. Curtis.

Circulars.

Handbook for Agricultural Clubs. T. R. Bryant.

Soil Fertility. George Roberts.

Alfalfa. E. J. Kinney.

Silo Facts. A. J. Reed.

Making Wheat Growing More Profitable in the Blue Grass. E. J. Kinney.

Press Bulletins.

No.

20. Pneumonia in Swine. Robert Graham.

21. Lessons Derived from the Kentucky Dairy Show. J. J. Hooper.

22. Agricultural Extension. T. R. Bryant.
23. Fatal Disease Caused by Spoiled Corn and Roughage. Robert Graham.
24. Securing Good Seeds. E. J. Kinney.
25. Orchard Pruning. C. W. Mathews.
26. The Farm Special Train. T. R. Bryant.
27. Lime for Agricultural Purposes. George Roberts.
28. Distribution of Anti-hog Cholera Serum in Kentucky. E. S. Good.
29. Legume Crops and the Nitrogen Supply. George Roberts.
30. Swine. T. R. Bryant.
31. Improving Wheat Varieties. E. J. Kinney.
32. Dodder in Clover. H. Garman.
33. Preventing the Souring of Milk in Hot Weather. W. D. Nicholls.
34. Bread Making. Aubyn Chinn.
35. Concrete Silos Popular in Kentucky. A. J. Reed.
36. The "White Fungus" as a Means of Destroying the Chinch-Bug in Cornfields. H. Garman.
37. Dairy Farming. J. J. Hooper and W. D. Nicholls.
38. Infectious Abortion of Cows. E. S. Good.
39. Timely Seed Corn Hints. T. R. Bryant.
40. The Fall Army Worm (Laphygma frugiperda) Injuring Alfalfa and Rye in Kentucky. H. Garman.
41. Free Seed Testing for Kentucky. H. Garman.
42. Mycotic Stomatitis. Robert Graham.
43. Disposal of Dead Hogs. E. S. Good and Robert Graham.
44. Farmers' Week and Agricultural Short Courses. T. R. Bryant.
45. Assistance for Kentucky Orchardists. J. H. Carmody.
46. Starting the Dairy Herd. W. D. Nicholls.

Scientific Papers.

Notes on Contagious Abortion in Cows. F. M. Surface. (Science.).

Bovine Infectious Abortion Epizootic Among Guinea Pigs. F. M. Surface. (Journal of Infectious Diseases).

Parturient Paresis (milk fever) and Eclampsia. Daniel J. Healy and Joseph H. Kastle. (Journal of Infectious Diseases).

The Toxic Character of the Colostrum in Parturient Paresis. Joseph H. Kastle and Daniel J. Healy. (Journal of Infectious Diseases).

The Internal Secretion of the Mammae as a Factor in the Onset of Labor. Daniel J. Healy and Joseph H. Kastle. (Journal of Infectious Diseases).

Calcium Salts and the Onset of Labor. Joseph H. Kastle and Daniel J. Healy. (Journal of Infectious Diseases).

The Normal Clinical Urinalysis of the Dairy Cow. Daniel J. Healy. (American Veterinary Review).

Asymmetric Color Resemblance in the Guinea Pig. Joseph H. Kastle and G. Davis Buckner. (American Naturalist).

On the Composition of the Ash of the Sap, Leaves and Young Stems of the Wild Grape Vine (Vitis cordifolia). Joseph H. Kastle and O. M. Shedd. (Journal American Chemical Society).



MELVILLE AMASA SCOVELL.

MELVILLE AMASA SCOVELL

DIRECTOR OF THE KENTUCKY AGRICULTURAL EXPERIMENT STATION, 1885-1912.

DEAN OF THE COLLEGE OF AGRICULTURE, STATE UNIVERSITY, LEXINGTON, KENTUCKY, 1910-1912.

Within the period covered by this report, the College of Agriculture of the State University and the Kentucky Agricultural Experiment Station suffered an irreparable loss in the untimely death of Dr. Scovell, which occurred on August 15, 1912. The report of the work of the Kentucky Agricultural Experiment Station for the year 1912, would be incomplete and wanting in one important particular, therefore, did it fail to give some account of his life and work as Director of the Experiment Station and as Dean of the College of Agriculture.

Within the first two decades of their existence, the land-grant colleges of the several States had performed an important service in the cause of higher education. By 1885, however, it had come to be recognized by the heads of the land-grant colleges, that something more was needed for the advancement of the rural population of the several States, than to provide instruction for the young in agriculture and branches related thereto. That, if these institutions were to fulfill their full measure of usefulness, something should be done of more immediate benefit to the farming classes of the several States and that our present knowledge of agri-

culture and of agricultural conditions and practices should, if possible, be further developed by scientific observation and discovery.

According to President Patterson,[1] the question of establishing experiment stations began to be agitated in the Association of Land-grant Colleges in 1885. The act donating public lands for the purpose of establishing the land-grant colleges provided that these colleges should afford instruction in those branches of learning related to agriculture and the mechanic arts, but no provision had been made for experimental and research work along these several lines. It was felt, therefore, by those who had organized and conducted these colleges for a period of twenty years that something more was needed than to teach the branches of learning already known and their application to agriculture, and that some provision must be made for experimental work along these lines. In July, 1885, the President of the Agricultural and Mechanical College of Kentucky attended a preliminary meeting in Washington, the object of which was to organize for cooperative work the Agricultural and Mechanical Colleges and to establish experiment stations in connection with the existing agricultural colleges, the object of which should be to advance agricultural science and practice by experiment and scientific discovery. Accordingly, an organization was effected at this time and the character and scope of the work agreed upon in a general way, and each head of the several agricultural and mechanical colleges returned home to organize an experiment station to meet the requirements of local conditions and in harmony with this general plan. It was likewise agreed at this time that the organization effected in Washington should be

[1] See "Origin of Experiment Stations," by James K. Patterson, Lexington Leader, September 12, 1912.

known as the Association of American Agricultural Colleges and Experiment Stations and that it should hold meetings annually and present through properly qualified committees the progress made from time to time in the work to which the Association addressed itself. On September 25, 1885, President Patterson submitted to the Executive Committee of the Agricultural and Mechanical College a plan for the establishment of an agricultural experiment station, whereupon it was resolved by the Executive Committee to establish such an experiment station and the President of the College was directed to tender to Professor M. A. Scovell the Directorship of the Experiment Station on behalf of the Executive Committee, Professor Scovell having been highly recommended for this position by Professor H. A. Weber and others. To the President of the Agricultural and Mechanical College of Kentucky and to Judge W. B. Kinkead, Major R. S. Bullock, Dr. R. J. Spurr and Major P. P. Johnston, all of Lexington and Fayette County, we owe the credit of founding an institution which from small beginnings has grown to a position of great usefulness to the State at large.

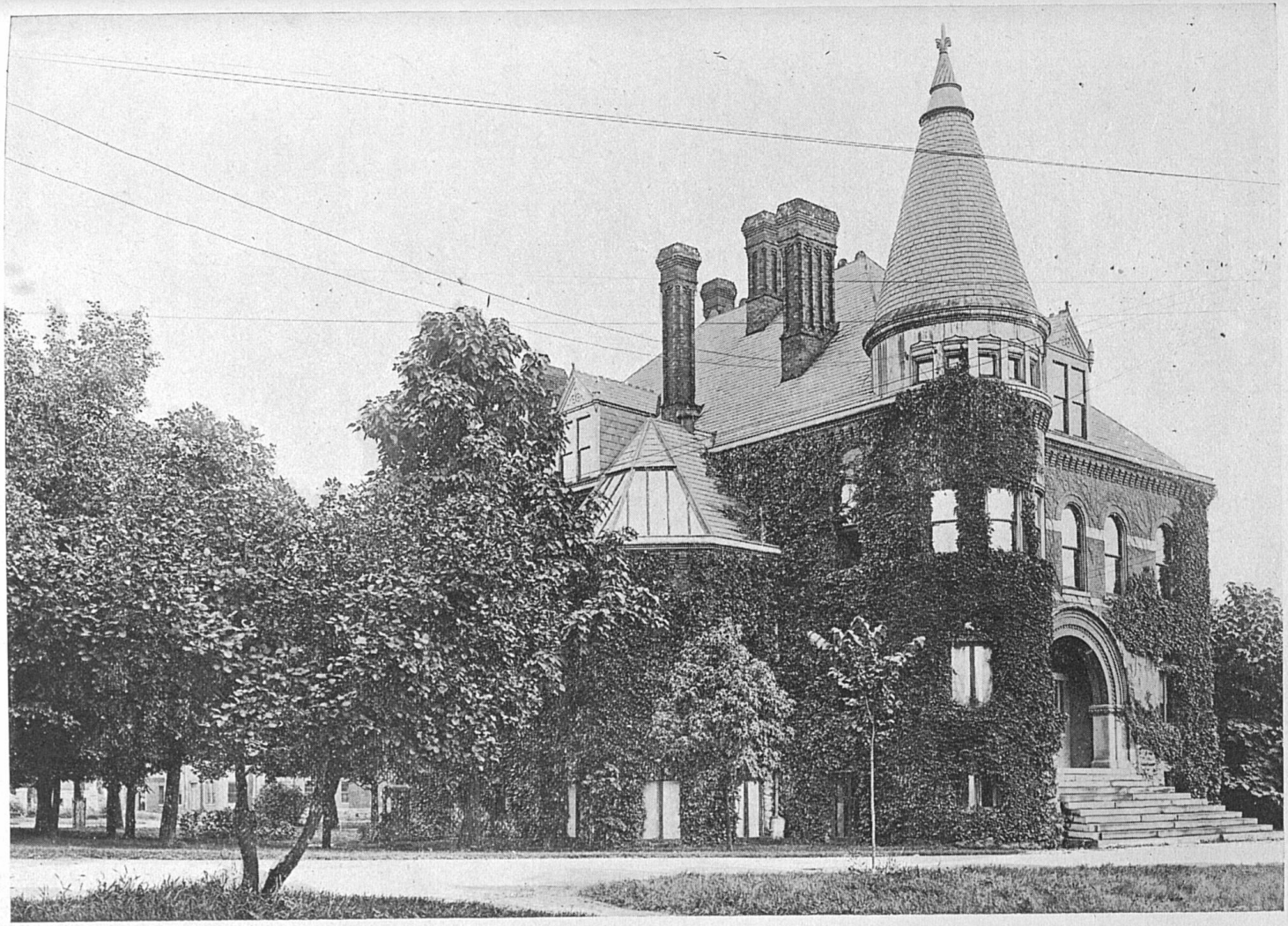
Professor Scovell entered upon his duties as Director of the Experiment Station the following November. In 1886, the General Assembly designated the Experiment Station as the Kentucky Agricultural Experiment Station and passed an act regulating the sale of commercial fertilizers in the State and empowered the Director of the Experiment Station to make official analyses of such products under the law and to make all necessary rules and regulations for its proper enforcement. In the spring of 1886, all tillable land owned by the College was assigned to the Experiment Station for field experiments and during the same year, Professor A. M. Peter was appointed Assistant Chemist to the Experiment

Station. In March, 1887, Congress passed the Hatch Act, appropriating the sum of fifteen thousand dollars annually out of the Federal Treasury to each State and Territory of the Union for the support and maintenance of agricultural experiment stations. In 1888, the Legislature of Kentucky gave its formal assent to the provisions of the Hatch Act appropriating funds for the benefit of the Kentucky Agricultural Experiment Station and steps were at once taken by the authorities of the Agricultural and Mechanical College of Kentucky to put the work of the Experiment Station on a firmer basis. Its management was placed in the hands of a Board of Control, consisting of the Executive Committee of the Board of Trustees, the President of the College and the Director of the Experiment Station. In 1887, the Strader place of 48½ acres on the Nicholasville Pike was purchased for an experimental farm, and in 1888, the contract was let for the first Experiment Station building now known as the "old chemistry building." This building was completed and ready for occupancy by the first of September, 1889.

The list of Experiment Station officers given in the first annual report of the Experiment Station, transmitted to the Governor of Kentucky, February 1, 1889, included the following persons:

M. A. Scovell, Director.
A. M. Peter, Assistant Chemist.
H. E. Curtis, Second Assistant Chemist.
H. Garman, Entomologist and Botanist.
A. T. Parker, Microscopist.
James Murray, Practical Horticulture.
C. L. Curtis, Assistant Agriculturist.
Sam E. Black, Secretary and Stenographer.

In the first four years of its existence, the Experiment Station published sixteen bulletins, giving the results of



OLD CHEMISTRY BUILDING, OCCUPIED BY THE KENTUCKY AGRICULTURAL EXPERIMENT STATION 1889 TO 1905.

various investigations of interest to Kentucky farmers; five of these were on commercial fertilizers, three on wheat experiments, two on experiments with potatoes, one on the effect of fertilizers on the quality of tobacco, one on corn fodder as a food for stock, one on milk, one on distillery slops, one on clover and one on analyses of feeding stuffs. In addition to the results given in these bulletins many chemical analyses were made of various agricultural products, such as grasses, hays and feedstuffs, mineral waters, sorghum juices, etc., etc. We have seen that the first annual report of the Kentucky Agricultural Experiment Station for the year 1888, in reality included a brief historical account of the establishment and organization of the Experiment Station, together with its work and progress for the first three or four years in the life of the institution. Beginning with the second annual report in 1889, annual reports of the work and progress of the Experiment Station have been issued, showing the work and progress of the Experiment Station during each succeeding year from 1889 to 1912.

In its new quarters and on the experimental farm, the real work for which the Experiment Station was organized was begun. Through the medium of its bulletins, of which six were published in 1889, the results of its investigations were carried to the farmers of the State. It is also significant that of these earlier bulletins, practically all have long since been exhausted, so eagerly has the information which they contained been sought by the Kentucky farmer. Pig feeding experiments were begun by Professor Connell. In the Division of Fertilizer Control, a large number of fertilizers were analyzed both for manufacturers and for farmers. The earlier field experiments included tests of a number of

varieties of wheat, oats, potatoes, sorghum, strawberries and other small fruits; field tests of fertilizers on wheat, corn, potatoes, hemp, tobacco and oats; pasture and meadow tests of different grasses and their adaptability to the soil of the bluegrass; the effect of different methods of planting and cultivating wheat, oats and corn. The earlier work in entomology under Professor Garman included a wide range of subjects, such as the brown rot fungus of plums, peaches, apples and cherries; the bitter rot fungus of apples; the apple scab fungus; the black rot of tomatoes and methods of controlling the same; a study of the grain louse, a new corn insect, the wheat thrips, the harvest fly, the wheat bulb worm, the clover bark louse, the bot fly of cattle, the cabbage flea-beetle, the potato flea-beetle, a tobacco flea-beetle, together with a description in all cases of the proper method wherewith to control the ravages of these various insect pests. The chemical work of the Experiment Station included not only analyses of a large number of fertilizers and various agricultural products, but also a great deal of work in cooperation with the Association of Official Agricultural Chemists, looking to improvements in the methods employed in the analysis of fertilizers, feeding stuffs, insecticides, etc., etc., and in a very careful and exhaustive investigation and adaptation of the Kjeldahl method for the determination of nitrates. The writer of this humble tribute to the memory of Dr. Scovell recalls from personal observation, the modest beginnings of the Experiment Station. A single basement room in the east corner of the old main building had been set apart to its use. This room was partitioned off into three small rooms, designed respectively for office, laboratory and weighing room. In the old chemistry building, the Experiment Station occupied the



KENTUCKY AGRICULTURAL EXPERIMENT STATION BUILDING, COMPLETED 1905.

entire first floor and the basement, together with a photographic room on the second floor, the second floor of this building being given over to the chemical department of the College. Gradually, however, the Experiment Station outgrew its quarters in the old chemistry building and in 1903, the erection of a new building, expressly designed for the use of the Experiment Station by Professors Anderson and Faig, was begun. This building was completed and ready for occupancy by February, 1905. In 1907, a beautiful greenhouse and insectary was erected in the rear of this building and in 1912, at the time of Dr. Scovell's death, a commodious new addition to the Experiment Station building was in process of erection. The completion of this new addition to the Experiment Station building gave to the Experiment Station approximately one hundred commodious rooms for laboratory and office work. We have seen that in the spring of 1886, twelve acres of land on the College Campus were assigned to the Experiment Station for field trials and experiments. At the time of Dr. Scovell's death, the Experiment Station owned an experimental farm of two hundred and forty acres, together with a number of smaller lots of land, such as that of four acres on which the main Experiment Station building is situated. It owns and operates successfully a model dairy that has probably done more than any other one thing to give to the people of Lexington a pure, wholesome milk supply. It is entirely within the bounds of truth to say that the Kentucky Agricultural Experiment Station began as a one-man institution, in the sense that upon the Director devolved all the work that was done within the first few months following its organization. It is true that the Executive Committee had placed at the disposal of the Director the services of certain members of the College

Faculty whose scientific work was held to be more or less germane to agriculture. In the main, however, their services were entirely perfunctory. At the time of Dr. Scovell's death, the organization of the Experiment Station included nine separate and distinct divisions of work and the Experiment Station Staff numbered forty-five persons. No thoughtful man, familiar with the facts, but what must stand amazed at the growth and development of the institution within the first twenty-seven years of its existence, and no one conversant with these matters can fail to pay a tribute of honor and respect to the genius of Dr. Scovell and to his untiring efforts on behalf of the institution that he served.

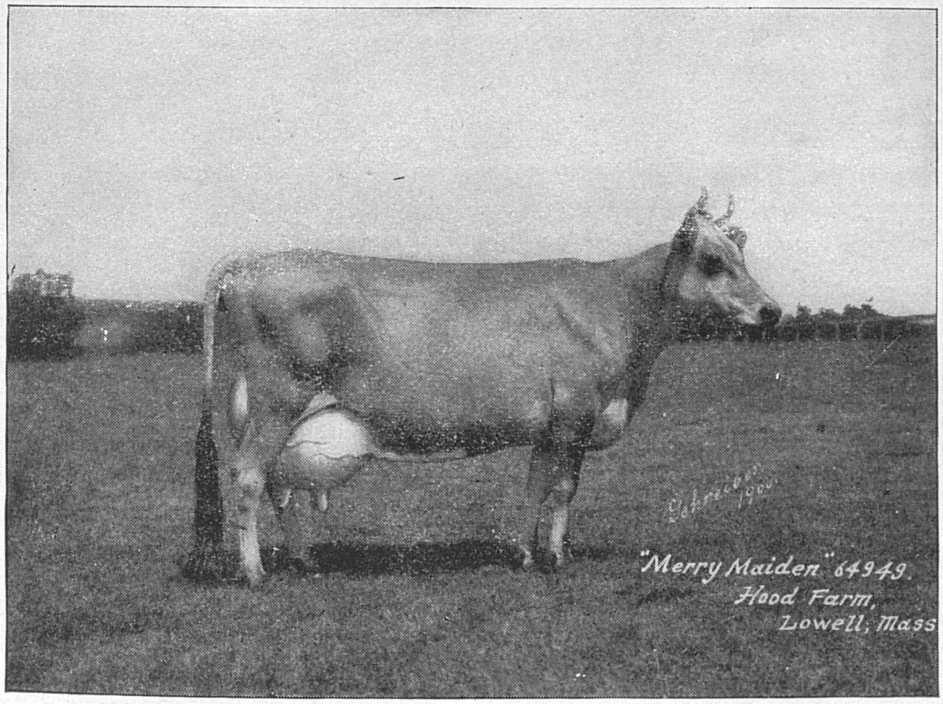
MELVILLE AMASA SCOVELL

Melville Amasa Scovell, the son of Nathan and Hannah Scovell, was born at Belvidere, New Jersey, February 26, 1855. Shortly after his birth, his father's family moved to Chicago and from there to a farm in Champaign County, Illinois. Dr. Scovell graduated from the high school in 1870, and in 1871, he entered the University of Illinois, where he specialized in chemistry, becoming student-assistant in 1872, and then instructor in chemistry, which last position he held for one year. While acting in the capacity of instructor in chemistry in the University of Illinois, he had charge of a chemical exhibit for the University of Illinois at the Centennial Exposition at Philadelphia. He also acted in the capacity of private secretary to Regent Gregory during the years 1876-79. He was appointed Instructor in Agricultural Chemistry, June 4, 1878; Assistant-Professor of Agricultural Chemistry in June, 1879, and finally Professor of Agricultural Chemistry in September, 1880, being the first incumbent of this position in the University of Illinois. During

this time, he became associated with Professor H. A. Weber and together they patented a number of processes for the clarification of the juice of sugar producing plants and for the manufacture of glucose, sugar and syrup from sorghum. In 1877, he received the degree of Master of Science from the University of Illinois, and in 1908, the degree of Doctor of Philosophy. On September 8, 1880, he married Miss Nancy Davis who survives him and to whose tact and unfailing devotion he owed a great deal of his success in life. In 1880-81, he was Secretary of the Illinois Cane Growers' Association, and in 1881-84, he was Secretary of the Mississippi Valley Cane Growers' Association. In 1883-84, he was Superintendent of the Kansas Sugar Works at Sterling, Kansas, and the following year he was Special Agent for the United States Department of Agriculture, having charge of the diffusion batteries for the extraction of sugar from sorghum and sugar cane, in Kansas and Louisiana. In 1885, he was appointed Director of the Kentucky Agricultural Experiment Station, which position he occupied with signal success until the time of his death. Early in his career as Director of the Kentucky Agricultural Experiment Station, Dr. Scovell assisted materially in the upbuilding of the University by cooperating with the Board of Trustees in the appointment of a number of instructors and in the creation of a number of new departments, among them the Department of Mechanical Engineering, the Weather Bureau established in Lexington in 1891, and the Departments of Veterinary Science and Horticulture. In 1888, he was placed in charge of the College grounds and many improvements were accomplished under his direction.

In 1886, he became a member of the Association of Official Agricultural Chemists and was given a place on

the Executive Committee and also on the Committee for the Determination of Nitrogen in Soils, Fertilizers and Agricultural Products. He was Vice-President of this Association in 1889, and President in 1889-90, and was prominently identified with the Association until the time of his death. He and his associates in the Kentucky Agricultural Experiment Station made a number of valuable contributions to the work of this organization and Dr. Scovell's own researches on a modification of the Kjeldahl method for the determination of nitrates attracted universal attention. On October 26, 1897, he was put on the Food Standards Committee of the Association of Official Agricultural Chemists, a special act of Congress having empowered this Committee to act in the interest of pure food standards in the United States. In 1897, a committee from the Association of Official Agricultural Chemists advocated pure food legislation and in that year, delegates were appointed to confer with the National Pure Food and Drug Congress. The Committee on Pure Food Standards was appointed in October, 1897, and consisted of Messrs. Wiley, Jenkins, Weber, Frear and Scovell. President Kilgore's address, November, 1900, gives an idea of the progress and development of the food work done by the Association of Official Agricultural Chemists. (Bulletin 62, U. S. Department of Agriculture, Division of Chemistry.) Meetings of the Food Standards Committee were held in most of the large cities of the country, including Washington and New York in 1904, Chicago, 1905, Boston, 1905, Washington and St. Louis, 1906. Dr. Scovell read a paper before the Association of Official Agricultural Chemists on tests of the modified Gunning method. (Experiment Station Record, vol. 2, p. 117). At the sixth annual convention of the Association of American Agricultural Colleges and Experi-



MERRY MAIDEN 64949. SWEEPSTAKES COW IN THE WORLD'S COLUMBIAN EXPOSITION DAIRY TESTS, CHICAGO, 1893. OWNED BY C. I. HOOD, LOWELL, MASS.

ment Stations in November, 1892, Dr. Scovell presented the report of the Section on Chemistry. (Experiment Station Record, vol. 4, p. 402), and in 1892, he was appointed a member of the Committee on Tests from the same Association to supervise the great dairy tests at the World's Columbian Exposition. At the first meeting of this Committee on February 6, 1893, Professor Scovell was elected to the Chairmanship of the Committee. At a meeting of the Association of Official Agricultural Chemists in 1896, he presented a paper, entitled "Some Sources of Error in the Determination of Potash in Fertilizers." In 1890-94, Dr. Scovell was Secretary and Treasurer of the Association of American Agricultural Colleges and Experiment Stations and in 1890, was extended a vote of thanks by the Association for his efficient services as Secretary and Treasurer of the Association, and also at a meeting in 1891, he received a similar vote for his very efficient services as Treasurer of the Association. He was fifth Vice-President of the Association of American Agricultural Colleges and Experiment Stations in 1899, was again Vice-President in 1906, first Vice-President in 1908, and presided at the meeting of this Association at Baton Rouge in 1908, at which time he was elected President of the Association of American Agricultural Colleges and Experiment Stations, but was unable to officiate at the meeting in 1909 on account of illness. Dr. Scovell served for a number of years on the Auditing Committee and for eleven years on the Executive Committee of the Association of American Agricultural Colleges and Experiment Stations, also on the Committee of Uniform Fertilizer Laws for eight years, and on the Committee of Experiment Station Work and Policy for a number of years and, in fact, until the time of his death. In 1897, he was appointed a member of the Commit-

tee on Station Exhibits for the Paris Exposition. At a meeting of the Association of American Agricultural Colleges and Experiment Stations in New Haven in 1900, he read a paper on "Burley Tobacco, Its Growing and Curing," and at the twelfth convention of the Association of American Agricultural Colleges and Experiment Stations he read a paper on "Some Notes in Connection with the Testing of Cows as to Milk and Butter Production." In 1903, he was elected Secretary of the Section on Experiment Station Work of the Association of American Agricultural Colleges and Experiment Stations and for a number of years was actively engaged in the consideration of methods of Experiment Station work and organization. In September, 1894, he was offered the position of Professor of Agriculture and Director of the Experiment Station in the University of Illinois, which offer he afterwards declined. In 1898, an amendment to the fertilizer law was passed by the Kentucky Legislature and also the first pure food law. In March, 1906, the commercial feeding stuffs bill was passed. In 1908, he secured the passage of the present pure food and drugs law. He obtained the degree of Doctor of Philosophy from the University of Illinois in 1908, his thesis for the degree being "A Modification of the Kjeldahl Method for the Determination of Total Nitrogen Including Nitric Nitrogen." Dr. Scovell was a member of the American Chemical Society and of the Society of Chemical Industry, London, also a member of the Society for the Promotion of Agricultural Science; a Fellow in the American Association for the Advancement of Science; a member of the American Breeders' Association and of the Academy of Political and Social Science, and a member of the American Jersey Cattle Club.

In 1909, the directors of the American Jersey Cattle Club contemplated the establishment of an Educational Department in connection with the Club, and the position as head of this department was offered to Dr. Scovell, which offer he declined. In 1910, Dr. Scovell was appointed Dean of the College of Agriculture of the State University, Lexington, Kentucky. In 1911, he made a trip to the Channel Islands as representative of Mr. J. B. Haggin, owner of the Elmendorf Farm, for the purpose of purchasing pure bred Jersey cattle, which mission he fulfilled very successfully and satisfactorily to all concerned. As a matter of fact, the Elmendorf herd headed by some of the animals purchased by Dr. Scovell, is considered one of the finest herds of Jersey cattle in America. Dr. Scovell judged dairy cattle at a great many fairs and expositions from 1896 until the time of his death and in this connection, the Breeders' Gazette says of him:

"Since 1893, Dr. Scovell has been a commanding figure in scientific and practical dairying and dairy cattle breeding. He was the best known and the best liked judge of dairy cattle in America."

Publications by Dr. Scovell.

In the first twenty-seven years of its existence, the Experiment Station published one hundred and sixty-eight bulletins on a great variety of agricultural subjects. Of these, Dr. Scovell is the author or joint author of sixty, the titles of which are as follows:

No. 2.—Corn Fodder as Food for Stock. Jan. 4, 1886. M. A. Scovell.
No. 5.—Analyses of Feeding Stuffs. M. A. Scovell.
No. 7.—Fertilizers. M. A. Scovell and A. M. Peter.
No. 8.—Experiments with Wheat. Sept. 25, 1886. M. A. Scovell.
No. 9.—Experiments with Potatoes. March 1, 1887. M. A. Scovell.

No. 10.—Fertilizer Analyses. May, 1887. M. A. Scovell.
No. 11.—Wheat Experiments. Sept., 1887. M. A. Scovell.
No. 12.—Fertilizer Analyses. Dec. 31, 1887. M. A. Scovell.
No. 13.—Commercial Fertilizers. April, 1888. M. A. Scovell.
No. 14.—Analyses of Commercial Fertilizers. July, 1888. M. A. Scovell.
No. 15.—Wheat Experiments. Sept., 1888. M. A. Scovell.
No. 16.—Potato Experiments. Dec., 1888. M. A. Scovell and A. M. Peter.
No. 17.—Corn Experiments. Feb., 1889. M. A. Scovell and A. M. Peter.
No. 18.—1. Hemp Experiments. 2. Notes on the Treatment of an Old Apple Orchard. M. A. Scovell and A. M. Peter,
No. 20.—Commercial Fertilizers. July, 1889. M. A. Scovell.
No. 21.—Wheat Experiments. The Grain Louse. Sept., 1889. M. A. Scovell, C. L. Curtis and H. Garman.
No. 22.—Potato Experiments. Dec., 1889. M. A. Scovell and A. M. Peter.
No. 23.—1. Experiments with Oats. 2. Tests of Fertilizers on Meadow Land. Feb., 1890. M. A. Scovell.
No. 25.—Strawberries. April, 1890. M. A. Scovell.
No. 26.—Corn Experiments. April, 1890. M. A. Scovell and A. M. Peter.
No. 27.—Experiments with Commercial Fertilizers on Hemp. April, 1890. M. A. Scovell.
No. 28.—Tobacco Experiments. May, 1890. M. A. Scovell.
No. 29.—Commercial Fertilizers. July, 1890. M. A. Scovell.
No. 30.—Wheat Experiments. A New Wheat Insect. Aug., 1890. M. A. Scovell, C. L. Curtis and H. Garman.
No. 33.—Corn Experiments. April, 1891. M. A. Scovell.
No. 34.—Commercial Fertilizers. Aug., 1891. M. A. Scovell.
No. 35.—1. Experiments with Wheat. 2. Experiments with Oats. Sept., 1891. M. A. Scovell and C. L. Curtis.
No. 36.—Commercial Fertilizers. Dec., 1891. M. A. Scovell.
No. 37.—Experiments with Potatoes. Dec., 1891. M. A. Scovell.
No. 41.—Commercial Fertilizers. July, 1892. M. A. Scovell.
No. 42.—1. Experiments with Wheat. 2. Experiments with Oats. Sept., 1892. M. A. Scovell.
No. 43.—Commercial Fertilizers. Dec., 1892 M. A. Scovell.
No. 45.—Field Experiments with Fertilizers. 1. Corn. 2. Potatoes. 3. Tobacco. April, 1893. M. A. Scovell.
No. 46.—Commercial Fertilizers. Aug., 1893. M. A. Scovell.
No. 48.—Commercial Fertilizers. Jan., 1894. M. A. Scovell.
No. 51.—Commercial Fertilizers. Aug., 1894. A. M. Peter, H. E. Curtis and M. A. Scovell.

No. 52.—Commercial Fertilizers. 1. Official Analysis. 2. Analyses of Farmers' Samples and Samples Collected by Deputy Inspectors. Dec., 1894. M. A. Scovell.

No. 55.—Field Experiments with Fertilizers. 1. Corn. 2. Potatoes. 3. Tobacco. 4. Hemp. April, 1895. M. A. Scovell.

No. 56.—Analyses of Commercial Fertilizers. Aug., 1895. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 57.—1. Wheat Experiments. 2. Oat Experiments. Sept., 1895. M. A. Scovell.

No. 60.—Analyses of Commercial Fertilizers. 1. Official Analyses. 2. Analyses of Farmers' and Inspectors' Samples. Dec., 1895. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 61.—Potatoes. 1. Experiments with Fertilizers. 2. Insects and Fungus Pests. 3. Tests of Varieties. March, 1896. M. A. Scovell, H. Garman and C. W. Mathews.

No. 63.—Tobacco. May, 1896. M. A. Scovell, A. M. Peter and H. Garman.

No. 64.—Analyses of Commercial Fertilizers. July, 1890. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 65. Analyses of Commercial Fertilizers. 1. Official Analyses. 2. Analyses of Other Samples. Dec., 1896. M. A. Scovell, A M. Peter and H. E. Curtis.

No. 66.—Tobacco. Feb., 1897. M. A. Scovell, R. J. Spurr and H. Garman.

No. 68.—Analyses of Commercial Fertilizers. May, 1897. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 69.—Wheat. 1. Test of Varieties. 2. Test of Fertilizers. 3. Description of Varieties. 4. Treatment for Smut. Sept., 1897. M. A. Scovell and H. Garman.

No. 71.—Analyses of Commercial Fertilizers. 1. Official Analyses. 2. Analyses of Other Samples. Dec., 1897. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 72.—Potatoes. 1. Experiments with Fertilizers. 2. Corrosive Sublimate and Sulfur for Potato Scab in 1896. 3. Corrosive Sublimate for Potato Scab in 1897. Feb., 1898. M. A. Scovell and H. Garman.

No. 75.—Commercial Fertilizers. June, 1898. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 76.—Commercial Fertilizers. Aug., 1898. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 77.—Wheat. 1. Test of Varieties. 2. Test of Fertilizers. 3. Notes and Descriptions. 4. Red Rust of Wheat. Sept., 1898. M. A. Scovell and H. Garman.

No. 79.—Commercial Fertilizers. Dec., 1898. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 82.—Commercial Fertilizers. July, 1899. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 83.—Wheat. 1. Experiments with Fertilizers. 2. Variety Tests. 3. Notes and Descriptions. Aug., 1899. M. A. Scovell and H. Garman.

No. 85.—Commercial Fertilizers. Dec., 1899. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 86.—Inspection and Analyses of Foods. Jan., 1900. M. A. Scovell and A. M. Peter.

No 88.—Commercial Fertilizers. Aug., 1900. M. A. Scovell, A. M. Peter and H. E. Curtis.

No. 89.—Wheat. 1. Test of Varieties. 2. Test of Fertilizers. 3. Descriptions of Varieties. Sept., 1900. M. A. Scovell and H. Garman.

In addition to these, his publications include a number of monographs, special articles and reports, many of which appeared in the transactions of the Association of American Agricultural Colleges and Experiment Stations and in the proceedings and reports of the Association of Official Agricultural Chemists.

It was the writer's good fortune to know Professor Scovell more or less intimately from the time of his appointment to the Directorship of the Kentucky Agricultural Experiment Station to the day of his death, and in this connection, it is a great and lasting pleasure to be able to acknowledge his indebtedness to him for many personal favors and courtesies. As I remember him, he had many attributes and characteristics that served to endear him to his fellowmen. In forming an estimate of him, one always thinks of him as an executive, a chemist, a dairy expert, an agronomist, a food expert, an educator and University official, and lastly in his capacity as citizen and in relation to the community in which he spent the more mature years of his life.

As an executive and in an administrative capacity, Dr. Scovell possessed a high order of ability. This is shown in

his eminently efficient management of the affairs of the Experiment Station. We have seen that this institution had with us the humblest of beginnings and for many years, its growth and development were greatly hampered through lack of funds, and yet under his careful and prudent management, there was scarcely a year during which certain savings and accumulations were not effected. In this way, the quarters of the Experiment Station have grown from a single basement room in the main University building to the commodious and beautiful structure on the corner of South Limestone Street and Virginia Avenue, in which the offices and laboratories of the Experiment Station are now housed—a building containing about one hundred rooms. A new addition to this building was in course of erection at the time of Dr. Scovell's death.

His executive ability was shown to further advantage in his active and helpful participation in the affairs of the University at large. A number of the most valuable appointments to the staff of the University were made largely upon his recommendation. He enjoyed the confidence of the Executive Committee of the Board of Trustees to an unusual degree. In fact, there were numerous occasions on which they seemed to rely entirely upon his judgement. In his own work, he had to an unusual degree, the ability to surround himself with able and progressive men who contributed in no small measure to his own success.

His skill as an executive is shown to further advantage in his work as an officer and as a member of numerous committees in the Association of American Agricultural Colleges and Experiment Stations and in the Association of Official Agricultural Chemists. In both Associations, he was unusually active and scarcely a year passed in the history of either of

these bodies that he was not actively engaged in the promulgation of new ideas and activities of the greatest importance to the success of both of these associations. He was instrumental in the framing and enactment of certain laws pertaining to the work of the State Department of Agriculture. As Director of the Kentucky Agricultural Experiment Station, he was *ex-officio* Vice-Chairman of the State Board of Agriculture and a member of the State Board of Forestry, and in both capacities he brought to the work in hand the same disinterested and valuable service that characterized all of his official acts. He assisted in the organization of the State Fair, and as member in charge of a number of important exhibits, he contributed largely to the success of this enterprise.

We have seen that Dr. Scovell's early training was in the field of industrial and agricultural chemistry and despite the vast number of things that engaged his attention during the later years of his life, he never relinquished his interest in the advancement and progress of chemical science. Indeed, he always seemed a trifle jealous of his title as Chief Chemist of the Experiment Station. His chemical patents with Professor Weber on the manufacture of glucose, the process of manufacturing sugar and syrup, a machine for defecating and clarifying the juices of sugar cane, etc., and the art of defecating the juices of sugar-producing plants, were valuable contributions to the sugar industry. Indeed, as one writer has expressed it, he narrowly escaped being a rich man as the result of these inventions.

Chemistry is the basis of scientific agriculture and yet the early workers in the agricultural experiment stations in this country found themselves confronted with an entire absence of suitable and reliable methods for determining the compo-

sition of soils, commercial fertilizers, feeding stuffs, farm crops and agricultural products generally. The first duty of those having this work in charge, therefore, was the unification and standardization of the methods of agricultural chemical analysis and unaided and in cooperation with the Association of Official Agricultural Chemists, which association was organized about this time, Dr. Scovell and his associates set themselves assiduously to the improvement of a number of analytical methods having a wide application in modern agriculture. His modification of the Kjeldahl method for the determination of total nitrogen, including nitrates, attracted universal attention and has found extensive application in the analysis of commercial fertilizers. In the same way, he came to the assistance of the Babcock method for the determination of butter fat in milk at a time when the value of this eminently useful method had been seriously called in question by practical dairymen, and more than anyone else perhaps, he brought to the support of this method the results of experiments and observations extending over a number of years, with the result that chemists and dairymen alike came to recognize the Babcock method as the simplest and most exact method of determining the economic value of the individual dairy cow or the dairy herd from the standpoint of milk and butter production, and paved the way for the great herd tests that were afterwards carried out so successfully under his (Scovell's) direction at the World's Columbian Exposition in 1893. His chemical studies covered a great variety of subjects, including analyses of commercial feeding stuffs, canned and preserved foods for adulterants, and studies on the sugar content of sorghum and the sugar beet, with the object of determining the suitability of these crops to the soil and climatic

conditions prevailing in Central Kentucky. The results of his chemical investigations have been published in the form of monographs, as special articles in scientific journals and in the proceedings and transactions of the Association of Official Agricultural Chemists. His chemical work led naturally to a study of the composition and nutritive value of commercial feeding stuffs and to the study and investigation of the broad subject of food adulteration. As early as 1880, Dr. Scovell read a paper before the Alumni Association of the University of Illinois on the subject of foods and in that paper he discussed the subject of food adulteration. In March, 1906, he secured the passage of an act by the Kentucky Legislature regulating the manufacture and sale of commercial feeding stuffs.

Dr. Scovell is justly entitled to be regarded, I think, as one of the greatest dairy experts and as one of the most capable judges of dairy cattle that this country ever produced. His interest in dairying and in milk and butter production probably had its beginning in his study of the accuracy and reliability of the Babcock method of determining butter fat in milk. On February 6, 1893, Dr. Scovell was elected Chairman of the Committee on Tests, a committee appointed by Hon. W. I. Buchanan to supervise and conduct a series of dairy tests at the World's Columbian Exposition. The Committee was composed of Professor S. M. Babcock, Chemist of the Wisconsin Experiment Station, I. P. Roberts, Director of the Cornell Experiment Station, H. P. Armsby, Director of the Pennsylvania Experiment Station, V. E. Fuller, representing the Jersey Association, W. H. Caldwell, representing the Guernsey Association, and H. H. Hinds, the Shorthorn Association. This committee met daily during the period of the tests,

JERSEY HEIFERS AND DAIRY BARN, EXPERIMENT STATION FARM.

which extended over a period of ninety days and represent the greatest piece of work of this kind ever attempted in this country. Over nine hundred pages of valuable data were collected, a resume of which was published by Professor Scovell in the Jersey Bulletin, Vol. XII, No. 51, December, 1893, pages 887-901. The results of these tests resulted pre-eminently in favor of the Jerseys in every point except live weight and the amount of milk produced in the thirty day butter test. The results of this gigantic test attracted great attention among all lovers of dairy cattle and served to arouse an increased interest in dairying and the pure bred dairy cow. It was in connection with the World's Fair dairy tests that Professor Scovell invented a milk sampling tube, whereby a small, uniform, aliquot sample can be accurately secured from a pail of milk. A description of this useful instrument was given by Professor Scovell in a paper read before the Society for the Promotion of Agricultural Science and afterwards published in Agricultural Science, 8 (1894), Nos. 6-9. Dr. Scovell's interest in dairying extended to the Experiment Station farm and in 1892 certain funds were definitely set apart to the establishment of an experimental dairy.

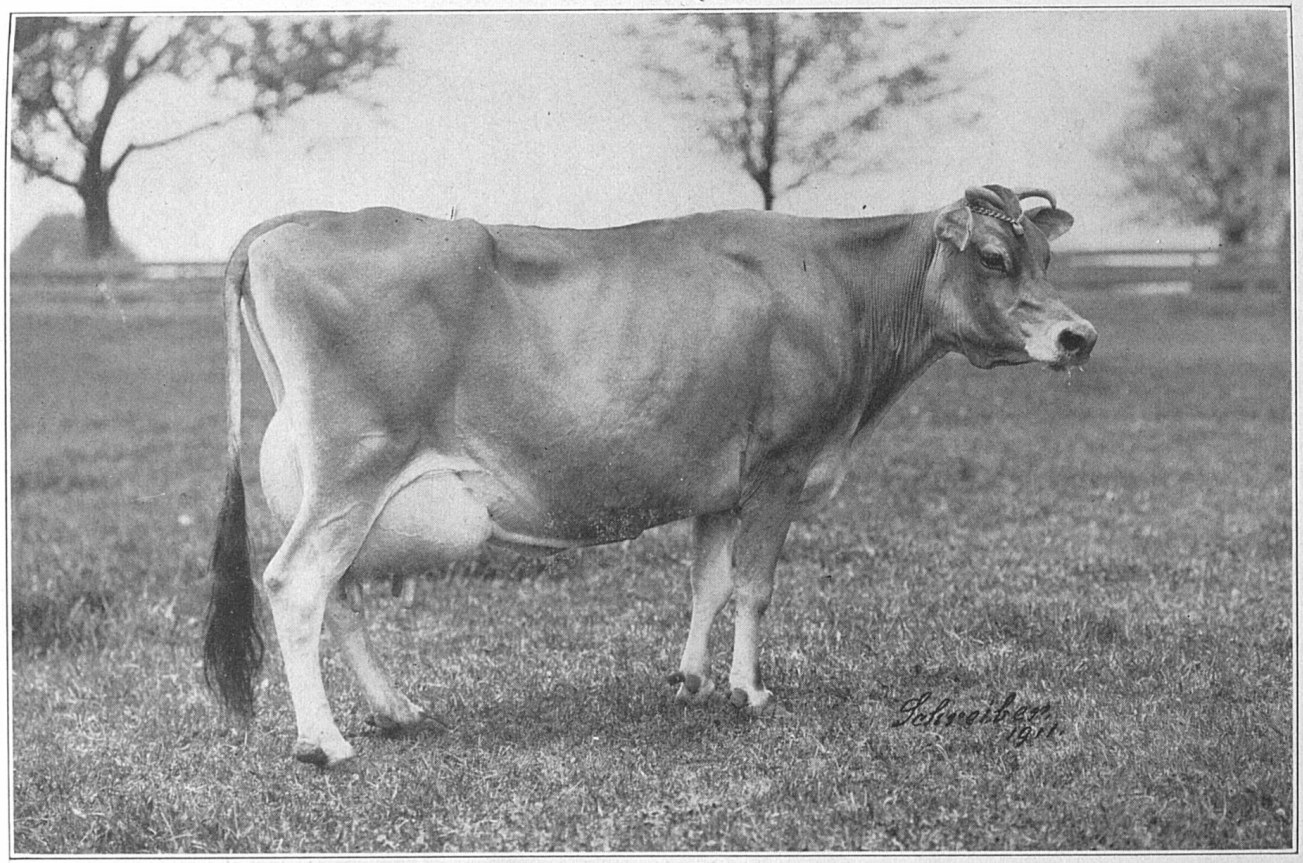
In the summer of 1901, a commodious dairy barn was erected on the Experiment Station farm which still serves as a model of its kind. Requests on the part of citizens of Lexington for Experiment Station milk have steadily increased from year to year until now it is practically impossible to meet these demands. The good example set by this model dairy, together with the vigorous and able milk inspection conducted by the Pure Food and Drug Department of the Experiment Station in various localities throughout the State, have done more than all other agencies operating to this end

to secure pure milk supplies for a number of Kentucky towns and have given the City of Lexington a milk supply that from the standpoint of cleanliness and freedom from bacterial contamination is second to none in the United States.

Professor Scovell's interest in dairy cattle, especially in the Jersey breed, continued unabated until the time of his death. As stated in an editorial in the Breeders' Gazette of the date of August 21, 1912, "he was the best known and the best liked judge of dairy cattle in the United States," and constant demands were made upon him to act as judge at state fairs and cattle shows all over the country. For example, Dr. Scovell judged dairy cattle at the Indiana State Fair in 1896, 1898 and 1905; at the Ohio State Fair in 1897; at the Illinois State Fair, 1901-1904, 1906 and 1908; at the Tennessee State Fair in 1906; at the Texas State Fair in 1906. He also judged Ayrshires and Jerseys at the Pan-American Exposition at Buffalo, and in 1906 was judge of Ayrshires at the National Dairy Show in answer to an emergency call for a judge. In 1911, he acted as judge at the Fair at Toronto, Canada, and at the National Dairy Show. In 1911, he made a journey to the Channel Islands as the representative of Mr. James B. Haggin to purchase pure bred Jerseys for the Elmendorf herd and it was largely, if not entirely, through his efforts, coupled with Mr. Haggin's almost unlimited means, that the Elmendorf dairy herd became one of the greatest herds in the United States. The celebrated Jersey bull, Noble of Oaklands and his dam, Lady Viola, were among the animals purchased by Dr. Scovell at T. S. Cooper's sale in 1911.

It has been said recently by one of the leaders in Experiment Station work in this country, that "chemistry is the basic natural science that has contributed most to the pres-

NOBLE OF OAKLANDS, OWNED BY JAMES B. HAGGIN, ELMENDORF FARM, LEXINGTON, KY.



LADY VIOLA, OWNED BY JAMES B. HAGGIN, ELMENDORF FARM, LEXINGTON, KY.

ent development of agriculture." While primarily a chemist, and while mainly interested in agricultural chemistry, Dr. Scovell's investigations were by no means confined to the laboratory. He took the liveliest and most intelligent interest in the agricultural experiments conducted on the Experiment Station farm. Even the most casual examination of the list of his publications will serve to give one an idea of the great variety of agronomical subjects that claimed his attention and occupied his thought especially during the early years of his service as Director. His experimental work on the farm included studies on the value of corn fodder as a food for stock; variety tests of wheat which resulted finally in the selection of a variety that seems admirably suited to the soil and climatic conditions of Central Kentucky, and which is now being grown throughout the State in constantly increasing amounts; experiments with potatoes; variety tests of strawberries; the cultivation, curing and marketing of burley tobacco; a large number of observations on the composition of commercial fertilizers and their effect on various Kentucky crops. His studies with Dr. Peter of the effect of potash and nitrogen on the yield of potatoes, corn and hemp attracted a great deal of attention at the time of their publication as Bulletins 17, 18 and 22 of the Kentucky Agricultural Experiment Station, the results of these experiments being all the more interesting and remarkable in view of the large amount of potash normally present in the soils of Central Kentucky. His bulletin on corn experiments, with Dr. A. M. Peter, was pronounced by the Rural New Yorker to be the most scientific bulletin that had been issued by any experiment station up to the time of its publication. At the meeting of the Association of American Agricultural Colleges and Experiment Stations in 1900,

he contributed a most interesting and valuable paper on the growing and curing of burley tobacco.

As an educator, Dr. Scovell contributed materially to the progress of the University at large and as already pointed out in the foregoing, he was directly or indirectly responsible for the appointment of some of the ablest men upon our faculty. His constant travels kept him in touch with the rapid developments in the field of technical and agricultural education, and in one way or another, he succeeded in enlightening our Board of Trustees in these matters and in giving them the valuable results of his observations and experience. Through lack of funds and for other reasons, the College of Agriculture, as one of the schools of the State University, was a thing of slow growth. Under the regency of John Bowman and at the time when the Agricultural and Mechanical College was a part of Kentucky University, the work of agricultural instruction had a good beginning. For years, however, after the separation of the Agricultural and Mechanical College from Kentucky University, and its incorporation as a separate institution, the work of agricultural instruction had been allowed to lapse, until for a time, at least, it was the veriest makeshift and for many years, there was not a single graduate from the agricultural course. The Experiment Station was the only thing that fostered and kept alive the agricultural interests of the institution. Accordingly, in 1910, the work of the College of Agriculture was reorganized by the Executive Committee of the University and Dr. Scovell was made Dean of the College of Agriculture. In this reorganization, the Experiment Station became an integral part of the College of Agriculture which also included the Department of Home Economics and the Department of Agricultural Extension. To the discharge of his

COLLEGE OF AGRICULTURE, STATE UNIVERSITY, LEXINGTON, KY.

new duties, Dr. Scovell brought a breadth of vision and a wealth of experience that at once resulted in a quickening and a rejuvenation of the work of the institution along agricultural lines. At the time of his death, one hundred and eighty students were registered in the College of Agriculture and during the two years of his incumbency as Dean of this College, there were eleven students graduated from the agricultural course. His services to the cause of agricultural education in America also included an extended service in many capacities, covering a period of many years, in the Association of American Agricultural Colleges and Experiment Stations, during which time he contributed in various ways to the spread of agricultural ideas in America. During the last few years of his life, he devoted considerable time to the inauguration of the work of agricultural extension as a part of the work of the Experiment Station and in securing the passage of a State act appropriating to the support of the Experiment Station the sum of fifty thousand dollars per annum, a part of which was to be employed "for providing the necessary equipment and paying the expenses of the extension work of said Experiment Station in order to bring the scientific knowledge already obtained, and that hereafter obtained, in the lines of agriculture and home economics, direct to the farm and home, by means of personal visitation, correspondence, cooperative demonstrations and experiments and the solution of local problems by Station experts visiting the locality and studying the problems on the farm." (Acts of the General Assembly of the Commonwealth of Kentucky, 1912, page 136).

Within the brief period of two years, immediately preceding his death, the work of the Extension Department had already begun to make its influence felt for good in a number of localities throughout the State and had already

contributed very materially to the uplift and general enlightenment of our agricultural population. Dr. Scovell had the foresight to see the value of extension work in the development of the agricultural resources of the State and had he lived, this phase of the work of the Agricultural College would undoubtedly have claimed a constantly increasing share of his attention.

Dr. Scovell was a public spirited citizen and in the twenty-seven years spent in the home of his adoption, he manifested an intelligent interest and took a vigorous and active part in all of those projects looking to the betterment and uplift of the community. For a number of years, he was President of the Park Commission, a member and officer of the Lake Ellerslie Fishing Club, a director in the Phoenix National Bank, and in other financial and mercantile institutions, including the Home Telephone Company. He also took an active part in the organization of the Country Club and did a great deal towards beautifying and adorning its grounds. To all of these diverse activities he brought the same intelligent and disinterested service that characterized the more serious business of his life. As the Editor of the Lexington Herald said of him in an editorial written shortly after his death:

> "It was, however, our good fortune, and we count it a most precious good fortune, to have been associated with him in more than one enterprise, and we received real aid from him on every occasion on which we came in contact with him. We have never met Professor Scovell, no matter in how poor temper we might be, that the world did not seem better, the task at hand easier, the future brighter. Were that the only service rendered by him to us and others, his memory would be cherished; but his services to the State, to the nation, to mankind, were such as to give him lofty rank among the benefactors of his race."

He left an impress for good upon the community in which he lived as enduring as the noblest of human impulses. In

SCOVELL RESIDENCE, EXPERIMENT STATION FARM.

his personal and private relations, he was always the same lovable, kindly man. It was the writer's good fortune to know him more or less intimately in a number of capacities for upwards of twenty-seven years. In all this time, he never recalls to have seen him angry, nor does he ever remember to have heard a single harsh or unkindly word fall from his lips nor an unkindly criticism of his fellowman. In him, I was continually reminded of the proverb:

"He that is slow to anger is better than the mighty; and he that ruleth his spirit than he that taketh a city."

And so, I like to think of him not so much for what he did, though this was all-sufficient for any man, as for what he was—gentle, equable, undaunted, undismayed by failure, not puffed up by achievement, energetic, fruitful in all good works, actuated by generous impulses, tolerant of the opinion of others, faithful to his friends, charitable to all men, loyal to the institution that he served and to the community in which he did so large a part. Above everything else, he was pre-eminently a kindly man, harboring no animosities, thinking only good of his fellowman. His gentle spirit liveth on in all good works and in patient service to his day and time.

"We have not lost him all; he is not gone
To the dumb herd of them that wholly die;
The beauty of his better self lives on
In minds he touched with fire, in many an eye
He trained to Truth's exact severity."

Resolutions Respecting the Death of Dr. M. A. Scovell

The following were among the resolutions of sympathy respecting the death of Dr. M. A. Scovell, by various organizations with which he was affiliated:

Board of Control of the Kentucky Agricultural Experiment Station.

M. A. Scovell was born in New Jersey in 1855, and graduated from the University of Illinois in 1875 with the degree of B. S. He was first an instructor, then an assistant-professor in his alma mater between the years 1875 and 1884. For a short while he was a special agent for the United States Agricultural Department. In 1885 his services were secured as director of the Kentucky Agricultural Experiment Station, in now the State University of Kentucky, which position he held until he was also made Dean of the College of Agriculture of the State University of Kentucky, and during that short period so reorganized that college as to greatly enhance its efficiency and to more than double the roster roll of its student body.

Ordinarily, to say of a man that he was born, that he lived, and that he is dead is to record the most important part of the annals of his life, but this is not true of Prof. Scovell. His was a splendid life of service to his country and to humanity. He literally built the Agricultural Experiment Station from practically nothing, until it ranks in useful efficiency with the finest of such institutions in the United States. He was a high authority in all the branches of science which have relation to agriculture and kindred subjects. He had all the conservatism of the true scientist and gave out no startling promises of discoveries which were without foundation in scientific verity. His certificates of fact were accepted by the world at their face value. It was publicly stated by a Kentucky agriculturist that he was told by a great house in Holland that there were but two certificates as to blue grass seed that they would accept; one was issued by an institution in Amsterdam, the other from the Experiment Station of the State University of Kentucky.

The dominant traits of Dr. Scovell's official character were unswerving fidelity to duty, indomitable industry in extending and making more efficient the influence of the great trust placed in his hands, and his loyal devotion to those engaged with him in the administration of this trust. His great department of the university is filled by men and women trained and disciplined by himself, whose loyal zeal first to the institution and then to their chief, has made it one of the greatest instruments for the advancement of public health, public education and agricultural wealth in the Commonwealth.

Prof. Scovell was indeed the farmer's friend and benefactor, and his

death is a calamity to the whole country. His life was simple and unostentatious; his words were few and always imported verity; his manner modest and unaffected, and those who knew him will bear testimony that the world is richer because he has lived and poorer because he is dead. He was an upright, stainless, Christian gentleman and for such as he

> "There is no death; what seems so is transition;
> This life of mortal breath
> Is but a suburb of the life Elysian
> Whose portal we call death."

Resolved, That this memorial of the life and work of Dr. Scovell be spread at large upon the minutes of the Board of Control and a copy be furnished Mrs. Scovell, to whom we tender our sincere sympathy in the great sorrow which we, in part at least, share with her.

R. C. STOLL,
CHARLES B. NICHOLS,
L. L. WALKER,
H. S. BARKER.

Experiment Station Staff and Faculty of the College of Agriculture.

Whereas, It has pleased Providence to call from the scene of his labors, our friend and Director, Dr. Melville Amasa Scovell, we, the members of the staff of the Kentucky Agricultural Experiment Station and the faculty of the Agricultural College of the Kentucky State University, desire to give expression to the sense of loss that we have sustained in the death of so kindly and helpful a man as Dr. Scovell, and to pay this simple tribute of love and respect to his memory.

Twenty-seven years ago, Dr. Scovell came to Lexington to assume the directorship of the Kentucky Agricultural Experiment Station. During this time, he has done more than any man, living or dead, to develop the great agricultural resources of Kentucky and to uplift and elevate to the dignity of a high, productive calling the position of the farmer, the dairyman and the stock breeder throughout the State and nation, and during the last years of his life, he devoted himself unsparingly and with the greatest possible success to the development of the Agricultural College of the Kentucky State University, doing more to realize the true spirit in which the land-grant colleges and universities of the country were orginally founded, than, at one time in the history of our institution, it seemed possible to do. He did much to point the way to the best utilization of our agricultural resources and to the younger men of our generation, he pointed out new paths of usefulness and honor. To all of us, he was not only the inspiring, helpful director, doing all in his power to stimulate and encourage and support the various departments of the Station and of the Agricultural College, but more

than all these, the gentle, kindly, sympathetic friend. His gentleness and real kindliness of spirit endeared him to all of us and have brought home to us the sad realization that in his untimely death, we have indeed sustained a great personal loss. His daily work brought him into intimate contact with all sorts and conditions of men, and all of them have felt his influence for good in their lives and occupations. In the highest and best sense, he was the good citizen and the pioneer in the spread of a higher civilization and nobler ways of living.

Be it, therefore, resolved, That we, the members of the Staff of the Kentucky Agricultural Experiment Station and the Faculty of the Agricultural College of the Kentucky State University, give this expression of our deep sense of loss in the death of Dr. Scovell, and that we extend to his dear wife, who has done so much to aid and sustain him in his great work among us, and also to his brother and sisters, our heartfelt sympathy and the assurance of our high esteem in this sad hour of their affliction.

JOSEPH H. KASTLE,
HARRISON GARMAN,
CLARENCE W. MATHEWS,
Committee on Resolutions.

Association of American Agricultural Colleges and Experiment Stations.

Melville A. Scovell, Director of the Kentucky Agricultural Experiment Station and a former President of this Association, died at his home in Lexington, Kentucky, on August fifteenth, 1912.

Of the Kentucky Station he became director in 1885 and served in that position for twenty-seven years. His long directorate in an institution—the longest term on record in our American Stations—is, of itself, the best tribute both to his efficiency and also to the esteem in which he was held by the people of his State for whom he labored.

His esteem found a touching expression in the stopping, for a time, of all traffic in his home town at the hour of his funeral.

While faithful to the special work of the Station, his interest was not bounded by it. He was a public spirited citizen, mindful of the obligations of good citizenship and a helper in the affairs of his neighborhood and State.

The members of this Association desire to record their deep feeling of loss at his departure and to express their grateful recollection of a life spent in earnest public services, and of a friend courteous, loyal, broad in sympathy and unspotted from the world.

E. H. JENKINS,
C. D. WOODS,
E. DAVENPORT,
Committee.

On motion, the report of the Committee was adopted by a rising vote.

Kentucky State Board of Agriculture.

Whereas, Death has removed from this Board Dr. M. A. Scovell, its Vice-President and our beloved associate, who expired Thursday, August 15th, 1912,

Therefore, Be it resolved by the State Board of Agriculture that we hereby express our deep sense of regret at this inestimable loss, and desire to record that we individually and as a Board sympathize with his family, and feel that we have lost a most valuable member and a personal friend.

Resolved further, That in the six years work that he has given this Board as a member thereof his services have been of untold value to this State and an immense help to the State Fair and to the agricultural interests of the State as a whole. He was always capable, energetic, faithful and conscientious in the discharge of his duty as a member of the State Board of Agriculture, and we regret his loss more than can be expressed in words.

Resolved further, That a copy of these resolutions be spread upon the minutes of this Board and a copy be sent to his beloved wife, Mrs. Nannie Scovell, as a last loving tribute that we can pay to his memory.

(Signed):

H. M. FROMAN,
J. W. NEWMAN,
G. N. MCGREW,
J. LEWIS LETTERLE,
FRED R. BLACKBURN,
JAS. M. TERRY,
R. J. BASSETT,
A. R. VAN METER,
Committee.

Association of Feed Control Officials.

Resolved, That this Association spread upon its records an appreciation of the life and work of the late Director of the Kentucky Agricultural Experiment Station, Dr. M. A. Scovell:

Dr. Scovell was fifty-seven years of age, was Dean of the College of Agriculture of Kentucky State University and Director of the Kentucky Agricultural Experiment Station at the time of his death. He was born at Belvidere, New Jersey, February 26th, 1855, and was raised in Jasper County, Illinois. He was graduated from the University of Illinois in 1875, taking his Master's degree in 1877, and was assistant professor in agricultural chemistry in that institution, where he also received his Doctor's degree in 1908. For a short time he was special agent for the United States Department of Agriculture, and in 1885 his services were secured as Director of the Kentucky Agricultural Ex-

periment Station. In 1910 the College of Agriculture, also, was put under his direction and the unifying of all the agricultural forces at the University had already resulted in the doubling of the students, increased interest in the college throughout the State, and similar evidences of marked growth.

As a man he was simple of habit, direct of speech, modest in demeanor; he was frank and met and treated all men as equals. He possessed unusual capacity for business affairs and his services in banking and life insurance circles were eagerly sought, both because of his wise counsel and the public confidence which followed whenever the people knew that his advice helped to guide and control such institutions.

He had barely approached the period of best service; his mind had scarcely reached its fullest maturity; his body, weakened though it was at times by disease, was so controlled and so animated by his indomitable spirit that he always seemed to be bearing the heaviest work as though it were no task at all.

During his life work, Dr. Scovell built one of the greatest of the state experiment stations and was a controlling force in the policy of experiment station work throughout the nation. Growing out of his work as a chemist, he contributed a strong influence towards the unifying of the fertilizer laws and methods of analysis and towards the pure food laws and methods of analysis and standards. He took up animal husbandry work, especially the judging of dairy cattle, as a side line or recreation and became one of the most proficient and most sought for judges of dairy cattle.

As an administrator in experiment station work, Dr. Scovell has had but few equals among the American agricultural colleges. He was indeed the farmer's friend and benefactor and his death is a great loss to the whole country. The world is richer because he has lived and poorer because he is dead.

Be it further resolved, That a copy of these resolutions be presented to Mrs. Scovell.

Board of Park Commissioners of the City of Lexington.

Whereas, Death has laid its impartial hand upon Melville Amasa Scovell, the President of this Board, who has been one of its most active and earnest members since its establishment eight years ago this month; now therefore,

Be it resolved by the Board of Park Commissioners of the City of Lexington, that we feel a profound sorrow, both personal and official, for the loss of one whose ability as a man and scholar had made his reputation world-wide, whose character was of the highest type, whose interest in the State of his adoption was surpassed by none, and whose enthusiasm and zeal for park development in this city was measured

only by his strength and intellectual attainments, for he gave to this work the best of which he was capable.

To the school to which he gave more than a quarter of a century of a strenuous life, to the State which will miss his counsel and judgment in all matters pertaining to its agricultural improvement, and to her who has been his constant companion and loving help-mate for so many years, we join with sorrowing friends scattered throughout many States of this Union in expressing sincere sympathy in this loss.

HENRY BRECKINRIDGE,
J. W. PORTER,
CHAS. SCOTT,
ROGER D. WILLIAMS,
Board of Park Commissioners.

Fayette Home Telephone Company.

At a meeting of the directors of the Fayette Home Telephone Company, held on August 16, 1912, the following resolutions were adopted:

Resolved 1. That in the death of Dr. Melville Amasa Scovell this community, the Commonwealth of Kentucky, and our nation at large have suffered a great loss. Dr. Scovell had a broad and thorough education as a scientist, he was a man of sterling honesty, splendid courage, and unusual executive ability. These high qualities rendered him easily one of the foremost men in the nation, in the development of agriculture and in the enactment and enforcement of the pure food regulations. His associates upon the board of the Fayette Home Telephone Company fully appreciate his attainments and now desire to recognize the fact that the success of this company, in the face of great obstacles, is to a large extent due to his interest, his wisdom and his rare business judgment, and it is with deepest grief we are now compelled to lose our able friend and associate. The city of Lexington and this community will always remember that in spite of his very busy life, Dr. Scovell was never too busy to give his thought, time and energy to the moral and material uplift of our city He lived and died among us an example and model of the best in citizenship.

Resolved 2. That these resolutions be spread upon the minutes of this board and that copies be furnished to the newspapers of Lexington and an engrossed copy be sent to Mrs. Scovell.

JOHN T. SHELBY,
C. N. MANNING,
DESHA BRECKINRIDGE,
L. DES COGNETS,
W. K. MASSIE,
GEO. S. SHANKLIN,
Committee.

Phoenix and Third National Bank.

Whereas, The Board of Directors of this, the Phoenix and Third National Bank of Lexington, Kentucky, have with profound sorrow learned of the death of our associate director, Professor Melville A. Scovell;

Therefore, be it resolved, That we desire to place on these records our personal and official expression of our loss and sorrow in the death of Professor Scovell, as well as an expression of our full appreciation of his business capacity; his moral worth, his conspicuous integrity, and intelligent and disinterested devotion with which he served as a director of this bank for many years; and it is a fact that in his death this bank has lost one of its efficient officers; the State of Kentucky and Fayette County one of its most upright, conscientious and valued citizens; and

Be it further resolved, That as a token of our respect, this Board of Directors attend in a body the funeral services to be held at the home of Professor Scovell on Sunday, August the eighteenth, nineteen hundred and twelve, at three o'clock in the afternoon; and

Be it further resolved, That this resolution be spread upon the records of this bank, and that a certified copy be sent to the family of Professor Scovell.

B. D. BERRY,
JOHN SKAIN,
J. W. RODES,
Y. ALEXANDER,
Committee.

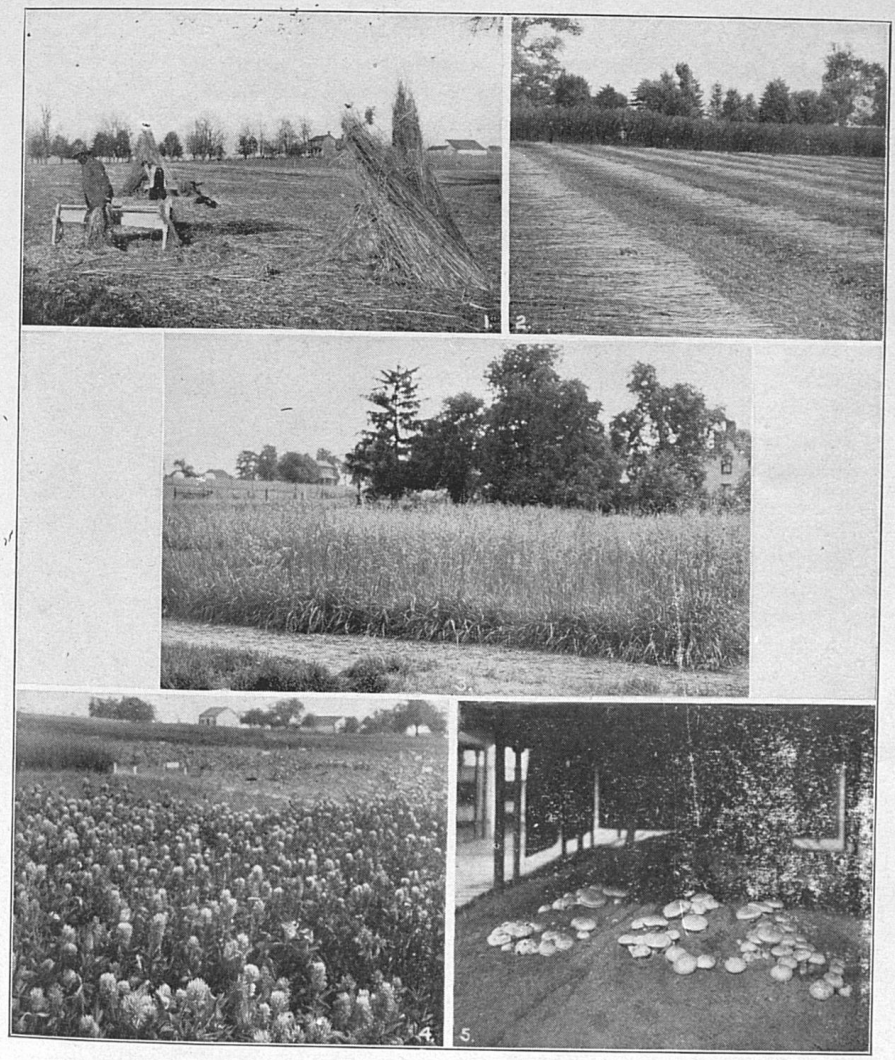
Letters and telegrams of condolence and sympathy, respecting the death of Dr. Scovell were received by Mrs. Scovell and others from the following persons:

Hon. James B. McCreary, Governor of Kentucky; Hon. W. M. Hays, Assistant Secretary of Agriculture, Washington, D. C.; Dr. A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture, Washington, D C.; Dr. E. W. Allen, Assistant Director of the Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.; Dr. W. H. Beal, Chief of the Editorial Division, Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.; Dr. H. W. Wiley, Chief of the Bureau of Chemistry, Washington, D. C.; Dr. Kenyon L. Butterfield, President of Massachusetts Agricultural College, Amherst, Mass.; Dr. W. E. Stone, President of Purdue University, Lafayette, Indiana; Dr. T. J. Burrill, Vice-President, Illinois State University, Champaign, Illinois; Dr. H. J. Waters, President of Kansas State Agricultural College, Man-

hattan, Kansas; Dr. Eugene Davenport, Director of Illinois Agricultural Experiment Station, and Mrs. Davenport, Champaign, Illinois; Dr. J. L. Hills, Director of Vermont Agricultural Experiment Station, Burlington, Vermont; Dr. E. H. Jenkins, Director of Connecticut Agricultural Experiment Station, New Haven, Connecticut; Dr. William Frear, Vice-Director of Pennsylvania Experiment Station, State College, Pennsylvania; Dr. Charles D. Woods, Director of Maine Agricultural Experiment Station, Orono, Maine; Dr. Thomas F. Hunt, Director of California Agricultural Experiment Station, Berkeley, California; Professor H. A. Morgan, Director of Tennessee Agricultural Experiment Station, Knoxville, Tennessee; Dr. W. H. Jordan, Director of New York Agricultural Experiment Station, Geneva, N. Y.; Professor B. W. Kilgore, Director North Carolina Agricultural Experiment Station, Raleigh, North Carolina; Dr. H. L. Russell, Director of Wisconsin Agricultural Experiment Station, Madison, Wisconsin; Dr. H. J. Wheeler, Director of Rhode Island Experiment Station, Kingston, Rhode Island; Dr. H. P. Armsby, Director of Institute of Animal Nutrition, State College, Pa; Professor J. N. Harper, Director of South Carolina Agricultural Experiment Station, Clemson College, South Carolina; Professor David W. May, Special Agent in Charge Port Rico Agricultural Experiment Station, Mayaguez, Porto Rico; Mr. James W. Robertson of the Royal Commission of Industrial and Technical Education, Ottawa, Canada; Mr. G. M. Mac Nider, Secretary, Association of Feed Control Officials, Raleigh, N. C.; Professor W. J. Jones, Jr., Indiana State Chemist, and Mrs. Jones, Lafayette, Indiana; Hon. J. Q. Emery, Wisconsin State Food and Dairy Commissioner, Madison, Wisconsin; Professor Elton Fulmer, State Chemist, Pullman, Washington; Professor J. G. Crabbe, President of the Eastern Kentucky State Normal School, Richmond, Kentucky; Professor H. H. Cherry, President of the Western Kentucky State Normal School, Bowling Green, Kentucky; Professor James G. White, State University of Kentucky, Lexington, Kentucky; Professor C. S. Plumb, Ohio State University, Columbus, Ohio; Professor V. E. Muncy, Ohio Mechanics Institute, Cincinnati, Ohio; Hon. J. W. Newman, Commissioner of Agriculture, Frankfort, Kentucky; Mr. R. M. Gow, Secretary of American Jersey Cattle Club, New York City; Mr. J. B. Haggin, Newport, Rhode Island; Mr. W. R. Goodwin, Editor of Breeders' Gazette, Chicago, Illinois; Mr. E. A. Darling, Lyndonville, Vermont; Mr. and Mrs. T. S. Cooper, Coopersburg, Pennsylvania; Hon. and Mrs. C. M. Clay, Paris, Kentucky; Mr. Richard Wathen, Lebanon, Kentucky; Mr. William Addams, Cynthiana, Kentucky; Mr. Guthrie Wilson, Bardstown, Kentucky; Mr. W. R. Spann, Shelbyville, Kentucky; Dr. H. D. Rodman, Louisville, Kentucky; Mr. C. M. Hutton, Minden, Louisiana; Mr. Irwin C. Stump, New York City; Mr. A. M. Bowman, Salem, Virginia; Mr. W. W. Blake Arkcoll, Paoli, Pennsylvania; Mr. F.

S. Peer, Cayuga Heights, New York; Mr. John A. Perree, Oaklands, St. Saviours, Island of Jersey; Mr. J. P. Nelson, Richmond, Virginia; Mr. Bennett H. Young, Louisville, Kentucky; Mr. H. C. Hersperger, Nicholasville, Kentucky; Mr. and Mrs. P. W. Grinstead, Cold Spring, Kentucky; Mr. N. B. Coffman, Chehalis, Washington; Judge Charles Kerr, Lexington, Kentucky; Mr. J. W. Porter, Secretary, Board of Park Commissioners, Lexington, Kentucky; Mr. O. F. Redd, Lexington, Kentucky; Mrs. Elise Bennett Smith, Frankfort, Kentucky; Woman's Club of the State University, Lexington, Kentucky; Lexington Chapter of the D. A. R.; Lexington Central W. C. T. U.

J. H. K.



SCENES ON KENTUCKY AGRICULTURAL EXPERIMENT STATION FARM.

1. Hemp breaking scene.
2. Hemp recently cut.
3. Grass plots.
4. View across the experiment plots.
5. Mushrooms.

KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY.

BULLETIN NO. 159.

A Preliminary Study of Kentucky Localities in which Pellagra is Prevalent, having Reference to the Condition of the Corn Crop and to the Possible Presence of an Insect or other Agent by which the Disease Spreads.

LEXINGTON, KENTUCKY,
January 15, 1912.

Kentucky Agricultural Experiment Station.

BOARD OF CONTROL.

RICHARD C. STOLL, Chairman, Lexington, Ky.
CHARLES B. NICHOLS, Lexington, Ky.
LEWIS L. WALKER, Lancaster, Ky.
HENRY S. BARKER, President of the University.
MELVILLE A. SCOVELL, Director, Secretary.

OFFICERS.

(In order of appointment).

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J. W. NUTTER, Assistant in Dairying, Animal Husbandry Division.
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ROBERT GRAHAM, Veterinary Science, Animal Husbandry Division.
F. M. SURFACE, Biologist, Animal Husbandry Division.
L. S. CORBETT, Assistant in Animal Husbandry.
H. H. JEWETT, Assistant in Research Entomology.
H. R. NISWONGER, Assistant in Nursery Inspection, Division of Entomology and Botany.
MISS F. C. ROGERS, Stenographer.
JOSEPH H. KASTLE, Research Chemist, Head of Division of Chemical Research.
B. F. SCHERFFIUS, Expert, U. S. Department Agriculture.

NOTICE:

The Bulletins of the Station will be mailed free to any citizen of Kentucky who sends his name and address to the Station for that purpose.

Correspondents will please notify the Director of changes in their postoffice address, or of any failure to receive Bulletins.

Address:
KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KENTUCKY.

BULLETIN NO. 159.

A PRELIMINARY STUDY OF KENTUCKY LOCALITIES IN WHICH PELLAGRA IS PREVALENT.*

By H. Garman, Entomologist and Botanist of the Station.

The suggestion somewhat recently made by European investigators that pellagra is in Italy and other European countries conveyed by a small fly belonging to the genus Simulium has aroused a good deal of interest on the part of the American medical practioner, and the question has been raised as to whether or not the insect species charged with the mischief occurs in this country, and if not whether we may have as intermediate host some related species of the genus. None of the species found by Dr. Sambon in regions in Italy in which the disease is prevalent occurs in the United States. *Simulium reptans*, said to have been accused more positively than others, does occur, however, in Greenland, and may possibly yet be discovered in the northern portion of the continent.

The disease is now prevalent in sections of the southern states, and within the past two years has attracted attention in some of the mountain counties of Kentucky, from which counties a number of cases have been sent to the Eastern Kentucky Asylum for the Insane at Lexington. The recognition of these cases in the Asylum has perhaps more than anything else served to concentrate attention on the disease as a danger in the State, and led to a conference of our

*The writer has not at any time committed himself to the "Insect theory" of the spread of pellagra. He is not satisfied with the evidence, and intends in this bulletin simply to present facts which may bear upon the problem.

medical men who met at Corbin some time ago with a view to considering the matter and if possible devising means of checking the further spread of the ailment.

At this meeting it was requested that the writer of this bulletin visit the region in which pellagra is prevalent and determine if any fly occurs there that might serve to convey the disease.

In response to this request I spent several days at Corbin in the latter part of August and in early September, and again in October at Pineville, studying the localities in which pellagrous cases are located, and giving special attention to the streams in the region as breeding places of the flies.

It may be explained at this point that I was aware that Fall is not the most favorable season to look for the flies. The late Dr. Riley, who studied the buffalo and turkey gnats (*Simulium pecuarum* and *S. meridionale*) some years ago, declared indeed that the species were one-brooded. It was known to me, however, that some of our species produce more than one annual brood, and in any case it seemed best to study the locality and familiarize myself with the disease in order that I might not lose time in the Spring when the flies of the genus generally appear in great numbers.

Two species of the flies were known to me to occur in Kentucky at this time. The buffalo gnat (*S. pecuarum*) was years ago very abundant periodically in April and May along the Ohio and Mississippi Rivers in Western Kentucky. This gnat still occurs locally some seasons in that part of Kentucky, attacking stock and sometimes, it is claimed, invading the nostrils of men, causing sneezing, but no other annoyance. The larvæ of a second species (*S. pictipes*) were collected by me in 1893 in large numbers in small rills running into Kentucky River about 14 miles from Lexington. This gnat is said not to sting and hence may be eliminated from the problem. I have also a few specimens of Simulium larvæ, not yet studied, collected at Lexington in a small stream, August 5. 1889.

At Corbin I inspected the surroundings of cases in charge of Drs. M. W. Steele and J. H. Parker. The weath-

er was very unfavorable for my work, rain keeping the water of streams roiled and making a search for insects in them difficult. The cases of pellagra were located, as I had been led to expect, near streams, some of them only a few hundred feet away from the water, though as a matter of fact most of those living in the country in these mountain counties are near springs and streams for obvious reasons. When questioned it was found in some instances that the patients had not contracted the ailment where they were then living. One had not had good health where she formerly resided and had moved "up here" where she thought her condition was improved. In several cases observed the disease had in all probability been contracted where the patients then lived. This seemed true of three individuals, a mother and two boys, living on the banks of Laurel River north of Corbin. The mother had been very severely affected early last spring about garden making time at which time she was confined to her bed. Her face, hands and feet still showed the effect of the disease, though she was about the house when I saw her. One of the boys was affected on the calves of the legs quite extensively, the dusky cuticle being visible as he walked beside the buggy. The second boy showed only a small area on one of his legs, and was said to have contracted the ailment a week or so later than the others. All seemed to have become affected in the spring of 1911 at the place where they were seen. Excepting for the diseased skin neither boy seemed to be in bad health. None of them showed signs of mental derangement. The house in which the family lived was a mere shed that had been abandoned by sawmill men on the bank of Laurel River. The water of the river where nearest the house was at a much lower level, having cut its bed so as to leave rather steep banks, but is only a few hundred feet away. Several hundred yards below the dwelling is a ford where the stream is more rapid and shallow, running over and among large rocks consisting of a red sandstone which blackens on exposure to the weather and gives the river a rather forbidding appearance. I was able to cross here on the rocks, and spent some minutes looking for in-

sects among them. The situation is an excellent one for Simulium, but the weather was threatening and dark and with the limited time at my disposal I was compelled to give up the search without finding larvæ, though I secured a number of other insects from among the rocks. I am confident that Simulium larvæ can be found here in the spring of the year.

At Pineville I searched the rapids of Cumberland River with care, and explored Clear Creek between the Pine and Log Mountains, giving special attention to the creek because a case of pellagra, in charge of Doctor Foley, of Pineville, was located on its banks. The dwelling in which this patient lives is on the banks of the creek in much the same position relative to the water as the one on Laurel River at Corbin, yet from what I learned by conversation with the patient it was probable that she had contracted the ailment at another place, though similarly situated with reference to the stream. The stream was inspected at intervals above this dwelling and below it down to its junction with the Cumberland. Numerous insects were found in it, and situations exactly suited to the breeding of Simulium, yet none were found.

In the Cumberland River as it flows through the Gap of the Pine Mountains I spent some hours on two days and found a few Simulium larvæ in its rapids among a scant growth of Nitella, with many other insects characteristic of swift-flowing, rocky streams.

At Cary, three miles north of Pineville, is a mining camp on the left Fork of Straight Creek. In company with Doctor J. H. Hendren of Cary I visited here some of the most interesting cases seen on my trip. At the outskirts of the settlement, perhaps one hundred and fifty feet from the stream, is a dwelling in which were four cases of pellagra, which, judging from Dr. Hendren's statements, had originated at this place. The stream was shallow at the time of my first visit (September 1) and consisted of stretches of quiet water a few feet in depth, in which some fishing with hook and line was going on, alternating with rocky rapids

in which the water was not much over one's shoe-tops and where it was possible to cross by stepping from rock to rock. One of these rapids just below the dwelling seemed to me an ideal place for Simulium larvæ, and a few minutes search here brought to light some larvæ and pupæ. They were not very common, however, and were so small that I felt some hesitation about committing myself until they could be more carefully examined. Examination, and in some cases dissection, made since my return to the University, leaves no doubt as to their identity.

On October 21, during a second visit to the region about Pineville, I examined the Left Fork of Straight Creek well up toward its source. Above the Coleman mining camp were found larvæ and pupæ of the same Simulium collected on my previous trip. They were scattered and difficult to find, and although not nearly so common as I have seen similar larvæ in the spring of the year at other places, yet judging by the frequency with which I found a few here and there many of them must be now hibernating in the creek. Most of the pupa cases were empty. Other specimens were secured from rocks in the rapids of Cumberland River at the point above Pineville where specimens were secured in August and September. Numerous other insects were found among the submerged rocks in Straight Creek, Cumberland River and Clear Creek. Some account of them is included in what follows, not because of any definitely determined relation to the main object of my search, but because some of them may later prove to have relations with this and certainly have with other subjects of interest to the people of the State. For it is to be remembered that it is not certain that gnats of the genus Simulium have to do with pellagra. It is possible that some other insect or animal is concerned in its spread.

Looking at the matter from the point of view of the entomologist and naturalist it seemed to me very evident when I had examined only a few cases of pellagra that some agent in the air had to do with its spread, and it may be of interest to recall the facts that most appealed to me. In the

first place the eruption on the hands began apparently about the bases of the fingers and extended thence upward to the elbows, where it stopped abruptly. On the legs it seemed to begin at the feet, affecting the upper surface and extending to the knees, where it terminated in a well marked line. On the head and neck it affected in all cases examined only the skin constantly exposed, and terminated at the hair and at the collar. Yet in some instances re-recorded there is an extension of the affected skin down upon the chest, coinciding somewhat closely with the opening in the shirt front. One such case, which I did not have a chance to see, was reported to me as residing at Old Straight Creek, above Pineville. All of these conditions seemed consistent with Dr. Sambon's theory that an insect carries the virus of the disease from ill to well, attacking the exposed skin and injecting into it something, bacteria or protozoa, which gives rise to the disease.

Furthermore the disease is contracted and afterward becomes active in early spring at just the time when our gnats of the genus Simulium come from the water in greatest numbers as adults.

Again it often affects children, who constantly go barefooted and bare-legged in this region and are disposed to play and wade in the streams. Women, too, were affected more than men, about the arms and neck generally, but also in some cases on the feet and calves. Men go less frequently perhaps with the limbs bare, and are much less often attacked. The skin trouble appears upon the trunk rather rarely, though cases are on record of parts generally kept covered by clothing becoming affected.

With these facts in mind, it was with very great interest that I examined a case at Moss's Camp above Pineville which seemed to oppose the idea of insect agency in the disease. The case was that of a middle aged woman whose arms showed in a marked manner the symmetrical development of the skin lesions, so often mentioned by writers on the ailment. It was interesting further because it was then (Sept. 1) in an active condition, whereas all the

other cases examined showed the usual summer cessation of the disease and an improvement in general health. The affected regions on the two arms were surrounded by a deep red border, as if something had got access to the blood in the center of the area and was spreading outward into the healthy skin, much as one sees in plants a fungus pushing outward from a point of inoculation by a growth of its mycelium. The area on the two arms and forearms seemed to be of about equal extent. This affected region was such as might at some time have been exposed to the air when the patient was busy about her domestic affairs. A more interesting and puzzling feature of this case was the presence of two isolated round spots of diseased skin, one on the point of each shoulder. If there had been one only, I should have thought a hole in a gown might at some time have exposed the part to infection, but the chances seem against the presence of two such holes exactly alike, one on each shoulder. I am giving this fact as an illustration of what some physicians claim to be an invariable feature of the ailment, no matter where the skin trouble appears, namely, a symmetry in the skin affection, which they regard as evidence that the seat of the disease is within and the skin lesions only incidental and dependent. The case appears to support this view, yet it may prove when we know more of the conditions attending the contraction of the disease that such cases are still explainable on the theory of insect agency.

THE STREAMS.

In general character the streams examined are much alike. A gap in the Pine Mountain range lets the Cumberland through from the south. It makes a bend after clearing the gap, and partially encircling Pineville, located at the base of the mountain, flows off to the westward. In its course it receives numerous small creeks and rills from springs, and farther west and north is joined by Laurel River. Its water was rather warm at the time of my first visit, and did not seem to me particularly well suited to the

requirements of Simulium larvæ, judging by what I had seen of them at other times and in other places. The numerous springs, however, send into it a good deal of cool and rather pure water at all times, and no doubt in the spring of the year its quality is much better because of the larger quantities present and the consequent dilution and rapid carrying away of sewage. The bed of the stream was cut in places through a conglomerate and red sandstone, and large fragments of this rock cumbered the channel and produced rapids. In the creeks the same conditions prevailed on a smaller scale. My photographs will convey a fuller idea of their character. (See Figures 59 to 63, inclusive.) The banks of the streams support a growth more or less thick, of willow and other deciduous trees. On the slopes, trees, though small, become more numerous and occur in greater variety. Where the valleys widen out are tracts of bottom land, generally planted in corn, which is the most important agricultural crop of the valleys.

The region is one of great natural beauty and attractiveness. The wooded slopes of mountains rise abruptly from the valleys and river beds, presenting constantly changing effects in light from both sun and moon, effects often enhanced by floating wisps of cloud about the peaks and slopes. The landscape of other parts of Kentucky may be in its own fashion as beautiful as this, but as a type of beauty the Cumberland mountain region stands unique in the State.

It is unfortunate that a section calculated naturally to be so healthful and attractive, should be permitted to become a center for the spread of so dangerous a disease as pellagra. The State Board of Health has shown commendable forethought and enterprise in taking hold of the matter at once, and making an effort to arrest its further spread.

Yet it should be known by the people of Kentucky that pellagra is no longer restricted to the mountain counties. Through the kindness of Dr. F. H. Clarke of Lexington and the authorities of the Eastern Kentucky Asylum for the Insane, I have been able to learn the distribution of the

cases that have been sent to the Asylum. To my surprise they have been found to come from widely scattered counties of Eastern Kentucky, extending from the mountains to the Ohio River. Judged by the distribution of these cases there is no county in the Eastern third of the State that can be regarded as exempt. And considering other cases occurring in other parts of Kentucky, together with those recorded from Tennessee, Illinois, Michigan and other states, it appears that pellagra may occur anywhere within our borders.

Yet it must be remembered that the history of these cases at asylums is not fully known. People attacked by a lingering malady sometimes become restive and dissatisfied because of their ill health, and move away from the locality where the disease was contracted. The cases scattered about Kentucky may thus in some instances have come originally from the mountains. I sometimes found on questioning patients about Corbin and Pineville that they had somewhat recently changed their residences.

Once introduced into a locality, however, the disease appears to spread, as if some agent of infection were everywhere at hand. In some asylums, numbers of cases are said to have developed after the admission of a single one. And it may be remarked in passing that the fact, if fact it is, that cases may originate within the walls of an asylum is opposed to the theory that Simulium is the agent of transmission, for these insects are pre-eminently creatures of the wild wood.

THE INSECTS FOUND IN THE STREAMS.

Most of the aquatic species collected in situations examined for Simulium were such as are constructed for living in swift currents. They are in some cases quick strong swimmers, but more often are of the lurking sorts that depend upon clinging tightly to rocks and other objects in the water. Species belonging to eight different orders were collected by me, representing over forty species.

SIMULIDÆ (SAND FLIES).

The members of this family are rather small stout-bodied, two-winged flies, as young, living in the water of rapid streams. Twenty-seven species of the genus Simulium are listed from North America, of which three are known to me to occur in Kentucky. To the accounts of these species have been added below description of the turkey gnat, which will probably be found here, and of the European *S. reptans*.

Simulium venustum (The Black Fly).

This is the species of which I collected larvæ and pupæ at Cary, Coleman, and elsewhere in the left Fork of Straight Creek. It is known as a pest in northern woods, especially in the Adirondacks, but has a wide distribution in this country, extending from Canada and Minnesota southward to Texas, Mississippi and Florida. The original description of the species written by Say, a pioneer entomologist, of New Harmony, Indiana, was based upon specimens collected at Shippingsport on the Ohio River in 1823. He describes the adult fly as black, with two pearly spots on the front of the thorax and a larger one behind, the poisers black; the wings whitish with yellow and iridescent reflections; and says of it: "This pretty species perched in considerable numbers on our boat at Shippingsport, Falls of the Ohio. It ran with considerable rapidity, constantly advancing its long anterior feet. Its bite is pungent."

Harris, writing of the same insect in 1852, says "Travelers and new settlers in some parts of New England are very much molested by a small gnat, called the black fly, swarms of which fill the air during the month of June. Every bite that they make draws blood and is followed by an inflammation and swelling which lasts several days. These little tormentors are of a black color; their wings are transparent; their legs are stout, and have a broad whitish ring around them. The length of their body rarely extends one-tenth of an inch. They begin to appear in May, and continue about six weeks, after which they are no more seen."

The insect has doubtless become less common than it was formerly, yet my brief stay in the mountains was sufficient to show that it is still there and probably more abundant than is commonly supposed. My own material is all immature, yet the characters of the pupæ and larvæ are such as to leave little doubt as to the correctness of their identification. The following detailed descriptions are based upon the material collected at Cary and Pineville, and together with the illustrations made by Mr. Matthews of the Division will serve for the recognition of the insects, should any one wish to search for them in the streams.

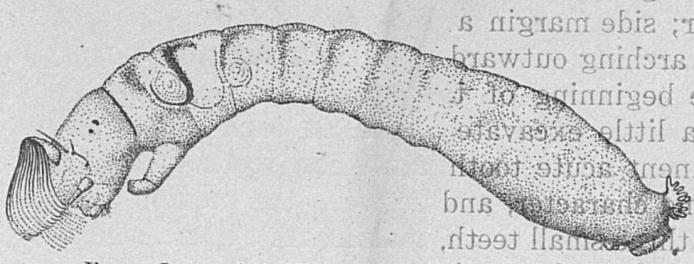


FIG. 1—Larva of Simulium venustum from the Left Fork of Straight Creek, Ky., 1911.

Larva.—Rather thick bodied, more slender at the middle, becoming greatly thickened at the posterior extremity, and enlarging somewhat behind the head. Head relatively large, brownish, bearing two large brushes of long curved bristles. A false leg, bearing rust-brown chitinous hooks at the tip, arises from the first body division and projects forward beneath the head. Posterior extremity with a ring of dusky microscopic hooks by which the insect secures itself to rocks and other objects. Translucent white, with blackish markings, in the larger examples sometimes assuming the form of cross bands. Length of largest example secured, 4 millimeters or about 0.16 inch; diameter of swollen posterior region about 0.6 mm. Collected, first, September 1, 1911, in a rapid of the Left Fork of Straight Creek, a few hundred feet from a dwelling in which were four cases of pellagra. Later, collected in Cumberland River, near Pineville, and at different points in Straight Creek.

Head large, its depth three-fourths its length. The fans

of curved bristles conspicuous, consisting of a stout basal stalk at each side of the head, bearing about 36 bristles, these flattened, strong, curved, expanded at their bases, the inner edges with short, rigid, straight, obliquely-placed, or erect setæ, excepting a small portion of the tip of each. Very minute soft hairs fringe the margin also, between the rigid setæ, and these soft hairs are present at the tips as well as elsewhere. Antennæ very slender and inconspicuous, erect, consisting of a long basal piece, then a short, very slender one, ending with a very slender short distal segment. Lower lip (labium) black along the anterior border; side margin a trifle excavated anteriorly, then suddenly arching outward, with four appressed marginal teeth at the beginning of the arched portion. Anterior median edge a little excavated, with, at each side, an outer rather prominent acute tooth, a median tooth of about the same size and character, and between the median and each outer tooth three small teeth, making nine in all. Nearly parallel with the lateral margin of each side are three hairs with divided tips, the most anterior being opposite the appressed teeth of the margin. Mandible of the usual structure in the genus, consisting of a central elongate piece, arched without, and bearing at the tip three rather strong acute black teeth, the median of which is smallest; proximal to these teeth is a series of three acute straight teeth successively shorter from the outermost; then succeeds a series of six close-placed, long, spine-like teeth, with two stouter ones completing the series within. Two stout teeth, looking as if cut out of the margin complete the armament, and are placed proximal to all the others. The usual brushes of hairs arise from the inner edge of the basal half of the mandible. The maxilla consists of a stout broad basal piece from which arises a cylindrical segment tapering a little to the tip but blunt and bearing at the extremity several short teeth. An inner lobe about as broad as long bears on its side a tuft of hairs extending beyond the tip; a triangular basal piece bears several setæ along its anterior edge and at its apex is one conspicuous pectinate spine. On each side of the head are

two black specks, the posterior the larger and reniform, the anterior elongate and nearly straight.

From the first body segment following the head, on its ventral side, arises a jointed leg extending forward and turning upward beneath the head. Its extremity is armed with rust-brown chitinous hooks by which it is enabled to cling, the structure being an organ of locomotion. At the posterior extremity of the body is a circle of microscopic hooks for clinging, this larva like others attaching itself to a web which it spins on the surface of rocks, and then standing erect swaying about in the current. The external respiratory organs consist of three tufts of soft white finger-like processes thrust out above the posterior extremity of the body, each lateral tuft consisting of four processes and the median of about the same number. These structures are retractile and are not visible on most of the specimens collected.

The colors of the larvæ secured vary somewhat with age and size, the very young being largely white, older ones showing evident bands of black on the middle body segments. An example before me shows a black dot posterior to the base of each fan-like brush of the head, while several close-placed brown points are visible from above near the posterior lateral margin, and a group of about six median ones appears between them. Sutures of the head and posterior margin black. Foot white, excepting the roughened tip, which is rust-brown. Swollen posterior part of body white beneath; ring of hooks brown.

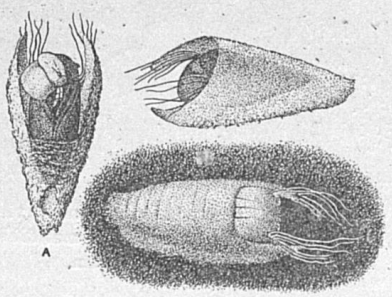


FIG. 2.—Pupae of S. venustum. A, adult emerging From Straight Creek, 1911.

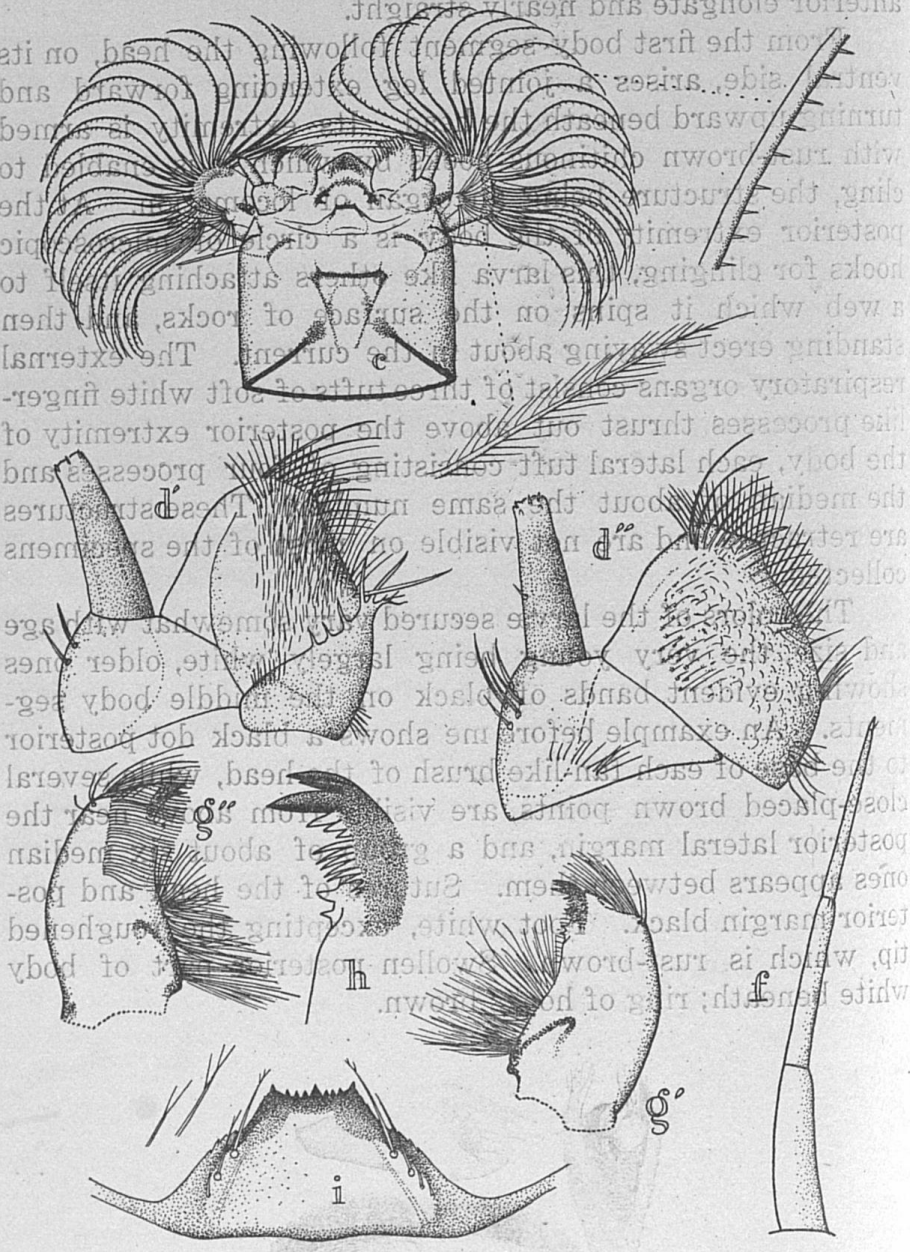


FIG. 3—Antenna and mouth-parts of S. venustum. *c*, ventral view of head; *d'*. maxilla; *d''*, opposite side of maxilla; *f*, antenna; *g' g''*, mandible; *h*, enlarged tip of mandible; *i*, labium.

Pupa.—Pupa cases were taken from the same rapids as the larvæ above described. They were of the "wall-pocket" type and were attached to a bit of submerged bark in one case, to rocks in others. They are elongate, leathery, pale brown, rounded from side to side, becoming gradually wider to the open end, from which projects the head of the brown pupa bearing two tufts of respiratory filaments, each tuft made up of six simple filaments. Length of case 4 mm. (0.056 inch). The case is closed beneath along the attached side for about one-half its length.

Only the rounded anterior extremity of the pupa shows in the case. The brown tapering filaments project some distance beyond the opening, and together with the case serve to distinguish members of the genus from any other aquatic Diptera. The six simple respiratory filaments are characteristic of but two species likely to occur here, namely, *S. venustum*, the black fly, and *S. meridionale*, the turkey gnat. The black fly larva differs, however, in having an independent pair of setæ near the tip of the mandible, on the convex side, and the three large teeth of its labium are about equal in size, characters in which the Kentucky specimens agree. No adult insects were collected, though I examined the creek carefully on several different days, between Pineville and Cary. One of the pupæ was in process of giving up the adult, as shown in Figure 2, A, a fact proving the emergence of a fall brood, as do a number of empty cases secured.

Simulium pecuarum (The Buffalo Gnat*).

In the southern states this gnat is the best known member of the genus. It has been at times a great pest to stock on the bottoms of the Mississippi and other streams in the South. In former years it was well known in Western Kentucky along both the Mississippi and the Ohio rivers. It is

*The impression has been conveyed that the writer of this bulletin regards the Buffalo Gnat as the species concerned in conveying the virus of pellagra. I have never regarded it as an agent of infection. All my inquiries of people residing in the region in which pellagra is most prevalent failed to produce any evidence that this particular species occurs there. Residents knew nothing about it, yet every man, woman and child seemed to know about the "new disease". On the bottoms of the Mississippi River near Columbus, on the other hand, residents are familiar with the Buffalo Gnat, but know nothing of pellagra.

still known to the dwellers on these streams. Apparently it is less common than it was in early pioneer days, when, according to information furnished me, it sometimes appeared in early spring in immense swarms, actually killing mules and other stock left unprotected in the bottoms. Yet I cannot find that such an insect is recognized by people living in the mountains where pellagra is prevalent, and although the insect is known to attack man, it seems unlikely that it is the insect agent for conveying the disease. If it were, we ought to find it in Illinois, and throughout Eastern Kentucky where pellagra occurs. Other species of Simulium occur, however, throughout all the territory in which pellagra is known at present, and even if we exclude this species from the problem these others must for the present be considered as possible agents of infection.

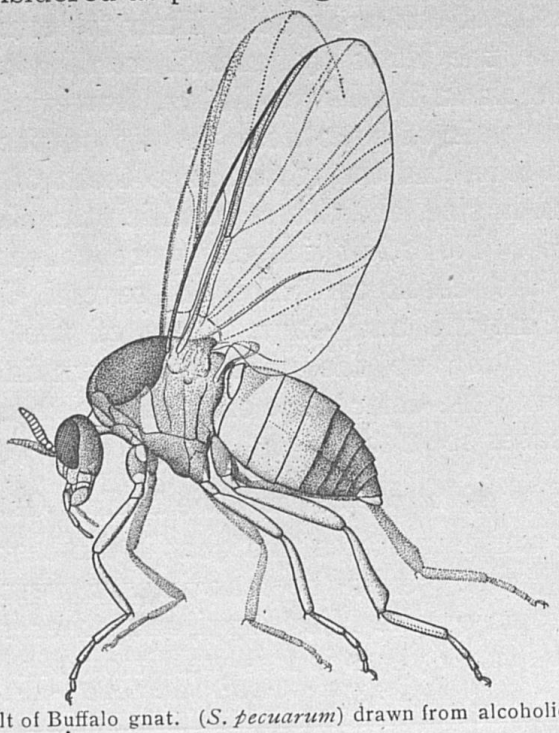


FIG. 4.—Adult of Buffalo gnat. (*S. pecuarum*) drawn from alcoholic specimen received from Texas. x 10.

The adult buffalo gnat is a good deal like the black fly in general form, being stout-bodied, the thorax especially prominent and rounded, the legs moderately long, the beak very short but stout. Its two wings are ample, transparent,

and few-veined, the stronger veins being close-placed near the anterior margin.

Alcoholic specimens of the fly received from Dr. M. Francis of College Station, Texas, many years ago, and thus probably altered in color, measure 3.3 mm. (0.13 inch) in length, the relatively large and broad wings measuring a little more, 3.6 mm. (0.14 inch). The head is somewhat produced in advance of the eyes, the palpi rather long and slender, curving downward and posteriorly. Puncturing mouth-parts rather short but sharp and strong, not in evidence, except by dissection and microscopic examination. Antennæ about as long as head, rather thick, of numerous divisions, these crowded, and mostly placed a little obliquely. Thorax very thick, and strongly convex dorsally to accommodate the powerful muscles of flight. Legs of moderate length, the posterior largest. Abdomen broadly attached to the thorax, oval and tapering to a point behind.

In his original account of the species the late C. V. Riley describes the sexes somewhat as follows:

Male.—Eyes meeting and with two sets of facets. Mouth-parts soft. Head black. Antennæ black, with some red. Maxillary palpi black. Thorax black above. Abdomen black, with grayish white posterior margins to segments.

Female.—Eyes not meeting. Head gray slate, with short yellow hairs. Eyes black, with coppery or brassy reflections. Antennæ black with whitish pubescence. Thorax grayish slate and generally distinctly marked with two medio-dorsal and two subdorsal longitudinal black bands. Under side of thorax, grayish slate. Abdomen with a broad gray longitudinal band from near the base of the second segment, where it is broadest.

This fly is distributed throughout much of North America, although often denominated the Southern Buffalo Gnat because of the immense numbers occurring in the southern states. It has been recorded from Alaska, New Hampshire, Indiana, Kentucky, Mississippi and Kansas, and unless several species have been confounded, it is to be found in many of the other states.

The gnat makes its appearance during the early spring at a time when bottoms are flooded. The larvæ require rather good water with a current, and are never at home in stagnant, badly polluted pools. They attach themselves to submerged sticks, leaves, logs and rails, clinging by means of the circle of hooks at the hind end of the body, their hold being made secure by a silken web spun over the surface.

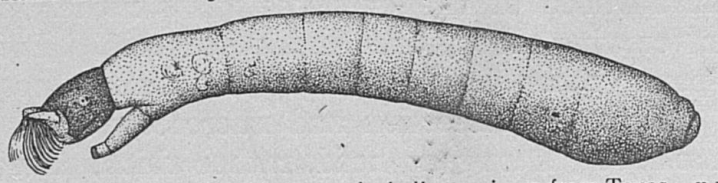


Fig. 5—Larva of Buffalo Gnat, from an alcoholic specimen from Texas. x 10.

When dislodged they drop down stream suspended by a silken thread let out from the mouth, and are by its use enabled to return again to the surface whence dislodged. The eggs were found placed on rocks on the banks a few inches above the surface of the water. They are placed in a close layer, are soft, ovoid in shape, except as influenced by pressure of other objects, and measure 0.40 mm in length by 0.18 in diameter. The young are believed to feed upon small crustaceans and other similar animal food brought to their mouths by the peculiar brushes of bristles on each side of the head. The pupæ are formed in leathery brown cases placed well down in the water on wood where they are not likely to be left dry during seasons of drought. The respiratory filaments arising from each side of the thoracic region are many-branched and project beyond the opening of the case.

In Kentucky in recent years the buffalo gnat has become almost unknown in sections where it was formerly troublesome. It is still to be found along both the Ohio and Mississippi rivers from Daviess County westward and southward, though some correspondents in this region say they have seen none for twenty or thirty years. It is evident, however, that the gnats do occur in noticeable numbers every season locally, and that in small numbers they are probably constantly present throughout the bottom land along the Ohio and Mississippi rivers in Western Kentucky.

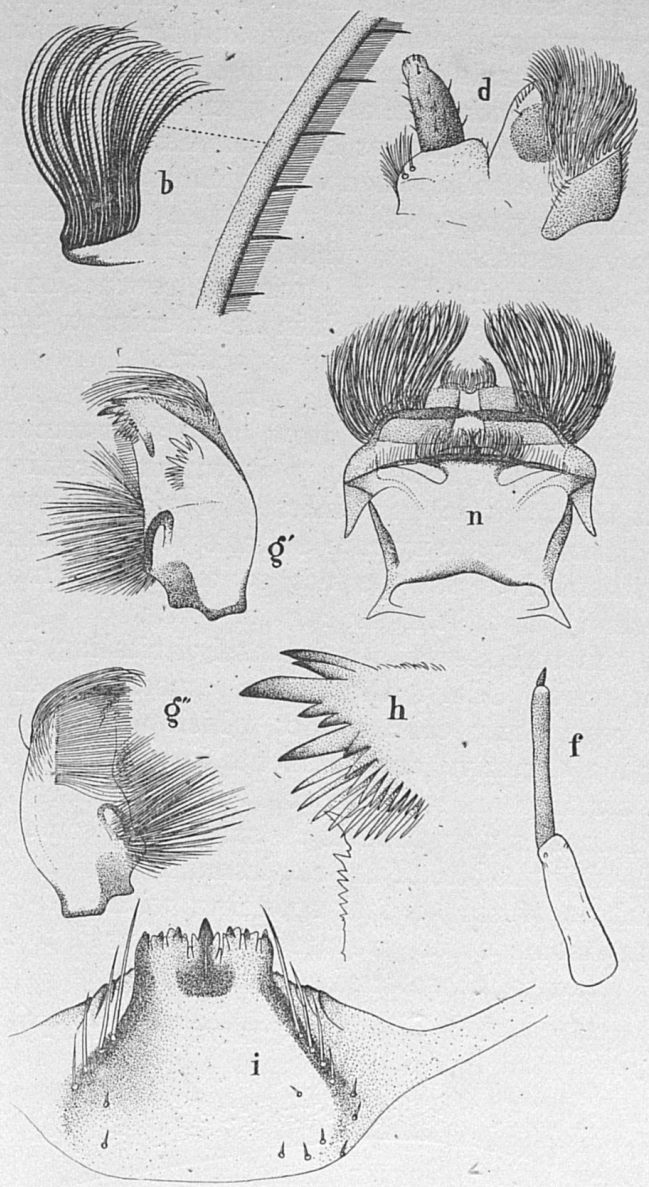


Fig. 6.—Antenna and mouth-parts of Buffalo Gnat larva. *b*, vibratile bristles from side of mouth; *d*, maxilla; *f*, antenna; *g' g''*, mandible; *h*, tip of mandible highly magnified; *i*, labium; *n*, hypopharynx.

The appearance of the adult is often very sudden in a neighborhood, sometimes accompanying a change in the wind. With strong wings it flies rapidly, and thus probably often migrates considerable distances from the waters in which it develops. The gnats attack stock by creeping into the ears and nostrils, and collect over the prominent veins along the under side of the body, when very abundant alighting upon and attacking any part. Riley, who studied the insects many years ago in Mississippi, says that they are most active during dark cloudy weather when a storm is brewing, but that in bright days from eleven o'clock in the morning to four in the afternoon they are inclined to be inactive.

When first attacked animals suffer greatly, and often become quite frantic. They grow more accustomed to the injury after a time and submit to it without fretting. It is said that the stock in gnat-infested regions become to an extent immune, or at any rate animals learn to take better care of themselves and do not so often succumb as does stock recently brought to the region.

The puncture seems to be intensely irritating, and brings blood at once. Oddly, the poison causes in animals an ailment resembling colic, a fact which will recall the accompanying digestive derangements in pellagra. A poison of some sort appears to be injected into the blood, and the result on badly stung animals is said to be somewhat like that following the bite of the rattlesnake.

Smudges of smoke, and sponging with coal-tar water, fish oil and some other preparations, are used to repel the insects. Many of those tried are ineffective.

Simulium pictipes (The Innoxious Sand Fly).

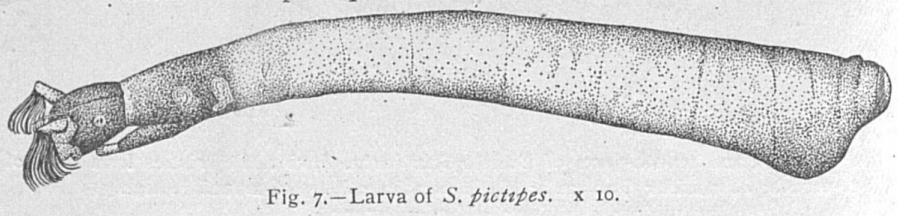


Fig. 7.—Larva of *S. pictipes*. x 10.

The larva of a third species of the genus has long been known to me as occurring in great numbers in small streams

flowing into Kentucky River in the region about Clay's Ferry about 15 miles southeast of Lexington. It was first observed July 14, 1893. By simply closing the blades of my forceps over the rocks in shallow water, then holding them together and removing them, numbers of the larvæ could be picked up by the silken threads they emit as they let go their hold and float down stream. They are true silk-spinners like the other members of the genus.

This is a very large species. Dr. Howard, writing of it in Insect Life (Vol. 1, p. 99) says of examples collected by him at Ithaca, New York, that some of them measured three-fourths inch in length. I have none from our streams as long as this, but the larvæ are much larger than the others collected in this State.

Adult male.—Dr. Johannsen in an article published in Bulletin No. 68, N. Y. State Museum describes the male as gray, the antennæ and palpi black; the metanotum with golden pubescence, black, with lateral margins gray, and a gray spot extending inward from each humerus; a pair of silvery spots within the gray ones. Beneath gray. Abdomen deep velvety black. Legs black or dark brown. Knobs of balancers, orange-yellow. Length 3.5 to 4 mm.

Adult female.—The same author describes the head and thorax of the female as opaque gray, the metanotum with three deep brown or black stripes; abdomen velvety black, beneath gray. Legs grayish or pallid; tips of tibiæ and tarsi generally black. Knobs of balancers yellowish white. Length 3 to 5 mm.

Larvæ in numbers were collected and preserved in alcohol in 1893. The largest measure about eleven millimeters in length, and are blackish, excepting the head, which is reddish brown, and the ventral side of the swollen posterior region of the body, which is white. Head of a decided reddish brown, the large brushes of strongly ciliate setæ of the same color. The usual pair of black specks on the side of the head, in a pallid area. Antennæ of three segments, the basal long and a little curved, with some appearance of being subdivided; second segment straight and

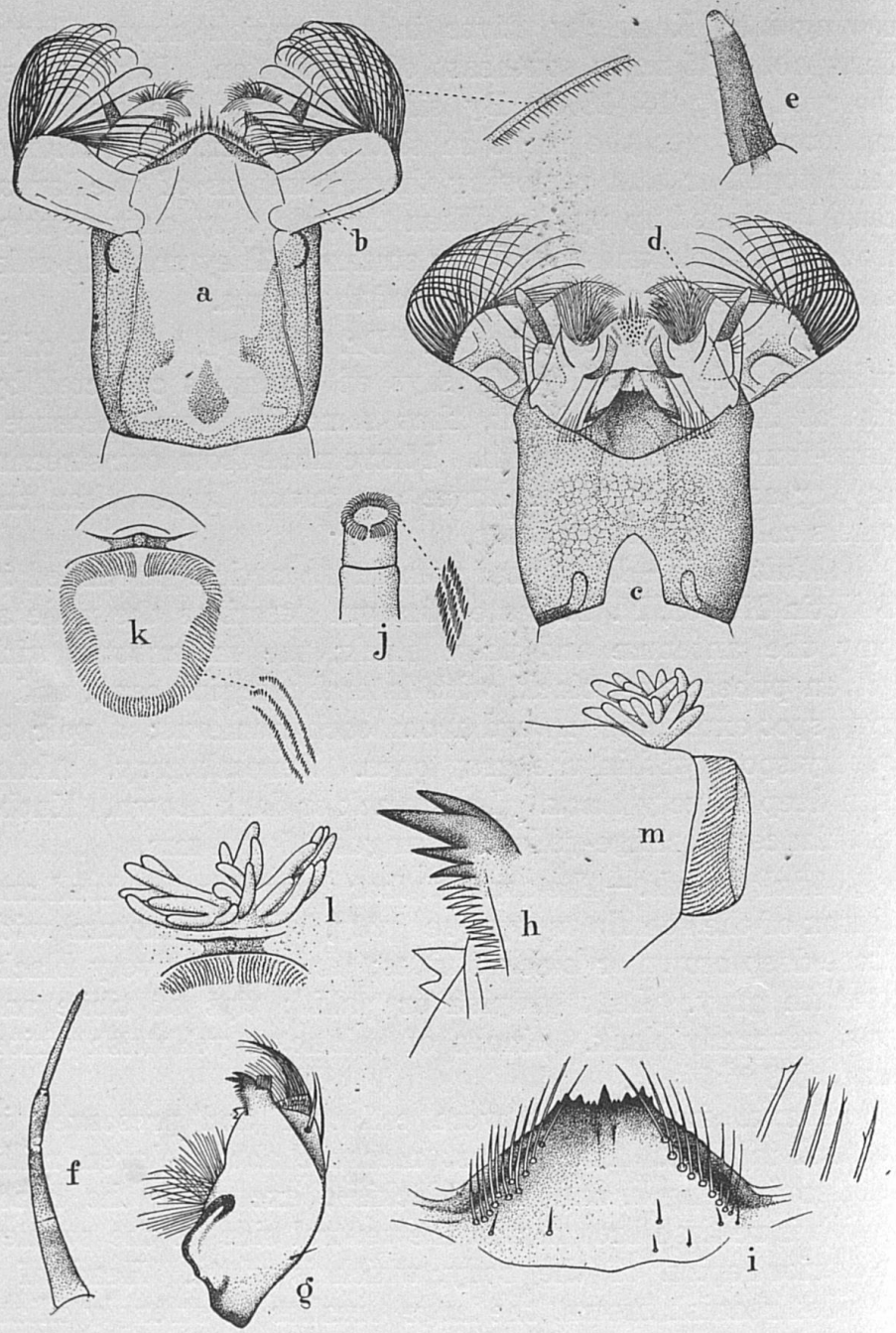


Fig. 8.—Mouth-parts and other structures of the larva of *S. pictipes*. *a*, dorsal view of head; *b*, stalk of vibratile bristles; *c*, ventral view of head; *e*, palpus of maxilla greatly magnified; *f*, antenna; *g*, mandible; *h*, tip of mandible greatly magnified; *i*, labium; *j*, tip of foot; *k*, ring of spinules at hind end of body; *m*, side view, extremity of abdomen showing protrusible respiratory appendages.

more slender, about half the length of the first; third segment very small and short, acute, one-tenth the length of the second. Mandibles with an anteapical pair of hairs; apical teeth strong, acute, black. Labium with a strong central tooth, outside which on each are three small teeth, the outer being largest; at each angle is a strong acute tooth somewhat like the median one but not so large. External margins slightly convex in outline or nearly straight, a half dozen small appressed teeth are present just external to the toothed angle.

The pupa has not been collected by me. Dr. Johannsen says its case is boot-shaped. Nine filaments are borne on each side of the thorax.

The species is not of the same interest at present as the others, because it is reputed not to sting, and can thus have nothing to do with the eruption accompanying pellagra.

Simulium meridionale (The Turkey Gnat).

Quite recently I have collected larvæ of a Simulium from rapids in Benson Creek at Frankfort, that possess the characters of this insect, but this material is so scanty that I do not care to pronounce on it finally. The turkey gnat is, however, distributed in the United States somewhat like the buffalo gnat, and so probably occurs here. It is a well known stinging species. In Insect Life for July, 1888 (Vol. 1, p. 14) is an interesting note from a correspondent writing from Virginia to Professor Riley, in which it is stated that these gnats destroy "thousands of chickens and turkeys yearly" and that it is called the cholera gnat because its attacks cause symptoms resembling those of chicken cholera. Gobblers and roosters are killed first because the wattles and combs afford an exposed region peculiarly open to attack.

The male, according to Riley, is from 1.5 to 2 mm. in length, the eyes meeting above, where the facets are coarser and of a brilliant coppery luster, those on the ventral side smaller and black. Thorax dense black with bluish luster, ventral side grayish. Legs reddish with black tarsi. Abdo-

men above black, posterior margin of segments edged with gray. Ventral sides of segments two and three light reddish gray, the rest blackish with gray posterior margins.

The female is described by the same writer as from 2.5 to 3 mm. long; the head slate-blue, with silvery pubescence; the thorax, slate-blue, with three longitudinal lines, the median narrow and widening at the apex, the outer curving in at the base and out at the apex; beneath slate-blue; abdomen with last five segments dark blue above; segments 2, 3 and 4 each, with a black cross bar; segments 5, 6 and 7, with two submedian stripes, disappearing on 7; bluish white everywhere beneath; legs brownish black.

Simulium reptans.

As already stated, this common European species has been recorded from Greenland, and may yet be found on this continent. It is described as black, the female with a white spot on each side of the thorax, the sides of the thorax silvery.

The name *S. reptans* has many synonyms, due apparently to the insect being somewhat variable. It would seem to be a near ally of our Kentucky insect, *S. venustum*. *Simulium columbaczensis*, on the other hand, notorious because of its injuries to cattle in Hungary and other countries of the same general region, is apparently the European analog of our buffalo gnat.

CHIRONOMIDÆ (GNATS).

With the Simulium pupæ I took from submerged wood and other objects in Straight Creek and Cumberland River a number of singular cases which may perhaps be mistaken for the pupa cases of Simulium. They are produced by a slender larva, which is sometimes secured with its head out of the case, as shown in Figure 9. It is the young of one of the gnats belonging to the family Chironomidæ, a group represented in ponds and lakes by blood-red larvæ living free or within transient tubes of loose granular material secured to the surfaees of stones. The group is

interesting in this relation, because while some of the genera of the family do not sting and cannot be regarded as noxious, some are pests, and may become the source of a good deal of annoyance to people living along streams. The punkie or no-see-em (*Ceratopogon nocivum*) of northern woods is an example. We have this, or a similar species, in Kentucky, sometimes encountered even about the City Reservoir at Lexington during the first warm spring days, and occasionly within the city limits. Harris says of them (Insects of Massachusetts, 1852): "So small are they that they would hardly be perceived were it not for their wings which are of a whitish color mottled with black. Toward evening these winged atoms come forth and creep under the clothes of the inhabitants, and by their bites produce an intolerable irritation." * * * * In my own experience these minute stinging gnats simply sting the moist back of of the hand and show little or no disposition to creep under the clothing.

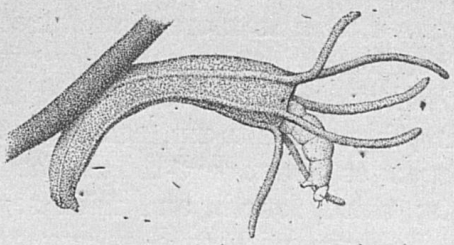


Fig. 9.—Larva and case of Tanytarsus from Left Fork of Straight Creek, 1911. X 8⅓.

The case-making species collected at Cary, Sept. 1, belongs to the genus Tanytarsus, and may prove to be *T. exiguus*, of Johannsen, though there are some differences to be accounted for before this can be considered established.

No. 1. Tanytarsus sp.—Length, 3.5 mm. Translucent, white, the head pale yellow. Cylindrical, the somites somewhat thicker anteriorly, segmentation very evident, the body consisting of twelve somites, of which the anterior bears a pair of clawed prolegs and the posterior is truncate and bears two tufts of long black setæ on its dorsum, a pair of retractile clawed prolegs on its ventral side and posteriorly four lanceolate respiratory appendages. The head

is small, firm-walled, with a few setæ arising from its dorsal surface; on each side with two black specks a short distance behind the base of the antenna, the dorsal of which is larger. Head 0.286 mm. long, being a little more than

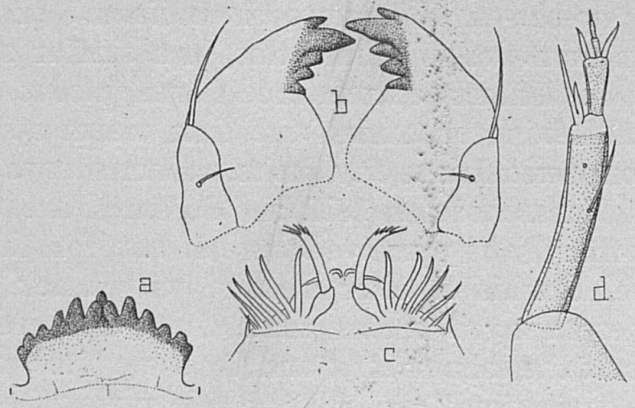


Fig. 10.—Mouth-parts of larva of Tanytarsus sp. *a*, labium; *b*, mandibles; *c*, labrum with characteristic spines; *d*, left antenna.

twice as long as the antennæ. Prominences on which antennæ arise, evident. Antenna, .01358 mm. long; 1st segment slightly curved, a little more than three times as long as the second, bearing at its tip a slender appendage somewhat longer than the second; second segment straight, slightly enlarging from base to tip, bearing at its extremity two acute appendages about two-thirds the length of the remaining joints; third, fourth, and fifth segments minute and tapering. Labrum with two strong pectinate claws curving toward the ventral side; on each side of these claws

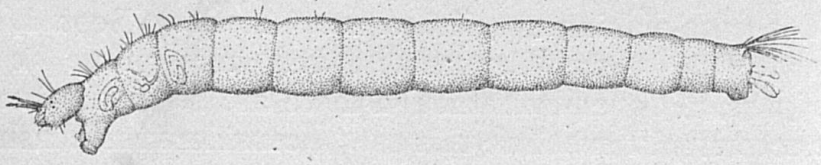


Fig. 11.—Larva of Tanytarsus removed from case. x 23.

are about five smaller simple claws of the same general character, all being evidently of service as grappling hooks. Mandibles strong, curved, with black teeth, as follows: an apical rather short tooth, a very long strong tooth just within it, then three shorter teeth of about equal size; within the latter the mandible expands, as in other related genera. Labium with black teeth, the median largest and

longest, with a slight lobe on each side, outside it on each side are five additional teeth gradually diminishing in size.

Case brown, elongate, straight, or slightly curved, gradually expanding to its open end, from the edges of which arise six more or less bent cylindrical processes continued as ridges along the surface of the case. Processes about half the length of the case, which measures 3.5 mm. long, the expanded open end measuring 1 mm. in diameter. Small cases are continued at the closed end into a slender stalk, but as far as observed were attached by the side, to stones, wood, and other objects, in the water. The case has an appearance of being composed of mud or refuse glued together, and is very fragile. The longitudinal ridges of the surface appear to be produced by building out the open end of the case by adding material between the projecting processes.

Dr. Johannsen's species was obtained from small streams at Ithaca, New York. The case is, he says, composed of silk, but those from Straight Creek are, as stated, composed very largely of refuse. Differences between the larva described by him and those collected by me are apparently as follows: (1) The shorter antennæ of the Kentucky species (about half the length of the head); (2) the acute appendages of the second antennal segment; (3) the strongly pectinate median claws of the labrum.

No. 2.—This is a second, cylindrical, elongate larva, taken with others on the under surfaces of rocks in rapids of the Left Fork of Straight Creek. It resembles the one inhabiting the brown cases so much that it would by most people be considered identical. The head is pale yellowish brown, the two black specks of the sides of the head well forward and contiguous, though a line separates them. Antennæ short, less than half the length of the head; first division long, bearing a seta at its distal extremity, nearly as long as all the rest of the antenna; second segment without appendages; three small distal segments tapering. Claws of the prolegs of the first body division numerous, simple. Posterior clawed legs long and diverging. Two

distal tufts of long diverging setæ arise from prominences near the posterior margin of the posterior body segment. Behind the tufts at the posterior margin of the segment are two additional setæ. Respiratory appendages three-jointed, tapering. Length of body 5.5 mm.

No. 3. Orthocladius sp.—This larva resembles the two preceding in a general way and was taken in some numbers about rocks in Straight Creek near a dwelling occupied by people affected with pellagra. Cylindrical, elongate, plainly segmented. Head yellowish brown, posterior margin at sides definitely black. Jaws black at tips, curved, acute, three sharp denticles within apex, then a strong process from which springs a very finely denticulate plate expanding toward the base of the jaw. Mentum black at lateral margin, brown medially; four lateral teeth large, acute, black, tooth next within smaller, brownish; the next obliquely truncate and brown; median broad, plate-like, brown. Antennæ on small prominences, less than one-fourth the length of the head; first segment longest, bearing at its distal extremity two acute appendages, one nearly as long as all the remaining segments, the second not quite two-thirds as long; second segment a little more than one third the length of the first. Black specks on side of head not quite contiguous, the anterior much smaller and lunate. Claws of the false legs of the first body division strongly curved, many of them toothed. Tufts of hairs at posterior extremity on small prominences. Respiratory appendages not jointed, the dorsal pair longer and club-shaped. Length 4.5 mm. The broad truncate median tooth of the mentum is suggestive of the genus Thalassomya, as described by authors.

No. 4 Ablabesmyia sp..—A single dipterous larva found at Cary in the Left Fork of Straight Creek is very different from all the above in a number of features. The body is rather short and stout, about 4.5 mm. long; the head relatively large, elongate and flat, with one black speck on each side, with an anterior fissure. Antennæ with the long first segment largely concealed by an extension of the crust. Hooks of anterior prolegs retractile. Each body division

with several long soft hairs. Segmentation distinct. Posterior prolegs long, projecting far beyond the posterior somite. Dorsal tufts of setæ of posterior somite arising from long pedicels. Two long setæ at posterior edge of the somite behind the tufts. Respiratory appendages dusky, tapering, about half the length of the prolegs. See Fig. 26.

Still other larvæ belonging to related genera were observed, among them one with swollen anterior body segments and evidently belonging to the genus Tanypus. They are largely fragile, harmless gnats when adult, and the relation they bear to Simulium as competitors or enemies may be the only one they sustain to the immediate subject of this paper. Such larvæ often constitute an important element of the food of other aquatic animals.

No. 5.—A number of singular dipterous larvæ were collected near the Roark cottage on Straight Creek, while searching for Simulium larvæ and have not been definitely determined. The figures 27 and 28, of larva and pupa, give a good idea of their character. The specimens were all taken together from a piece of submerged wood in rapid water.

It is a sluggish rather stout, tough-skinned grub, with a small head which widens rapidly from the anterior extremity to the base, giving it a somewhat triangular outline. The sides of most of the body divisions are produced and pointed, each process bearing a long, curved bristle near its tip. Posterior extremity of body expanded into a clawed disc. Ventral sides of first body division (prothorax) with two clusters of obliquely-placed, curved, black hooks. Head dusky brown; antennæ short, erect. A black speck at the base of each. First body division dusky at sides, widest posteriorly; second, widest of the three thoracic segments; third, a little narrower, with a very short lateral point and bristle; first to seventh somites constituting the abdomen, each with a strong lateral extension and bristle; eighth division narrower, a little angular at middle, but with no process; ninth expanded and provided with strong curved hooks beneath, a pair of long hairs projecting pos-

teriorly and a median pair of teeth. A pair of bristles arises on the dorsum of each of the body divisions two to eleven inclusive, each bristle originating in a black dot. Posterior somite black centrally. Skin everywhere roughened with small granulations.

Apparently gregarious. Pupæ were taken with the larvæ, and still retained the cast larval skin about the posterior part of the body.

CULICIDÆ (MOSQUITOES).

Members of this family are present in the mountains, but appear to attract less attention than they do in more level countries in which are more ponds and sluggish streams. Some larvæ commonly known as wrigglers are to be found there in barrels of water and in ditches and pools of various sorts. They were about gone from their usual haunts, however, and I saw less of them at Pineville than I probably should earlier in the season. The streams themselves because of their rapid current are not well suited to the requirements of mosquitoes. People with whom I conversed reported some mosquitoes as giving trouble during the hot summer months. I found confirmation of their statements in an engorged adult of *Anopheles punctipennis* in my room in Pineville. My attention was of necessity concentrated on the genus Simulium, and I learned less of the mosquitoes as a consequence than I otherwise should. More attention will be given to them later.

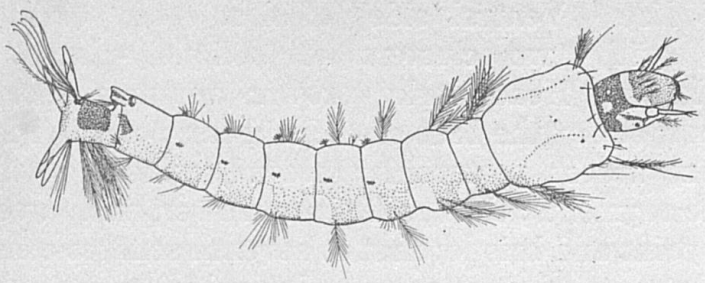


Fig. 12.—Larva of *Anopheles maculipennis*, from Horse Creek, Corbin, Ky., August, 1911. x 13.

Anopheles sp.—A few minutes use of a dip net in a sluggish pool of Horse Creek near Corbin, August 29, 1911,

resulted in the capture of a larva (figure 12) belonging to the genus Anopheles. It does not quite agree in structure or coloration with the species known to me from Kentucky, but larval characters are rather uncertain quantities, and with a single example it is not worth while to attempt a determination at present. Even the "combs" of teeth sometimes made use of in separating species, appear to be variable in the same batch of larvæ.

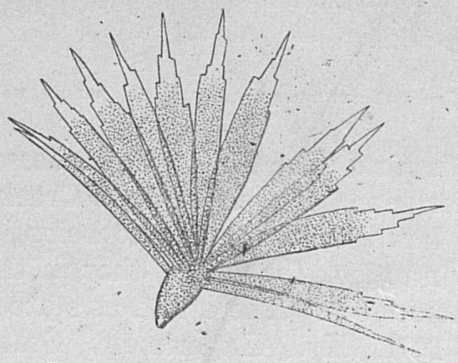


Fig. 13.—Characteristic stalked tuft of spines from body of larva of Anopheles from Horse Creek. x 376.

The markings of the head are well represented in the figure. The singular dusky tufts (figure 13) on the abdominal somites 3 to 7 inclusive, consist of blade-like spines denticulate on the margins and mounted on a short stout pedicel. Six plumose hairs ranged across the head between the eyes are attached within a dusky area. Body in general dull gray, with a black dorsal plate on the last abdominal segment. Length 5.5 mm.

Anopheles punctipennis.—As stated, a single engorged adult of this strikingly marked species was taken on the wall of my room at Pineville. It is to be recognized among our species of mosquitoes by its wings, which are conspicuously marked with dusky and yellow, and by a sharply defined ash-gray area along the dorsal side of the thorax. These characters, together with its disposition to elevate the abdomen when at rest should enable any one to recognize it, and at the same time distinguish it from the ob-

scurely marked *Anopheles maculipennis*, also frequently found in dwellings in this State.

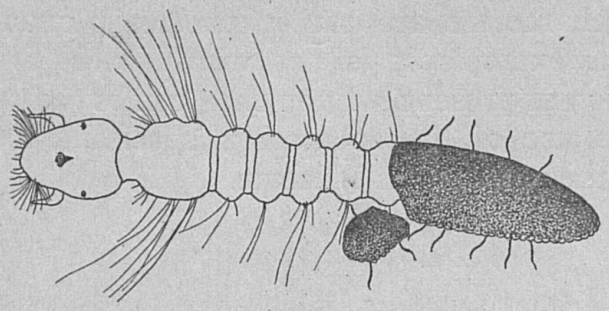


Fig. 14.—Larva of yellow fever mosquito (*Stegomyia fasciata*) when hatching.

Stegomyia fasciata (The Yellow Fever Mosquito).—From a barrel of water near Cary on Straight Creek I took, October 21, 1911, a larva that appears to belong here. It was late in the season to look for adults, though they occur until after frost at Lexington. The adult, as stated in a bulletin published in 1901 (Ky. Experiment Station, No. 96) is a common household insect in Kentucky, breeding close about dwellings in buckets, barrels, troughs, etc. If we should ever be visited by yellow fever refugees this little pest stands ready to do its part in spreading the disease. Its disposition to sting the wrists, backs of hands and ankles is well known, and may suggest a possible relation between it and the spread of pellagra.

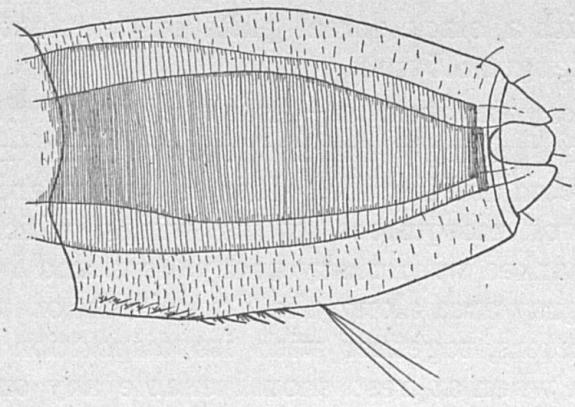


Fig. 15.—Respiratory tube of yellow fever mosquito larva greatly magnified, showing the two large tracheal trunks.

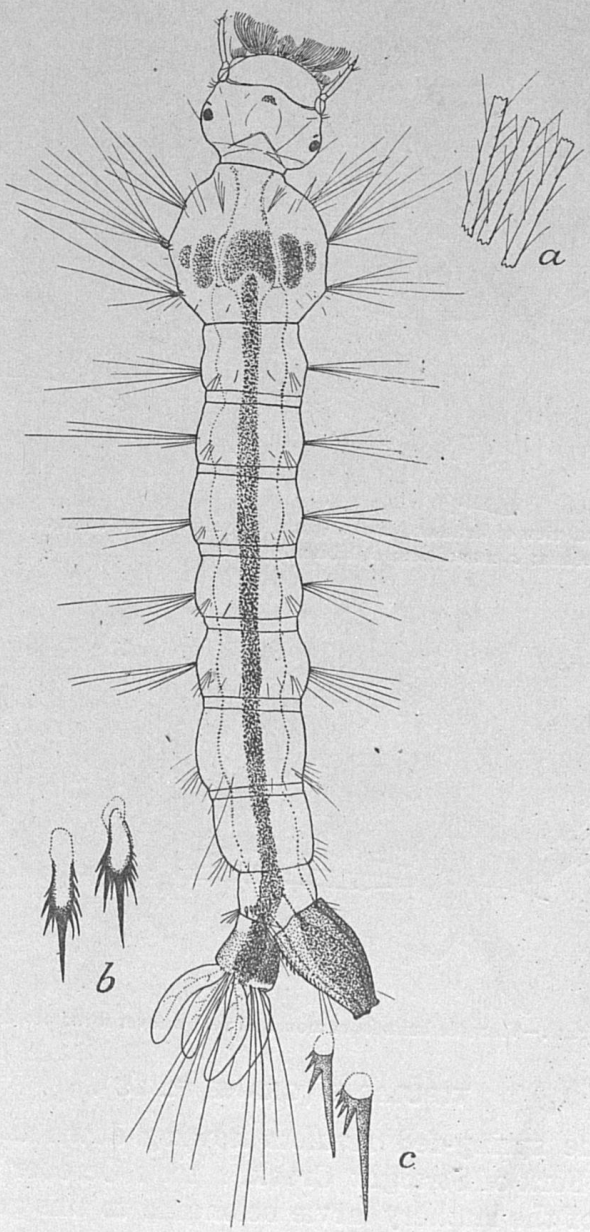


Fig. 16.—Well grown larva of yellow fever mosquito. *a*, plumose hairs of body tufts *b*, spines from "comb" of posterior body segment; *c*, spines from series on side of respiratory tube. x 14½.

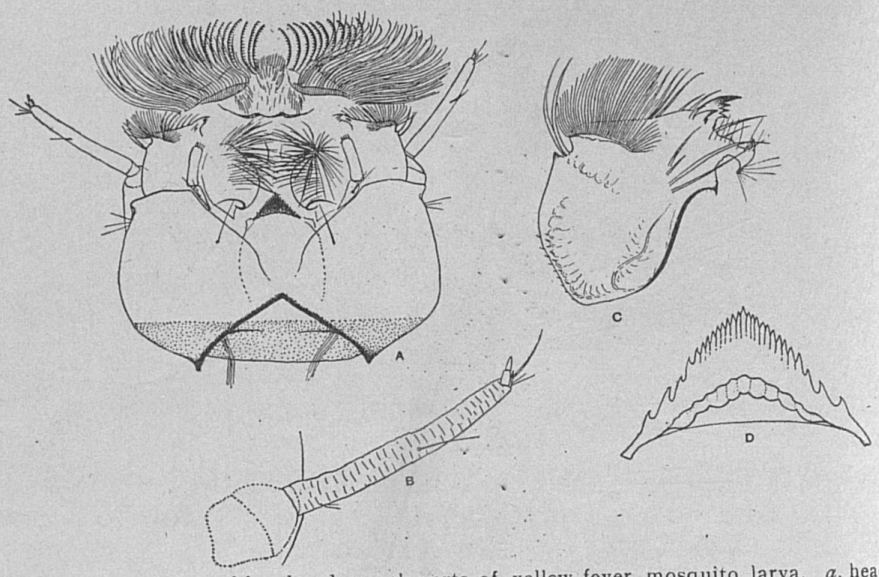


Fig. 17.—Ventral view of head and mouth-parts of yellow fever mosquito larva. *a*, head; *b*, antenna; *c*, mandibles; *d*, labium.

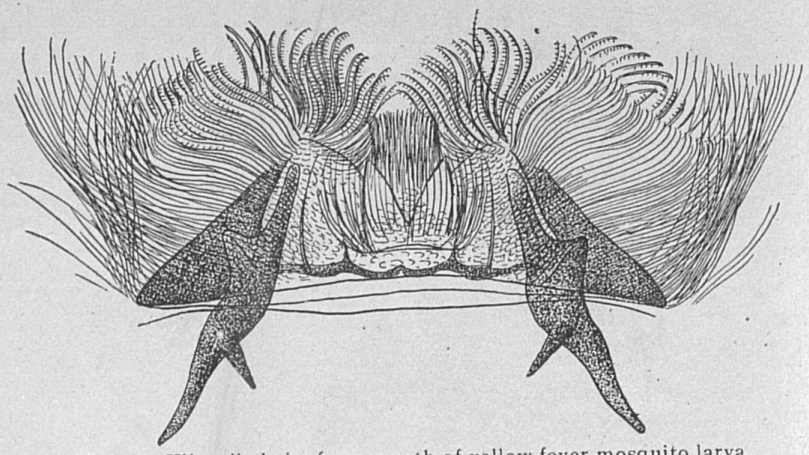


Fig. 18.—Vibratile hairs from mouth of yellow fever mosquito larva.

TIPULIDÆ (CRANE FLIES).

In the spring-fed rivulets flowing down the banks of the Left Fork of Straight Creek, I took October 21, 1911, a number of the leathery larvæ belonging to this group. None of the adults are known to sting, and excepting as they are sometimes attracted to lights are not often seen about dwellings. Larvæ of terrestrial species are often found in large numbers about decaying vegetable matter on lawns,

and in fields, where they constitute an important element of the food of robins.

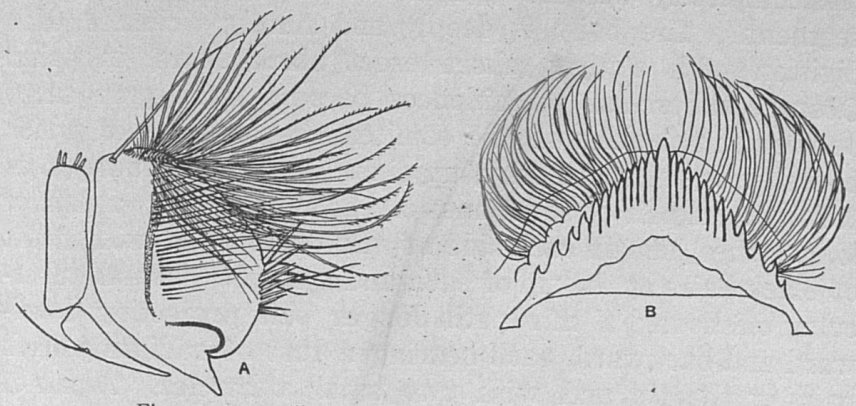


Fig. 19.—*a*, maxilla; *b*, labium. Yellow fever mosquito larva.

The aquatic species are generally found among dead leaves and other vegetable refuse washed into streams, and probably obtain their food from such sources.

The larvæ collected near Cary are like other members of this family of flies, soft-bodied, leathery-skinned, cylin-

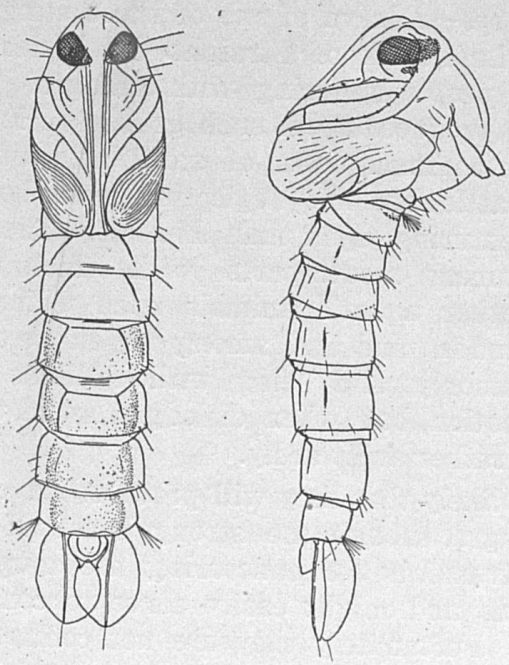


Fig. 20.—Pupa of yellow fever mosquito, ventral and side views. x 14½.

drical, dull-gray grubs, with a rather small head more or less completely withdrawn and concealed in the first body segment. The body is deeply and simply wrinkled, each division with a few short erect black hairs, in pairs. Obscure tubercular prominences become more pronounced on the ventral sides of the somites, the last one of which bears three pairs of fleshy, unjointed, dusky appendages, as follows: A pair of short ones on the dorsal side; a pair of longer ones, one on each side of the dorsal pair, with a tuft of black hairs at the tip of each and a couple of small tubercular offshoots; a third still longer pair projecting downward and backward, each bearing a tuft of radiating black hairs at the tip and with two small tubercles. A pair of eye-like structures is conspicuous at the back of the short dorsal pair of appendages. The under side of the posterior somite bears six soft contorted appendages. Length of largest example 20 mm.

TABANIDÆ (GADFLIES).

Tabanus sp.—A larva of one of these stinging flies was taken in the Left Fork of Straight Creek near a dwelling occupied by people suffering with pellagra. The strong-flying adults produced from such grubs are known as gad flies, and are common pests of stock, attacking especially horses and cattle, but not neglecting even hogs, and now and then venturing upon man himself. The young have sharp puncturing mouth-parts with which they destroy snails and other aquatic animals upon which they feed. They are found in mud and among vegetable refuse at the bottom, commonly, and being without limbs move by a wriggling motion, but when dislodged swim to some purpose though rather awkwardly.

It is not likely that they will prove to have anything to do with pellagra, though the strong beaks of the flies are efficient instruments for puncturing the tough and thick skins of cattle, and might easily serve to convey the virus of diseases. Fortunately they are not commonly disposed to attack us.

A single pure white larva twenty millimeters long was taken among rocks in the Left Fork of Straight Creek, September 1, 1911. Its body is composed of eleven somites and an additional small terminal segment is cylindrical and tapers toward its extremity. A faint brown band follows the anterior margins of the segments behind the first. At the anterior edge and ventral sides of segments four and five are six tubercles. Succeeding segments, except the two posterior, bear a ring of tubercles, two on the dorsum, the rest at the sides and beneath.

HEMIPTERA (TRUE BUGS).

This order contains members that are generally to be found in either standing or running waters, in which they reside at all periods of their lives, some swimming beneath the surface where they remain much of their lives concealed from us. When their surroundings become from any cause unsuited to them, they may, as in the case of the large electric light bugs (*Benacus griseus and Belostoma americanum*) and of the water boatman belonging to the genus Corisa, leave the water, and fly about in search of a better stream or pond. They are as a consequence often captured about electric lights and even in dwellings on hot summer evenings. The species observed in the Cumberland River and the tributaries are well known to every boy as water striders or water skaters, because of their manner of progression on the surface of water. When pursued they dive and conceal themselves, but soon reappear at the surface where they float and row themselves about in a leisurely fashion generally in small schools of from three or four to a dozen. All these insects are provided with beaks, with which they capture and kill other animals upon which they feed. Occasionally the collector receives a severe stab from such species as *Naucoris poeyi*, when handling water plants, but so far as I know, the aquatic species do not at any stage of their lives deliberately attack man. They are interesting in this connection because of their association with Simulium and other stinging gnats in our waters.

Two small, blackish species were rather common in Straight Creek and in the Cumberland River at Pineville. The commonest one is represented by figure 35. It is without wings, and rows itself about with such rapidity that it is not easily captured. On each of its middle feet is a fan composed of feathered hairs which are caught and held expanded by a claw of the split tarsus. This fan appears to dip beneath the surface when in use and gives its possessor a purchase on the water much like that obtained by a boatman with an oar.

Rhagovelia obesa, Uhler.—At the edges of the creeks and of Cumberland River small schools of these water striders, so-called, were often observed. They were especially common near Cary in Straight Creek and in the gap of Pine Mountain along the rapids of the river. They generally stayed in the sheltered places about submerged rocks in the larger stream, but are surprisingly quick in escaping the collector's net, and are quite able to care for themselves under any circumstances likely to arise in the swift current. These little insects are provided with a jointed beak and prey upon other insects which fall upon the water.

Length 3.2—3.3 mm. Division of body following the head widest. Front of head nearly even with the rounded eyes. Legs long, slender, the middle pair longest and bearing a fan-shaped tuft of plumose hairs (lacking in the young), kept expanded by claws of the tarsus. Last tarsal segment long, split. Abdomen of the male with straight carinæ along the margins of the abdominal somites terminating abruptly at the sides near the tip without meeting. In the female ridges originate at the sides of the thorax, thence curve backward and inward extending along the dorsum of the abdomen and meeting behind. Posterior femora of male noticeably thickened, and bearing behind a spine followed outwardly by a series of small denticles. In the female the large spine alone is present and the femora are not thickened. Both sexes are wingless in all examples collected. Color black. Antennæ and legs whitish at bases. A pair of transverse yellow spots on the dorsal

side of the thorax just behind the head. Carinæ of abdomen brown.

Metrobates hesperius.—A second species resembling the preceding in a general way, but with the four long slender tapering hind legs attached well back and close together, was found on one occasion, August 31, 1911, in the water at the edge of Cumberland River. It is a very alert species, and somewhat difficult of capture. Two females and one male were secured.

It is broad oval in shape, the female 3.8 mm. long, the male about the same in length, but much more slender and with a protruding cylindrical terminal abdominal segment. Wingless. Color black, a dull yellowish red spot on the occiput, excised in front. Eyes reddish brown. A relatively large bright yellow spot in the middle of the prothorax above, touching the posterior margin, but not reaching the anterior edge. Antennæ black, yellow at base. Legs black, bases of front pair and the prosternum dull yellow. A yellow mark in front of the bases of the middle legs. Under a lens a blue-gray longitudinal band is seen to extend along the middle of the thorax above. Another similar well-defined area extends along the sides. At the edges of the abdominal somites also the same color appears, and much of the ventral surface is so colored.

This insect resembles another water strider, *Trepobates pictus*, collected by me in 1889 and subsequently in rocky streams at Lexington, but the latter is elaborately marked with yellow and is more slender. Other larger species of the group *Hygrotrechus remigis* and *Limnotrechus marginatus*, are common in most streams in Blue-grass Kentucky. They are predatory insects, feeding upon flies and other insects that become stranded on the surface of water. As far as known they have no objectionable traits.

COLEOPTERA (BEETLES).

In most quiet fresh waters are to be found numbers of flattish beetles which swim well by means of their legs, which are in many cases expanded and fringed for the pur-

pose. In the swift streams of mountain regions these beetles of the family Hydrophilidæ and Dytiscidæ are not commonly seen. They appear not to endure buffeting well enough to hold their own in such waters. But their places are taken by others which are perfectly able to take care of themselves in the swiftest currents. One of the whirligig beetles was observed repeatedly in both creeks and rivers, often lurking in sheltered nooks among partly submerged rocks, but striking out in the swift current if pursued and when pressed diving to the bottom. These beetles are exclusively aquatic, their form and flattened middle and hind

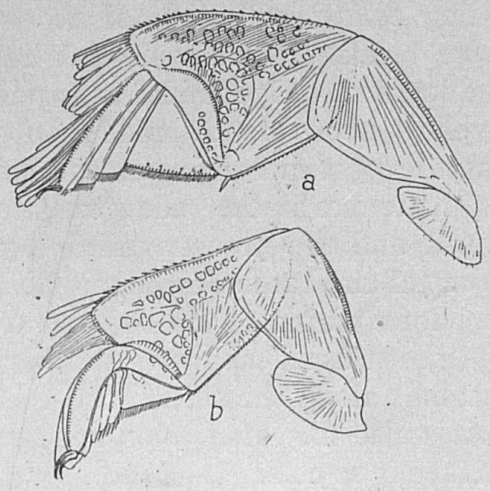


Fig. 21.—Expanded legs of the whirligig beetle, *Dineutes discolor*. *a*, right hind leg; *b*, right middle leg. Greatly magnified.

legs rendering them strong swimmers and unsuiting them for locomotion on the land. They have four compound eyes, or at any rate four independent divisions, two looking downward in the water and two looking upward.

The only species collected was *Dineutes discolor*. It is shining black with an olivaceous cast, in some lights with purple and bronzy reflections, especially about the head and the anterior edges of the wing covers. Eyes in preserved examples, reddish brown. Body rapidly contracted forward from the middle of the wing covers and meeting evenly behind with angles little evident and margin not serrulate. Labrum protruding, rounded, with a dense silken white

fringe of hairs. A tuft of similar hairs about the bases of the antennæ. Body beneath yellow to reddish, darker at the sutures. Legs reddish yellow. Male, length 11.1; diameter 5.5 mm. Female, length 13.4; diameter 6 mm.

These insects are predatory, both in the larva and adult stages. The young were not seen. Larvæ of the genus may be recognized by their elongate slender bodies bearing on each abdominal segment a pair of long lateral plumose respiratory appendages, the posterior somite with four such appendages directed posteriorly.

Parnidæ.

Perhaps the most characteristic beetles of the waters are members of this family. The adults appear by structure completely unadapted to life in the water, being provided with legs of the type seen in most terrestrial members of the order Coleoptera. They do not swim, but by means of long and strong tarsal claws cling tightly to the under sides of stones and wood, and are there shielded to some extent from the force of the current. Several species were rather common in the streams, and examples are figured.

The larvæ are among the most singular of the immature stages of aquatic insects. The crust of the dorsal side of the body is in them greatly developed, expanded, and the segments closely fitted to each other, producing a convex shield, the edges of which are held close against the underside of objects in the water. The limbs and head of the insect itself are to be seen only when the larva is detached and turned over. Like the adult it does not swim, but trusts to its capacity to cling tightly, and thus lives and thrives where the water races and tumbles among the rocks. The species are so generally present where Simulium was found that I have thought it worth while to note below the different species collected in the streams, having in mind a possible relation between the two, either as competitors or enemies.

Dryops lithophilus, Germ.—An elongate moderately convex black beetle, of a faint bronzy green color, found

clinging to the undersides of rocks in swift water. Head withdrawn in thorax up to the eyes. Thorax with sides rounded, anterior lateral angles acute, projecting forward as a spine alongside each eye. Wing covers contracted and sloping rapidly behind the middle, meeting behind in an acute angle. Surface evenly clothed with fine appressed silky pubescence. Antennæ, palpi and tarsi reddish. Legs in the main black. Length 4.3—4.4 mm.; diameter 2 mm. The most common and generally distributed species in Straight Creek and Cumberland River.

Dryops fastigiatus, Say.—This species resembles the preceding in a general way and is of about the same size. Black, rather coarsely and unevenly pubescent, the hairs being largely wanting from the region adjacent to the suture of the wing cover, and on the sloping posterior region of the thorax. Head immersed. Prothorax broadly rounded and a trifle angulate behind the middle. Anterior lateral angles slightly apiculate. Pubescence yellow. Legs black; tarsi reddish. Palpi reddish. Antennæ short. Length 5 mm; diameter 2.3 mm.

This insect was found associated with the preceding in Straight Creek, August 29, 1911, and in Cumberland River, August 31, but is relatively rare.

Stenelmis crenatus, Say.—A small rather slender gray beetle collected August 31, 1911, in the Cumberland River, at Pineville, September 1, in rapids of the Left Fork of Straight Creek, and on September 4, in Benson Creek at Frankfort. Head projecting. Antennæ slender, reddish. Prothorax with a rather deep median longitudinal channel bounded by two carinæ. Several obscure prominences on each side. Front angles acute, sides rounded behind, converging and nearly straight in front. Wing cover dull gray, with a ridge beginning on each side of the scutellum and gradually fading out a little beyond the middle of the elytron. A second decided ridge begins at each humerus and extends posteriorly and a little inwardly, terminating rather abruptly where the posterior slope descends to the tips. Legs gray, tarsi reddish, an obscure red spot between

the ridges of the wing cover and a second at the extremity of the lateral ridge. Length 3.2; diameter 1.4 mm.

The examples of the species collected in the Left Fork of Straight Creek, September 1, and in Benson Creek at Frankfort, September 24, differ in having the red of the elytra continued to form an obscure stripe.

Macronychus glabratus, Say.—Black, elongate, shining, punctured. Antennæ short, reddish; palpi reddish; distal segment of maxillary palpi black. Thorax elongate, widest behind, sides straight and rapidly converging from an angle behind the middle. Anterior margin pallid, wing covers with an obscure ridge near the suture, fading out beyond the middle. A conspicuous ridge terminates abruptly at the slope behind. Outside the latter ridge, and extending inward beyond it, is a silken whitish stripe. Legs long, sprangling, black, tarsi reddish; tibiæ with silken pubescence within. Pubescence of thorax scattered, golden, a trifle longer and more conspicuous on each side of the median line. A similar line of conspicuous golden pubescence on each side of the elytral suture. Length 2.7; diameter 1 mm.

Next to *Dryops lithophilus*, the most common species. It occurs in similar situations, but is less generally distributed. Cumberland River, Pineville, August 31; Left Fork Straight Creek, Sept. 1.

Ancyronyx variegatus, Germ.—This oddly marked beetle was not rare in the waters collected from. Specimens were collected in Clear Creek, August 31, and in the Left Fork of Straight Creek, Sept. 1.

Head black, exserted, antennæ slender, pale yellow, apex black. Thorax wide behind, strongly narrowed in front, and projecting over the head. A broad yellow transverse band along the anterior margin. Posterior margin more narrowly and obscurely yellow. Wing covers with a conspicuous bent yellow band beginning at the humerus and extending inward to the suture where it is narrowed, then widening and extending outward nearly to the margin. An elongate yellow spot on each side near the suture on the

sloping part of the wing cover. Legs black; femora yellow at base; tibiæ largely yellow; tarsi black, with yellow claws. Length 2.7; diameter 1.7 mm.

Larva No. 1 (Parnidæ).—Yellow, marked with dark brown. A series of round dots follows the margin, each placed just before a suture between segments. Anterior and lateral regions just within the dots reticulate with brown. Central region more completely brown, with a series of round dots along the median line and a second series on each side of it on the abdominal segments, the latter dots transversely lengthened. Margin fringed with close-placed rigid golden yellow hairs.

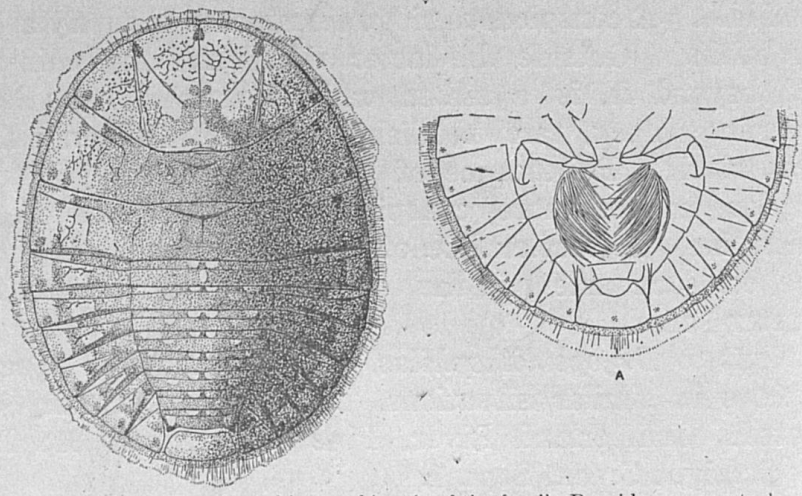


Fig. 22.—Buckler-shaped larva of beetle of the family Parnidæ. *a*, ventral view of posterior part of body, showing the two tufts of gill filaments. Larva No. 1 of Text. x 6.

Largely yellow ventrally, the marginal dots the only conspicuous markings.

Convex above, beneath concave, the body proper elevated, and the head free, with a pair of slender yellow antennæ and dark eyes. Legs strong, not reaching beyond the expanded terga, and thus giving the insect an appearance of being legless when viewed from above. Just posterior to the third pair of legs on each side are several tufts of long white respiratory filaments. Ten somites appear to be outlined in the terga, with median anterior and posterior plates added. Length 7—9; diameter 4.7—7.6 mm.

Collected adhering to the under sides of stones in Laurel River, Corbin; Clear Creek, August 31; Cumberland River, Pineville, August 31.

Larva No. 2 (Parnidæ).—A smaller and more slender species of the family was taken from Laurel River at Corbin in August. The preserved specimen is reddish brown, dusted with black, the sutures at the sides sharply black. Beneath yellow, with the black sutures at the sides conspicuous. Four white respiratory filaments behind the legs. Length 9 mm.; diameter 6 mm.

Larva No. 3.—An elongate brown larva was taken from Cumberland River, October 12, 1911, that appears to belong to the order Coleoptera, but cannot be exactly placed with the literature at hand.

Elongate, brown, tapering to the posterior extremity, with two dusky longitudinal lines along the middle of the back and outside this a series of dots. Head well developed. Three pairs of jointed legs. A brush of retractile hairs at the posterior end of the body. These are thrust out when the insect is detached from its hold on submerged plants or roots and seem to be kept concealed when the insect is at rest. It was found clinging to exposed roots in Cumberland River in October, and lies lengthwise of the root to which it clings, thus escaping observation. When detached it is evidently uncomfortable, and returns as soon as possible to any root or stick within reach, at once placing itself lengthwise of the object, and clinging tightly even when removed from the water. Length 3 mm.

TRICHOPTERA (CASE-FLIES).

In working among the rapids of the rivers and creeks I frequently came across pebbles secured together and attached loosely to the under sides of rocks. They were recognized as the shelters made by certain larvæ belonging to this group of insects. The insects construct a delicate net between the pebbles, often of considerable size, so as to catch floating objects suitable for food. The shelters and nets are often broken up and destroyed when the rocks are moved, and the larvæ are thus likely to be encountered

creeping about as if free. Several species were collected in the waters examined, together with others which construct and drag about with them very characteristic cases. Some of these cases obtained are composed of bits of sand glued together in a spiral form so as to resemble a small snail shell, the larva living within, keeping its head and rather long legs in the opening. Other cases collected are cylindrical and composed of bits of wood or other vegetable matter. Types of the different larvæ and of the cases are described and figured so as to give a definite idea of their appearance. These singular and interesting larvæ are in part predatory and carnivorous, such members of the group frequenting the situations preferred by Simulium larvæ, and probably at times act as enemies or competitors of the latter; in fact Miall definitely states it to be a fact that European species feed upon Simulium.

When ready to become pupæ case-fly larvæ secure their cases to rocks or other heavy objects in the water, close up the apertures, leaving, however, openings for the circulation of the water, and become quiescent. A single pupa, probably one of the net-making species, was taken from Straight Creek near Pineville, enclosed in a short case made of coarse bits of sand, the whole attached to a rock. Adult case-flies are delicate little four-winged insects often seen at lights in dwellings, and in very large numbers about the arc electric lights of towns and cities in the State. They look somewhat like a clothes moth, and are not commonly discriminated from these insects, all being called candle flies. A species (*Hydropsyche speciosa*) with blotched wings is especially common at times in midsummer about the electric lights at Lexington. They are all harmless to us.

Case-fly No. 1.—A cylindrical case, with small bits of woody material fastened over the surface. Straight, or a little curved, the smaller extremity fitted with a round disc within the aperture, provided with a single slit-like opening. About this end, some bits of sand are attached as if to anchor it. Length 13 mm.; diameter 2.5 mm.; at smaller end, 1.8 mm. Another example measures 14x2.9x2.6 mm.

Case-fly No. 2.—A second case collected is cylindrical and covered with elongate bits of woody material, some of it obliquely placed. Rougher than No. 1, and thicker. Both apertures closed, and thus probably contains a pupa. Large aperture with a grating, and with sand grains attached about it. The opposite end has a small aperture with three rounded extensions. Length of case 16.5 mm.; diameter at smaller end 3.4 mm.; at larger end 3.9 mm.

Case-fly Larva No. 3.—Case spiral, covered with grains of sand firmly glued together and making a hard tough structure. Diameter 4, depth 2 mm. Convex above, with a small, deep, round central cavity below. Whorls three, separated by a slight groove. Aperture wide, the head kept just within, the legs more or less projecting. Taken from rocks in very rapid water in Clear Creek, Pineville August 31. Larvæ were removed from these cases with some difficulty. The body is curved to fit the case, and clings by hooks at the posterior end. The case itself, as already noted, is extremely tough and hard, so that one is likely to damage the insect before it can be removed.

Larva pure white in general, the head brownish black, with a pallid area about the eye speck on each side. With erect black hairs. Jaws acute, black; other mouth-parts largely pallid and protruding. Throat white, with several brown dots on each side. Thoracic divisions with erect hairs; first division of thorax with black shield; second and third with some black above, on sides, and about the bases of legs, Legs of moderate length, those of the third pair longest, projecting forward before the head. Tarsal claw strongly curved. First abdominal division with an elongate prominence above. All the abdominal divisions smooth, with delicate respiratory appendages on some of the anterior somites. A pair of brown claws on the ventral side of the last division of the body. See Fig. 41.

This interesting species is widely distributed in Eastern Kentucky and can probably be found in most of our small streams. It was collected by me in a rocky stream in a meadow at Lexington, August 5, 1889, when the cases were

closed by a thin flexible brown concentrically striate silken disc, each with an excentric curved slit. Pupæ were already formed in some of them, lying with the head just behind the disc. Other specimens were collected in Elkhorn Creek, near Lexington, July 4, 1890, and at Elk Lick Falls, July 14, 1893. The late A. S. Packard named the species producing a spiral shell in New England, *Helicopsyche glabra*, but in the American Naturalist for 1869, p. 160, quotes Hagen as pronouncing it *H. borealis*. Hagen in the same connection states that he thinks a species described by Lea, the concologist, as *Valvata arenifera*, from the Cumberland River, near Nashville, is different. Ulmer in "Genera Insectorum" lists Lea's name as a valid one. It was used by Lea in the Transactions of the American Philosophical Society, Vol. 4, p. 104, 1834. There is some reason for thinking that the Kentucky material represents the supposed snail described by Lea. Judging by Packard's description and figures the case of the Kentucky insect differs from that of *H. borealis* in being composed of much coarser material, and the silken disc spun in the aperture before pupation appears to lack the slender teeth which he says project from each side over the slit and form an imperfect grating.

The pupa is enclosed in a thin pellicle, probably cast when the adult emerges. A sharp tooth projects forward from the mouth. Eyes conspicuous. The long antennæ and legs lie free along the sides of the body. On the back of the abdominal segments are short spines, some projecting backward and the others forward, probably of service in getting out of the shell finally. The long body is curved to fit the shell and bears a bar and tuft of hairs at the end. Length about 6 mm.

Case-fly Larva No. 4.—A third larva resembles the preceding in general structure, but is provided with branched appendages of respiration on the ventral side of the body. While the surface everywhere is rather densely pubescent, the last segment bearing a pair of long, clawed, false legs, each with a brush of long plumose hairs, generally loaded with dirt and often bearing living stalked Protozoans, which

thus obtain free transportation. It was collected in the broken up shelters made of pebbles and found under rocks. It is probably the owner of these shelters and a member of the genus Hydropsyche.

Body pubescent. Head small, and with three thoracic somites, brownish black dorsally. Eye in a pallid area. Jointed legs yellow, pubescent. Second and third thoracic and six abdominal somites with whitish ventral branched appendages.

Possibly several species are represented among material collected with the above. One example noted has a green abdomen. Others show several protrusible finger-like appendages dorsal to the posterior false legs. The head has a peculiar unfinished appearance, and is shorter and smaller every way than the heads of other free-living larvæ collected. The pubescent body and long brush of hairs on the false legs were generally loaded with sediment in the streams of Bell County. Examples of what appears to be the same insect from Benson Creek in Franklin County bore very little such material. This same insect was collected at Elk Lick Falls, July 14, 1893.

Case-fly Larva No. 5.—A single example of this species was taken from the Left Fork of Straight Creek, October 21, 1911. It resembles No. 4 in a general way, having a fine pubescence over head and body, and being provided with similar branched ventral appendages on the thorax and abdomen. The brush of the false legs at the posterior extremity is not so dense. The head is larger, more elongate, thickened dorso-ventrally in the occipital region. Dusky above on head and thorax. A pallid region about the eye extends posteriorly on the side of the head and then dorsally along the occiput. It is probably a Hydropsyche.

Case-fly Larva No. 6.—Length of large examples 10 mm. Pure white. No ventral branched appendages. Head large relatively and elongate, yellow, the eye well forward just posterior to bases of mandibles. A large white membranous T-shaped expansion of the upper lip overlying the mandibles. Dorsal plate of prothorax and legs pale yellow. Posterior

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edge of head at sides, and sutures on side of thorax at bases of the legs, black. Body with scattered erect hairs. No branched respiratory appendages. False legs at posterior end of body somewhat tapering, with a claw and a couple of long hairs. Fleshy terminal protrusible appendages are apparent in some examples, dorsal to the false legs on the last somite. One example, Cumberland River, September 1, another October 22; a half dozen examples, Left Fork of Straight Creek, October 21, 1911. The unprotected, soft condition of the body indicates a larva inhabiting a close shelter, or case of some sort. The head, with its strong sharp jaws denotes carnivorous habits. It is probably a member of the genus Polycentropus.

Case-fly Larva No. 7.—One small larva differing from all of the above case-fly young was taken from the Cumberland River, August 31. It is yellowish, a trifle dusky on the terga of the abdominal segments, with scattered erect hairs on head and thorax, becoming more numerous but of the same character on the abdomen. Head large relatively, elongate and oddly flattened from the mouth backward, the area produced sloping gradually upward to the occiput and with a definite margin at each side, passing just over the small eye. Head and thoracic plates yellow. Jointed legs pallid. Branched ventral appendages white. Two divergent posterior false legs with strong curved claws, and about six long straight hairs. This species resembles No. 5, but its flattened head and lack of pubescence distinguishes it. Probably a Hydropsyche.

Case-fly No. 8.—A rather large cylindrical case was collected by me in Clear Creek near Pineville, June 16, 1892, and appears to be different from Nos. 1 and 2. It is pretty even in diameter from end to end, measuring 6 mm. in diameter and 24 mm. in length. It is occupied by a larva with a short reddish-brown head. The hooks at the hind end of its body still retain it in its case so securely that to examine it would involve breaking the case or injuring the insect. The whole case is covered with bits of gravel, and one end is closed with a rather large white frag-

ment. This case has the dimensions and general character of one described as Halesus sp., by Professor Cornelius Betten, New York Mus. Bul. 47, p. 569. The Kentucky case has no wood about it, and the head of the larva is not marked with black.

Case-fly No. 9.—A rather slender cylindrical case with thin walls covered with fine grains of sand was collected by me June 15, 1892, in the Cumberland River, at Pineville. Length 15 mm., diameter 3 mm. Very slightly tapering from the head end. Both ends closed with a thin disc of silk set a little distance within the aperture, the one in the larger opening with a straight eccentric slit for respiration. Edges of the apertures with bits of woody material attached.

NEUROPTERA (HELLGRAMMITES).

One of the most characteristic insects of the creeks and rivers is the singular and formidable looking dobson or hellgrammite (*Corydalis cornuta*). It is more common under rocks in these streams than I have ever observed it elsewhere in the United States. Boys who were attracted by curiosity to my operations called the larvæ grampuses, and expressed fear of them. They nip with their strong mandibles with a good deal of spirit, and no doubt prove very destructive to the small fry living in the rapids with them. Adults gather in large numbers about the electric lights of Pineville, in July, and some years ago I secured at an arc light at the edge of the town more than I have collected elsewhere in many years. They are calculated to have a decided influence on the organisms of these waters, but are at no stage of their lives to be greatly feared by man. The adult males have a ferocious appearance from the great length of their jaws, and will use them freely if given an opportunity, yet they are ordinarily used only in self-defense. The young make good bait, it is said.

The Grampus (*Corydalis cornuta*).—Large, reaching a length of over two inches. Black, pubescent, rough, forbidding in appearance. Body flattened. Head large, flattish, jaws strong. Legs short and stout, provided

with two claws, these sometimes double and often reinforced by curved spines. Prothoracic shield longer than wide, large. Middle and posterior thoracic somites with small transverse shields. Abdominal somites with a hairy, tapering, lateral filament on each side; beneath and within the filaments of each side are tufts of slender branchial filaments on the abdominal somites one to seven, inclusive. A pair of terminal false feet present, each with two long curved claws and a filament, like those along the sides, but more slender.



Fig. 23.—Larva of grampus or hellgrammite (*Corydalis cornuta*). x ½.

It was constantly met prowling about under rocks, often with its body coated with mud and refuse, as if for concealment. Its eyes are in a cluster on each side of the head, but are not conspicuous in the large larvæ because of the dark hue of the whole animal. Younger larvæ presumed to be this have the head and first body division reddish brown, marked with black, and the black eye-specks are conspicuous, forming a cluster on each side of the head, one of them occupying the center, the rest ranged in a curved series about it, the ventral median one smaller than the rest.

The smallest larva of the family collected is white, and the branched respiratory structures of the abdominal somites consist of a basal piece and several simple branches, as in some of the case-fly larvæ described. Possibly it is a different species. It was taken in the Left Fork of Straight Creek, September 1, 1911.

EPHEMERIDA (MAY FLIES).

Perhaps the commonest insects inhabiting the swift waters collected from about Pineville and indeed everywhere

in the State, are the larvæ of fragile, gauzy-winged insects known as May flies. Though holding their own against the current as well as tougher-skinned and more strongly built insects, they do this more by virtue of their expertness in sticking close to the under sides of rocks than by their capacity to swim. They resemble somewhat the stone flies in general appearance, being, like them, provided with slender, tapering antennæ and long, jointed, caudal stylets, three in number, however, in well-grown examples, whereas the stone fly young have at all stages only two. They can always be distinguished by the presence of gills, plate-like in all the species collected, along the sides of the abdomen, and by the presence of but one tarsal claw. Adults of small species belonging to this group of insects were emerging October 23, 1911, at Pineville, and were found in some numbers early in the morning in the mud and sand at the edge of the water, though the temperature at the time was close to freezing. These were doubtless from some of the small larvæ, noted farther along under No. 4 of this part of my account. They are slender, pallid, fragile insects, with large membranous front wings and small or minute hind ones. At the end of the body are two long slender setæ. The creatures are rather feeble fliers and after mating drop their eggs in the water and soon die. The members of the group are sometimes called day flies, the adults being popularly supposed to live but a day. They do indeed last but a short time, once adult, but live for a year or more in the water.

Ephemeride Larva No. 1.—A common and widely distributed larva of the group was taken in all the mountain streams examined. Its body is flat, the head broad, the outline everywhere rounded. The simple eyes are accompanied by three pale dots. The series of gills along the sides of the abdomen are terminated by a simple fringed filament behind. The abdominal segments are provided with a strong sharp tooth at each side. The caudal appendages are noticeably setose. The color above is a mixed pattern of black and pale yellow; the legs are banded with

dusky. The caudal setæ are of a decided yellow. Beneath, pale yellow, the posterior edges of the abdominal somites dusky, the posterior ones more completely so. Length 10 mm. Cumberland River, Straight Creek, Benson Creek, and brooks about Lexington.

Ephemeride Larva No. 2.—This larva is figured in this bulletin (Fig. 46). It is less common than No. 1, but bears a close general resemblance.

The abdominal segments are not toothed. The caudal setæ are only very slightly setose and are distinctly banded with white and black. Length 9.5 mm. Cumberland River and Straight Creek.

Ephemeride Larva No. 3. (Chirotenetes sp.)—One of the most striking insect larvæ collected is of a deep umber-brown color, with a pale stripe along the back, the legs sharply banded with black and white. Head small and not flat. Thorax strongly convex and not expanded. Tibiæ of anterior legs with strong spines and a double fringe of long hairs. Wing-pads black. Gill-plates alongside of abdomen turned outward, each with a large purple central area. Abdomen marked with black at the edges of segments, two at the posterior extremity with the lateral angles produced into a sharp spine. Central caudal seta shorter than the others, heavily fringed along the sides, the extreme base black, then more than half the length a deep yellow, then a band of black, the distal portion white. Lateral setæ heavily fringed within, marked like the median seta, but with a slender black terminal unfringed region beyond the white. Length 12.3 mm. Cumberland River, Left Fork of Straight Creek, Benson Creek.

An adult of this insect was collected October 21, 1911, at the edge of Cumberland River at Pineville. Its body resembles somewhat closely in form, general structure, and even color, that of the young. The second and third pairs of legs are pure white. The wings are smoky, the veins black. Two slender caudal setæ are pallid. I take this to be *Chirotenetes albomanicatus*, described by Professor Needham, who says of the larva, that it feeds upon the larvæ of

Simulium, but appears to take a mixed food, consisting of algæ as well as insects.

Ephemeride Larva No. 4.—Several very small larvæ, having the same general form as No. 3 were everywhere common in the rapids of the streams. They are generally pale whitish with obscure dusky markings, most of them with a dusky band across the heavily fringed caudal setæ.

Adults from some of these larvæ were emerging from the water October 23, 1911, at Pineville, and were found stranded on mud and sand at the edge of the river. The males have singular large cap-shaped eyes meeting on the top of the head and in addition a smaller second eye is present on the side of the head beneath the other. The abdomen is provided with but two seteæ. Dried specimens brought home with me measure from two to four millimeters in length, and probably represent several species.

ODONATA (DRAGON FLIES).

This group of striking insects is represented by individuals about all fresh waters of this country. The species are not very closely discriminated by the angler and hunter, but every one knows them by the name dragon flies, snake doctors, and mosquito hawks. They are powerful fliers, with enormous eyes and often gaudy colors, which flit back and forth over the water, some species appearing very early in spring, but most of them during the hot weather of July and August. The adults are provided with strong jaws, but never attack large animals of any sort, their prey being small insects which they capture on the wing. No doubt their influence is felt by the small fry of this sort, especially in the immediate neighborhood of streams and pools. They do not so often appear about dwellings, and it may be questioned if they have any special effect on the members of our house-infesting mosquitoes, since these generally breed close about dwellings.

The young of these showy insects are rather obscure water-frequenting animals, lurking about the bottom, partly buried in mud or rubbish, sometimes clinging to water

plants, and to be found in some numbers under stones and boards. In contrast with the habit of the adult these larvæ are still-hunters, lying in wait, often concealed, until suitable prey comes within their reach, when suddenly they thrust out a peculiar lower lip with strong jaws at its extremity and fasten upon it. They destroy in this way hosts of small insects, Simulium probably among the rest, and attack and sometimes do a good deal of mischief to very young fish fry.

The larvæ of this order collected in Laurel River, Cumberland River, Straight Creek, and Clear Creek, represent two main groups, one of which comprises rather slender species (Represented by Fig. 45) with three long flat plates for respiration at the hind end of the body. These are the young of the damsel flies, very slender and rather small gauzy-winged insects known to everybody from their disposition to alight on one's float or cork when fishing. The second group lacks these plates, and is composed of larger broader species (See Fig. 44) which respire by means of gills placed on the walls of the hind portion of the digestive tube.

Species of Progomphus, Gomphus, Macromia, Calopteryx, etc., were collected among the rocks on which Simulium larvæ occurred.

PLECTOPTERA (STONE FLIES).

In every locality collected from, I found a few representatives of this group of aquatic insects. The larvæ were associated with many examples of the group Ephemerida, but not more than one of the stone fly larvæ to a hundred of the others was seen. They are flat insects with wide heads, the thorax in three broad divisions, the antennæ many jointed and long, the abdomen terminating in two long, tapering jointed stylets, much like the antennæ in structure. They are active predatory insects, feeding with special relish upon gnat larvæ, according to Miall. They are found with Simulium in rapids, on the under sides of rocks, which surfaces they quickly regain if permitted when

rocks are overturned. Three different forms of these larvæ were collected. By far the commonest is represented by Figure 47.

Larva No. 1.—Elongate, flattish, the head wide, produced into a pronounced angle behind each eye. Next three divisions (thoracic) of body with expanded dorsal plates, the two hindmost a little produced backward at sides. Six tufts of fine gill-filaments are placed about the legs of each side, and another within the base of each long posterior abdominal sylet, making fourteen in all. The back is brightly marked with black and yellow. The longest example, taken June 15, 1892, from the Cumberland River, at Pineville, is about three-quarters of an inch long. Other examples collected from Straight Creek, Clear Creek and Cumberland River, in August and October, 1911, range from 5 to 20 mm. in length.

Larva No. 2.—Small, slender, the head and thorax but little wider than the abdomen, the sides of the head behind the eyes rounded and not produced. Abdomen rather long, its sides parallel. No gills. Color plain olive. One example 5.5 mm. long, but with the wing pads well developed and thus ready to produce the adult, was taken from Horse Creek at Corbin, August 29, 1911.

Larva No. 3.—A singular, flat larva was taken from a spring-fed rill near Cary along Straight Creek, October 21, 1911. It is represented in my Figure 48. In general shape it resembles a small roach, the head and thorax being excessively expanded, the antennæ tapering, and the stout legs with two tarsal claws. The length of this example is 6 mm., its greatest width 2.5 mm. On looking over some old material collected by me at Pineville in June, 1892, I find a second example of the same insect, measuring 2.5 mm. in length. Head wide, bent downward; eyes at outer angles; antennæ long, regularly tapering, many jointed (broken at tips). Dorsal plates of the three thoracic divisions broadly expanded, overlapping, the posterior lateral angles rounded, the posterior margin broadly and evenly, though slightly concave. Abdominal somites abruptly narrower, contracting

gradually in width to the posterior end of the body; posterior margins straight, except that of the last which is angled; edged with a fringe of short bristles. Legs short and stout, gradually increasing in size from first to third; femora very stout and flattish. Sterna of thoracic divisions large, plate-like; the sides and posterior angles of first rounded, the posterior margin broadly incised; sides of second rounded, posterior margin broadly and deeply excised; third narrower, angled, the posterior margin still more deeply concave. Body everywhere clothed with a fine felt-like pubescence. Edges of segments above and at sides with series of short rigid spines. At the posterior end of the body is the usual pair of tapering jointed appendages, characteristic of the family. Respiratory organs in the form of simple tapering white filaments arising at the bases of the legs, both above and beneath.

Color brown, eyes black; obscure dusky markings on first segment of the thorax; second, with three elongate dusky dots; third with three similar dots, the median longest, all concealed by the overlapping second tergum.

ARACHNIDA (MITES, ETC.).

Members of this group of animals could be found about the edges of the streams at any time, but there were none that attracted special attention because of any apparent relation to the object of my investigations, except jiggers, chigoes, or harvest mites. These microscopic mites were common about the streams in the vicinity of Pineville in August, and are the cause of a good deal of annoyance during the summer to those who go much among blackberry bushes and other shrubbery along the banks of the streams. Berry pickers are especially liable to attack. But the mites attack by preference the covered parts of the skin, and generally those regions upon which the clothing presses most closely, as about the waist and under socks and stockings. In the case of men I know from experience that jiggers sometimes manage to get under the tongues of shoes and cause red mounds on the upper surface of the feet.

The mites are the young of red species belonging to the genus Trombidium. They enter the skin to complete their development, but appear to be unable to do this on human beings. Their habit of making the attempt seems to be one of nature's mistakes, for all of those entering the human skin die there. Women and children often suffer greatly from the attacks, probably because of their more tender skin. Men constantly living in the infested regions become more or less completely immune, either because their skins become tough and thick, or because they do not from long exposure to the attacks become inflamed by the presence of the imbedded mites. The fact of importance, however, from the point of view here taken is that the mites do not attack a person subsequent to an attack upon another, and hence cannot well be concerned in carrying skin diseases from ill to well.

Clearing away close-growing vegetation by mowing, or by fire, is a good way to get rid of them about premises.

PROTOZOA.

The microscopic unicellular organisms of this sort, were, of course, common in all the waters. Water taken from the river and brought to Lexington in jars was found to contain large numbers of several species. A large ciliate species in a general way resembling Paramœcium, was extremely

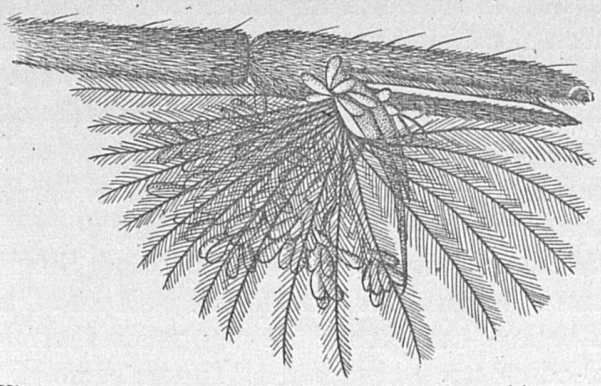


FIG. 24.—Hind tarsus of the water strider, *Rhagavelia obesa*, with expanded oar, and a cluster of stalked Protozoans attached. Greatly magnified, as seen under the microscope.

common, and so large that it could be seen with the naked eye by holding a jar up to the light. A stalked species was observed attached to the foot of one of the bugs known as water striders and is represented in one of my figures (Fig. 24).

CRUSTACEA (CRAWFISHES, ETC.).

The best known crustacean of the fresh waters of this country are known everywhere as crawfishes, sometimes simply as craws, and among college men, as crayfishes, this British word having been imported with laboratory manuals. All of the species of the Eastern United States belong to the genus Cambarus, of which there are about sixty known, eleven of them, possibly a few more, occurring in Kentucky. They are all much alike in general structure, being provided with a pair of strong forceps, on the forward pair of walking legs, and at the hind end of the body with a fin composed partly of the flattened last segment and partly of the hindmost expanded and branched appendages. With this caudal fin they swim swiftly backward, as everybody knows, a method of progression with the advantage of keeping the strong claws and eyes directed toward pursuing enemies, but with some disadvantages also, as when one of them swims thus into the mouth of a black bass. They are in fact excellent fish bait. They are common in the streams about Pineville, and though my attention was concentrated on the search for Simulium, two species of crawfish, *Cambarus bartoni* and *C. putnami* were collected in the Cumberland River, and a third, apparently *C. girardianus*, was collected in the rapids near the Roark cottage at Cary.

The crawfishes are of special interest as inhabitants of these waters because of their value for fish food. But their great abundance in situations frequented by Simulium may give them an important relation to the welfare of the latter. As a rule, I believe they are more vegetarian than predatory, but while feeding upon plants at all times, some of them undoubtedly seize and devour animals coming within their reach, when prowling about under rocks, and they are

known when in confinement to eat one another if other food is not available.

In addition to the crawfishes, several species of small flat crustaceans belonging to the group Isopoda were now and then encountered in the streams. One of the most interesting was the blind crustacean (*Cecidotea stygia*) taken in October from a spring-fed stream flowing into Straight Creek near Cary. It is a common species throughout Eastern Kentucky. In addition to this Isopod a few specimens of an eyed species of Asellus were obtained under rocks at the edge of Cumberland River. So far as known to me our species of this group are vegetable feeders.

BRYOZOA OR POLYZOA (MOSS ANIMALS).

Water mains in cities sometimes become infested with a singular small animal growing associated in groups and forming branching colonies attached to the inner surfaces of the pipes. At times these growths become so numerous as to offer a serious hindrance to the flow of water, and their decay at certain seasons pollutes water supplies so as to be a source of danger to health. One of these branching growths was common in the swiftest water of Cumberland River and Straight Creek. When rocks lying in the water were turned over, extensive and often rather pretty patches were revealed closely attached to the under surfaces, so closely in fact that they were liable to be broken into small fragments by attempts to remove them. At the extremity of each branch is an opening through which an individual may protrude its beautifully tentacled forward extremity. The same species has been repeatedly collected by me in rocky streams at Lexington. The food consists of microscopic plants and animals.

The winter is passed in the egg stage and at this season the singular winter eggs (statoblasts) may be collected from water mains and streams. Animals of this group are much more common in fresh waters of all sorts than is generally supposed. The reason they are not recognized for what they are is because of their plant-like appearance. They

are true animals of an ancient type, being better represented as fossils than as recent species.

The presence of Bryozoa in water pipes may be determined by securing a fine sieve, or piece of muslin, over a tap and allowing the water to flow through it for an hour or two. In the winter brown tubular fragments of the enclosing test or shell of the organisms may be thus collected in quantities and with them the winter eggs. The latter are very singular and characteristic, being oval, flattish, the surface granular under the microscope, the color of the outlying regions pale brown, and a round central region, the egg proper, of a deep umber-brown. The length of these eggs or buds is about .35 mm; the diameter 0.24 mm.

VERMES (TRUE WORMS).

No worms of special interest were collected, but on the roots of plants growing on the edge of Cumberland River in the gap of the Pine Mountain, were noted small knots or nodules somewhat like the bacterial nodules of clovers and other leguminous plants. These knots were recognized as the work of a small thread worm, and on subsequent examination with the microscope the eggs and young of the worm were found in the plant tissue. It is possible that this is the root-knot worm, *Heterodera radicicola*, which is so destructive to cultivated plants of different sorts in the South Atlantic states. If so, it would appear to be making its way northward with pellagra along the Cumberland River. This worm is parastic only on plants. The plant on which the knots occurred could not be identified positively because of its having been browsed by stock, leaving only the stubble and roots in the river's edge.

MOLLUSCA (SNAILS AND CLAMS).

These animals are scavengers and vegetarians. One small snail (*Goniobasis brevispira*) with an elongate spiral shell was constantly present about and on the rocks in all of the streams, and in Cumberland River could often be followed for some distance by a trail left behind it, the surface

having been cleared along the line of travel of its coating of algæ and slime. This coating of the rocks was everywhere present, and seems to furnish food to a host of microscopic animals, and some larger ones, including some of the insects. A large percentage of it consists of algæ and protozoa, and grazing animals, such as the snails, find it nutritious forage easily obtained. Several other species of snails (*Physa sayi* and *Planorbis bicarinatus* among them) were collected, and a small elongate clam. The collection, however, gives a wholly inadequate idea of the molluscan fauna of the streams. The material collected was merely picked up incidentally and because it chanced to catch my attention when searching for other things.

The shells mentioned were identified by Drs. Pilsbry and Sterki.

FISHES.

The community of insects and other animals, of which Simulium larvæ form a part, inhabiting the rapids of our mountain streams, is relatively free from the attacks of the larger fishes. Such fishes cannot follow them here. Frogs and water birds, also, have little chance to get them, hidden as they are in narrow spaces among the rocks and generally clinging to the under surfaces. Even the larger carnivorous beetles and bugs, such as Dytiscus and Belostoma, cannot maintain themselves in the rapids, and the small species suited to the peculiar situation are thus here as nowhere else in our waters free from their attacks. A single family of fishes, however, contains members that have been driven like the insects in the struggle for existence to these same waters, and has become adapted to the peculiar conditions here prevailing. The sand darters (Etheostomatidæ) are very small often brightly colored fishes, the largest reaching a length of six inches or thereabouts, that habitually lurk in shallow running waters, many of them under rocks in the swiftest streams. They are relatively slender, often with pointed snouts, and naked napes, the scales being gone as if rubbed away by probing under stones for shelter and food.

Though small, they are quick, strong swimmers, the pectoral fins especially being relatively large. When uncovered they dart at once under another rock, and are thus not very easy to observe and capture. Indeed they are not often seen excepting by collectors of fishes, and are all but unknown to anglers. When by accident brought to the notice of the latter they are generally regarded as the young of wall-eyed pike and other large game fishes which they somewhat resemble.

These diminutive fishes can pursue the insects living in rapids wherever they may go, and being exclusively carnivorous must have a decided regulative effect on the numbers of insects inhabiting the rapids. The species collected at Cary in Straight Creek in October is *Etheostoma obeyense*, originally described from small tributaries of the Cumberland River in Whitley and Clinton counties. The stomach of an example captured with a small dip net in a rapid in which Simulium occurred contained an almost perfect Mayfly larva.

Etheostoma obeyense.—Length 1.36 inches; depth 5.2 in length. Eye a trifle longer than snout. Cheeks, opercles, and nape, naked. Lateral line with 46 scales, 25 to 26 of the anterior ones with tubes. Spinous dorsal moderately low, with 8 spines; soft dorsal with 11 rays. Ventral, with two spines and seven rays. Color pale olivaceous with a series of dusky blotches along the back and another of small dots along the lateral line. Head with a dusky bar from the eye to the tip of the snout, and a faint vertical bar ventral to the eye. Head dusky above, pallid below, minutely specked with black. Spinous dorsal dusky edged. Soft dorsal barred with dusky. Caudal with six bars of dusky, the anterior partly on the extremity of the caudal peduncle.

I do not know any other fish of our waters very likely to be mistaken for this, though no less than eighteen members of its family occur in the Cumberland River and its small tributaries in this part of Kentucky. The above species is highly characteristic of the locality.

The game fishes and the small competitors of the sand darters adapted to the quieter and deeper parts of streams appear to be the barrier which keeps the sand darters pretty closely confined to the more rapid and shallow parts of the Cumberland. Fifty-four species of fishes in addition to the darters are known to inhabit the headwaters of the Cumberland, giving a total of seventy-two. The number will be increased, I have no doubt, with careful collecting.

AMPHIBIANS.

The common spring frog, a large, olive, obscurely marked species, is very common in the small creeks emptying into the Cumberland in the vicinity of Pineville. The adults were not seen, but the large slippery tadpoles, some of them with the legs of considerable size, occurred in numbers in the shallows at the edges of the creeks, and attracted attention by the disturbance they made in retreating to deeper water. They were easily captured because of their lack of alertness. An example is just about three inches long (76 mm.), the color olive brown, minutely dotted on the head and upper part of the sides with black. The mouth is small, inferior, with several lines of black filaments backed by papillæ at the sides and behind. The tail is broad and lanceolate, constituting a very effective means of propulsion.

These larvæ pass the winter in the water, they were very common during my first visit to the streams in August and September. In October they were not seen, having retreated from the shallows for hibernation. The abundance of this animal renders it an important feature of the life of the waters, and no doubt its presence is felt by other organisms in many ways. The capacious body cavity of the tadpoles is filled with the slender, closely coiled intestine; it is coiled in several horizontal layers, one above the other, looking very much like a small red rubber hose. A larva before me, taken August 31, 1911, from Straight Creek, measured two and five-eights inch (2.5 inch) in length, while its uncoiled digestive tube measures a little over

twenty-one inches. The food as seen under the microscope consists of the slimy ooze which collects in summer on the bottom and over objects in the water. It contains vast numbers of microscopic plants known as diatoms, of desmids, and of the rod-shaped Oscillaria, of numerous protozoans, and of granular matter, vegetable and animal, in process of decomposition.

The adult frog is one of our largest American species, next in size to the bull frog and a good deal like it. The bull frog, however, prefers swamps, and is common in bottom lands along the Mississippi River in the West. The spring frog frequents springs and spring-fed streams. It may always be distinguished by the incurved edges of the webs of the hind feet and the presence of a glandular fold along the sides of its body. An example of the adult caught some years ago in Edmonson County near Mammoth Cave had fed on water beetles.

VEGETATION IN AND ABOUT THE STREAMS.

A rust-brown material, coating objects in the streams, looked at first like iron and I thought might result from the washings of mines and heaps of slaty material thrown out of them. It proved when examined with the microscope to be a filamentous alga, and was composed of fiber-like strands becoming smaller and smaller as they divided. I judge they are denuded strands of Batrachospermum. They were not in good condition for examination when I reached home.

Algæ were of course common in the waters, on rocks and wood. With diatoms and desmids, both of which were numerous, they constitute the most important feature of the aquatic vegetable life of these waters.

But one strictly aquatic plant of the higher groups was observed: A slender species of Nitella was collected in August from the Cumberland.

The banks of all the streams are fringed more or less closely with shrubs and trees. Without giving them any-

thing like close attention, I noted the following while working along the banks at different times.

Scrub Pine (*Pinus virginiana*). Common on slopes.

Yellow Pine (*Pinus echinata*). Well up on slopes along the Cumberland at Wasioto.

Willow (Salix sp.)

Butternut (*Juglans cinerea*).

Black Walnut (*Juglans nigra*).

Shell-bark Hickory (*Carya ovata*).

Iron Wood (*Carpinus caroliniana*).

Sweet Birch (*Betula lenta*).

River Birch (*Betula nigra*). Common.

Alder (*Alnus sp.*)

Beech (*Fagus grandifolia*).

Chestnut (*Castanea dentata*). Common.

Postoak (*Quercus stellata*).

Black Oak (*Q. velutina*).

Spanish Oak (*Q. falcata*).

Rock Elm (*Ulmus racemosa*).

Slippery Elm (*Ulmus fulva*).

Winged Elm (*Ulmus alata*).

Hackberry (*Celtis occidentalis*).

Mulberry (*Morus rubra*).

Cucumber Tree (*Magnolia acuminata*).

Umbrella Tree, Eklwood (*Magnolia tripetala*). Common.

Great-leaved Magnolia (*Magnolia macrophylla*).

Tulip Poplar (*Liriodendron tulipifera*). Common.

Papaw (*Asimina triloba*). Common.

Sweet Gum (*Liquidambar styraciflua*). Occasional.

Sycamore (*Platanus occidentalis*).

Red Haw (Cratægus sp.)

Blackberry (*Rubus sp.*) Common.

Red Bud (*Cercis canadensis*).

Black Locust (*Robinia pseudacacia*).

Tree of Heaven (*Ailanthus glandulosus*).

Dwarf Sumach (*Rhus copallina*).

Holly (*Ilex opaca*).

Dahoon Holly (*Ilex cassine*).

Strawberry Bush (*Euonymus americanus*).
Sugar Maple (*Acer saccharum*).
Red Maple (*Acer rubrum*).
Box Elder (*Acer negundo*).
Sweet Buckeye (*Aesculus octandra*).
Muscadine Grape (*Vitis rotundifolia*). Corbin, Horse Creek.
Frost Grape (Vitis sp.)
Stewartia pentagyna. Clear Creek.
Dogwood (*Cornus florida*)).
Kinnikinnik (*Cornus amomum*).
Great Laurel (*Rhododendron maximum*).
Mountain Laurel (*Kalmia latifolia*).
Sorrel Tree (*Oxydendrum arboreum*).
Checkerberry (*Gaultheria procumbens*).
Buttonbush (*Cephalanthus occidentalis*).

The woody growth of all sorts is being cleared away rapidly, and merchantable timber will not last many years longer. It is important on many accounts that the State bestir itself soon to the end that its young forest growth may not also be destroyed.

BACTERIA.

I did not take a compound microscope with me, and so could do little with the microscopic organisms. No doubt the waters would furnish a rich field of study in this line. The suggestion sometimes made that something of this sort in drinking water is responsible for pellagra led me to look at springs used by pellagrins with some interest. At the Roark cottage at Cary the surface of the ground sloped toward the creek, and at the bottom of this slope a hundred feet from the house and perhaps twenty-five from the edge of Straight Creek is the spring. It is badly located with reference to the house, and the flow from it is sluggish. From its situation and character one would expect people using it to suffer from bowel troubles as the very least of its ill effects. A sample of this water was taken October 23, in a sterile bottle, and brought to Lexington with me. The

results of tests made from it in the laboratory are given below, and confirm the impression received from an examination of the spring itself. Such water may not have anything to do with pellagra, yet pellagrins more than others should avoid any possible evil that may lurk in bad drinking water.

Sample No. 1161.—At twenty-four hours it gave 30,600 colonies of bacteria per cubic centimeter; at forty-eight hours it gave 41,000 colonies per cubic centimeter. The dextrose fermentation test gave 35 per cent. gas at the end of the first day; 67 per cent. at the end of the second. The litmus-lactose, acid-lactose, neutral red and acid agar tests each gave positive results. The lactose-bile test gave 25 per cent. gas.

The water of the streams is of course badly polluted with sewage in and below towns. In the mining camps practically all sewage is received sooner or later by the small creeks. In summer especially when the flow is not great the water must be exceedingly dangerous for drinking. Certainly it ought always to be boiled before using it for this purpose.

THE CONDITION OF THE CORN CROP ALONG THE STREAMS.

Corn grows well on the bottom lands along the mountain streams of Bell and adjoining counties. It appeared to me quite as good as that grown elsewhere in the State. Like corn grown in other parts of Kentucky, it was in some fields badly infested with the corn worm (*Chloridea obsoleta*). The injury done by the insect, even when slight, is generally followed by an invasion of molds, and thus often more harm results from the opening it makes in the husks than from the amount of grain it destroys. Corn brought home with me showed on some of the kernels at the tip of an ear a pink mold, and on the husks dusky blotches, appearing on the inner surface as brown spots with the tissues somewhat elevated and disturbed. The pink fungus appears to be the same as one observed on corn at Lexington and elsewhere in Kentucky. It gets to the kernels only by way of burrows

made by the corn worm, and would thus probably be controlled by preventing the injuries of the insect.

The only other fungus observed on this corn is a dull green mold which with age becomes brownish-black. Cultures were made from this corn October 19, 1911, on Soy bean agar. A Fusarium was obtained in a dense cottony white growth, completely covering the slanted surface and bearing numerous conidia. The pink fungus of this corn did not grow, but has been isolated from corn received since from the same locality. The green fungus grew readily in gelatine and is a species of Aspergillus; I think it only attacks kernels that have been injured by other agencies. It is generally present on the gnawed kernels left by the corn worm at the upper end of the ear.

Corn sent me from London, Ky., December 13, 1911, by Mr. B. F. Johnson, is in about the same condition as that observed earlier at Corbin and brought home with me. The injury by the corn worm, though slight, is evident at the tips of every one of the six ears in the lot, and accompanying it is the pink growth on some of the kernels. The cobs of these ears are mostly sound, though one is affected with some fungus and shows a purple discoloration about the margins of the pithy center. Some kernels on three of these ears have germinated, and indicate that the corn was too damp at some time, probably after being shocked.

Another lot of six ears sent me December 14, 1911, by O. W. Stamper, of Corbin, shows the same prevalence of slight injury by the corn worm, every one of the six being affected. Three of them have sound cobs, but show scattered pink kernels, sometimes broken and crumbling.

A large ear of this lot with thin, sharp-edged seeds shows scattered brown discolored kernels, and when broken a purple discoloration extending to the center of the cob. I take this to be the work of a Fusarium, which in cultures on sterile rice produces a cottony growth and a purple discoloration like that seen in the cobs. It appears to be associated with the pink fungus and also with Diplodia in some samples.

The fifth and sixth ears received with the above and still in their husks are utterly destroyed by the fungus *Diplodia zeæ*, the kernels being brown and dead, the cobs spongy and brown from base to tip, in one with a whitish mycelium between the husks and a sooty discoloration on their outer surfaces near the tip. Both are injured by the corn worm, but the Diplodia evidently came up from the shank.

These sample give a good idea of the condition of moldy corn everywhere in Kentucky. Since pellagra has been under discussion the writer has examined such corn from a good many counties representing all parts of the State. From the mountain section samples have been examined from Letcher, Knott, Laurel, Bell, Wayne and Whitley. Other samples represent the central and western sections, coming, some of them from Fayette, Kenton, Jefferson, Warren, Taylor, McCracken and Fulton. They have not been fully studied, but examinations and cultures indicate the general distribution in Kentucky, from Letcher County to Fulton, of the fungus *Diplodia zeæ*, of the pink fungus and of a Fusarium producing a white cottony growth, and of the green Aspergillus. The distribution of the corn ear worm coincides with that of the latter fungus and with that of the pink mold, these fungi being most common where the worm does its greatest mischief. Accordingly, Jefferson County, because of the large quantities of early table corn grown there, is badly infested with both worms and molds. The *Diplodia zeæ* is not dependent on the openings made by the worm, generally invading ears by way of the shank. Its distribution is a little more general and its presence more constant on corn of all sorts, as a result.

For a number of years the writer has made a point of inspecting the exhibits of corn at local and state fairs, both with reference to the adaptability of varieties and with regard to their susceptibility to disease. Corn infested with the pink mold, and sometimes with Diplodia, has at times been seen in these exhibits, and in some instances judges have assigned the blue ribbon, and even the purple ribbon,

to entries on which the fungi were apparent. The time is coming, I believe, wnen such corn will be barred from exhibits, and no good corn breeder will think of showing diseased corn, any more than a breeder of Jersey cattle would think of competing for premiums with animals affected with tuberculosis. Seed corn is worth thinking about by farmers and seed corn men as one of the agencies by which molds may be scattered about the State.

Seed infested with molds, even slightly, should not be planted. As a precaution against introducing the molds it may be well to treat suspected corn with formalin or blue stone in the manner customary for wheat.

Judging from statements coming to me from farmers I should think the percentage of loss this year to the crop alone would not fall below ten per cent., which means a loss to the State of about 10,000,000 bushels. Some farmers would, I have no doubt, place the percentage of loss much higher. One of my correspondents asserts that fifty per cent. of the crop is moldy in his county this year.

THE EFFECT OF MOLDY CORN ON STOCK.

That some of these fungi are capable of injuring stock is evident from complaints reaching the Station every year, and coming from farmers who have suffered loss of horses, cattle, hogs, or poultry. Correspondents writing this Fall have asserted that numerous cases of blind staggers have resulted from feeding such corn. Corn being fed to these animals have in some cases reached my hands, and bore the pink fungus and the Aspergillus. An ear of this sort has recently been handed me by Dr. Graham of the Station and was received by him from Shelby county, where stock has been dying. Diplodia fed to mice has been found to cause paralysis and ultimate death. Corn smut fed to animals in large quantities has been shown, on the contrary, to have no ill effect. Some recent claims have been put forward with reference to the effect of corn fungi on poultry, and it has been asserted that a disease presenting some of the symptoms of pellagra has been induced ex-

perimentally in fowls by feeding certain organisms cultivated on ground maize. Dr. C. C. Bass, for example, claims in the Southern Medical Journal for August, 1911, that a disease of chickens regarded by the Italians as pellagra is produced by feeding them moldy corn. The symptoms appear in summer, and especially in the young, which shed their feathers, and practically all die with blistered backs if turned out in the sun. Again, in the American Medical Journal for November 18, 1911, the same writer claims to have himself produced in poultry a disease resembling pellagra, by feeding spoiled maize inoculated with a "specific Bacterium."

But while Dr. Bass may prove to be on the right track, it is well to note that physicians who have studied the subject, hold widely divergent opinions as to the relation of corn to pellagra*, and some very emphatic statements have been published with reference to several different agencies, not all of which can have to do with the disease.

Treatment for Corn Mold.—This bulletin is in the nature of a preliminary survey, and the corn ear fungi must be dealt with briefly, the publication of some details and results of cultures being reserved for a later date. But it may be said that the molding of corn is greatly encouraged by conditions over which the farmer has some control.

In the first place the fungus Diplodia remains in the fields and continues developing there in the grain and stalks long after the crop is cut. Old stalks lying about fields may continue to produce the spores of the fungus for several seasons, and thus infect growing crops. Where mold is prevalent, and especially after a season favorable to mold, it is important to get the crop, stalks and all, off the land and disposed of as soon as practicable. The corn should be husked at once when mature and put in a dry cool crib. The fodder should be either fed or burned.

* In an article entitled "Pellagra, Its Etiology, Pathology, Diagnosis and Treatment", written by Dr. C. W. G. Rohrer, Medical Assistant to the State Board of Health, of Maryland, and published in the Transactions of the National Conference on pellagra, in 1910, it is positively stated that the disease is due to the fungus *Aspergillus fumigatus*, and that the author has observed this fungus growing on corn, peas, beans and buckwheat, when "beaten to the ground by heavy rains.

When kernels of corn are completely invaded by mold the germ is killed, and common sense will teach that such corn is not to be planted. But it sometimes happens that ears bear only a little of the fungi and these are the ones most likely to be fed, or used for planting. As suggested under another head moldy corn should be avoided as far as practicable for such purposes, and when suspected of bearing the fungi, seed corn may well be treated with formalin, or bluestone, as a precaution against conveying mold fungi to the corn field.

Judges of corn exhibits can help to rid the State of these molds by discouraging the exhibition of diseased corn.

Unfortunately it is not possible to say at present whether or not the spores remain alive in manure. The spores of the smut fungus of corn are, it will be remembered, capable of living in manure, and are believed to be distributed thus to corn fields. But in the absence of definite experimental data with reference to the ear molds, it would be well to use manure from moldy corn fodder only on land planted in some other crop than corn.

And because of the disposition of the fungus to remain alive in the fields and on the corn stalks, it is always best to practice rotation of corn with other crops not subject to injury.

The fungus Diplodia is believed to be restricted to maize. It is widely scattered in the United States, and occurs in Italy where pellagra is prevalent. Of the distribution of the species of Fusarium it is impossible to speak positively at present, though they are known to be common on corn over a large part, and perhaps all, of our territory.

DR. SAMBON'S THEORY AS PRESENTED IN HIS PUBLISHED PAPERS.

Since writing the above I have had an opportunity to see the articles published by Dr. Louis W. Sambon, in the Journal of Tropical Medicine and Hygiene, in the library of the Surgeon General of the United States Army at Wash-

ington. I find that Dr. Sambon has weighed the evidence for and against his idea with a good deal of care. He went over the territory in Italy where pellagra is most prevalent, studying the disease, and found Simulium larvæ or pupæ, in the streams wherever he found pellagra. He states his views in concise form as follows: (Vol. XIII. Sep. 15, 1910, p. 271.)

"So far I have been able to establish:

(1) That pellagra is not due to the eating of maize, either sound or deteriorated, as hitherto almost universally believed.

(2) That it has a striking, peculiar and well defined topographical distribution.

(3) That its endemic foci or 'stations' have remained exactly the same in many places for at least a century.

(4) That its stations are closely associated with streams of running water.

(5) That a minute blood-sucking fly of the genus Simulium is, in all probability, the agent by which pellagra is conveyed."

Dr. Sambon admits that he has made no experiments testing his theory, but thinks the facts he has brought together are sufficiently powerful as evidence to render it almost a certainty.

After enumerating fully the various theories held in Italy as to the origin of pellagra, Dr. Sambon declares that there is no foundation for the belief that pellagra broke out on the introduction of maize into Europe, and that the topographical distribution of pellagra does not coincide either with the distribution of maize, its cultivation, or its consumption; and, further, that all preventive means based on the maize theory have failed.

Maize appears to have been used in Italy as early as 1554, by the records, and was certainly used in this country much earlier, in fact the early explorers make frequent mention of maize used as food by Indians, and often so badly prepared as to be inedible to the white man. Samuel de Champlain in his narrative of exploration written in 1613,

says, after describing different methods by which the Indians prepare maize:

"They have another way of eating Indian corn. To prepare it they take ears of it and put them in the water under the mud, leaving them two or three months in this state until they think it decayed. Then they take it out and boil it with meat or fish; then eat it. They also roast it and it is better so than boiled. There is nothing that smells so bad as this corn when it comes out of the water all muddy." * * *

In addition to the evidence collected by Dr. Sambon, showing the presence of species of Simulium wherever pellagra occurs, he gives several other reasons for believing the disease to be insect borne. In the first place, the alternate periods of latency and activity in pellagra correspond in a way with malaria produced by the protozoan parasite, *Plasmodium vivax*, a parasite known to be conveyed by mosquitoes of the genus Anopheles. Its symptoms, course, duration and characteristic lesions are, he says, like those of parasitic diseases. "It is insect borne because not directly contagious; because neither food nor water account for its peculiar epidemiology." It is limited to rural districts only, he asserts, towns and villages almost invariably escaping.

In Kentucky, it must be said, the disease is rural in general, but puzzling instances are known to me of well-to-do people becoming affected while living in the heart of a city. Cases believed to have originated in asylums also appear to contradict the sand fly theory. Yet it should in fairness be added that the circumstances under which these cases have appeared are not fully known, and more complete knowledge of the disease at its inception in each case might bring all of the apparent exceptions into agreement with the idea so well presented and supported by Dr. Sambon.

ACKNOWLEDGMENTS.

In concluding, it is appropriate that acknowledgment be made of courtesies extended to me by physicians at Corbin, Pineville and Cary. To Doctor M. H. Steele and

Doctor Parker of Corbin; to Doctor J. G. Foley of Pineville, and to Doctor J. H. Hendren, of Cary, I am indebted for information as to cases of pellagra in their charge. Drs. Steele and Hendren were so good as to accompany me to points of special interest, at the cost to them, I felt sure, of valuable time. Mr. Robert Asher, of Pineville, provided me with photographs relative to one of the cases in charge of Doctor Foley. To Doctor J. N. McCormack, Secretary of the State Board of Health, I am indebted for addresses of physicians having charge of cases, information which proved of much value by saving time in locating places at which observations and collections could most profitably be made. Doctor F. H. Clark, of Lexington, has shown at all times a keen interest in the matter, and has secured for me a list of cases in the Eastern Kentucky Asylum. Each of of these gentlemen has my sincere thanks for his kindness.

All drawings illustrating the bulletin are original, and were made under my direction by Mr. Matthews of this Division. Excepting those of the buffalo gnat and a few others, they were made from material collected about Corbin and Pineville. The photographs reproduced are also new, and were made inpart by Mr. Vaughn of the Division, and in part by myself.

CORRIGENDA.

Page 17, first paragraph, for (*0.056 inch*) read (*0.16 inch*) and add: *greatest width, 1.6 mm. (0.064 inch); greatest depth, 1. 4 mm. (0.056 inch).*

Page 26, fourth paragraph, for *columbateczensis* read *columbatczensis.*

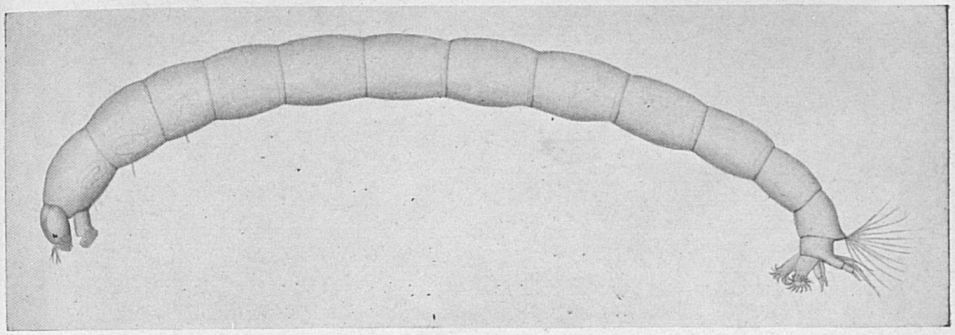


Fig. 25.—Larva of Orthocladius sp. (No. 3) from Left Fork of Straight Creek, Cary, Ky. x 22.

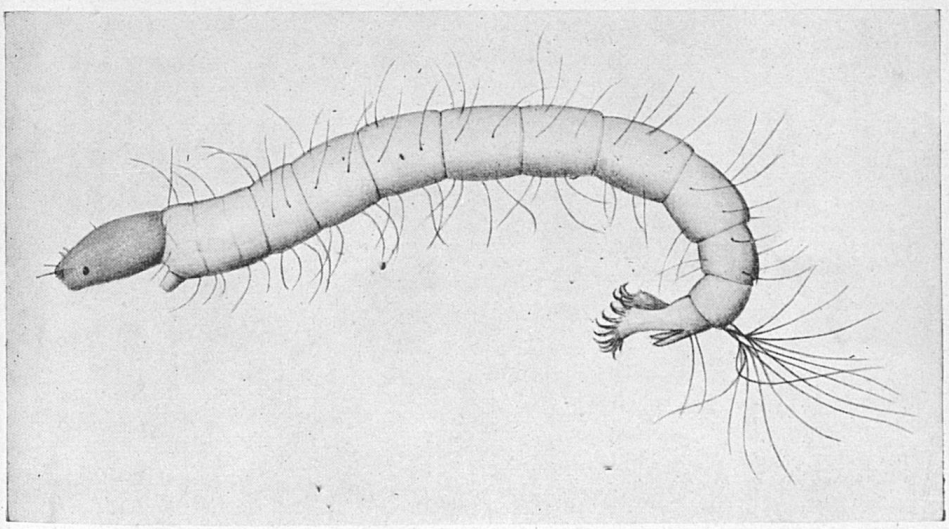


Fig. 26.—Larva of Ablabesmya (No. 4) Left Fork of Straight Creek, Cary, Ky. x 21.

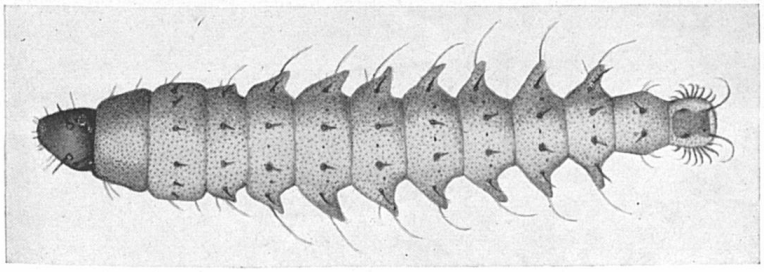


Fig. 27.—Fly Larva (undetermined) from Left Fork of Straight Creek, with Simulium larvæ. x 20.

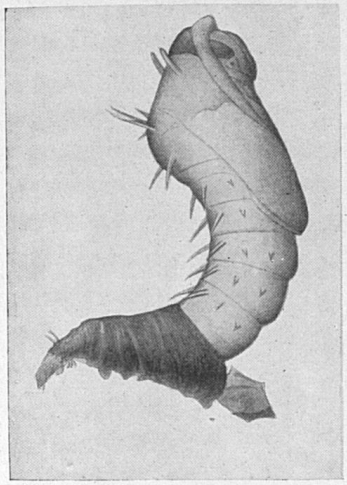


Fig. 28.—Pupa of preceding species (Fig. 27). x 20.

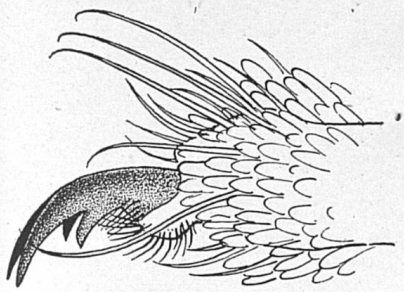


Fig. 29.—Tarsal claw of fore-leg adult female yellow fever mosquito.

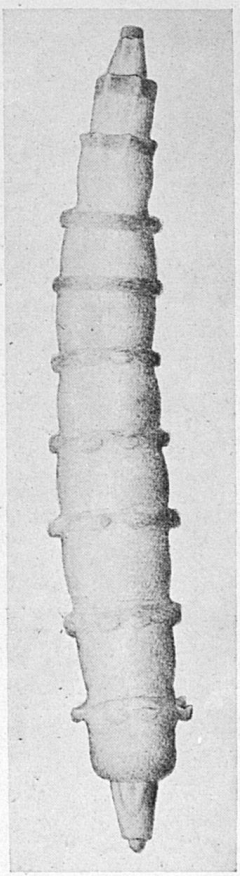


Fig. 31.—Larva of gad fly from Left Fork of Straight Creek, near Roark Cottage. x 4½.

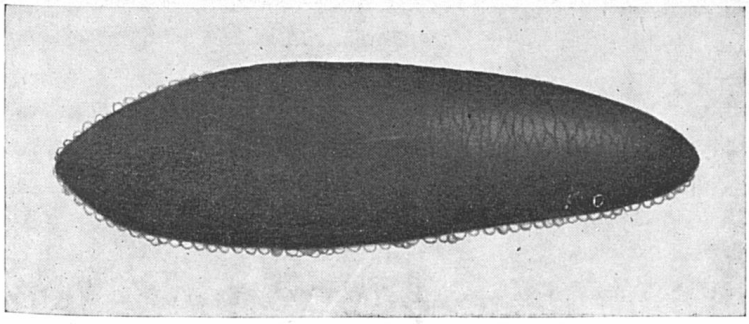


Fig. 30.—Egg of yellow fever mosquito greatly magnified. x 100.

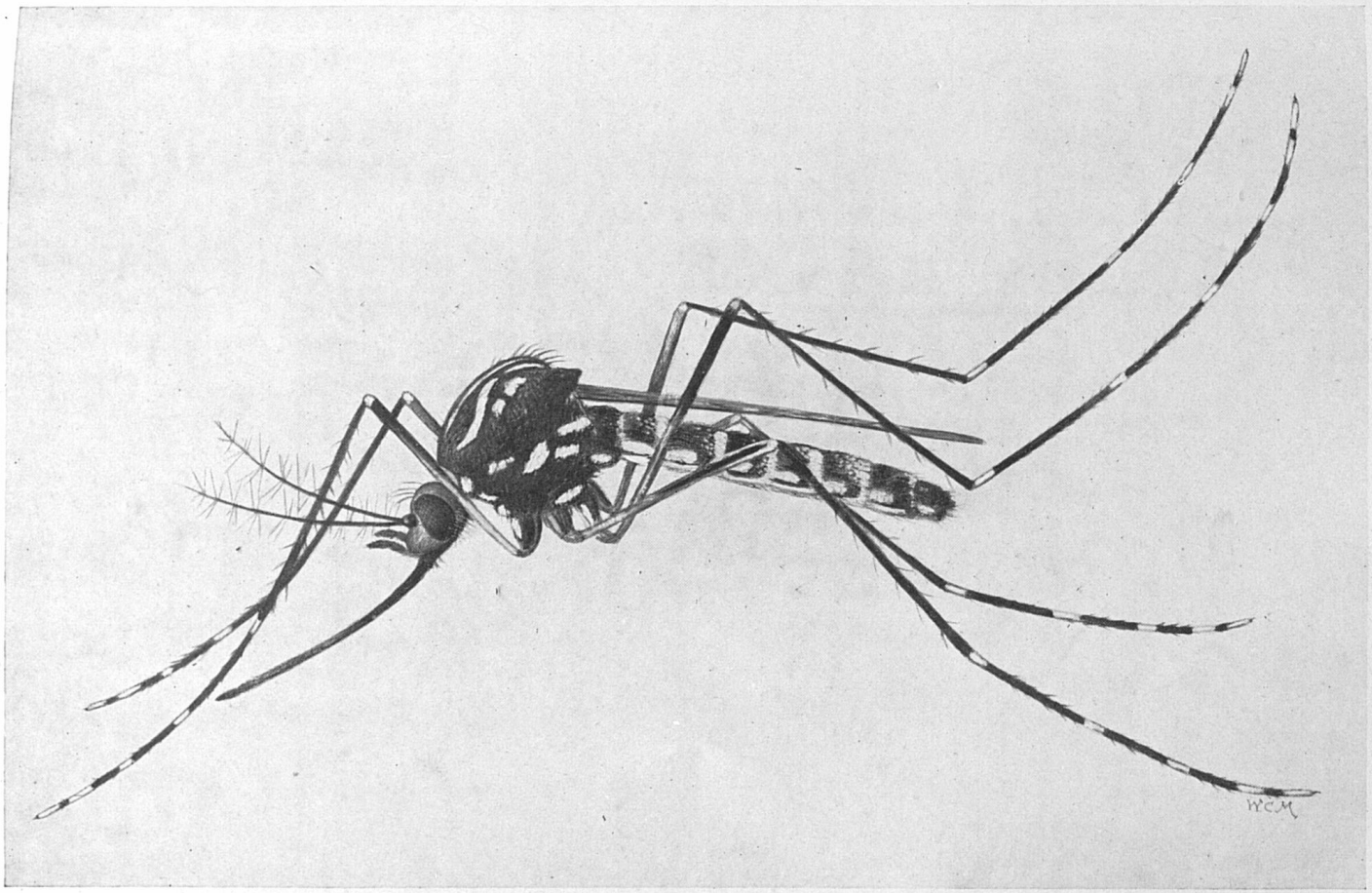


Fig. 32.—Side view of female yellow fever mosquito. x 13.

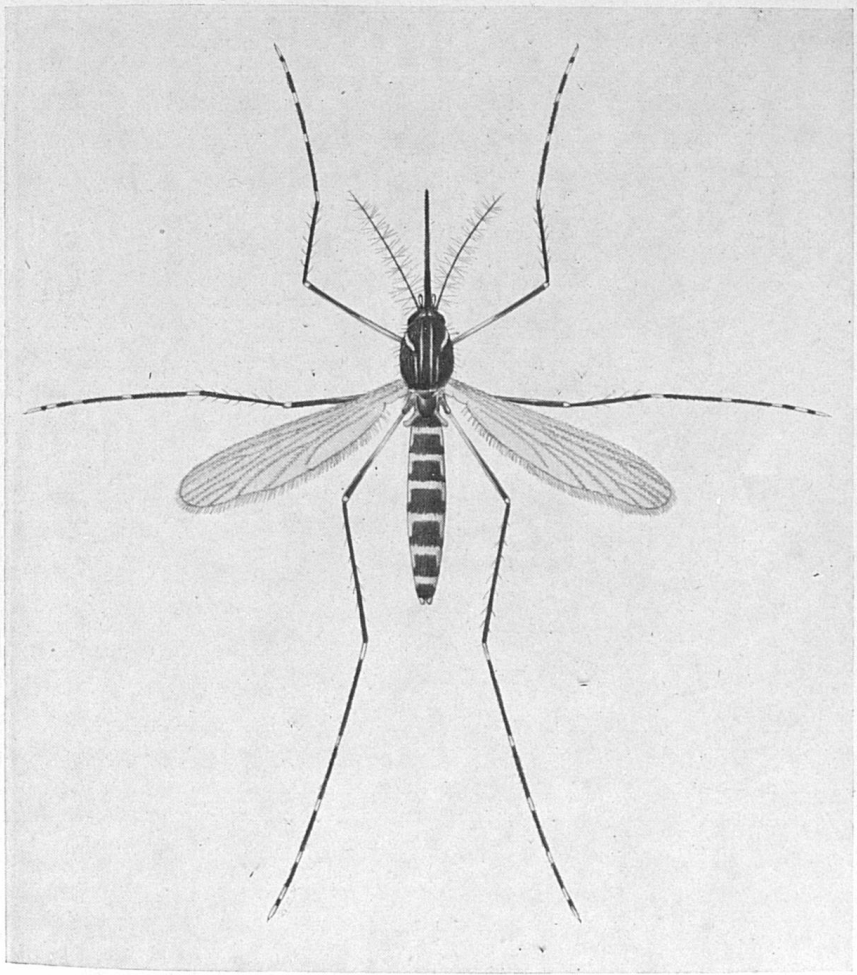


Fig. 33.—Dorsal view of female yellow fever mosquito. x 7.

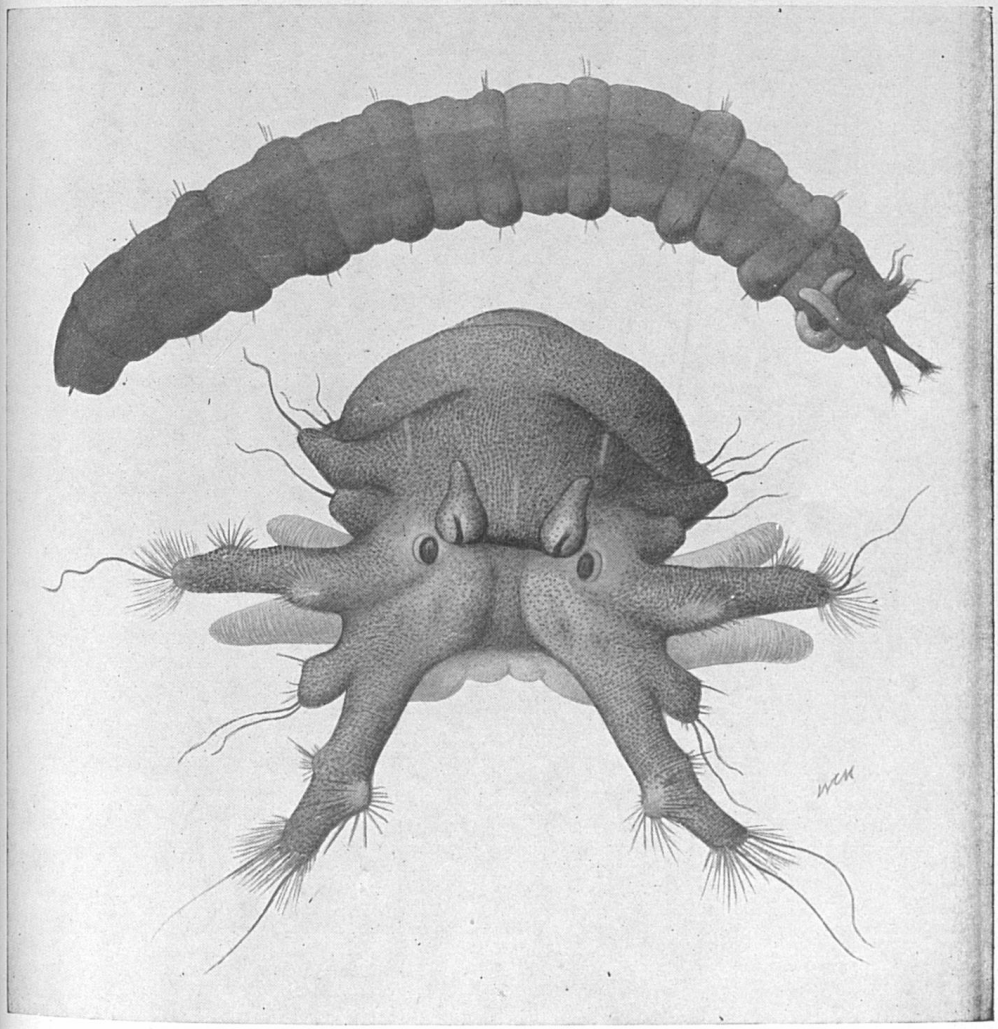


Fig. 34.—Crane fly larva x 5½ (family Tipulidæ) from Left Fork of Straight Creek. Lower figure shows hind end of body magnified to show appendages.

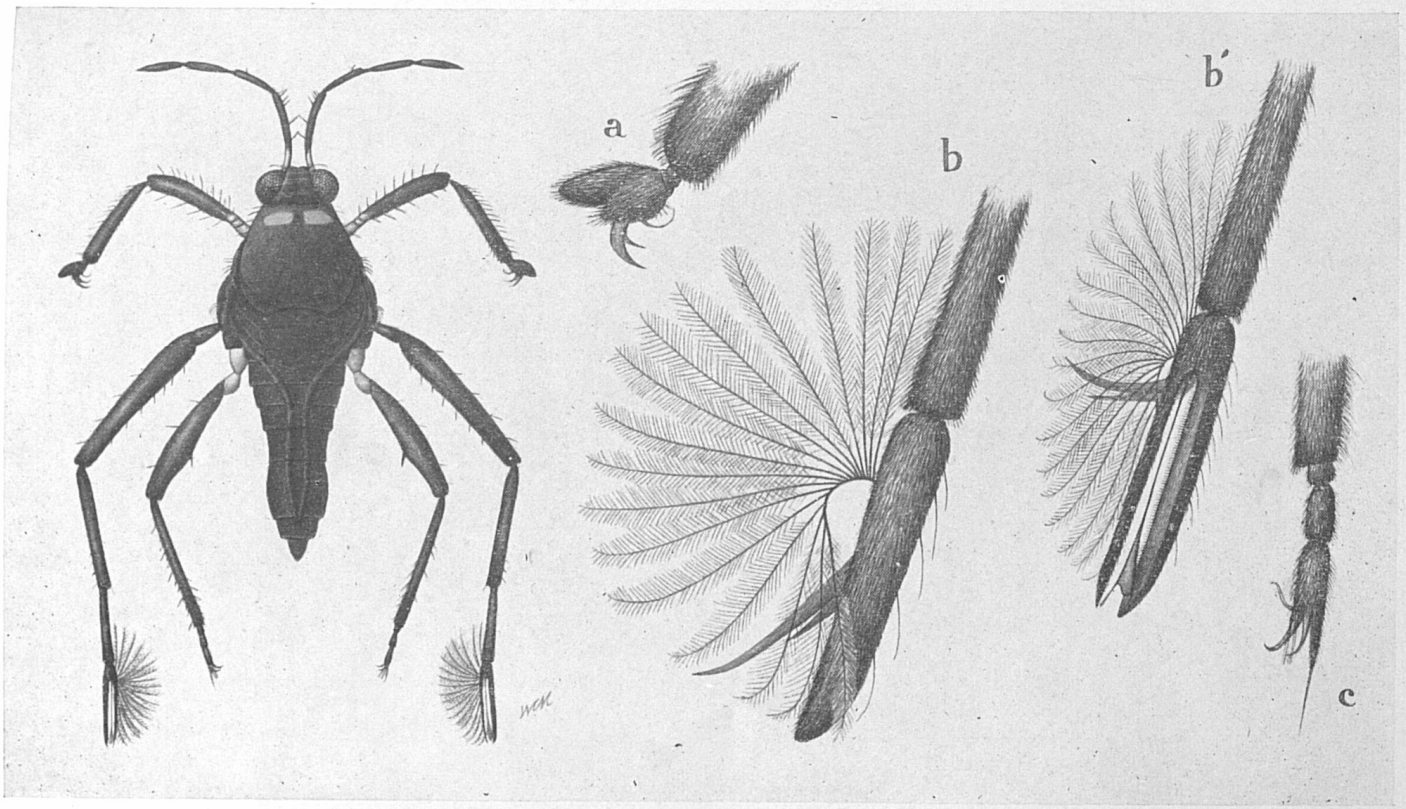


Fig. 35.—Water strider *Rhagovedia obesa*, x 14, from Straight Creek and Cumberland River. *a*, anterior tarsus; *b*, tarsus of middle leg; *b'*, same turned to show the split segment; *c*, hind tarsus.

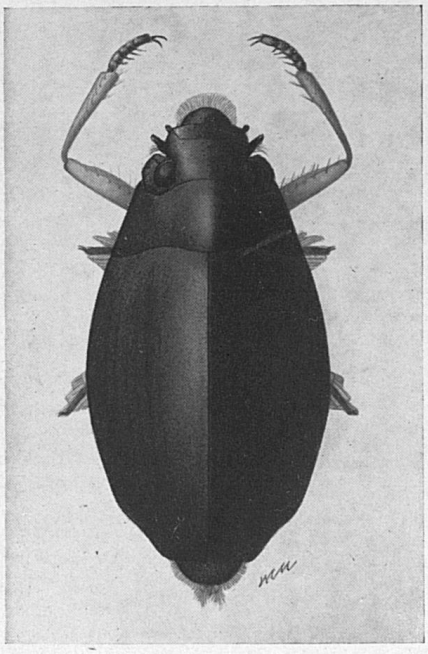


Fig 36.—Whirligig beetle (*Dineutes discolor*) from the creeks and rivers. x 4½.

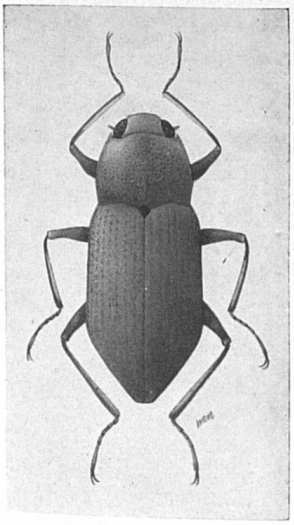


Fig. 37.—Spider beetle, *Dryops lithophilus*. x 8.

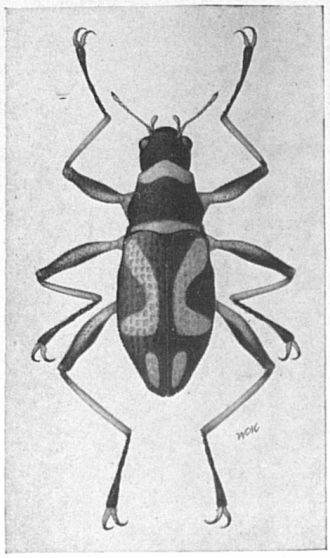


Fig. 38.—Spider beetle, *Ancyronyx variegatus*. x 11.

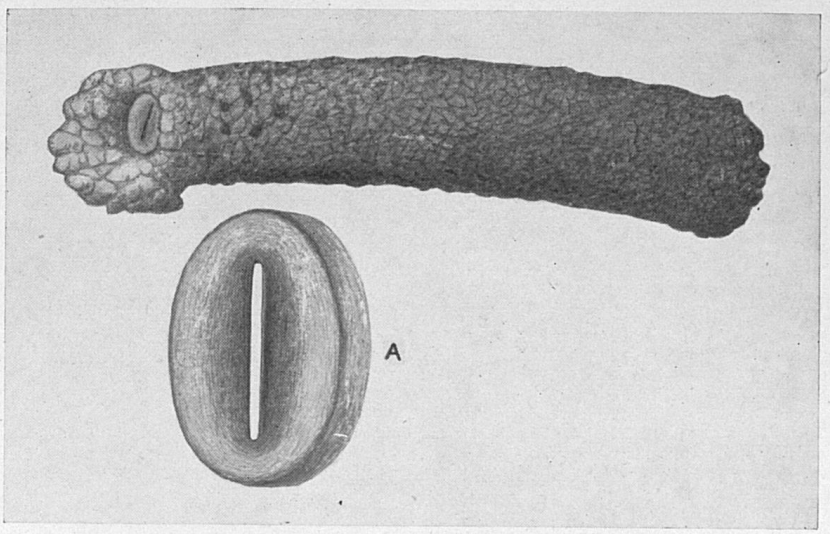


Fig. 39.—Case fly No. 1. x 6½. Disc closing case shown more enlarged at *A*.

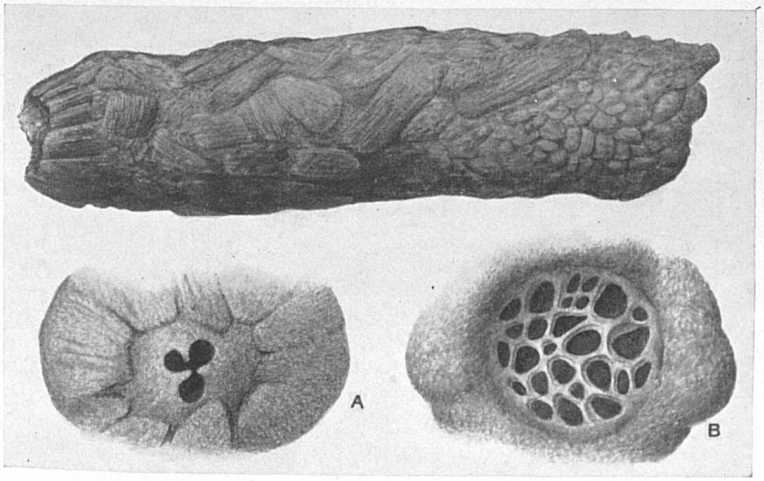


Fig. 40.—Case fly No. 2. x 5. Discs closing case when pupa is formed shown at *A* and *B*, more highly magnified.

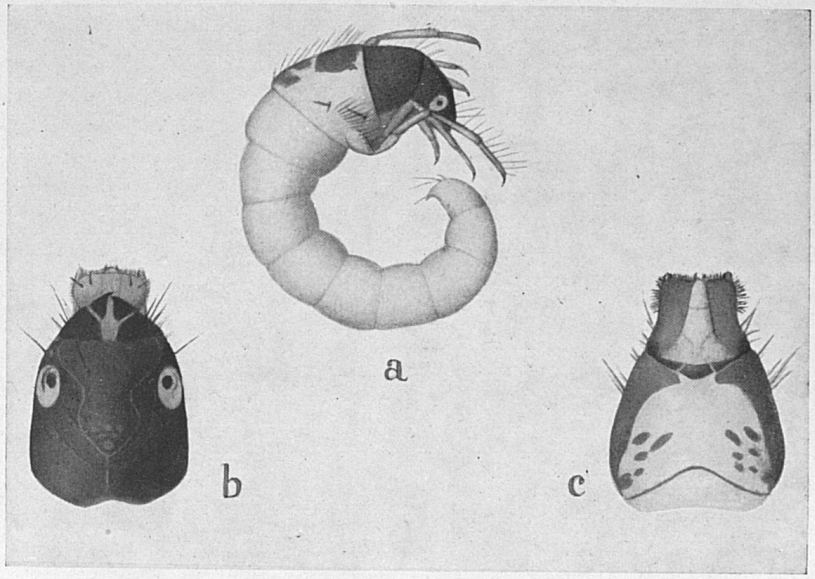


Fig. 41.—Helicopsyche sp. (No. 3.) *a*, larva removed from case x 11½ (delicate respiratory filaments not shown); *b*, dorsal view of head; *c*, ventral view of head.

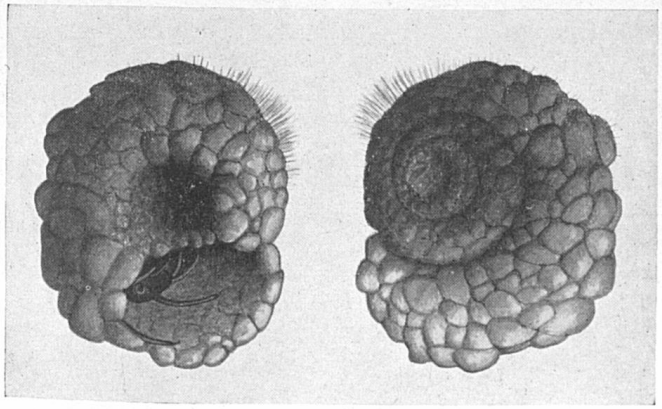


Fig. 42.--Spiral case of larva shown under figure 41. x 7½.

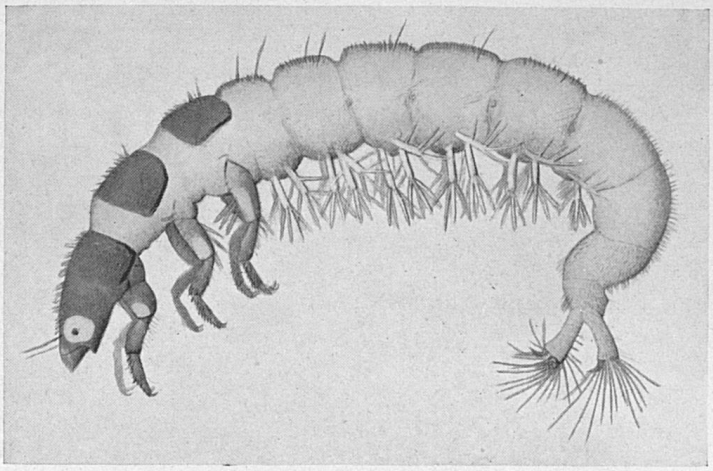


Fig. 43.—Larva of Hydropsyche sp. a common species in all the streams, living among gravel under rocks. x 17.

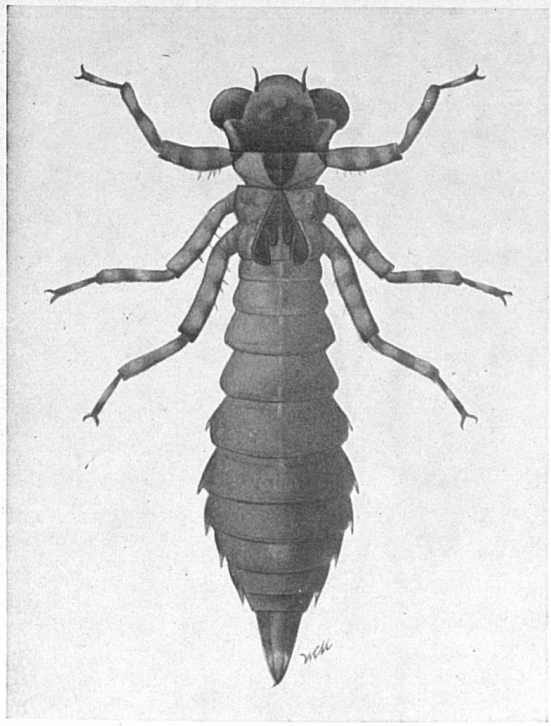


Fig. 44.—Dragon fly larva, Left Fork Straight Creek. x 4½.

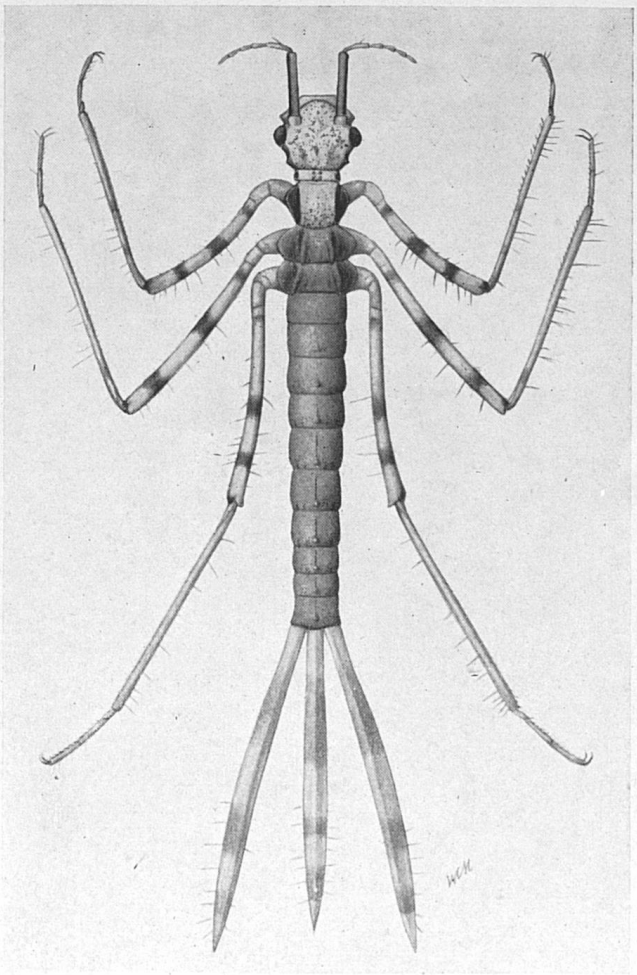


Fig. 45.—Damsel fly larva (*Calopteryx maculata*) Clear Creek, Pineville. x 9.

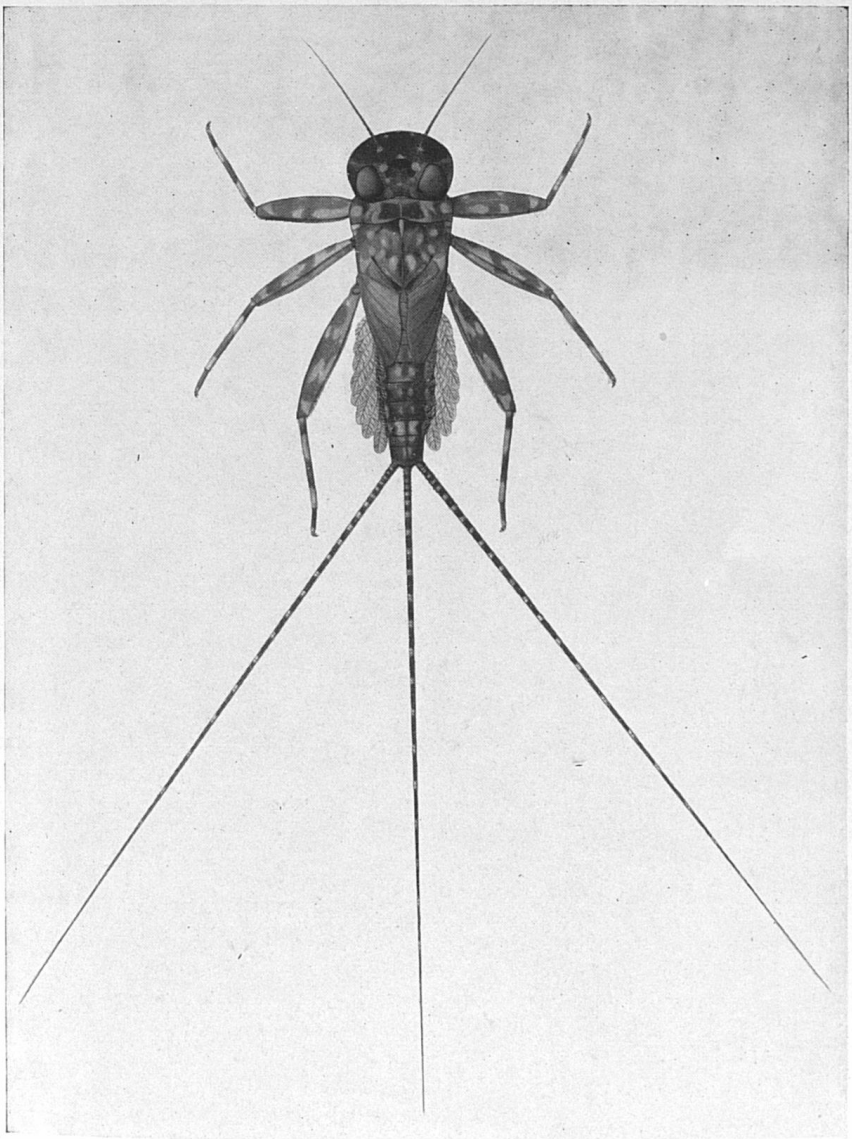


Fig. 46.—May fly larva (No. 2) common under stones in all the streams. x 4.

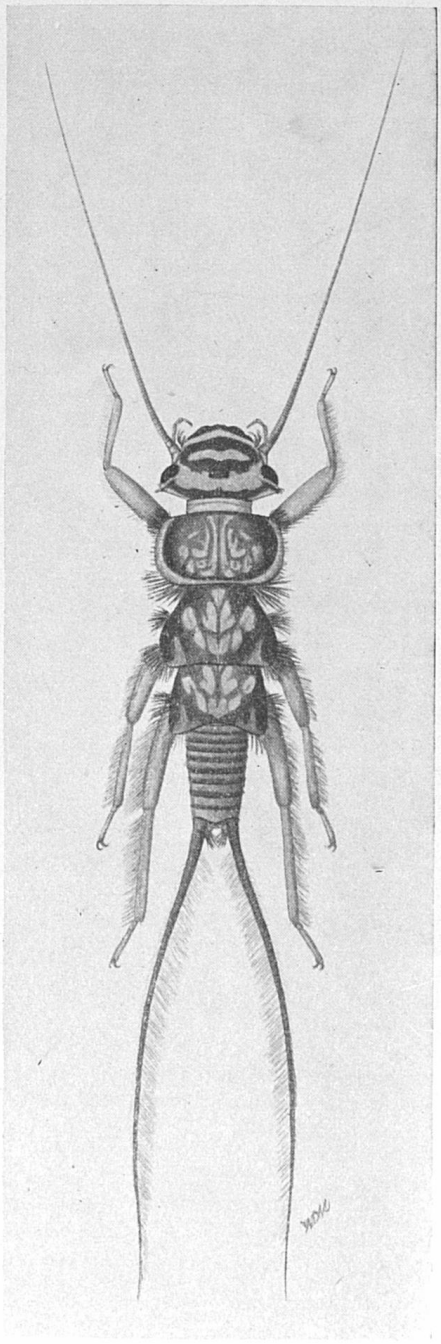


Fig. 47.—A common stone-fly larva (No. 1) in the creeks and rivers. x 4.

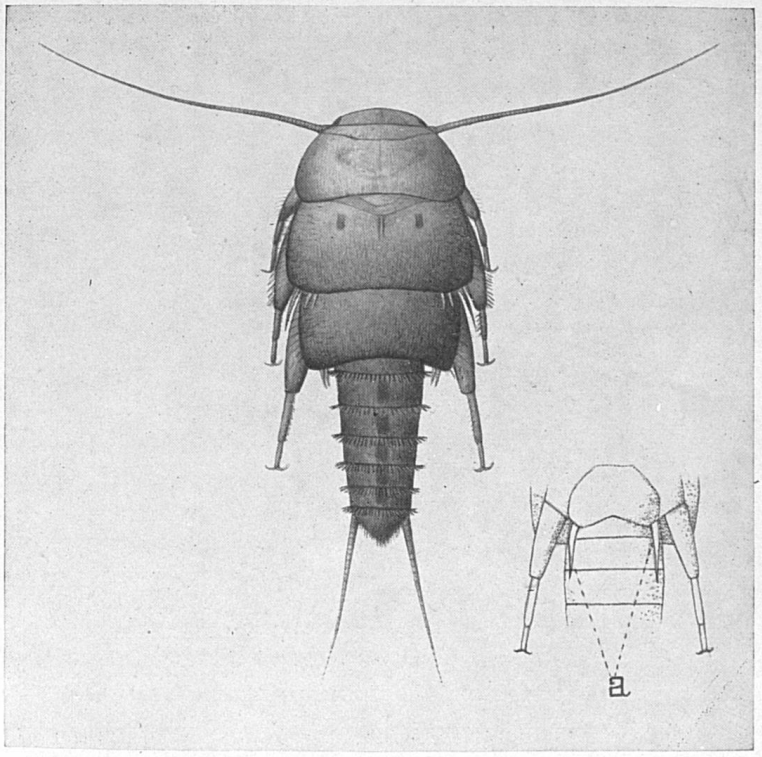


Fig. 48.—An undetermined stone-fly larva (No. 3) from spring-fed rill flowing into Straight Greek, near Cary, Ky. x 8.

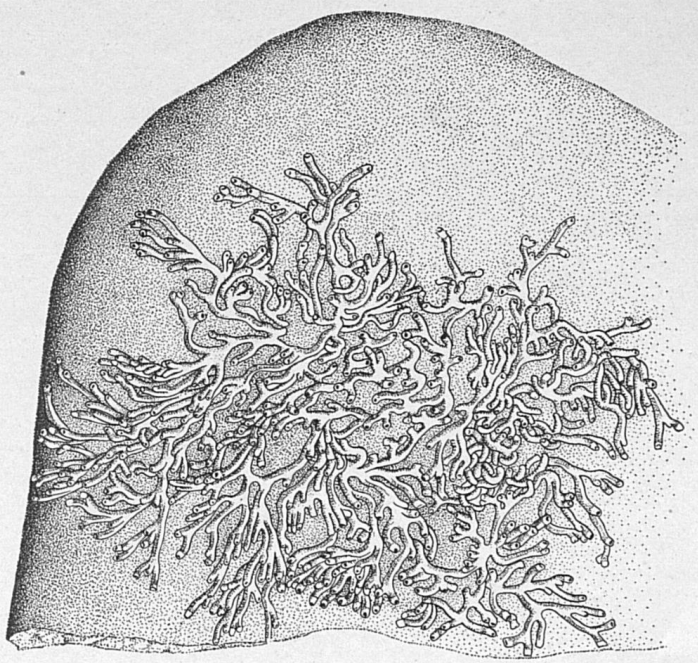


Fig. 49.—Colony of a Polyzoan, Plumatella sp. as it grows on the under sides of rocks in Cumberland River and other Kentucky streams. x 2.

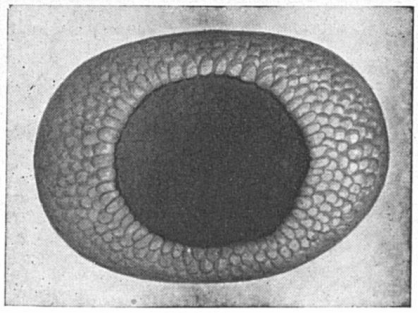


Fig. 50.—Statoblast or winter bud of the fresh water polyzoan Plumatella. x 120. From Benson Creek, Frankfort, Ky., Sep. 14.

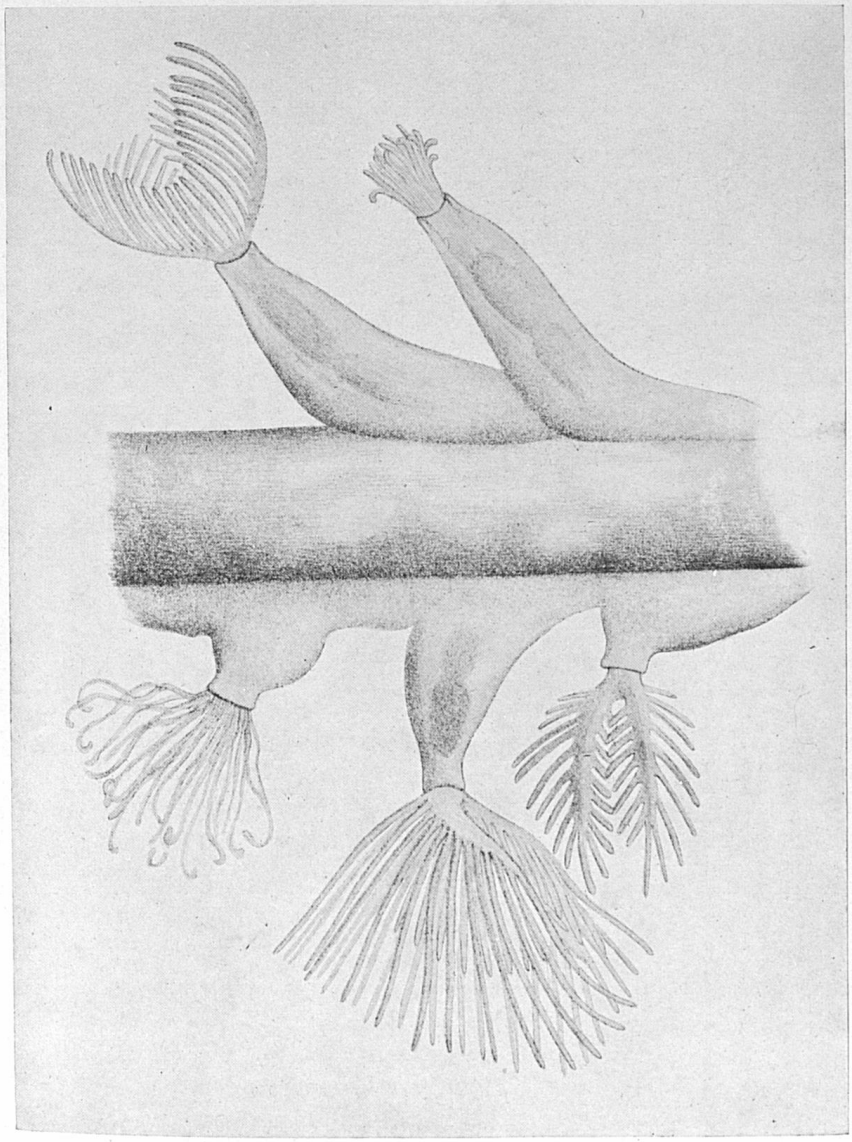


Fig. 51.—A few individuals with tentacles expanded of a species of polyzoan from a pond at Lexington. Greatly magnified.

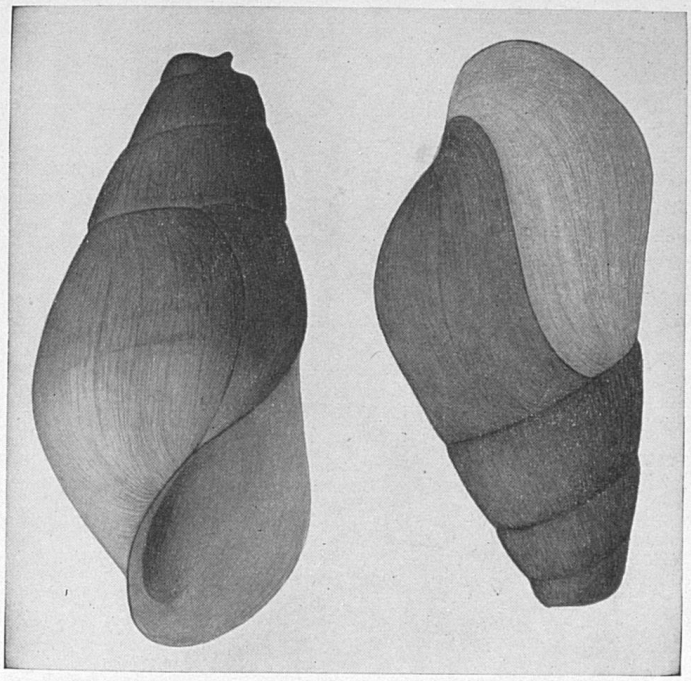


Fig. 52.—*Goniobosis brevispira*, the commonest snail of Cumberland River and Straight Creek. x 4.

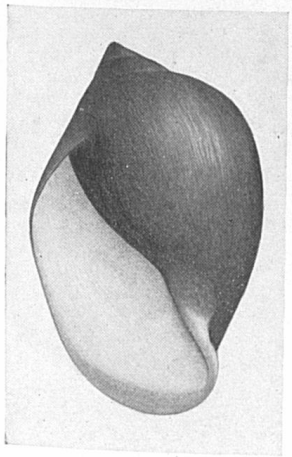


Fig. 53.—*Physa sayi*, from Straight Creek. x 4.

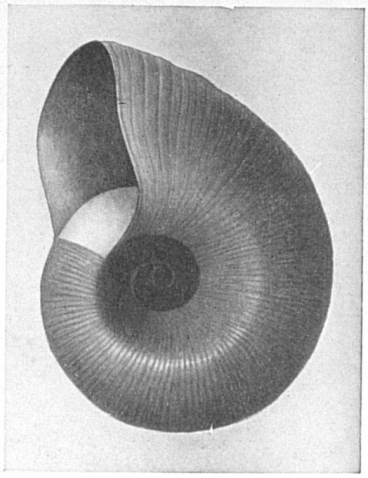


Fig. 54.—*Planorbis bicarinatus*, from Straight Creek. x 4.

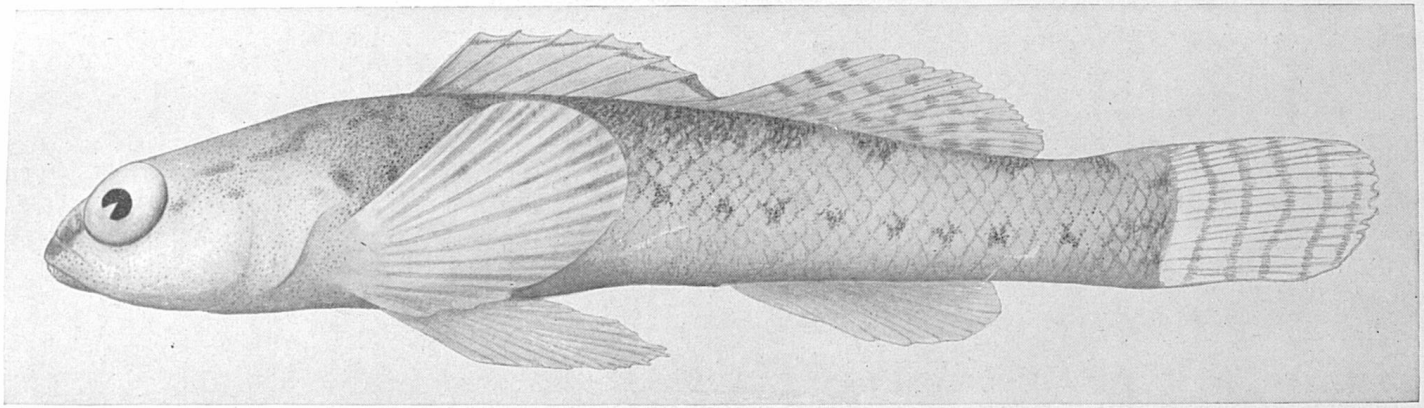


Fig. 55.—*Etheostoma obeyense*, from the rapids of Straight Creek in which Simulium larvæ were found. x 4.

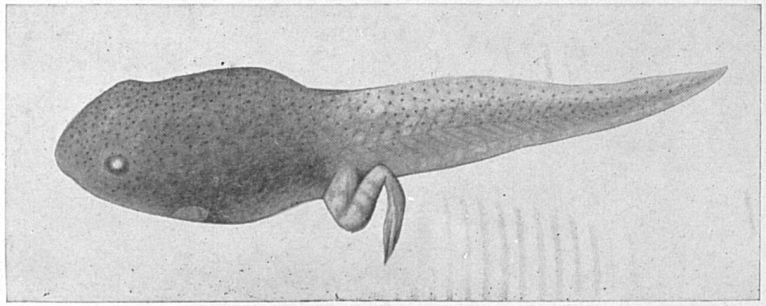


Fig. 56.—Tadpole of the spring frog, *Rana clamitans*, abundant in August in Straight Creek. x ⅓.



Fig. 57.—*A*, an ear of corn destroyed by the fungus, *Diplodia zeæ*, received from J. B. Walker, of Christian County. *B*, kernels twice enlarged, bearing black fruiting bodies (pycnidia) of *D. zeæ* about the germs, from Lexington. *C*, an ear with scating kernels affected with the pink fungus (*Trichothecium roseum*). A and C reduced in size; B, x 2.

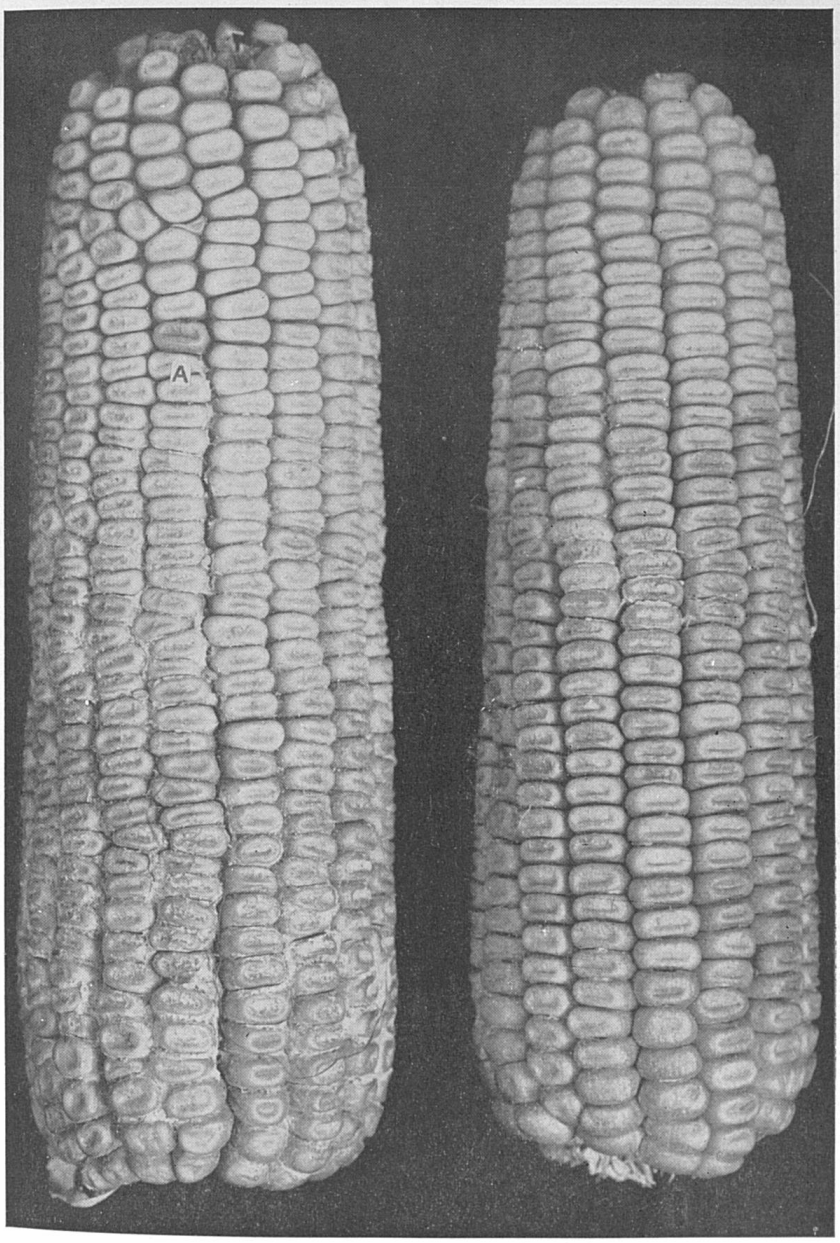


Fig. 58.—Ears of corn from Lexington, damaged by the fungus *Diplodia zeæ*, the basal parts and scattered kernels (as at A) killed and embrowned by the attack, the rest of the kernels appearing sound. A more dangerous condition than when the ears are completely invaded and destroyed, as at A, Fig. 57. Natural size.



Fig. 59.—Cottage on bank of the Left Fork of Straight Creek, near Cary, in which reside several cases of pellagra. The spring and washing kettles are located near A.



Fig. 60.—Looking to the left and down stream from point from which Fig. 59 was photographed. Simulium larvæ and pupæ were collected September 1 at A.

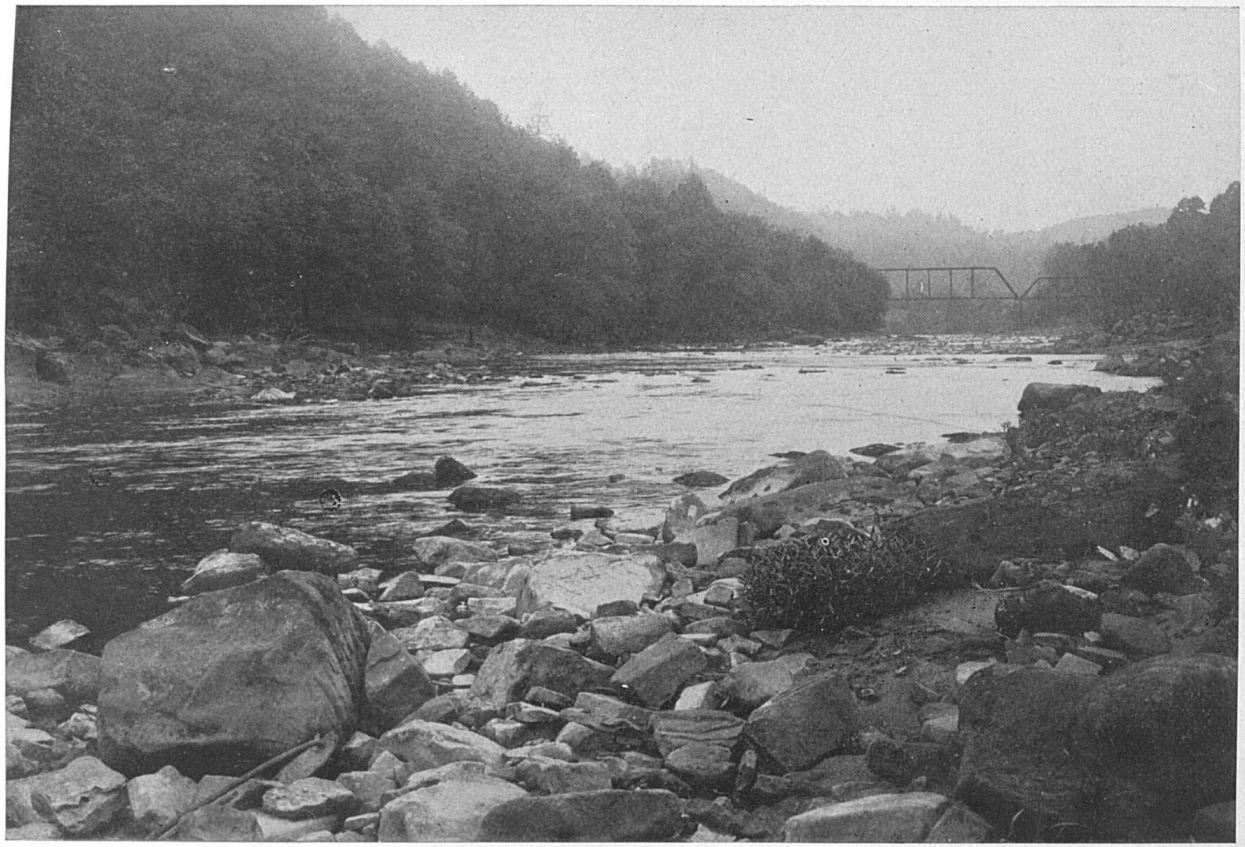


Fig. 61.—Rapids of Cumberland River near Pineville. Stmulium larvæ were collected among the rocks in August and September, 1911.

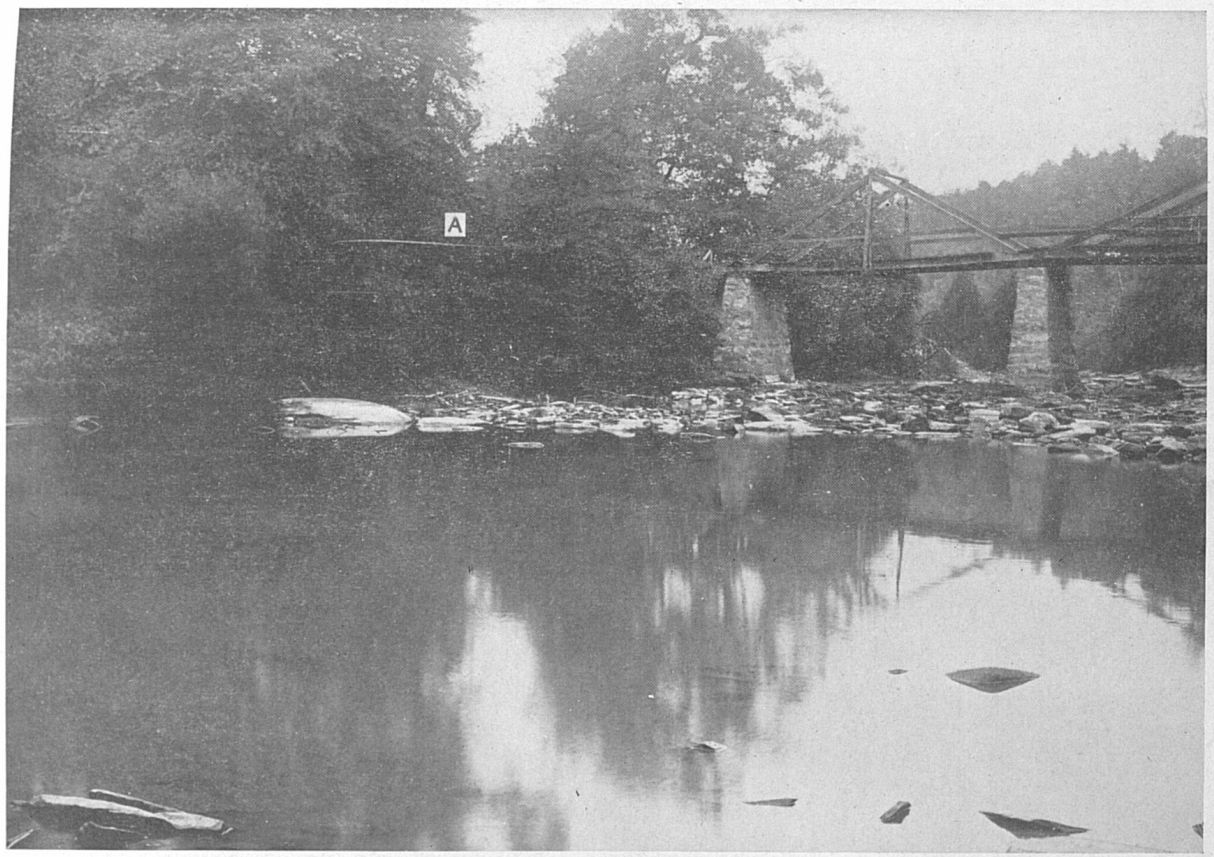


Fig. 62.—Laurel River near Corbin. A dwelling containing pellagrins is located near A, but is concealed by the trees.



Fig. 63.—Clear Creek, Pineville. An occupant of the cottage at A is affected with the disease.



Fig. 64.—A family in which are three pellagrins—the second, third and fifth, counting from the left.



Fig. 65.—Two of the cases represented in Fig. 64, not so much reduced. The skin lesions are best shown on the leg of the left figure.

Kentucky
Agricultural Experiment Station

OF THE

STATE UNIVERSITY

BULLETIN No. 160

Parturient Paresis (Milk Fever) and Eclampsia; and the Internal Secretion of the Mammae as a Factor in the Onset of Labor.

LEXINGTON, KENTUCKY,
Feb. 1, 1912.
81

KENTUCKY AGRICULTURAL EXPERIMENT STATION

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BULLETIN No. 160

PARTURIENT PARESIS (MILK FEVER), AND ECLAMPSIA.

Similarities Between These Two Diseases.

By Daniel J. Healy and Joseph H. Kastle.

In June, 1909, the attention of one of us, Healy, was called by Dr. M. A. Scovell, Director of the Kentucky Agricultural Experiment Station, to the condition known in Veterinary Medicine as parturient paresis, or milk fever. Dr. Scovell's intention was to have, if possible, the etiology of this condition definitely cleared up.

Owing to the press of other work, it was impossible to take up this problem until a year ago. As our studies progressed, the similarity between parturient paresis and that condition known in Human Medicine as eclampsia, became more and more evident, and it is the object of this paper to point out those observations upon which we base this similarity.

Parturient paresis, then, according to the best veterinary authorities, "is a nervous disorder which develops suddenly in heavy milkers after calving. It is characterized by loss of sense, of consciousness, of muscular control, by hypothermia or by hyperthermia, convulsions, coma and mellituria."(1)

Eclampsia, according to the best medical authorities, "is an acute toxaemia, occurring in the pregnant, parturient, or puerperal woman, and is usually characterized by clonic and tonic convulsions, loss of consciousness followed by more or less prolonged coma, and presenting characteristic lesions." (2)

(1) James Law, Veterinary Medicine, 1905.
(2) J. W. Williams, Obstetrics, 1908.

The following are the established facts in the etiology of parturient paresis:

The most important factor is parturition, and Hess states(1) that in 170 cases he did not observe it during, nor preceding labor, nor did he observe it later than 96 hours following labor.

Next in importance to parturition comes heavy milk production. It is a disease, not only of cows, but preëminently of individual cows that give the most abundant milk, and particularly at that age when they have reached their greatest productiveness. It is rare or unknown in other animals.

High feeding, high condition, drying up of the milk secretion in normally heavy milkers, and easy delivery are also important points in the etiology. Constitutional predisposition is important, and an animal which has survived one attack is more liable to another.

In the etiology of eclampsia, parturition also plays the most important role. Here, however, there are some slight differences. Eclampsia occurs most frequently during labor, next in frequency just before labor, and least frequently just after labor. The majority of cases occur in primipara, and twin pregnancy and hydramnios are predisposing factors. Constitutional predisposition is evident in the hereditary character insisted upon by some authors. It is also of interest to note the greater mortality of cases occurring in multipara.

Briefly, the symptoms of parturient paresis are a sudden appearance of discomfort, without evident reason, within a period of twelve to ninety-six hours following an easy parturition; loss of appetite; rumination ceases; the calf is neglected; the eyes are dull and clouded, with drooping eyelids, and reddened conjunctiva; the pulse normal and sometimes strong; the breathing excited; and the animal moans or groans. As the attack progresses, the senses are dulled and the legs become unsteady and soon give way, leaving the animal prostrate. She may make an effort to arise but is rarely able to do so. The head rests on the shoulder or upper flank. The somnolence increases passing into complete torpor and insensibility; the reflexes are all abolished; the pulse becomes soft, small and

(1) Hess, Schw. A., 1905.

almost imperceptible; and breathing slow and stertorous. There is constipation and retention of urine. Death may occur quietly from apoplexy, cerebral compression or cardiac failure. On the other hand, death may be preceded by marked excitement, or disorderly muscular movements, amounting to convulsions, and during which bones are frequently fractured and the animal otherwise seriously injured. In the beginning of the attack, the temperature may rise to 103 degrees F., or 104 degrees F., but as the condition progresses the temperature diminishes steadily until it falls below normal. With recovery, it promptly rises again to normal. In favorable cases, after the animal is down, and even without treatment, the secretion of the milk may continue, and spontaneous defecation and micturition occur and the animal may arise and commence feeding. It is of particular interest to note that the suddenness of improvement is often as marked as that of the attack. It is also of interest to note that in some animals, the hind limbs remain paralytic for days or even weeks.

While the eclamptic convulsion may occur with the suddenness of "a bolt from a clear sky," it is much more common to see the outbreak preceded by a longer or shorter period of premonitory symptoms among which occur œdema, headache, epigastric pains and disturbances of vision. The convulsion is ushered in with a fixed expression of the eyes, which soon roll from side to side. The convulsive movements appear first about the mouth, the entire face becoming distorted, then extend rapidly to the arms, body and legs. They are usually clonic but may be tonic in form. The breathing is stertorous, face congested and flushed, and the mouth foams. During the convulsions the patient is unconscious, and after the convulsions cease passes into coma. There may be but a single convulsion, after which the patient makes an uninterrupted recovery. More frequently, however, there are many convulsions, the number of which varies greatly in different cases. A fatal coma may, in rare cases, follow a single convulsion. The pulse is full and bounding, but in severe cases is weaker, more rapid, becoming soft and very small. The temperature rises at the onset to 104 degrees F., or 105 degrees F., and steadily falls with the improvement of the patient. The temperature may, however, remain normal.

Williams calls attention to the fact that there are cases in which convulsions do not occur, and states that a correct diagnosis can usually be established only by the demonstration of typical eclamptic lesions at autopsy. He further states, that in the few instances reported, in which the disorder did not appear until several weeks after the birth of the child, the cases were probably not eclamptic at all, but that the seizures were due to other causes.

The urinary findings are the most important clinical features of eclampsia; there is always diminished secretion of urine, and frequently almost entire suppression. Albumen is almost always present, but this albuminuria is only temporary and rapidly disappears. The total nitrogen is diminished, as is also the urea, and the ammonia is markedly increased. Hyaline, granular and a few epithelial casts are found microscopically, as well as isolated renal cells and blood cells.

In parturient paresis, the following urinalyses of three cases will show that the urinary findings also constitute the most important clinical features. There is always diminished secretion, as well as retention of urine, the retention in one of our cases lasting twenty-two hours. There is always albumen present. The total nitrogen is increased. The hippuric acid is diminished, while the urea is increased. The ammonia is markedly increased. Microscopically, one finds hyaline, granular and a few epithelial casts and leucocytes.

As the result of 100 urinalyses of the dairy cow, covering a period of three winter months and three summer months, we have established the following as a normal clinical urinalysis:

Physical Properties.—Colorless to deep yellow, clear, either no precipitate or a slight flocculent, or granular and occasionally a heavy white precipitate of calcium sulphate or triple phosphates. Reaction, alkaline, neutral or amphoteric; specific gravity—1014.

Chemical Properties.—Hippuric acid, 1.17 per cent.; urea, 1.06 per cent.; ammonia, 0.0009 per cent.; total nitrogen, 0.58 per cent.; no albumen; no sugar.

Microscopical Examination.—Crystals of calcium sulphate, calcium oxalate, triple phosphates, ammonium urate, amorphous urates, squamous epithelial cells and irregular vegetable cells.

The following are the urinalyses of three cases of parturient paresis:

Fannie Darnall, 7 years, fifth calf, first attack, attack occurred twelve hours after labor. Her recovery was prompt and complete with oxygen treatment. Her mother died of parturient paresis.

Urinalysis.—Deep yellow, clear, white flocculent precipitate, strongly alkaline, specific gravity, 1055; hippuric acid, 0.93 per cent.; urea, 3.23 per cent.; ammonia, trace; total nitrogen, 1.58 per cent.; abundant albumen; sugar, 6.25 per cent.

Microscopical Examination.—Hyaline, granular and epithelial casts; quantities of leucocytes, squamous epithelial cells and irregular vegetable cells.

Oxford Lad's Granddaughter, 6 years, fourth calf, first attack, attack occurred six hours after labor. Prompt and complete recovery with oxygen treatment.

Urinalysis.—Yellow, slightly cloudy, flocculent precipitate, amphoteric; specific gravity, 1023; hippuric acid, 0.34 per cent. urea, 2.2 per cent.; ammonia, 0.037 per cent.; total nitrogen, 1.05 per cent.; abundant albumen; sugar, 2.2 per cent.

Microscopical Examination.—Numerous small granular casts, some large granular casts, and a few hyaline casts; quantities of degenerating squamous and cuboidal epithelial cells, leucocytes and irregular vegetable cells.

Countess McEachen, 7 years, fifth calf, first attack, attack occurred thirty-six hours after labor. Recovery prompt and complete with oxygen treatment.

Urinalysis.—Yellow, clear, slight flocculent precipitate, slightly acid; specific gravity, 1018; hippuric acid, 0.83 per cent.; urea, 1.20 per cent.; ammonia, 0.035 per cent.; total nitrogen, 0.65 per cent.; moderate amount of albumen present; sugar, 1.64 per cent.

Microscopical Examination.—Granular and hyaline casts, squamous epithelial cells and leucocytes, irregular vegetable cells.

The characteristic lesions found in autopsy in cases of eclampsia are, areas of necrosis, in which blood cells may or may not be present in the liver, in the neighborhood of the smaller portal vessels. That is a hemorrhagic hepatitis. An acute parenchy-

matous degeneration of the kidneys, with but little disturbance of the glomeruli and interstitial hemorrhages. There is also a coagulation necrosis, either focal or diffuse, of the adrenals, and pneumonia is not infrequent.(1)

Unfortunately, the finer pathological changes occurring in parturient paresis have not been established, and of the three cases which we had during the past year none died. Nevertheless, we shall show in our second paper, that three guinea pigs which died under the influence of the toxin of parturient paresis in five, six and seven days, presented upon microscopical examination, areas of hemorrhagic necrosis in the liver, an acute parenchymatous nephritis with interstitial hemorrhage, and an acute degeneration of the adrenals with interstitial hemorrhage; and, in one case, a left lobar pneumonia. That in another guinea pig, which received a smaller amount of the toxin, the immediate result was an intense diuresis, accompanied with an albuminuria, the animal passing more than 200 c. c. of urine in the twenty-four hours. This animal apparently recovered, and ten days later was chloroformed. Upon microscopical examination, we found an acute parenchymatous nephritis, with some interstitial hemorrhage; a rather extensive necrosis of the liver cells, but without hemorrhage; and localized areas of necrosis in the adrenals.

We now come to the most interesting part of this whole problem, namely, the cause underlying, on the one hand, eclampsia, and on the other, parturient paresis.

As Zweifel has aptly put it, "Eclampsia is the disease of theories." It has been identified with ureamia; it has been held that it was the result of anæmia and œdema of the brain; of the circulation of ammonium carbonate in the blood; that it was the result of bacterial invasion; of the circulation of carbamic acid in the blood; that it was due to poisons arising from the foetal elements; that it was due to poisons absorbed from the placenta; that it was due to thrombosis, caused by placental cells passing into the maternal circulation; that it was due to the circulation of lactic acid in the blood; that it was due to thyroid insufficiency; and

1. Adami and Nichols, Principles of Pathology, Vol. II, 1911. (This contains the best description of the kidney of pregnancy which we have seen.)

again to irregularities in the metabolism of the parathyroid bodies; and, lastly, that it was due to autointoxication. There is not sufficient experimental evidence, however, to establish any of the above theories, and it is of interest to note that the possibility of the breast elaborating the toxin has not, as yet, been investigated.

Parturient paresis has also been explained by many theories. It was considered the result of emotional excitement; of cerebral anaemia; of cardiac hypertrophy; of bacterial infection; as the reaction of surplus nerve force, following an easy labor; and of an increased percentage of sugar in the blood. The most remarkable feature presented by parturient paresis, is the rapid response to and the entire success of, the modern treatment. This treatment has reduced the mortality from 60 per cent. to 0.5 per cent., and the rapidity of recovery is very striking indeed. An animal, apparently in the last stage of coma, will, often within a few hours after the treatment, or even in twenty minutes, be up and eating and licking her calf, apparently well and contented. The treatment consists of acute dilatation of the udder, by means of suitable liquids or gases. This treatment was first introduced by J. Schmidt, of Kolding, Denmark, and was based upon the theory that the disease was due to a bacterial infection of the udder. He used, for injections into the udder, solutions of potassium iodid, but it has since been shown that solutions of lysol, or of sodium chloride, will act as well, and that injections of sterile water, sterile air, and of oxygen are even more successful. Injections of oxygen or of sterile air, accompanied by vigorous massage of the udder, now constitute the generally used treatment.

That the disease is due to a toxin elaborated in the udder, as the result of its own metabolism preceding normal milk production, there can be no reasonable doubt, and that the success of the modern treatment is due to preventing, by means of pressure, the absorption of this toxin seems most highly probable.

We are of the opinion that eclampsia is due to a similar toxin elaborated by the breast in a similar manner, and would strongly recommend, as the most promising treatment, dilatation of the breasts with oxygen or sterile air, accompanied by vigorous mas-

sage of the breasts, or forcible compression of them by means of a properly applied bandage, at the same time using whatever medical measures may be indicated. We, ourselves, shall thoroughly test this method of treatment as soon as the opportunity occurs.

THE TOXIC CHARACTER OF THE COLOSTRUM IN PARTURIENT PARESIS.

By Joseph H. Kastle and Daniel J. Healy.

In our first article on the resemblances between parturient paresis and eclampsia we have given the essential characteristics of both of these diseases. There is, therefore, no need to go into this subject further, except to say that parturient paresis is a disease which among the lower animals seems to be confined to plethoric cows and heavy milkers. As pointed out by Law (1) it is essentially a disease of the cow by reason of the fact that, of all domestic animals, the cow only has been bred long and systematically for the purpose of securing the greatest powers of digestion and assimilation and the highest yield of milk. In other words as the result of careful breeding the cow has been converted into a living machine for the transformation of various food-stuffs into milk. Parturient paresis is pre-eminently a disease of plethoric, heavy milking breeds of cows and of those individual animals which give the greatest yield of milk. The disease is rare or unknown in the scrub cow or among common herds, and it is fatal in the best milking breeds. It is influenced by age, feeding, ease of calving, drying up of the milk secretion before calving, parturition, such weather conditions as influence the character and abundance of the food supply, and by certain individual idiosyncrasies and constitutional predispositions, by cardiac hypertrophy and by increased blood tension in the arteries and capillaries and by the driving of the blood from the great vascular viscera back of the diaphragm, as the result of severe compression, in the expulsive movements of labor. Emotional excitement must be practically excluded as a

(1) Text-book of Veterinary Medicine, Law, 2nd Edition, Vol. 3, 1905, pp. 301-317. Ithaca, N. Y. This book contains the best account of parturient paresis that we have thus far seen.

cause of this disease. Among the prime and immediate causes we have parturition, a permanent or transient plethoric condition of the blood vessels, with corresponding increase of pressure on the nerve centers of the brain, the phenomenal trophic and secreting activity of the udder of heavy milkers and the intensely active physiological activity of the mammary glands, resulting in the sudden rise and absorption into the circulation of leucomaines or toxic alkaloids of the cells of the mammae. These according to Law are the principal causes operating to bring on an attack of this disease. In the present state of our knowledge it is of little moment whether we call the substances other than milk, resulting from the sudden disintegrative changes occurring in the udder at, or about the time of parturition, leucomaines, alkaloids, toxins, or what not. It seems reasonably certain, however, that no gland of the size and physiological activity of the udder of a heavy milking cow but must contribute largely and sometimes malignantly to the internal secretions of the animal. The question, therefore, immediately before us in the study of this acutely toxic condition in the cow, is to determine experimentally whether immediately preceding or during an attack of this disease, the udder does actually secrete poisonous substances which if not quickly eliminated or prevented from entering the blood-current could be held responsible for this disease. It, therefore, occurred to one of us, Kastle, to test the conduct of the first colostrum of the cow, obtained during an attack of parturient paresis, upon the lower animals.(1) Accordingly these tests have been carried out on the guinea pig.

Our experiments have also included a few other substances besides the colostrum of cows suffering from parturient paresis, such as the first colostrum of the normal cow, fresh milk from the Station herd, the urine of the normal cow and the first urine of a cow suffering from parturient paresis, normal salt solution (0.85 per cent. NaCl), and the aqueous solution of certain residues from

(1) On the day after our three papers on parturient paresis and eclampsia were mailed to the Editor of the Journal of Infectious Diseases, Chicago, viz: on February 13th, 1912, Dr. Surface called our attention to an abstract by Helfer of a paper by Hoyois in the Berliner Tierarztliche Wochenschrift, October 5, 1911, No. 40, pp. 727-728, the original of which appeared in the Annales de Med. vet. de Bruxelles, Juli, Aug., Sept., 1910?, in which according to Hoyois the colostrum in cases of parturient paresis, on intraperitoneal injection in doses of 10 to 20 grams, caused paralyzing symptoms in rabbits and guinea pigs, with subsequent death at the end of seven to twelve days.

colostrum and milk left after precipitating the colostrum and milk with dilute acid, and evaporating. In the following we give the results of these experiments under their respective headings as to the substances tested.

Fresh Milk.

Experiment 1. A healthy male guinea pig received into the peritoneal cavity, by injection, 5 c. c. of fresh milk containing 22,500 bacteria per cubic centimeter. This pig seemed distressed for an hour or so, and then ate some. On the following morning he had some diarrhea, from which he promptly recovered. One month later he was alive and well.

Experiment 2. A healthy male guinea pig received into the peritoneal cavity, by injection, the dried residue of the filtrate of 200 c. c. of fresh milk, which had been precipitated with alcohol. The dried residue was rubbed up with 10 c. c. of sterile distilled water before injecting. This pig showed no discomfort, had no diarrhea. One month later was alive and well.

Colostrum from Normal Cow.

Experiment 3. A healthy male guinea pig received into the peritoneal cavity, by injection, 5 c. c. of fresh, first colostrum from a normal cow. This colostrum contained 3,000 bacteria per c. c. mostly streptococci. This pig seemed distinctly distressed for remainder of day. The following morning he had a bad diarrhea from which he promptly recovered. One month later he was alive and well.

Experiment 4. A healthy male guinea pig received into the peritoneal cavity, by injection, 5 c. c. of fresh colostrum from a normal cow, which had calved 60 hours previously. The cow had induration of one quarter of the udder. No bacterial count was made of this colostrum. This pig seemed distressed for an hour or so, and then ate some. The following morning he had some diarrhea from which he promptly recovered. One month later he was alive and well.

Experiment 5. A healthy, male guinea pig received into the

peritoneal cavity, by injection, the dried residue of the filtrate of 100 c. c. of fresh first colostrum prepared as in Experiment 2. This pig showed no discomfort and had no diarrhea. One month later he was alive and well.

Experiment 6. A healthy, male guinea pig received into the peritoneal cavity, by injection, the dried residue from 100 c. c. of fresh colostrum from a cow, which had calved 60 hours before colostrum was obtained. The material was prepared as in Experiment 2. This pig showed no discomfort. The following morning he had a diarrhea from which he promptly recovered. One month later he was alive and well.

Experiment 7. A healthy guinea pig (sex not observed), received into the abdominal cavity, by injection, 3 c. c. of the fresh, first colostrum from a normal cow, which had been diluted 1 in 3 with water. This pig showed no discomfort. Two days later had a slight diarrhea. It now received in a similar manner 5 c. c. of the colostrum diluted with equal volume of water. The following morning, had diarrhea which continued several days. One month later the pig was alive and well.

Experiment 8. A healthy guinea pig (sex not observed), received into the abdominal cavity, by injection, 2.5 c. c. of colostrum whey which had been obtained by precipitating the colostrum with acetic acid, filtering and neutralizing the filtrate with N|10 sodium hydroxide and diluting with four times its volume of water. This pig showed no discomfort, had no diarrhea. Two days later received 5 c. c. of colostrum whey diluted with equal volume of water and prepared as above. The pig showed no discomfort, had no diarrhea. One month later was alive and well.

Colostrum from Cow ill with Parturient Paresis.

Experiment 9.* A healthy, female guinea pig received, in the manner above indicated, 10 c. c. of fresh, first colostrum from a cow ill with parturient paresis. The colostrum contained 34,600 bacteria per c .c. This pig seemed well for six days, had no

* In our abstract of this paper published in the Proc. for the Society of Experimental Biology and Medicine, pigs 9, 10, and 11 are referred to by the numbers 1, 2, and 3 respectively.

diarrhea at any time, and then died. On post mortem examination this pig showed acute parenchymatous nephritis with interstitial hemorrhages, acute peranchymatous hepatitis with interstitial hemorrhages, acute degeneration of the cells of the adrenal cortex, with complete destruction of the medullary cells, and interstitial hemorrhages. There was no evidence of tuberculosis. The pig was not pregnant. Cultures from the liver, kidney and spleen were negative. No peritonitis.

Experiment 10. A healthy, female guinea pig, received as above indicated 10 c. c. of the fresh, first, skimmed colostrum from cow ill with parturient paresis. This pig seemed well and had no diarrhea for five days and then died. On post mortem this pig showed acute parenchymatous nephritis, with interstitial hemorrhage; acute parenchymatous hepatitis with interstitial hemorrhage, and marked peripheral necrosis. Acute degeneration of cells of the adrenal cortex, with complete destruction of the medullary cells, and interstitial hemorrhages. There was no evidence of tuberculosis. The pig was in the very early stages of pregnancy. Cultures from the liver, kidney and spleen were negative. No peritonitis.

Experiment 11. A healthy, female guinea pig received in the manner above indicated 10 c. c. of fresh, first colostrum cream of a cow ill with parturient paresis. This pig seemed well and had no diarrhea for six days, and then died. Aborted during the first 12 hours. Foetus 5.5 cm. long. On post mortem this pig showed acute parenchymatous nephritis, with interstitial hemorrhages, acute parenchymatous hepatitis, with areas of complete necrosis, and interstitial hemorrhages. Some degeneration of the cells of the adrenal cortex, with complete destruction of medullary portion and interstitial hemorrhages. Acute lobar pneumonia of left lung. There was no evidence of tuberculosis. Cultures from liver, kidney and spleen negative. Culture from lung contained a diplococcus; no peritonitis except over upper and anterior surfaces of liver.

Experiment 12. A healthy, female guinea pig received as above indicated 10 c. c .of skimmed colostrum of a cow ill with parturient paresis, which had been kept 17 days at 8 degrees C. The colostrum was very acid, reaction equal to 10.5 per cent. normal

sodium hydroxide. This pig steadily lost weight, otherwise seemed well, had no diarrhea, and lived 16 days, then died.

Experiment 13. A healthy, female guinea pig received as above indicated, 10 c. c. of the 17 days old colostrum, which had been neutralized with normal sodium hydroxide. The colostrum was from a cow ill with parturient paresis. This pig steadily lost weight, has not seemed quite well at any time. Had no diarrhea. Aborted on the 5th day. Foetus was 8 cm. long. This pig is still living, and is regaining weight. There is a slight increase in the quantity of urine which contains albumen.

Experiment 14. A healthy, female pig received, as above indicated, 10 c. c. of 17 days old colostrum which had been neutralized with normal sodium hydroxide and boiled. Colostrum was from a cow ill with parturient paresis. This pig steadily lost weight, had no diarrhea, aborted within the first twelve hours. Foetus 8 cm. long. This pig is still alive, and is regaining weight. There is a slight increase in the quantity of urine which contains albumen.

Normal Salt Solution on Pregnant Guinea Pigs.

Experiment 15. A healthy, female guinea pig, 5 to 7 weeks pregnant, received into the abdominal cavity, by injection, 10 c. c. of sterile, normal salt solution (0.85 per cent. NaCl) at 38 degrees C. This pig showed no discomfort and had not aborted at the end of five days. Had no diarrhea. At the end of five days from the time the pig had received the injection of normal salt solution she received intraperitoneally, by injection, 10 c. c. of the fresh milk from the Station herd, which had previously been heated to 38 degrees C. This caused no discomfort and no diarrhea. She had not aborted at the end of four days. At the end of this time she received by intraperitoneal injection 8 c. c. of the first, fresh, whole colostrum of a normal cow (2nd calf), which had previously been heated to 38 C. Following this injection, this pig aborted in 60 hours, giving premature birth to two foetuses, each 6.5 cm. in length, and 60 hours after this, she aborted a second time, giving premature birth to one foetus, 7 cm. in length.

Fresh Milk from Station herd on Pregnant Guinea Pig.

Experiment 16. A healthy, pregnant guinea pig received by intraperitoneal injection, 10 c. c. of fresh milk from Station herd, the milk being previously heated to 38 degrees C. before the injection. This pig suffered some discomfort from the injection but had not aborted at the end of five days. She was not well, however, showing loss of appetite and falling off in weight. At the end of five days the pig was chloroformed. The post mortem showed accumulation of blood in left side of peritoneal cavity, and some unabsorbed particles of cream over omentum. Pregnant in left horn of uterus, two foetuses, 1 cm. in length. Right horn of uterus empty, and evidently had not been pregnant. The bad condition of this pig was undoubtedly due to puncture of a blood-vessel in the peritoneal cavity, as a result of the injection.

Cow's Urine.

Experiment 17. A healthy, male guinea pig received as above indicated, 10 c. c. of fresh clear urine of normal cow. This pig showed no discomfort, had no diarrhea, and had no diuresis. Lived seven days and was then chloroformed. On post mortem organs and tissues were found normal.

Experiment 18. A healthy, male guinea pig received, as above indicated, 10 c. c. of the first, fresh, clear urine of cow, ill with parturient paresis. This pig showed no discomfort, and no diarrhea, but had a very marked diuresis, passing at least 200 c. c. of urine in 24 hours. This urine contained a small amount of albumen and no sugar. This pig recovered from the diuresis and seemed well and was chloroformed on the 13th day. The post mortem showed, small areas of acute parenchymatous nephritis, without interstitial hemorrhages, rather extensive necrosis of the liver cells, especially in the periphery of the lobules, but without interstitial hemorrhages. Localized areas of necrosis in the adrenal cortex, with normal medullary layer.

It is evident from these results that normal salt solution, fresh milk from normal cows, the colostrum of normal cows, and the urine of a healthy cow cause no serious disturbances in the

normal guinea pig, when injected into the peritoneal cavity. The injection of the colostrum of normal cows invariably caused a diarrhea in healthy guinea pigs, male and female, from which they gradually recovered after a few days. In this connection it is interesting to note that it has long been known that human colostrum acts as a mild cathartic on the suckling.(1) As already indicated in the above (See Exp. 16), the pregnant guinea pig that received the injection of the milk of a healthy dairy herd did experience a good deal of discomfort immediately following the injection. This was followed by loss of appetite and corresponding loss of weight, during the four days that the pig lived. On January 29th this pig was chloroformed. The post mortem showed a rupture of one of the blood vessels in the peritoneal cavity, and in all probability the abnormal condition of this pig after the injection of the fresh milk was the result of slow bleeding into the body cavity. No evidence was obtained to show that the pig had aborted. With this possible exception which evidently resulted from accidental, mechanical injury and with the exception of the diarrhea resulting from the injection of normal colostrum, no noteworthy disturbances followed from the intraperitoneal injection of normal salt solution, fresh milk, normal colostrum or the urine of the normal cow. On the other hand, death resulted from the injection of the colostrum of the cow, having parturient paresis, and the post mortem and microscopical examinations of the organs of the four guinea pigs that were thus killed showed the same pathological degenerations and changes that are characteristic of eclampsia. Unfortunately but little if anything seems to be known regarding the micropathology of parturient paresis in the cow. We have shown however, that cows recovering from an attack of this disease invariably show a nephritis. Our results with the colostrum of the cow suffering with parturient paresis certainly go to show the presence therein of some substance toxic to guinea pigs and certainly point to the udder and the mammary glands as the place of origin of the toxins or internal secretions producing parturient paresis and eclampsia respectively. The fact that the urine of the cow, with parturient paresis, causes such a profound diuresis

(1) Williams, Obstetrics. 1908, 351-352.

in the guinea pig also points to the presence of toxic substances in the urine of animals so affected and indicates that these toxins are not entirely destroyed in the tissues of the cow, but are in part at least, and it may be in somewhat modified form, excreted by the kidneys.

The fact also that the colostrum of the cow during an attack of parturient paresis invariably caused an abortion in pregnant guinea pigs is a matter of considerable physiological significance and will be discussed more fully in the following paper.

We hope in the near future to attempt the isolation of the particular substance in the colostrum or the udder, responsible for parturient paresis, or at any rate, its more careful study, and accurate identification, and also to undertake a careful microscopic and chemical study of the mammary gland in this condition. Obviously this must be deferred until we can obtain the material necessary for this investigation.

The idea that parturient paresis is the result of some toxic internal secretion product elaborated in the udder of the cow, its absorption into the blood and action on the nerve centers, is in harmony with all that is known concerning the etiology of this disease and with the modern therapeutic practices which have proven of such inestimable benefit in its treatment and cure. In this connection it is only necessary to point out that these several modes of treatment have effected a reduction in the mortality of this disease from 70 to 15 and finally to less than one per cent. and can be most readily explained on the assumption that through extreme dilatation of the udder by oxygen or sterile air, the blood supply of the mammary gland is practically cut off entirely or at any rate greatly diminished, until the milk gland has the opportunity to resume its ordinary excretory activity, thereby eliminating the toxic products in the colostrum and the milk.

In 1897, Schmidt effected a great reduction in the mortality from this disease by the use of sterile solutions of potassium iodide. Later aqueous solutions of other antiseptic substances were found equally efficacious and still later it was found that normal salt solution accomplished the same result. Obviously no antiseptic or antidotal properties can be ascribed to an 0.85 per cent. solution

of common salt. In this connection the practice of the Jersey Island dairymen is of great interest. This consists merely in leaving the udder unmilked for 24 hours after calving. In this way their predisposed cows were protected against an attack of paturient paresis. Obviously in such cases the necessary dilatation of the udder was effected through its own secretions. Finally there came into modern veterinary practice the use of oxygen gas and later the use of sterilized air, whereby the mortality from this disease was reduced to less than one per cent. Here the dilatation necessary to the prevention of the absorption of poisonous products is produced by a comparatively inactive mixture of gases, its only other possible effect being to maintain an aerobic condition of the udder, until the gland has had the opportunity to resume its normal excretory functions. Upon no other grounds than those involving the elaboration within the udder, at the period of parturition, of toxic substances and the passage of these into the blood stream, do we have so complete an understanding of the saving of animal life by the therapeutic methods now employed in the treatment of parturient paresis. While by no means an uncommon pathological condition among plethoric, heavy milking dairy cows, it is not always an easy matter to secure a case of this disease at the moment when it is desired. We, therefore, reserve the right to continue these investigations along the lines indicated in the above, with the object of throwing further light on the nature of the toxin contained in the colostrum of cows suffering from parturient paresis, and the possible occurrence of this toxin in the colostrum of women suffering from eclampsia, and with the still further object of studying the precise conditions under which it is elaborated in the udder and mammary glands.

THE INTERNAL SECRETION OF THE MAMMAE AS A FACTOR IN THE ONSET OF LABOR.

By Daniel J. Healy and Joseph H. Kastle.

The importance of the internal secretions has come to be well recognized in modern physiology and certain of these secretions, notably that of the thyroid and suprarenals have been turned to great practical account in modern therapy. The profound influence of one organ or gland upon another organ or gland, through the stimulus of its peculiar internal secretion has also been brought to light through the masterly researches of Bayliss and Starling.(1) The rapid secretion of the pancreatic fluid under the influence of secretin is a sight that will never be forgotten, when witnessed for the first time, and when one recalls the former difficulty of getting even a few cubic centimeters of the pancreatic secretion. It would lead us too far afield from the subject of the present communication even to mention the various hormones which have been discovered since Bayliss and Starling's first epoch-making research upon secretin, not to mention the various applications of the hormone theory to bio-chemical phenomena that have been made in the past few years.(2) Among these may be mentioned the fact, however, that Miss Lane-Claypon and Starling (3) have shown that the stimulus to the hypertrophy and lacteal activity of the mammary gland in pregnant animals comes not from the ovaries, or placenta, or uterus, but from the foetus itself. These observers found that injections of aqueous extracts of rabbit foetuses, into a virgin rabbit, every one to three days over a period of three weeks, led the glands, which were, at first, almost invisible to become markedly hypertrophied, with enlargement of the ducts

(1) The Croonian Lectures, Lancet, 1905, I and II.
(2) Armstrong, H. E. and Armstrong, E. F. Proc. Roy. Soc. 1910, 82, B 588-602; and Journ. Lond. Chem. Soc. 1910, Abs. II, 883-884.
(3) Proc. Roy. Soc. 1906, B. 505. See also for a general discussion of the hormones, Howell, Scient. Amer. (Suppl.) 1910, p. 378.

and epithelium and to the discharge of a thin fluid and in multiparous rabbits to the discharge of true milk. At present nothing apparently is known concerning the stimulus which brings on the onset of labor in the pregnant female, and nothing as to the cause of premature or delayed labor. It is known of course that this can be accomplished in certain instances by the action of certain drugs, such as ergot; or by mechanical injury to the foetus, or by shock or emotional disturbances or even perhaps by pronounced fatigue, but as yet nothing is known concerning the precise causes which bring about normal labor in the pregnant female.

Our attention was first directed to this subject as the result of our studies on the effect of the colostrum of a cow, ill with parturient paresis, on guinea pigs. It will be seen from experiment 11, the details of which are given in our second paper, that a pregnant guinea pig aborted during the first twelve hours, following the intraperitoneal injection of 10 c. c. of fresh, first colostrum cream of a cow ill with parturient paresis. Foetus 5.5 cm. in length.

In another case, experiment 13 (second paper), a pregnant guinea pig aborted on the fifth day, after receiving intraperitoneally 10 c. c. of the colostrum of the cow, ill with parturient paresis, and which had been kept in the refrigerator for 17 days, and neutralized with sodium hydroxide, immediately before the injection. Foetus 8 cm. in length.

The unexpected results of these experiments, in so far as the abortion is concerned, naturally led us to believe that the colostrum of the cow, ill with parturient paresis, contains a substance, or substances, capable of stimulating the mother to premature labor and to the further thought that perhaps this substance, or substances, is not confined to cows suffering from parturient paresis, but is present also in the colostrum of normal cows or for that matter in that of healthy animals generally. For fear that the abortion had been brought about in experiments 11 and 13 (second paper), by some imperceptible mechanical injury or by the large volume of liquid injected we have controlled these experiments, on pregnant guinea pigs, by the injection of normal salt solution and fresh milk from a healthy, dairy herd. In this connection the results of

experiment 15 (second paper) are of particular interest. It will be observed that a pig in the 5th to 7th week of pregnancy did not abort in five days following an injection, intraperitoneally, of 10 c. c. sterile, normal salt solution (0.85 per cent. NaCl). Five days after she had received the injection of the normal salt solution, she received by the intraperitoneal injection, 10 c. c. of fresh milk from a healthy, dairy herd. This caused no apparent discomfort and no abortion after four days. She now received, by intraperitoneal injection, 8 c. c. of the first, fresh whole colostrum of a normal cow (2nd calf), which had been heated to 38 degrees C. immediately before the injection. Following this last injection, this pig aborted in 60 hours, giving premature birth to two foetuses, each 6.5 cm. in length, and 60 hours after this she aborted a second time, giving premature birth to one foetus, 7 cm. in length.

That the normal colostrum of the cow contains a substance capable of causing abortion in pregnant guinea pigs is also shown by the results of experiments 19 and 20.

Experiment 19. A healthy, female guinea pig, five to seven weeks pregnant, received by intraperitoneal injection, eight c. c. of skimmed, boiled colostrum from a normal cow. This colostrum was cooled to 38 degrees C. before the injection. The pig showed no discomfort and ate cabbage one hour after the injection. Eight days later she aborted, giving premature birth to two foetuses, one 7 cm. long and weighing 17.7 grams, and the other 7.5 centimeters long, and weighing 26.7 grams.

Experiment 20. A healthy, female guinea pig, five to seven weeks pregnant received by intraperitoneal injection, 8 c. c. of the whole, fresh normal colostrum. The pig showed no discomfort and ate cabbage one hour after the injection. Had no diarrhea and at the end of eight days aborted two foetuses, one of which was 9.5 cm. long and weighed 47.7 grams, the other was about the same size and age. Both were covered with hair.

We have still another case to show that fresh milk from a healthy, dairy herd and certain forms of mechanical injury are incapable of bringing about abortion in pregnant guinea pigs. That such is the case is seen from experiment 16 (second paper).

In this experiment it is evident that the intraperitoneal injection of 10 c. c. of fresh milk does not produce abortion in pregnant guinea pigs. Neither did the rupture of a blood-vessel in the peritoneal cavity, with considerable internal hemorrhage, as the result of mechanical injury during the injection.

It is evident from these results that the colostrum of the normal cow, as well as that of the cow suffering from parturient paresis, contains a substance, or substances, capable of bringing about abortion in pregnant guinea pigs.

Whether this substance causing the abortion is a hormone or a toxin can only be determined by further experiment which we hope to undertake as soon as the necessary material can be obtained. It will be seen from experiment 19, however, that the substance or substances in the fresh colostrum of the normal cow which excite the pregnant guinea pig to premature labor, withstands heating to boiling for a short time. In this respect it is similar to the hormones and differs from the soluble ferments and many toxins.

At any rate, we have evidence here of a new and hitherto unrecognized correlation between the mammary glands and the foetus. According to Lane-Claypon and Starling the foetus through its internal secretions stimulates the hypertrophy and lacteal activity of the mammary gland. It is evident from our experiments that the internal secretions of the mammary gland stimulate the mother to labor and the birth of the offspring.

We hope to continue these experiments with the view of learning something as to the precise nature of the substance capable of causing abortion in pregnant guinea pigs and of determining whether the colostrum of other species of animals, besides the cow, has the power of stimulating the pregnant animal to premature labor.

In conclusion we desire to express our thanks to Mr. J. W. Nutter, assistant in dairying, for much valuable assistance in the practical details of these investigations, and to Professor L. E. Nollau, Assistant Professor of Drawing, for making the photomicrographs used in the illustration of these papers.

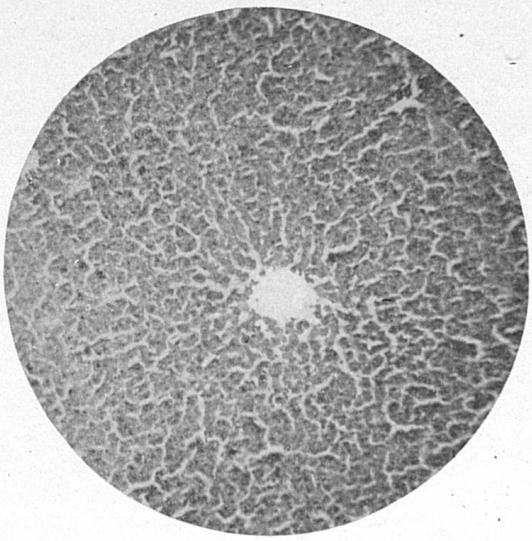
All the following photomicrographs are magnified 100 diameters:

PLATE 1. EXPERIMENT 17.



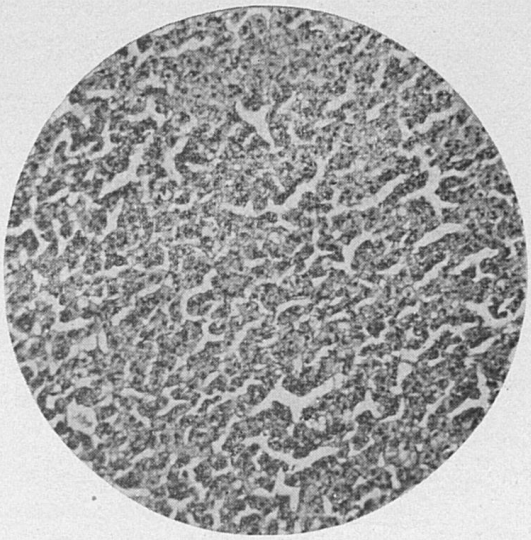
Normal Kidney.

PLATE 2. EXPERIMENT 17.



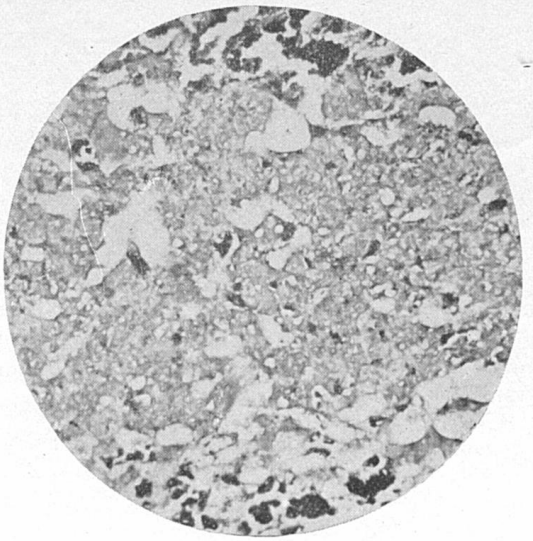
Normal Liver.

PLATE 3. EXPERIMENT 17.



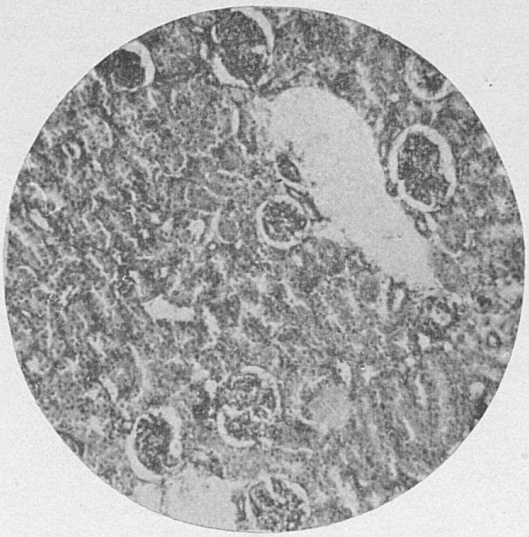
Normal Adrenal: Cortex.

PLATE 4. EXPERIMENT 17.



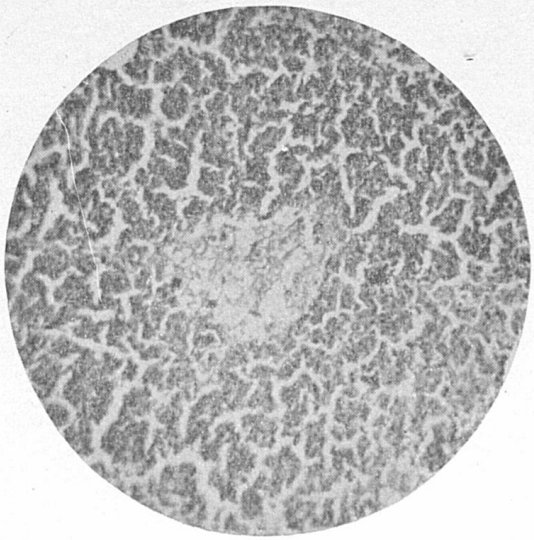
Normal Adrenal: Medulla.

PLATE 5. EXPERIMENT 9.



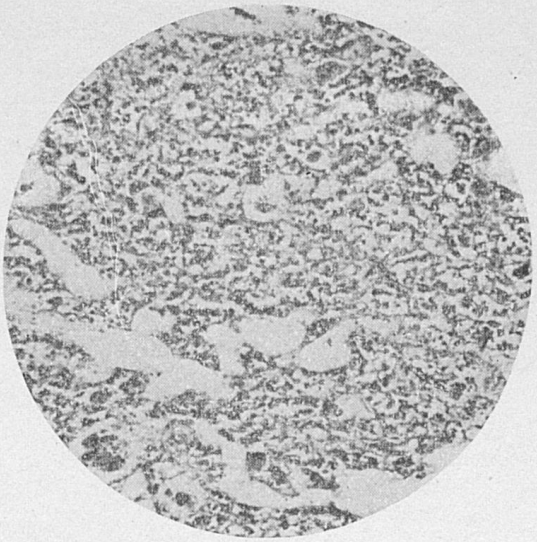
Acute Nephritis.

PLATE 6. EXPERIMENT 9.



Liver: Focal Necrosis.

PLATE 7. EXPERIMENT 9.



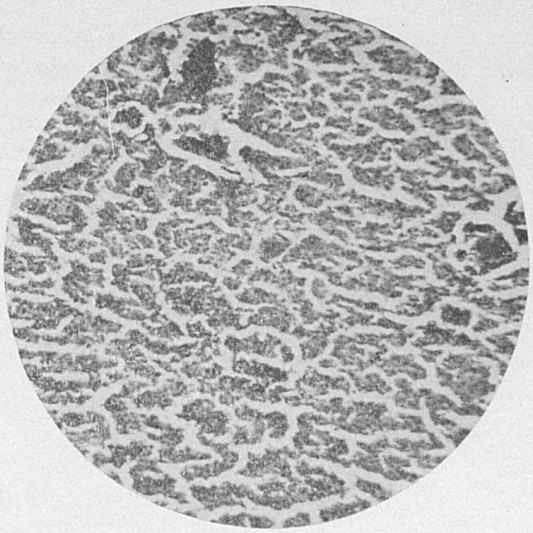
Adrenal: Necrosis of Medulla.

PLATE 8. EXPERIMENT 10.



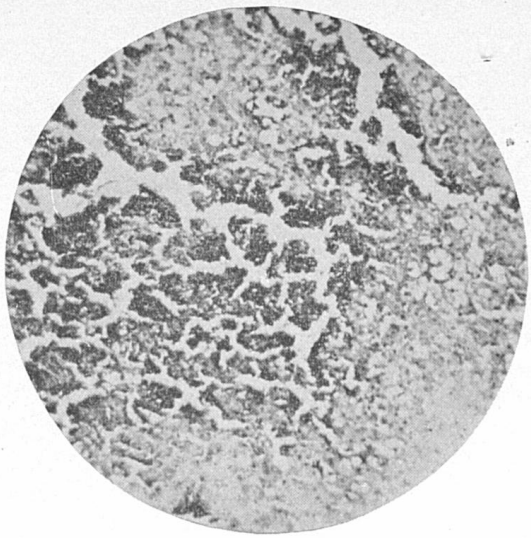
Acute Nephritis: Hemorrhage.

PLATE 9. EXPERIMENT 10.



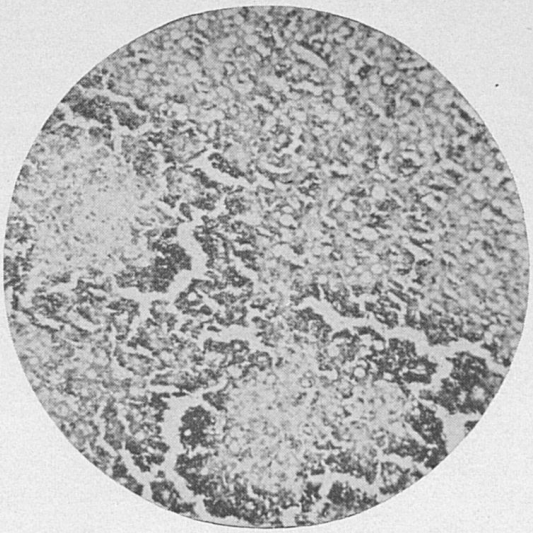
Liver: Hepatitis; Hemorrhage.

PLATE 10. EXPERIMENT 10.



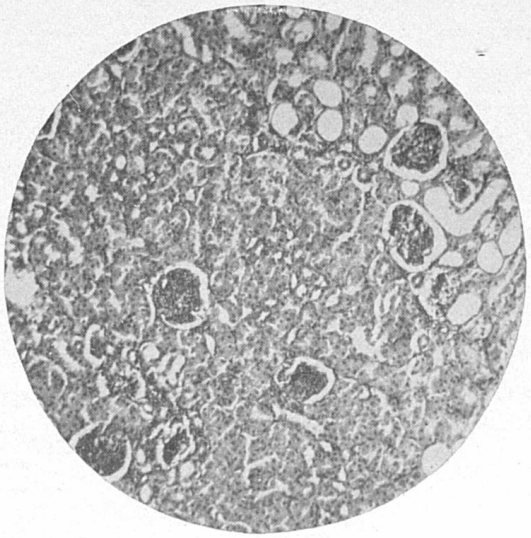
Adrenal Cortex: Hemorrhage.

PLATE 11. EXPERIMENT 10.



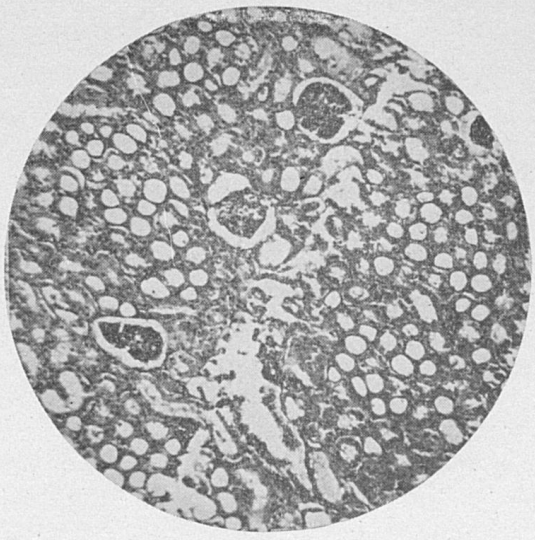
Adrenal Cortex: Necrosis; Hemorrhage.

PLATE 12. EXPERIMENT 11.



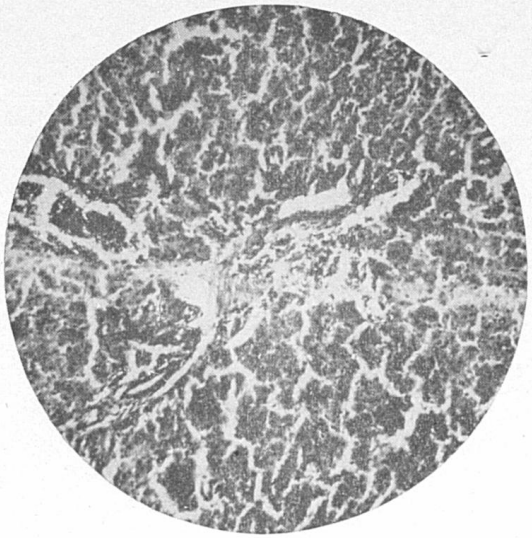
Acute Nephritis.

PLATE 13. EXPERIMENT 11.



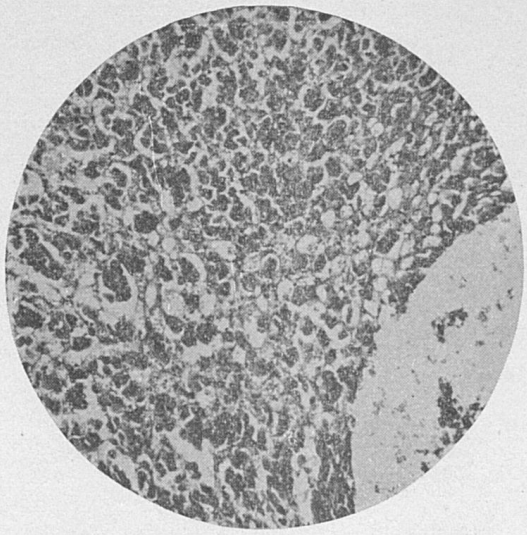
Nephritis: Destruction of epithelial cells.

PLATE 14. EXPERIMENT 11.



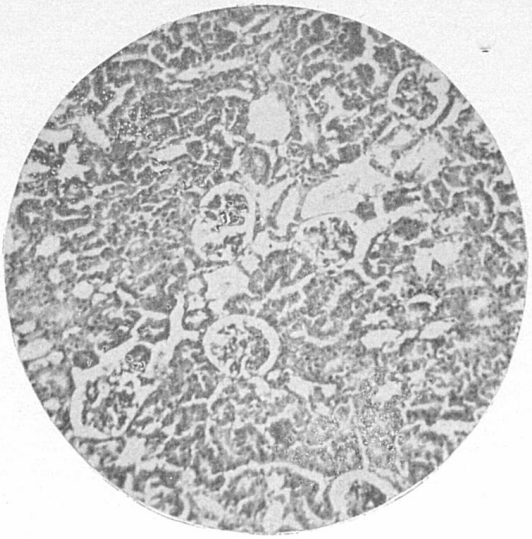
Liver: Hepatitis; Hemorrhage.

PLATE 15. EXPERIMENT 11.



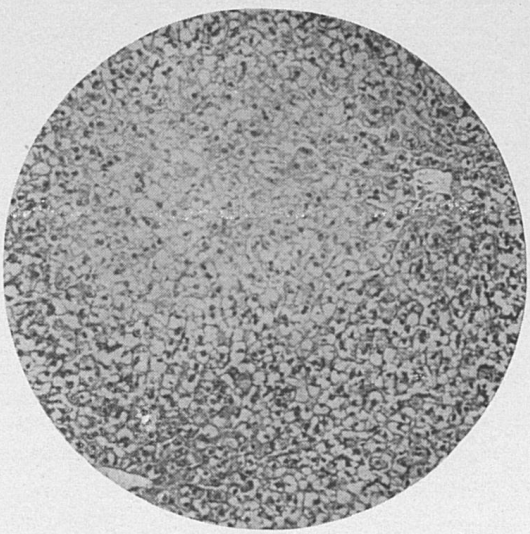
Adrenal: Necrosis of Cortex and absence of Medulla.

PLATE 16. EXPERIMENT 18.



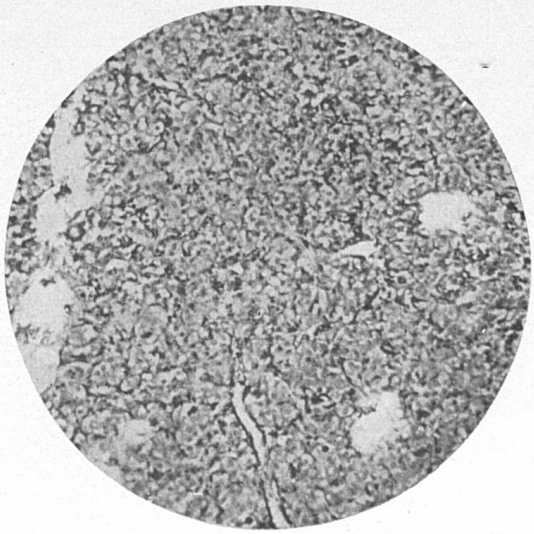
Acute Nephritis.

PLATE 17. EXPERIMENT 18.



Liver: Necrosis.

PLATE 18. EXPERIMENT 18.



Adrenal: Normal Medulla.

KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY

BULLETIN NO. 161

SOY BEANS

LEXINGTON, KENTUCKY,
FEBRUARY, 1912.
105

Kentucky Agricultural Experiment Station.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
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BULLETIN No. 161

SOY BEANS

By GEORGE ROBERTS AND E. J. KINNEY.

INTRODUCTION.

Although the soy bean was introduced into this country a number of years ago, and has been the subject of much discussion in agricultural literature, most of it favorable, it is yet grown only in a small way and is unknown to the majority of farmers except by hearsay. This is unfortunate, for there can be no question of its value, especially in the southern part of the United States, where the rainfall is abundant.

Kentucky is very favorably situated for the production of this crop, and the writers believe it is destined to become one of the most important crops of the State, and one that will prove very profitable both as a money crop and as an aid in maintaining the fertility of the farms. The chief use of the soy bean will probably be as a grain crop, although it is well adapted for other uses. It enjoys the distinction of being perhaps the only legume that can be profitably raised for this purpose in Kentucky and states similarly situated. A leguminous grain crop has the advantage over other grain crops in that it does not deplete the soil of nitrogen. Nitrogen is used by most plants in larger quantities than any of the other soil elements. It is easily lost from the soil, and is usually the first element to become deficient. Moreover, it is so expensive when purchased in commercial fertilizers that this source will not prove practical in the production of ordinary farm crops.

Leguminous crops are able to obtain a part of their nitrogen from the air where it exists in unlimited quantities in the form of gas. This is rendered available to this class of plants only through the agency of certain bacteria which find a home upon their roots. Nodules are formed in which these

bacteria live and multiply, and in their growth they take free nitrogen from the air circulating in the soil and combine it with other elements to form compounds of nitrogen which are suitable for the use of plants. Leguminous plants are thus able to obtain a very large part of their nitrogen requirements from this source, a fact of great importance in considering crops for a rotation with reference to soil fertility.

It is believed that the chief reason for the slowness with which farmers have made use of the soy bean arises from the fact that reliable information in regard to its use and production has not been available to the majority of the farmers of this State in a practical and complete form. While many articles dealing with the soy bean appear from time to time in farm journals, they usually deal with special phases of production, as lack of space forbids any very complete discussion.

The Agronomy Department of the Experiment Station has been conducting investigations with soy beans during the past few years in an endeavor to obtain such information as would prove of value, and the results of these investigations are given in this bulletin, in the hope that many farmers may be encouraged to make a trial of the crop.

The cow pea is a well known crop and as it is similar in many respects to the soy bean, it is discussed in a limited way in connection with the latter, and their comparative value for different purposes considered.

Description of the Soy Bean.

The soy bean may be briefly described as an upright bushy, well branched annual plant, attaining a height of from 20 to 50 inches according to the variety and to the amount of rainfall during the growing season. The above characters will not appply to all varieties, however, as some of those more recently introduced having vining habits similar to the cow pea. All varieties may be easily distinguished from the cow pea by the covering of fine hairs over all parts of the plant, giving the leaves a soft velvety appearance, while

the leaves of the cowpea are smooth and glistening. The leaves are also borne on longer leaf stalks than the leaves of the cowpea. The flowers of the soy bean are small and borne in clusters on the stem and main branches. The pods are short and usually plump, containing from two to three beans each, usually two. The seeds vary in size in different varieties from less than three-sixteenths inch in diameter to three-eighths inch and more. The shape varies from flat to almost perfectly round, and the color from light yellow to black, with various shades of green, yellow, brown and olive, while a few sorts have mottled or otherwise curiously marked seeds.

The soy bean ripens all its seed at practically the same time, and in this respect presents one of its greatest advantages over the cowpea for seed production, as the latter has no definite time of maturity and may continue to produce green pods until frost occurs. The soy bean is killed by hard frosts, but is not as tender as the cowpea, and is less easily injured by cold damp weather in the spring.

Uses of the Soy Bean.

The Seed.

The seed of the soy bean is very rich in protein and oil and contains no starch, and as a feed occupies the same place as cotton seed meal and oil meal or similar concentrated protein feeds. Below is given its composition and for comparison the composition of cotton seed meal, oil meal and cowpeas is also given. The figures are from Henry's "Feeds and Feeding."

	Water Per Cent.	Ash Per Cent.	Protein Per Cent.	Crude Fiber Per Cent.	Nitrogen Free Ex. Per Cent.	Fat Per Cent.
Soy Bean Meal	11.7	4.8	33.5	4.5	28.3	17.2
Cotton Seed Meal ..	7.0	6.6	45.3	6.3	24.6	10.2
Old Process Oil Meal	9.8	5.5	33.9	7.3	35.7	7.8
Cowpeas	14.8	3.2	20.8	4.1	55.7	1.4

In feeding experiments at different Experiment Stations soy bean meal has given results equal to either oil meal or cotton seed meal, and in some instances even better results

have been secured. These high protein concentrates are necessary in all successful stock feeding, and especially so in milk production, and in the feeding of immature animals. Growing the soy bean will enable the farmer and feeder to produce at least part of the required quantity at a moderate cost, and, as before stated, the nitrogen supply in the soil will not be exhausted by this crop, as is the case in growing non-leguminous crops of high protein content.

It is not improbable that uses will be found for the oil of soy beans in the near future, and that it will become a valuable product, as is linseed and cotton seed oil at the present time. The residue after the extraction of the oil is a more suitable feed in some cases than if the oil were present, and the percentage of protein is of course higher.

In China and Japan soy beans furnish a very important article of food for human consumption. They have been used but little in this country, and probably would not be relished by the majority of people. While very nutritious and not unlike the common garden bean in some respects, they have a rather peculiar flavor, which does not appeal to many tastes.

Hay and Forage.

The soy bean is capable of producing large yields of hay on good lands, frequently as high as two tons per acre and even more being harvested. The hay is rich in nutritive constituents, ranking ahead of red clover in this respect and equalling alfalfa. Stock will not eat soy bean hay as readily as clover or alfalfa unless accustomed to it. They will soon learn to relish it, however, if it has been cut at the proper time and carefully cured.

The chief obstacle in growing soy beans and cowpeas for hay is the difficulty of properly curing the crop when grown for this purpose. Cowpeas take longer to cure than soy beans but several days of bright weather are necessary in case of both. This is due to the amount of water in the green plants. In regions where rains are liable to be of frequent occurrence at almost any season, as is the case in Kentucky, curing a

large crop may prove a rather difficult task, and one in which considerable loss is possible. The hay must also be handled with great care in order to prevent the loss of the leaves, which are the most valuable portions of the plant. Chiefly for these reasons, soy beans and cowpeas will probably never take the place of clover or alfalfa, where these crops can be successfully grown. Their greatest value as a hay crop will be to supplement the clover crop when the latter is a failure, which is frequently the case.

The soy bean makes a better quality of hay than does the cowpea, in addition to its being more easily cured. The yields on good land in a season of normal rainfall are about equal if both are planted early in the season. On poor land, or when planted late, as for instance on wheat land after the wheat is harvested, the cowpea gives heavier yields. In a dry season the cowpea will also yield better than the soy bean because of its indeterminate period of maturity.

The following results were secured at the Experiment Station in 1911 in a comparative test of the yield of cowpeas and soy beans for hay purposes:

Crop.	Variety.	When Planted.	How Planted.	When Cut.	Yield Per Acre
Cowpea	Whippoorwill	May 25	Drilled with grain drill using all cups.	Aug. 11	3600 lbs.
Soy Bean	Small Brown	May 25		Aug. 11	2700 lbs.
Cowpea	Whippoorwill	July 7		Oct. 3	4700 lbs.
Soy Bean	Ito San	July 7		Oct. 3	2500 lbs.
Soy Bean	Yellow Southern	May 25	In rows 28 in. apart.	Oct. 3	4100 lbs.

Some explanations should go with these figures. The season of 1911 was an abnormally dry one, and soy beans as was expected suffered more than cowpeas. During the latter part of August rains fell, breaking the severe drouth. The late planted cowpeas and the Yellow Southern soy beans, which is an extremely late variety and had survived the drouth, took on a wonderful growth and made heavy yields of hay. The late planted Ito San soy beans made a short growth and gave most of their energies to seed production.

As a green forage crop either when cut and fed or even for pasture, the soy bean will prove a valuable crop. On rich

soil it produces a large amount of forage high in protein, which renders it suitable for feeding in connection with green corn, sorghum and other crops low in protein but high in starch. The variations in the time of maturity of the different varieties enables the feeder to have a supply at the right stage for feeding from the middle of August until frosts occur, and yet make the plantings at the same time, which is a decided advantage. This will also be found the most profitable method as the later maturing varieties furnish a much greater amount of forage. Soy beans as a pasture are better adapted for hogs and sheep than for larger animals. In connection with corn a pasture of soy beans will prove of great value in cheapening the production of pork.

Silage.

Soy beans form a valuable addition to corn for silage purposes, tending to make such silage a more nearly balanced ration. They can well be used for this purpose in the proportion of one part soy beans to four or five of corn.

The Soy Bean in Relation to Soil Fertility.

Place in the Rotation.

The value of the soy bean as a grain crop makes it particularly adapted to systems of rotations. The Experiment Station is so favorably impressed with its value for this purpose that it has adopted a four-year rotation of corn, soy beans, wheat and clover. This brings a leguminous crop every two years, thus conserving the nitrogen supply, and in addition the soy beans leave the soil in splendid tilth for wheat, a condition not obtainable when wheat follows corn. (For further discussion of wheat following the soy bean crop, see Bulletin 155.) In fact soy beans leave the land in splendid condition for almost any crop.

When it is considered that the soy bean is a valuable seed crop, that it does not make a heavy draft upon soil nitrogen, and that it leaves the soil in splendid physical condition and

with a good content of available nitrogen for the succeeding crop, its value in a rotation can not be questioned.

As a Nitrogen-Gathering Crop.

The importance of nitrogen as an element of plant food, and the difficulty of maintaining a supply in the soil sufficient for all crop requirements, has been discussed in a previous paragraph. In all systems of soil improvement and maintaining fertility, leguminous plants, because of their ability to secure nitrogen from the air, must play an important part. Employing them at frequent intervals as a regular crop in rotations is always an advisable and even necessary practice in successful agriculture.. However, it does not follow that this will maintain the nitrogen content of the soil. Leguminous crops always obtain some of their nitrogen from the soil supply, although when the soil is well inoculated with the proper bacteria, this part will be small. Now when the leguminous crop is removed from the land, as is usually the case, some of the nitrogen obtained from the soil will be removed in the tops. This, however, is balanced by the amount contained in the roots secured from atmospheric sources, so that there is probably neither material gain nor loss in the soil supply of nitrogen. Of course where stock farming is practiced a large per cent of the plant food removed by a crop may be returned to the soil in manure. Where grain farming is practiced, however, the supply of nitrogen may be maintained only by plowing under leguminous crops, when all the nitrogen gained from the air will be added to the soil, and be available for succeeding non-leguminous crops.

As a Green Manure Crop.

The practice of plowing under green crops of any kind is known as green manuring and is an important factor in maintaining or increasing soil fertility. Any kind of plants may be used for this purpose, but leguminous plants are greatly to be preferred because they may obtain a large part

of their nitrogen from the air, and thus, in addition to returning the nitrogen obtained from the soil, they add that obtained from the air. As there is always some loss of nitrogen from soil and manures, the growth of legumes is necessary if the nitrogen content is to be kept up or increased.

While it may be necessary occasionally to use the leguminous crop regularly grown in the rotation for green manure, especially in exclusive grain farming, most of the needed supply may be obtained by the use of catch crops grown in the intervals between regular crops. By good management some such crop may be grown nearly every year and at a very slight expense.

Soy beans are fairly well adapted for this purpose and under most conditions will give a good growth in a relatively short time. They may be sown in corn at the last cultivation and while not injuring the corn in the least, make a considerable growth of plants rich in nitrogen. They may also be sown in wheat or oat stubble after these crops are harvested, and good results obtained. Cowpeas are better adapted for catch crop purposes, however, than soy beans, and as a rule will give a much heavier growth under adverse conditions of soil and moisture than the latter. Soy beans when sown late, as is necessary with catch crops, have a tendency to produce small vines, which is not true of cowpeas. Cowpeas succeed better in a poorly prepared seed bed, as they germinate more surely and quickly. On the other hand, the seed of soy beans can be produced on the farm much more cheaply than can cowpeas because of the larger yield and, as already stated, the greater ease of handling. For this reason the soy bean may be profitably used instead of the cowpea.

Varieties of Soy Beans.

There have been a great number of varieties of soy beans introduced into this country, chiefly by the U. S. Department of Agriculture. Unfortunately there is considerable confusion as to the names of these, especially with the earlier introductions, the same variety being frequently known under

different names in different parts of the country. This makes it very difficult to discuss varieties.

Variety Tests.

When this Department first undertook soy bean investigations, the greatest need seemed to be for information in planting, handling and harvesting the crop, and most of the work attempted was along this line. For these purposes the Ito San was chosen as being a variety widely known and grown under this name, the seed of which could be procured in the open markets. Since the work was started with this variety, it has been thought best to continue using it, although subsequent tests have shown that some of the more recently introduced sorts are better adapted to this State and are more productive.

As already indicated, this Department has done comparatively little variety testing with soy beans. In 1909 Prof. H. Garman furnished the Department seed of two varieties which had been grown on the forage plots of his Department for several years in a small way. One of these was an early round black sort, the other a medium early flat black. These varieties were tested in 1909 and 1910, but did not prove equal in value to the Ito San under field conditions, and were discarded. In 1911 seed of several of the more highly recommended sorts was secured and a test made, using Ito San as a standard. Several of these seem to be quite valuable and superior to the Ito San in yield. Among them were some especially adapted for hay production. The yield of all soy beans was very low this year on account of the severe drouth which occurred as the beans were maturing, preventing the pods filling out properly. All varieties were planted May 20th in rows 28 inches apart, at the rate of one bushel per acre. The following is a description of the varieties and the yield:

ITO SAN: Plant stiff, upright, slightly branched. Stems rather slender, height 24 to 30 inches. Ripe September 1st. Seed medium size, straw yellow. Does not shatter readily, or crack easily in threshing. Yield, 8 bushels per acre. The Ito San, like all early varieties, is capable of giving good yields

under favorable conditions of soil, moisture, etc., but in soils of medium fertility is not so productive, because the plants do not attain sufficient size to produce heavily. It is not as productive of hay or forage for the same reason, as many of the later varieties. Notwithstanding, it is about the best of the medium early varieties for both hay and grain, and has many desirable qualities.

HABERLANDT: Plant coarse, stiff, upright. Height 30 to 35 inches; very vigorous. Ripe September 25th. Seed above medium size, straw yellow. Yield, 14 bushels per acre. A splendid variety for seed production.

EBONY: Plant slender, not upright, much branched, leafy. Height 30 to 40 inches. Ripe September 15th. Seeds rather small, flat, black. Shatters easily. Yield 10 bushels per acre. A good hay bean, but not desirable for seed.

HOLLYBROOK: Plant coarse, woody, moderately upright. Height 30 to 35 inches. Ripe October 10th. Seeds medium size, straw yellow, almost round. Handles well. Yield 16.2 bushels per acre. A good yielder of seed but a little too late. Of no value for hay production.

BROOKS: Very similar to Haberlandt, but not quite as desirable. Ripe September 25th. Yield 13.6 bushel per acre. Seed a bright straw yellow, slightly above medium size, very attractive.

MEYER: Plant slender, branching freely, moderately stiff and erect. Height 30 to 35 inches. Ripe September 25th. Seed medium size, mottled, brown and olive. Handles well. Yield 14 bushels per acre. This is a desirable variety, adapted for seed or hay production. It is very highly recommended by other stations.

AUSTIN: Plant sturdy, erect, vigorous. Height up to 40 inches. Ripe October 1st. Seeds rather large, round, greenish yellow. Yield 12 bushels per acre. Handles well and is a desirable seed producer.

WILSON: Plant only fairly erect. Rather slender stems, inclined to curl a little at tips. Height 25 to 45 inches. Ripe September 25th. Seeds medium size, flat, black. Yield 10.2

bushels per acre. Desirable for hay or for seed production.

SOOTY: Plant very slender, vining considerably. Vines up to 45 inches. Ripe October 1st. Beans small, flat, rusty brown color. Yield 14 bushels per acre. Shatters easily. A good variety for hay.

MAMMOTH YELLOW: Plant very tall, up to 50 inches. Stiff and erect, few branches. Grows slowly at first but is capable of producing an immense amount of forage. It is very late and will not as a rule mature all its seed in this latitude. For the South it is probably the most valuable variety for seed production, and may mature in Southern Kentucky. It is also known as Yellow Southern.

MEDIUM YELLOW: Identical with Ito San.

These tests must be carried further before a variety can be given an unqualified recommendation.

Varieties for Grain Production.

In selecting a variety for grain production, the following qualities should be sought: The plant should have an upright habit of growth, with the beans growing high enough from the ground to prevent loss in harvesting. The pods should hold the beans when quite dry and ripe; some varieties shatter badly. The beans should be tough enough to prevent splitting when threshing, as some varieties will split badly with the slowest speed of the machine. The variety should mature in time to permit the seeding of grain crops. The following varieties are recommended for this purpose: Haberlandt, Austin, Hollybrook and Meyer.

Varieties for Forage.

For forage a variety having fine stems and an abundance of leaves is to be preferred. The crop is more easily cured and of greater value than that produced by a variety with coarse woody stems. If to be used for hay, it is important that the beans be in the proper condition to harvest by the middle of September at latest. If much later than this the

fall rains, which usually occur in October, are likely to make the curing of the crop uncertain and difficult. A variety which ripens its seed the first of October will be in the right condition for hay by about the 1st to the 15th of September. The following varieties are recommended for hay: Meyer, Wilson and Sooty. For late green forage and silage, Mammonth Yellow. For catch crops, Ito San or Medium Yellow.

Cultural Directions.

Soil Requirements.

Soy beans require a well drained soil, free from acid and of fair fertility. No leguminous crop will succeed in the presence of free acid and where this condition exists the soil must be sweetened by the use of lime to produce satisfactory yields. Given these conditions, soy beans will succeed on any type of soil in the State, perhaps reaching their greatest development on a medium loam.

The soy bean will not give satisfactory yields on soils poor in the mineral elements of plant food, neither must the best results be expected when the soil is deficient in organic matter. Many of the soils of Kentucky are very deficient in phosphoric acid, and on such soils this must be supplied before soy beans, or in fact any crop, can succeed. Until the supply of organic matter in the soil is increased, cowpeas will probably prove a better crop than soy beans. After this is accomplished, soy beans will give the more satisfactory returns, for reasons already mentioned.

Inoculation.

When soy beans are grown on land for the first time there are usually few nodules found on the roots of the plants, unless the seed or soil has been inoculated with the soy bean nodule bacteria. The ability of the plant to obtain nitrogen from the air depends upon the presence of these nodules, and in order that the soy bean crop may accomplish all for which it is intended the nodules must be present.

Probably most of the unsatisfactory results in the first trials with soy beans are due to the absence of nodules, for except in soil very rich in nitrogen, the plants cannot obtain a sufficient amount of this element to satisfy their heavy requirements. There are a few nodules produced even the first year, and if another crop is grown on the same land within the next two or three years, nodules will usually be abundant, showing that the soil has become well inoculated during the growth of the first crop. This would seem to indicate that inoculation by soil or cultures would hardly pay, especially since the soy bean is an annual crop. The first crop grown on the land is the only one that would be lacking in nodules, and it is suggested that catch crops of soy beans be grown on the land intended for the regular crop the succeeding year. This would entail but slight expense, as the seeding need not be heavy, a few quarts per acre being sufficient. After soy beans have been grown on one field on the farm, soil can be taken from this field and used to inoculate other fields. For this purpose the soil is taken to a depth of 6 or 7 inches from different parts of the field, well dried, mixed and pulverized. The drying must be done in the shade and the soil used immediately after drying. It may then be sown on the field to be inoculated at the rate of 100 to 200 pounds per acre. It is necessary to get this inoculating material under the surface, and using the grain drill with the fertilizer attachment will prove the best method. However, it may be sown by hand either when dried or fresh from the field. More bulk is needed for hand sowing, and it should be mixed with more earth, being sure that the mixing is thorough. It should be sown on a cloudy day and immediately harrowed in.

Artificial cultures* with which to inoculate the seed may be purchased and may prove satisfactory, but it is believed that the plan referred to above will prove cheaper and more satisfactory in most cases.

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*See Ky. Exp. Sta. Bul. No. 125.

Cultural Directions.

Preparing the Seed Bed.

Owing to their tender, fleshy stems and the manner of germinating, young soy bean plants have not the power possessed by corn and some other plants of pushing their way through hard cloddy soil. Securing a good stand depends upon the seed having a light but thorough covering of finely pulverized and unpacked earth, and this can be secured only in an exceptionally well prepared seed bed.

The land intended for soy beans should be plowed early. Early plowing conserves moisture, the soil is made more friable and the surface less likely to crust after heavy rains. The formation of a hard crust after the beans are planted and before they are up is liable to result in a poor stand of plants. The disk harrow should precede the plow. This practice has several advantages. It prevents loss of moisture until the land can be plowed; prevents the soil breaking up in clods by destroying the hard crust, and the layer of fine earth when turned under by the plow insures the close contact between surface and subsoil necessary for the free movement of capillary moisture.

When the plowed land becomes crusted by rains, it should be given a thorough disking to pulverize clods and prevent loss of moisture. Later stirrings with the drag harrow should be given after hard rains until planting time. When this time arrives, if the field is not in good condition already, it must be harrowed and dragged before planting the seed.

Planting.

Our method of planting soy beans is by using a disk drill with the fluted disk feeds, and stopping up part of the feed cups to get the rows the proper distance apart. This has proven quite satisfactory. A marker similar to those used on corn planters is attached to the rear of the drill as a guide, to enable the driver to run straight rows. As a drill will not sow soy beans at the same rate as it will small grains, it is neces-

sary to test its rate of sowing in order to get the desired seed per acre. This is easily done by measuring off say a quarter of an acre of land and sowing with the drill set at an approximate figure, weighing the seed before starting the drill and after the quarter acre is sown. One or two trials will secure the proper setting. A better way is to measure the circumference of the drill wheel and calculate how many revolutions it makes in sowing say one-fifth of an acre. If the rows are to be 28 inches apart, a ten-hoe drill will sow three rows at one passage occupying a space 7 feet wide. One-fifth of an acre contains 8,710 square feet of surface. Divide this by 7 to find the distance the drill must travel to sow one-fifth acre. In turn divide this by the circumference of the wheel to find how many revolutions the wheels make in sowing this area. If the rows are 35 inches apart, divide 8,710 by 5 5-6 and proceed as above. The formulas in a condensed form would be as follows:

Rows 28 inches apart: 1244 divided by circumference of wheel equals number of revolutions of wheel in planting one-fifth acre.

Rows 35 inches apart: 1493 divided by circumference of wheel equals number of revolutions of wheel in planting one-fifth acre.

One wheel of the drill should be jacked up, a canvas spread under the disks to catch the beans, and the wheel turned the required number of revolutions. A few trials will soon determine where to set the indicator. Once found, it should be written down on the drill lid for future reference. This rate will not be the same for beans of different size.

When rows are 35 inches apart, the drill set at the 16 peck mark for oats with the oat cup used, will plant about 55 pounds per acre of medium sized beans. Set at 9 pecks, will plant about 30 pounds. For rows 28 inches apart, the drill set at 10 pecks will sow about 60 pounds per acre. At 5 pecks about 30 pounds. The seed should be free from hulls and other trash.

Corn planters and drills are sometimes used for planting

soy beans. The objections to the two-horse corn planter are that the rows are placed farther apart than is desirable or necessary, and when the planter has solid wheels the soil is packed over the beans. This latter feature is very objectionable in some soils, for should a rain occur after planting the soy beans, crusting the surface of the ground, the plants cannot get through the packed soil. The single drill is satisfactory if plates can be secured to sow the right quantity of seed. In trials with these at this Station we have been unable to get enough seed on the land.

Distance Between Rows.

Practically all grain drills used now have a seven-inch space between the disks or hoes, making the rows 7 inches apart when all feed cups are used. For sowing soy beans enough of the feed cups can be stopped up to make the rows 21 inches, 28 inches or 35 inches apart. With the ten-hoe drill, the common size, four rows 21 inches, three 28 inches, and two 35 inches apart may be planted at one passage of the drill. All these distances have been tried on the Station farm, but the 21-inch distance only one year, as this space is too narrow to permit easy cultivation. With distances of 28 and 35 inches, three years' results are available.

Rate of seeding experiments have been conducted in connection with the distance between row experiments, and the rsults are given together for convenience. They are as follows:

Distance Between Rows.	Seed per Acre	Yield 1909	Yield 1910	Yield 1911
35 inches	55 lbs.	11.5 bu.	14.7 bu.	7.7 bu.
35 inches	30 lbs.	10.5 bu.	12.6 bu.	7.6 bu.
28 inches	55 lbs.	10.5 bu.	17.1 bu.	7.0 bu.
28 inches	30 lbs.	8.5 bu.	12.3 bu.	7.6 bu.

The average for the three years is slightly in favor of the closer planting, but there is not enough gain to pay for the additional time required to cultivate the closer planted beans.

With the rows 28 inches apart one-horse cultivators must

be used. When 35 inches apart the two-horse riding or walking cultivator may be used, enabling one man to do as much work or even more than two with the single horse outfit. It should also be remembered that these tests given above were with the Ito San, a variety producing rather small plants. With later and larger growing varieties, it is probable that there would be little difference in yield between the two distances of planting.

In planting for hay or forage the 28-inch distance is preferred, or if land is quite free from weeds, good results may be secured by using all the drill hoes and not cultivating the crop. As a rule, however, soy beans will give better results if cultivated even if grown for hay. The stems may be made slender by thicker seeding.

Rate of Seeding.

It will be seen by the results already given that planting nearly a bushel per acre gave considerably the largest yield for two years, while the thinner planting gave about the same results in 1911, a very dry year. This would indicate that for a medium early variety like the Ito San, from three pecks to a bushel per acre will give the best yields. This applies when the seed of the variety is of medium size. It is apparent that the variation in the size of the seed of different varieties will necessitate different rates of seeding to secure the same number of plants on the land. But the plants of some varieties are much larger than of others, and this would admit of some variation in the rate of seeding. The rate of seeding for grain production may vary from one-half to one and one-half bushels per acre. Thick sowing apparently does not reduce the yield, but tends, in the case of some varieties, to produce weak stems, making harvesting difficult.

For hay and green forage, especially the former, fine stems are desired and the seeding should be heavy. If sown in drills for cultivation, about one bushel per acre of varieties having medium size seeds should be sown. If sown broadcast or all drill hoes used, one and one-half bushels will not be too much.

For larger seeded varieties more seed should be used, and for the very small seeded varieties, which include some of the best for hay, a little less may be used. For the very small vined varieties the seeding should be heavy to secure profitable yields.

Time of Seeding.

For grain production or when used as a main hay crop, the soy bean should be planted May 10th to June 1st. Medium early varieties may be planted as late as July 15th and mature their seed. The earliest varieties of soy beans will mature in a shorter time than the earliest varieties of cowpeas.

Cultivation.

Soy beans are very tender when they first come through the surface, and cannot be cultivated with a weeder or harrow. At the Station the first cultivation is given with the 14-tooth harrow cultivator, a one-horse cultivator with harrow-like teeth. With this the beans can be worked very close without being covered, and the small weeds are destroyed. The later cultivations are given with the ordinary implements used in cultivating corn. The beans grow so rapidly that three cultivations are usually all that are required. After the ground is shaded by the plants, weeds do not get much chance. The cultivation should be shallow, and should be especially thorough when the plants are small.

HARVESTING.

Stages for Cutting.

When the soy bean approaches maturity the leaves begin to turn yellow and drop, and before all the pods are ripe the leaves are all off. When grown for seed this is the proper time to cut, or when about three-fourths of the pods are ripe. If cut earlier it is difficult to cure them properly, and if not cut until very ripe the beans are liable to shell out badly, and the dry woody stems are hard to cut. If taken at

this stage the beans may be cut at any time of the day with little loss by shattering, but if allowed to become very ripe they should be cut in the morning and evening.

For hay the beans should be cut when the pods are a little less than half filled. They contain as much nutriment at this time as it is possible to get and not have hard woody stems.

Cutting for Seed.

The mower, self rake and binder have all been used at the Station for cutting soy beans and all have proved more or less satisfactory. If cut with the mower, especially when very ripe, running over them with the machine and the tramping by the team will shell some. It is also necessary to rake them into windrows, which also causes some loss. The old self rake reaper is very satisfactory, as the beans are placed in bunches out of the way of the machine and the team. These bunches can be turned and allowed to dry, and then two or three rows of them put together so they may be loaded on the wagon conveniently. Unfortunately few of these old reapers are in use now.

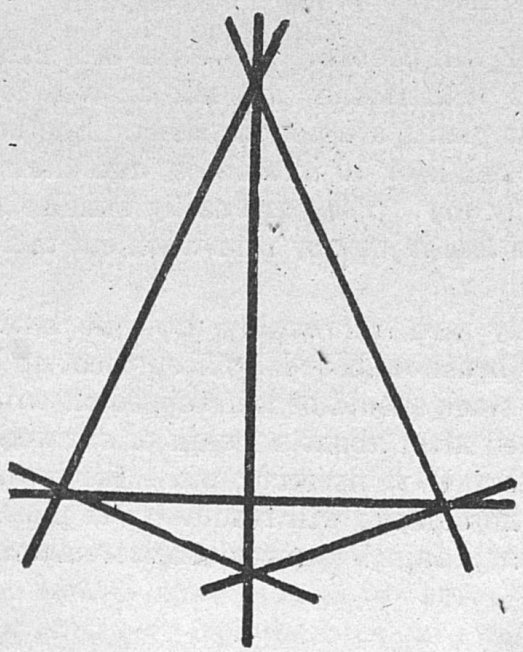
The binder will probably prove the best machine to harvest soy beans with if they are not allowed to become too ripe, and if the plants are not too short. The bound bundles should be shocked, 8 or 10 to a shock, and allowed to remain until thoroughly dry. They are easily handled, and there is less waste, and less injury by rain when cut this way than in any other.

After they are thoroughly dry, the beans should be stacked, using brush or boards to keep them up off the damp earth, and the stack should be well topped off with hay. They may be threshed after about a month or six weeks, or left as long as desired. If rains occur while the beans are in the field, little or no damage will result. If in piles, they should be turned after a rain to prevent their remaining damp too long a time.

Cutting and Curing for Hay.

For hay the beans are cut with the mower and as soon as wilted raked into small windrows. They are allowed to dry here for a short time, and should then be put into small shocks and allowed to stand until well cured. Experience is necessary in curing soy bean hay, but those who have made cowpea hay will find less trouble in curing that of soy beans. A correspondent writes in regard to curing cowpea hay that he sets posts about one foot into the ground, nails cross pieces near the bottom, and shocks the hay over the posts as soon as cut. The forkfuls of pea vines are slipped over the post, which is sharpened, and a good sized shock made. No further attention is given until the hay is cured. He claims that hay cured in this way is of extra fine quality, but does not say how much time it takes to handle the hay in this manner. It would probably not prove practical on a large scale, but is worth trying with a small crop.

Another contrivance often used in curing soy bean or cowpea hay is illustrated below. The hay is allowed to wilt



Device for Curing Soy Bean Hay in Shock.

and is then raked into windrows and piled over these frames. Being held up from the ground and having an air space in the center of the shock, the hay of course cures quite rapidly. This apparatus appears to the writers to be more practical than the one described above.

Neither soy bean nor cowpea hay keeps well in a stack unless given a good covering of timothy or other grass, because the coarseness of the stems allows the water to penetrate so readily. The stack should also be made on brush, rails or boards to keep the hay from becoming damp and mouldy on the bottom.

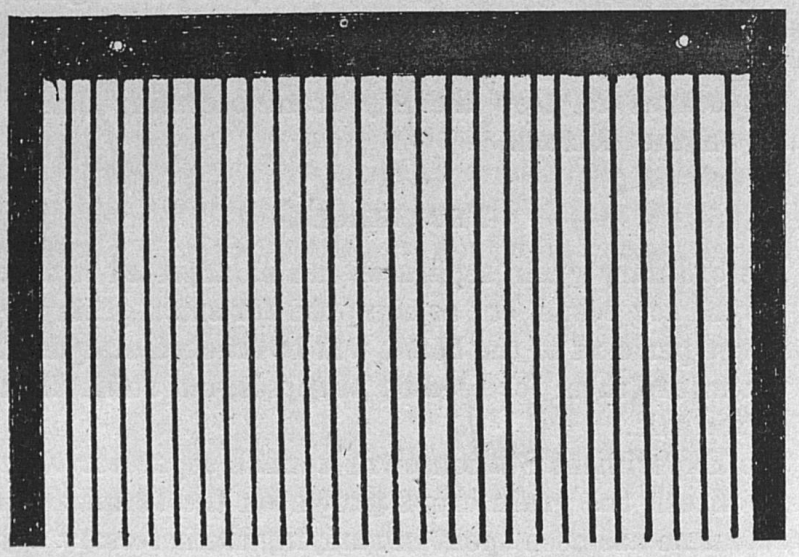
THRESHING.

The ordinary grain separator can be adjusted to successfully thresh soy beans, but as equipped for small grain threshing a large per cent of the beans will be cracked or split. This does not injure them for feeding purposes, but ruins them for seed or for sale.

The Experiment Station owns a small separator which is used to thresh the grain crops grown on the farm, and considerable time has been spent in studying the necessary adjustments for threshing soy beans. In general the machine is like all separators and the same adjustments will apply to all machines.

The chief cause of split beans is the high speed of the cylinder. The speed is reduced one-half and the speed of the fans and other parts is maintained by doubling the size of both cylinder pulleys. A special set of thin concaves is used. The ordinary thick concaves leave so little space between cylinder teeth and concaves that some of the beans will be cracked in passing. Only as many rows of concaves are used as are necessary to insure clean threshing. This depends of course upon the condition of the beans. If very dry, as they should always be when threshed, a very few rows may be required and the rest of the space may be filled with blanks. The iron grating behind the cylinder should be replaced by a sheet-iron pan, for the beans are hurled against the grating

with such force that many may be split. Another adjustment found necessary was the conveyor extension. In threshing soy beans many hulls are detached from the stalks and stems and fall through the straw conveyor to the conveyor sieves. Being heavy, the blast is not strong enough to drive them out, and they fall through the conveyor extension into the tailings



Improvised Conveyor Extension used in Threshing Soy Beans.

screw, choking this and the return elevator. At first a solid conveyor extension was substituted, but the heavy load of hulls carried by the conveyor sieve also carried some threshed beans along, and these were carried out to the straw carrier. To avoid this a conveyor extension was made of parallel rods about one-half inch apart, which allows the beans to drop through into the tailings screw but prevents many of the hulls going through. All beans must be threshed at first passage. The fan blast is not strong enough to separate filled pods from unfilled ones, nor can a conveyor extension be made to accomplish this. The only function of the latter is to allow the threshed beans that have not gone through the sieves to drop into the tailings screw and be carried back to the cylinder. If an extension made as described above is

used, the tailings will be very small in quantity.

All the necessary adjustments mentioned above, except the conveyor extension, can be secured of separator manufacturers at a relatively small cost. It will pay a farmer growing a considerable acreage of soy beans to buy the necessary equipment if the owner of the separator does not feel justified in doing so. If the size of the crop justifies, a special bean huller may be purchased in partnership by several men and an engine hired to run it. Such a machine can be bought for about $300. There is no question that when the soy bean crop receives the recognition it deserves, every owner of a thresher will equip himself to handle this crop. When only an acre or two is grown, the beans may be threshed out with flails. This is not such a slow process as would be imagined, as 10 to 15 bushels per day, when the air is thoroughly dry, can be threshed by a good man.

Soy beans cannot be satisfactorily threshed unless thoroughly dry. They should stand in the stack for a month or more and then a bright dry day be chosen for the work. One year an attempt was made on the Station farm to thresh damp beans. Later the straw was rethreshed, yielding 16½ bushels more from eight acres.

Care of the Seed.

Some care is necessary in storing soy bean seed to prevent heating, which is especially liable to happen if the seed is bulked together in large quantities in a bin or other poorly ventilated receptacle, and almost certain to happen if the beans are not perfectly dry when threshed. All seed stored in this manner should be examined occasionally for a month or so to detect any tendency to heat. If it should show such signs it must be removed at once and spread out until perfectly dry. Heating will ruin the beans for seed purposes as the power of germination is destroyed.

At the Station we have never had any difficulty in keeping the seed and have never lost any by heating. As stated, the beans are allowed to remain in the stack for a

month to six weeks, when they will be very dry. When threshed the seed is put into burlap sacks and ricked up in a well ventilated place. In ricking the sacks of seed, two are placed beside each other and the next two laid across these in the opposite direction. This gives more space between the sacks and better ventilation. They are left in the sacks until used. Soy beans are seldom attacked by weevil, as are cowpeas, but when a seed house becomes badly infested with these troublesome little beetles, they will infest almost any grain, including soy beans. They may be destroyed by carbon bisulphide.

All soy beans should be tested for germination before planting, as they lose their germinating power through age or improper handling.

Discussion of Yields.

Some yields have been given in this bulletin in connection with certain experiments. They are rather low in most instances but do not represent the best yields secured on the Station farm, and by no means represent the productive capacity of soy beans. Extensive work with this crop was undertaken in 1909. There was little available information on handling the crop, and the Department was ignorant as to how it should be done. All the knowledge had to be gained by practical experience. The greatest problem was in harvesting and threshing the beans, and in the first attempts a heavy percentage of the seed was wasted. This was in the experimental field, the yields from which have been given. A later maturing field of 6 acres, which looked no better than the above field, yielded 18.3 bushels per acre, but the experience gained in handling the first lot of beans made possible the handling of the latter without much waste.

In 1910 the land to be planted to soy beans was in rye, and for certain reasons it was necessary to pasture this as long as possible. It was June 1st before the land was plowed. The soil turned up hard and cloddy, and could not be gotten into good condition. As a result a very poor stand of plants

was secured. Before the plants had attained much size, continuous rains occurred, which prevented cultivation, and the weeds got a grand start. The soy beans were injured, of course, and the yield was low, as was expected.

In 1911 a splendid prospect for a heavy yield was ruined by the severe drouth, the worst in fifty years. This drouth caused an almost complete failure of the corn crop in this immediate vicinity, and a half crop of soy beans.

In addition, the variety used is not considered the best adapted for the conditions in Kentucky, as noted before. The soil was not inoculated and the crop was not grown the second time on the same field, except in 1910. This probably reduced the yield. All things considered, large yields could hardly have been expected.

On the forage plots of the Botany Department yields of from 40 to 60 bushels per acre have been secured on small plots where the soil is rich and every condition is made favorable for the growth of the plants. The Department receives reports of yields of from 20 to 30 bushels per acre from correspondents whose farms are of only medium fertility.

It is not advised to start out on an extensive scale with this crop. Rather a farmer should experiment with a small acreage until he becomes familiar with handling the beans to the best advantage.

KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY

BULLETIN NO. 162

THE SOILS OF WEBSTER COUNTY

LEXINGTON, KENTUCKY,
MARCH, 1912.
(133)

Kentucky Agricultural Experiment Station

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Kentucky

BULLETIN No. 162

The Soils of Webster County, Ky.

SUMMARY.

This Bulletin is the result of co-operation between the Kentucky Geological Survey and the Agricultural Experiment Station.

In it, the five important soil types of Webster County are described, outlined on the map and their physical and chemical characters illustrated by mechanical and chemical analyses of typical samples.

Three of the five types described, two upland and one bottom land, together, cover nine-tenths of the county.

Four of the five types are shown to be low in nitrogen, phosphorus and lime, the low nitrogen indicating, also, low organic matter.

All five types contain a large reserve supply of potassium.

One of the types of bottom land is strongly acid in both top and subsoil and both of the upland types are acid in the subsoil.

The general plan suggested for improving these soils is to grow more leguminous crops, in suitable rotation, with the aid of ground limestone and rock phosphate, and to maintain more live stock.

One type of bottom soil was found to be quite rich and well supplied with lime, but its area is small.

An interesting chemical relation brought out by the analyses is that as the acidity of the soil increases, the solubility of the phosphorus in one-fifth normal nitric acid (availability) is diminished.

A series of pot culture experiments with fertilizers upon soil from an adjoining county but similar to the upland types, is reported.

The area studied is typical of the Western Coal Field of Kentucky which includes some 4,500 square miles, or about one-eighth the total area of the State, to which the observations herein reported should generally apply.

INTRODUCTION.

By A. M. PETER.

The work reported in this Bulletin is the result of co-operation between the Kentucky Geological Survey and the Kentucky Agricultural Experiment Station. In this co-operation, Mr. S. C. Jones, of the Survey, studied and outlined the soil types in the field, using for this purpose the accurate topographical maps of the United States Geological Survey, and collected the samples for analyses and for pot experiments. He also made the mechanical analyses in the Experiment Station laboratory and conducted the pot experiments in the Experiment Station greenhouse, under the supervision of the writer. The chemical analyses were made by the chemical force of the Experiment Station. The Bulletin itself was written by Mr. Jones, in collaboration with the writer. It is published as a part of Bulletin No. 23 of the Kentucky Geological Survey as well as Bulletin No. 162 of the Kentucky Agricultural Experiment Station. The accompanying map is the work of the State Survey draftsman after Mr. Jones' working map.

A few words here in regard to the methods followed in this work may be appropriate.

The samples for analysis are average samples obtained by means of a steel sampling tube cutting a core about 1¼ inch in diameter. The tube is driven into the ground to the desired depth and when withdrawn, brings up a core of soil representing a section taken to that depth. Eight or ten cores were taken for each sample representing the first 6 inches, and half that number, from each alternate hole, representing the next foot, i. e., 6 to 18 inches. These samples were allowed to dry at ordinary temperature, sifted through a sieve with circular openings, 2 mm. in diameter, and the sifted soil used for analysis, both mechanical and chemical. In each case,

the percentages are calculated for the sifted soil, exclusive of any gravel which may have been removed by the 2 mm. sieve, and this is true, also, of the weights per acre.

In the mechanical analyses essentially the same procedure was followed as is used by the Bureau of Soils of the United States Department of Agriculture. In both the chemical and the mechanical analyses allowance was made for moisture content in weighing out the portions taken, so that the results represent the moisture-free soil.

In the chemical analyses, total nitrogen was determined by the Kjaldahl method, total phosphorus by the magnesium nitrate method and total potassium by the J. Lawrence Smith method, all as approved by the Association of Official Agricultural Chemists.

Easily soluble, or "available" phosphorus, potassium and lime were determined by digesting 200 grams of soil in two liters of dilute nitric acid of one-fifth normal strength, for five hours at room temperature, with ocacsional shaking, allowance having been made for the neutralizing power of the soil, determined from a preliminary test. The solution thus obtained was analyzed by appropriate methods for phosphorus, potassium and calcium.

Acidity was determined by the method of Hopkins.

The soils of Webster County are representative of the greater part of the Western Coal Field, and it is believed that the data and conclusions presented in this report will be helpful to the farmers of the other counties of that field, including Hopkins, Union, Henderson, Davies, McLean, Muhlenburg, Ohio and Butler. This area is about four thousand five hundred square miles or about one-eighth the total area of the State.

A SOIL SURVEY OF WEBSTER COUNTY.

By S. C. JONES,

Of the Kentucky Geological Survey.

Webster County lies in the Coal Field of Western Kentucky, within parallels 37 degrees 40 minutes and 37 degrees 21 minutes North Latitude and Meridians 87 degrees 23 minutes and 87 degrees 56 minutes West Longitude. Union and Henderson, two counties lying on the Ohio River, form its northern boundary. On the east, Green River separates Webster from McLean County, while Hopkins forms the southern, and Crittenden the Western boundary. Its greatest length is about 33 miles and its greatest width 15 miles, with an area of approximately 335 square miles.

Webster County was established in 1860 out of part of Henderson, Hopkins and Union, and received its name from the noted statesman, Daniel Webster. It has, according to the census of 1910, a population of 20,974. Dixon, a town of 741 people, situated about the center of the county at the terminus of the Dixon branch of the Illinois Central Railroad, is the County seat. Providence, Sebree, Clay, Slaughterville, Blackford, Wheatcroft, Lisman and Pool are other important towns in the county. Besides these, there are a number of small towns or villages, such as Hearin, Free Union, Vanderburg, Onton, Luzon, Tildon, Wanamaker, Ortz, Pratt, Stanhope, etc.

Providence, Sebree and Clay are mining towns. Providence is situated in the southwestern portion of the county on branch lines of the L. & N. and Illinois Central Railroads, and has a population of 2,084. Clay is about 8 miles northwest of Providence on the same railroads, and has a population of 1,098, while Sebree lies in the northeastern portion of the County on the main line of the L. & N. Railroad, and has a population of 1,500.

Physiography and Drainage.

The County represents three phases of topography: First, the low flat bottoms lying mainly between 350 and 400 feet above sea level; second, the undulating or gently rolling upland lying between 360 and 440 feet above sea level, and, third, the broken or hilly upland lying between 400 and 640 feet above sea level.

This broken area lies, in the main, in a broad range of hills eight or ten miles in width, extending from the County line on the south, just west of Slaughterville, across the central portion of the County in a northwesterly direction, striking the Union County line some three miles southwest of the juncture of Union, Henderson and Webster Counties. This escarpment forms the main water shed of the County, and lies about half way between Green and Tradewater Rivers and divides the County into an eastern and western drainage area of about equal size. The western area is drained mainly by Craborchard Creek and its tributaries, Caney Fork, Lynn Fork, Slover Creek, Whiteside Creek and Owens Creek, while the eastern area is drained by Pitman Creek, Graves Creek and Deer Creek and its tributaries, Knoblick Creek, East Fork, Havana Creek, etc.

Just west of this range of hills, extending across the County in a parallel direction, is a low undulating valley some five or six miles in width, made up of broad bottoms with low undulating upland lying between. This valley was perhaps at one time the channel of Tradewater River or of a kindred stream which has long since shifted westward.

Still further west, lying between this valley and the Tradewater River, extending in the same direction entirely across the County, is another range of disconnected hills interspersed with undulating areas and narrow bottoms.

On the east side of this escarpment is a narrow range of hills reaching out in a line from Dixon to Sebree almost to Green River. On the north, between this range of hills and the County line, is another strip of low, gently rolling land

with wide bottoms along the streams. East of this area are the wide bottom lands of Green River and Deer Creek.

Geology.

Webster County lies entirely within the Western Coal Field and its geology is characteristic of this field. Coals Number 9 and 11 and probably, in places, still higher coals, outcrop at points over the more rugged area of the County. The formation consists of alternating strata of sandstone, sandy shales, clays, coals, slaty materials, and, at certain horizons, thin layers of limestone. Sand is the predominating material composing these formations and on disintegration rather uniform sandy or silty soils are formed.

Soils.

Classifying the soils of the County as to origin, two kinds are recognized, viz., residual and transported. The residual soils occupy the upland and have been formed from the materials remaining in place after the disintegration of the overlying rocks, thus forming a cover over the deeper unaltered rocks, while the transported soils occupy the bottom lands and have been carried in by the waters of the small streams and rivers. Of the total area, 335 square miles, there is 123 square miles of land of transported origin and 212 square miles of residual origin.

Soil Types.

Classifying the soils of Webster County according to their origin, topography and physical characteristics, such as their content of sand, silt, clay, organic matter, color, etc., five types are recognized. Three are in the area of transported origin and two in the upland or residual area. Naming in order of area these five types are as follows:

TABLE I.—*Areas of the Soil Types.*

	Sq. Mi.	Acres.	Per Ct.
Yellow Silt Loam (Hilly)	121.0	77,440	36.1
Yellow Silt Loam (Undulating)	91.3	58,432	27.3
Gray Silt Loam (Bottom)	84.8	54,272	25.3
Gray Clay Loam (Bottom)	27.1	17,344	8.1
Dark Brown Clay Loam (Bottom)	10.8	6,912	3.2

YELLOW SILT LOAM (HILLY).

This type occupies mainly the central portion of the County with also a number of minor areas in the eastern and western sections. It occupies the broken or dissected portion of the area and is derived from the alternating sandstone, sandy shales, sandy slates, clays, etc., whose constituents on disintegration intermix, giving rise to soils of rather uniform physical characteristics. In its origin it is very closely related to the yellow silt loam of the undulating area, the chief difference being that of topography, which for agricultural purposes, separates the two types quite widely.

The hills of this area are usually rather steep and vary from 40 to 240 feet in height, averaging perhaps scarcely more than 100 feet. As a rule, the ridges are very narrow and irregular in trend.

The surface soil is a yellowish or grayish silt loam of varying depth, ranging from 6 to 10 inches. While the soil of these two upland areas is referred to as a silt loam, it is, in fact, practically on the margin between a silt loam and a fine sandy loam. It is mellow and open and, unless tramped when wet, seldom breaks into hard clods and is almost as easy to plow as a real sandy loam.

The subsoil is more claylike in its properties. At a depth of from 10 to 15 inches it has a brighter yellow color with gray streaks and, in places, iron stains, while at from 15 to 30 inches it usually becomes decidedly more plastic, due to the much larger proportion of clay. It is a well drained soil, but at the same time possesses very good water holding properties. The surface soil is of such character as to allow rain

water to enter easily, which is stored up in the more compact subsoil within easy reach of growing plants. Through the porous surface soil much moisture is rapidly lost, whereas much of it could be retained if the organic content of the soil were increased.

Beech, maple, hickory, sassafras, persimmon, walnut and the different varieties of oak constitute the characteristic vegetation.

Corn, wheat, tobacco and hay are the principal crops grown on this type. The yield of corn varies from 15 to 30 bushels per acre, that of wheat from 10 to 15 bushels, and tobacco from 600 to 1,200 pounds. Hay is made from timothy, clover, red top, cow peas and wild grasses. In recent years, clover is practically a failure unless manure is applied to the soil. A large amount of hay is made in the fall from cow peas, which often contain a rank growth of wild grass.

Forty years ago the greater portion of this area was in timber and when first cleared, good crop yields were obtained, but the soil has been very badly handled and but little effort has been made toward preventing the soil from washing. The writer has not found an area in the State where land has been gullied more than in this area. The soil being loose and the topography hilly, conditions have been conducive to erosion. However, if the proper system of rotation and cultivation had been practiced, much of this land would not have gullied to such an extent.

Coal rights in this area are held at from $8.00 to $15.00 per acre, while the surface for farming purposes is valued at from $5.00 to $20.00 per acre.

The following table contains a mechanical analysis of a typical sample of the surface and subsoil of this type:

TABLE II.—Mechanical Analyses of the Yellow Silt Loam (Hilly), Calculated Moisture Free.

Laboratory number	36013 Surface Soil	36014 Subsoil.
Fine Gravel 2 to 1 mm	0 %	0 %
Coarse Sand 1 to .5 mm	0.4 "	0 "
Medium Sand .5 to .25 mm	0.3 "	.2 "
Fine Sand .25 to .1 mm	0.9 "	.3 "
Very Fine Sand .1 to .05 mm	4.7 "	5.1 "
Silt .05 to .005 mm	80.3 "	72.0 "
Clay .005 and under	12.6 "	24.6 "
Total	99.2 "	102.2 "

All passed through the 2 mm. sieve.

The mechanical analysis shows it to be decidedly a silty soil with practically twice as much clay in the subsoil as in the surface, while there is a larger per cent of silt in the surface. The sample of surface soil represents the first six inches and that of the subsoil the succeeding twelve inches.

The following table contains the results of the chemical analysis of the same samples, surface and subsoil:

TABLE III.—Chemical Analyses of the Yellow Silt Loam (Hilly). Calculated Moisture Free.

Laboratory number	36013 Surface Soil.	36014 Subsoil.
Total nitrogen	.056 %	.038 %
Total phosphoric acid	.0613 "	.0863 "
Phosphoric acid dissolved by n|5 nitric acid	.0024 "	.0019 "
Total potash	1.779 "	1.989 "
Potash dissolved by n|5 nitric acid	.013 "	.0112 "
Lime dissolved by same	.087 "	.061 "
Acidity calculated as lime required to neutralize	.005 "	.0945 "

In the following discussions the quantity of phosphoric acid, potash and lime dissolved by one-fifth normal (n|5)

nitric acid will be designated "available," because we think this may be taken as a measure of what is immediately available as plant food.

Over an acre to a depth of six inches, figuring from their apparent specific gravity, there are in the silt loams of this area approximately 1,900,000 pounds of soil. Figuring on this basis and expressing the amount of plant food in terms of the elements, this soil contains, in the first six inches, 1,064 pounds of total nitrogen, 509 pounds of total phosphorus and 28,055 pounds of total potassium, while, in the subsoil (6 inches to 18 inches, 3,800,000 pounds), there are 1,444 pounds of total nitrogen, 1,421 pounds of total phosphorus and 62,733 pounds of total potassium.

In the surface soil, the fifth normal nitric acid solution shows an availability of 3.9 per cent of the total phosphorus, or 19.9 pounds per acre, and 0.73 per cent of the total potassium, or 205 pounds per acre, while in the subsoil it shows an availability of 2.2 per cent of the total phosphorus, or 31.6 pounds per acre, and 0.56 per cent of the total potassium, or 353 pounds per acre.

This soil is poor in both total nitrogen and total phosphorus, but a fair proportion of the total phosphorus is soluble in fifth normal nitric acid, or "available." While it contains a large percentage of total potassium, only a small proportion of this is soluble in fifth normal nitric acid, or "available." Both the surface and subsoil are poor in lime (CaO), yet the surface soil is only slightly acid, requiring only 95 pounds of lime (CaO) to the acre to neutralize the acid, while the subsoil (3,800,000 pounds) requires 3,591 pounds, or about two tons.

Yellow Silt Loam (Undulating).

This type includes 58,432 acres or 27.3 per cent of the entire county. It is embraced mainly in two areas, one lying between the hilly area and the Henderson County line on the north, and the other southwest of this area. Other small outlying tracts are found through the hilly region.

This type is gently rolling and occupies the low upland areas, the gentle slopes and the broad ridges. In its origin it is very similar to the "hilly" region, though the soil is much deeper, ranging from 12 to 20 feet to native rock, while on the hills, native rock is sometimes found at from 3 to 5 feet; as a rule, however, from 5 to 10 feet.

The surface soil is a yellow or grayish silt loam varying in depth from 6 to 12 inches. It is a very loose, open soil and usually contains more organic matter than the soil on the hills. It usually lies rolling enough to afford fairly good natural drainage, although, in the more flat portions, the soil becomes quite gray in color, indicating, of course, the need of artificial drainage.

The subsoil is of about the same nature as that of the hills, being slightly more gray in color in the flat or level areas.

The native vegetation on this type of soil seems to differ somewhat from that of the hills. On the hills the oaks seem to predominate, while on the undulating soil maple and beech are found more abundantly.

Practically the same crops are grown on the soil of this type as on the hills, with, however, much better yields. Corn yields from 20 to 50 or 60 bushels per acre, wheat from 10 to 30 or 35 bushels and tobacco from 1,000 to 1,500 pounds. The writer found in this area one farmer who produced in 1910, 33 bushels of wheat per acre on 35 acres, and harvested in the summer from the same field one ton of clover per acre, which had been sown in the spring of the same year. The soil had been fertilized and manured, which seems necessary in recent years, if clover is to be successfully grown on either of these types of soil. This undulating land sells at from $20.00 to $75.00 per acre, the price depending on the location, state of cultivation, etc. In spite of the fact that this land lies well, there are to be found fields that, through lack of care, have gullied quite badly.

Below are given the physical and chemical analyses of

two samples of both surface and subsoil from this area. No. 36018 is the subsoil of No. 36017, and 36026, of 36025:

TABLE IV.—Mechanical Analyses of the Yellow Silt Loam (Undulating) Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36017	36025	36018	36026
Fine Gravel 2—1 mm	2.1	1.4%	1.5	1.0%
Coarse Sand 1—.5 mm	2.5	1.5 "	2.0	1.0 "
Medium Sand .5—.25 mm	0.9	0.7 "	0.8	0.6 "
Fine Sand .25—.1 mm	1.6	1.2 "	1.4	1.1 "
Very fine Sand .1—.05 mm	6.2	3.9 "	5.2	3.7 "
Silt .05—.005	76.5	82.8 "	72.3	67.8 "
Clay .005 and under	8.9	9.5 "	17.1	22.4 "
Total	98.7	101.0 "	100.3	97.6 "

Sample 36018 left a little sandstone gravel on the 2 mm sieve, amounting to 0.06% of the original. The other samples passed through entirely.

TABLE V.—Chemical Analyses of the Yellow Silt Loam (Undulating), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36017	36025	36018	36026
Total nitrogen	.074	.075	.033	.040
Total phosphoric acid	.0925	.0913	.0888	.0725
Phosphoric acid dissolved by n|5 nitric acid	.0027	.0011	.0022	.0006
Total potash	1.454	1,613	1.648	1.865
Potash dissolved by n|5 nitric acid	.0069	.0068	.0065	.0091
Lime dissolved by n|5 nitric acid	.084	.115	.073	.137
Acidity, calculated as lime required to neutralize	.0065	.004	.108	.0955

These samples are typical of the area from which they were taken, and, as shown by the foregoing tables, are very similar in both their physical and chemical nature.

Figuring the average for the two samples on the acre basis (0 to 6 inches, 1,900,000 pounds of soil) there are in the surface soil 1,416 pounds of total nitrogen, 763 pounds of total phosphorus and 24,184 pounds of total potassium, while in the subsoil (6 to 18 inches, 3,800,000 pounds), from the average of the two samples, there are 1,387 pounds of total nitrogen, 1,339 pounds of total phosphorus and 55,400 pounds of total potassium.

In the surface soil the fifth normal nitric acid solution shows an average availability of 2.07 per cent of the total phosphorus, or 15.8 pounds per acre, and 0.45 per cent of the total potassium, or 110 pounds per acre, while for the average of the two subsoils (6 to 18 inches, 3,800,00 pounds) it shows 1.7 per cent of the total phosphorus or 23.3 pounds per acre, and 0.44 per cent of the total potassium, or 246 pounds per acre.

This soil, also, is poor in total nitrogen and total and available phosphorus, and rich in total potassium but low in available potassium.

The content of lime and acid in this soil compares with that of the soil described above as the hilly phase of this type. To neutralize the acid in the surface, 1,900,000 pounds, requires 100 pounds of lime, while 3,867 pounds are required to neutralize the acid in the succeeding 12 inches (3,800,000).

Gray Silt Loam (Bottom).

In the Western Coal Field there are hundreds of square miles of this low bottom land, 84.8 square miles of which are found in Webster County. This represents 54,272 acres or 25.3 per cent of the entire county. It lies mainly along the small streams and has been derived chiefly from the immediate upland. A good deal of this type is of recent origin, having been formed since the land was cleared and may be

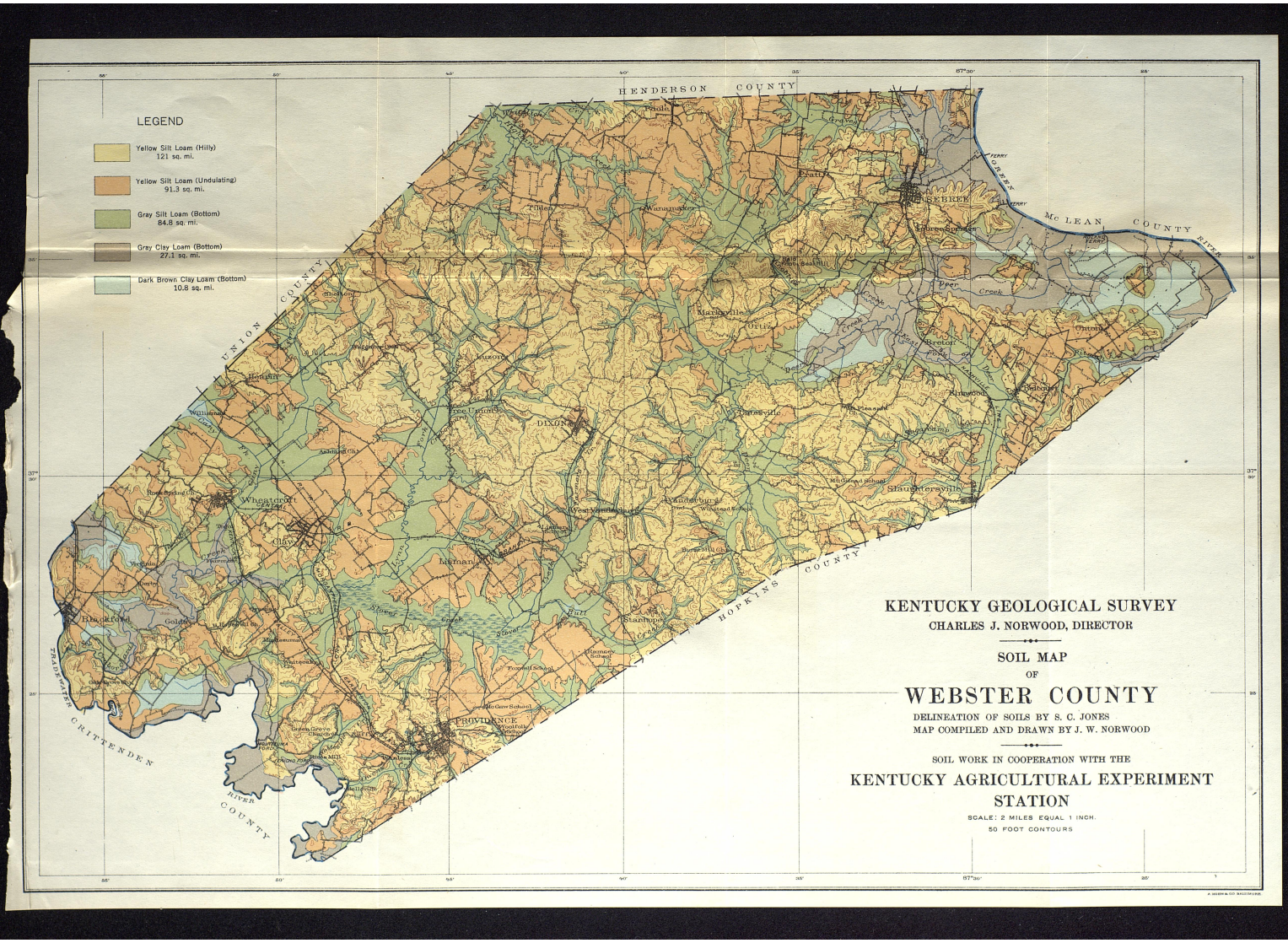
attributed largely to the hand of man in the increase of surface erosion due to cultivation of the uplands.

The surface soil is in the main a gray or yellowish silt loam, usually eight inches or more in depth, underlain by an incoherent silt of mealy texture. However, in the vicinity of the other types where back-water from the larger streams has played a part in soil formation, some variations have been introduced. Such areas are found on Slover Creek, Caney Fork and Deer Creek. Here the soil is underlain by a bluish or grayish loam, in places forming the surface soil. Generally, however, the surface is covered more or less with wash from the upland which gradually becomes deeper year by year.

With the exception of the narrow bottoms at the heads of the streams in the hilly area, the bottoms of this type are rather broad and low and the great problem concerning their agricultural value is that of drainage. A large proportion of the area in these bottoms is wet and swampy, and except during dry seasons crops are drowned out. This land can largely be reclaimed by a well planned system of ditching and tiling. Some ditching has been done in the way of straightening and deepening streams, but so far, little tiling has been done.

Because of the high price of tile, the cost of laying and the doubt as to the value of drainage, the farmers are, as a rule, rather reluctant in attempting artificial drainage. These bottoms are timbered with a growth of black oak, red oak, sweet and black gum, sycamore and elm. The two varieties of gum are especially characteristic of the low wet areas.

Corn and hay are practically the only crops grown on this type. Tobacco is sometimes grown on the higher and better drained bottoms. Hay is made from timtohy and from cow peas and wild grasses mixed. The average yield of corn and hay is low because of poor drainage. Land well drained will produce from 30 to 50 bushels of corn per acre, while the average yield is not more than 15 bushels per acre, and hay, of course, is likewise low in yield.



KENTUCKY GEOLOGICAL SURVEY

CHARLES J. NORWOOD, DIRECTOR

SOIL MAP

OF

WEBSTER COUNTY

DELINEATION OF SOILS BY S. C. JONES

MAP COMPILED AND DRAWN BY J. W. NORWOOD

SOIL WORK IN COOPERATION WITH THE

KENTUCKY AGRICULTURAL EXPERIMENT STATION

SCALE: 2 MILES EQUAL 1 INCH.

50 FOOT CONTOURS

The value of land in these bottoms ranges from $10.00 to $50.00 per acre, the price varying with location, state of cultivation and drainage conditions.

Below are given the physical and chemical analyses of two samples of both surface and subsoils from this area. Sample 36016 is the subsoil of 36015, and 36020 that of 36019.

TABLE VI.—Mechanical Analyses of Gray Silt Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36015	36019	36016	36020
Fine Gravel 2—1 mm ..	0.2	0.5 %	1.4	0.8 %
Coarse Sand 1—.5 mm..	0.7	0.6 "	0.6	0.8 "
Medium Sand .5—.25 mm	0.5	0.6 "	0.2	0.6 "
Fine Sand .25—.1 mm...	1.5	2.2 "	0.9	2.0 "
Very Fine Sand .1—.05 mm...	8.3	13.4 "	5.5	18.6 "
Silt .05—.005 mm.....	82.1	70.0 "	80.2	68.2 "
Clay .005 and under....	8.2	11.5 '	11.8	9.6 "
Total	101.5	98.8 "	100.6	100.6 "

Sample No. 36016 left a little sandstone gravel on the 2 mm sieve, amounting to 0.25 per cent. of the original. The other samples passed through entirely.

TABLE VII.—Chemical Analyses of the Gray Silt Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36015	36019	36016	36020
Total nitrogen	.087	.086	.028	.057
Total phosphoric acid	.100	.090	.065	.080
Phosphoric acid dissolved n|5 nitric acid	.0085	.004	.0025	.0039
Total potash	1,576	1.76	1.760	1.702
Potash dissolved by n|5 nitric acid	.0045	.0062	.0048	.0045
Lime dissolved by n|5 nitric acid	.105	.191	.097	.165
Acidity, calculated as lime required to neutralize.	.002	.001	.005	.005

This soil, like those of the upland types, contains a large per cent of silt, as shown by the mechanical analysis.

Figuring the average of the two samples on the acre basis (0 to 6 inches, 1,900,000 pounds of soil) there are in the surface soil 1,644 pounds of total nitrogen, 789 of total phosphorus and 26,304 pounds of total potassium, while in the subsoil (6 to 18 inches, 3,800,000 pounds) for the average of the two samples there are 1,615 pounds of total nitrogen, 1,204 pounds of total phosphorus and 54,596 pounds of total potassium.

In the surface soil the fifth normal acid solution shows an average availability of 6.6 per cent of the total phosphorus, or 51.9 pounds per acre, and 0.32 per cent of the total potassium, or 84.4 pounds per acre, while for the average of the two subsoils (6 to 18 inches, 3,800,00 pounds) it shows 4.4 per cent of the total phosphorus, or 53.1 pounds per acre, and 0.27 per cent of the total potassium or 147 pounds per acre. This soil is much richer in available phosphorus and much poorer in available potassium than the soils of the upland.

ERRATUM

For the heading "Gray Silt Loam," page 151, read *Gray Clay Loam.*

It is also decidedly richer in lime and is not as strongly acid. The surface six inches requires only 28.5 pounds of lime to neutralize the acid in an acre, while the succeeding twelve inches requires 190 pounds.

Gray Silt Loam (Bottom).

In the area included in this type there are 27.1 square miles or 17,344 acres or 8.1 per cent of the entire county.

Taken as a whole, the soil is the poorest of any of the types recognized in the county, and the most variable in its physical characteristics. It is found in the bottoms in the eastern portion of the county along Green River and Deer Creek and in the western portion in the bottoms along Tradewater River and Craborchard Creek.

It differs in origin from the bottom (Gray Silt Loam) lying along the small streams in that the materials composing the soil have been largely transported from the Chester, St. Louis and Waverly areas by the Green and Tradewater Rivers.

The topography of this type is much more broken, especially near the streams, than either of the other bottom soils, having in some places undergone considerable erosion.

The natural drainage of much of this area is fairly good, but away from the streams the more level parts would be greatly benefitted by artificial drainage. A great deal of the land along Tradewater River, Craborchard Creek and Deer Creek is overflowed during high water, while a large proportion lying along Green River is seldom overflowed.

Although other phases of soil are included, the larger portion as outlined in the area may be classed as a gray clay loam, locally known as "post oak." The surface is a gray loam underlain with a waxy clay subsoil usually of a bluish gray or yellow mottled color. Over much of the flat land, three or four inches of silty material is often found covering the surface and in places along Green and Tradewater Rivers are found patches of loam soils.

The growth of timber on this soil is usually scrubby and consists of post oak, red oak and hickory. Corn and hay are

practically the only crops grown and the yields are very low, that for corn averaging from 12 to 15 bushels and hay about one-half ton per acre.

Only a small per cent of the land is under cultivation and is valued very low. Sample 36028 is the subsoil of 36027, and 36030 that of 36029.

TABLE VIII.—Mechanical Analyses of Gray Clay Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36027	36029	36028	36030
Fine Gravel 2—1 mm....	2.8	2.6 %	2.2	0.0 %
Coarse Sand 1—.5 mm...	5.2	2.4 "	3.0	0.8 "
Medium Sand .5—.25 mm	2.6	1.6 "	2.0	0.6 "
Fine Sand .25—.1 mm...	6.4	3.0 "	3.8	0.8 "
Very Fine Sand .1—.05 mm....	7.1	7.5 "	4.4	4.8 "
Silt .05—.005 mm.....	53.1	47.1 "	51.5	38.0 "
Clay .005 and under.....	22.3	34.7 "	32.0	54.2 "
Total	99.5	98.9 "	98.9	99.2 "

Samples 36027 and 36028 left a little sandstone gravel on the 2 mm sieve, amounting to 0.10% and 0.16% of the original, respectively. The other two samples passed through entirely.

TABLE IX.—Chemical Analyses of the Gray Clay Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36027	36029	36028	36030
Total nitrogen	.099	.103	.054	.070
Total phosphoric acid.....	.1775	.0988	.1288	.0838
Phosphoric acid dissolved by n|5 nitric acid....	.0018	.0019	.0010	.0027

Total potash	1.973	2,365	2.221	2,752
Potash dissolved by n|5 nitric acid	.0082	.014	.0076	.0182
Lime dissolved by n|5 nitric acid	.098	.095	.038	.114
Acidity, calculated as lime required to neutralize.	.096	.2135	.295	.426

The two samples representing this type differ considerably in physical characteristics. The one containing the largest percentage of silt and the smallest percentage of clay was taken from near the border of the area and has been somewhat modified by an intermixture of material from the neighboring type.

As determined by the apparent specific gravity, the soil of this type weighs to the acre, six inches deep, 1,800,000 pounds, while the succeeding twelve inches weighs approximately 3,700,000 pounds.

Figuring on this basis, and using the mean of the two analyses, the surface soil (0—6 inches, 1,800,000 pounds) contains 1,818 pounds of total nitrogen to the acre, 1,087 pounds of total phosphorus and 32,405 pounds of total potassium, while the subsoil (6—18 inches, 3,700,000 pounds) contains 2,294 pounds of total nitrogen, 1,718 pounds of total phosphorus and 76,360 pounds total potassium.

In the surface soil the fifth normal nitric acid solution shows an average availability of only 1.01 per cent of the total phosphorus or 11.1 pounds per acre, and 0.51 per cent of the total potassium or 166 pounds per acre, while for the subsoil (6—18 inches) it shows 1.74 per cent of the total phosphorus or 29.9 pounds per acre, and 0.52 per cent of the total potassium or 396 pounds per acre.

Although this soil is comparatively rich in total plant food, it is generally recognized as a poor unproductive soil, which is perhaps due to the low content of available plant food, especially the low available phosphorus, as well as to its high acidity, it being low in lime and strongly acid. According to the acidity determined, the surface soil requires 2,786

pounds of lime per acre, and the subsoil (6—18 inches) 13,339 pounds of lime to neutralize the acid.

Dark Brown Clay Loam (Bottom).

Of this type there are 10.8 square miles or only 3.2 per cent of the whole county. It represents the most fertile land in the county and is found in practically the same localities as the Gray Clay Loam. It is of a similar origin, but appears to be more recent since it has a higher altitude and is underlain by a material resembling very much the Gray Clay Loam. It may have covered much of the territory now occupied by the Gray Clay Loam but has long since been eroded away.

This soil is a dark brown clay loam rather impervious and difficult to work when poorly drained. It bakes hard in the sun and when plowed wet forms compact clods which crumble and fall to pieces like quick lime when rain falls on them. The subsoil is usually plastic and has a dark blue gray color. The dark color of this soil is due to an accumulation of vegetable matter. Only the areas near the upland along the small streams are subject to overflow, but the land lies level and is not fit for cultivation until drained. Twenty years ago this land was looked upon as being worthless, but recently much of it has been cleared and brought under cultivation. In the area in the eastern portion of the county in the Green River bottom, are now to be found farms valued at $50.00 and $60.00 per acre. In this tract much land has been drained. The native forest growth consists of sweet gum, oak and hickory.

Corn, wheat and hay are grown on this soil and occasionally tobacco, which, however, is usually of a very poor quality. Corn yields from 60 to 75 bushels, wheat from 20 to 30 bushels and hay two tons per acre on land tile drained. Hay is made from clover and timothy. The soil seems especially adapted to the growth of both.

TABLE X.—Mechanical Analyses of the Dark Brown Clay Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches	Subsoil 6—18 inches
Laboratory number	36023	36024
Fine Gravel 2—1 mm	0.8 %	1.4 %
Coarse Sand 1—.5 mm	2.2 "	6.2 "
Medium Sand .5—.25 mm	2.6 "	5.2 "
Fine Sand .25—.1 mm	9.2 "	9.8 "
Very Fine Sand .1—.05 mm	13.4 "	5.7 "
Silt .05—.005 mm	46.7 "	48.5 "
Clay .005 and under	21.1 "	20.2 "
Total	96.0 "	97.0 "

The 2 mm sieve removed from samples 36023 and 36024 some gravel consisting mainly of rounded sandstone fragments and quartz pebbles and amounting to 0.44% and 3.80% of the original, respectively. Samples 36021 and 36022 passed through entirely.

TABLE XI.—Chemical Analyses of Dark Brown Clay Loam (Bottom), Calculated Moisture-free.

	Surface Soil 0—6 inches		Subsoil 6—18 inches	
Laboratory number	36023	36021	36024	36022
Total nitrogen	.163	.226	.118	.163
Total phosphoric acid	.0963	.1200	.075	.1163
Phosphoric acid dissolved by n|5 nitric acid	.0084	.0061	.0059	.0057
Total potash	2.144	2.737	2.221	2.748
Potash dissolved by n|5 nitric acid	.0133	.0278	.0127	.0199
Lime dissolved by n|5 nitric acid	.431	.526	.417	.501
Acidity, calculated as lime required to neutralize	.002	.001	.0025	.002

Sample 36022 is the subsoil of 36021, and 36024 that of 36023.

The chemical analysis, in harmony with the crop yields, indicates in this instance a fertile soil. In fact, this is decidedly the most fertile soil in Webster County.

As determined by the apparent specific gravity, the surface soil to a depth of six inches over an acre weighs approximately 1,750,000 pounds, while the suceeding twelve inches weighs approximately 3,600,000 pounds.

Figuring on this basis, from the average of the two analyses, the soil on an acre, to the depth of six inches, contains 3,403 pounds of total nitrogen, 827 pounds of total phosphorus and 36,174 pounds of total potassium, while the subsoil (6—18 inches) contains 5,058 pounds of total nitrogen, 1,505 pounds of total phosphorus and 74,237 pounds of total potassium.

In the surface soil the fifth normal nitric acid solution shows an average availability of 6.7 per cent of the total phosphorus or 55.4 pounds per acre and 0.82 per cent of the total potassium or 298 pounds per acre, while in the average subsoil (6—18 inches) it shows 6 per cent of the total phosphorus or 91 pounds per acre and 0.66 per cent of the total potassium or 487 pounds per acre.

This soil is fairly rich in both total and available plant food and is also quite rich in lime, and according to the acid test, only 26 pounds of lime is required to neutralize the surface (0—6 inches) and 81 pounds to neutralize the subsoil (6—18 inches).

Agricultural Conditions.

The land of Webster County is assessed at $1,844,685 or 48 per cent of the total taxable property, which is $3,843,550. Figuring on this basis, land is assessed at an average of $8.64 per acre, which is in all probability not far from one-half of the real value.

In many counties in the State, land constitutes more than one-half of the total wealth, but in Webster County at present, mining interests predominate.

Formerly there was much large timber which, had it been preserved, would to-day be worth far more than the land, but because of a lack of thought and foresight it has been wasted until at present but little remains. In the upland there is practically none, while some small tracts are yet to be found in the bottoms.

Webster is at present, and has long been, a great tobacco producing county. Hopkins, Union, Henderson, Crittenden and Webster counties produce a dark tobacco, which is fire cured. These five counties produce annually an average of about twenty-five million pounds. For the last few years they have been selling together, and received in 1908, 8 cents and 1909, 7 cents per pound, the difference in price being due to a difference in quality.

In Webster County practically all of the tobacco is grown in the two upland soil types. Through the use of the poor methods that have been practiced in handling these soils, tobacco culture is largely responsible for their depleted and worn condition. The growing of tobacco might have been made a profitable industry, and at the same time the fertility of the soil might have been maintained, had conservative methods of cultivation, fertilization, and rotation of crops been employed.

It has been a custom to clear land and cultivate continuously for a few years until no longer profitable yields are obtained and then, to hold up the yields, the use of low grade commercial fertilizers has been resorted to, which has, in fact, served to rob the soil more rapidly of its fertility. After reaching this state, the land has often been thrown out without being sown in grass, and new fields have been cleared and this process repeated. Even when grass was sown, it has been difficult to get a growth and the soil of the cleared uplands has, consequently, suffered greatly from washing. This improvident kind of farming has been practiced until new land is no longer to be had. Many of the farmers who have participated in this wastefulness have lived to face the punishment of their sins. They have not only committed a crime

against themselves but against future generations as well. If with new and fertile soils they could not live and preserve the fertility of their lands, how now with worn and infertile soils are their sons to live and at the same time reclaim these worn lands? The solution of the problem depends upon the farmers themselves. The effort here is to present such information as will enable them to reach the solution. The conditions referred to above are especially true of the hilly type. However, they are true to some extent of the undulating soils.

Through practicing a well planned system of diversified farming, these worn lands may eventually be made profitable. The uplands are especially adapted to fruit growing and particularly peaches and apples, which are not now profitable because the proper attention is not given to their care. The rougher portions should be planted in trees of a quick growth, such as locust, which in twenty years will begin to yield profits. The cultivated areas should remain in grass at least three-fourths of the time and more attention should be given to grazing.

At present, Japanese clover constitutes the chief grass for pasturage. It is a very valuable plant, both for grazing and for storing nitrogen in the soil, but it is inadequate for the former purpose, because it does not appear until late in the spring, disappears with the first frost in the fall and will not stand drouth. There are many kinds of valuable grasses which thrive under varying soil conditions, and some, no doubt, exist which, if introduced, would completely revolutionize stock raising in the Western Coal Field. Professor Garman of the Experiment Station, who has charge of the experimental work on grasses, suggests sheep fescue, orchard grass, red top and alsike clover for the upland silty soils.

According to the 1910 report of the Assessor of Webster County, there is, including all kinds of stock (horses, cattle, sheep and hogs) an average of one animal for every 14 acres of land, or less than seven head of stock for each one hundred acres in the county. While information from this source is

not absolutely reliable, it no doubt represents fairly well existing conditions. Such a system of live stock farming is entirely too extensive to be profitable, even on land as cheap as this.

When the proper attention is given to growing grasses, the rotating of crops with a judicious purchase and use of plant food on these soils, and when the bottom lands are reclaimed by artificial drainage, four times as much stock may be kept and agriculture may be made a profitable industry for Webster County.

Both the crop yields and the chemical analyses indicate a lack of plant food in all these soils, with the exception of the Dark Brown Clay Loam. Even in this, the per cent of phosphorus is less than is desirable. According to both the crop yields and its chemical nature, it would be classed as a fertile soil. But it is probable that the use of phosphate on it, most economically in the form of fine ground phosphate rock, would be beneficial.

By comparing the chemical analyses of the five types of soil in the tabulation given below, a number of interesting relations may be brought out. The analyses have been arranged in the order of lime requirement, as determined by the acidity test, beginning with the lowest.

The weights of soil to the acre, calculated from the apparent specific gravity, are: For the Dark Brown Clay Loam, first 6 inches, 1,750,000 pounds to the acre, and the next 12 inches 3,600,000 pounds to the acre; for the three Silt Loams, first 6 inches, 1,900,000 pounds, the next 12 inches, 3,800,000 pounds; for the Gray Clay Loam, first 6 inches, 1,800,000 pounds, and the next 12 inches, 3,700,000 pounds.

TABLE XII.—Plant Food in the Surface Soils (0 to 6 inches), Calculated in Pounds to the Acre.

	Total Nitrogen.	Total Phosphorus.	Phosphorus dissolved by N|5 nitric acid.	Total Potassium.	Potassium dissolved by N|5 nitric acid.	Lime dissolved by N|5 nitric acid.	Lime required to neutralize the acidity.
Dark Brown Clay Loam (Bottom)	3303.	826.	55.	35,441.	298.	8365.	26.
Gray Silt Loam (Bottom)	1644.	789.	52.	26,304.	84.	3912.	26.
Yellow Silt Loam (Hilly)	1064.	509.	20.	28,055.	205.	1653.	95.
Yellow Silt Loam (Undulating)	1416.	763.	16.	24,184.	110.	1891.	100.
Gray Clay Loam (Bottom)	1818.	1087.	11.	32,405.	166.	1737.	2785.
Average of 4 types, omitting the Dark Brown Clay Loam	1486.	787.	25.	27,737.	141.	2298.	

TABLE XIII.—Plant Food in the Subsoils (6—18 inches), Calculated in Pounds to the Acre.

	Total Nitrogen.	Total Phosphorus.	Phosphorus dissolved by N|5 nitric acid.	Total Potassium.	Potassium dissolved by N|5 nitric acid.	Lime dissolved by N|5 nitric acid.	Lime required to neutralize acidity.
Dark Brown Clay Loam (Bottom)	5040.	1488.	91.	73,502.	472.	16,524.	81.
Gray Silt Loam (Bottom)	1615.	1204.	53.	54,596.	147.	4,978.	190.
Yellow Silt Loam (Hilly)	1444.	1421.	32.	62,733.	353.	2,318.	3591.
Yellow Silt Loam (Undulating)	1387.	1339.	23.	55,400.	246.	3,420.	3867.
Gray Clay Loam (Bottom)	2294.	1718.	30.	76,360.	396.	2,812.	13339.

One very striking fact is that the amount of phosphorus soluble in the fifth normal nitric acid solution, assumed to be available, decreases as the acidity (lime required to neutralize the acidity) increases, with only one exception. This relation, however, does not hold in respect to the potassium. Roughly speaking, the soils showing most lime are least acid.

By considering the approximate amounts of plant food removed in farm produce, as given in the table below, the significance of these analyses may be more easily understood.

——Crops——		Pounds of Plant Food.		
Kind.	Amount per acre.	Nitrogen.	Phosphorus.	Potassium
Corn grain.....	50 bu.	50	8.5	9.5
Corn stover	1½ tons	24	3.0	26.0
Corn, whole crop		74	11.5	35.5
Wheat grain ..	25 bu.	35.5	6.0	6.5
Wheat straw ...	1¾ tons	12.5	2.0	17.5
Wheat, whole crop		48.0	8.0	24.0
Clover	2 tons	80.0	10.0	60.0

It will be seen that the total amount of potassium in these soils is greater in proportion to the amounts removed in corn, wheat and clover, than are the total amounts of either phosphorus or nitrogen in proportion to the amounts of these substances removed in the same crops. Omitting the Dark Brown Clay Loam, and taking the average of the figures for nitrogen, phosphorus and potassium in the surface soil of the 4 poorer types, we have 1,486 pounds of nitrogen, 787 pounds of phosphorus and 27,737 pounds of potassium to the acre in the first six inches of this average soil. Dividing these figures, respectively, by the weights of nitrogen, phosphorus and potassium in a 50 bushel crop of corn, (74, 11.5 and 35.5 pounds) we find that this supposed average soil contains to the acre, in the first 6 inches, 20 times as much nitrogen, 68 times as much phosphorus, and 781. times as much potassium as there is in a 50 bushel corn crop. Hence, measured by the requirements of such a crop, the total supply of potassium is 11 times as great as the total supply of phosphorus and 39 times as great as that of nitrogen.

This would seem to indicate that nitrogen is the limiting

element of fertility in these soils, which is perhaps true, especially on the upland soils where grain crops are grown, while where legumes are grown phosphorus would be the limiting element. It must be remembered, however, that the reserve supplies of nitrogen, phosphorus and potassium in soils do not become available with equal rapidity and this circumstance may have great influence on the result.

In studying the chemical nature of soils, not only the total amount of plant food, but its availability, also, should be considered. This is one of the questions relating to soil fertility that is being studied at the Experiment Station. By available plant food is meant that which is in a condition to be utilized by growing plants. As a rule, only a small proportion of the total plant food in a soil is in an available form.

The chemists of the Kentucky Experiment Station employ a "fifth-normal" nitric acid solution to extract from a soil the available phosphorus and potassium. This is a very weak acid solution and is supposed to take up just about the amount that is in a form to be utilized by growing plants. Of course, the acid coming in contact with all the soil grains may remove from a soil a much larger proportion of plant food than a plant could and such a test is arbitrary, and may not be an absolute measure of the available plant food, but its results seem to have considerable relative value.

By considering the amounts of phosphorus and potassium dissolved by N|5 nitric acid in the five types given in Table XII. above, it will be seen that the Dark Brown Clay Loam is the only soil that is rich in both available phosphorus and available potassium, and it has already been stated that it is by far the most fertile, as indicated by crop yields. It is also about twice as rich in total nitrogen, as the richest of the other four soils, and about three times as rich in lime.

Figuring the average for the other four types, there is practically twice as much available potassium in proportion to the amount of potassium removed by a 50 bushel crop as there is available phosphorus in proportion to the amount of phosphorus removed by such a crop. These relations are

much closer than in some of the limestone soils of the State, where even the total supply of potassium is only about two-thirds the amount in these soils.

According to the facts brought out by the chemical study of these soils, unbalanced conditions in regard to plant food seem to exist. If maximum crop yields are to be obtained and at the same time the soils remain fertile, their nitrogen and phosphorus content must be increased and a larger per cent of their great store of inert potassium made available.

In Webster County, thousands of dollars are expended annually for the low grade commercial fertilizers carrying only a small quantity of all three of these elements, especially nitrogen and potassium, when, as the evidence at hand indicates, really only phosphorus should be purchased. Because of the high price of commercial nitrogen, the farmer can not afford to buy it for general farm crops. It can be added to the soil much more cheaply from the large store in the atmosphere by growing clover and other legumes, and at the same time accumulate organic matter, which will aid in rendering available the inert phosphorus and potassium of the soil. The legumes may be turned under directly or fed as hay and the manure returned to the soil, the latter method being regarded the more profitable. Then, assuming that potassium may be made available, only phosphorus remains to be purchased. The phosphorus may be purchased in the form of acid phosphate, bone meal or finely ground rock phosphate. The ground rock phosphate is much the cheapest form and will, no doubt, be practically as profitable with the proper system of crop rotation employed.

While the first 6 inches of only one of these soils is strongly acid, the application of lime would, in all probability, greatly improve them all, except the Dark Brown Clay Loam, for the growth of leguminous crops. In all these soils, except this, the subsoil is decidedly acid.

Limestone is scarce in the western coal field, but all around its border occurs an abundance of very pure limestone, which will furnish fine material for correcting acid soils when

finely ground. There would, no doubt, be a market for such material, if it were only being produced.

Of the three types of bottom soil, there are, all together, about 78,500 acres, or 36.6 per cent of the whole area. Of this amount, the larger proportion is practically worthless until reclaimed by artificial drainage, which will, no doubt, increase the yielding capacity tenfold. So far, the farmer has been slow to take to the drainage proposition, because of the cost involved. As a rule, he is not ready to look ahead, but must see an immediate income for the money expended before he is willing to invest.

At present, the cost of drainage is decidedly more than it should be because of the great distance tile must be transported. There is, no doubt, an abundance of clay in the county suitable for the production of tiling which, if worked by a plant of small capacity, would in all probability be a profitable industry for the operator and at the same time a big saving for the farmer.

Results of Pot Culture Experiments.

While the soil with which the following results were obtained is not a Webster County soil, it is in every respect typical of the western coal field and has practically the same origin as those of the upland types in Webster.

It was collected from near Bremen, Muhlenberg County, in the fall of 1909 and may be correlated with the yellow silt loam (undulating) soil area of Webster County. Only the surface soil was taken, to the depth of 6 inches.

Its chemical nature, as determined by analysis, is very similar to that of the Webster County soil. It will be noted, however, that the amount of available potassium is about twice as large as in those from Webster County. Figuring on the same basis and expressing the plant food content in terms of elements, this soil contains to the acre, in the first 6 inches, 1,577 pounds of total nitrogen, 623 pounds of total phosphorus and 25,705 pounds of total potassium. The fifth-normal nitric acid solution showed an availability of 1.86 per cent of the

total phosphorus, or 11.6 pounds per acre, and 1.6 per cent of the total potassium, or 411 pounds per acre. The acidity test showed 47.5 pounds of lime required to neutralize the acid in the first six inches.

In the fall of 1909, three series of pot culture experiments were begun with this soil, in the Experiment Station greenhouse. Series No. I. was planted in tobacco; Series No. II. in clover, and Series No. III. in wheat. After harvesting the crops, the soil in the pots was allowed to become dry during the summer. In the fall of 1910, the soil of each pot was emptied out, worked over and the same kind and amount of fertilizer mixed with it as before, after which it was returned to its proper pot, moistened and the seed planted. Series No. I. was planted in oats; Series No. II. in tobacco, and Series No. III. in clover.

Series Nos. I. and III. were in 4-gallon jars, while Series No. II. was in 2-gallon jars. Into each 4-gallon jar, 15,000 grams, or about 30 pounds of soil, were put, and one-half that amount into each 2-gallon jar.

Whether used alone or in combination, the following amounts and kinds of plant food were thoroughly mixed with the soil of the 4-gallon jars, before planting, viz.: Ground limestone (98%) 15. grams, containing 8¼ grams of pure lime; dried blood (12%) 6½ grams, containing 0.78 gram nitrogen to supply nitrogen. "Banner Dissolved Bone" (24% P_2O_5) 3.8 grams containing 0.4 grams phosphorus or 20.0 grams fine ground Tennessee phosphate (28% P_2O_5) containing 2.46 grams of phosphorus to supply that element. Sulphate of potash (54% K_2O) 3.2 grams, containing 1.43 grams potassium to supply potassium. Manure, 35 grams of the dried and powdered material.

The 2-gallon pots received half these quantities.

In the following tables, N. stands for nitrogen. P. for phosphorus and K. for potassium. Where there are two pots without fertilizer, the average of their yields is used in calculating the increase. The minus sign (—) before a number

in the columns headed "Increase" means that there was *decrease,* instead of increase, in the yield.

SERIES No. I. 1909-10, Tobacco. 4-gallon pots.

Pot No.	Fertilizer.	Yield of Stalks and Leaves. Grams per pot.	Increase Grams per pot.	Per Cent.
352	none	12.8		
353	none	14.7		
354	limestone	12.0	—1.75	—12.7
355	N	20.3	6.55	47.6
356	P	10.3	—3.75	—27.2
357	K	13.8	.05	0.4
358	N & P	21.1	7.35	53.4
359	N & K	21.2	7.45	54.2
360	P & K	7.9	—5.85	—42.5
361	N, P & K	22.1	8.35	60.7
362	rock phosphate	13.2	— .55	— 4.5
363	manure	9.7	—4.05	—29.4
364	rock phosphate & manure	10.3	—3.45	—25.1

SERIES No. I. 1910-11, Oats, after Tobacco. 4-gallon pots.

Pot No.	Fertilizer.	Whole Crop Yield Grams per pot.	Whole Crop Increase Grams per pot.	Grain Yield Grams per pot.	Grain Increase Grams per pot.	Per Cent.
352	none	50.		10.4		
353	none	45.		9.8		
354	limestone	61.	13.5	13.5	3.4	33.6
355	N	63.	15.5	15.0	4.9	48.5
356	P	83.	35.5	15.0	4.9	48.5
357	K	64.	16.5	11.4	1.3	12.9
358	N & P	104.5	57.0	27.7	17.6	174.3
359	N & K	82.0	34.5	18.7	8.6	85.1
360	P & K	86.0	38.5	14.4	4.3	42.2
361	N, P & K	124.0	76.5	25.0	14.9	147.5
362	rock phosphate	68.5	21.0	13.4	3.3	32.7
363	manure	93.5	46.0	16.5	6.4	63.4
364	rock phosphate & manure	84.0	36.5	15.4	5.3	52.4

SERIES No. II. 1909-10, Clover. 2-gallon pots.

Pot No.	Fertilizer	Weight of 3 cuttings. Grams per pot.	Increase Grams per pot.	Per Cent.
366	none	16.		
367	limestone	20.4	4.4	27.5
368	N	19.4	3.4	21.3
369	N & limestone	15.7	—0.3	—1.9
370	P	32.1	16.1	100.6
371	P & limestone	43.1	27.1	169.4
372	K	21.7	5.7	35.6
373	K & limestone	19.8	3.8	23.8
374	N & P	31.2	15.2	95.0
375	P & K	24.8	8.8	55.0
376	N & K	15.3	—0.7	—4.4
377	N, P & K	35.1	19.1	119.8
378	rock phosphate	30.8	14.8	92.5
379	manure	25.7	9.7	60.6
380	manure & rock phosphate	27.6	11.6	72.5
381	manure & limestone	25.0	9.0	56.3

SERIES No. II. 1910-11, Tobacco after Clover. 2-gallon pots.

Pot No.	Fertilizer	Stalks & Leaves Grams per pot	Increase Grams per pot	Per Cent.
365	none	3.8		
366	none	3.7		
367	limestone	5.0	1.25	33.3
368	N	6.2	2.45	65.3
369	N & limestone	5.3	1.55	41.3
370	P	4.6	.85	22.7
371	P & limestone	5.5	1.75	46.9
372	K	7.3	3.55	94.7
373	K & limestone	4.5	.75	20.0
374	N & P	7.0	3.25	86.7
375	P & K	1.1	—2.65	—70.7
376	N & K	5.9	2.15	57.3
377	N, P & K	7.5	3.75	100.0
378	rock phosphate	7.4	3.65	97.3
379	manure	9.5	5.75	153.3
380	manure & rock phosphate	7.6	3.85	102.4
381	manure & limestone	4.2	.45	12.0

SERIES No. III. 1909-10, Wheat. 4-gallon pots.

Pot No.	Fertilizer.	Whole Crop Yield Grams per pot.	Whole Crop Increase Grams per pot.	Grain Yield Grams per pot.	Grain Increase Grams per pot.	Per Cent.
382	none	34.3		11.8		
383	none	35.5		12.0		
384	N	41.5	6.6	15.2	3.3	27.7
385	P	44.6	9.7	14.6	2.7	22.7
386	K	47.7	12.8	15.0	3.1	26.1
387	N & P	70.4	35.5	22.5	10.6	89.1
388	N & K	61.2	26.3	20.6	8.7	73.1
389	P & K	50.6	15.7	16.2	4.3	36.1
390	N, P & K	74.4	39.5	26.3	14.4	121.0
391	rock phosphate	45.6	10.7	15.7	3.8	31.9
392	manure	44.5	9.5	16.2	4.3	36.1
393	manure & rock phosphate	36.3	1.4	14.9	3.0	25.2

SERIES No. III. 1910-11, Clover after wheat. 4-gallon pots.

Pot No.	Fertilizer.	1st cutting Grams per pot.	2d cutting Grams per pot.	Total Grams per pot.	Increase Grams per pot.	Increase Per Cent. Per Cent.
382	none	13.	15.2	28.2		
383	none	14.6	15.9	30.5		
384	N	14.7	15.5	30.2	8.5	2.9
385	P	45.8	24.6	70.4	41.05	139.9
386	K	12.4	17.0	29.4	.05	0.2
387	N & P	51.2	21.5	72.7	43.35	147.7
388	N & K	17.7	19.3	37.0	7.65	26.1
389	P & K	49.3	22.0	71.3	41.95	143.0
390	N, P & K	44.0	25.5	69.5	40.15	136.8
391	rock phosphate	32.2	21.0	53.2	23.85	81.3
392	manure	46.5	25.0	71.5	42.15	143.6
393	manure & rock phosphate	36.5	24.5	61.0	31.65	107.8

These results are reported here as being interesting and suggestive of what may be expected from the use of fertilizers in the field, though it is to be remembered that pot experiments and field results are not always concordant.

As the experiments are being continued, a discussion of them will not be attempted at this time. It may be noted, however, that, on the whole, phosphorus decidedly increased

the yields of wheat, oats and clover, but not that of tobacco. That nitrogen decidedly increased the yields of wheat, oats and tobacco, but not that of clover. That potassium moderately increased the yields of wheat and oats and slightly increased that of clover, but did not have a marked effect on that of tobacco. Rock phosphate, used alone, gave consistent gains, except with tobacco. Used with manure, however, its effect seems to have been negative, contrary to the usual teaching. Limestone produced moderate increase with oats and clover and with tobacco following clover. Used with phosphorus on clover there was a decided increase over the pot where phosphorus alone was tried.

KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY

BULLETIN NO. 163

CORN PRODUCTION

LEXINGTON, KENTUCKY,
MARCH, 1912.
171

Kentucky Agricultural Experiment Station.

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Correspondents will please notify the Director of changes in their post-office address, or of any failure to receive Bulletins.

Address
KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Kentucky.

BULLETIN No. 163

CORN PRODUCTION

By George Roberts and E. J. Kinney.

Introduction.

Attention has frequently been called to the low average yield of corn in this State. This average for the last ten years is 27 bushels per acre. Such crops barely pay for the expense of production, considering the farmer's wages at the lowest price paid for common labor. It is certainly desirable that the yield be increased to a point where the farmer may secure a reasonable profit from the crop. Kentucky is especially well situated in regard to climatic conditions for the growth of corn. The rainfall is usually abundant, and the growing season of sufficient length to perfectly mature the crop. Most of the soils are well adapted to corn, and, if properly managed, are capable of producing good yields. A few men in every community in the State, and upon every type of soil produce an average of from 50 to 75 bushels of corn per acre at a cost little above that required to produce a small yield. This proves that the yield in all parts of the State can be greatly increased if more improved methods are used.

The prospects for early improvement is encouraging. The Station receives many requests for information on various phases of corn production, which shows a general desire to make the growing of the crop more profitable.

In response to the demand for information the Agronomy Department has deemed it advisable to issue a general bulletin on corn production. In this an effort has been made to point out what are regarded as the chief causes for the low yields and to give in as brief a way as possible the methods of handling the crop which long and careful experiments and observations in this and other states have shown to give the best results.

Methods of improvement are conveniently discussed in the following order: 1. Soils and Fertilizers. 2. Improvement of Seed. 3. Cultural Methods. 4. Harvesting.

Soils and Fertilizers.

The condition of the soil has more influence upon the yield of corn than all other factors combined and the greatest improvement in yield may be expected from improving the conditions of the soil. Soils may be improved by increasing their fertility, by improving their physical condition, by drainage, by prevention of washing and in other ways. This is a very comprehensive subject, however, and can not be satisfactorily discussed in a few pages. It is a question of general farm practice without reference to any special crop. Only a few of the general principles of improvement, as suggested by the requirements of the corn crop, will be considered here. For more complete discussions of this most important problem, the reader is referred to Bulletin No. 140 of this Station.

The ideal soil for corn is a deep loose loam, well drained and well supplied with organic matter and plant food. Soils that are too poor to produce a good crop of corn should be improved before being planted to corn again. Other crops, grass, oats, etc., will pay much better until the fertility can be restored. This can not be profitably done by the use of commercial fertilizers alone. Small applications of mixed fertilizers, which are so often depended upon for increasing the yield on poor land, only result in more complete exhaustion of the soil. Permanent fertility can be profitably restored only by the use of stable manure, green manuring with leguminous crops, or both, supplemented by the intelligent use of commercial plant food to supply the mineral elements in which the soil may be deficient. In addition, soils may be acid, and lime must be applied to correct the acidity before leguminous crops will succeed. The price of commercial nitrogen prohibits its use except in small quantities as a stimulant. It is cheaply obtained by growing and plowing under leguminous crops or feeding them and returning the manure

to the land. The other two elements supplied by commercial fertilizers are phosphorus and potassium. Outside of the Blue Grass section the soils are generally deficient in phosphorus. The potassium content of Kentucky soils is usually sufficient for crop requirements when the soil is well supplied with organic matter, which helps to make the potassium available. The farmer should prove by actual test with growing crops which of these two elements is deficient in his soil, or if both are deficient, and supply the deficiency by the application of that element or elements in quantities sufficient for crop requirements. The failure of clover to grow well on any soil is one strong indication that lime is deficient.

Some Other Factors Which Reduce the Yield.

In addition to the general lack of plant food in soils, there are some minor factors which tend to further reduce the yield in many fields of corn. Small areas too wet to produce crops often exist. Such places may be tile drained at small expense and are apt to prove the most productive land in the field. Very thin or worn out spots often reduce the total yield. Such spots should have careful attention in order to bring them up to the same fertility as the rest of the field. On rolling lands, gulleys are often allowed to form. This is unnecessary if the lands are properly managed. Washing is seldom serious on soils well supplied with organic matter. In addition, such lands should always be protected with a cover crop during the times when not occupied by the regular crop. Some lands are so steep that washing can not be prevented by any means except terraces. It is not advisable to attempt growing cultivated crops on such lands. Overgrown fence rows, trees and stumps, all help to cut down the yield. Their removal is necessary before land can produce a maximum crop. In addition to reducing the yield, such features add much to the cost of cultivation by the inconvenience they cause and by entailing work without any returns. Fields should be laid off in regular form, and be free from obstructions, so as to permit the use of labor saving

machinery. Corn must be produced cheaply to prove profitable, and only under the above named conditions is cheap production possible.

Rotations for Corn.

When once the land has been brought up to a good state of fertility, every effort should be made to keep it productive. One factor in maintaining fertility is the adoption of a good rotation and adhering strictly to it. Rotations must vary under different systems of farming and with the kind of crops grown. The greater the difficulty in maintaining fertility, the more often should leguminous crops be grown. A rotation should also provide an opportunity for the growing of catch crops in the intervals between regular crops, if possible.

This Department is advocating a four-year rotation* of corn, cowpeas, wheat and clover for the poorer lands of the State. This gives a leguminous crop every two years and provides an opportunity for producing catch crops.

Whatever the rotation, corn will be found to give the best results when following the clover or grass crop. At this time the soil is at its highest productive capacity. It is better supplied with organic matter and plant food, and has a greater water holding capacity.

Applying Manures and Fertilizers.

The application of stable manure to land intended for corn is always a profitable practice. It should be applied in the fall or winter if the land does not wash, or if rolling, should be applied just before the land is plowed. Many prefer, however, to use manure on the preceding grass or clover crop, and this is a convenient and satisfactory plan.

If commercial fertilizers are used they should be applied broadcast previous to the final preparation of the seed bed. It is seldom advisable to apply in the hills unless it be a very

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* Ky. Exp. Sta. Bulletin No. 155.

small quantity designed to give the corn an early and vigorous start.

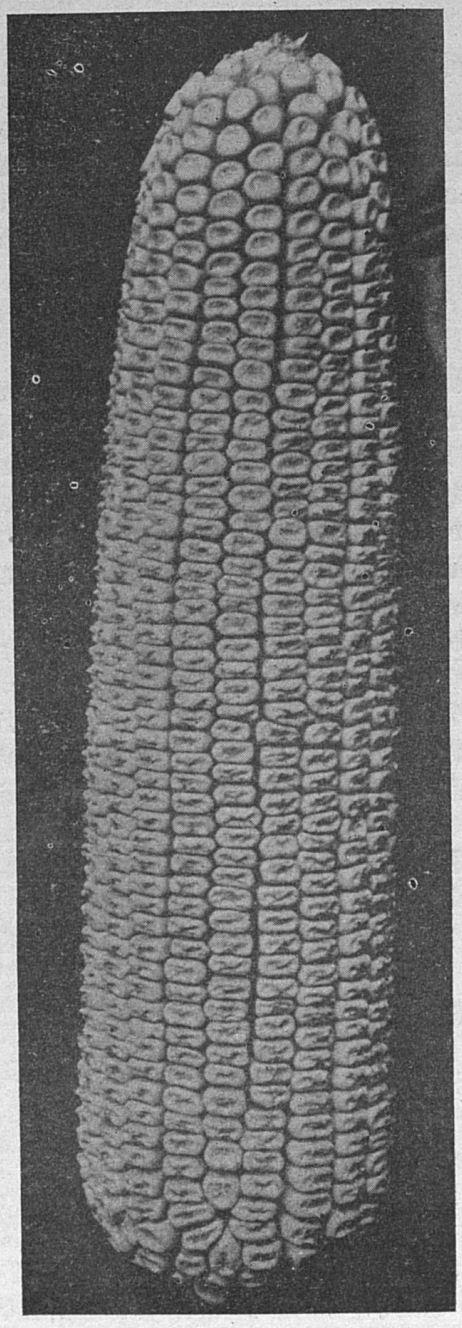
Improving the Quality of the Seed.

The quality of the seed may be improved in two ways, viz., by more careful selection and breeding, and by more careful preservation. The two are equally important and offer a very cheap and sure means of increasing the yield of a variety of corn.

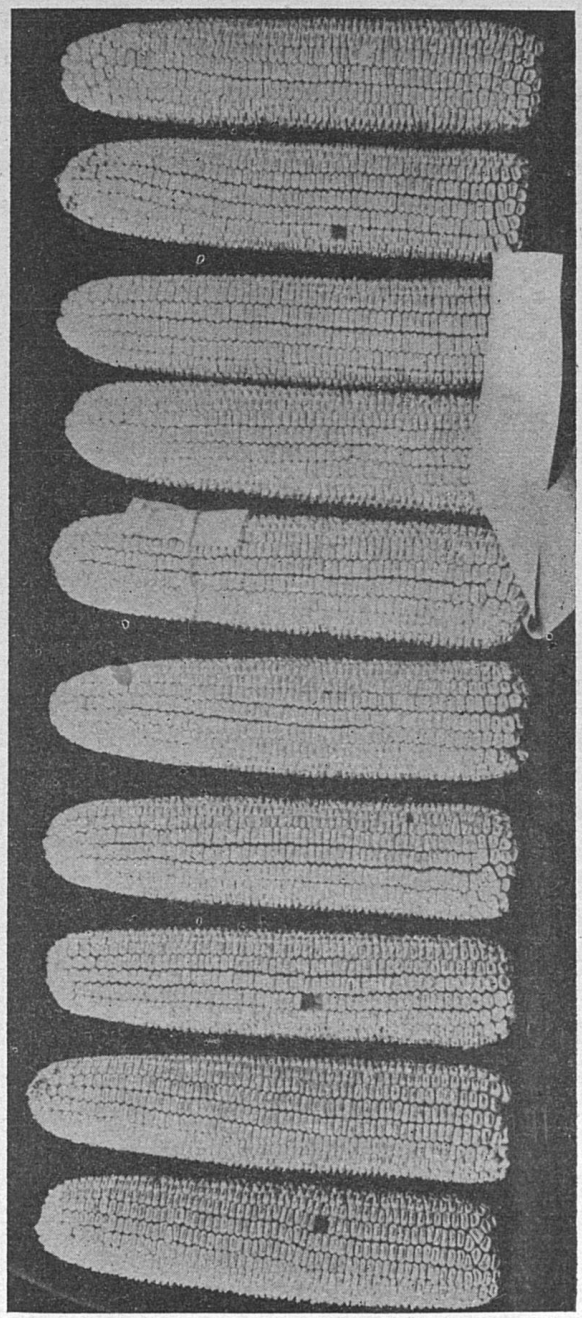
Field Selection.

The simplest method of improving a variety of corn is that of going into the field before the corn is harvested and selecting the best ears for seed. This method is followed by many farmers, and while simple, it offers an opportunity for great improvement. The ears are marked, and at harvest time gathered and stored. The success in this method depends wholly upon the ability of the grower to recognize the best corn. In this selection several factors should be taken into consideration. First, the type of stalk; a stalk of medium height and sturdy appearance should be chosen. The ear should be at a convenient distance from the ground to make for ease of gathering. Ears high on the stalk cause the stalk to blow over more easily. The ear should be of good shape, have a shank of medium size and length, and droop sufficiently to prevent water entering the tip of the ear. The stalk selected should be growing under normal conditions, that is, it should be selected from a hill having a full stand of stalks and surrounded by other full sized hills producing good ears. Finally, the ear should show sufficient size to indicate its superiority over other ears.

Enough ears should be secured to allow for further selection after husking. Many of the ears selected in the field will be found, when husked, not to be a desirable type and perhaps a third will be discarded on this account. An ear of corn should be of good length, preferably 10 to 11 inches for the large varieties. Ears of this length should have a circumference of from 7½ to 8 inches, should not taper too much and



A Good Ear of Corn.



A Good Exhibit of Corn.

have straight rows. The ears should be of uniform type of grain, as this indicates good breeding. The grains should have a good depth and be wedge shaped, which insures a large proportion of grain. The cob should be of medium size and all ears should have cobs of a uniform color. Of course the grains should also be of uniform color. Careful selection of ears showing a definite type will do much to fix the character of a variety of corn.

It is recommended as a good practice the following season to select the very best ears from those collected in this way, and plant an acre or so from these ears. The next year select the seed corn from this area. Each year a seed block should be planted from the best ears that can be found.

Ear-to-Row Tests.

If the corn grower has the time and inclination to go further in the work of corn improvement, the following ear-to-row system may be used:

Select 25 to 50 of the best ears saved from the general field crop the previous fall; the larger the number of ears the better. See that each ear represents the desired type. Next select the most uniform piece of land in the field intended for corn, and plant a row of at least 100 hills from each ear selected. It is well to plant five grains to a hill, and after the corn is four to five inches high, thin to two or three stalks to the hill, according to the stand desired. Each row should contain as nearly as possible the same number of stalks. If space and time permit, it is well to repeat the experiment, planting another series of rows in the same order, and from the same ears. This will help the breeder to eliminate differences due to soil. Treat all rows exactly alike and at tasseling time detassel alternate halves of each row by pulling out the tassels as they appear and before they have shed any pollen. The following diagram will illustrate the plan of detasseling:

Row 1 ——————————.....
Row 2.....——————————
Row 3 ——————————.....
Row 4.....——————————
Row 5 ——————————.....
Row 6.....——————————
.....Detasseled.

When the corn is mature, husk each row separately and weigh, keeping the corn from the detasseled parts separate. The corn from the portions not detasseled should be discarded after weighing. Enough ears should be selected from the best four or five rows for next year's test. The best of the corn from the balance of the block should be used to plant the general crop the next year. The breeding block is to be continued from year to year, care being taken not to plant in adjacent rows, ears previously grown in adjacent rows. Also in order to prevent too much inbreeding, which would prove injurious, it is advisable to introduce occasionally a few ears of corn from some other grower who grows corn similar in type. The corn is of course detasseled to eliminate inbreeding.

At this Station both this method is used and another ear-to-row test similar in many ways, but requiring more time and labor. After the rows are planted as described in the previous method, the remnants of the ears from which they are planted are carefully saved. None of the corn is detasseled, the sole object being to get comparative yields. The corn is harvested and weighed and the best yielding rows determined. The remnants of ears from which these best rows were planted are crossed the next year in small isolated breeding plots, to produce seed for planting the general crop.

Corn Breeding at the Experiment Station.

The Kentucky Experiment Station has been carrying on breeding work with corn for a number of years, using the ear-to-row methods as described above. Very striking differences in the yields from different ears have been secured. Two ears almost identical in size and appearance sometimes

give yields differing 100 per cent or more. In 1909 the highest yielding row produced at the rate of 88.4 bushels per acre, and the lowest yielding row at the rate of 39.1 bushels per acre. In 1910 the highest and lowest yielding rows produced at the rates of 104.9 bushels per acre and 60.3 bushels per acre respectively. In both these instances it could not be said by looking at the ears from which these rows were planted that one was superior to the other. To test the ability of the corn produced in the best row of the 1909 test to transmit its yielding qualities, several rows were planted with seed from that row. These rows were alternated with others planted with seed also from high yielding rows of 1909. The average yield of the corn planted from seed from the best row exceeded that obtained from the other good rows by 3 to 5 bushels per acre.

The Care of Seed Corn.

The proper care of the seed has much to do with obtaining a full stand of vigorous plants, and the yield from any field is largely determined by this factor. Examination of many corn fields in this State has shown that the stand on few fields exceeds 80 per cent of a perfect stand and on some not much over half a stand is obtained. An acre of land provides space for nearly 3,600 hills of corn when planted 3½ feet by 3½ feet. If a perfect stand of two stalks is obtained and each hill produces two ears weighing only 8 ounces each, the yield would be 51 bushels per acre, or double the average yield for the State. An 8-ounce ear is usually considered a nubbin. If each hill produces one ear weighing a pound, and one weighing one-half pound, the yield would be approximately 75 bushels per acre. There are of course other factors which help to produce a poor stand, but it is safe to say that poor seed is the chief cause.

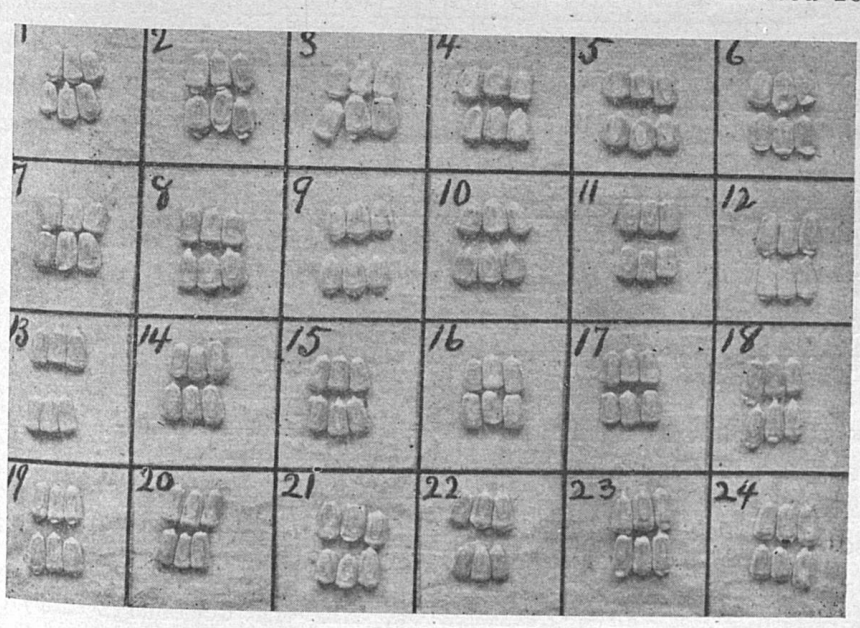
The vitality of seed corn is injured greatly or even destroyed by freezing while the grain contains a large amount of moisture. To prevent this, the seed should be gathered early and thoroughly dried before freezing weather. This is

accomplished in several ways, one of the simplest, where moderate quantities of seed are saved, being to tie about ten ears together with binder twine or other strong cord and hang in an attic or other dry well ventilated place. Where large quantities are to be dried a special seed room, provided with shelves upon which the corn may be spread, is advisable. Of course such a room must be mouse and rat proof. If the weather is damp, artificial heat will prove of advantage in hastening drying.

It is almost impossible for corn in a crib to dry out thoroughly and the vitality is almost sure to be injured, although it is seldom completely destroyed in this climate. This is the greatest objection to securing seed corn from the crib in the spring, although this method is also very objectionable for the reason that it permits no inspection of the plant and the conditions under which it grew.

Germination Test.

Previous to planting time, a final selection of the most desirable ears for seed should be made, and each tested for



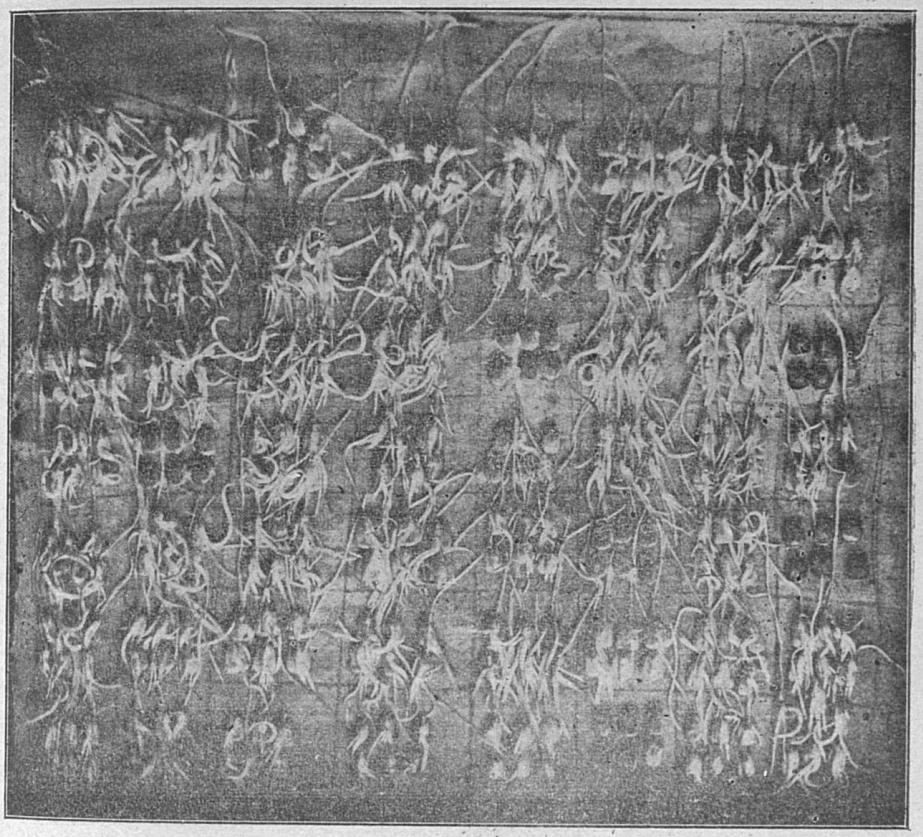
Grains of Corn in Position on Germinating Cloth.

germination. The less the care that has been given the seed, the more imperative is it that such a test be made, but the test is so easy to make that it should not be neglected under any circumstances. By its use all ears that will not grow or that will not produce strong, vigorous sprouts can be detected and discarded, and the chances for getting a good stand greatly increased.

The home-made tester has proven most efficient, and is used by most Stations in preference to the patented ones. The one used at this Station is made and used as follows: A shallow box, about two feet square, is made and filled to within two inches of the top with old sawdust well dampened and packed. If sawdust can not be obtained, damp sand or soil is used. Sawdust is preferable, as it is light, easily handled and holds moisture well. A closely woven white cloth is provided and marked off into 2¼ inch squares, with a pencil, and each square numbered. This cloth is then spread over the sawdust or other material and fastened to the sides of the box by tacks.

The ears of corn are numbered by attaching small pieces of stiff paper, bearing a number, to the butt of each ear with a shingle nail. From each ear two grains are taken from opposite sides near the butt. The ear is then revolved one-third around and two more grains taken from opposite sides at the middle of the ear, then revolved one-third around again and two more grains taken in like manner from near the tip. This gives a representative sample. The grains are placed, germ side up, in the square whose number corresponds to that on the ear. When all the squares are filled, another cloth the same size is dampened and carefully laid over the grain, and another large enough to cover this and reach over the edges of the box is laid over this in turn. Then the remaining space in the box is filled with the moist sawdust or sand and the box placed in a warm place. A box two feet square is large enough to test 100 ears, which will plant about 8 acres of corn.

In from 6 to 10 days, depending upon the temperature, the grains will have germinated, and the coverings can be removed and the results determined. If any of the grains in



Box of Germinated Corn. Note failure of some grains to germinate and others showing weak germination.

any square fail to show good strong sprouts the ear from which they were taken should be discarded. If the seed will not germinate under such circumstances, it is sure not to germinate in the field. During germination the box should be examined occasionally to see that enough moisture is present; if not, a little lukewarm water should be applied.

Shelling the Seed Corn.

Since most of the corn crop is now planted by machinery, it is very necessary that the grains be uniform in size if the planter is to drop a uniform number in each hill. A seed corn grader will prove useful in securing uniformity where an

edge drop planter is used, as the uniformity in thickness of the grains determines the uniformity with which the seed is dropped with this style of planter. When only a few bushels of seed are to be graded, however, or when the old style planters with round holes are used, the best plan of securing uniformity in the grains is by selecting the ears having similar sized grains and shelling them together. This will probably give several lots of corn, and each lot should be planted before the other is put into the planter box. It is needless to say that the butt and tip grains should not be included, because of the difference in size.

Cultural Methods.

The ability of the corn plant to obtain plant food depends to a large extent upon the preparation of the soil. In a loose, finely pulverized seed bed the roots penetrate easily and are able to secure close contact with the maximum number of soil particles. Roots can not readily penetrate hard clods and the plant food in such clods is practically locked up from the plant. The available supply of moisture is also greatly influenced by the preparation of the land and the subsequent cultivation of the crop, as will be explained later. While the corn crop is usually pretty well cared for, there are yet many farmers who are careless in their methods of preparing the soil, and who do not cultivate so as to secure the best results.

Time of Plowing.

Fall or winter plowing or plowing very early in the spring has the advantage of conserving moisture and of making the final preparation of the soil easier. Fall and winter plowing also affords a better distribution of labor on the farm and when practical is good farm management. Sod lands that do not wash badly may be safely plowed in the fall. Land not in sod, land subject to washing, or very heavy clay lands should not be plowed until spring. The very heavy clay soils run together and pack so solidly if fall plowed that final preparation is sometimes impossible without re-breaking. Fall

plowing also helps to destroy insects, which, when disturbed in their winter quarters, are killed by the cold weather.

Later spring plowing is of advtange on soils poor in organic matter, as it permits cover crops which may occupy the land to attain a considerable growth before being turned under, thus adding organic matter. It also is of benefit in destroying weeds on badly infested fields. On the other hand unplowed hard soil permits much moisture to escape, which is saved by early breaking. Often the lands break up very cloddy and are difficult to get in proper condition. A thorough disking of the land previous to plowing prevents, to a considerable extent, the land breaking up in large clods, and aids greatly in securing a finely pulverized seed bed the entire depth to which the land is plowed.

In late plowing the harrow, or drag, should follow the plow closely, or the sun will bake the clods so hard that they can not be crushed without a great deal of extra labor, and sometimes a good seed bed can not be secured at all.

Depth of Plowing.

Land for corn should be plowed deep as compared to other crops. It is apparent that no absolute depth of plowing can be recommended for all types of soil. Six to eight inches is a good depth where the nature of the soil will permit, and it will probably not often prove economy to plow deeper than this, as it greatly increases the cost of the work. Where the surface soil is very shallow it will be good practice to turn up a little subsoil at each plowing to incorporate with the surface soil, thus gradually increasing the depth of the soil until the land can be safely plowed 6 to 8 inches deep. Where subsoil is turned up it is much better for the plowing to be done in the fall. In a majority of experiments in this country plowing over 6 inches deep has not given increase in yield. At this Station an experiment with deep and shallow plowing was conducted in 1910. A special disk plow was used for the deep plowing, and the ordinary mould board plow for the shallow. The depths were 12 inches for the deep and 6 to 7 inches for

the shallow. The yield per acre for the deep plowing was 44.4 bushel per acre and for the shallow 46.3 bushels. This seems to prove that excessively deep plowing has no advantage.

Subsoiling.

Subsoiling is little practiced in this State, and only in a few section of the United States is it carried on to any considerable extent. It is accomplished by following the ordinary breaking plow with an implement which breaks up the subsoil for a depth of 6 to 8 inches without bringing it to the surface. But few of the experiments with subsoiling have shown any particular advantage of the work. In some instances injury has resulted. Where the soil is underlain by an impervious hardpan or a sticky impervious clay which prevents the free movement of moisture, it is probable that benefits would result from subsoiling. Subsoiling should not be done when the soil is wet, as there is great danger of puddling. The best time to do the work is in the fall when the soil is dry and settled.

Subsoiling with dynamite has been strongly advocated recently by the manufacturers of dynamite, who claim great benefits from the practice. There has not been sufficient work done as yet to prove the assertions made. It may prove a valuable practice, especially upon those classes of land in which ordinary subsoiling proves beneficial. It would be interesting for the farmer to try this method on a small area. The dynamite manufacturer will give full directions for the work to those interested. An acre was dynamited on the Experiment Station farm in the fall of 1911, and in due time the results will be given.

Final Preparation.

Where land is fall or winter plowed, it needs no working until it begins to dry out in the spring and a crust begins to form. It should then be disked, and after rains, run over with a smoothing harrow. It will then be in good shape when planting time arrives. It will not be out of place here to repeat the advice about following the plow closely with the

harrow or drag when land is plowed late in the season. It will certainly pay to stop the teams from the plow twice a day to cover the ground already plowed.

In final preparation of the land, a good disk harrow or a spring tooth harrow seems almost essential. Unless the soil breaks up exceedingly mellow it is impossible to prepare a suitable seed bed without the use of these or similar implements. To do proper work with a disk harrow at least three good horses or mules are necessary, if good progress is to be made. The work can be done so much better, and so much more rapidly with three animals that their use will prove real economy.

After disking, if the ground is free from clods, a smoothing harrow will usually put it in condition for planting. If clods are present it will be necessary to follow the disk with a plank drag or roller. A good heavy plank drag is about the best tool for this purpose, and one that all can afford. It levels the land, pulverizes the clods, and yet does not pack the soil as does the roller. It is usually best to follow the drag or roller with the smoothing harrow, or the corn may be planted and the smoothing harrow run after the planter.

Time of Planting.

It seems to be the general opinion among farmers that early planted corn can usually be relied upon to give the best results. There is little difference of opinion upon this subject, the planting being done as soon as frosts and freezes are over and the ground is warm enough for quick germination. This varies with the season, of course, but in Kentucky the proper time to plant seems to be from April 25th to May 15th.

Rate of Seeding and Methods of Planting.

This Station has been carrying on a series of experiments during the past two years in an effort to determine the rate of seeding that will give the best yield, and to compare the yield of drilled corn with the yield of corn planted in

checks. The corn crop in 1911 was so nearly a failure on account of excessive drouth that the results secured mean but little. The results secured this year are exactly the reverse of those obtained in 1910, which was about a normal year for corn production. The results in 1910 and 1911 were as follows:

Method of Planting.	Yield in bushels per A. 1910	1911
2 stalks per hill 3½ by 3½ feet	72.	31.1
3 stalks per hill 3½ by 3½ feet	90.4	25.8
4 stalks per hill 3½ by 3½ feet	98.4	22.4
Drilled, stalks 12 in apart, rows 3½ ft. apart	103.0	19.5
Drilled, stalks 14 in. apart, rows 3½ ft. apart	96.8	20.6
Drilled, stalks 18 in. apart, rows 3½ ft, apart	87.0	28.9
Drilled, stalks 21 in. apart, rows 3½ ft. apart		29.2

The figures here given indicate that in a favorable season 3 stalks per hill will give a higher yield than 2 stalks, and that drilled corn yields better than corn planted in hills when the rates of seeding were equal. (Stalks 14 inches apart drilled equal 3 stalks per hill.) It also indicates that even thicker planting—four stalks per hill and drilled 12 inches apart in the rows—will give a higher yield. The latter would be equal to 3½ stalks per hill. The 1911 results show that in a dry season the thin planting gives the best results, and that corn planted in hills will yield better than drilled corn. It is proposed to carry on these experiments for a number of years as must be done to get conclusive results. It is expected, however, that the results will vary as indicated above, but not to such a great extent, for 1911 was a very trying year on the corn crop.

It should be mentioned that thick planting in 1910, while resulting in the highest yield of corn, gave a higher percentage of spoiled and unmarketable corn than thinner planting. The ears were smaller and of course took a longer time for gathering. Thick planting encouraged a slender growth of stalks which broke easily, and at harvest time quite a large percentage of the stalks were fallen. This causes more labor in harvesting. The variety of corn used was Boone County

White, which is naturally a very tall growing sort. Thick planting seemed to affect the strength and size of the stalk rather than the height. It is probable that in the case of earlier, shorter stalked varieties this trouble would not be so apparent.

It can be seen by the yield secured in 1910 that the soil on the Station farm is above the average in fertility. It is not likely that the results secured here would be duplicated on land not so fertile. Experiments carried on in some of the Southern States, where the land is thin, indicate that the best yields can be secured by having but one stalk in a hill, with the hills 4 feet each way.

To summarize, it would seem that on rich soil in a normal season relatively thick planting will give the highest yields. In dry seasons, thin planting gives the best results. On poor land the best yields will be secured from rather thin planting. Planting more than 3 stalks to the hill may result in a higher yield, but the corn is liable to fall badly and the quality of the corn will not be as good. Drilling the corn may give a slightly increased yield, but scarcely sufficient to pay for the extra work often necessary to keep the weeds down. Where corn can be cultivated but one way, or on steep hillsides, it should be drilled. Large varieties of corn are not as well adapted to thick planting as small varieties. The cost of harvesting the corn when planted thick is greater. Finally it may be said that on good corn land of fair fertility 3 stalks per hill or the equivalent in drilled corn will probably give the best results when an average of a number of years is considered.

Cultivation of Corn.

The chief objects of cultivation are (1) to destroy weeds and (2) to keep the surface loose and well pulverized to prevent loss of moisture. If the seed bed has been thoroughly prepared there is seldom occasion for deep cultivation. A heavy, beating rain following planting which packs the surface down hard may necessitate deep stirring to loosen up the soil. Or a protracted rainy period may give the weeds

such a start that they can not be destroyed by shallow cultivation. These are about the only occasions when deep stirring is necessary or advisable. There is quite a strong sentiment among farmers in favor of making the first cultivation deep. It may be that there is some virtue in it, and at any rate it can do little harm, as the roots of the plants have not extended sufficiently to be disturbed. In some sections the so-called "barring off" the rows with a barshare plow is practiced. This is a practice which adds considerably to the cost of cultivating the crop, and except under unusual conditions is unnecessary. With few exceptions, weeds can be held in check by shallow cultivation as well as by deep cultivation, provided proper implements are used. To destroy weeds by shallow stirring it is necessary for an implement to have a number of small shovels so that all the surface will be stirred. Single-horse cultivators should have at least five cutting or stirring points, and in the double cultivators from three to five on each gang. Probably the reason farmers frequently denounce shallow cultivation is that they attempt it with tools unsuited to the work. In case of a double shovel plow it is impossible to destroy weeds with shallow plowing, for their efficiency in this respect depends chiefly upon covering the weeds. There are many good cultivators made now, and the farmer should have little difficulty in finding one suited to his needs. Except on very small farms the two-horse cultivator should be used. The efficiency of cultivation lies in getting it done at the proper time, and there is no economy in a man working a single animal when by the use of a team he can accomplish twice as much work and do it fully as well or better.

The first cultivation may be given before the corn is up, if weeds seem liable to prove troublesome. It is entirely practical to use the ordinary cultivator for this work, and the marks made by the planter can be followed as easily as a corn row. In general practice, however, it is usually sufficient to wait until the corn is up, and then to stir the soil with a weeder or light harrow. This will destroy the weeds and not injure or cover the corn to any extent. If the soil is very loose, or perhaps cloddy, rolling the corn before the weeder

or harrow is used is a good practice which tends to prevent the young corn plants being covered by loose dirt or clods. It is difficult to realize, if one has never tried this early cultivation, how effective it is in destroying weeds and keeping them in check until the corn is large enough for regular cultivation. It can be done so rapidly, too, that it is the cheapest cultivation that can be given. If this practice were to be followed there would be little occasion for later deep cultivation, "barring off" the corn, and hard work with the hoe.

As soon as the corn is large enough it should be given a careful cultivation, getting close to the young plants. Future cultivation should be given after rains, to prevent the soil becoming crusted and the consequent loss of moisture and also to destroy weeds that will start up. A definite rule can not be given as to the number of times it will be necessary to cultivate the crop. In some seasons two cultivations may accomplish as much as four in other seasons. It is a question largely determined by weather conditions. As to whether corn should be cultivated after it has reached a height of say four feet is rather an unsettled question. Evidence on this subect is conflicting, but the prevailing belief is that the advantage, if any, will not pay for the cost of the work. After the plants have attained sufficient size to shade the ground and the root system has occupied practically all the soil there is probably little escape of moisture from the soil except through the corn plant. Weeds are not likely to give much trouble if they have been well controlled by previous cultivation. If cultivation is practiced at this time it should certainly be very shallow, and not close to the plants, or more harm than good will result.

This Station carried on a series of experiments in 1911 designed to secure more evidence on the subject. No advantage was found to result from cultivation after the corn was 3½ feet high. The season was so abnormal, however, that not much dependence can be placed on the results.

Harvesting Corn.

Farmers now generally recognize the value of stover for

feeding purposes and a large percentage of the corn crop is cut. Many farmers follow corn with wheat, and this necessitates cutting the corn. Stover, to have full feeding value, must be well cared for. As a general thing the corn is allowed to become too ripe before being cut to make good stover. If all the leaves on the stalk are allowed to dry up, and even the stalk itself to become dry, the stover has little feeding value. Corn should be cut when the ears are all well dented, the husks dry, and part of the leaves green. There is little danger of affecting the yield or quality of grain by cutting at this stage, and the stover will have the maximum feeding value.

There have been no machines invented for harvesting corn as yet that offer much advantage over harvesting by hand; from the standpoint of economy perhaps none. The corn binder may prove a profitable implement where silos are to be filled and labor is difficult to secure; but with plenty of help available, this work can be done about as cheaply by hand. Corn harvesting machinery is expensive, heavy and in many seasons can not be used at all. Corn should be carefully shocked, and the shock well tied, if it is to be well preserved.

Corn can usually be husked in about a month after cutting. The general custom in this State is to re-shock the stover after the corn has been husked, and to leave it in the field until needed for feed. This necessitates going out in all sorts of weather, mud, snow and rain. The stover becomes weather beaten and much of its value is lost. It is certainly a good practice to haul stover in near the feed lot before bad weather comes, and shock it up carefully, or put it under shelter. Stover can be handled much more rapidly if tied in good sized bundles as fast as husked. Special tarred twine, cut into proper lengths, can be secured for this purpose, or binder twine may be used. The strings are looped at one end and the bundle drawn together tightly and tied. The bundles can be handled with a fork much as wheat or oat bundles, and can be stacked or ricked. Little additional time is required and once the method is tried it is pretty certain to be continued.

Shredding Stover.

In some vicinities the corn husker is widely used. These machines shred and cut the stover up finely and in this condition it is very convenient to handle. The great difficulty in keeping shredded fodder where a large amount is put in one place is the drawback of this method. Stover seldom becomes dried out sufficiently to keep well after being shredded. In addition, many feeders do not favor shredded fodder, claiming that stock does not thrive well on it. There is possibly some basis for this claim, as the animal fed on shredded stover can not select the most nutritious part as is the case when fed whole. Usually, however, the difficulty can be traced to the fact that the shredded stover is musty or mouldy.

Husking corn by machinery is satisfactory where the corn is to be fed on the farm. The cost is about the same as hand husking, but has the advantage of getting the work done in a short time.

Corn for the Silo.

There is no better method of handling the corn crop where cattle are fed than putting it into the silo. Handling the corn this way results in less loss and more satisfactory results than any other method now known. Silos are constantly increasing in numbers and popularity, and it appears that their use will be quite general in the near future.

Corn for filling a silo should not be allowed to become as ripe as is necessary in other methods of harvesting. Neither should it be too green. When part of the leaves have yellowed and the grains are well dented is the proper condition of the corn for this purpose.

Harvesting by Stock.

Where hogs are fed on the farm a good practice, but little followed, is to fence off a portion of the corn field with a temporary fence and let the hogs do the harvesting of the crop. Unless the fall is very wet there will be scarcely any waste

of grain and it will be entirely satisfactory. The stover of course, will be largely wasted, but the hogs will even eat some of this before it becomes too dry. The expense of cutting and husking is avoided and the droppings of the animals are well distributed over the fields. As manure from hogs fed in a lot or pen is usually largely wasted, there is a decided advantage from this standpoint.

If cowpeas or soy beans are sown in the corn after the last cultivation an additional amount of feed may be secured. Or if rye is sown early in September the young growth would prove a valuable addition to the corn diet.

In reference to the temporary fence, it is claimed by some that woven wire fencing fastened to the hills in a row of corn will prove entirely effective in confining the hogs.

Statistics of Corn for Kentucky.

From 1910 U. S. Census. Figures for 1909 Crop.

County.	Acres in Corn.	Total Yield.	Yield per Acre.
Adair	37,319	669,512	17.9
Allen	34,899	733,137	21.0
Anderson	13,156	375,923	28.6
Ballard	37,327	1,083,806	29.0
Barren	53,439	1,132,820	21.2
Bath	23,246	727,445	31.3
Bell	11,734	190,788	16.2
Boone	16,995	638,987	37.6
Bourbon	29,550	1,202,542	40.7
Boyd	9,521	237,776	24.9
Boyle	16,937	768,734	45.4
Bracken	12,378	397,540	32.1
Breathitt	28,547	527,960	18.5
Breckinridge	54,262	1,048,235	19.3
Bullitt	21,264	566,932	26.6
Butler	43,553	607,823	13.3
Caldwell	29,996	622,666	20.8
Calloway	45,955	969,256	21.1
Campbell	9,774	265,032	27.1
Carlisle	25,175	717,165	28.5
Carroll	9,894	316,805	32.0
Carter	30,884	657,738	21.3
Casey	28,843	647,783	22.4
Christian	64,104	1,570,784	24.5
Clark	20,597	842,710	40.9
Clay	33,983	633,315	18.6
Clinton	19,357	295,129	15.3
Crittenden	45,780	986,682	21.5
Cumberland	23,251	500,734	21.5
Daviess	59,762	1,694,399	28.4
Edmondson	24,917	403,469	16.2
Elliott	20,264	398,586	19.7

County.	Acres in Corn.	Total Yield.	Yield per Acre.
Estill	21,533	548,558	25.5
Fayette	28,480	1,227,357	43.1
Fleming	30,013	1,017,485	33.9
Floyd	29,582	626,669	21.2
Franklin	17,021	512,012	30.1
Fulton	26,987	890,103	32.9
Gallatin	7,019	233,178	33.2
Garrard	24,443	948,368	38.8
Grant	16,598	621,556	37.3
Graves	70,259	1,716,958	24.4
Grayson	56,076	896,213	15.9
Green	28,404	511,445	18.0
Greenup	23,486	489,739	20.9
Hancock	20,631	516,183	25.0
Hardin	59,566	1,358,202	22.8
Harlan	14,956	254,148	17.0
Harrison	23,474	911,932	38.8
Hart	37,441	683,839	18.2
Henderson	72,822	2,073,092	28.5
Henry	20,166	703,123	34.8
Hickman	35,097	1,091,797	31.1
Hopkins	52,165	1,035,000	19.8
Jackson	20,506	325,174	15.8
Jefferson	31,200	947,024	30.3
Jessamine	17,209	640,611	37.2
Johnson	25,195	466,214	18.5
Kenton	9,445	303,126	32.1
Knott	18,325	372,111	20.3
Knox	29,909	479,677	16.0
Larue	26,513	550,633	20.8
Laurel	27,262	410,316	15.1
Lawrence	37,257	735,391	19.7
Lee	12,773	259,005	20.3
Leslie	15,633	276,778	17.7
Letcher	17,224	303,136	17.6

County.	Acres in Corn.	Total Yield.	Yield per Acre.
Lewis	23,760	519,433	21.9
Lincoln	28,930	924,978	31.9
Livingston	40,180	932,200	23.2
Logan	53,853	1,188,216	22.1
Lyon	21,708	517,106	23.8
McCracken	29,372	726,771	24.7
McLean	30,184	617,500	20.5
Madison	45,426	1,539,385	33.8
Magoffin	27,305	479,316	17.6
Marion	26,523	799,177	30.1
Marshall	39,807	866,230	21.8
Martin	9,643	173,866	18.0
Mason	22,831	1,024,161	44.8
Meade	24,953	541,655	21.7
Menifee	12,128	210,747	17.4
Mercer	21,510	786,737	36.6
Metcalf	23,594	395,288	16.7
Monroe	30,785	543,206	17.6
Montgomery	16,889	585,634	34.7
Morgan	32,780	622,322	18.9
Muhlenberg	39,970	613,675	15.4
Nelson	35,086	1,096,037	31.2
Nicholas	14,357	557,546	38.8
Ohio	55,373	840,649	15.2
Oldham	14,804	482,143	32.6
Owen	21,590	723,139	33.5
Owsley	15,516	291,324	18.7
Pendleton	19,283	588,755	30.5
Perry	19,539	351,471	17.9
Pike	43,183	862,681	19.9
Powell	12,268	259,176	21.1
Pulaski	58,060	889,010	15.3
Robertson	7,083	236,653	33.4
Rockcastle	24,777	430,176	17.3
Rowan	13,350	244,708	18.3
Russell	27,220	451,408	16.6

County.	Acres in Corn.	Total Yield.	Yield per Acre.
Scott	24,202	912,229	37.7
Shelby	31,584	1,133,885	35.9
Simpson	25,957	550,663	21.2
Spencer	15,992	500,924	31.3
Taylor	25,193	457,181	18.1
Todd	36,563	817,835	22.4
Trigg	36,800	904,673	24.6
Trimble	11,831	326,148	27.5
Union	69,012	2,306,415	33.4
Warren	61,938	1,381,442	22.3
Washington	23,116	751,900	32.5
Wayne	36,052	548,248	15.2
Webster	41,992	959,343	22.9
Whitley	35,505	474,601	13.4
Wolfe	19,291	351,658	18.2
Woodford	16,359	690,034	42.2
State	3,436,340	83,348,024	24.3

KENTUCKY

AGRICULTURAL EXPERIMENT STATION

OF THE

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THE CATALPAS AND THEIR ALLIES.

LEXINGTON, KENTUCKY,
February 15, 1912.

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Kentucky Agricultural Experiment Station.

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JOSEPH H. KASTLE, Research Chemist, Head of Division of Chemical Research.
B. F. SCHERFFIUS, Expert, U. S. Department Agriculture.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KENTUCKY.

BULLETIN NO. 164.

THE CATALPAS AND THEIR ALLIES.

By H. Garman, Entomologist and Botanist of the Station.

Interest in the catalpas has been increasing in Kentucky for the past ten years, having relation to the scarcity of timber suitable for fence posts and railroad ties. The wood is undoubtedly one of the very best for use in contact with the soil, and in the State has no rivals excepting woods produced by the common black locust and the red cedar. It may be questioned if either is as good, all things considered, for the purpose of making ties as the catalpa, and with the rapid extension of interurban traction lines everywhere in the country, the demand for such timber, now large, is bound to increase greatly during the next decade or two.

But there are two quite different American species of catalpas, both beautiful trees for the lawn or park, though not equally good for the production of timber. The *Catalpa speciosa* should always be planted for this purpose. For ornamental uses it does not matter so much which is employed, though there may be some room for choice even here. Both are attractive trees because of their fine foliage and handsome flowers. When young, the trees are much alike. But later, *C. speciosa* assumes an upright position and the bark becomes strongly grooved lengthwise of the trunk. *C. bignonioides*, on the other hand, is disposed to a spreading, straggling growth, does not attain as great a size, and the bark is broken into thin scales, the checks being shallow and directed both lengthwise and crosswise.

By this difference in the character of the bark one can always recognize the trees after they are ten to fifteen feet in height. It is important, however, to be sure one has

C. speciosa when starting a planting for posts or ties, and on this account it is advisable that young trees be secured only from a well informed nurseryman, or that the grower collect and plant the seeds himself, when, if he has exercised proper care, he will know with certainty which tree he has. Disappointment and loss have sometimes resulted from failure to exercise this care in getting a proper start. To help to a right choice those contemplating making plantings of catalpa, some additional characters of the two trees are given below.

THE WESTERN CATALPA

(*Catalpa speciosa*).

Upright of growth, reaching in good soils a height of one hundred feet or more, the trunk then attaining a diameter of three or four feet. Crown contracted, conic in general shape, the branches having no great disposition to spread.

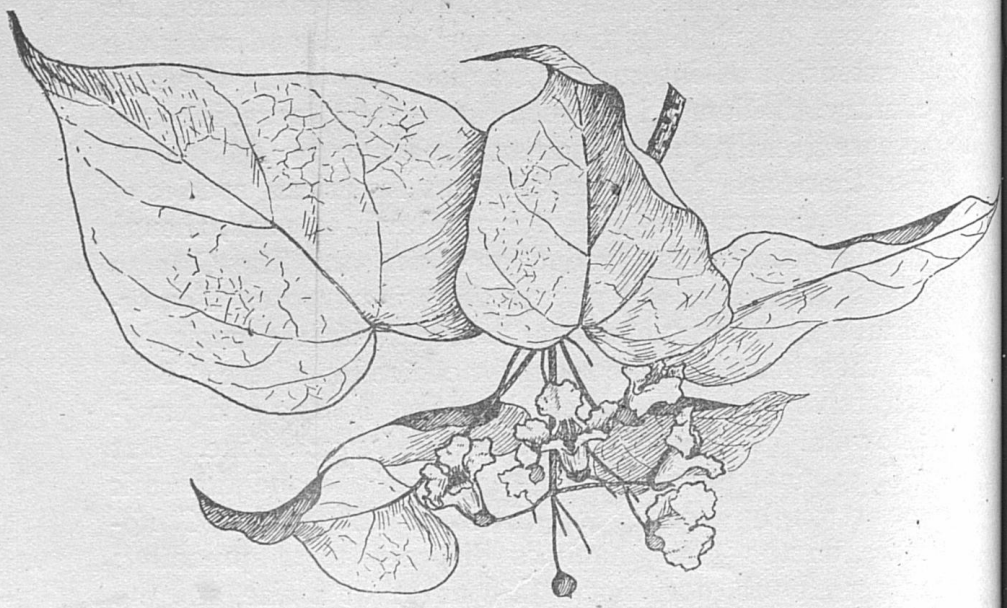


Fig. 1.—Leaves and flowers of *Catalpa speciosa*.

When the trunk is two feet in diameter some of the grooves of the bark may be an inch deep and several feet in length. This species is in full bloom ten days before *C. bignonioides*;

when the latter is in full bloom (May 28, in 1911) every blossom has fallen from *C. speciosa.*

Flowers pure white, with an orange stripe on each side in the throat, which breaks within into dots. Between the outer ends of the stripes are several purple lines, branching outwardly, while outside the orange stripes on each side are other purple lines. No markings of any sort are visible on the outside of the corolla, though the stripes show through when a flower is held to the light. Fully expanded flowers measure 1.2 inch in spread of petals, and 2.48 inch the opposite way. The cavity measures about 0.74 inch from side to side and about the same in the opposite direction. The tubular part is about one inch deep.

The flowers are pleasantly scented. A cluster or panicle may consist of sixteen or more flowers.

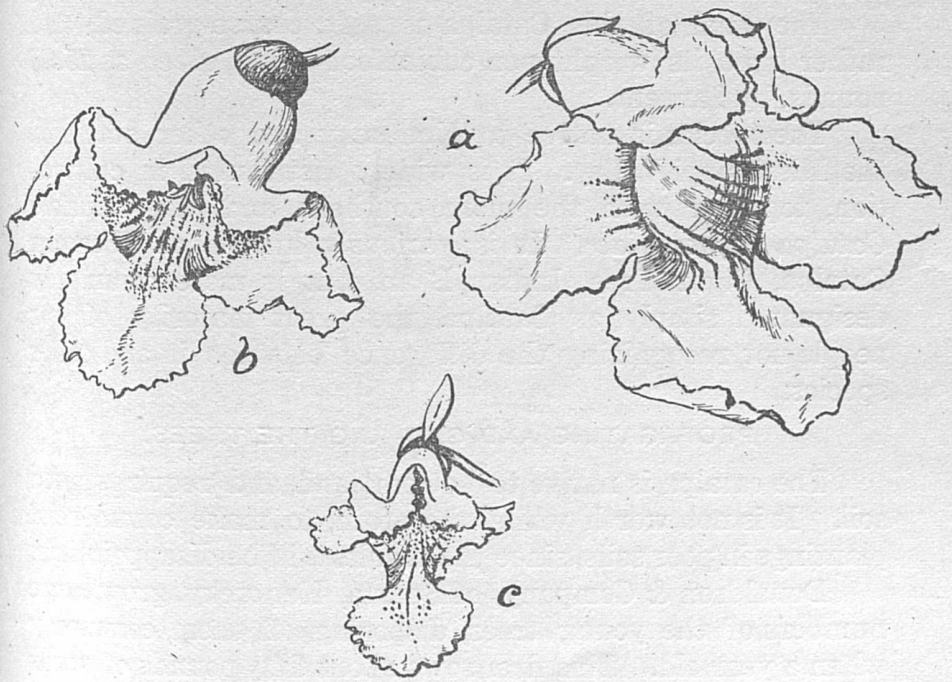


Fig. 2.—Flowers of three species of Catalpa: *a*, *C. speciosa*; *b*, *C. bignonioides*; *c*, *C. kæmpferi.*

The leaves are broad, heart-shaped, a large one measuring nine inches long and seven inches wide, while the petiole is three and three-fourth inches long.

Pods slender, grooved longitudinally, ten to twenty inches long and about three-quarters inch in diameter. Cylindrical in the main, a trifle tapering toward the extremities. A few (frequently but one) developing for each panicle of flowers.

The flat seeds, packed closely in the pods, are somewhat variable in both size and shape, but a general form prevails and will serve to distinguish seeds taken from this tree.

Seeds measure about 1.32 inch long and 0.33 inch in width, the sides nearly parallel in some examples, the extremities rather widely and completely fringed. In every pod some departures from the typical form just described will be found. The size may be much smaller, in some cases the length being about 0.80 inch, but the wide fringe and the broadness of seeds generally serve to distinguish the species, even when nothing else is at hand.

The wood of this Catalpa is soft, coarse-grained, and rather light, its weight per cubic foot being given as 25.96 pounds, by Sargent.

The species is native to Kentucky and other states of the Mississippi Valley. It is widely distributed in cultivation, together with the more southern and less valuable *Catalpa bignonioides*. It is variously known as Western Catalpa, Cigar Tree, Indian Bean, but is more commonly designated simply as Catalpa, the great majority of our people not recognizing the difference between it and other species.

PROPAGATING AND GROWING THE TREES.

The catalpa is native to bottom land and requires good soil. It is not worth while, therefore, to make commercial plantings in poor soils, since the results will be disappointing.

Donaldson & Company, of Sparta, Kentucky, grow large numbers of the young trees, disposing of them commonly when a year old. This firm sows about fifty pounds of seeds to the acre, and with a good stand this quantity of seeds gives about 150,000 young trees.

The seeds are planted closely, in drills, so that the young trees can be plowed. When a year old they are ready to

transplant to the wood-lot, where they are spaced four feet apart each way, or six by eight feet, always in rows so as to permit cultivation the first two or three years. Afterwards they will shade the ground and prevent the growth of most weeds.

The lower branches may be cut away in early spring from time to time, close up to the trunk, so as to leave it straight and without large knots.

When trees three or four years old are not disposed to make a straight growth, or have been badly injured in any way, they may be cut back to the ground and new shoots be permitted to take their places. To get straight trunks it is sometimes recommended that trees of this age be in all cases thus cut back the third year in early spring before growth begins. The most promising of the new shoots may then be selected and the rest cut away. Such shoots grow very rapidly and make unnecessary the pruning sometimes required where cutting back is not practiced.

The average cost of starting a plantation of catalpa is given by R. I. Kellogg of the United States Forest Service at $15.00 per acre and the annual income at the end of eighteen to twenty-three years as determined by the inspection of various plantings at from $1.25 to $16.70. The best returns as a rule were obtained from plantings not too closely crowded, and from 4x8 to 6x8 feet may be considered the spacing best calculated to produce the greatest number of good posts.

The best result in product obtained in any of the plantings reported by Mr. Kellogg was a planting of about two-thirds of an acre at Marshall County, Illinois. It yielded at the end of twenty years at the rate of 2,955 first-class posts per acre, 1,350 second-class posts, and seven cords of wood, giving an annual net income per acre of $16.70. This planting was, he says, on a rich prairie loam, and was started from seeds sown in drills. The young trees were thinned to two feet in the row, and thinned themselves as they increased in size to about four feet in the row. Judging by the reports made by this writer and others, from $2.50 to $9.50 per acre, counting interest on investment at 3 per cent,

is about what can be expected as the annual income from a planting for posts.

In the communication received under date May 4, 1911, from Mr. W. L. Mapother, First Vice President of the L. & N. Railroad, the writer states that his road has made numerous plantings of catalpa and other trees for posts and ties in several different states, those made in Kentucky, however, (Edmonson, Bell and Whitley Counties) consisting of black locust, poplar and walnut. In other states the Road has made plantings of *Catalpa speciosa*, and Mr. Mapother informs me that some of them have shown remarkable growth, while others have not been very good. He thinks, however, that as a whole the results are satisfactory.

The L. & N. plantings are spaced 8x8 feet, giving six hundred and eighty trees to the acre. Five hundred and ten of these are to be removed for fence posts at the end of the seventh to the tenth year, leaving one hundred and seventy trees to make more prolonged growth. It is expected, Mr. Mapother writes, that at the end of twenty years each one will make five to seven sawed ties. These plantings are calculated to be of value to our people as showing what profit may be expected from forest tree plantings and as showing also how best to manage them.

The following letter from Mr. W. F. Cook, of Hickman County, Kentucky, contains the results of experience which, though unfortunate, is calculated to be of value to those contemplating making plantings of catalpa trees. It is dated June 26, 1911:

"We planted some catalpa, about 3,500, in the fall of 1904, on what is known as white crawfish land. It overflows from the Mississippi River, and is very poor soil. They have not made a very good growth. During the winter of 1904 the land was overflowed only a little, followed by heavy freezing which heaved a great many of them entirely out of the ground, some of them so badly they fell over. They were reset in the spring, and began to make a fair growth, but a late frost killed the tender wood. They were a little

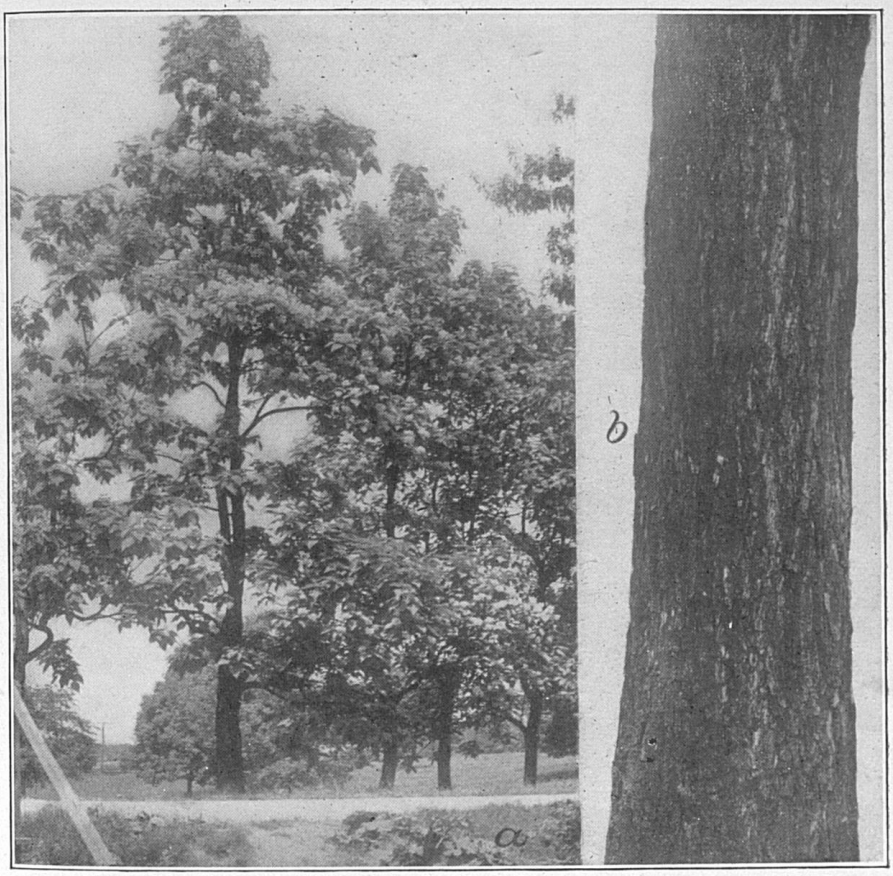


Fig. 3.—Showing upright growth and grooved bark of *C. speciosa*



Fig. 4.—Showing straggling growth and scaly bark of *C. bignonioides.*

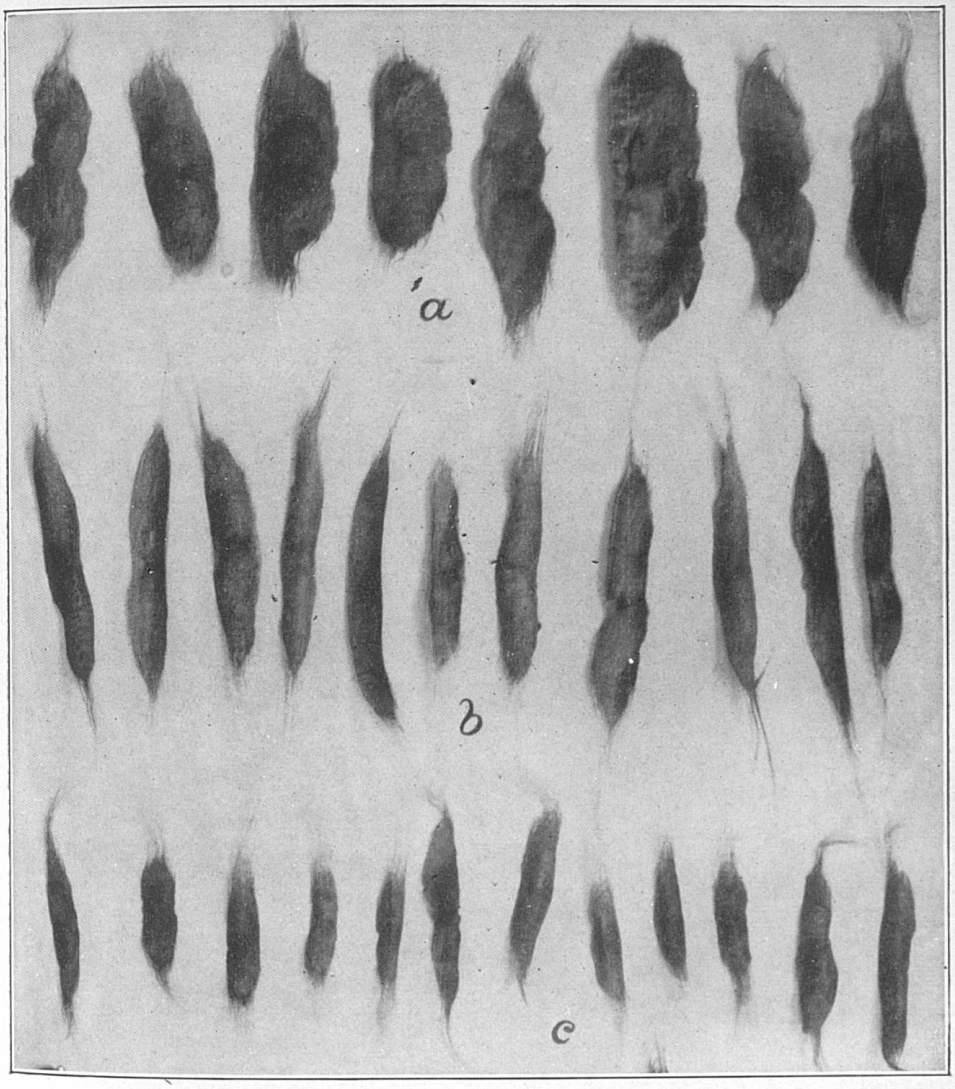


Fig. 5.—Seeds of three species of Catalpa: *a*, *C. speciosa*; *b*, *C. bignonioides*; *c*, *C. kæmpferi*. Natural size.



Fig. 6.—Young *Catalpa speciosa* in the Willadean Nursery, Donaldson Nursery Company, Warsaw, Kentucky.



Fig. 7.—A forestry planting of *Catalpa speciosa* four years old. Planted by the St. Bernard Mining Company, Earlington, Kentucky. Photograph by courtesy of the late John B. Atkinson.

slow in starting to grow after the frost, and they have not made a satisfactory growth since then, and surely could not be considered a valuable investment. But considering the value of such land, I think they are by no means a failure. If the land had been cultivated they would have done much better. But it is usually covered with water till late in the spring."

"They were planted in checks, seven feet each way. But if I should plant catalpa on good soil I would plant them not closer than 9 or 10 feet, as the branches would very soon fill the space between the rows. I have one catalpa tree growing, from a seed planted April 19th, 1904, and transplanted in rich soil, which measures full 8 inches in diameter 2 inches above the ground, and is about 22 feet high. This tree, however, is perhaps better than an average. Yes, I feel quite sure catalpa planted on fair to good soil would prove a paying investment. Nearly every farm has more or less waste land not profitable to cultivate, which, if planted to timber, catalpa or black locust, would, in a few years, be a very valuable investment."

"We have a few hundred black locust which are making a very satisfactory growth. They are planted in checks 6 feet each way, now making their third years growth from transplanting, and will average about 2½ inches in diameter at the ground and 18 to 20 feet high."

"It is much more valuable than giving the land over to weeds and wild briers."

The late John B. Atkinson, President of the St. Bernard Mining Company, at Earlington, Kentucky, expressed his interest and belief in practical forestry by planting catalpa and other trees in large numbers. He wrote shortly before his death that the Company has at the present time the following:

210,000 catalpa on 300 acres.
300,000 black locust on 300 acres.
500,000 black walnut on 350 acres.
10,000 tulip poplar (Liriodendron) on 20 acres.

In addition to the above the Company has 900,000 walnut

planted on vacant places "in our forests". The catalpa are from two to seven years old and were started from seeds. In an article published in *The Bee*, of Earlington, April 14, 1910, Mr. Atkinson states that his company began planting trees twenty years ago, and writes in explanation, "My experience as a mining man indicated to me that the time would come when timber would be far more valuable and difficult to secure for mining operations."

THE RATE OF GROWTH.

The young trees grow rapidly in suitable soils and situations, gaining half an inch in diameter yearly, many of them reaching a size suitable for posts in from 12 to 15 years.

A section before me taken from a tree cut down in 1911 on the State University Campus at Lexington measures 6.75 inches in diameter in one direction and 5.75 inches in another, being unsymmetrical. It shows 14 annual rings and has thus gained an average of 0.41 to 0.48 inch in diameter per year. This tree started as a sprout from the base of another one in 1898 in about average blue-grass soil. During 1901 and 1902 it made very little gain in diameter, two rings together representing these years amounting to but 1-8 inch on one side and 1-16 inch on the other. But during other more favorable single seasons it gained fully an inch in diameter. It is safe to say from this and other facts in my possession that trees on good soils will make an average gain of about 0.50 inch in diameter per year. At an age of ten years trees in such soils may reach a height of 20 feet, but the average gain in height is about 1.5 ft. per year.

THE SOFTNESS OF THE WOOD AND ITS DURABILITY.

Mr. O. Piper, of Clinton, writes me that he considers the black locust preferable to catalpa because of the softness of catalpa wood, a staple being necessary, he says, to make it hold. It is a soft wood but its durability in some situations more than compensates for this defect, and in contact with soil, especially, catalpa must be accorded a place as one of the best of woods.

The wood must be properly cured to give the best results, and where this has been attended to will last as posts for twenty years or more, without application of preservatives. White oak, elm, beech and ash will not last half as long.

ENEMIES OF CATALPA.

In the nursery, catalpa is sometimes damaged by rabbits, though not more than other trees, and generally when the nursery is near neglected land or is itself allowed to grow up in weeds and other growths. The remedies for this difficulty are so obvious as hardly to need stating. Where rubbing young trees with tallow is impracticable because of the number grown, a cheap slat fence may be built about the trees through which rabbits cannot go. In short, clean culture, fencing, traps, and watchfulness to prevent rabbits making the plantation a lurking place, are sufficient in all ordinary cases to keep rabbits from doing the trees mischief.

The large black-backed "horn worm" of catalpa is at times quite destructive to the leaves, generally locally and temporarily, but still is often very annoying. It may be checked by spraying the trees with arsenate of lead, 3 pounds in 50 gallons of water, just as soon as the worms appear. Paris green and lime, 1 pound in 125 gallons of water with 3 pounds of slaked lime, can be made to do the work of destroying the worms, if the arsenate of lead is not to be readily secured.

When of large size the worms may be jolted from the trees and may then be destroyed on the ground, but this supposes the injury to the leaves already done, and can be considered only a precaution against the injuries of future broods.

The immature seeds in the pods are often destroyed by a small yellow grub, the larva of a gnat. A large proportion of the seeds are destroyed during some seasons at Lexington. The immature insect is a footless yellow maggot, that when removed from the pod bends the extremities of its body together and then suddenly straightening out,

leaps for some distance. It was first observed by me in pods July 25, 1889, when I noted at Lexington certain pods with a half dozen or more blackened slits from 1-8 to 1-2 inch in length, through which the maggots seemed to have got into the interior, where they were mining the tissues in large numbers. Later, in 1891, the adult gnats emerged through these slits, the first appearing August 20, and others emerging as late as September 13. The adult is pale yellowish, with dusky head, and long legs and antennæ. The eggs appear to be placed in the slits in the sides of pods. Whether the slits are made by the maggots has not been determined. The adults are so small and fragile that they would probably be unable to escape if no such outlets were provided.

A second gnat produces a blotch mine on the upper sides of the leaves, beginning as a tortuous linear brown mine, then expanding and sometimes containing several larvæ all busily gnawing away the green substance. This insect was first noticed by me August 25, 1891. The larvæ cut a slit in the cuticle over the mine finally, and emerge to complete their changes. The mine was again noted as common June 16, 1911, by Miss Didlake of the Division, large mines brought to the laboratory by her measuring in some cases nearly two inches in length by 1.20 inch in width. A single small yellowish maggot was present in some, in others four or five, while still others were empty, these in all cases having the slit at one edge. This gnat has capacity for mischief should it ever become very common, but can probably be controlled to a great extent by early spraying with arsenate of lead.

The trees should always be kept free from dead branches, since these convey a destructive rot into the heart wood, often leaving the trunk a mere shell.

Trees growing on lawns sometime blight badly, and half or more of the branches may during very hot weather wilt and die suddenly from no apparent cause. It is probably a bacterial disease, like that causing pear blight, the symptoms and effect being similar. Whether this trouble attacks

native trees growing in favorable situations has not been determined. It may be encouraged by exposure of the trees to the sun in soils that are quickly deprived of their moisture by drought. The catalpas require a rather damp soil when the period for growth arrives.

One other disease is to be observed on the trees during most seasons, and while not often doing severe injury, it sometimes disfigures the foliage so as to attract attention. It is the work of a fungus (*Macrosporium catalpæ*) which invades the leaves, causing round brown spots to appear. Spraying with Bordeaux mixture before the disease appears is to be recommended on "general principles" as a means of preventing the injury. Carefully prepared experimental data as to the effect of such treatment are not at present available.

THE SOUTHERN CATALPA

(*Catalpa bignonioides*).

This tree is more southern in distribution than the *C. speciosa*, occurring originally in the Gulf States, though now widely scattered as an ornamental tree in other parts of the country. Its value for posts and ties is less than that of the other species, not because the wood is less desirable, but solely because of its straggling growth.

The crown is broad and low as a rule, the trunk often inclined instead of upright, while the bark is thin, and breaks up into small flake-like bits, there being none of the deep lengthwise grooves present, which are so characteristic of *C. speciosa*. The pods of *Catalpa bignonioides* are produced in larger numbers than those of *C. speciosa* and they are somewhat smaller, about 8 to 10 inches long, though similar in shape. In a cluster before me are seven pods. The flowers in a panicle are much smaller and more numerous, as many as seventy in a single panicle in some cases. An example measures 1.37 inches across the petals. The throat of the corolla has about five purple lines, branching

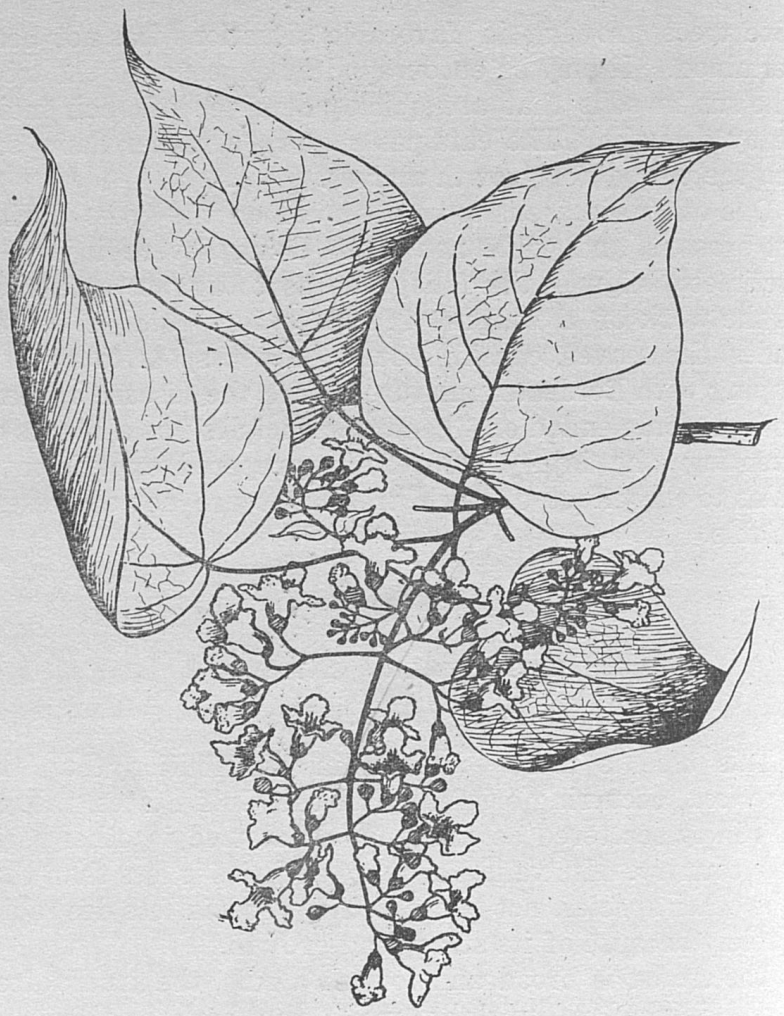


Fig. 8.—Flowers and leaves of *C. bignonioides*.

outwardly. Outside the lines of each side is an orange blotch followed within by a series of well defined dots. Outside the orange blotches, on each side, the throat is thickly dotted with purple. A few purple dots appear on the outer surface under the edges of the calyx lobes. Lower lobe of the corolla rather long, and with no appearance of a median notch. This tree was in full bloom May 28 in 1911, when *C. speciosa* had lost all its blossoms. Some trees were still in bloom June 17, though most had by that time passed the blooming period.

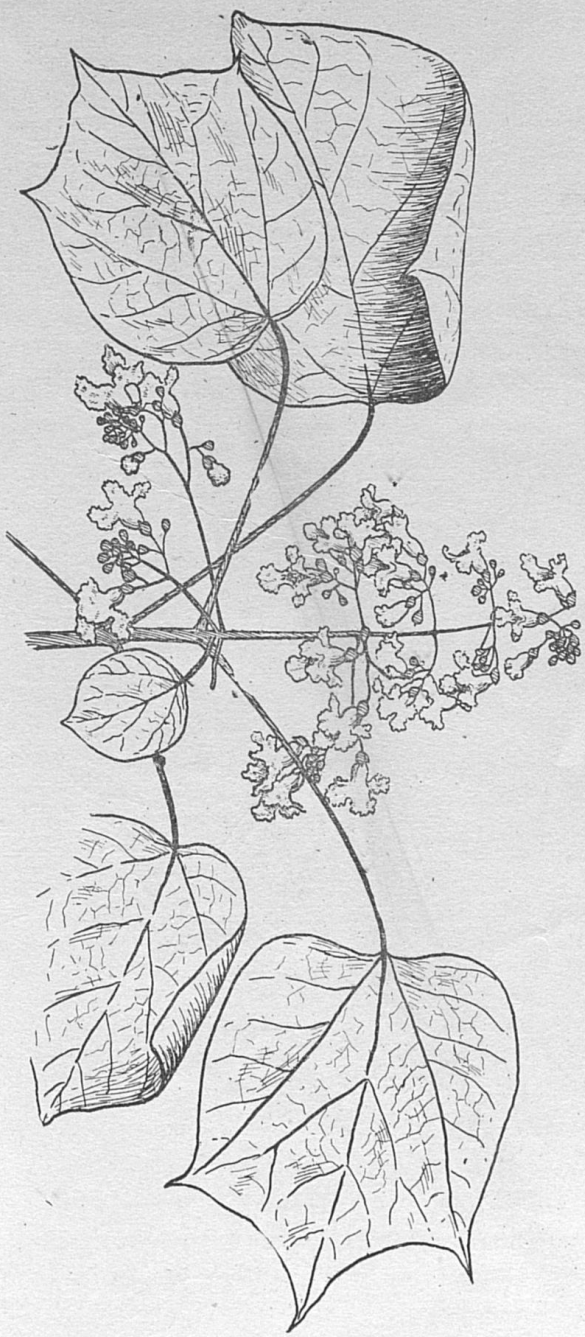


Fig. 9.—Flowers and leaves of *C. kæmpferi*. Note the angled leaves characteristic of this species.

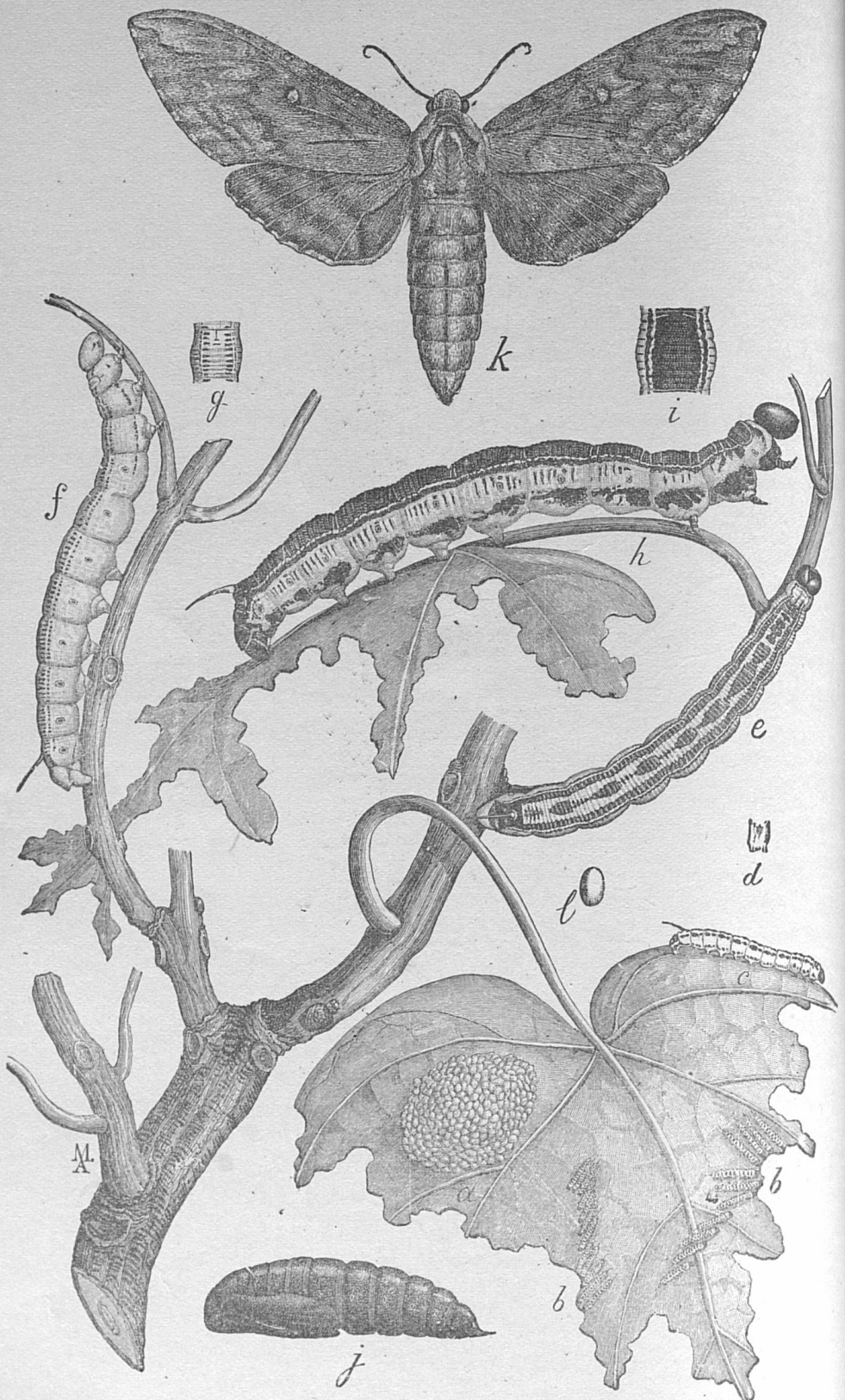


Fig. 10.—The Catalpa Sphinx (*Sphinx catalpæ*). *a*, mass of eggs; *b*, young larvæ just hatched; *e*, a half-grown larva; *f* and *h*, well grown larvæ; *k*, adult moth; *l*, egg magnified; *j*, pupa.

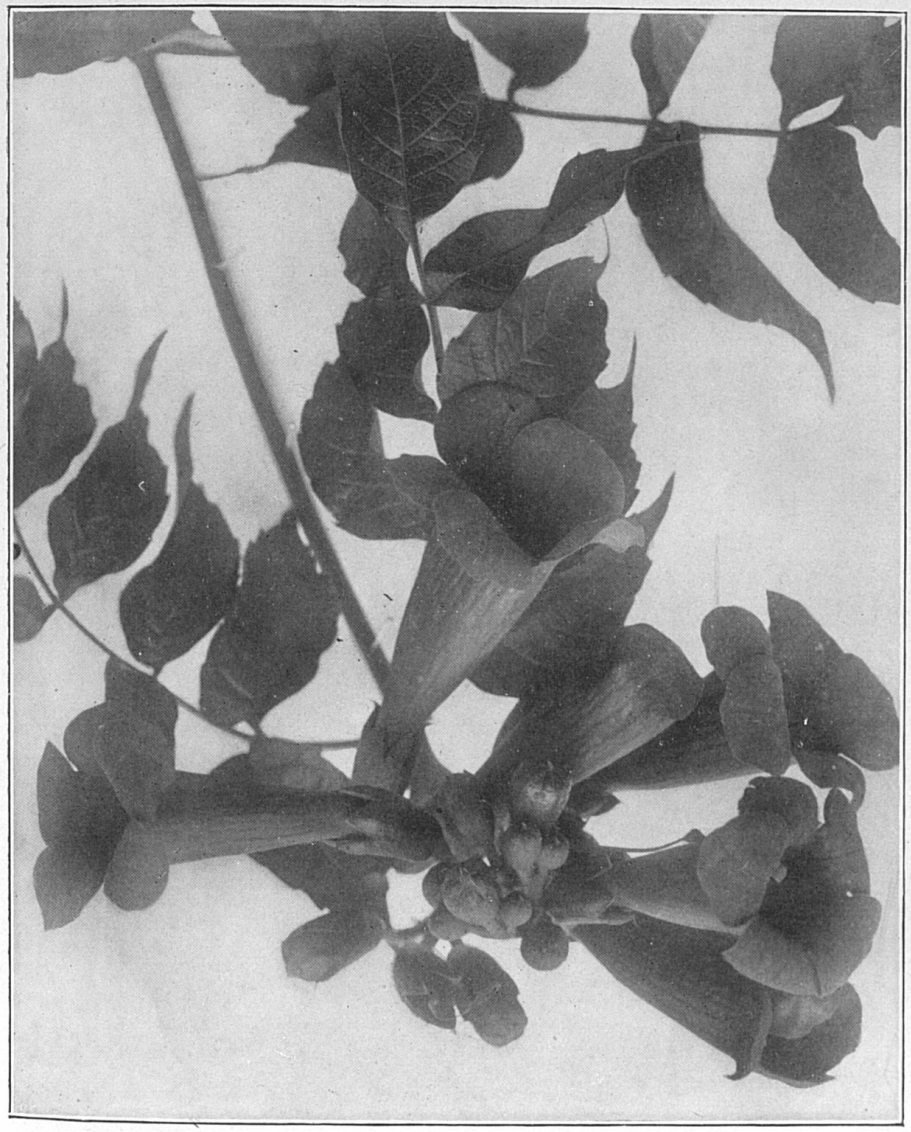


Fig. 11.—Flowers and leaves of the Trumpet Creeper. Reduced from natural size.

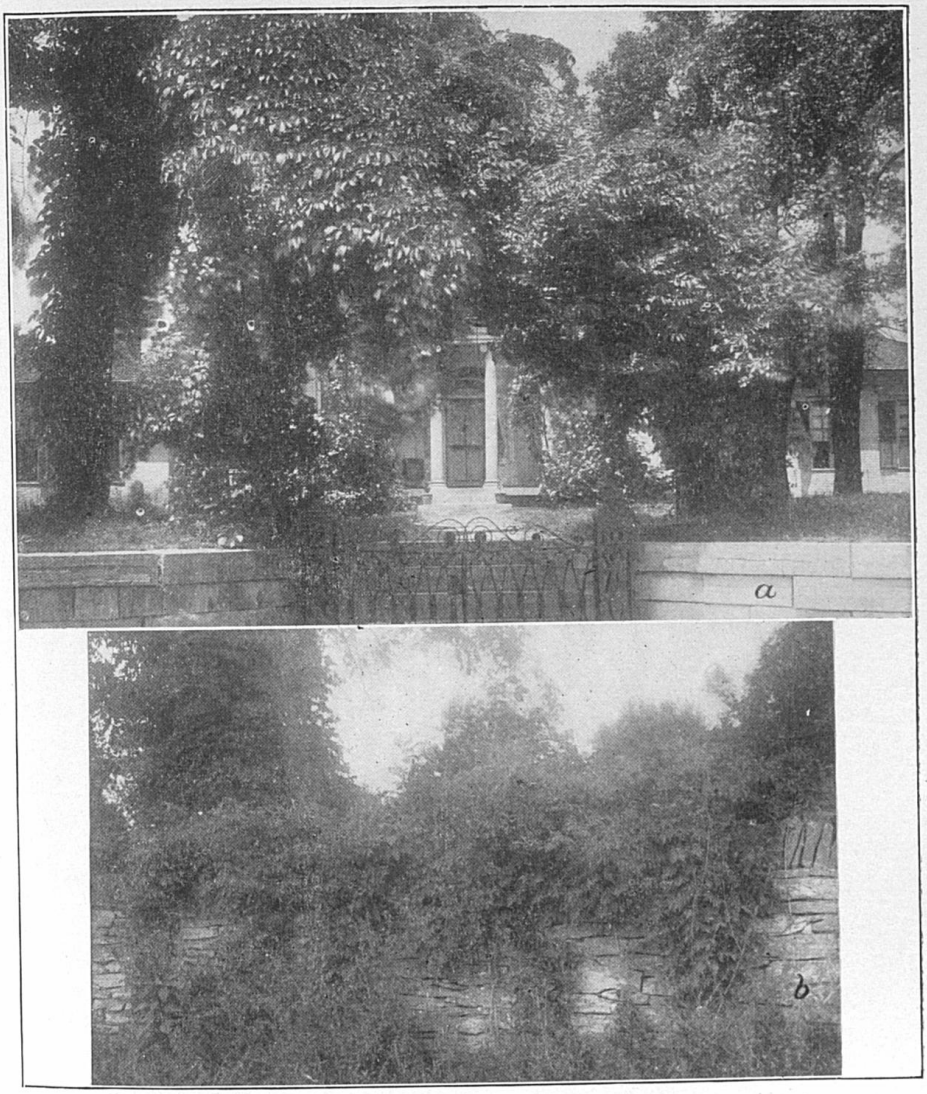


Fig. 12.—Showing the use of the Trumpet Creeper as an ornamental plant: *a*, at front of dwelling, North Limestone Street, Lexington, Kentucky; *b*, covering stone fence, Maysville Pike, near Lexington.

The seeds of *Catalpa bignonioides* are more slender than those of *C. speciosa* and taper to the extremities, where the scanty fringe is disposed to form a wisp or slender brush. They measure about 1.14 inch long by 0.27 inch wide. More small seeds develop in the pods than in those of *C. speciosa*, some of them not more than a half inch long.

The trees are subject to the same enemies and diseases as the related species.

THE TRUMPET CREEPER

(*Tecoma radicans*).

One of the most common and attractive woody vines occurring in Kentucky is the Trumpet Flower, or Trumpet Creeper, as it is called. It is a member of the same family as the catalpas, and possesses some of their attractiveness as an ornamental plant. It is very characteristic of thickets and clearings in the State, and has been adopted everywhere as a desirable plant for lawns and parks. Left to itself it produces a rank growth of graceful foliage clambering over trees, stone walls, fence posts, and the like, and with the large deep reddish orange tubular flowers peeping from the green of the foliage it presents a most attractive appearance. July 17, 1903, numbers of splendid growths in full bloom were observed along the Illinois Central Railroad, just south of Valley Station, Jefferson County, Ky.

When without support it lies flat on the ground, and has sometimes been complained of as a weed in meadows and pastures. It is not, however, to be considered a serious pest, and a little intelligent and persistent labor will get rid of it in any situation where it is not desired. The pods reach a length of eight inches and a diameter of an inch or more, at the thickest part.

Some years ago it was proposed and adopted as the State Flower, and appears to me to be an appropriate one for the purpose. It is not a first-class vase flower, however,

but the foliage is of a soft green, and rank of growth, the flowers very striking and artistic, so that the whole plant lends itself well to decorative uses. It is a native plant, too, and thus fulfills about all the requirements for a State Flower for Kentucky.

THE CROSS VINE

(*Bignonia capreolata*).

A second ornamental vine native to Kentucky and not uncommon along our rivers in wooded sections of the State is known as the Cross-vine because of the cross-shaped mark visible on the cut ends of the stems. The flower is showy and handsome, being trumpet-shaped, orange without and yellow within, measuring about two inches long, being thus shorter than that of *Tecoma radicans*. The leaves are very different, each consisting of two oval or arrow-shaped leaflets, with a tendril between. This latter feature has given rise to the name "tendrilled trumpet flower," sometimes applied to the species. The pods are curved, tapering decidedly to the extremities. One before me measures five inches in length and a half inch across.

The vine makes a good cover for stone walls, being of vigorous growth and handsome appearance. It has the reputation of becoming a pest at times by clambering over trees where it is not desired. This cannot be regarded as a serious objection to it, since it may be suppressed by simple practice familiar to every farmer and gardener.

OTHER SPECIES BELONGING TO THE FAMILY BIGNONIACEÆ.

In cultivation several exotic catalpas and trumpet vines may be encountered.

The Japanese Catalpa (*C. kæmpferi*) is frequently seen about lawns in Kentucky, but may always be recognized by

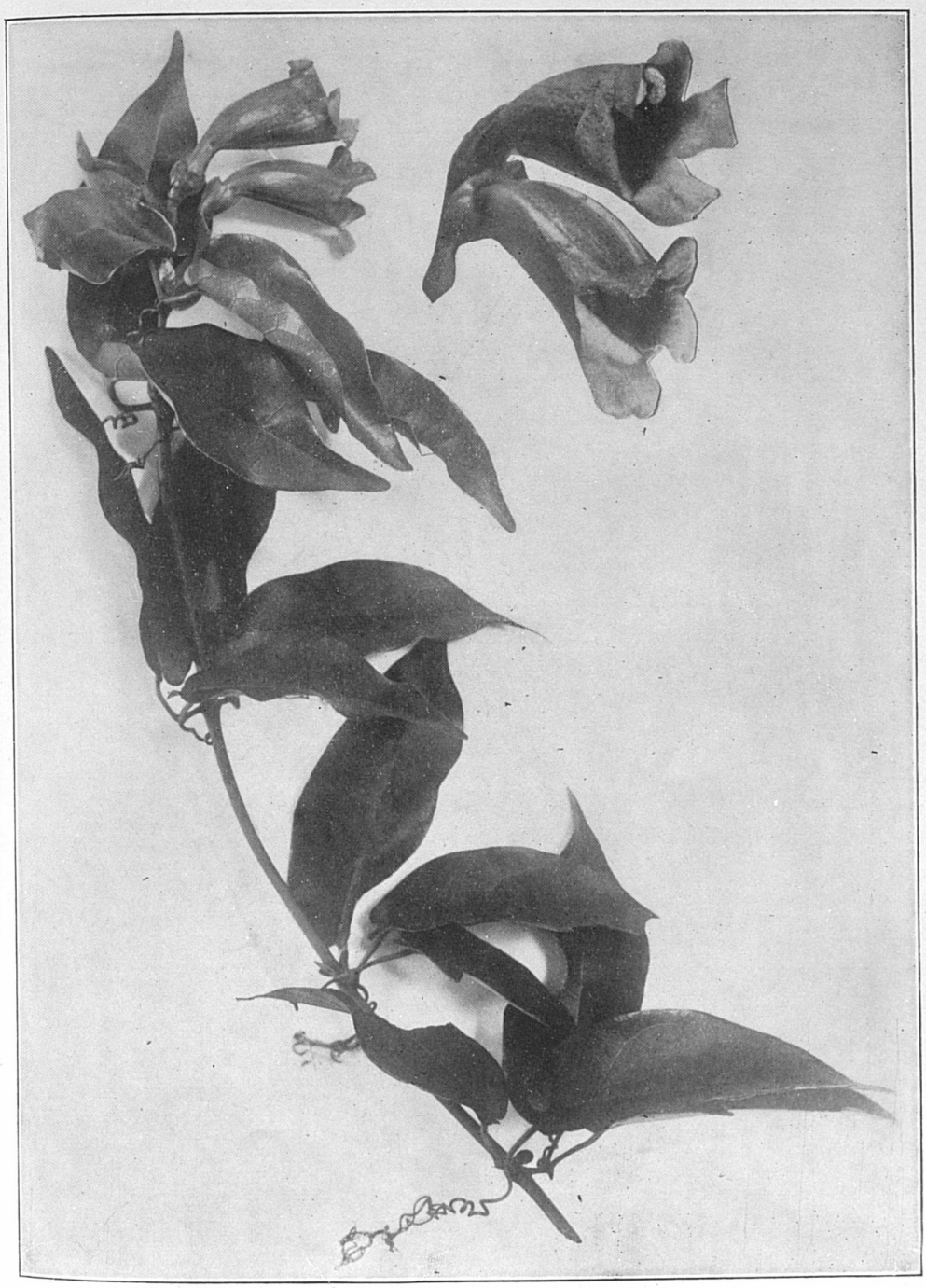


Fig. 13.—The Cross Vine (*Bignonia capreolata*). Flowers of natural size at the right. Photographed from specimen kindly furnished by Miss Emilie Yunker, of Louisville.

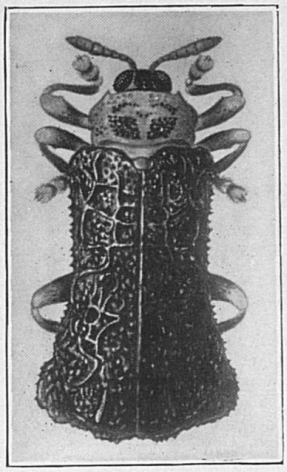


Fig. 14.—The Trumpet Creeper Leaf-mining Beetle (*Octotoma plicatula*). x 9.

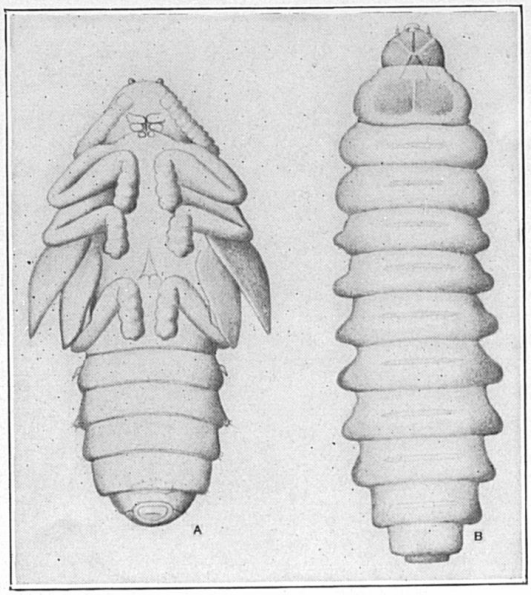


Fig. 15.—*A*, ventral view of the pupa of *Octotoma plicatula*; *B*, dorsal view of larva. x 9.

its numerous, very small, pale yellow flowers, its angled leaves, and small, very slender pods, these being produced at times in large numbers. A cluster before me is made up of twelve pods. The tree is smaller than either of the native catalpas.

THE TRUMPET-CREEPER LEAF-MINER

(*Octotoma plicatula*).

The trumpet creeper compared with other ornamental plants is relatively free from pests, but it is subject to the attacks of a singular small black beetle that may injure the leaves so badly and cause them to become so unsightly as to render the plant valueless for the purposes for which it is planted. Fortunately the insect is local in its distribution.



Fig. 16.—Showing manner of placing the eggs after gouging the leaflets.

An isolated plant may year after year be severely damaged, while others not far away remain untouched. This feature of its habits implies that the adults do not wander much, and affords some assurance of general immunity from attack so long as the plant is not very commonly kept in cultivation.

The adult insect is a flattish elongate black beetle belonging to the same family as the cucumber beetle, but to

another section sometimes called Hispides. Seen on the leaves in July when it is abundant as an adult, it looks like a bit of bark, or other rubbish, and since it remains quiet to escape detection, with its legs folded up about the body, and drops to the ground if the leaves are disturbed, the collector is more likely to collect it by accident, than from a recognition of it as an insect. The adults appear in the latter part of June and early July and are then to be seen resting on the under sides of the leaves. If followed up closely until they recognize that they are observed, they take to their wings. They creep but slowly. They feed on the leaves freely, gnawing the surface away or cutting elongate holes in them, riddling them badly when many of the insects are present. The females begin placing their eggs promptly in June, and may be found on the plants until July 18, or thereabouts. Somewhat later they disappear, but reappear again in numbers about September 11, these being the individuals that hibernate.

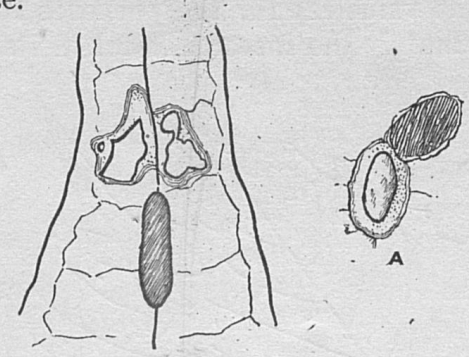


Fig. 17.—Magnified view of egg sealed down with gum. *A*, enlarged and with gum cover turned aside.

The egg, unlike those of the black locust leaf miner (*Odontota dorsalis*), are placed singly on the upper side, generally over the midrib, and toward the tip of the leaflet. They are fastened down with a brown glue which hardens and gives them the appearance of being a deadened part of the leaf. This separates from the leaf readily when pried up with a needle. The adult always gouges the leaf just above the place where the egg is attached as if she meant to brand it and warn away other females bent on similar errands.

Larvæ just hatched were noted July 1, 1910, under the gummy material which fastens the egg to the leaf. They occur from this time until the latter part of July. On July 18, 1910, about fifty per cent. of the mines contained larvæ, the remainder pupæ.

Pupæ have been collected only on July 18. The record thus implies a single brood and hibernation as an adult.

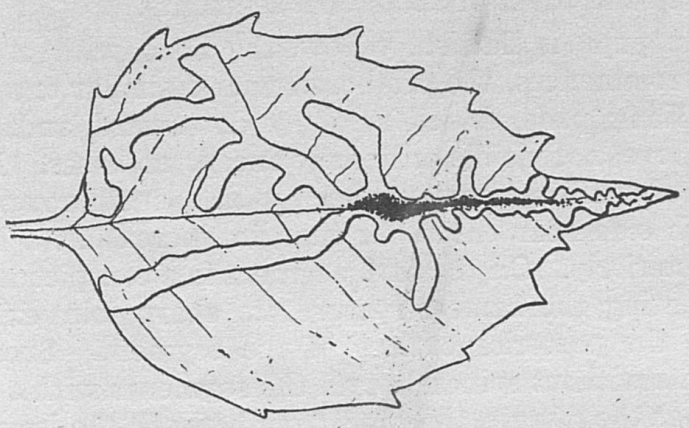


Fig. 18.—A leaflet mined by *Octotoma plicatula.*

The mines are very striking and characteristic. The larva penetrates the leaflet above the midrib and works toward the center in a straight course at first, then at intervals makes excursions to the right or left on each side of the mid-rib, and often reaches nearly to the margin of the leaflet before turning back and starting another. The final result is a branched mine with long curved or slightly tortuous extensions on each side of the mid-rib. When ready to pupate the larva returns to the center of the leaflet and pupates in the central chamber over the mid-rib.

Description.—Adult elongate, flattish, gradually widening toward the posterior end of the wing covers, which are finally a little flared and rounded, the hind margin regularly rounded. Head small, antenna rather short, expanded at the tip into a club. Prothorax wider, its dorsal surface with elevated ridges; a sharp point projecting forward on each side of the head. Wing covers with elevated reticulate

carinæ, the interspaces with round punctures. Legs rather stout and short; the tarsi thick and clumsy. General color black, varied with yellow. Antennæ yellow except the club, which is dusky. Head yellow at bases of antennæ and beneath. Prothorax yellow on carinæ and beneath. Legs yellow at base; tips of femora, bases of tibiæ, and the tarsi also yellow. Individuals possibly not quite mature, show yellow on the edges of abdominal segments.

The pupa is flattish, yellow, the head with a pair of small prominences, the prothorax with a similar one on each side. Wing pads folded strongly downward and, viewed from above, not visible ordinarily except at bases. First to fourth abdominal segments each with a small rough thorn at each side near the outer margin, increasing a little in size posteriorly. On the fifth segment is a conspicuous spine representing the same structure, its sharp point extending beyond the posterior outline of the segment. Succeeding segments without spines, but all the segments with a minute spinule at the margin. Viewed from beneath the legs appear folded close against the breast. The thighs extend obliquely outward and backward; the tibiæ extend obliquely forward and inward; the tarsi extend directly backward, the tips of the posterior pair being level with the tips of the folded wing pads, which cover the posterior legs largely. Seventh abdominal segment with a curved series of small brown tubercles anterior to the posterior margin. Last segment small and ventral in position. Length 4.3 millimeters (.17 inch); diameter 1.8 mm. (.07 inch).

The larva is more slender and elongate than the pupa, and whitish. The body is flattened, the head small, the thirteen segments wider and with sides protruding, in the case of the first seven abdominal with rather slender rounded protuberances. The posterior somites contract and have straightish sides, the last being much the smallest, and somewhat retractile. The head shows protruding mouth-parts and on each side of them the short antenna projects forward; it bears a pair of terminal segments at its tip, and is thus branched. The simple eyes are ranged in a curved

series at and beneath the margin and are marked by round black points, four or five in number. A conspicuous brown median longitudinal suture of the crust of the head above divides behind to enclose a triangular occipital area. Limbs are absent, but enclosed areas on the ventral sides of the three thoracic segments appear to mark their situation. Length 6 mm. (0.24 inch); diameter 2 mm. (0.08 inch).

The egg is a whitish fragile elongate object easily crushed by attempts to remove it. Length 0.85 mm. (0.034 inch); diameter 0.42 mm. (0.017 inch).

Treatment for the insect is simple. The adults can be destroyed in the spring when they appear on the leaves to place their eggs by spraying with arsenate of lead.

KENTUCKY AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY

BULLETIN No. 165

INVESTIGATIONS OF THE ETIOLOGY OF INFECTIOUS ABORTION OF COWS AND MARES

LEXINGTON, KENTUCKY,
APRIL, 1912.
(225)

Kentucky Agricultural Experiment Station

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Kentucky

BULLETIN No. 165

INVESTIGATIONS OF THE ETIOLOGY OF INFECTIOUS ABORTION OF COWS AND MARES.

By Edwin S. Good.

INTRODUCTION.

Infectious abortion in live stock is a disease which annually causes a tremendous loss to the stockmen of America as well as to the breeders in European countries. The disease is most prevalent where stock farming is highly specialized. This is especially true among the dairies of middle Europe. This disease has been and is prevalent in England. Mascal notes that in 1567 as many as 50 to 60 per cent. of the cows in certain localities of England were aborting. MacFadyean and Stockman, who have been making a recent study of the disease in Great Britain, report that it is very prevalent in certain districts and that it sometimes occurs among flocks of sheep as well as in studs of horses. In America the dairyman, the beef cattle breeder, and the breeder of horses, probably suffer greater financial loss from the ravages of this disease than do any other classes of breeders.

A noted authority living in a State where dairying is carried on to a considerable extent estimates that infectious abortion among the cows of his State causes an annual loss of ten million dollars. To the dairymen the loss of the immature calf is simply one item of the loss occasioned by this disease, as the yearly flow of milk from an aborting cow is much less than it would have been had she delivered a normal calf. Also a cow that gives premature birth to a calf due to infectious abortion afterwards conceives with difficulty, and in some cases not at all.

Kentucky's greatest loss from this disease has been among its horses, especially by outbreaks in the studs of Thoroughbred and Standardbred mares of the Blue Grass Region. In some seasons as high as 75 per cent. of the mares of certain studs have aborted, while in a few instances all of the foals have been lost. To be deprived of a foal crop in a stud of high priced animals means a heavy financial loss. There have even been instances where as high as $1,500.00 has been given for service fee to certain stallions. For the past three or four years the mares of this region have been comparatively free from this disease. Occasionally, however, there are outbreaks in various studs, while numerous dairy herds throughout the State have been visited with infectious abortion.

Infectious or epizootic abortion has been known to exist among stock for centuries. Much speculation over its cause has been made by the breeders, while in recent years the scientific investigator interested in veterinary problems has given this subject much of his attention. It is interesting to note the opinions of various breeders of horses of the Blue Grass Region of Kentucky concerning the different causes of abortion. Some of these theories are: That the trouble is caused by the mare eating frost bitten grass late in the fall, or early in the spring; the flushing of the system by eating too much succulent feed; the presence of mal-odors, i. e., if a mare aborts in a field and the fœtus and afterbirth are not removed at once and the place on the ground from which they were taken covered with dirt, the odor will of itself cause the remainder of the mares to abort; the running of mares on the same pasture year after year; or the infection of the mother and fœtus with some micro-organism.

The belief is on the whole more common among owners of herds of cattle than of studs of horses that this disease is caused by a microbe and, therefore, is of an infectious nature. To gain some definite knowledge as to the etiology of this disease among the stock of this State, and a possible preventive or cure for the same, a bacteriological laboratory was equipped by the Department of Animal Husbandry of the

Kentucky Experiment Station, in 1907, and since that time investigations along this line have been conducted under the Adams Fund.

Classification of Abortion in Live Stock.

Before entering upon any further discussion of this subject, it might be well to note briefly the characteristics of the distinct types of abortion.

Williams, in his text on Veterinary Obstetrics, recognizes three classes of abortion in domestic animals,

1. "Sporadic or accidental abortion, in which, owing to the disease of, or accident to, the fœtus or mother, the fœtus may be expelled dead or in a state of disease which renders it impossible for it to live.

2. Enzootic abortion, due to some infectious disease of the mother, which brings about the death and expulsion of the fœtus as a complication of the maternal disease.

3. Infectious abortion, an infection of the fœtus and its membranes which cause the death and expulsion of the fœtus or its expulsion in a living and enfeebled state at any period of gestation from the date of conception to the normal completion of pregnancy, without directly inducing material evidence of the disease in the mother."

Accidental and Enzootic Abortion.

Accidental abortion is usually caused by pregnant animals being crowded with other animals, or by a severe hook, kick, or heavy fall. We have known of a cow giving birth to an immature fœtus in a few hours after falling on a cement floor, and striking her side against a cement gutter. We have also noted a case where a severe hook caused a premature delivery of the fœtus. Another instance came to our notice where a valuable cow had traveled a long distance by the train and was then hauled for several miles over a very rough road in a wagon, thus being severely jolted. Upon arriving at her destination the cow appeared very much fatigued and shortly after her arrival aborted.

Ergot is supposed to be a common cause of abortion, al-

though there are numerous instances on record where ergot has been fed to pregnant animals without causing them to abort. While this fungus may at times cause abortion in cows and mares when taken into the alimentary tract by ingestion of grass and hay bearing it, we believe that it does not frequently produce abortion in these animals.

The writer was informed by a large feeder of beef cattle and hogs that young, green rye would cause brood sows to abort. At this Station we are very partial to a rye pasture for hogs, and have run pregnant sows on it for some time without any cases of abortion.

It has been a common observation in our work with hog cholera that pregnant sows recovering from the disease will abort. It is known that mares afflicted with dourine and cows with foot-and-mouth disease will abort. These are examples of enzootic abortion.

It is a difficult thing at times to distinguish between accidental and infectious abortion, as the infection may be among the animals and not be recognized. After the first three years of our investigations we were strongly inclined to believe that accidental abortion played a larger role in abortions among our domestic animals than we had supposed, while now we feel quite convinced that abortion of the infectious type is more common than formerly supposed.

PART I.

INFECTIOUS ABORTION OF COWS.

Results of Investigators. Although infectious abortion among stock has been recognized for a long time, there has been considerable variance in the conclusions of different investigators as to the organism producing this transmissible disease. The following is a brief review of some of the findings of a few of the most prominent investigators in this field during the last thirty years:

It is reported on reliable authority that Franck, Braurer, Galtier, Nocard and other European workers produced abortion experimentally by injecting some of the uterine exudate from aborting animals intravaginally into pregnant animals of the same species. The organism, however, producing the disease was not discovered.

In 1886 Nocard of France carried out the first extensive investigation of a bacteriological nature with reference to this disease. He recognized a small baccillus and cocci or globular bodies, singly or in chains, as being most often associated with the fœtal membranes of an aborting animal. He was unable, however, to produce abortion experimentally with pure cultures of these organisms.

Law and Moore of Cornell, and Chester of Delaware, have been prominent investigators who have given publicity of their results in this country. These gentlemen have found a type of the colon bacillus associated with the fœtal membranes of aborting cows.

In 1896, Bang and Stribolt of the Royal Veterinary College, of Copenhagen, Denmark, announced that they had discovered a germ associated with infectious abortion of cows that was able to produce the disease when inoculated intravaginally of intravenously into pregnant cows. As far as the writer knows these gentlemen went at the problem in a different manner from that of any previous investigator, in that they slaughtered a cow showing symptoms of abortion and removed the

unopened uterus to the laboratory where it was opened as aseptically as possible. An abundant grayish-yellow, odorless exudate was found between the ovum and the inner wall of the uterus. Upon standing, this exudate separated into two layers, a reddish-yellow serum above and a grayish-yellow, partly solid layer below. Preparations of this exudate stained with methylene blue revealed numerous very small organisms that resembled, under the low power of the microscope, cocci, but on examination under a higher power, they proved to be bacilli containing one, two or three granules. After many efforts these gentlemen were able to cultivate this organism on serum-gelatin-agar, the germ developing in a particular zone of the medium, beginning about 5 mm. beneath the surface of the medium and extending downward 10 to 15 mm. Their inoculation experiments were affirmative.

Manner of Infection and Pathology. It seems to be conclusively proven to the minds of European investigators that the main channels through which infection reaches the uterus is through the vagina, and through the alimentary canal, by ingestion. They claim that the infection may reach the uterus before pregnancy, or if the infection is introduced into the vagina after pregnancy, the germs are able to pass the mucous plug in the neck of the uterus, whereupon they increase between the fœtal and mucous membranes, setting up inflammatory processes, resulting in a purulent exudate between the mucous membrane and the chorion. The connection between the tissue layers loosens, resulting in a partial separation of the membranes, and the premature delivery of the fœtus follows. Investigations show that the germ at times is able to enter into the circulation of the fœtus through the medium of the placenta to the blood stream.

Symptoms of Infectious Abortion in Cows.

The first symptom that attracts one's attention to an approaching abortion in the heifer, is the springing of the udder and increase in size of the vulva. However, some authorities claim that heifers may at times present symptoms as described

above to a slight degree and not abort. There may be a slight odorless discharge from the vagina which is yellowish white, tinged at times with blood. At times just before the cow aborts, the discharge is quite noticeable, and upon inserting the hand into the uterus a quart or more of this material can be removed. The individual often appears somewhat dull and at approaching abortion has a tendency to remain away from the herd. If the cow is giving milk a gradual falling off of the amount of milk given may be noted for sometime before the cow aborts. There may, or may not be a decrease in the milk flow for a day or two previous to the premature discharge of the fœtus. Occasionally cows will abort without giving much if any previous warning. The fœtus is generally dead when expelled. However, if the cow carries it until in the eighth or ninth month of gestation she may deliver it alive. Such calves are usually very weak and are termed "living abortions." Stockmen sometimes say that a seven months old fœtus has a better chance of living than one eight months along in gestation. This seems to us as improbable, for in our experience a fœtus at seven months is not completely haired over, though different fœtuses vary somewhat in their development at that stage of gestation. (See plate 15.) We are told of an instance, however, by an extensive breeder of Hereford cattle that a calf dropped in his herd so young as not to be completely covered with hair lived and developed into an excellent individual. What is usually meant, no doubt, is that a fœtus dropped in the eighth month has a better chance of living than a premature delivery in the ninth month of gestation. Occasionally a well advanced fœtus may appear dead when dropped, but upon examination one finds that one or both of the lungs have performed their function. When the abortion occurs in the very early stages of gestation the small embryo usually comes away enveloped in the inconspicuous fœtal membranes and easily escapes detection. (Plate 17.) If the cow aborts after the fœtus has attained considerable size, the fœtal membranes are usually retained by the cow and the assistance of the veterinarian is required to remove them. Occasionally aborting cows die as a result of retaining the

fœtal membranes for too long a time. If these membranes are not passed in twelve hours, they should be removed. A catarrhal condition of the uterus may cause the gradual death of the fœtus which does not result in its immediate expulsion, and in such a case the fœtus becomes mummified. All the afterbirths that we have examined from aborting cows were alkaline to litmus.

Time Elapsing Between the Beginning of Pregnancy and Abortion in Cows.

Danish investigators found abortion most frequent from the fifth to the sixth month in cows, but at the beginning of an outbreak as early as the third or fourth month. The history of three herds which we have examined in which statistics have been kept show that there is some variation in this regard between herds recently affected and a herd in which the infection has been present for some time, in that the aborting cows in a herd of the latter description carry their calves longer on the average before premature delivery than do those in a herd more recently infected. In the herd which we shall designate as No. 1, six abortions occurred in the fifth month of gestation; six in the sixth month; sixteen in the seventh month; twenty-two in the eighth month, and ten in the ninth month. Herd No. 1 has been affected more or less with infectious abortion for the past ten years. In herd No. 2, one cow aborted in the second month of gestation; two in the fourth month; three in the fifth month; six in the sixth month; eight in the seventh month; seven in the eighth month; and one in the ninth month of gestation. Abortion has existed in this herd for the past two years. The infection has only been in Herd No. 3 for one year. The cows were bred in December and began aborting in March and the last abortion occurred in July. There were sixteen cows and five heifers in this herd, and all but five aborted. From the above statistics relative to herds 1, 2, and 3, it can be seen that the average period of gestation of aborting cows in Herd No. 1 is longer than is the case in either Herd 2 or 3. Herd No. 1 had been kept under

the best of sanitary conditions for years and an effort has been made to control abortion among the cows. This fact, together with partial immunity obtained by some of the females previously aborting would, no doubt, tend to make the average abortion in a herd of this kind occur later in gestation than in a herd recently affected with the disease.

After the uterus of a cow or other animal becomes once infected with the virus it is reasonable to suppose that the infection will remain in the uterus and cause the animal to abort in a succeeding pregnancy. Usually after a cow aborts one or two times she carries her next calf full time and delivers it alive. This is, no doubt, due to her increasing tolerance to the infection. There are, however, exceptions to this rule as a cow may abort twice in succession then drop one or two live calves, then abort again. This procedure has come under our observation, but we are in no position to say in these special instances whether or not any or all of these abortions were not accidental. Heifers as a rule abort at an earlier period than do cows.

Considerable discussion has taken place as to whether or not a cow affected with infectious abortion has a tendency to carry the fœtus at consecutively longer or shorter intervals before expelling it. It is stated on good authority that if the vagina and uterus of an aborting cow be irrigated with a mild antiseptic at stated intervals and the breeding of the cow delayed until all discharge ceases, she will usually carry her calf a longer period between each abortion until she delivers a live normal calf. This statement seems to be confirmed by the statistics of Herd No. 1 (see table No. 1), where it is shown in nine instances, when the second consecutive abortion occurred, that the period of gestation was of longer duration than that of the first premature delivery, while in three instances the reverse was true. If on the other hand, the nature of the disease is not well understood by the husbandman, and the vagina and uterus of the cow not thoroughly irrigated with a mild antiseptic, and she be bred soon after aborting, the second consecutive abortion will occur in a shorter time after conception than in the first instance. We have

been told of one herd located near Lexington, where the aborting cows were bred soon after aborting, that the time which elapsed between pregnancy and abortion was of shorter duration the second year. For two years nearly every cow on this farm aborted and the neighbors' cows bred to this herd bull also aborted.

The general observation is that if several months elapse after a cow aborts before she is bred, frequently a live normal calf is dropped. On the other hand we have noticed that if the breeding of an aborting cow is delayed for several months after aborting it is often very difficult and at times impossible to get her in calf.

TABLE NUMBER 1

Statistics of Aborting Cows in Herd No. 1

No. of Cow and Date dropped	Date Served	Bull Served by	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 1	April 13, 1902	No. 1	190		Oct. 20, 1902	
No. 2	September 1, 1901	No. 2	281	June 9, 1902		Heifer
Feb. 6, 1900	July 10, 1902	No. 1	216		Feb. 11, 1903*	"
No. 3	Sept 23, 1903	No. 1	190		April 1, 1904	
June 9, 1902	Nov. 4, 1904, May 30, Oct. 5, 1905, Mar. 9, 1906	No. 1-5-3	285	Dec. 19, 1906		"
No. 4.	Oct. 31, 1903	No. 4	204		May 23, 1904	
Aug. 12, 1902	May 20, 1905	No. 1	286	Mar. 2, 1906		Bull
	June 28, 1906	No. 5	294	April 18, 1907		"
	May 16, 1907	No. 6	284	Feb. 24, 1908		Heifer
	April 2, 1908	No. 6	257	Jan. 14, 1909		Bull
	November 2, 1909	No. 3	284	Aug. 13, 1910		"
No. 5	October 28, 1902	No. 7	279	Aug. 3, 1903		Bull
Dec. 17, 1901	October 10, 1903	No. 1	226		May 24, 1904	"
	October 4, Oct. 28, Dec. 7, 1904. Jan. 4, Jan. 23, Feb. 12, March 31, 1905	No. 1-5	288	Jan. 13, 1906		Heifer
	April 10, 1906	No. 1	289	Jan. 24, 1907		Bull
	March 9, 1908	No. 6	284	Dec. 18, 1908		"
	February 7, 1909	No. 6	278	Nov. 12, 1909		Heifer
	December 25, 1909	No. 6	294	Oct. 15, 1910		Bull
	December 7, 1910	No. 8	268	Sept. 1, 1911		Heifer

* Cow No. 2 was severely hooked on February 9th, 1903, and this case should no doubt be classed as accidental abortion.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 6	January 15, 1904	No. 5	164	.....	June 28, 1904	
Jan. 20, 1901	October 7, 1904	No. 5	251	.....	June 15, 1905	Heifer
	August 24, 1905	No. 9	284	June 4, 1906†	.....	"
	August 16, 1906	No. 3	270	May 13, 1907	.....	"
	June 11, 1907	No. 5	286	Mar. 24, 1908	.....	
	May 4, May 28, June 17, July 27, Aug. 31, Nov. 14, 1908, January 9, March 15, 1909	No. 5-6		.....	.....	
No. 7	March 1, 1904	No. 1	137	.....	July 16, 1904	
Feb. 7, 1895	November 24, 1904	No. 1	285	Sept. 5, 1905	.....	Heifer
No. 8	April 26, 1904	No. 1	218	.....	Nov. 30, 1904	
Jan. 30, 1902	May 4, July 8, 1905	No. 5	278	April 12, 1906	.....	Heifer
	March 14, April 2, June 22, July 27, 1906	No. 3	288	May 11, 1907	.....	Bull
	July 2, 1907	No. 5	215	.....	Feb. 2, 1908	Heifer
No. 9	September 1, 1904	No. 1	154	.....	Feb. 2, 1905	
April 11, 1902	June 2, June 25, July 17, Sept. 2, 1905	No. 1	296	June 25, 1906	.....	Bull
	August 25, 1906	No. 3		?	.....	"
No. 10	December 9, 1904	No. 5	220	.....	July 17, 1905	
Aug. 12, 1897	February 8, 1906	No. 5	204	.....	Aug. 31, 1906	
No. 11	June 10, 1904	No. 4	287	Mar. 24, 1905	.....	Heifer
Dec. 13, 1902	May 6, May 29, June 8, June 17, July 6, July 27, August 14, Sept. 1, Sept 18, 1905	No. 4-5	149	.....	Feb. 14, 1906*	Bull
	May 10, May 19, June 6, June 24, July 12, 1906	No. 5	284	Apr. 22, 1907	.....	Bull

† Cow No. 6. The calf dropped June 4th, 1906, was very weak and minus a tail. The calf was subsequently killed.
* Cow No. 11 fell on the ice February 14th, 1906, and aborted shortly afterwards.

Statistics of Aborting Cows in Herd No. 1—Continued.

† Cow No. 6. The calf dropped June 4th, 1906, was very weak and minus a tail. The calf was subsequently killed.
* Cow No. 11 fell on the ice February 14th, 1906, and aborted shortly afterwards.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Drodped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date af Abortion	Sex of Calf
No. 11	May 25, 1907	No. 5	282	Mar. 3, 1908	.....	Heifer
Continued.	April 19, May 7, May 26, 1908	No. 5	171	.....	Nov. 13, 1908	"
	February 10, 1909	No. 6	136	.....	June 26, 1909	
	December 17, 1909	No. 6	144	.....	May 10, 1910	
No. 12						
Aug. 3, 1900	November 1, 1901	No. 5	222	.....	June 11, 1902	
	Aug. 28, Sept. 17, Oct. 3, Oct. 30, Nov. 18, Dec. 5, 1902	No. 5-12	279*	Sept. 30, 1903	.....	Bull
	December 4, Dec. 24, 1903 [July 2, 1905	No. 5	280	Oct. 1, 1904	.....	"
	Oct, 26, Nov. 17, Dec. 7, 1904; Feb. 18, Mar. 4, Apr. 22, June 11,	No. 5-1-13	289	Apr. 17, 1906	.....	"
	June 12, 1906	No. 5	206	.....	Jan. 4, 1907	Heifer
	March 26, 1907	No. 5	271	Dec. 22, 1907‡	.....	"
No. 13						
Mar. 24, 1905	August 24, 1906	No. 6	177	.....	Feb. 17, 1907	
	May 31, 1907	No. 6	123	.....	Oct. 1, 1907	
	March 6, 1908	No. 6	289	Dec. 20, 1908	.....	Bull
	Feb 11, 1909	No. 6	185	.....	Aug. 15, 1909	" (2)
	October 29, 1909	No. 3	252	.....	July 8, 1910	
No. 14						
May 30, 1902	September 14, 1903	No. 1	283	June 24, 1904	.....	Bull
	July 27, Oct. 21, Nov. 16, 1904, Jan. 7, Jan. 28, 1905	No. 1	243	.....	Sept. 28, 1905†	"
	June 16, 1906	No. 3	259	.....	Mar. 2, 1907	Heifer
	September 28, 1907	No. 6	281	July 6, 1908	.....	"
	August 15, 1908	No. 6	293	June 4, 1909	.....	Bull
No. 15						
Sept. 3, 1905	October 1, 1906	No. 6	199	.....	April 18, 1907‡	

‡Cow No. 12 could not be gotten in calf after 1907, as the os uteri had become closed with a growth.
†Cow No. 14. Calf dropped Sept. 28, 1905, came alive but was very weak. The calf was subsequently killed.
‡Cow No. 15 was bred a number of times after dropping calf in 1905 without becoming pregnant. She then discontinued coming in heat and became fat. It was found on examination that the os uteri had become closed with a growth.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 16	October 4, 1906	No. 6	212		May 4, 1907	
Sept. 5, 1905	September 18, 1907	No. 6	280	June 25, 1908		Heifer
	June 1, 1909	No. 3	281	March 9, 1910		"
	April 3, 1910	No. 6	281	Jan. 9, 1911		Bull
No. 17	March 15, 1907	No. 6	229		Oct. 30, 1907	Bull
July 21, 1905						
No. 18	Oct. 31, 1906	No. 6	181		April 30, 1907	
Oct. 2, 1905	Oct. 2, 1907	No. 6	271	June 30, 1908		Heifer
	July 20, 1908	No. 6	283	Apr. 29, 1909		Bull
	May 21, 1909	No. 3	281	Feb. 26, 1910		"
	Mar 23, 1910	No. 6	283	Dec. 31. 1911		"
No. 19	Oct. 28, 1903	No. 4	281	Aug. 5, 1904		Heifer
July 15, 1902	Aug. 31, Sept. 26, Oct. 25, Nov. 14, 1904	No. 5	289	Aug. 30, 1905		Bull
	Oct. 14, 1905	No. 5	264	July 5, 1906		Heifer
	July 31, Aug. 24, Sept. 18, Oct. 8, Dec. 15, 1906	No. 6-5	239		Aug. 11, 1907†	Bull
No. 20	March 20, 1907	No. 6	256		Dec. 1, 1907	
May 19, 1905	July 10, 1908	No. 5	283	Apr. 19, 1909		Bull
No. 21	July 24, 1906	No. 3	280	Apr. 30, 1907		Heifer
May 19, 1904	June 12, 1907	No. 6	203		Jan. 1, 1908	Bull
	April 20, 1908	No. 6	279	Jan. 24, 1909		" (2)
	March 16, May 11, 1909	No. 6	279	Feb. 14, 1910		"
	April 8, April 29, June 25, July 15, 1910	No. 10	279	April 20, 1911		"

† Cow No. 19. The calf dropped Aug. 11th, 1907, came alive though very weak. Calf killed.

† Cow No. 19. The calf dropped Aug. 11th, 1907, came alive though very weak. Calf killed.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 22 Jan. 30, 1902	May 31, June 21, 1903	No. 1	278	Mar. 26, 1904		Heifer
	April 26, 1904	No. 1	218		Nov. 30, 1904	
	July 8, 1905	No. 5	278	Apr. 12, 1906		Heifer
	July 27, 1906	No. 3	283	May 11, 1907		Bull
	July 2, 1907	No. 5	215		Feb. 2, 1908	Heifer
No. 23 Aug. 5, 1904	Nov. 14, Dec. 26, 1905, Mar. 3, Mar. 21, April 25, August 1, 1906	No. 3	282	May 10, 1907		Heifer
	June 25, 1907	No. 6	232		Feb. 12, 1908	Bull
	May 31, July 10, July 31, Aug. 19. Sept. 4. Oct. 1, 1908	No. 5	....			
No. 24 Mar. 28, 1902	November 5, 1903	No. 1	284	Aug. 16, 1904		Bull
	Nov. 16, Dec. 12, 1904, March 19, April 20, July 7, July 31, 1905	No. 5	284	May 11, 1906		Heifer
	June 15, August 1, August 24, 1906	No. 5	285	June 5, 1907		"
	July 6, 1907	No. 6	227		Feb. 18, 1908	"
No. 25 July 20, 1904	November 9, 1906	No. 3	280	Aug. 16, 1907		Heifer
	October 8, 1907	No. 6	214		May 10, 1908	Bull
	July 28, 1908	No. 5	285	May 9, 1909		Heifer
No. 26 April 30, 1907	February 13, 1909	No. 14	141		July 4, 1909	
	January 13, 1910	No. 15	213		Aug. 14, 1910	
	August 14, 1911	No. 8	217		Mar. 16, 1912	Bull
No. 27 June 4, 1904	October 2, 1906	No. 3	280	July 9, 1907		Heifer
	August 21, 1907	No. 6	269	May 15, 1908		"
	August 27, 1908	No. 6	238		Apr. 22, 1909	Bull
	November 1, 1909	No. 3	283	Aug. 11, 1910		"

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 28	June 14, 1904	No. 1	285	Mar. 26, 1905	.....	Bull
Jan. 30, 1903	April 24, May 17, June 14, July 13, 1905	No. 4-1	288	Apr. 27, 1906	.....	Heifer
	June 17, 1906	No. 16	288	Apr 1, 1907	.....	Heifer
	May 19, 1907	No. 6	268	Feb. 11, 1908	.....	Heifer
	November 16, 1908	No. 6	249	.....	July 22, 1909	Bull
No. 29	February 24, 1909	No. 6	222		Oct. 4, 1909	Heifer
April 1, 1907				.....		
No. 30	August 5, 1906	No. 6	280	May 12, 1907	.....	Heifer
Oct. 13, 1904	June 25, 1907	No. 5	291	Apr. 12, 1908	.....	Bull
	June 13, 1908	No. 16	293	Apr. 2, 1909	.....	Bull
	April 24, 1909	No. 6	183	.....	Oct. 24, 1909	
	December 30, 1909	No. 6	204	.....	July 22, 1910	
No. 31	May 20, 1908	No. 6	282	Feb. 26, 1909	.....	Heifer
Nov. 19, 1906	June 14, 1909	No. 6	251	.....	Feb. 20, 1910	
	June 4, 1910	No. 17	283	Mar. 14, 1911	.....	Heifer
	April 10, 1911	No. 10	188	.....	Oct. 14, 1911	Bull (2)
No. 32	August 12, 1909	No. 15	207	.....	Mar 7, 1910	Heifer
July 6, 1908	July 7, 1910	No. 10	262	.....	Mar. 26, 1911	Bull
	June 13, 1911	No. 8				
No. 33	September 12, 1909	No. 15	226	.....	Apr. 26, 1910	
June 10, 1908	August 26, 1910	No. 10	274	May 27, 1911	.....	Heifer
No. 34	October 25, 1909	No. 15	186	.....	Apr. 29, 1910	
June 30, 1908	August 14, 1910	No. 10	274	May 15, 1911†	.....	Heifer

† Cow No. 34. The calf dropped May 15th, 1911, came very weak and died eleven days later.

June 30, 1908	August 14, 1910	No. 10	274	May 15, 1911†		Heifer

† Cow No. 34. The calf dropped May 15th, 1911, came very weak and died eleven days later.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 35	May 27, 1910	No. 15	159		Nov. 2, 1910	
Feb. 17, 1909	May 5, 1911	No. 8	170		Oct. 21, 1911	Bull
No. 36	April 22, 1909	No. 6	278	Jan. 25, 1910		Heifer
May 12, 1907	April 9, 1910	No. 6	231		Nov. 26, 1910	
No. 37	May 23, 1910	No. 15	249		Jan 27. 1911	Heifer
Dec. 14, 1908						
No. 38	June 30, 1910	No. 10	219		Feb. 4, 1911	
Jan. 27, 1909						
No. 39	January 1, 1911	No. 18	189		July 9, 1911††	Bull
No. 40	February 9, March 14, July 20, 1906	No. 3	286	May 2, 1907		Bull
Nov. 1, 1904	August 13, 1907	No. 6	278	May 18, 1908		Bull
	June 17, August 3, 1908	No. 6	279	May 9, 1909		Bull
	May 21. June 13, 1909	No. 6	276	Mar. 16, 1910		Heifer
	March 28, April 12, May 6, 1910	No. 15	250		Jan. 11, 1911†††	Bull

†† Cow No. 39. A culture of the Abortusbacillus, Bang, was obtained from the uterine exudate of this cow, and also from the internal organs of the foetus.

†††Cow No. 40. Calf dropped Jan. 11th, 1911, came alive, though very small and weak. Was killed two weeks after birth. A culture of the Abortusbacillus, Bang, was obtained from the uterine exudate of this cow.

Statistics of Aborting Cows in Herd No. 1—Continued.

No. of Cow and Date Dropped	Dates Served	Bull Served By	Period of Gestation Days	Date Normal Calf Dropped	Date of Abortion	Sex of Calf
No. 41	Sept 24, 1908	No. 6	279	June 30, 1909		Heifer
May 12, 1907	August 11, 1909	No. 15	271	May 9, 1910		Heifer
	(?)	No. 18			(?)	
	August 4, 1911	No. 10	204		Feb. 23, 1912	Bull
No. 42	January 21, 1911	No. 8	192		Aug. 1, 1911	
Aug. 23, 1909						
No. 43	February 9, 1911	No. 18	224		Sept. 21, 1911††	
No. 44	August 26, Sept. 16, Oct. 10, 1902, Jan. 25, 1903	No. 1-5	274	Oct. 26, 1903		Heifer
Jan. 18, 1901	January 2, 1904	No. 1	284	Oct. 13, 1904		Heifer
	December 23, 1904	No. 1	283	Oct. 2, 1905		Heifer
	December 22, 1905	No. 1	282	Sept. 30, 1906		Heifer
	June 23, 1907	No. 6	291	Apr. 10, 1908		Bull
	September 1, 1908	No. 6	282	June 10, 1909		Heifer
	August 5, 1909	No. 6	275	May 7, 1910		Heifer
	June 9, 1910	No. 10	280	Mar. 16, 1911		Bull
	April 20, 1911	No. 10	218		Nov. 4, 1911	Bull

†† Cow No. 43. A culture of the Abortusbacillus, Bang, was secured from the uterine exudate of this cow.

Results of Our Investigation as to the Etiology of This Disease in the Cow.

Owing to the ravages infectious abortion has made among the Thoroughbred and Standardbred mares of the Blue Grass Region we at first directed our attention to the isolation of the germ causing the trouble among the mares. We soon learned from experience that on account of a definite breeding season, mares usually abort in the late fall and in January, February, March and April. Of course, they abort at other times in the year, and at times soon after conception, but this is the exception and not the rule. Finding that the investigation of this disease with the mare was limited to a few months of the year, we began the study of the disease in the cow as well. Cows on dairy farms are bred at different times of the year, and as a consequence abortions are liable to occur in any month. Then, too, the investigation of the etiology of the disease in the cow might throw some light upon the etiology of the disease in the mare. Many difficulties were involved in our investigations. In the first place it is impossible to tell the exact time that an animal will abort and as the fœtal membranes become contaminated with many species of bacteria in a short time after expulsion, it is quite difficult to secure fresh, uncontaminated specimens for the laboratory. This is especially true during the summer months. To isolate the different species of germs that one might think would have some bearing on the problem and to make a study of their physiological properties and carry on inoculation experiments with small animals with the same, is an endless task and it would be useless and burdensome to give a synopsis of this work in this bulletin.

During our early investigations we secured a specimen that led us to believe that a small diplococcus might have something to do with the disease in the cow. The afterbirth of an aborting cow was obtained on which little whitish nodules were seen, ranging in size from a number six shot to a small pea. Some were nearly round, while others were irregular in shape. Upon staining the contents of one of these

nodules it was found to be crowded with a small diplococcus. The germ grew readily in the air. Two pregnant guinea pigs were inoculated, one intraperitoneally and the other intravaginally, with pure cultures of this organism. Four days afterwards the pig inoculated intravaginally gave birth to four dead pigs. The germ was not isolated from the uterus. The other sow carried her pigs full time and delivered them alive.

In one instance (Herd No. 1, Cow No. 28) we found the fœtal membranes and amniotic fluid of an aborting cow teeming with the Staphylococcus pyogenes aureus in pure culture. Although skillful medical attention was given to this cow she became weaker and weaker, and when it became evident that she would die, she was slaughtered and posted. The uterus was a mass of pus, and pus was found in numerous other internal organs, the Staphylococcus aureus being the invader. It is evident that this organism entered the uterus and caused the expulsion of the fœtus and afterwards became generalized and would have killed the cow.

In all our early investigations we were continually on the outlook for the bacillus discovered by Bang. The first review given in the United States of Professor Bang's work, was by Dr. Charles E. Marshall, and appeared in Special Bulletin No. 13, of the Michigan Experiment Station, dated December, 1899. In this bulletin the statement is made that the germ in question grew in serum-gelatin-agar. The statment was also made that the germ behaved peculiarly towards oxygen. Later Bang gave out the impression that the germ he had discovered was anærobic, and it is so recorded in one of our best American text books on animal pathology. Afterwards Dr. Bang found that this bacillus would grow in an atmosphere of pure oxygen and in an atmosphere nearly depleted of oxygen; that the germ grew in the air and in serum-gelatin-agar, beginning in a particular zone about 5 mm. below the surface and extending downward some millimeters. This medium was prepared by adding half the volume of an equal amount of three-fourths per cent. agar and five per cent. gelatin with liquid blood serum after the agar-gelatin had been liquified, and cooled to 45 degrees C.

In our early investigations we tried the serum-gelatin-agar method, both ærobically and anærobically, without success. The afterbirth as obtained from the aborting animal is usually contaminated. This is especially true during the summer months and many a time in our investigations have we encountered foreign germs that covered a plate or clouded a semi-liquid medium with their growth in 24 hours. This is not to be wondered at when we consider what a favorable medium serum-gelatin-agar is for most bacteria. This combination also makes a soft medium even if 2 per cent. agar is used in connection with the serum-gelatin. Later, we discarded the gelatin using three times as much 2 per cent. agar as serum.

During our investigations in the summer and fall of 1910 and early winter of 1911 we often found a diplococcus in the afterbirth of a cow and umbilicus, at the entrance to the body of the aborted fœtus, which resembled morphologically the diplococcus found earlier in our investigations and which we believed had some relation to the etiology of the disease.

Considering all the information at hand relative to the requirements of oxygen by the germ discovered by Bang, we endeavored to isolate it, if present in any material, by means of a partial vacuum which would still present suitable conditions for the development of the diplococcus, were it also present in the material. It had been determined that one of our Novy jars for growing anærobes slowly leaked air, i. e., if a partial vacuum obtained by a vacuum pump would measure 27 inches of mercury at the beginning, at the end of six days it would measure from 3 to 6 inches of mercury. It was concluded that if the Bang bacillus were present in any of the platings it would find some definite pressure of oxygen in which to grow in this wide range of diminished atmospheric pressure, and hence pressure of oxygen. In our later investigations we made a great effort to obtain the afterbirth of an aborting cow as free from contamination as possible so as to facilitate the work of determining the organism causing the disease. It was while bending every effort to secure the afterbirth of an aborting cow as aseptically as possible, endeavor-

ing to determine whether the diplococcus we were finding connected with the fœtal membranes of aborting cows was the only organism present that we secured a culture of the Abortusbacillus, Bang. On January 11, 1911, cow No. 40 in Herd No. 1 was giving evidences of aborting by a swollen vulva, and a purulent yellowish exudate from the vagina. This cow aborted at 2 p. m. January 11th, and was taken at once to the open field for the removal of the afterbirth. As the ground was moist there was no dust flying to contaminate the material as it was taken from the cow and placed in sterile jars. The cow was washed with a disinfectant from the hook points backward. The veterinarian washed his hands thoroughly with soap and water, cleaned his finger nails, and then washed his hands in bichloride of mercury 1 to 500. The first material taken from the cow was discarded. Three or four cotyledons and large pieces of compact pus were then taken from this cow and placed in sterile jars. Streaks of these different materials were made on serum agar as is customary in streak dilutions. These petri dishes were then placed in a partial vacuum by extracting a part of the air from the Novy jar as has been described. These plates were incubated six days. Some of the serum used, as was demonstrated by controls, was contaminated and hence the bacteria growing on these plates reduced some of the oxygen that leaked into the jar. One dish that had been streaked with a cotyledon developed a scanty growth of the Abortusbacillus, Bang, in different parts of the plate. The diplococcus was also growing on two small areas. The growth of the abortion bacillus was very scanty in most places and might easily have escaped the detection of the naked eye in direct light. The medium, however, in places in the dish had a bluish tinge, when examined by reflected light that suggested further investigation. The dish examined under the low power of the microscope revealed in numerous places a growth resembling thin drops of water, and in a few places where the growth was more aboundant, a very light straw color. Staining some of this material with plain fuchsin for several minutes revealed a very small organism that resembled when in masses, a very small coccus. On examining

the specimen under high magnification it could be plainly seen that the organism in the stain varied in morphology for some of the germs appeared as diplococci or short bacilli taking the bipolar stain, the length, however, varying; others stained their entire length, while occasionally one took the stain in three places with intervening non-stained portions. The germ was also non-motile, gram-negative and did not produce spores. These characteristics corresponded with the description given by Bang of the bacillus of abortion isolated by him which contained one, two, or three round or elongated granules; was non-motile, gram negative and did not produce spores.

From this time on we employed the cultural methods of Nowak* of Austria, in isolating this bacillus from the uterine exudate of aborting cows. This method consists in lowering the pressure of oxygen necessary for the growth of Abortus-bacillus by means of the Bacillus subtilis, allowing one square centimeter of surface culture of the subtilis to each fifteen cubic centimeters capacity of the sealed jar in which it is grown. We find that the Novy jar for growing anærobes is admirably adapted for this work. By this method Nowak has furnished a very practicable plate method for isolating this germ from a highly contaminated specimen. The technique is, in short, to streak a piece of cotyledon or other part of the afterbirth over two or three petri dishes in succession as is ordinarily done in making streak dilutions. The plates are then incubated at 37 degrees C. for twenty-four hours in the air. At the end of this time, there may be some clear places on the plate. If so, they are marked with a wax pencil or India ink. The plates are then incubated for three days, as mentioned above, at the end of which time the transparent colonies of the Abortusbacillus, Bang, if present, may appear in the clear places on the plate. We find that plain two per cent. agar is a very good medium on which to grow this germ, if correctly standardized for this germ. We standardize it neutral (faint pink) to phenolphthalein.

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*Annales de l'Institut Pasteur—Vol. 22, Pages 541-556.

While we have occasionally examined the afterbirth of aborting cows of a number of miscellaneous herds, our attention has been mainly directed to four herds. Abortion of an infectious type was without doubt existing among the cows and heifers of these herds during our investigations. We shall designate these herds as Numbers 1, 2, 3 and 4.

History of Herd No. 1. The cows of Herd No. 1 have been afflicted more or less with abortion for several years. (See Table No. 1.) During the past ten years an average of about thirty cows and heifers have been bred annually and during the whole time sixty-two abortions among these animals have occurred. The cows have been well housed during the winter months in a sanitary barn and have received the best attention as to feed and care. Disinfection of stables and lots where abortions have occurred has been a common practice. The cows have been thoroughly cleaned each time after aborting, and afterwards the vagina and uterus were frequently irrigated with a mild antiseptic and some time was allowed to elapse between abortion and the breeding of the animal. Careful disposition has been made of the fœtuses and afterbirths from these cows. The heifers have, as a rule, been on pastures not occupied by the cows, and allowed the run of a large shed in the winter time. Occasionly outside cows were allowed to be bred to the herd bulls and then only when the man in charge was satisfied that such cows had not aborted. A few heifers in this herd have been known to abort their first calves even when bred to a young bull that had never served any other individuals. It is difficult to state just how these heifers were infected unless the infection was obtained by ingestion while grazing for short periods of time on pastures occupied by the cows.

Herd No. 2 consisted of thirty-five females of breeding age. This herd was gotten together during the past two years. We began our investigations in this particular herd in March, 1911, when the man in charge appealed to us for aid, saying that he was satisfied that a number of the cows were affected with abortion of the contagious type. At the time the investigations were begun, eighteen cows and heifers had aborted.

The place was visited and sterile jars left in which to express the uterine exudate of aborting cows to the laboratory. Up to the present time, twenty-seven abortions have occurred on this farm.

Herd No. 3 consisted of sixteen cows and six heifers, all of which were bred in December, 1910. They began aborting in March, 1911, and the last abortion occurred in July, 1911. All but five of these animals aborted. This herd is located a considerable distance from Lexington and nearly all of the cows had aborted before we were requested to investigate the cause.

Herd No. 4 consists of twenty cows, of which two have recently aborted.

THE FOLLOWING EXAMINATIONS WERE MADE OF INDIVIDUALS IN THESE HERDS, AFTER SECURING OUR FIRST CULTURE OF THE ABORTUSBACILLUS, BANG.

Herd No. 1—Cow No. 37.—This cow aborted January 27, 1911, in the 249th day of gestation. The calf was alive when it came, but very weak and soon died. The placenta was examined and the Abortusbacillus could not be isolated.

Herd No. 1—Cow No. 38.—Cow aborted during night of February 4th, 1911, in the 219th day of gestation. Plates streaked with pieces of the afterbirth were incubated in a partial vacuum. The Abortusbacillus, Bang, was not isolated.

Herd No. 1—Repeated efforts were made to secure a culture of the abortion bacillus from the sheath of the herd bull. This bull, however, had not been used in the breeding of any cows for a few months. A culture of the Abortusbacillus could not be isolated.

Herd No. 2—Case No. 1.—On March 21, 1911, an effort was made to secure a culture of the abortion bacillus from the herd bull used in this herd. Sterile glass rods were pushed up the sheath for a foot or more and then streaked over several petri dishes of serum-agar. The bacillus in question was not isolated. The sheath of this bull, however, was always disinfected after breeding any cow.

Herd No. 2—Case No. 2.—On March 21, material from

the uterus or a heifer that had aborted ten days previously was examined and produced a pure culture of a diplococcus. This germ was in the uterus of this cow in large numbers.

Herd No. 2—Case No. 3.—On March 21, a sterile jar containing parts of the uterine exudate of an aborting cow in this herd reached the laboratory. Decomposition had set in to quite an extent, as this material had been kept for three weeks before being expressed to us. Streaks of this material were made on numerous dishes of serum-agar, and incubated as usual. The results were negative.

Herd No. 2—Case No. 4.—On April 3, we received by express small pieces of afterbirth from a cow aborting on this place. This cow aborted on April 1. The material had some odor of decomposition. We were not successful in isolating the abortion bacillus.

Herd No. 1—Cow No. 32.—This heifer gave birth to a live calf on March 25th. The calf was weak and died four hours after being dropped. Plate cultures were made of the spleen, liver, intestinal contents and umbilical vein as it terminates in the liver. These plates were then inserted in sealed jars with the Bacillus subtilis, with negative results. We were unable to find the afterbirth from this cow, although she was running in a stable when the abortion occurred. It had evidently left her without the need of aid from the veterinarian and she may have eaten it. Platings made from the small bits of uterine exudate found in the uterus failed to reveal the Abortusbacillus, Bang.

Herd No. 2—Case No. 5.—A weak calf that had been dropped 25 days before the cow was due to calve was expressed to our laboratory. The calf was slaughtered and an examination made of the liver, heart, stomach, large and small intestines, but the bacillus of abortion could not be isolated. The stains of smears from these different organs did not reveal any germ.

Herd A—Case No. 1.—A fœtus from an aborting cow in this herd was expressed to the laboratory. The bacillus of abortion was not isolated from the internal organs.

Herd No. 2—Case No. 6.—On April 8th, 1911, pieces of

the afterbirth of an aborting heifer were brought to the laboratory. She aborted in the 196th day of gestation. The heifer was three years of age and as a two-year-old had given birth to a normal calf. As per our instructions in obtaining material from this herd, the man who removed the afterbirth washed his hands first with soap and water, then with a disinfectant. Cotyledons not touching the ground were torn off from the afterbirth and placed in sterile jars. When the material reached the laboratory it had a slight odor of decomposition and was alkaline to litmus. Smears of the material stained for several minutes with Lofflers methylene blue revealed the Abortusbacillus, Bang, on certain parts of the slide. One of the leukocytes in this material was found crowded with the germ.

The following technique was used in plating this material: A small piece of a colyledon was streaked consecutively over five agar plates and the plates numbered 1, 2, 3, 4, and 5. A small platinum loop was then streaked across plate 1, and streaked on plate "a." Then a loopful was taken from plate 2 and streaked on plate "b"; and similar streaks were made from plates 3, 4, and 5, and marked "c," "d" and "e," respectively. This method of plate dilutions has given us better results than by streaking a small bit of the afterbirth over several consecutive plates. These plates were then incubated ærobically for 38 hours, and the following notes were made: Plate 1, was nearly covered with a heavy growth of contaminating bacteria; plate 2, the same; plate 3, the growth not so dense—a few clear spaces; plate 4, a heavy growth on one-half of the dish, the other half containing numerous clear places; plate 5, little contaminated; plate "a" completely covered with growth of contaminating bacteria; plate "b" containing but little growth of contamination; plate "c" nearly free from contaminating growth; and the same was noted with reference to plates "d" and "e." The clear places on the different dishes were then marked with India ink, after which the plates were placed in a Novy jar with petri dishes of agar flooded with a bouillon culture of the Bacillus subtilis, one square centimeter of culture of subtilis allowed to each 15

cubic centimeters capacity of the jar. These dishes were then incubated four days at 37 degrees C. When the jar was opened there was some sound of suction indicating a partial vacuum due to the utilization of a part of the oxygen by Bacillus subtilis. The following is a description of the plates in detail: Plate 1, showed places in the areas of contamination where the growth of the Bang bacillus had evidently taken place; on plate 2, colonies of the Abortusbacillus, Bang, could be seen covered with a thin film of growth of other bacteria; plate 3, was covered with growth of contaminating germs; one-half of plate 4 was heavily covered with a growth of foreign germs. Protruding from the growth on plate 4, however, was seen a seam of bacterial growth one-fifth inch wide and an inch long of a smooth, shiny, bluish-gray appearance, which upon staining proved to be the Abortusbacillus, Bang. There were also three colonies of the bacillus in the clear spaces. There were 22 colonies of the abortion bacillus in the clear places in plate "a," some, however, were covered with a thin film of foreign bacteria. Plate "b" was covered with a heavy growth of contamination. There were so many colonies of the Abortusbacillus, Bang, in the clear places of plate "c" that many were confluent. The clear places in one-half of the dish "d" presented exceedingly numerous colonies of the Bang bacillus varying in size from a pin point to 2 mm. in diameter and many were confluent. The colonies of the bacillus in question in the different dishes were transparent to transmitted light and of a decided bluish color to reflected light. Under the low power of the microscope individual colonies appeared well raised, round, with edge well defined, and homogeneous with the exception of a few small granules in the centers of a goodly number of colonies (see plate 5). Smears of these colonies on plain agar incubated Nowak method at 37 degrees C. for four days showed an abundant growth, while similar tubes incubated ærobically for six days produced no growth. These tubes were then incubated in a jar with the Bacillus subtilis for three days and produced a luxuriant growth.

Herd No. 2—Case No. 7.—On May 20, 1911, the man-

ager of Herd No. 2 brought some pieces of afterbirth of an aborting cow in a sterile jar to the laboratory. This cow aborted during the night of May 19. The cow was due to calve on June 27th. The fœtus from appearance was dead when it came. On cleaning this cow no solid pieces of afterbirth in the uterus were found. The cow had perhaps passed the afterbirth during the night and may have eaten it, as sometimes happens. The material taken from this cow was of a purulent gelatinous consistency, and contained much substance of a yellowish color, as well as small white flakes and streaks of blood. Plate cultures were made of the yellow material, the blood streaks, and a mixture of blood streaks and white substance. Bits of the above materials measuring about 3 millimeters in diameter were used to smear the original plates. Smears on slides stained four minutes with plain fuchsin revealed the bacillus of abortion scattered freely over the slides, and in places they were exceedingly numerous. With but few exceptions we have never found these bacilli numerous in the stains made direct from the afterbirth. In some cases it took considerable searching to find one or two of these germs that could be called Abortusbacillus, while in some instances numerous colonies were obtained by cultural methods where no bacilli could be found on smears of the afterbirth. The original and sub-plates of this case were incubated 24 hours in the air, the clear places marked with India ink and incubated in sealed jars with Bacillus subtilis for three days. The following are the results of the platings of the yellow pus: There were forty-four colonies of foreign germs in plate 1, varying in size from 1 to 5 millimeters in diameter, and the remainder of the plate was nearly covered with the transparent colonies of the Abortusbacillus, in most places so numerous as to be confluent, resembling a streak culture. Plate "a" of the yellow pus had but two contaminating colonies and one-half of the plate presented exceedingly numerous colonies of the abortion bacillus. Other plates made from the yellow pus were sterile. Plate 1 of the blood streak presented a complete growth of foreign germs, while plate "a" of the same material showed 44 colonies of the Abortus-

bacillus in the clear places, varying in size from a pin point to three-fourths millimeter in diameter. The other plates made of the blood streaks were sterile. Plate 1, of mixture of blood streaks and white substance had six clear places on which were from four to fifty colonies of the abortion bacillus. Plate "a" from this mixture had thirty-six colonies. All other plates were sterile. From the growth in the different petri dishes it could be plainly seen that the yellow material contained many more bacilli of abortion than did the other material used.

Herd No. 3—Case No. 1.—On June 26th, 1911, the afterbirth of an aborting cow was expressed to us from a point at a considerable distance from the Experiment Station. There had been numerous cases of abortion in the herd from which this came. We examined material from this herd on three occasions with negative results. It always came, however, highly contaminated.

Herd No. 1—Cow No. 45.—June 8th, 1911, a cow in this herd dropped a fully matured dead calf. Plates were made of the afterbirth and internal organs of fœtus with negative results.

Herd No. 1—Cow No. 39.—This cow aborted on July 9th, 1911, just after being milked. The milker noticed that she acted peculiarly as if she wanted to lie down. As soon as the milking was completed this cow aborted a six months and nine days fœtus. Soon after the fœtus was dropped the cow began to eat it and had taken a mouthful from the abdomen before being noticed. The intestines, however, had not been punctured. After thoroughly washing the fœtus with hot water it was put in a pail that had been scalded, and taken at once to the laboratory. The fœtus weighed 5,390 grams, and measured two feet from nose to tail head. It was washed with 95 per cent. alcohol and opened up with sterile knives. We found all the internal organs apparently normal with the exception of the peritoneum, kidneys, and one lobe of the liver. The kidneys appeared enlarged and were highly congested, being nearly black in color. Each kidney measured 2 by 2½ inches. The parietal peritoneum showed local areas of con-

gestion. The quadrate lobe of the liver was very much inflammed. These organs were seared and then punctured with sterile lances and one and two small loopfuls of contents streaked on petri dishes of plain agar. In this manner plate cultures were made of the contents of liver, fourth stomach, small intestines, kidneys, and umbilicus at the entrance to the body. The plates were incubated at 37 degrees C. ærobically, for twenty-four hours, at the end of which time no growth was seen on any plate except that from the umbilicus. The plates were then incubated for three days in sealed jars with Bacillus subtilis, allowing one square centimeter of subtilis to each 15 cubic centimeters capacity of jar, with the following results: Plate 1 from the congested part of the liver, contained exceedingly numerous colonies of Abortusbacillus, Bang, on one-half of the dish with fewer on the other half. These colonies measured one-fourth to three-fourths of a millimeter in diameter. The colonies on two other plates, streaked with blood taken from different parts of the liver, were as numerous as on the platings made from the congested part. Two dishes streaked from contents of small intestine contained about one-tenth the growth obtained from the liver. Colonies of the abortion bacillus were exceedingly numerous on plates made from the kidney. Streaks made from the contents of stomach produced colonies numerous enough to be confluent in most places and on a few parts of the plate so much so as to resemble a streak of pure culture of the germ. The plate made from the umbilicus had but one place clear from contaminating bacteria, measuring three by five millimeters, upon which many of the small transparent colonies of Abortusbacillus developed. The most abundant growth of this bacillus from streaks of the different organs, was obtained from the contents of the stomach. The germ was also identified from the different organs by stains. Considering the small amount of material plated and the abundant growth secured, it was evident that this germ must have been exceedingly numerous in the parts examined.

The afterbirth of this cow was removed the next morning, and the attending veterinarian reported her uterus to be

extremely sensitive, showing typical symptoms of metritis. Plates were made of the cotyledons of the afterbirth. Bits of the cotyledons were injected subcutaneously into a pregnant guinea pig. The pig died over night and upon being posted was found to be infected with the colon bacillus. She had, however, aborted one pig before dying. Although the cow was given every attention, receiving daily vaginal douches, she exhibited on the ninth day after calving symptoms of septicæmia, and on the 23rd day of July, two weeks after calving, died. The veterinarian posted the cow and pronounced her death due to metroperitonitis, the organism causing her death was found to be an invasion of the Bacillus pseudomonas pyocyaneus, Migula.

Plate cultures of the afterbirth of this cow had been made in the usual manner. After being incubated twenty-four hours ærobically most of them presented considerable growth of colonies of foreign germs ranging in size from a pin point to two millimeters in diameter. The clear places were marked and the plates incubated three days, Nowak method. After a great deal of searching with a microscope a few very small colonies of the Abortusbcallus, Bang, were found on a limited area of one of the plates. The control not growing well, it was thought that perhaps something was wrong with the incubation so the plates were returned to the jar and incubated as before for an additional three days. At the end of this time the colonies were no larger, and an examination revealed the fact that there must have been some mistake in standardizing the agar used in connection with the platings of the fœtal membranes of the cow as it was found to be 1.5 per cent. acid to phenolphthalein, while the agar used in the platings of the contents of the internal organs of the fœtus was only 0.4 per cent. acid. Hence we concluded the acidity of the agar had retarded the growth of the bacillus in the platings made from the afterbirth.

On August 1st, 1911, cow No. 42, of Herd No. 1, aborted a male fœtus in the 192nd day of gestation. This cow aborted in the pasture and the fœtus was not discovered until the next day. The fœtus weighed 4,940 grams and measured two feet

from nose to tail head. It was opened up aseptically and plate cultures made of the following organs: Mesenteric lymphatics, ascitic fluid in the abdominal cavity, small intestines, liver, lung, heart and brain. All these plates were incubated for three days, Nowak method, with negative results, as regards securing colonies of Abortusbacillus, Bang, or colonies of any other germ, with the exception of platings made from the ascitic fluid which produced a few colonies of contaminating bacteria. The plates from the afterbirth of the cow were also negative as far as obtaining colonies of Abortusbacillus, Bang, were concerned.

On September 21, 1911, it was reported that cow No. 43, of Herd No. 1, had aborted, in the 224th day of gestation. The fœtus was well developed and haired over. The umbilicus was highly congested. The right lung floated in water, showing it had performed its function, and that the calf was alive when delivered, although to all appearances, dead. The stomach and kidneys both showed small hemorrhages in several places. Plates were made of the spleen, liver, heart blood, stomach, small intestines, umbilicus, large intestine, mesenteric lymphatics and kidneys, with negative results. Plates were made from the yellowish flocculent and semi-gelatinous material as well as a mixture of these two substances, obtained from the afterbirth of this cow. These plates were incubated twenty-four hours in air to allow contaminating bacteria to develop. The clear places on the plates were then marked and all the dishes incubated three days, Nowak method, with the result that colonies of Abortusbacillus, Bang, developed in the clear places in all the plates made, with the exception of one. Most of the colonies were, however, very small—so much so as to escape detection by the naked eye. The plates were incubated again for three days, Nowak method, at the end of which time some of the colonies were the largest we had ever been able to obtain (see plate 3), measuring 2½ mm. in diameter. The dishes were then incubated for another three days, with slight increase in the size of the colonies.

On October 14th, 1911, cow No. 31, of Herd No. 1, aborted twin male fœtuses in the 188th day of gestation. One of the

fœtuses weighed 5,990 grams, and the other weighed 6,180 grams. Plate cultures were made by the Nowak method of the internal organs of the fœtuses, with the result that all the plates remained sterile. The plates made from the afterbirth of the cow were also negative.

On October 21st, 1911, cow No. 35, of Herd No. 1, aborted in the 170th day of gestation. The fœtus weighed 2,840 grams. Streaks made from the heart blood, and contents of liver, spleen, kidneys, small intestine and stomach, and incubated the usual way were negative, as were also smears from the afterbirth of this cow.

Herd No. 4—Case No. 1—This cow aborted November 13, 1911. The abortion occurred at 3:30 p. m. and the fœtus and afterbirth reached the laboratory at 4 p. m. The size of the fœtus indicated an age of about five months. It weighed 3,420 grams. It was opened at once and platings made in the usual manner, of the heart, lungs, omasum, reticulum, kidney, liver, large intestine, small intestine, umbilicus, bladder, testicle (male fœtus) and penis. Plate cultures were also made from the afterbirth in the usual manner. After being incubated for 34 hours in the air at 37 degrees C. to allow contaminating bacteria to develop, the plates were incubated for five days at 37 degrees C. in sealed jars with the Bacillus subtilis, and the following results were obtained: There was no growth, of any kind, from the platings of the heart, lungs, liver, kidney, bladder, umbilicus, testicle, and penis. There were, however, 85 colonies of the Abortusbacillus, Bang, ranging in size from three-quarters to 2 mm. in diameter in the plate streaked with contents of the omasum. These colonies were slightly different than those usually noted of this bacillus in that they were a trifle more raised and the margins not quite so regular and well defined. There were also no granules in the centers of the colonies which is unusual for colonies of this germ after five days' incubation. The smaller colonies were much more typical than were the larger ones. A number of colonies were also obtained from the streaks of material taken from the reticulum. Several hundred colonies were obtained from the platings made from the contents of the small intestines

resembling those obtained from platings of the stomach. There were 35 colonies, of the abortion bacillus, in the clear places on one of the plates streaked with bits of a cotyledon. On making a stain from one of these colonies we were at first led to question whether the organism was the Abortusbacillus, Bang, in that it took the stain quickly and intensely and stained its entire length—in other words, when examined under the low power of the microscope the organism appeared to be a distinct bacillus, while in most of the cultures which we had heretofore isolated some of the germs resembled cocci and some of them bacilli when the slide was examined this way, and in one case all the germs appeared like cocci when examined in this manner. However, on staining the organism isolated at this time, for a much shorter time than usual and examining it with the high power of the microscope it could be seen that it exhibited the characteristic granules usually observed. Its morphology was sufficently different, however, that we did not decide it was the bacillus in question until testing its cultural characteristics. Individual colonies and smears of colonies streaked on plain agar and incubated in the air three days presented no growth, while similar tubes incubated for the same length of time in a sealed jar with Bacillus subtilis made an excellent growth. The tubes that had been originally incubated in the air were then inserted in sealed jars with cultures of subtilis and they also exhibited a good growth at the end of three days. The organism was also non-motile and Gram negative.

Herd No. 2—Case No. 8.—On December 24, 1911, we obtained the fœtus and afterbirth of an aborting cow from this herd. This fœtus was dropped in the 220th day of gestation and weighed 7,450 grams. The hair on the head and hoofs was well developed, but on the body it was very short and fine. The fœtus came dead. All the internal organs appeared quite normal, having but slight areas of congestion. The large intestine was distended with hard fecal matter. The stomachs contained considerable material of a gelatinous consistency which was alkaline to litmus. The ascitic fluid found in the abdominal cavity was also alkaline to litmus. The fœtus was

opened up aseptically and the heart, liver, spleen, large intestine, small intestine, kidney, and testicle were seared, opened with a sterile lance and streaks of contents of these organs made on numerous plates of plain agar. As usual, the material from the stomach was of such consistency as not to adhere readily to a platinum loop, so the stomach was tied at both ends, severed from the body, washed in sterile water, and then in alcohol. As soon as the alcohol evaporated the different stomachs were punctured with a sterile lance and the contents caught in sterile petri dishes. A few drops of this material were streaked consecutively over several dishes of agar. Streaks were also made of different parts of the afterbirth and of mixtures of these parts. All the above plates were incubated 24 hours in the air at 37 degrees C., after which the clear places were marked with India ink. The plates were then put in three Novy jars, and incubated Nowak method, for five days. Upon taking this material from the jars it was discovered that in two of the jars a number of the plates were nearly covered with contaminating growth which had largely developed since their previous incubation of 24 hours in the air. There were no colonies of Abortusbacillus, Bang, on any of the plates taken from these jars, while a few plates from the third jar showed typical colonies of the abortion bacillus as hereby indicated. There were 44 colonies of the abortion bacillus in the clear places on plate No. 2, of the afterbirth. These colonies measured from 1 to 2 mm. in diameter. Plate No. 3 of the afterbirth contained 25 colonies in the clear places, measuring 1½ to 2¾ mm. in diameter. A plate smeared with the contents of the reticulum was nearly covered with colonies of the abortion bacillus and they were so numerous in most places as to be confluent. The largest single colonies in this dish measured 2 mm. in diameter. Plate 1 made from the contents of the rumen was completely covered with colonies, which were so confluent as to resemble streaks of a pure culture. The same was also true of plate No. 2 from this organ which was streaked from plate No. 1. From the growth obtained it was evident that the germ of abortion was exceedingly numerous in the stomachs of this fœtus. The

germ was also identified from stains of smears of the contents of the stomach. Owing to the fact that some of the plates on the other two jars contained a large amount of actively growing bacteria of a contaminating nature it was evident that they took in their multiplication too much oxygen from the jars to leave a suitable pressure of oxygen for the development of the Abortusbacillus, Bang. Therefore, the plates were again incubated with Bacillus subtilis for three days in sealed jars. At the end of that time the following results were tabulated: Nearly one-half of plate No. 2, from the red cotyledon, was covered with a growth of the colon bacillus. There were, however, 22 colonies of the abortion bacillus in the clear places of this plate, measuring from ½ to 1¼ mm. in diameter. Plate No. 1 of the red cotyledon also contained 22 colonies of Abortusbacillus, Bang. Plate No. 1 of the mixture of afterbirth contained two colonies of Abortusbacillus, Bang, and the remainder of the plate was covered with contaminating growth. Plate "c" of mixture of afterbirth was negative, of any growth with the exception of the development of a seam of the Abortusbacillus at the end of the dish, measuring 15 mm. long and 1 mm. wide. Colonies of this bacillus were exceedingly numerous on one-fourth of one of the dishes streaked with the contents of the large intestine. Streaks from the kidneys were negative of growth of any kind. Plate "b" of the liver contained two colonies of the abortion bacillus. Streaks of the blood from the spleen, lungs, heart, and testicle were negative of growth of any kind.

Herd No. 2—Cow No. 9.—On January 15, 1912, we received the afterbirth and fœtus of an aborting cow in this herd. The fœtus was haired over. The lungs of this fœtus were slightly congested and the spleen slightly hemorrhagic. One small ulcer on this organ was noted. The Abortusbacillus, Bang, was demonstrated on smears from the afterbirth and contents of stomach, of fœtus. The usual technique in growing this germ was observed, but no growth of the same could be obtained.

Herd No. 1—Cow No. 41.—On February 23, 1912, this cow gave evidence of impending abortion, or having aborted,

by exuding a purulent material from the vagina. Doubt as to whether or not she had already aborted led to an examination. The external genitals were washed with a disinfectant. The veterinarian washed his hands with soap and water, then with a disinfectant, and inserted his hand into the uterus. About a quart of an odorless exudate was taken from that organ, the color of which was grayish white, tinged with pink. The fœtus could be plainly felt. Bits of this exudate were streaked on numerous petri dishes of plain agar. The cow aborted during the night. Blood from the heart, liver, spleen and kidney were streaked on plain agar, as were also the contents of the stomach, and large and small intestines. All these plates were incubated two different times, Nowak method, with negative results, as far as securing a growth of the Abortusbacillus, Bang, was concerned, although this germ was found in goodly numbers on some of the slides smeared with the uterine exudate and from the contents of the stomach of the fœtus. Just why the organism failed to grow is difficult to explain.

The Morphological, Physiological and Cultural Characteristics of the Abortusbacillus, Bang.

Morphology and Staining.—The Abortusbacillus, Bang, is a very small polymorphic germ, with rounded ends varying in size from .4 to .6 u wide, by .6 to 2.25 u long, usually single, though sometimes found in short threads of two to four cells. The polymorphic characteristic is also noted of this germ in the tissues. We have found that different cultures isolated at this laboratory vary somewhat in the readiness with which the stain is taken, when strains recently isolated from the animal tissue are taken into consideration. Usually when a culture of the organism is stained and magnified about five hundred diameters it resembles small cocci and very small rods, taking the stain differently, thus giving such a preparation rather a ragged appearance. (Plate 6.)

Occasionally a strain will resemble small cocci throughout the stain and again we have obtained a culture from the

uterine exudate of an aborting cow, as well as from the fœtus, that resembled a distinct bacillus when stained in the usual manner and examined under the low power of the microscope. The germ of this latter culture took the stain much more readily than any previously isolated. However, when a weaker stain than usual was used, this culture had nearly the same characteristics morphologically as that usually observed. The organism of the average culture takes the stain differently as can easily be seen by examination with high magnification—most individuals take the stain the entire length, some, however, appear as diplococci; others appear as short bacilli taking the bipolar stain; a few others are slightly bent, taking the stain in three places, usually at the end and in the center, leaving two unstained portions of the bacillus—even the cell wall of those unstained places can seldom be seen. Under very high magnification, however, a very dim stain may at times be noted in the spaces between the well stained granules. There are some individuals in a preparation that appear wedge shaped. The methods of staining usually employed by us are as follows: Plain fuchsin, two to three minutes, slightly warmed; Lofflers methylene blue, several minutes, slightly warmed; carbolic fuchsin, two to five seconds, unwarmed. (See plates 6, 7, 8.)

Gram's Stain.—An actively growing culture four days old and one fourteen days old of the same strain were used in this test. The one fourteen days old had been incubated for four days and then put in the ice chest until used. The germ growing in either tube was Gram negative, and as far as could be seen, exhibited the same characteristics relative to the stain. The two following methods of making Gram's stain were employed in the test: Method 1 is practically that accepted for the standard methods of water analyses as reported in American Public Health Association, Vol. 30, Part 2, page 101.

METHOD 1.

1. Cover the preparation with aniline, gentian-violet, for one minute.
2. Wash in water and dry.
3. Cover the preparation with Lugol's solution for 2 minutes.

4. Wash in water and dry.
5. Decolorize in 95 per cent. alcohol with constant agitation for five mnutes.
6. Wash in water.
7. Mount in balsam and examine.

METHOD 2.

The technique of this method is that used by MacNeal in estimating the relative numbers of morphologically different bacteria in feces as reported on page 133, Volume 6, Journal Infectious Diseases.

1. "Float the coverglass on aniline water, gentian-violet, three minutes.
2. Drain off the excess of dye with filter paper without washing.
3. Float on Lugol's solution two minutes.
4. Drain and dry the preparation between filter papers.
5. Decolorize in aniline-xylol by immersing for one-half minute.
6. Dry between filter papers.
7. Decolorize further in absolute methylic alcohol for about five seconds.
8. Wash in water.
9. Counter-stain with a dilute aqueous solution of fuchsin for a few seconds.
10. Wash in water, blot, dry in air, mount in rectified balsam and examine.

The aniline water gentian-violet is freshly prepared by adding 0.5 c. c. saturated alcoholic solution of gentian violet to 10 c. c. of saturated aqueous solution of aniline. The Lugol's solution used contains one gram iodine and 2 grams potassium iodide in 300 c. c. distilled water. The aniline-xylol is made by mixing aniline, one part, with xylol, four parts."

Motility.—This germ has no real motion. There is at times apparent motion as the germs are carried in one direction toward the shore line by currents in the liquid and a person who has not studied a hang drop of this organism carefully might say there was some motion, even at times resembling somewhat of a "tumbling" motion. This same phenomenon, however, is seen when the germs are heated at

sixty degrees for one hour, thus destroying the life of the organism, and then examined.

Sporulation.—None observed.

Plain Agar.—Our experience indicates that this bacillus grows nearly as well on plain agar when standardized neutral (faintly pink) to phenolphthalein as it does on serum-agar. Then, too, we have been more successful in getting less spread of foreign germs on plain agar and thus a larger number of isolated colonies of the Abortusbacillus than where serum-agar is used. In fact, we have discarded serum in isolating cultures from the placentas of aborting cows, although in some instances no doubt serum is indispensible in obtaining a culture direct from the tissues. Two per cent. agar is especially preferred to a less amount in isolating the germ from the uterine exudate of an aborting cow when contaminated with other bacteria, as it gives a firmer medium on which to make the streak dilutions than where a less per cent. agar is used. We use infusions of fresh beef instead of beef extract in making our agars and bouillons, as we believe it better because of the muscle sugars which it contains.

Petri Dish Culture.—The surface colonies grown in a closed jar with Bacillus subtilis are transparent to transmitted light and have a bluish or greenish color according to angle of reflected light. The color, however, of young colonies to reflected light is decidedly bluish. To direct light the young colonies (three days old) look like minute dew drops and are homogeneous with the exception that now and then a colony may be seen with a few granules in the center (see plate 2). When incubated for a day or two longer there are usually numerous colonies having granules in their centers (see plate 5) and colonies resulting from six days incubation or longer, though quite transparent to transmitted light, assume some amber color. To reflected light they take on a greenish blue tinge and the center of the colony may have a whitish appearance. As such a colony is magnified 20 to 30 diameters it can be plainly seen that its center has assumed somewhat of a coarsely granular consistency, the granules becoming smaller toward the circumference of the colony. The outer portion

of such a colony is homogeneous and transparent (see plate 4) After three days incubation at 37 degrees C. the surface colonies measure from a pin point to 1.5 mm. in diameter. After six days incubation they may measure from a small point to 2½ mm. in diameter (see plate 3). After nine days incubation we have secured a few surface colonies that measured 2¾ mm. in diameter. Isolated colonies are usually round, raised, with exceptionally well defined borders (see plates 2, 3). Our experience is that surface colonies of this bacillus do not disintegrate when dishes containing them are kept a long time, as is usual with colonies of most bacteria, but become hard in consistency and retain their shape and transparency. The organism, however, in such colonies, is always dead. The colonies further down in the medium grow slowly even when incubated the Nowak method. Such colonies are oval or triangular in form, margins well defined, and finely granular, the color being of light brown.

Bouillon.—Plain bouillon inoculated with Abortusbacillus assumes a slightly cloudy appearance when incubated three days at 37 degrees C., Nowak method. The same is true of glucose bouillon. When grown in the air, however, for same length of time at 37 degree C. no cloudiness is noticed.

Solidified Blood Serum.—Grows well on solidified blood serum when enclosed in jar with Bacillus subtilis. The growth is slightly better on Loffler's blood serum than on plain serum.

Potato.—The surface of the streaks on potato are undulating, smooth, glistening and of a very light straw color.

Agar Streaks.—Light and heavy streaks of the organism on plain agar and incubated three days Nowak method present different characteristics. The surface of the light streaks is undulating, smooth, glistening and of a very light amber color to direct light and of a bluish color to reflected light. The margins of growth are well defined. A heavy streak of a culture on plain agar incubated the same length of time presents quite a smooth uniform glistening growth of a light amber color to direct light and of a greenish blue color to reflected light. The margins are well defined. The growth leaves the agar readily when touched with the point of a platinum needle—in

fact, reminds one of touching a drop of water. (See plates 9, 10.)

Stab Culture.—Grows well in agar (Nowak method) to a depth of 10 millimeters and then scantily to a depth of 20 millimeters, where the growth stops. Outside of the jar no growth takes place in plain agar. No other media were tried in this connection.

Fermentation Tube.—Did not ferment glucose bouillon even on being incubated seven days, Nowak method. The growth, however, was abundant in open arm of fermentation tube, and bouillon was clouded in the closed arm to a height of 15 mm., measuring from the bottom of the tube.

Milk.—Did not coagulate milk on being incubated twelve days, Nowak method. Some of the casein, however, was precipitated.

Temperature.—Optimum 37 degrees C. Grows well at 39 degrees C.

Oxygen Requirements.—This germ possesses peculiar biological properties with its relation to oxygen, being neither an ærobe nor an anærobe. We have never been able to grow this germ in the air, directly from the uterine exudate of an aborting cow or from the internal organs of the fœtus. We have, however, isolated one culture, sub-cultures of which (directly from the original colonies obtained) made a scanty growth in ten days time in the air when streaked on plain agar or on serum-agar and incubated at 37 degrees C. When streaked on a gelatin slant this same strain made some growth in thirty days time in the air at room temperature. A serum gelatin-agar tube (two per cent. agar, five per cent. gelatin, and blood serum equal parts) heavily inoculated with similar colonies of the culture mentioned, while the medium was warm (40 degrees C.), quickly solidified in ice water and incubated at 37 degrees C., produced a slight hazy growth 2 mm. below the surface of the medium in 48 hours. At the end of five days the growth had reached and was growing on the top of the medium. The growth also proceeded downward from the original line to a depth of about 1 mm. Ten days from the time this tube was inoculated a portion of the mate-

rial from the top of the medium was streaked on plain agar and incubated at 37 degrees C. ærobically, for six days. Growth occurred on three places near the bottom of the streak, which was inoculated heavier than the upper part. This material was mixed and streaks from it were made on tubes containing plain agar, some of which were incubated ærobically while others were grown the Nowak method. At the end of three days the cultures were examined and it was found that these cultures grew about as well ærobically as they did in a closed jar with the Bacillus subtilis. It should be stated, however, that the original colonies from which these subcultures were derived had been incubated three times, three days at each time, by the Nowak method. The object in doing so was to determine how large a colony could be produced from the germ direct from the animal tissue and no doubt that part of the procedure had something to do in accustoming this particular culture to grow in the air. In no other instance in our experience has growth occurred in the air when colonies of this bacillus obtained directly from the uterine exudate were streaked on plain agar or on serum-agar. If, however, such tubes were incubated in connection with the Bacillus subtilis, a good growth of the Abortusbacillus occurred in three days' time. This test will of itself, as far as our experience has gone, demonstrate whether or not the organism isolated is the Abortusbacillus, Bang. The germ often dies or is attenuated when streaks of it on plain agar or on serum-agar are incubated ærobically as long as ten days, as is indicated by negative results when subsequently subjected to the cultural methods of Nowak. We have incubated streaks of the germ for several days ærobically with no sign of development, after which the same tubes presented a good growth in three days' time, when enclosed in a jar with the Bacillus subtilis. It is found, however, that subcultures require less oxygen to be taken from the jar for development than do the original cultures, showing that the germ, when cultivated, has a tendency to adapt itself to nearly ærobic conditions.

We have been able to secure only scanty growth of the

bacillus by endeavoring to grow it in a partial vacuum, and have, therefore, discarded this method as impracticable.

We endeavored to reduce the oxygen in the Novy jar to the right degree for the bacillus to grow by using different small amounts of pyrogallic acid and a strong solution of caustic potash. After experimenting with different amounts of the acid without much success as to growth of the bacillus, we finally succeeded in obtaining about one-fourth of the growth obtained by the Nowak method by using 0.75 gram of pyrogallic acid and 5 c. c. of a strong caustic potash solution (1 to 4) to each 2000 c. c. capacity of the jar. The potash solution was not allowed to come in contact with the acid until the jar was sealed. This was accomplished by using a deep petri dish with the crystals of pyrogallic acid in one end of the dish and the caustic potash solution in the other, and the dish tilted so as to prevent the two substances from coming together until the jar was sealed and afterwards tipped to secure that end.

Nowak found this germ to make a good development when grown under a pressure of three atmospheres. The bacillus grows well in nearly a pure atmosphere of oxygen.

Bang and Stribolt grew this germ at first in serum-gelatin agar, the growth beginning about 5 mm. below the surface of the medium and extending downward some millimeters. This laboratory has not been able to secure the growth that far below the top of the medium, owing no doubt to using different proportions of serum-gelatin agar than that used by the Danish investigators, and also from the fact that the culture we tested had been grown for a considerable time in the laboratory before the trial was made, thus accustoming it to grow under nearer aerobic conditions. The germ always developed in our experiments within 2 to 3 mm. of the top of the medium and in the course of a few days actually reached the top of it. In the experiments of Nowak, of Austria, illustrations of which are given in Vol. 22 of Annals de l'Institut Pasteur, it is noted that the germ developed in different zones of such a medium.

Vitality of the Abortusbacillus, Bang.—On the whole we

have had no trouble in keeping and growing the different strains of the Abortusbacillus, Bang, which we have isolated by occasionally making sub-cultures. During a short time, however, we were obtaining but a slight development of the germ even on being incubated several days, and we were led to believe it was dying out. A careful investigation of the cause revealed the fact that the jars used for cultivating the germ slowly leaked air. As an extra precaution, thereafter, all cracks of joints of jars were covered with paraffin of high melting point.

All cultures of the bacillus are kept in a refrigerator, for they soon die out, especially in petri dish culture, if kept warm and in the light. In the refrigerator we find that cultures on the agar slants retain their vitality for a few months. A sub-culture on a serum-agar slant kept for eight months in the refrigerator as a test, was found to be dead. Nowak was able to keep a culture alive in straight serum-agar for two years, and Bang reports that the germ may live for a long time when in the fœtus or in the uterine exudate where it is protected from light and desiccation.

On December 18th, 1911, we received a strain of the abortion bacillus in cows direct from Bang's laboratory in Denmark, through the kindness of Dr. John Reichel, of Mulford & Company. Dr. Reichel had obtained two cultures and gave one to us. As far as could be seen the cultural characteristics of sub-cultures were the same as were strains of the bacillus isolated at his laboratory. We have also received a sub-culture of the Abortusbacillus, Bang, isolated by MacNeal and Kerr, of the Illinois Experiment Station, and find the organism isolated by us identical with the one isolated at the Illinois laboratory.

During the summer of 1911, Dr. F. M. Surface, of this Station, made a study of this germ at the laboratories of Bang and Holth, in Copenhagen, Denmark, and pronounces the organism isolated at this laboratory to be identical with the bacillus discovered by Bang and Stribolt.

In addition to the investigations of Bang, Stribolt and Holth, of Denmark, this germ has been isolated from the

uterine exudate of cows affected with infectious abortion by other European investigators, namely, Nowak of Austria, McFadyean and Stockman of Great Britain, Preisz of Hungary, and Zwick of Holland.

We have given the name "Abortusbacillus, Bang," to this organism on the suggestion of MacNeil and also because the specific name "Abortusbacillus" was on the label of the culture received from Bang's laboratory.

Explanation of Plates.

Plate 1.—The arrow on this plate points to a few colonies of the Abortusbacillus, Bang, growing in the clear space. Some of the colonies can be seen while others were too small to be taken by the camera. Other colonies of this bacillus were seen near the place marked with a "cross." This dish had been streaked with a small piece of the uterine exudate of an aborting cow. The ink lines were placed around the growth of contamination (original).

Plate 2.—A very small portion of above plate (place indicated by arrow) magnified 30 diameters, showing colonies of the Abortusbacillus, Bang, growing in the clear places. The dark lines surrounds growth of contamination. The colonies are the result of three days' incubation in a sealed jar with Bacillus subtilis and show no granules. The "high lights" at margin of some colonies are due to the reflection of light owing to transparency and luster of the colonies (original).

Plate 3.—Natural size of colonies of the Abortusbacillus, Bang, after six days' incubation. Ink lines surround growth of contaminating bacteria. Plate was originally streaked with uterine exudate of an aborting cow (original).

Plate 4.—One of the medium sized colonies of Abortusbacillus, Bang, shown in plate 3, magnified 20 diameters, showing granular center and transparent margin (original).

Plate 5.—Abortusbacillus, Bang. Superficial colonies, single and confluent (four days old upon serum-agar), obtained direct from the uterine exudate of an aborting cow. The colonies were transparent and homogeneous with the ex-

ception of a few granules at the centers of some of the colonies, as is shown in photograph; x 25 (original).

Plate 6.—Abortusbacillus, Bang; x 500 (original).

Plate 7.—Abortusbacillus, Bang; x 1500 (original).

Plate 8.—Abortusbacillus, Bang; x 3000 (original).

Plate 9.—Abortusbacillus, Bang; streak upon agar-agar three days old, natural size (original).

Plate 10.—Abortusbacillus, Bang, light and heavy streak on agar-agar, three days old; x 4 (original).

Plate 11.—Abortusbacillus, Bang, growing in serum-gelatin-agar (after Nowak).

Plate 12.—Abortusbacillus, Bang; streak on agar-agar of a section of an abscess in the uterus of an aborting guinea pig which had been inoculated subcutaneously with a pure culture of the germ; x 3 (original).

Plate 13.—Jars used in this laboratory in growing Abortusbacillus, Bang.

Plate 14.—Fœtuses of a cow aborting in the sixth month of gestation (original).

Plate 15.—Fœtus of a cow aborting in the 210th day of gestation (original).

Plate 16.—Fœtus of a cow aborting in the eighth month of gestation. Too weak to live (original).

Plate 17.—Fœtus of a cow aborting in the 73rd day of gestation—actual size (original).

Inoculation Experiments.

At the beginning of our investigations one of our objects was to produce abortion in guinea pigs experimentally by intravaginal inoculation of bits of uterine exudate from an aborting cow or other animal, and then if possible secure the organism producing the disease from the pig. During the first year we were unable to carry on these experiments to any extent on account of the weak strain of guinea pigs at our disposal. These pigs were undoubtedly diseased to some extent, for they seemed to have no vitality and a goodly number died. Finally they all died or were killed and the pens that



PLATE 1 (see page 273)

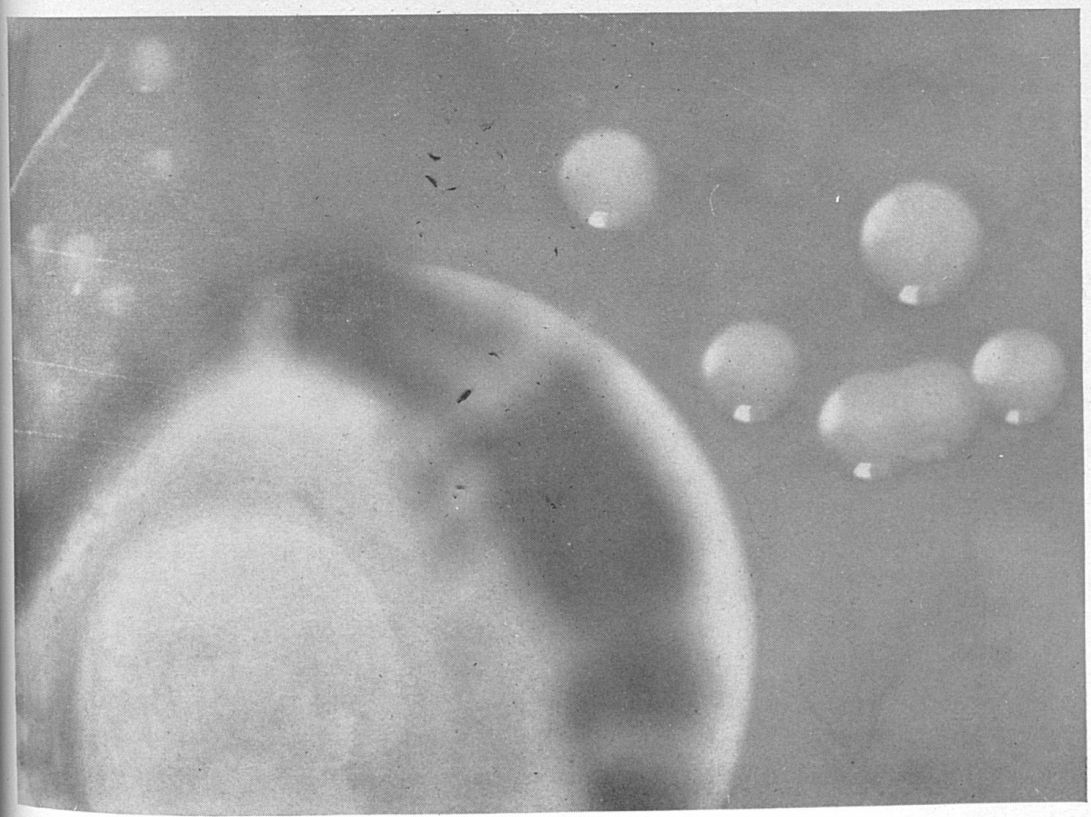


PLATE 2

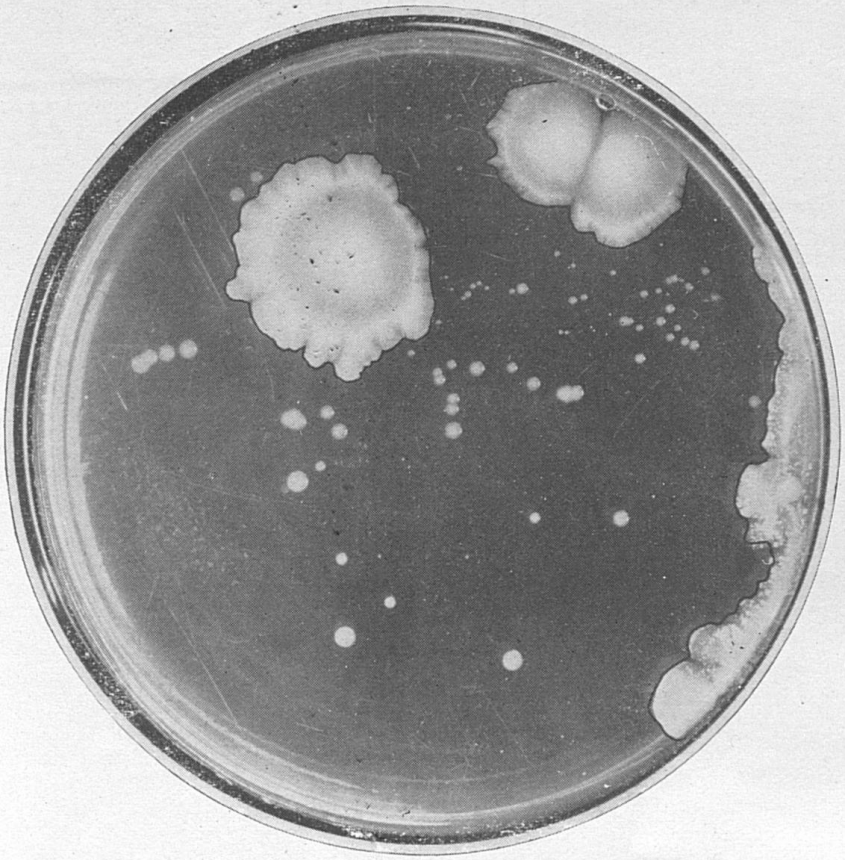


PLATE 3

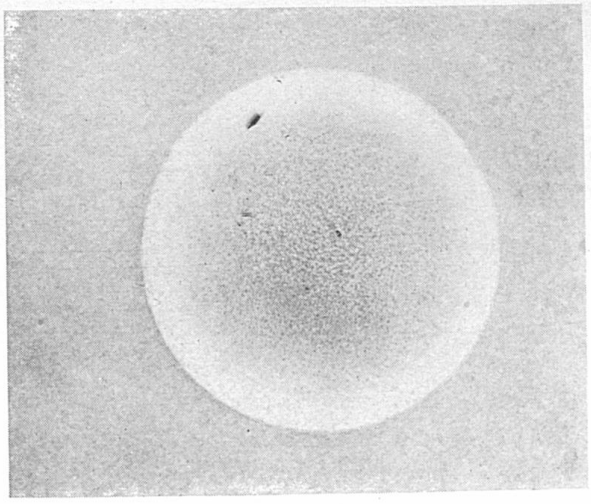


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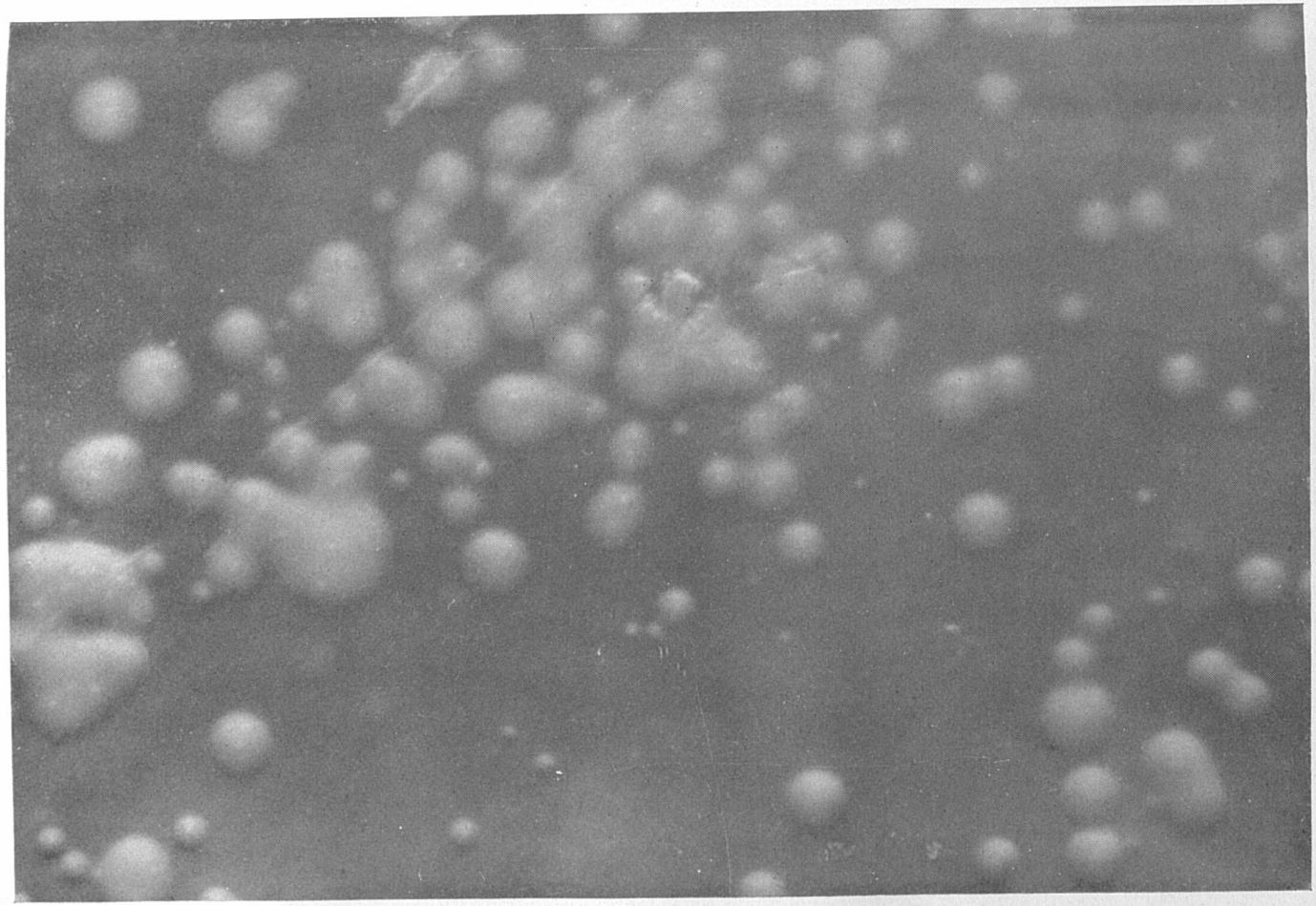


PLATE 5

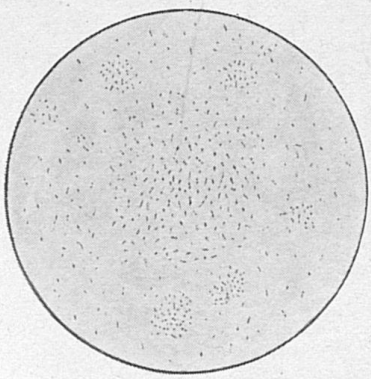


PLATE 6

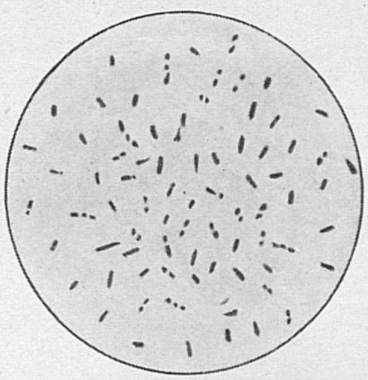


PLATE 7

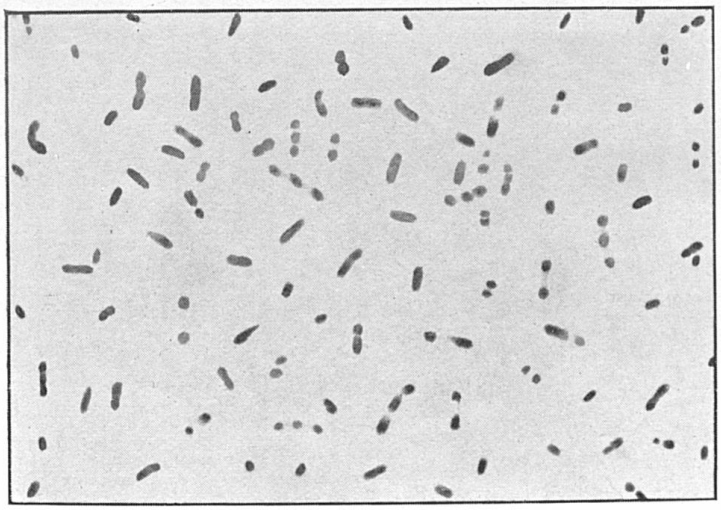


PLATE 8



PLATE 9

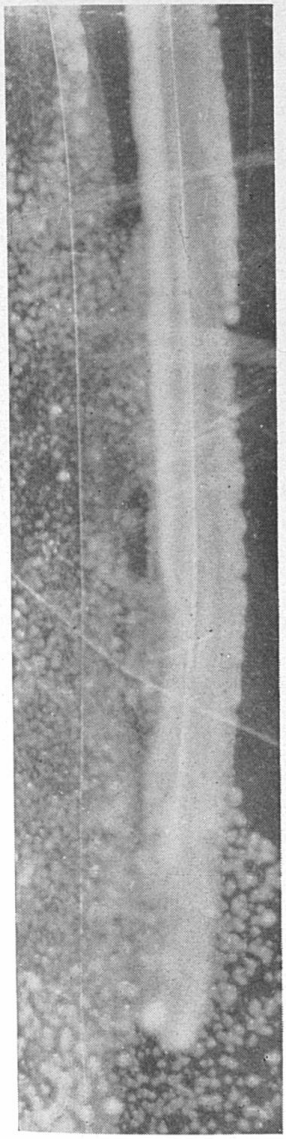


PLATE 10

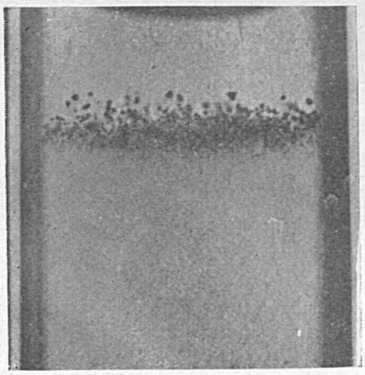


PLATE 11

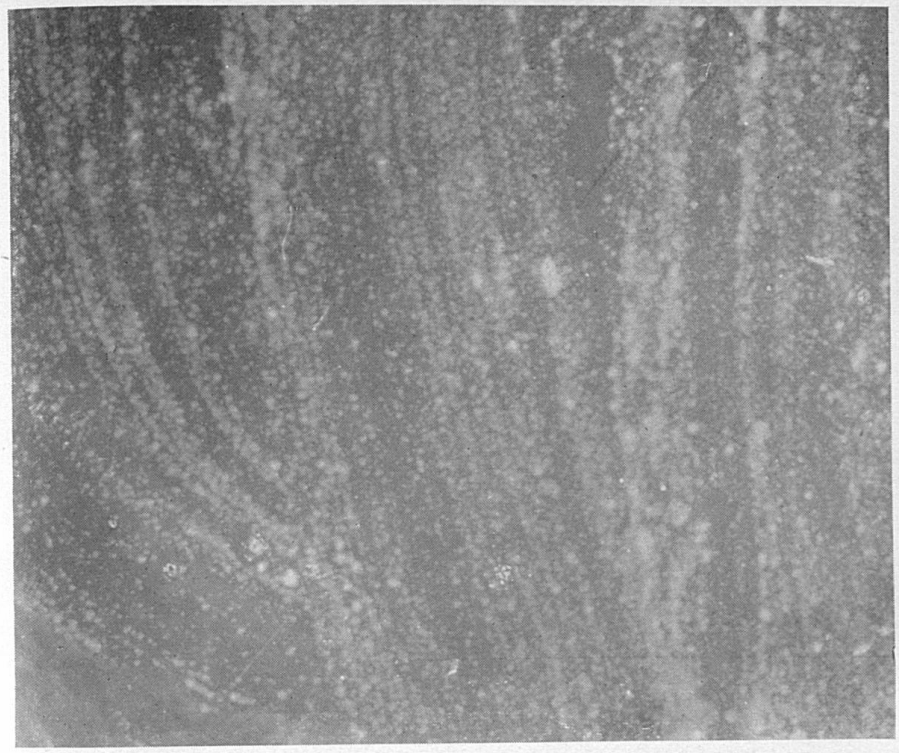


PLATE 12

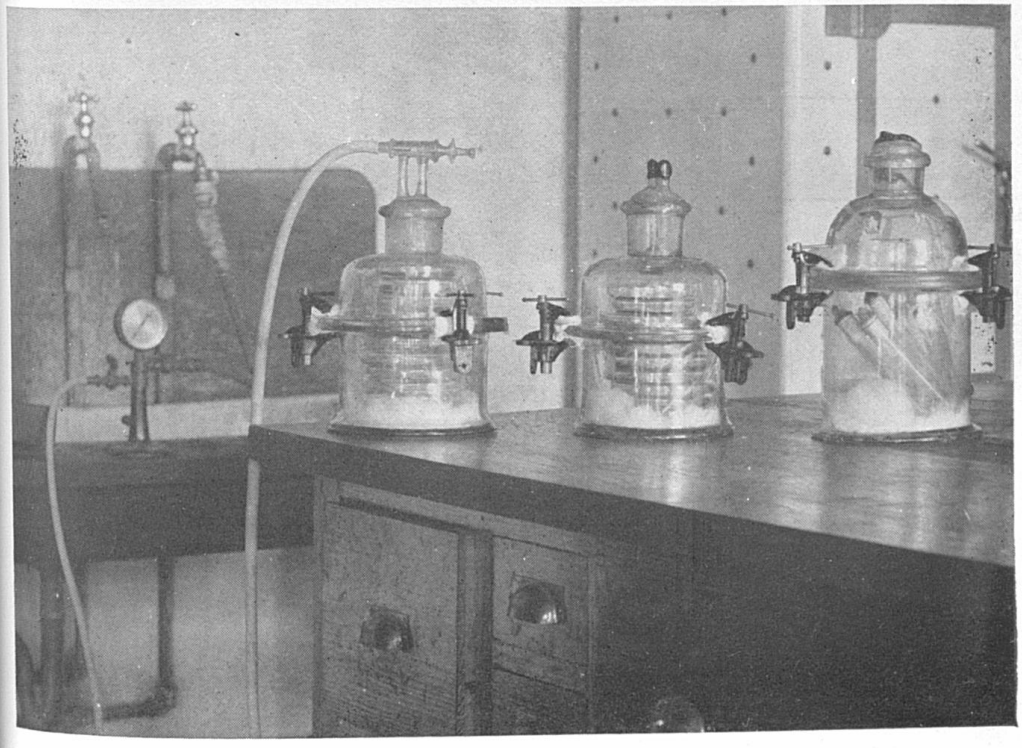


PLATE 13



PLATE 14

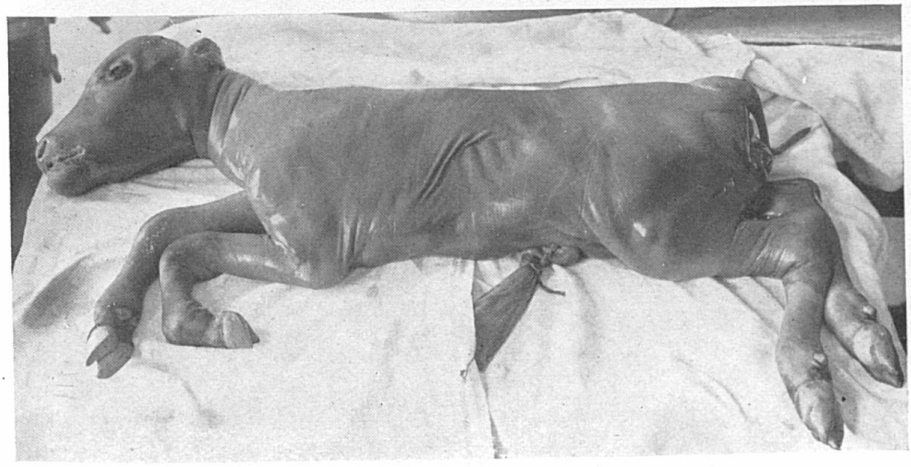


PLATE 15

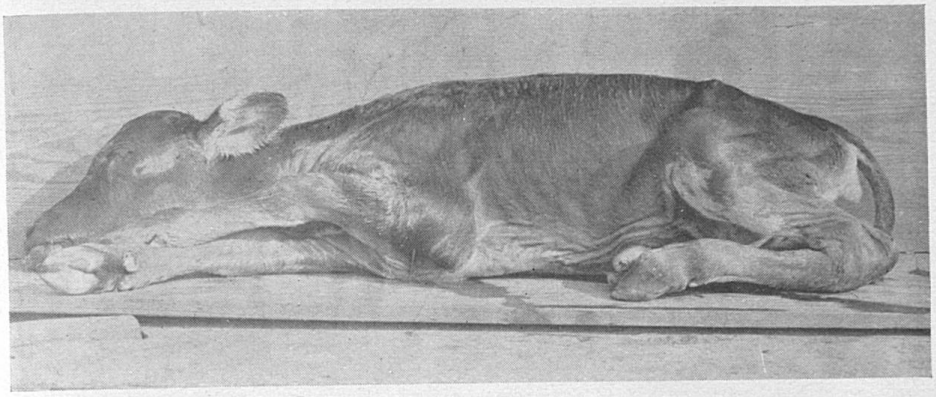


PLATE 16

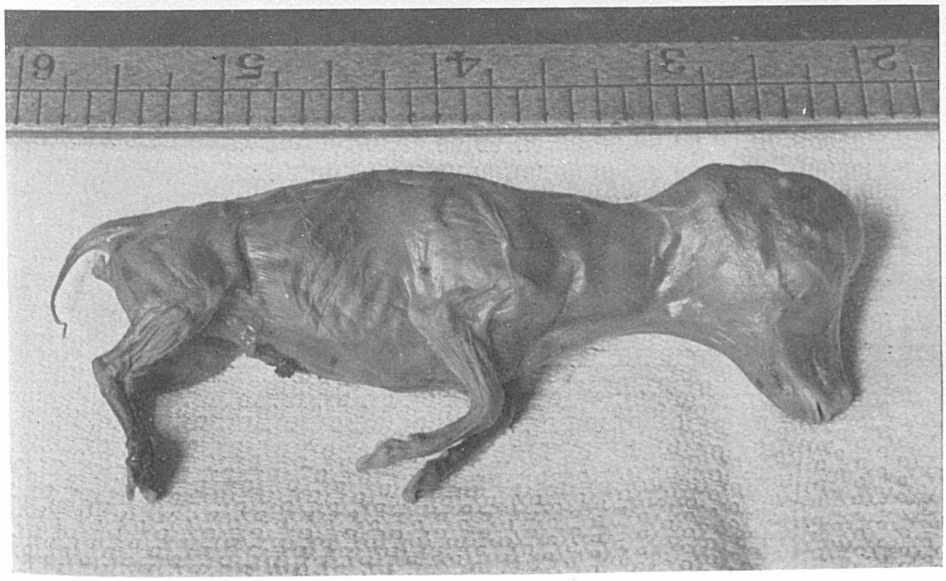


PLATE 17

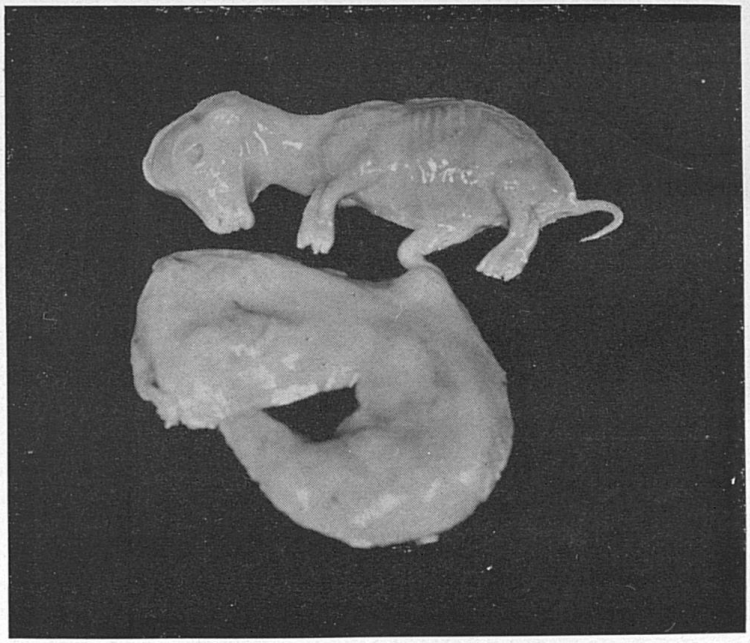


PLATE 17½—Fœtus and fœtal membranes of a cow aborting in the 64th day of gestation (actual size). The membranes were removed from fœtus before the photograph was taken. In all probability cows seldom abort at such an early stage of gestation. The specimen was recently secured by Dr. Surface and kindly loaned the author for the photograph while this bulletin was in press.

they were in thoroughly disinfected. Healthy foundation stock was then secured, and for the last three years we have followed the practice of inbreeding, and the results have been very satisfactory, for the progeny is as vigorous as the foundation stock, if not more so. This may be due in part to the most excellent care that has been given these animals. After the first year we were able to carry on our investigations at will as far as the guinea pigs were concerned. Bits of cotyledons and other material from an afterbirth of an aborting cow were cut up finely with sterile scissors, suspended in sterile water or bouillon and injected intravaginally into pregnant sows. Sterile water was often injected intravaginally as controls. A few times we used the intraperitoneal method of inoculation. Intravaginal inoculations were also made from time to time with different germs isolated from the uterine exudate of aborting cows. From 2 to 10 pigs were usually injected at a time. We occasionally secured one or two abortions from the number of pigs inoculated by this method, but were never able to isolate a germ in common from these abortions. At times a different species of germ was isolated from the uterus of the aborting pig from that inoculated. At other times no germ at all could be isolated from the uterus. In one instance a small abscess was noticed in the left horn of the uterus of an aborting sow. We were, however, unable to secure a culture of any germ from the uterus of this pig. Dr. D. J. Healy, Bacteriologist of the Pure Food Department, and a pathologist of wide experience, made a study of this abscess, but was also unable to secure a culture of any kind from it. He also sectioned it and after a long search found two germs that conformed to the morphology of the Abortus-bacillus, Bang, and the writer is inclined to believe it was that organism. One was a short bacillus taking a bipolar stain and the other was a longer one, taking the stain its entire length.

Since isolating the germ in pure culture at this laboratory, we have not followed the practice, as a rule, of injecting uterine exudate from an aborting cow into pregnant guinea pigs. On one occasion we injected a pregnant guinea pig sub-

cutaneously with 2 c. c. of a physiological salt solution containing bits of uterine exudate of such a cow, and one and one-half c. c. into another pig. Neither pig aborted, but ten days after inoculation we did obtain a pure culture of the Abortus-bacillus from the pus at the seat of inoculation from one of the pigs. The germ, however, was obtained from no other organ of this sow.

May 6, guinea pig designated as No. 1, was inoculated with 2 c. c. of bouillon suspension of a growth of the abortion bacillus isolated from Herd No. 2. Pig No. 2 was inoculated with 2 c. c. of the same suspension. On the morning of May 19th, pig No. 2 aborted three dead fœtuses. There was no hair on the fœtuses. This sow was chloroformed on May 22. Ante-mortem Notes.—Pig appeared normal. Postmortem Notes.—sack of pus at seat of inoculation three-quarters of an inch in diameter. Upon opening the uterus it could be seen to be apparently enlarged and congested, being blackish in color. The three placentas were still in the uterus and were nearly black in color. The germ was found in stains made of the placenta, abscesses at the seat of inoculation, uterine exudate and cross section of uterus. Plates were made of the following material: Pus at seat of inoculation, liver, heart, placenta, and cross section of uterus. The material was incubated four days, Nowak method. The plates made from the pus at seat of inoculation contained numerous colonies of Abortusbacillus, Bang, some as large as 2 millimeters in diameter. The plates streaked with bits of placenta were negative, as were also those from the liver and heart blood. The plates streaked with cross sections of the uterus contained so many colonies of the abortion bacillus as to be confluent in some places.

Guinea pig No. 1 aborted May 27th, four dead fœtuses. Two of the fœtuses were haired over and were apparently nearly developed. One fœtus was not well haired over and not fully developed, while the fourth pig was not well developed and was still enclosed in the fœtal sack. This pig was about half the size of the others, apparently mummified, and the eyes shrunken. The placenta was still attached to this fœtus. Plates were at once made of the liver of each fœtus,

the placenta of the one pig and the stomach contents of one of the fœtuses. The plates were all incubated three days by the Nowak method, and all negative with the exception of the plate smeared with the placenta, which contained numerous colonies of the germ. On May 28th, pig No. 1 was chloroformed. The notes of autopsy were as follows: Internal organs apparently normal, with the exception of the uterus, which organ was very much congested and contained four abscesses, situated at the placental attachments. One abscess measured 15 mm. in diameter. The covering of an abscess was thick—somewhat cartilaginous. Plate cultures were made of the heart, liver, pus at seat of inoculation, cross section of the uterus and a cross section of an abscess in the uterus. These plates were incubated three days, Nowak method. The plate cultures of heart blood and liver were negative. All the other plates showed abundant growth of the Abortusbacillus, Bang. The streaks of the cross section of the abscess produced such an abundant growth as in places to represent a streak of a pure culture of the germ (see plate 12).

On May 20, a pregnant guinea pig was inoculated subcutaneously with a bouillon suspension of a small amount of the uterine exudate from an aborting cow of Herd No. 2, Case No. 5. On May 29th this pig gave normal birth to two live pigs. The mother pig, however, was chloroformed and plate cultures made from the pus at the seat of inoculation, heart blood, kidneys, spleen, liver and uterus. All plates negative with the exception of those made from the pus at seat of inoculation. The growth of the Abortusbacillus from that source was abundant. The young pigs were chloroformed and streaks on agar made from the heart blood, liver, uterus (one being female), were negative.

On July 10, 1911, we inoculated 2 c. c. of a uterine exudate of an aborting cow in physiological salt solution into a pregnant guinea pig. Twenty-four hours later this pig died, being affected with septicæmia. Plate cultures of the internal organs revealed the colon bacillus. The Bacillus coli communis, as well as the Abortusbacillus, Bang, was isolated from the uterine exudate of this sow.

On August 9th, 1911, we inoculated a pregnant guinea pig with a pure culture of the Abortusbacillus, Bang, obtained from cow No. 2, of Herd No. 2. A culture on an inclined agar tube was flooded with bouillon and 2 c. c. of the suspension was injected subcutaneously into this pig. At the same time a pregnant pig was injected with a bouillon suspension of exceedingly numerous colonies of Abortusbacillus, Bang, obtained from a fœtus of an aborting cow of Herd No. 1. Five c. c. of this suspension was injected subcutaneously into this pig, producing abortion inside of 24 hours. The fœtuses were about two-thirds developed. The mother pig appeared very weak. She was immediately chloroformed and plate cultures made from the different internal organs as usual. All were negative with the exception of those made from the liver and uterus. Plates made from the internal organs of the fœtuses were negative. On August 16, the first named pig aborted three dead fœtuses. She was immediately chloroformed and streaks from the heart, liver, and uterus were made on plain agar. Colonies of Abortusbacillus, Bang, were obtained from the plates made of the liver, uterus and placenta. Plates made from the liver of fœtuses were negative.

On September 6th, 1911, the contents of an agar slant of Abortusbacillus, Bang, were washed down in 4 c. c. of bouillon and injected into a pregnant guinea pig. This pig aborted in 36 hours. She was chloroformed and the germ secured from the point of inoculation, placenta and uterus of the mother pig, and from the liver of one of the fœtuses.

Two other pregnant guinea pigs inoculated subcutaneously with two cubic centimeters of bouillon suspension of Abortusbacillus, Bang, aborted in 8 and 11 days, respectively, and the germ was found in large numbers at the point of inoculation, and uteruses of these sows.

We have not as yet tried any of our cultures on pregnant cows. On June 28th, 1911, we flooded three agar tubes, of the Abortusbacillus, Bang, with bouillon and injected the same into a supposedly pregnant sow, weighing 220 pounds. On July 8th this operation was repeated by injecting into the ear

vein the growth on twelve tubes of inclined agar, diluted in physiological salt solution. Seventy-five cubic centimeters of this material were injected at this time. There was no noteworthy reaction with the exception that the sow refused to eat for two days. On July 31st, it was noticed that this sow was in heat. It was not certain that this sow was pregnant, as she was purchased, though she gave every evidence of being well along in pig when inoculated. On August 7th she was slaughtered and plates made of the uterus, ovaries, kidneys, and liver. The results were negative.

Dr. Bang of Denmark was able to produce abortion in cows by intravaginal injections of pure cultures of this bacillus, the incubation period being from 70 to 80 days after the first inoculation. He was also able to produce the disease in a mare by introducing intravenously a pure culture of the germ, the incubation period being 28 days. MacFadyean and Stockman of Great Britain were able to produce the disease in eight cows with the intravenous injection of the germ in pure culture. They were also able to produce the disease by feeding in three out of four cases.

The methods employed at the present time in suppressing this disease will be discussed in a future bulletin.

PART II.

INFECTIOUS ABORTION IN MARES.

History.—Infectious abortion among mares has been recognized in European countries for a long time, but according to Williams, it first acquired prominence in the United States in 1886, when the disease appeared in several States of the Mississippi Valley, in which region the breeding of horses had become a very important industry. He states that at this time the disease soon acquired a very extensive distribution and high degree of virulence. The disease has been noted for some years past among the Thoroughbred and Standardbred mares of the Blue Grass Region of Kentucky, where, as has been stated before in this bulletin, a large percentage of the mares on some farms have aborted in certain seasons. It is a common practice in this region to run a large number of brood mares in the same field, so that an infection of any kind could easily pass from one animal to another. The disease, however, has not been as prevalent among the mares in this locality during the past few years as was formerly the case.

Symptoms.—In this part of the country the mares are bred soon after foaling. The foals are usually weaned in September and October, and if infectious abortion is present in a stud, a few of the mares are apt to abort at this time. A few months may then elapse before other mares in the stud abort, at which time a majority of the abortions occur. The manager of a large breeding establishment, who has had considerable experience with abortion among mares in this region, has observed that more mares abort in the eighth month of gestation than at any other period during pregnancy. He has never known, however, of a mare aborting after carrying her fœtus ten and one-half months. On the other hand, cases have come under our observation where mares have aborted in the early stages of gestation. It is difficult to state just how prevalent abortion is during this period of pregnancy since the mare presents but slight symptoms of disturbance on the abortion of such a small fœtus, or embryo, and since the fœtus is small

it often escapes notice. An extensive breeder of Thoroughbred horses informed us that at one time as he was looking at a mare in a box stall he saw something drop from her. A careful search in the straw revealed a very small embryo not much longer than his fore finger, but sufficiently developed to represent a miniature horse, the sex of which could be determined. We have in our possession two small embryos (see plate 19) that were passed by mares in the second month of gestation, in each case the passing of which had no apparent effect on the mare.

Mares further along than the first few weeks of gestation usually present symptoms of impending abortion in the swelling of the vulva and in a chocolate colored discharge from the vagina. This discharge may continue for some time after the mare aborts. Usually a mare will abort a fœtus well along in gestation with little effort, and in most cases with no injurious sequelae. However, in a large stud of mares afflicted with this disease a few individuals may at times succumb after aborting. The symptoms presented in such cases are a continued discharge from the vagina, elevated temperature and marked depression. The amnion (inner covering of foal) of an aborting mare sometimes shows blister-like pustules scattered over its surface. Our investigations also show that the internal organs of the fœtuses of aborting mares usually present marked pathological conditions. The veterinarians in this section of the country note a peculiar odor associated with the fœtus and fœtal membranes of a case of typical abortion. We have found this odor to be more pronounced in some cases than in others, and not only detected on the exterior of the fœtus but in the internal organs as well. The laymen usually speak of it as a "sour odor." The contents of a stomach of an aborted fœtus, which had this characteristic odor, was submitted to a number of chemists at the Kentucky Experiment Station, and some pronounced it an ethereal odor, while others said that the odor reminded them of an alcoholic extract of fresh animal matter not necessarily muscular tissue. The contents of such a stomach is acid to phenolphthalein at first, but upon standing soon turns to an alkaline reaction. The odor

described above is sometimes noted on the afterbirth. Some of the organs, particularly the ovaries and testicles, are at times exceedingly enlarged. Occasionally small nodules about 1 mm. in diameter are found on the exterior of the auricle. These nodules are easily squeezed out between the finger nails and resemble the early stage of an ulcer on the ileocecal valve of a hog suffering with hog cholera. The lungs show areas of hepitization. The spleen is usually enlarged and covered with petechæ. The mesenteric lymphatic glands are very much congested and the liver may show hemorrhagic areas on its surface.

Colts that come alive from a stud of mares affected with abortion are generally rheumatic and have swollen joints. This malady is known among breeders of horses as "rheumatism" or "joint ill." Colts affected with "joint ill" appear very lame and walk with difficulty, while in some cases abscesses form at the joints. The hock, knee, ankle, or any joint may be affected, but the articulation at the hock is the favorite seat of this trouble. The eyes may be involved, interfering with the sight, and may cause total blindness. It has been noted that an epidemic of "joint ill" among the colts of a stud will occasionally occur a year previous to a general outbreak of the disease of abortion among the mares of that stud. In some cases in a stud afflicted with contagious abortion, colts delivered at the full term of gestation appear strong and healthy at first, then suddenly sicken and die with a form of pneumonia, while others become affected with white diarrhea, which usually terminates fatally. A large number of mares in a stud may abort one year and nearly all deliver live healthy colts the next year.

Results of Other Investigators as to the Etiology of the Disease.

Ostertag of Germany has been one of the most prominent foreign investigators of the etiology of this disease among mares. He found in the heart blood of the fœtus, in the thoracic cavity, and in the intestinal tract, short streptococci, which usually grew in pairs. The organism was Gram-nega-

tive. He also secured this germ from the fœtal membranes. He was able to produce abortion experimentally by injecting a culture of this germ into the jugular vein of mares.

In 1890 Theobald Smith of this country found a short bacillus possessing pathogenic properties in the vagina of a mare which had recently aborted. This mare was one of a number of mares that aborted in a large stud in Pennsylvania. Rabbits inoculated intravenously with pure cultures of this germ died within a few days' time. Smith decided that morphologically and physiologically this bacillus was nearly identical, if not entirely so, with the Bacillus cholera suis, and raised the question as to whether this germ could affect two species of animals but produce an entirely different disease in each species. Of course, at this time it had not been determined that the disease of hog cholera was due to a filterable virus. However, it is well understood at the present time that the Bacillus cholera suis has pathogenic properties under some conditions. A pure culture of the bacillus isolated by Smith injected intravaginally in pregnant mares and cows produced a catarrhal discharge from the vagina for some time. The mares and cows, however, carried their foals full time and delivered them alive.

Results of Our Investigations.

For reasons stated before in this bulletin, our investigations relative to infectious abortion have been directed largely to the disease in the cow. During the past year, however, we have given considerable attention to this disease in the mare. This work has been carried on mainly with four studs of mares and one stud of jennets. The stud which we shall designate as No. 1 consisted of five jennets, of which all aborted. The veterinarian in charge informed us that these jennets, from all symptoms, were afflicted with abortion of the infectious type. The stud which we shall designate as No. 2 has one hundred and fifty mares. There have been three or four abortions on this place during the past year. On the whole the symptoms presented by the mares aborting on this farm

would indicate that they were not affected with abortion of the infectious type. Stud No. 3 had fifty-five mares in foal during the summer. Ten out of nineteen mares in one paddock on this farm have aborted within the past six months. The veterinarian attending this stud believes that the symptoms of the mares aborting on this farm are typical of abortion of the infectious type. Stud No. 4, consists of one hundred mares, of which three have aborted during the past six months. The symptoms indicate that infectious abortion is not present in this stud. Stud No. 5 has forty brood mares, of which number three have so far aborted during the past six months.

In 1907 we received the afterbirth from an aborting mare that presented peculiar characteristics in that small whitish nodules, ranging from number six shot to a small pea, were found on the amnion. On staining the contents of one of these nodules it was found to be packed full of a small organism resembling a coccus. Stained sections of these nodules showed these germs in large numbers. The organism multiplied readily ærobically in plain agar, at the same time increasing in size. Stab culture on agar-agar soon produced bubbles of gas, indicating that it was a gas producing organism. Before the cultural characteristics of this germ were determined the cultures were accidentally destroyed. Upon a recent examination of the stained sections prepared from the nodules mentioned, we believe that this germ was a type of the colon bacillus, the organism in the tissues resembling a coccus.

Stud No. 1—Case No. 1.—On June 24th, 1911, we received the fœtus of an aborting jennet from this stud. This fœtus was dropped eleven days before it was due. There were five jennets on this farm and they all aborted. The fœtus we succeeded in getting was from the fifth jennet that aborted. To all appearances this fœtus was fully developed. The veterinarian who was in charge had had considerable experience with this disease of infectious abortion in mares and thought this a typical case of that disease. The jennets had aborted without any apparent inconvenience; had emitted a chocolate colored dis-

charge from the vagina and the odor of the afterbirth and fœtus was characteristic of that usually noted in this disease. The fœtus reached the laboratory within half an hour after it was dropped and after being washed with a disinfectant was opened up at once and the following notes taken: The lungs did not float in water, showing that they had never performed their function; the liver appeared large, even for a fœtus weighing 930 grams, and was dark in color; the spleen was enlarged, measuring four and one-half by eight inches, and there were numerous petechæ on its surface; the heart was dark in color and somewhat enlarged; the mesenteric lymphatics were highly congested; the ovaries were very much enlarged, each measuring one and one-half inch wide by two inches in length, and both highly congested, being blackish-red in color; the kidneys were highly congested and hemorrhagic, and the uterus was also highly congested. Streaks of blood and contents of the following organs were made on numerous plates of plain agar: Heart, liver, spleen, kidneys, stomach, lymphatic system, large intestines, small intestines, uterus and ovaries. Each organ was seared and afterward opened with a sterile lance and one or two loopfuls of the contents streaked on consecutive plates of agar, as is ordinarily done in making streak dilutions. These plates were then incubated for 24 hours at 37 degrees C., and examined, with the result that growth was found on all the plates, more abundant on some of the dishes than others. On some of the petri dishes the growth was so abundant as to resemble a dish flooded with a pure culture of some organism. Such growth appeared moist, glistening and of a bluish color to reflected light. On other plates not quite so heavily streaked the growth assumed a branching appearance (ameboid), the edges of which were well defined. Still other plates produced exceedingly numerous colonies measuring from a pin point to one-fourth millimeter in diameter. These colonies appeared transparent to the naked eye, glistening to direct light, and of a bluish-gray color to reflected light. On other plates where the growth was scarce the colonies measured nearly half a millimeter in diameter at the end of twenty-four hours, and had a

glassy appearance. After three or four days incubation of all the plates, the individual colonies on dishes containing but little growth, measured two to three millimeters in diameter, and took on a glassy color shaded to a slight extent with yellow. When examined under the low power of the microscope, the smaller colonies were found to be finely granular (like fine felting). The larger colonies assumed different characteristics as some were irregular in outline the edges appearing as if they had been pressed flat; others assumed a crater form; some had small wart-like prominences over the surface; while a few others were concentrically ringed. The dishes were further incubated three days, Nowak method, without additional growth. Judging from the diversity in appearance of the colonies and growths on the numerous dishes that we were dealing with, a mixed culture was suspected, but after studying the morphological, physiological and cultural characteristics of the germs producing the different forms of colonies and growths noted, it was determined that they were all produced by the same organism, the apparent difference in appearance being due to the varying densities of growth caused by the lack of uniformity in the amounts of material used in the original streaks. The germ was also identified by streaks of the contents of the different organs on slides and stained with an aniline dye. The organism in the tissues resembled a coccus and a short plump bacillus with rounded ends, measuring 0.3 to 0.5 u. wide by 0.5 to 1. u. long. When grown on plain agar the size was slightly increased. When the germ was taken from the drop of condensation of an eighteen-hour agar tube culture and examined it was found to have some motility and to be Gram-negative. The organism was a facultative anærobe and did not produce spores. It did not liquify gelatin nor did it produce indol in Dunham's solution after being incubated five, ten or even twenty days. Milk was not coagulated on being incubated 10 days and the end reaction was alkaline to litmus. The casein of the milk, however, was precipitated. It produced 55 per cent. of gas in one and a half per cent. litmus glucose bouillon in 24 hours, and 72 per cent. of gas in 48

hours, the end reaction being acid. Litmus glucose agar was also turned acid. This organism did not change litmus lactose agar acid nor did it ferment or turn litmus lactose or saccharose bouillon acid. All bouillon or agar into which lactose or glucose were added had previously been deprived of all sugars by inoculating the beef infusion from which they were made with vigorous twenty-four hour old bouillon cultures of the colon bacillus and incubated at 37 degrees C. for 20 hours. Streaks of the bacillus on plain agar were very characteristic in that after the culture had been incubated for three or four days the growth became dry and parchment like, and developed thin wrinkles near the drop of condensation. The drop of condensation was also covered with a thin film. The growth on a slant was so dry and membranous that bits of the same could not be readily obtained with the platinum loop. Bouillon inoculated with the germ became clouded with a heavy whitish growth at the top of the medium, which on shaking slightly broke up and settled to the bottom of the tube.

Taking into consideration the above morphological, physiological and cultural characteristics this germ was placed in sub-group II. (or Intermediate Sub-group) of the Colon-typhoid group to which Sub-group belongs such pathogenic organisms as Bacillus enteritidis, causing meat or ptomain poisoning in man, and enteritis in cattle; also to the same sub-group to which belongs the Bacillus cholera suis.

A twenty-four hour old agar slant of the above bacillus was flooded with bouillon and 2 c. c. injected subcutaneously into a pregnant guinea pig. At the end of ten days the pig aborted. She was chloroformed and the organism inoculated was obtained from the point of inoculation and from the uterus.

Case No. 1—Stud No. 2.—On September 2nd, 1911, the fœtus and afterbirth were taken from a mare which was in labor. The fœtus was dropped in the 80th day of gestation. It was highly congested over the surface and the internal organs showed slight development. The amnion was covered with fine granules. Plates were made from the kidney, liver

and intestinal contents of the fœtus, and from the amnion of the mare. The plates were then submitted to the cultural methods employed in isolating the Abortusbacillus. The Abortusbacillus, Bang, however, was not obtained, but instead colonies of the colon bacillus belonging to Subgroup I were obtained in large numbers on all the plates. This organism was able to produce 55 per cent. of gas in glucose bouillon tube in 24 hours, and 60 per cent. of gas in Jackson's bile tube (one per cent. of lactose and one per cent. of peptone added to bile obtained from the ox) in 24 hours. The organism fermented litmus lactose bouillon with acid reaction. It was destained by Gram's method. Growth of this bacillus on an agar slant was washed down with bouillon and 4 c. c. injected subcutaneously into a pregnant guinea pig produced abortion in 22 hours. The mother pig was found to be in a very poor condition. She was chloroformed and the bacillus isolated from the placenta; also from the point of inoculation. Another guinea pig inoculated similarly died in 21 hours without aborting. The point of inoculation could not be ascertained, so we are inclined to believe that the pig was inoculated intraperitoneally. Lesions resembling those of septicæmia were found in different internal organs, especially in the liver, intestines and uterus. The colon bacillus was isolated from the liver, the placenta and from the uterus of this pig. The organism was not isolated from the fœtuses. Another pig inoculated similarly aborted in 32 hours. The bacillus in question was isolated from the heart blood, liver and uterus.

Stud No. 3—Case No. 1.—On November 1st, 1911, a fœtus covered with the fœtal membranes from a mare aborting in the 232nd day of gestation was brought to the laboratory. (See plate 18.) The fœtus was dropped at 10 a. m. opened up at once and the notes of the autopsy were as follows: All the internal organs showed congestion. Heart, diffused congestion; lungs, slightly congested; liver, hemorrhagic; spleen, apparently enlarged (3½ by 5 inches), very dark in color, soft, friable, and hemorrhagic; kidneys, slightly hemorrhagic; intestines, highly inflammed. The mesenteric



PLATE 18.—Fœtus of mare (Stud No. 3, Case No. 1), aborting in the eighth month of gestation. As can be seen the fœtus was entirely enclosed by the amnion. (Original.)

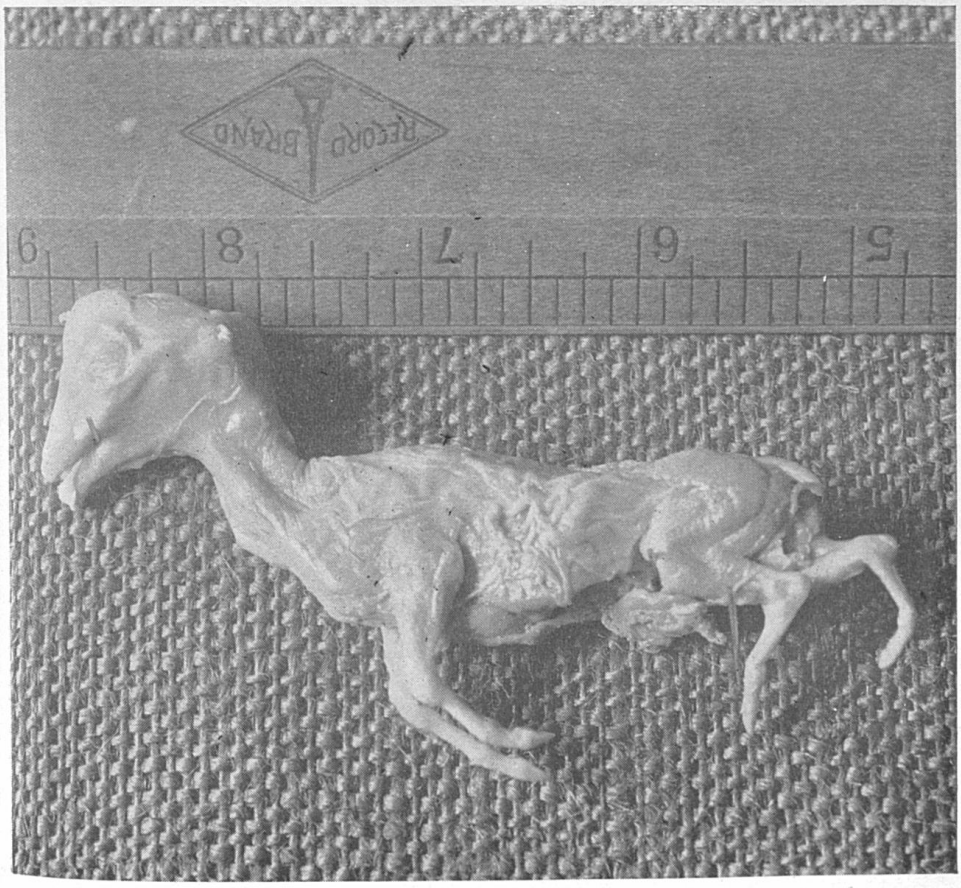


PLATE 19—Actual size of a fœtus of a mare aborting in the latter part of the second month of gestation. This fœtus was enclosed in the fœtal membranes which were entirely removed before photograph was taken. (Original.)



PLATE 20—Fœtus of a mare aborting in the eighth month of gestation. In this case the fœtal membranes were removed from the fœtus, but left attached to the umbilicus. (Original.)



PLATE 21—Fœtus of a mare aborting in the sixth month of gestation. This fœtus was dropped enclosed in the fœtal membranes, which were removed before the photograph was taken. (Original.)

lymphatics were highly congested, being nearly black in color. Plate cultures were made of the following organs, each of which was seared and then opened with a sterile lance: Heart, liver, spleen, kidney, stomach, large intestine, small intestine, testicles (male fœtus), and umbilicus, with the result that after 24 hours' incubation each plate showed a dense covering of a pure culture of the same bacillus which was discovered in the fœtus of the aborting jennet. Streaks of the afterbirth on plain agar revealed the same bacillus in large numbers.

Stud No. 3—Case No. 2.—This mare had aborted on October 31st, 1911, in the 212th day of gestation, and the fœtus and afterbirth destroyed by burning. The uterine exudate taken directly from the uterus of this mare by means of inserting a small sterile bottle into that organ was found to contain bacilli in large numbers identical with that obtained from the fœtus of the jennet and from the fœtus of Case No. 1, Stud No. 3.

Stud No. A—Case No. 1.—On November 3rd, 1911, a fœtus covered with the fœtal membranes was delivered to the laboratory from this stud. There were no abortions among the mares on this place previous to this date. The fœtus was four months along. The ovaries of the fœtus appeared greatly enlarged, measuring one and one-half by two inches, and were dark brown in color. The other organs appeared normal. Agar plate cultures were made of the heart, lungs, liver, spleen, kidneys, stomach, large and small intestines, ovaries and uterus. These were incubated for 24 hours in the air at 37 degrees C., with the result that they were all negative of any growth. The dishes were then incubated for three days, Nowak method, to see if the Abortusbacillus, Bang, was present. The results were still negative of any growth. The dishes were then incubated 6 days anærobically with no growth resulting.

Stud No. 3—Cases Nos. 3 and 4.—While the veterinarian who was attending the mares in this stud was away two mares aborted on the 13th of November, 1911. One mare aborted in the 212th day of gestation, and the other in the 242nd day of gestation. The fœtuses were burned. On November 16th,

the veterinarian, at our request, visited this place and inserted small sterile tubes in the uteruses of these mares, secured some of the uterine exudate, holding his finger over the mouth of the tube as it was inserted in the vagina. The lower nine-tenths of this material in the test tube was of a light chocolate color, while the upper one-tenth was a reddish colored serum. Plate cultures of this uterine exudate revealed two organisms, the predominating one being the bacillus before isolated connected with abortion in this stud, and from the fœtus of the aborting jennet.

Sutd No. 3—Case No. 5.—One of the stallions in this stud had had a swollen testicle (orchitis) of a chronic type. On November 16th, the veterinarian disinfected the outer covering of this testicle and opened it with a sterile lance. Some of the discharge was caught in a sterile test tube. Streaks of this material on plain agar revealed a bacillus predominating which produced a green growth on agar, while there were also a number of colonies of the bacillus isolated from the fœtus and afterbirth of aborting mares in this stud.

Stud No. 4—Case No. 1.—On November 18th, 1911, a young mare on this farm showed a slight discharge from the vulva, apparently having aborted. In other ways the mare appeared entirely normal. After a careful search the fœtus was found and buried. At our request it was exhumed, having been buried six hours, and it together with parts of the afterbirth from the mare were brought to the laboratory. The afterbirth was so completely covered with dirt that no attempt was made to make plate cultures from it. The fœtus was about seven and one-third months along in gestation. The ovaries of the fœtus in this case were the only organs to show much change. They appeared very much enlarged, one of which weighed 50 grams. Plate cultures made of the heart, lungs, liver, spleen, kidney, stomach, large and small intestines and ovaries presented no growth on being incubated 24 hours in the air. They were then incubated for three days Nowak method to see if the Abortusbacillus, Bang, was present, at the end of which time there was no growth. There

had been no abortions on this farm during the previous six months.

Stud No. 2—Case No. 2.—On December 12th, 1911, twin male fœtuses from an aborting mare on this farm were sent to the laboratory. Streak dilutions on plain agar were made of the blood of the heart, liver, kidneys, spleen, and testicles, and from the contents of the stomach, large intestines, and small intestines, of each fœtus. These plates were incubated ærobically for 24 hours and then for three days Nowak method, with no growth of any kind. It is generally understood among breeders of horses that a mare will frequently abort twin fœtuses.

Stud No. 5—Case No. 1.—On December 18th, we received a 55 day old embryo from an aborting mare on this farm. This foal was entirely wrapped in the fœtal membranes. Mummification of this fœtus had begun. Plate cultures were made of the fœtal covering and amniotic fluid, with the result that all the plates presented heavy growths of the colon bacillus belonging to Subgroup I, as was obtained in Case No. 1, from this stud. The germ was found to take the stain unevenly as is typical of the colon bacillus of Subgroup I. Litmus lactose bouillon and agar were fermented with acid reaction. Eighty per cent. of gas was produced in glucose bouillon in fifteen hours and seventy-two per cent. in twenty-four hours. It did not ferment one-half per cent. saccharose bouillon. Milk was entirely coagulated in six days' time. The germ was found to be a facultative anærobe, Gram-negative, and did not produce spores. Gelatin was not liquefied, No indol reaction was noted in Dunham's solution on the sixth day. On the tenth day an almost imperceptible pink tint was noted, and a decided indol reaction was produced at the end of twenty days. This decided reaction may have been produced by the fifteenth day but no test at that time was made.

Stud No. 3—Case No. 6.—On December 21st, a male fœtus aborted in the 8th month of gestation was sent to this laboratory. Weight 18 kilos. The fœtus was at once opened up and the liver was found to be very dark and congested in areas. The testicles of this fœtus were very large, one of

which weighed 84 grams. An experienced horseman being present, said that they compared in size to those of a weanling. The large intestine was distended with fecal matter. Streaks of blood from the heart, lungs, liver, testicle, kidney, and the contents of the stomach, large and small intestines were made on plain agar. On 24 hours' incubation at 37 degrees C. it was found that all the plates were densely covered with a pure culture of the same bacillus as was obtained from the fœtus of the aborting jennet and from the previous aborted fœtuses examined from this stud as well as from the uterine exudate of aborting mares of this stud.

Stud No. 2—Case No. 3.—On January 14th, 1912, a fœtus and afterbirth from an aborting mare on this farm were sent to the laboratory. This fœtus was well developed, being haired over. It was opened up at once and the internal organs with the exception of the spleen appeared normal. The spleen appeared very much enlarged, measuring 5 by 7½ inches, and was blue-black in color, and a good many petechiæ were noted on the edges. Stained smears from this organ revealed no organism. A testicle in this instance weighed but 7.8 grams and measured one and one-half by three-quarters inches, a decided contrast to the ones found in Case No. 6, of Stud No. 3. Agar streaks made from the lungs, heart, liver, spleen, stomach, kidney, large intestines, small intestines, testicle and afterbirth presented no growth after being incubated 24 hours ærobically, three days Nowak method, nor after five days' incubation under anærobic conditions.

Stud No. 3—Case No. 7.—On January 18th, 1912, a fœtus was taken from a mare about to abort in this stud. The fœtus was completely haired over. On making an incision in the liver it was found to be congested, soft and spongy. Spleen showed areas of petechiæ, especially along the edge; lymphatic system congested. A few ulcers were found on auricle of heart. Streaks of blood from heart, lungs, spleen, liver, lymphatic system, and ovaries, on plain agar did not produce growth of any kind. Streaks of contents of intestines and stomach were also negative. The plates were incubated in air, Nowak method and anærobically with negative results.

Stud No. 3—Case No. 8.—On January 26th, 1912, we received a male fœtus of an aborting mare in the 8th month of gestation from this stud. The autopsy revealed the following conditions: Minute ulcers on auricle of heart; hemorrhages on ventricle of heart; spleen much enlarged, measuring 7 by 11 inches, weighing 320 grams. Petechiæ were exceedingly numerous on the spleen. The lungs were completely hepatized and covered with hemorrhages measuring 3 to 4 mm. in diameter, and the costal pleura showed similar hemorrhages. Streak dilutions were made as usual from the different internal organs on plain agar, revealed the same bacillus as was obtained from Cases Nos. 1, 2, 3, 4, 5, 6, of this stud, and from the fœtus of the jennet of Stud No. 1. The growth was dense on the plates made from the lungs, lymphatic system, liver, spleen, large and small intestines, stomach, umbilicus, kidneys, and testicles as was also the case of plates streaked with bits of the afterbirth. Streaks made from the heart were negative. A pregnant guinea pig inoculated with 4 c. c. of a sterile water suspension of material taken directly from the stomach, liver, spleen, and kidney, of this fœtus aborted in 24 hours and the germ was obtained from the heart blood and uterus of this pig, but was obtained from no other organs. Plates streaked with bits of the interior of the uterus produced sufficient growth of the bacillus as to completely cover the dishes. The pig had eaten the fœtuses, thus giving no opportunity to determine if the germ could be isolated in them. So far as could be seen the pig showed no other ill effects, than aborting, after being inoculated with this material.

Stud B—Case No. 1.—On February 9th, 1912, we received a fœtus from an aborting mare in the 266th day of gestation from this stud. There are four pregnant mares on this farm and this one is the first to abort. One cow has also aborted of late at this farm. On opening the abdomen the typical odor connected with abortion in mares was strongly noted. The liver was mottled; petechiæ of spleen as noted in former cases; liver showed mottled areas and was very friable; ovaries enlarged with pustules or excresences over left one; heart, ane-

mic. Streak dilutions of the blood of the heart, lungs, liver, spleen, kidneys, ovaries and contents of stomach, large and small intestines, were made on plain agar. The result was that the same germ was obtained on all the plates as was obtained from the fœtus of the jennet and fœtuses of aborting mares of Stud No. 5. On some plates the growth was exceedingly heavy. There was considerable dirt and litter on the afterbirth, therefore a portion of it was first washed with tap water, then with 95 per cent. alcohol, after which it was repeatedly washed with sterile water. Small pieces of it were then cut up finely and streaked over several dishes of agar. A large number of colonies of the same bacillus as was found in the fœtus was obtained from streaks of the afterbirth.

In conclusion, we found with but one exception, a short thick bacillus connected with the fœtal membranes, or in the uteruses of every aborting mare examined in Stud No. 3. The same germ was also isolated from the internal organs of three out of four fœtuses from aborting mares examined from this stud. The same organism was found in the internal organs of the only fœtus examined from a stud of aborting jennets; the same germ was also isolated from the afterbirth and internal organs of the fœtus of an aborting mare from Stud B. This germ, according to our investigations, belongs to Subgroup II or Intermediate Group, of the Colon-typhoid group to which Subgroup belongs such pathogenic organisms as Bacillus enteritidis and Bacillus cholera suis. Taking into consideration that the internal organs of fœtuses of aborting cows examined by us were found sterile when not invaded with the Abortusbacillus, Bang, it is reasonable to suppose that the organism isolated from the fœtuses as well as from the afterbirth of aborting mares, and jenents, has some relation to, if it is not the cause of, infectious abortion of mares in this region. The pathological changes found in the internal organs of fœtuses of aborting mares are much more marked than is the case with the internal organs of fœtuses of aborting cows. This germ is able to produce abortion in pregnant guinea pigs the same as the Abortusbacillus, Bang. Inocula-

tion experiments with larger animals are in progress at this time.

Summary of Bulletin No. 165.

1. A disease known as infectious abortion has been recognized in cows and mares for a long time, both abroad and in the United States.

2. In 1896 Bang and Stribolt of the Royal Veterinary College, Copenhagen, Denmark, isolated a bacterium from the uterine exudate of aborting cows which was capable of producing the disease in that animal. This organism has also been isolated by workers in other European countries and recently in the United States.

3. This laboratory has isolated this germ (Abortusbacillus, Bang) in ten cases from three herds of aborting cows in Kentucky, three of which were from the internal organs of the fœtus.

4. In one instance we secured a growth of this bacillus from the blood of the liver, kidneys, and umbilicus, and from the contents of the stomach and large and small intestines of the fœtus.

5. There were instances in which we were able to find this germ in the afterbirth and stomach of the fœtus, but unable to secure a growth of the organism.

6. Methods of isolation as well as the physiological, morphological and cultural characteristics of this germ, together with illustrations of the same are given in this bulletin.

7. The bacillus causing the disease of infectious abortion in cows has not as yet been isolated from the uterine exudate of aborting mares, by this laboratory, nor as far as we know by any other laboratory.

8. A bacillus belonging to Subgroup II, or Intermediate group, of the Colon-typhoid group (to which subgroup belongs such pathogenic organisms as Bacillus enteritidis and Bacillus cholera suis) has been isolated by this laboratory from the afterbirth, the uteruses and the internal organs of fœtuses, of two studs of aborting mares and one stud of aborting jennets.

9. In two instances the Bacillus coli communis was found in large numbers in the fœtal membranes of mares aborting in the early stages of gestation.

10. The pathological changes in the afterbirth and internal organs of fœtuses of aborting mares are much more marked than is the case with aborting cows.

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All specimens for photographing were prepared by the author. The photos for plates 2, 3, 5, 9, and 10 were taken by E. C. Vaughn, of the Department of Entomology and Botany. Drawings for plates 4 and 8 were made by W. C. Matthews. Drawings for plates 6 and 7 were made by the author. Photos for plates 1, 13, 14, and 16 were taken by T. R. Bryant, and photos for plates 15 and 17, by L. E. Nollau.

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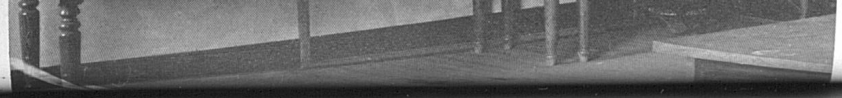
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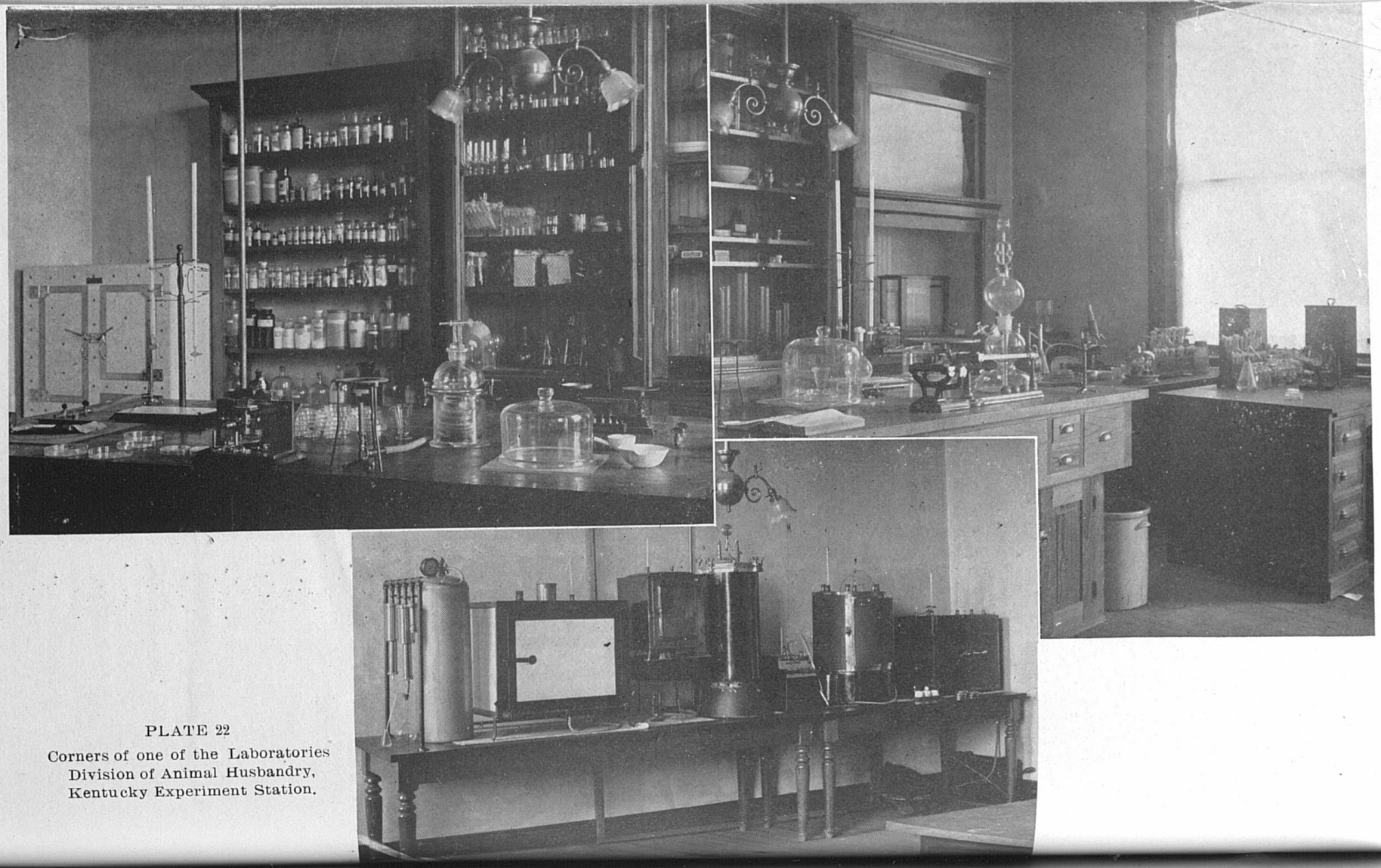


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Division of Animal Husbandry,
Kentucky Experiment Station.

KENTUCKY

Agricultural Experiment Station

OF THE

STATE UNIVERSITY

BULLETIN NO. 166

THE DIAGNOSIS OF INFECTIOUS ABORTION IN CATTLE

LEXINGTON, KENTUCKY
June, 1912
301

Kentucky Agricultural Experiment Station

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Kentucky.

The Diagnosis of Infectious Abortion in Cattle

By Frank M. Surface.

It is safe to say that, with the exception of tuberculosis, there is no single disease which is causing greater loss to our dairymen and cattle breeders than that known as infectious or contagious abortion. There are no statistics available as to the number of calves which are annually lost in this state through abortion. If the total number could be presented it would, without doubt, show a financial loss of many thousands of dollars. This is particularly true in a state like Kentucky, where so large a portion of the animals are of registered stock. Among such cows the calf alone, valued at from fifty to one hundred dollars, or more, at birth, is a serious loss. With grade cows the loss of the calf is but a small portion of the total loss to the owner. In the majority of cases the calf is slipped at such an early period of gestation that the mother produces little or no milk. Further, infectious abortion quite often results in temporary sterility of the cow. In many cases it is only after many months and after many repeated attempts that she will again become pregnant. Again, a cow may slip two or three calves in succession. It is clear that a disease which often deprives an animal of her usefulness for one half or more of the best period of her life is a very serious affliction.

Since the beginning of the nineteenth century it has been believed that much of the abortion among domestic animals was caused by an infectious disease. It was not until 1896, however, that the organism which causes abortion among cattle was discovered. In that year the Danish Veterinarian, Professor Bang, and his assistant, Stribolt, isolated a small bacillus from aborting cows. This organism has now been proven beyond all doubt, to be the cause of infectious abortion among cows.

Owing to certain peculiarities in the method of growth of this bacillus, many of the best bacteriologists of this country failed

to find it for a long time. Recently, however, McNeal* has isolated the same bacillus in Illinois. Professor Good of this Station has just published a bulletin** giving the results of an extended bacteriological study of this organism. He has been able to isolate this bacterium from a number of herds in Kentucky. Recently the same bacillus has been found in several herds in Wisconsin.*** There can no longer be any doubt that the disease in this country is caused by the same organism as that found in Europe.

It must be recognized in the beginning, however, that all abortions are not caused by an infectious disease. Injuries, poor condition of the breeding animals, exposure to severe weather, undue excitement, uterine infection with tuberculosis**** and other causes may result in the casting of the calf. Such abortions are, of course, mainly accidents, and the remedy lies in better methods of management. No serious consequences usually attend such accidental abortions, if the mother receives the proper care. However, the relative number of such abortions is much smaller than is usually supposed. In an extensive investigation in Denmark conducted with modern serum methods Wall† showed that among herds where infectious abortion was already present more than 93% of the abortions were due to this specific organism. Among herds where slips occurred only very rarely, i. e., in herds apparently not infected, he found that 27% of the abortions were nevertheless due, in all probability, to this infectious disease.

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*McNeal, W. J., and Kerr, J. E.:—Bacillus of Bang, the cause of Contagious Abortion in Cattle, Jour. Infect. Diseases, Vol. 7, pp. 469-475, 1910.

McNeal, W. J., and Mumford, H. W.:—Contagious Abortion of Cows. Ill. Agric. Exper. Station, Bulletin No. 152, 1911.

**Good, E. S.:—Investigations on the Etiology of Infectious Abortion of Cows and Mares. Ky. Agric. Exper. Station, Bulletin, 165, 1912.

***Russell, H. L.:—Science, N. S. Vol. XXXIV, p. 494, Oct. 13, 1911.

****It has been shown by McFadyean and Stockman and by Holth that uterine infection with tuberculosis as well as with streptococci may cause abortion.

†Wall, Sven:—On Diagnosticering af infektoes Kastning hos Kvaeget ved Agglutination og Komplementbindung. Maanedsskrift. f. Dyrlaeger XXI, p. 395, 1910.

Also. Uber die Festellung des seuchenhaften Abortus beim Rinde durch Agglutination und Komplementbindung. Zeit. f. Infektionkr. usw. der Haustier. Bd. 10, 1911.

In Germany, Zwick* has emphasized the fact that this disease is much more widely spread than is usually recognized. He believes that the so-called infectious granular vaginitis is itself not a cause of abortion, but that abortions in such cases are due to a separate infection with the abortion germ. From this work, as well as from our own, it is certain that in a great many cases the owner believes the abortion to have been accidental when in reality it has been due to the infectious disease. This is especially true if only a few abortions have occurred in his herd. Proper measures of isolation and disinfection are not carried out and in the following year more abortions occur and the infection becomes firmly established in his herd.

The disease is transmitted from one animal to another in several ways. It is the prevailing opinion among breeders that the infection is transmitted only by the bull. While it is true that the bull plays an important part in the transmission of the disease, this is by no means the only method. Perhaps the next most important means of transmitting the disease is through the mouth and alimentary canal. McFadyean and Stockman** found that outside of intravenous injections, the easiest method of experimentally infecting a cow was by feeding her the infectious material. In stables where infected animals are kept, the bedding and sides of the stalls are certain to become contaminated. The grass in the pastures may contain the living bacilli. In numerous ways it is possible for cows to take the abortion bacilli into the mouth. The infection may also be introduced into the vagina from soiled bedding or from the contaminated stalls. Thus, as is shown in the latter part of this paper (cf. tables 6 and 8) it often happens that a heifer is infected before she has been put to the bull.

The usual course of the disease in a herd is to have one or two abortions the first year. The next year there will be a larger number and about the third or fourth year the disease reaches its height.

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*Zwick: Central f. Bakteriol, usw. Bd. 47, 1 Abt. Ref. (Beilage), 1910.

———Berl. Tierärzt. Woch. Bd. 27, No. 6, pp. 111-112, Feb., 1911.

——— Berl. Tierärzt. Woch. Bd. 27, No. 52, pp. 965-969, Dec., 1911.

**Report of the Committee to inquire into Epizootic Abortion, Part I and appendix, London, 1909.

Often sixty per cent or more of the cows will abort in a single year. Many other calves are born near enough to full term to live for some time at least. Such calves are usually weak and fall an easy prey to the many calf diseases. After the disease has reached its height the number of abortions gradually decreases. Animals which abort once or twice are, in a measure, immune to the disease, for a time at least. It is almost invariably true that after a herd has been badly infected with the disease, nearly all the subsequent abortions occur among the heifers and recently purchased cows. In herds where but little young stock is raised, the disease may practically disappear in a few years.

Another matter which has been brought out by the work of Wall* and Holth** is that many animals may be infected with the abortion organism and yet bear their calves at full term. This apparently curious phenomenon is explained by the fact that *the abortion is really only a symptom of the disease.* As Bang and Stribolt first pointed out the abortion organism causes a catarrhal condition of the walls of the pregnant uterus. Infectious abortion is thus a disease of the uterus. If the diseased area spreads far enough, in all probability, it interrupts the food supply of the foetus.*** In this manner the calf is killed and is later cast out of the uterus the same as any other foreign body. On the other hand, if the inflammation does not proceed far enough to seriously injure the developing calf, the latter will be born at full term and may be perfectly healthy.

Cows which are infected, even though they do not themselves abort are, nevertheless, probably able to spread the infection to other cows. Especially during the periods of heat and after parturition there is always considerable discharge from the vagina.

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*Loc. cit.

**Holth, Halfdan:—Kastningsbacillens Biologi og Immunitetsforholdene ved Sygdommen. Masnedsskrift. for Dyrlaeger. XXII, 1911.

Also, Untersuchungen über die Biologie des Abortusbacillus und die Immunitätsverhältnisse des infektiösen Abortus der Rinder. Zeit. f. Infektions-krankheiten usw. der Haustiere Bd. X, 1911, 94 pp.

***It is, of course, conceivable that the abortion organism might act in some way as the immediate cause of parturition. This seems very improbable. However, we know, as yet, too little regarding the actual cause of normal parturition to speculate upon the immediate cause of the abnormal process, viz., abortion.

In infected cows this discharge will contain the abortion organism. Thus, it is not only cows which have aborted, but also those which are infected, which are a serious menace to the future of a herd.

The purpose of the present bulletin is to present certain methods of diagnosis which have been carefully tested. By the use of these methods it is possible to ascertain which animals in a herd are or have been infected, recently with this disease. It is also possible to ascertain in the case of a cow which has aborted whether the slip was due to infectious abortion or to some other cause. By these methods, it is possible to isolate the infected individuals and especially at the beginning of an outbreak, it will be possible to stamp out the disease. The diagnostic methods referred to are somewhat complicated in their technic and require the use of a well equipped laboratory and considerable experience in carrying them out. This Experiment Station has devoted considerable time to the study of these reactions. We are now prepared to carry out the diagnosis for the farmers and veterinarians of the State, who will send us samples of blood as directed below. (cf. p. 317.)

There are several different methods which have been tried in the diagnosis of abortion. A few of these will be mentioned below. It is also desirable to include a brief statement regarding the symptoms accompanying the disease.

SYMPTOMS.

Infectious abortion is an insidious disease. There are no well marked symptoms. In a majority of cases it is possible to foretell the abortion for a few hours or perhaps a few days. One of the first symptoms to be noticed is the swelling of the udder. In animals which are in the later stages of pregnancy, this may occur three weeks or more before abortion. In many cases, however, no noticeable swelling of this organ occurs. A few days before the actual abortion the vulva often become swollen and somewhat relaxed. More or less mucous may be discharged. In the later stages this often has a yellowish tinge. The animal may become uneasy and move restlessly about and sometimes appears to be in pain. It is clear, of course, that these latter symptoms are simply evidences that the calf is about to be expelled. Exactly the same symptoms occur in cases of accidental abortion.

If the abortion occurs at an early stage of gestation the foetus may be expelled still enclosed in its membranes. In the later stages the membranes are usually retained and are often difficult to remove. These often give rise to metritis and other complications due to retained placenta. Examination of the expelled membranes will often give some clue to the nature of the trouble. If the abortion was due to the infectious disease, a dirty, yellowish, odorless, exudate will usually be found around some of the cotyledons. In cases of sporadic abortion this is usually absent. However, little or no reliance can be placed upon this means of diagnosis.

McFadyean and Stockman, of the English Abortion Committee* found in animals experimentally infected with the disease, that occasionally there was a slight rise in temperature after the infectious material was given. This was not always the case and they decided that "Under natural conditions infection is insidious and that no noticeable symptoms arise until the animal is about to abort."

MICROSCOPICAL EXAMINATION.

It is possible in many cases to determine the presence of abortion bacilli by the microscopical examination of smears from the placental exudate, or from the contents of the foetal alimentary canal. In making this examination a glass slide is smeared very thinly with the material. After gently warming the slide to "fix" the material, it is stained with a solution of methylen blue or of carbol-fuchsin. After washing the slide it is examined under an oil immersion lens. If the abortion bacilli are present in large numbers they can readily be seen. It requires, of course, some experience in observing the organism in order to identify it.

This method is fairly satisfactory and has been used in many laboratories to determine the presence of infectious abortion in a herd. There are, however, several objections to the method. In the first place only positive results are of value. If the abortion bacilli are not found, it is by no means certain that they might

*Board of Agriculture and Fisheries of Great Britain. Report of the Committee appointed to inquire into Epizootic Abortion. Pt. 1. London, 1909.

not be found in some other place on the placenta. We know that often there are only a few areas on the placenta that show the infection. Another very serious objection, especially during the warmer months is, that the material frequently reaches the laboratory in a very bad state of putrifaction. In such cases, the excessive growth of putrifactive germs renders it impossible to identify the abortion bacillus.

BACTERIOLOGICAL EXAMINATION.

A somewhat more satisfactory method of determining the presence of abortion germs is to inoculate appropriate culture media and thus grow the organism in the laboratory. This involves, of course, a considerable amount of time and labor. Methods for successfully growing this organism have been described in many places.* In the writer's experience, the simplest method is to inoculate tubes of serum-agar (10 to 20 per cent. raw, sterile serum) with material from the stomach and intestines of the aborted calf. These tubes are then incubated at 37 degrees C. for seven to ten days. If the bacilli were present in the calf small spherical colonies will appear in the agar about one-half inch below the surface, i. e., at the point where the oxygen pressure is most favorable for their growth. In many cases pure cultures of the organism may be obtained in this way. The manner of growth, i. e., in a narrow zone, about one-half inch below the surface of the agar, is practically specific for this organism. No other organism is known which habitually shows this mode of growth.

The English Abortion Committee reports a case of a strain of tubercile bacilli isolated from the uterus of a cow, which also showed this peculiar mode of growth. Holth obtained streptococci from a uterus which showed a similar growth. Apparently growth within the closed uterus favors the growth of organisms in a diminished pressure of oxygen. After the abortion bacilli have been grown for some generations in the laboratory, they will then grow very well on the surface of the agar.

*cf. Good, E. S., Kentucky Experiment Station Bulletin No. 165, 1912; also English Abortion Committee, Loc cit. and Holth, Zeit. f. Infectkr. d. Haustiere. Bd. 10, 1911.

Occasionally it may happen that the abortion bacilli are present in the stomach contents as shown by microscopical examination, and it will still be impossible to obtain a growth from them. In this laboratory we have several times obtained aborted foeti in which it was possible to demonstrate the presence of abortion bacilli, but from which no growth could be obtained. In some cases both serum-agar tubes and Nowak's* plate method were used. Further, in several cases, serum tests (agglutination and complement fixation) of the mother's blood showed that she had been infected.

One or two possible reasons may be suggested for this peculiarity. First, it may be due to an idiosyncrasy of the particular strain of bacteria. The abortion organism when first isolated is never an easy one to grow under laboratory conditions. It is quite conceivable that some strains might not accommodate themselves to the usual laboratory conditions.

Another possible explanation lies in the possibility of partial immunity. We know that one or two attacks of the disease will confer a measure of immunity upon a cow. It is possible that in the cases described above, there were sufficient immune bodies in the cow's blood to render the bacteria incapable of further growth. In such cases, sufficient immune bodies would have developed too late to prevent the abortion and they would not have been in the blood long enough to bring about the solution or complete destruction of all the bacteria.

In the majority of cases it is possible by the combined microscopical and bacteriological examinations to ascertain whether or not the abortion bacilli are present. It is clear, however, that such methods can only be used after the animal has actually aborted. It offers no opportunity to foretell the abortion or to ascertain which animals are infected, but which may not have aborted.** (cf. p.

*For description of this method see—Nowak, Jules—Ann. Past. Inst. T. 22, pp. 541-557, 1908.
MacNeil and Kerr—Loc. cit.
Good, E. S.—Loc. cit.

**Attempts have been made to diagnose abortion by inserting sterile cotton swabs into the vagina of cows and then examining these microscopically and bacteriologically. This method may be of use shortly before abortion or for some time after the act. At other times the mouth of the uterus is closed so that but few abortion bacilli can be found in the vagina. These are so contaminated with other organisms that it is not possible to identify them.

306.) It is clear that the problem of diagnosis has not been solved until some method has been developed by which it is possible to distinguish the diseased from the healthy animals, without waiting to see if they abort. After the act of abortion such animals have already spread the infectious material about the stables and thus have endangered the healthy animals. Further, it has been pointed out above (cf. pp. 306) that cows may be infected and still bear their calves at normal time. By the above mentioned methods, it is impossible to recognize such individuals. In many herds such infected animals serve to keep the disease alive, when from the number of abortions it would seem to be practically checked. A year or so later it may break out again, even worse than before.

The following pages are devoted to a discussion of several methods by which it is possible to distinguish between animals which are or have been infected, within the year previous.

McFaydean and Stockman were the first to investigate possible methods of diagnosing this disease in animals which had not aborted. At the same time, and independently, Holth* used similar methods in Denmark. The work of Holth and Wall has greatly extended our knowledge of these diagnostic methods. Three methods were proposed by McFaydean and Stockman. These were the use of "abortin," of agglutination and of complement fixation. These may best be discussed separately.

ABORTIN.

Reasoning by analogy with tuberculin and mallein which have been successfully used in the diagnosis of tuberculosis and glanders, McFadyean and Stockman prepared a similar material from the abortion bacteria. The method of making this is described as follows:**

"Rich cultures were obtained by sowing the abortion bacillus in glycerine-broth-serum (heated) plus 1 per cent of grape sugar, and incubating at 37° C. for a month or six weeks. The cultures

*Holth, Halfdan:—Die Agglutination und die Komplementbindungs-methode in der Diagnose des Seuchenenhaften Verwerfens der Kühe. Berl. Tierärzt. Woch. Bd. 25, pp. 686-688, 1909.

**Report of the English Abortion Committee, Part 1, Appendix, p. 34, 1909.

were then sterilized at 99° C. for two hours after which the liquid was filtered through several layers of filter paper or a Berkefeld filter to remove the dead bacilli. One per cent. of carbolic acid or one per 2,000 of corrosive sublimate was then added to the liquid as a preservative if it was to be used shortly after its preparation. When it was to be stored for use at a more or less distant date, it was evaporated in a water bath to one-tenth of its original bulk. This gave a dark syrupy liquid like crude mallein or tuberculin, containing from 40 to 50 per cent. of glycerine. This proportion of glycerine is in itself preservative, but ½ to 1 per cent. of carbolic acid was also added."

This material which they called "Abortin," was then tested on a number of animals. Of these, some had been experimentally infected, others had aborted, and still others were believed to be free from the disease. The abortin was injected both intravenously and subcutaneously in doses of 5 to 10 c. c. of the unevaporated abortin. The intravenous injections were often attended by more or less serious anaphylactic symptoms, and for this reason, could not be used as a practical method of diagnosis. Subcutaneous injections required a larger dose (10 c. c.) to produce a reaction.

McFadyean and Stockman give the detailed report of 37 tests on 30 different animals. In nearly all cases the injection was followed by a rise in temperature in from four to twelve hours. In animals which were stated to be "not infected" the temperature never rose above 103.6° F. In infected animals or those which had aborted, it varied from 104 to 106.8° F. One animal from an infected herd showed a temperature of 107.2° F. after an intravenous injection. It would appear from these data "that a rise of temperature to 104° F. or more, after the injection of 'abortin' may possibly be indicative of infection." However, the difference in the temperature reaction of some non-infected animals (103.6°) and of several of the infected cows (104°) is not sufficient to inspire much confidence in the test. As McFadyean and Stockman realize, the method must be tested upon a large number of animals before it can be relied upon.

In a recent paper from the Veterinary School in Wien, Brüll*

*Brüll, Ziga.—Beitrag zur Diagnostik des infektiösen Abortus des Rindes. Berl. Tierärzt. Woch. Bd. 27, pp. 721-727, 1911.

gives the results of a test of this method. His results are controlled by means of agglutination* tests of the blood of each cow. Brüll tested forty cows with an "abortin" which he prepared from serum—glycerine—bouillon cultures incubated from three to seven weeks and preserved with one per cent. carbolic acid. Subcutaneous injections of 10 to 15 c. c. were given. Seven of the cows tested were healthy controls. None of these agglutinated the abortion bacilli in dilutions higher than 1 to 32.** Likewise none of these cows showed a thermal reaction after the injection of the abortin. In most cases there was a rise above the normal temperature of the cow, of from two-tenths to four-tenths of a degree and in one case of six-tenths of a degree, centigrade. The remaining 33 cows tested by Brüll had either aborted recently, or at least, came from infected herds. In each case the cow's blood was tested for its agglutinating properties before the abortion test. The results of these tests varied widely. In many cases, animals, whose serum showed very high agglutination titre gave only very insignificant thermal reaction. Thus, in one case, the cow had aborted two months previous and her blood showed complete agglutination in a dilution of 1 to 16,000! Yet, the rise in temperature, after the injection of 10 c. c. of abortin, was, at no time, more than six-tenths of a degree, centigrade, above her normal temperature.

Brüll sums up the result of these tests as follows:*** "Of the 16 animals which had aborted before the injection (of the abortin) and whose sera, without exception, showed positive agglutination, only seven reacted to the abortin. The result of the tests on pregnant, infected cows, which also showed positive agglutination, was just as unfavorable. Of 8 such cows, only three showed clear thermal reactions. The investigation has shown that abortin prepared in this way is not suitable as a diagnostic agent."

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*cf. pp. 314-319 of this bulletin.

**On the basis of other experiments he had found that infected cows always showed a higher agglutination titre than 1 to 32.

***The original (Loc. cit. p. 725) reads: "Von 16 Tieren, die vor der Impfung abortiert hatten und deren Sera ausnahmslos positiv aglutinierten, reagierten auf das Abortin nur sieben. Ebenso ungünstig war das Ergebnis der Versuche an trächtigen, kranken Kühen mit gleichfalls positiver Agglutination, da von 8 geimpften nur 3 deutliche thermische Reaktionen zeigten.

Die Untersuchungen haben somit ergeben, dass nach dieser Art bereitetes Abortin für diagnostische Zwecke ungeeignet ist."

It is possible that different methods of making or of administering this substance will be found which will render its use practicable as a diagnostic agent. At the present time, however, it is clear that we must rely upon other methods for accurate diagnosis.

AGGLUTINATION.

In 1896 Widal first used the phenomenon of agglutination for the diagnosis of typhoid fever. He found that when a very small amount of the blood serum of a patient suffering with typhoid fever was added to a culture of the typhoid bacilli the latter soon became motionless, and later became aggregated into irregular masses, whereas the blood of normal persons or of patients suffering from other diseases did not affect the typhoid bacilli. By this reaction it is often possible to make an accurate diagnosis before any of the characteristic symptoms of the disease have appeared.

In later years it has been found that the sera of animals suffering from many other bacterial diseases possess the power of agglutinating cultures of the causitive organism. When an animal has been infected either naturally or experimentally with a certain species or strain of bacteria, the blood of that animal acquires a large number of so-called anti-bodies. One of the varieties of anti-bodies thus formed, is the "agglutinins" which are responsible for the above phenomenon.

In general, the agglutinating action of a serum is specific but this is not always true. Thus, in certain instances, what are believed to be normal sera show slight agglutination with certain kinds of bacteria. Normal sera always show much smaller amounts of agglutinins than the sera of animals infected with the disease. The amount of agglutinins in a given serum is measured by the dilution which the serum will stand and still cause complete agglutination. In some cases, complete agglutination may be obtained by using a dilution as high as 1 to 20,000 or more.

The agglutination test may be carried out in two different ways. (1) The serum may be mixed with the culture in varying proportions and the results observed under the microscope by the hanging drop method. Here the time when the clumping begins

and when the agglutination is complete can be noted in the various dilutions. (2) The serum may be added in varying amounts to test tubes containing a slightly turbid suspension of the bacilli to be tested. These tubes are then incubated and the results observed after some hours. In tubes where agglutination has taken place the bacilli will have clumped together and settled to the bottom, leaving the liquid above water-clear. In the other tubes the liquid will still be uniformly turbid.

The agglutination test for the diagnosis of infectious abortion in cows was probably first used in 1907-1908, by a Danish Veterinarian, Grinstead. His results, however, were not published* until near the end of 1909. Grinstead showed that the blood of cows which had aborted agglutinated the abortion bacilli in higher dilutions than the blood of normal cows. He found that 19 out of 23 cows which aborted gave agglutination with serum doses of 0.013 c. c., to one cubic centimeter of culture. Many of these cows showed agglutination with much smaller amounts of serum.

McFadyean and Stockman** published the first account of the use of agglutination as a diagnostic agent. Very shortly afterwards and working independently, Holth*** also published some preliminary observations on this method. McFadyean and Stockman give the results of seventeen tests on fifteen different cows. Five of these cows were not infected and gave no agglutination in a dilution as high as 1 to 25. The remaining twelve cows had been experimentally infected and with the exception of one cow all showed agglutination in dilutions higher than 1 to 25. In most cases agglutination occurred in dilutions as high as 1 to 100. On the basis of these rather meager data, they conclude (p. 28) that "Having regard to what has been the experience in other diseases for which the test has been extensively used, the difference between the agglutinating power of the serum of a cow affected with abortion, and that of some normal animals, is too slight to inspire confidence in the test."

*Maandsskr. fr. Drylaege. 1909, p. 395.
cf. also Berl. Tierärzt. Woch. 1909, p. 931, Referat.
And Deut. Tierärzt. Woch. 1910, p. 312.

**Report of the Departmental Committee to inquire into Epizootic Abortion. Pt. 1 and Appendix, London, 1909.

***Berl. Tierärzt. Woch. Bd. 25, pp. 686-688, 1909.

Holth's preliminary account reported tests on thirty-nine cows which had aborted and seven normal heifers and cows. None of the latter showed any agglutination, while thirty-seven of the aborting cows showed the agglutinating reaction in dilutions of 1 to 100, one in a dilution of only 1 to 50 and one other showed no agglutination.

The work thus begun by Holth was greatly extended under his direction by Wall.* Wall examined the sera of eleven hundred cows with both agglutination and complement fixation (cf. p. 319). He has shown that the agglutination test alone is a reliable method of diagnosis but that it is subject to a larger error than the complement fixation test.

Wall tested the specificity of the agglutination reaction by using a number of different kinds of immune sera with the abortion antigen. Of 26 different sera tested, three agglutinated the abortion bacilli in dilutions of 1 to 20 and two others in dilutions of 1 to 50. The remaining 21 sera showed no trace of agglutination. On the other hand abortion immune serum gave complete agglutination in a dilution of 1 to 2,000. A similar result was obtained by using cultures of different bacteria with abortion immune serum.

Other papers dealing with the agglutination test in the diagnosis of abortion are by Zwick** and by Brüll.*** Brüll concludes that agglutination offers a reliable method of diagnosis. He found that cows not infected with the abortion germ might agglutinate the bacillus in dilutions up to 1 to 32, but not higher. Blood of infected cows showed agglutination in dilutions of from 1 to 120 up to 1 to 16,000. Out of 190 cows tested there were only 6 in which the diagnosis was doubtful.

The writer has tested the agglutination reaction upon a large number of cows and has found it reliable in most cases. The results of a number of these tests are given in tables 6-10 (pp. 344-353).

The technic of the agglutination test for abortion, as used in this laboratory is as follows: The antigen or test fluid is prepared

*Loc. cit.

**Zwick—Central. f. Bakter. usw. (Beilage), 1910.

***Brüll, Ziga.—Beitrag. zur Diagnostik des infektiösen Abortus des Rindes. Berl. Tierärzt. Woch. Bd. 27, pp. 723-727, 1911.

from a bouillon culture of the abortion bacilli incubated at 37° C. for three weeks. For this purpose only cultures which have been grown in the laboratory for some generations and are thus able to grow under the atmospheric pressure of oxygen, are used. The culture is killed by heating to 70-75° C. for one or two hours. After this it is centrifuged until the bouillon is clear. The latter is pipetted off and its volume replaced with sterile salt solution (0.9 per cent.). One-half per cent. carbolic acid and one per cent glycerine is then added and the fluid is ready for use. It should have a distinctly turbid or milky appearance due to the suspended bacilli. Since the bacilli tend to settle on standing, it should be thoroughly shaken before using.

The titre of each new flask of test fluid is determined by using an immune abortion serum. The titre of the new fluid is then adjusted so that it is the same as a standard solution which is known to give good results. In this way the results of all tests are directly comparable.

The blood from the cows to be tested is easiest obtained from the jugular vein. To do this, one assistant firmly grasps the animal by the horns, or by the nose and one horn, to prevent her striking the operator. A second assistant passes a rope about the base of the cow's neck and draws it tight. In this manner, the jugular veins lying on either side of the wind pipe are made to stand out prominently. The operator then inserts a large hypodermic needle through the skin and into the vein. The blood is allowed to flow into a small vial. This should not be filled more than half full and the vial placed in a slanting position until the blood is firmly clotted. In this way it yields much more serum than if allowed to clot in a perpendicular position.

The needle for drawing the blood should be sterilized at the beginning, but the same needle may be used for a number of different cows if it is thoroughly washed out each time by forcing clean water through it. All traces of blood must be removed. It is not necessary to shave or disinfect the neck of the cow. The writer has drawn several hundred samples of blood in this manner and has never observed the slightest infection. Five c. c. (about one tablespoonful) of blood will yield sufficient serum for these

tests if allowed to clot as described above. The blood is allowed to clot over night. If sufficient serum has not separated the vials are centrifuged for twenty minutes at 2,000 revolutions per minute. The serum is then used directly from the vials.

In the routine examinations five tubes* are used for each cow. The serum is placed in these tubes in the following amounts: 0.05; 0.02; 0.01; 0.005; and 0.002 c. c. These amounts of serum are measured by means of a one-tenth c. c. pipette graduated in hundredths of a c. c. The first tube (0.05 c. c. serum) is measured directly from the serum. The remaining four tubes are measured from a one to ten dilution. If blood from more than one cow is to be tested the pipette must be thoroughly cleaned between each sample. This is accomplished by first washing in running tap water. Next it is rinsed in boiling water and this drawn through the pipette several times. The pipette is then cooled and rinsed in sterile salt solution. This precaution is necessary in order to avoid carrying over particles of serum to the next test.

After the serum has been placed in all the tubes, one cubic centimeter of the test fluid is added to each. The tubes are all well shaken and incubated at 37° C. for six hours. After this, they are placed in the refrigerator (+ 9° C.) over night and the results recorded the following morning.

The dilutions of the serum thus obtained are approximately 1 to 20; 1 to 50; 1 to 100; 1 to 200; and 1 to 500. It will be noted that these dilutions are not exact, since one c. c. of the fluid is added to each tube regardless of the amount of the serum previously added. However, Wall has pointed out, and the writer has verified his results, that the amount of serum, and *not* the dilution (within certain limits) is the important thing in such agglutination tests. For example in the above series we can add one-half or one c. c. of sterile salt solution, to each tube and still obtain the same result as before. In routine examinations the above technic is much simpler than to attempt to make each dilution exact. Further, exactly the same procedure is carried out in each test so that, in any case, the results are comparable.

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*Since it requires some hours for complete agglutination to occur, the microscopic method is not practicable with the abortion bacilli.

In recording the results of the agglutination test, if the last tube, containing 0.002 c. c. of serum, shows complete agglutination the titre of the serum is said to be less than 0.002 (<0.002). If the last tube of the series shows very nearly complete agglutination the titre is recorded as equal to 0.002 (=0.002). If the last tube shows no agglutination or only very slight traces while the next to the last tube shows complete clumping, the titre is equal to 0.005. In this way it is possible to obtain a very close approximation to the agglutinating titre of a given serum.

Further discussion of the results and reliability of this test are deferred until a later section of this paper. (cf. pp. 357-359.)

FIXATION OF COMPLEMENT.

The phenomenon of the fixation of complement has become widely known in recent years through its application to the diagnosis of Syphilis by Wasserman and his collaborators.* After the demonstration of its specificity in this disease it has been successfully applied to the diagnosis of many other bacterial diseases. It is only in recent years that it has been introduced into veterinary science. In veterinary circles, it is probably best known in the diagnosis of glanders.**

The complement fixation reaction is undoubtedly one of the most delicate and specific of known biological reactions. The technic of the test is somewhat complicated and requires some experience in order to successfully use it. When conducted with proper care in the titration of all reagents, the reaction is perfectly specific and accurate. In the following pages the writer has attempted to give as simple a description of the principles and technic of this reaction as the available space and the nature of the subject will permit.

The complement fixation reaction is based upon two closely related phenomena, viz., Haemolysis and Bacteriolysis. Haemolysis refers to the solution of red blood corpuscles, while bacteriolysis is concerned with a similar solution or destruction of bacteria.

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*Wassermann, Neisser and Bruck—Deutsche Med. Woch. 1906, pp. 745.

**For work done in this country cf. Mohler and Eichhorn—The Diagnosis of Glanders by Complement Fixation. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin No. 136, 1911.

HAEMOLYSIS.

The phenomenon of haemolysis was first discovered by the French investigators, Bordet and Gengou. Our knowledge of this subject has since been greatly extended by Ehrlich, Morgenroth, Sachs, and many others.

It is only in exceptional cases that the blood serum of a normal animal is able to dissolve the red blood corpuscles of another species of animal. Bordet and Gengou found, however, that if an animal is first injected with the red corpuscles from a different species of animal the blood serum of the injected animal will then be able to dissolve the corpuscles of the second species. In other words, the one animal is immunized against the corpuscles of the other. If a small amount of the fresh serum of the immunized animal is added to a suspension of the corpuscles in a test tube, these corpuscles rapidly dissolve, leaving the liquid a bright red.

It was further found that if this immune or haemolytic serum is allowed to stand for several days, or if it is heated to 56° C. for one-half to three-quarters of an hour, it then loses its ability to dissolve corpuscles. It is said to be inactivated. However, if a small quantity of fresh serum from any normal animal is added to this heated haemolytic serum, it will again acquire the property of dissolving the corpuscles.

From this it is evident that there are two substances contained in the haemolytic serum. One of these is destroyed by standing or by heating to 56° C. This thermo-labile substance is further found in the serum of practically all normal animals, for when any fresh serum is added to the heated (inactivated) haemolytic serum the latter acquires all of its former properties. This thermo-labile substance has been given several names, but is most commonly known as the *Complement*.

The second substance contained in the haemolytic serum is not destroyed by heating to 56° C. It is thus said to be thermo-stabile. It is this substance which is added to the serum by the immunizing process, i. e., by injecting the red corpuscles of another animal. This substance is most usually known as the immune body or the *amboceptor*.

An example will aid in understanding this phenomenon. If

we inject a rabbit with the washed red corpuscles of a sheep, the rabbit's serum soon acquires the property of dissolving sheep's corpuscles. If a little of this fresh rabbit's serum is added to a test tube containing a suspension of sheep's corpuscles, the corpuscles will dissolve, setting free the contained haemoglobin. The liquid in the tube will become a bright red. Now, if the rabbit's serum is inactivated by heating to 56° C. for one-half hour, it will no longer dissolve the sheep's corpuscles. In a tube prepared as above, but with the *inactivated* rabbit's serum, the corpuscles will not dissolve, but will settle to the bottom on standing, leaving the fluid above, water clear. If now, in a third tube containing the suspension of sheep's corpuscles, we place a little of the inactivated rabbit's serum, and a little fresh serum from a normal animal, e. g., a guinea pig, then the corpuscles *will dissolve*. However, if only the guinea pig's serum and none of the rabbit's serum is added, the corpuscles will not dissolve. Further, if a suspension of any other kind of corpuscles than sheep's had been used in the above tubes, no solution would have taken place.

We may summarize the above facts as follows: The serum of all normal animals contains a thermo-labile substance known as the *complement*. This substance is necessary in order for haemolysis to take place but it will not cause haemolysis by itself. The second substance necessary to bring about haemolysis is produced by injecting some animal with the kind of corpuscles which it is later desired to dissolve. This second substance is thermostabile, and may be known as the *amboceptor*. This substance alone will not cause haemolysis but in the presence of complement it will dissolve the corresponding kind of corpuscles. It thus appears to act as a connecting link between the complement and the corpuscle and allows the former to act.

The following schematic representation of these facts as interpreted by Ehrlichs theory will aid in remembering the essential details of this process.

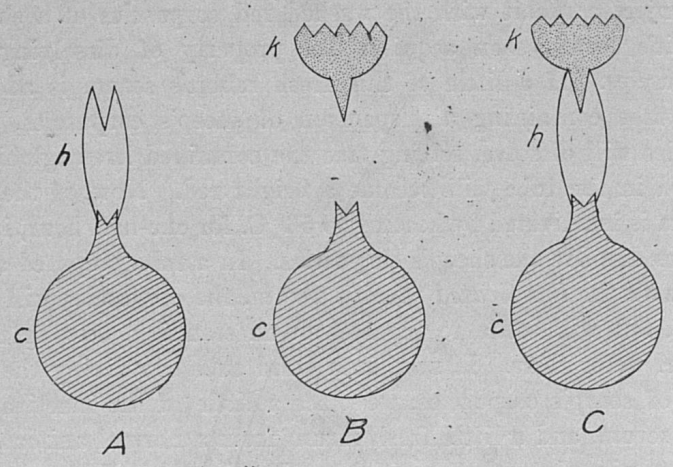


Figure 1—A.—Shows the red corpuscle *c*, united with the haemolytic amboceptor, *h*. No complement is present, hence there is no haemolysis. B.—Shows the presence of the corpuscle *e* and complement *k*, but no amboceptor. No haemolysis. C.—represents the corpuscle *c*, amboceptor *h* and complement *k*. Here the haemolytic chain is complete and haemolysis will take place.

BACTERIOLYSIS.

Bacteriolysis, as the name implies, refers to the solution or destruction of bacteria. In all respects it is a parallel phenomenon to haemolysis. If a guinea-pig is injected with a culture of bacteria, for example, the vibrios of Asiatic cholera, then this guinea pig's blood will be able to dissolve cholera vibrios. The animal is thus immune, in a measure at least, to Asiatic cholera. The destruction of the bacteria will take place either inside the animal's body (in vivum), or outside, as in a test tube (in vitro).

Just as in haemolysis two different substances are necessary to produce the bacteriolysis, viz., the complement and the amboceptor. Many experiments have further shown that the complement necessary for bacteriolysis is the same as that necessary for haemolysis. The amboceptor, on the other hand, is entirely specific. Haemolytic amboceptors immune to sheep's corpuscles, will dissolve only sheep's corpuscles, and no other kind. Likewise, bacteriolytic amboceptors will destroy only the specific kind of bacteria which were inoculated into the animal.

Not only animals which are inoculated with a given kind of

bacteria, but also animals suffering from a bacterial disease contain amboceptors in their blood. These, as stated above, are always specific. Thus, an animal affected with contagious abortion will have abortion amboceptors in her blood. After the disease is cured these amboceptors are gradually eliminated from the blood. In many diseases, however, they persist for long periods of time. We may use a diagram similar to Figure 1, to illustrate bacteriolysis. In Figure 2, the red blood corpuscle of Figure 1, is replaced by a bacterium (a) and the corresponding bacteriolytic amboceptor (b) replaces the haemolytic amboceptor of Figure 1. In each case the complement (k) is the same.

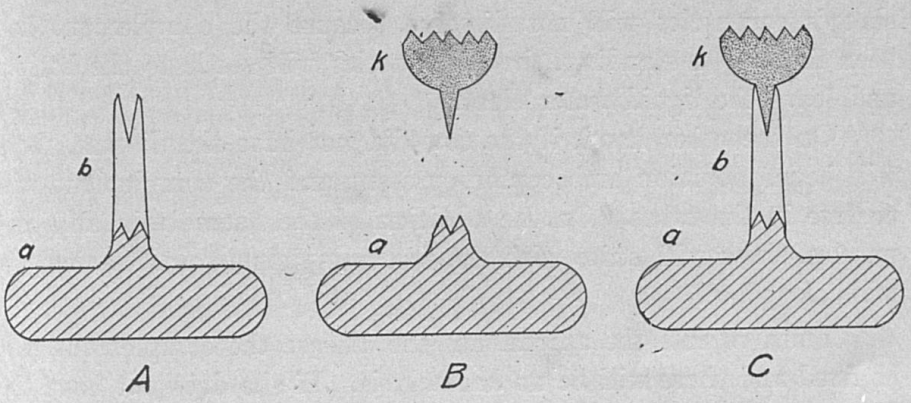


Figure 2—A.—Shows the bacterium (a) anchored by its amboceptor (b) but no complement is present. No bacteriolysis. B.—shows the complement (k) with the bacteria but no amboceptor to unite them. At C. all three elements, complement (k), amboceptor (b) and the bacterial cell (a) are present. Here bacteriolysis will take place.

THE COMPLEMENT FIXATION TEST.

The complement fixation reaction is a test for the presence of these immune bacteriolytic amboceptors in the serum of an animal. The principle of the test is contained in the fact that the complement necessary for haemolysis is the same as that necessary for bacteriolysis. Thus, we first determine just how much complement (fresh guinea pig's serum)* is necessary to cause complete haemoly-

*Experiments have shown that guinea pig's serum furnishes the best complement for this reaction. The serum of many other kinds of animals might be used for this purpose.

sis with a known amount of sheep's corpuscles, and the necessary rabbit's haemolysin. Now we add this amount of complement to a test tube containing a little of the serum of the animal to be tested and a suspension of the bacteria. In the case of abortion we would use the serum of a suspected cow and a suspension of the abortion bacilli. If the cow's serum has abortion amboceptors in it, these will unite with the bacteria and the complement. In this union *all* of the complement in the tube will be used. After this mixture has stood long enough for the reaction to take place, a little of the inactivated rabbit's serum (haemolysin) is added, and also some of the sheep's corpuscles. Now if the cow had the disease, all of the complement will have been used up in the first part of this reaction and none left in the tubes. Consequently the sheep's corpuscles will not dissolve because the complement had been fixed. On standing, these corpuscles will settle to the bottom and leave the liquid water clear.

On the other hand, if the cow did not have the disease, there will be no abortion amboceptors present and the complement will be free in the tubes. On the addition of the haemolysin and corpuscles, these will unite with the free complement and haemolysis will take place.

Thus, in case the animal has the disease the complement will be fixed and there will be no haemolysis. If she does not have the disease, the complement is not fixed and haemolysis *will take place.*

The reaction thus takes place in two parts: First, the bacteriolytic system is placed in the tubes. This consists of complement (k); blood of the suspected animal, which may contain the specific amboceptors (b) and the bacterial suspension (a) (cf. A. Figures 3 and 4). After these reagents have had time to act, the haemolytic amboceptors (h) (rabbit's serum) and the sheep's corpuscles (c) are added (cf. B, Figures 3 and 4.)

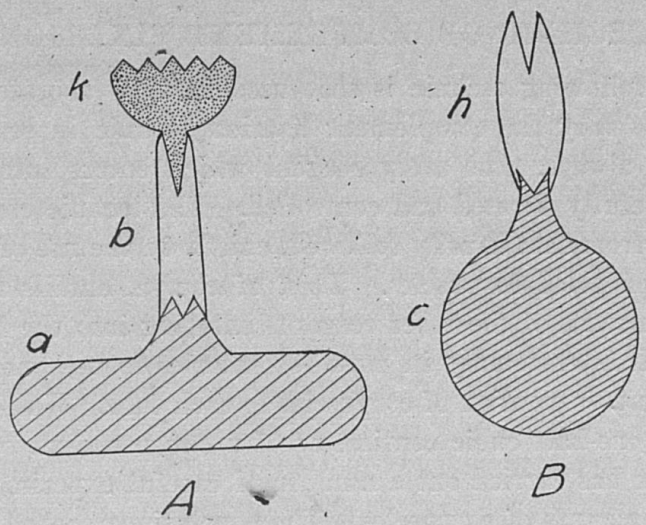


Figure 3—Schematic representation of the complement fixation reaction with an infected cow. A. represents the first part of the reaction. Here the bacterium *a* is united to the bacteriolytic amboceptor *b* contained in the cow's blood. These two have anchored the complement *k*. The bacteriolytic chain is thus complete. At B. the haemolytic amboceptors (rabbit's serum) and the sheep's corpuscles have been added but all the complement was used in the first part of the reaction. Consequently, the corpuscles will not dissolve. (Cf. Figure 5.)

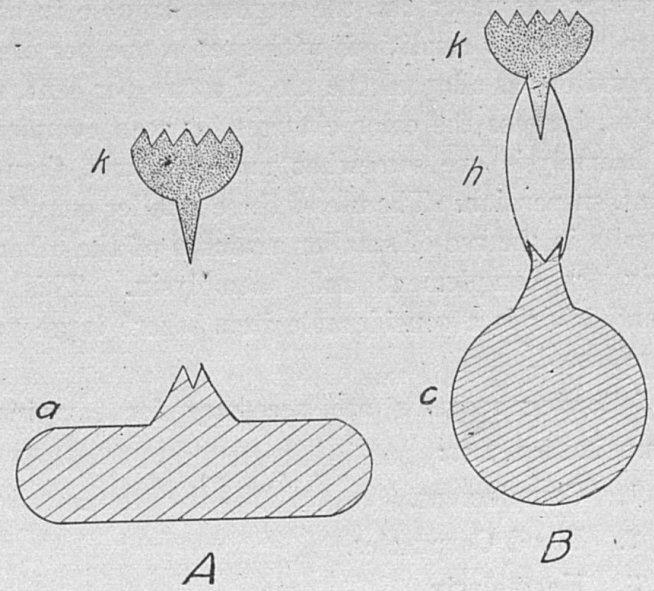


Figure 4—Schematic representation of the complement fixation reaction with an uninfected cow. Since there are no bacteriolytic amboceptors present in A, the complement *k* cannot act on the bacterium *a*. When the haemolysin *h* and the sheep's corpuscles, *c*, are added, these unite with the free complement as at B and haemolysis takes place. (cf. Figure 6.)

TECHNIC OF COMPLEMENT FIXATION.

The following technic is that used in this laboratory. It is possible to vary the complement fixation technic in several ways providing always, that every reagent which enters into the final test is carefully titrated and controlled. The technic employed by us differs from that usually followed, chiefly in the use of a smaller quantity of blood corpuscles. This, of course, entails the use of smaller amounts of the other reagents entering into the haemolytic system. It is customary in most laboratories to use one c. c. of a five per cent. suspension of corpuscles to each tube. Wall (loc. cit.) uses only one-half cubic centimeter of a *one* per cent. suspension. The writer has carried out a number of careful experiments using different amounts of corpuscles. The conclusion reached is that so long as all reagents are carefully titrated with the given amount of corpuscles the results are just as accurate and trustworthy in one case as in the other. The greater the mass of corpuscles, the more striking is the difference in the appearance of the tubes showing haemolysis and those showing fixation of the complement. However, the writer has never had the slightest trouble in distinguishing between these two conditions with even a one per cent. suspension. The writer has adopted the use of a two per cent. suspension of corpuscles, because the color changes between complete and incomplete haemolysis are somewhat more distinct than with the one per cent. suspension. The use of these smaller quantities of corpuscles results in the use of smaller amounts of the other reagents, particularly the complement and haemolysin. This saving in material and labor is a considerable item where large numbers of animals are tested.

The following reagents are necessary for carrying out the complement fixation test:

1. Complement.
2. Blood Corpuscles.
3. Haemolysin.
4. Antigen (Bacterial Suspension).
5. Blood of suspected animal.
6. Sterile physiological salt solution (0.9%).

COMPLEMENT.

The complement is obtained from guinea pigs. In bleeding the guinea pig, the hair about the throat is first clipped and the throat washed. The animal may then be chloroformed but this must be done rapidly and only sufficient chloroform given to make the animal insensible to the first cut. Too much chloroform will injure the complement content of the blood. The jugular veins on both sides are then severed and the blood collected in a sterile 50 c. c. centrifuge tube. The blood is then placed in the incubator at 37° C. for an hour when it is firmly clotted. It may then either be centrifuged at once or placed in the ice chest to allow the serum to separate from the clot. The serum is then pipetted off and mixed with two times its volume of sterile salt solution (0.9%). It is then ready to be titrated (cf. p. 329). If placed on ice at a temperature of about + 6° C. the complement may be used for four or five days. It gradually loses strength, however, and it is necessary to retitrate it every day.

BLOOD CORPUSCLES.

The blood is drawn from the jugular vein of a sheep with a canula or a large hypodermic needle. The blood is allowed to flow into a sterile bottle containing glass beads. The bottle must be shaken for several minutes in order to defibrinate the blood. The blood is then strained through sterile cotton into 50 c. c. centrifuge tubes. It is centrifuged for 15 minutes at 4,000 to 5,000 revolutions per minute. The super-natant serum is pipetted off and its volume replaced with sterile salt solution and thoroughly mixed with the corpuscles. The tubes are again centrifuged and the fluid removed. This washing must be repeated at least three times, until all traces of the serum have been removed. After the salt solution has been removed the last time, a two per cent. suspension of the corpuscles is prepared for use in the titrations and the test proper. (cf. pp. 329-340.) Such a suspension of corpuscles if kept on ice may be used for four or five days with equally good results. The remainder of the corpuscles may be used to inject the rabbit for haemolysin.

HAEMOLYSIN.

Washed sheep's corpuscles prepared as above and mixed with an equal volume of salt solution, are injected into the peritoneal cavity of a full grown, healthy rabbit. This injection must be repeated three or four times at intervals of a week or ten days. The amount of the centrifuged corpuscles should be increased with each dose. It is best to start with about 6 or 8 c. c. of the corpuscles and increase this to 10 or 12 in the following injections.

Ten days after the last injection a little blood should be drawn from the rabbit's ear vein and the serum titrated (cf. p. 331) for its haemolytic power. If the titre is 0.001 c. c. (0.05 c. c. of a 1 to 50 dilution) the rabbit may be killed and the serum collected. The rabbit may be chloroformed and bled from the jugular veins. After clotting the blood should be centrifuged and the serum pipetted into small vials. One-half of one per cent. of carbolic acid should be added to the serum as a preservative. If the rabbit's serum is to be used before it is ten days old it should be inactivated by heating to 56° C. for one-half hour. If placed in the ice chest, haemolytic serum, preserved as above, may be kept for many months without losing its strength.

ANTIGEN.

The antigen is a suspension of the abortion bacteria. This is prepared from a bouillon or serum bouillon culture grown in the incubator at 37° C. for two to three weeks. The bacteria are then killed by heating at 75° C. for one or two hours. One-half per cent. carbolic acid and one per cent. glycerine is then added and the suspension titrated (cf. p. 333) with an immune serum of known strength. The titre of each new flask of antigen is adjusted to correspond with a standard antigen. By adding either salt solution or more bacteria it is very easy to obtain the desired titre. If kept in the ice chest the antigen will maintain its strength for many months.

The blood from the cows to be tested is drawn from the jugular vein by the method described on page 317. A little of the serum is poured into small test tubes and inactivated by heating in a water bath at 56° C. for one-half hour. This inactivation is necessary in order to destroy the complement normally present in the cow's blood.

The remaining reagent, viz., physiological salt solution is necessary to give the proper volume to the different tubes. This is prepared from chemically pure sodium chloride in the strength of 0.9 per cent. After the salt is dissolved the solution is placed in small bottles (200 c. c.) and sterilized by steaming for twenty minutes.

TITRATION OF REAGENTS.

It is of the utmost importance that all reagents entering into the final complement fixation test should be carefully titrated and controlled. Slight errors in titration may give entirely erroneous results in the final tests.

TITRATION OF THE COMPLEMENT.

As noted above, the guinea pig serum is first mixed with two times its volume of physiological salt solution. This mixture is then titrated in order to find the smallest amount which will cause complete haemolysis of a known amount of corpuscles mixed with sufficient inactivated haemolysin (rabbit's serum). The sera of different guinea pigs differ considerably in their amount of complement. It is absolutely necessary that the serum of every guinea pig should be titrated before using. With one titration any number of tests can be conducted during the next twenty-four hours. If tests are to be made more than twenty-four hours after the last titration, the complement should be retitrated. There is always a gradual loss of complement and sometimes there will be a sudden drop in the titre, even when the serum is kept under the best of conditions.

The following table, which gives a sample titration of a complement mixture will illustrate the method.

TABLE 1.

Titration of Complement.

Tube No.	NaCl. Solution 0.9%	Complement. (Diluted 1—3)	Haemolysin. (Diluted 1—50)	Sheep's Corpuscles. 2%		Result.
					Incubated 1 hour at 37°C.	
1	c. c. 1.5*	c. c. 0.01	c. c 0.25	c. c. 0.5		No haemolysis.
2	"	0.02	"	"		Slight haemolysis.
3	"	0.03	"	"		Complete "
4	"	0.04	"	"		" "
5	"	0.05	"	"		" "
6	"	0.06	"	"		" "
7	"	0.07	"	"		" "
8	"	0.08	"	"		" "
9**	"	0.08	.....	"		No haemolysis.

*It will be noted in this and the following tables that no attempt is made to make the volume in the different tubes exactly equal. The effect of increasing the dilution is to lengthen the time necessary for the reaction to take place. Within the narrow limits exhibited in these tables no noticeable difference results from the variation in dilution.

**Tube No. 9 is a control without haemolysin. This is to make certain that the guinea pig's blood alone will not dissolve the sheep's corpuscles.

Thus, in the above example the titre of the complement is 0.03 c. c. of the dilution 1 to 3. This is the smallest amount of complement which will completely dissolve 0.5 c. c. of the two per cent. sheep's corpuscles. In the actual test, it is necessary to use a little more complement than the exact titre. This is due to the fact that the antigen itself absorbs a small amount of the complement. Consequently we always add one and one-half times the titre of the complement to each tube in the test (cf. pp. 339-340). Thus, in the above example, the complement "dose" for each tube in the actual test would be 1.5 x 0.03 c. c. = 0.045 c. c. With this amount, we are certain to have enough complement, but not too much to be "fixed" if the antibodies are present in the cow's serum.

TITRATION OF THE HAEMOLYSIN.

It is necessary to titrate the haemolytic rabbit serum in order to establish the smallest quantity which will produce complete haemolysis with a known amount of blood corpuscles and a sufficient quantity of complement. In titrating the haemolysin it is first diluted with salt solution in the proportion of one cubic centimeter of the rabbit's serum to fifty cubic centimeter's of salt solution. No more haemolysin is diluted at one time than will be used within the next few days. A fresh mixture should be prepared and titrated at least each week.

The following table gives a sample titration of the haemolytic serum:

TABLE 2.

Titration of Haemolysin.

Tube No.	NaCl. Solution 0.9%	Complement. (Diluted 1—3)	Haemolysin. (Diluted 1—50)	Sheep's Corpuscles. 2%	Incubated 1 hour at 37°C.	Result.
	c. c.	c. c.	c. c.	c. c.		
1	1.5	0.045*	0.01	0.5		No haemolysis.
2	"	"	0.03	"		Partial haemolysis.
3	"	"	0.05	"		Complete "
4	"	"	0.08	"		" "
5	"	"	0.1	"		" "
6	"	"	0.15	"		" "
7	"	"	0.2	"		" "
8	"	"	0.3	"		" "
9	"	"	0.5	"		" "
10	"	.....	0.3	"		No haemolysis.

*In this case the complement had the titre of 0.03 c. c. (cf. Table 1). The dose used is 1.5 times the titre or 0.045 c. c.

In the above example the titre of the haemolysin mixture is 0.05 c. c. since this is the smallest amount which will give complete haemolysis. Tubes Nos. 7, 8 and 9 are controls to make certain that large doses of the haemolysin alone will not interfere with the action of the complement. Tube 10 is a control to show that the haemolysin alone will not dissolve the corpuscles. If the rabbit's serum has been properly inactivated, tube 10 will not show haemolysis.

In the complement fixation test proper (cf. p. 336) it is better to have an excess of haemolytic amboceptors as the reaction will then take place more rapidly. In our work, we have adopted the custom of using five times the titre. Thus, in the above example we would use 5 x 0.05 c. c. = 0.25 c. c. of the haemolysin dilution, to each tube in the actual test. The control tubes in the above table have shown that twice this amount, viz., 0.5 c. c. will not interfere with the complement action. We are thus safe in using so large a dose.

TITRATION OF THE ANTIGEN.

It is of the utmost importance that every flask of antigen should be carefully titrated before it is used in a complement fixation test. In titrating the antigen, it is necessary to establish two limits. First, it is necessary to know the smallest amount of antigen which will give complete fixation of the complement when used *with* the proper dose of an immune serum. Second, it is necessary to establish the smallest quantity of antigen which will prevent haemolysis *without* the use of an immune serum. The proper "dose" for the tubes in the actual test must lie between these two limits.

It is further necessary to have each flask of antigen of the same titre, otherwise successive tests would not be exactly comparable. If we use too weak an antigen there will be no fixation of the complement with a weak serum. Such a serum, however, would show a reaction with antigen of the proper strength. On the other hand if the antigen is too strong it will show fixation with certain sera which give no reaction with an antigen of the proper strength.

In titrating the antigen it is first necessary to have an immune serum of known strength. The immune serum which we use, is

obtained by injecting a rabbit with a living abortion culture. Two or more intraperitoneal injections of 4 c. c. of culture are given the rabbit at intervals of ten days. The blood is then tested and if it is of the proper strength, the rabbit is bled and the serum preserved with one-half per cent. carbolic acid. The titre of the immune serum with 0.25 c. c. of the standard antigen should be at least 0.001 or 0.002 c. c. That is, these are the smallest amounts which show a complete fixation of the complement. If the titre of the immune serum is 0.002 c. c. the dose to be used in titrating the antigen would be 0.01 c. c. or five times the titre.

The following table gives the results of titrating a sample of antigen of the proper strength.

TABLE 3.

TABLE 3.

Titration of Antigen.

Tube No.	Immune Abortion Serum. (Titre 0.002.)	NaCl. 0.9%.	Complement. (Diluted 1 to 3. Titre 0.04.)	Antigen.	Incubated 1 hr. at 37°C. Haemolysin. (Diluted 1 to 50.)	Sheep's Corpuscles. 2%.	Incubated 2 hrs. at 37°C. Results.
	c.c.	c.c.	c.c.	c.c.	c. c.	c. c.	
1	0.01	1.5	0.06	0.01	0.25	0.5	Complete haemolysis.
2	"	"	"	0.03	"	"	Partial "
3	"	"	"	0.05	"	"	No "
4	"	"	"	0.08	"	"	" "
5	"	"	"	0.1	"	"	" "
6	"	"	"	0.2	"	"	" "
7	.....	"	"	0.05	"	"	Complete haemolysis.
8	.....	"	"	0.1	"	"	" "
9	.....	"	"	0.2	"	"	" "
10	.....	"	"	0.3	"	"	" "
11	.....	"	"	0.4	"	"	" "
12	.....	"	"	0.5	"	"	" "
13	.....	"	"	0.6	"	"	Nearly complete.
14	.....	"	"	0.8	"	"	No haemolysis.

In the above table tubes 1 to 6 inclusive contain 0.01 c. c. of the immune serum and varying amounts of the antigen to be tested. The titre of the antigen is 0.05 c. c. as this is the smallest amount which will cause fixation of the complement and thus prevent haemolysis.

Tubes 7 to 14 inclusive contain varying amounts of antigen but no immune serum. Here, there is practically complete haemolysis in all tubes except number 14. In this tube with 0.8 c. c. of antigen, the complement has been absorbed without the presence of the specific amboceptors.

The dose of antigen for use in the actual tests is taken as five times the titre or 5 x 0.05 c. c. = 0.25 c. c. Since twice this amount, or 0.5 c. c. of the antigen does not cause fixation without the serum we are safe in using such a dose.

If properly preserved with carbolic acid and kept in the ice chest the antigen may be used for many months without any change in its titre. In using the antigen a sufficient quantity should be poured into a test tube and any that remains should be thrown away. This avoids carrying any substances back into the flask which might interfere with future tests.

THE COMPLEMENT FIXATION TEST IN INFECTIOUS ABORTION.

All the reagents entering into the actual complement fixation test have now been titrated. With each set of tests it is further necessary to run a number of control tubes to be sure that all reagents are working as they should. After the reagents have been titrated any number of tests can be carried out on the same day.

In the routine testing of cows for infectious abortion four tubes are used for each cow. As shown in the table, each tube contains a different amount of the cow's serum. The first tube containing 0.2 c. c. of serum is a control to which no antigen is added. This tube must always show complete haemolysis thus proving that double the amount of the cow's serum in any other tube will not fix the complement without the antigen. As a matter of fact, in testing several hundred cows, we have never found a case in which the cow's serum alone interfered with the complement.

In the tests the various substances are added to the tubes in the order shown in table 4. First, the proper amount of the cow's serum (inactivated) is placed in the tubes. These amounts are measured directly from the undiluted serum by means of a one-tenth cubic centimeter pipette, graduated in hundredths of a cubic centimeter.* Next the salt solution and the complement are added.

The labor of pipetting is greatly reduced by first mixing the salt solution and the complement in such proportion that 1.5 c. c. of the mixture, contains exactly the complement dose. Next the antigen is added to all tubes except the first in each series. As noted above this first tube is always a control. The tubes are next thoroughly shaken to mix the contents and incubated for one hour at 37° C. This allows time for the complement to be fixed, if the abortion amboceptors are present in the cow's serum. The tubes are then removed from the incubator and the proper amount of haemolysin and blood corpuscles are added. After shaking the tubes once more, they are incubated for two hours at 37° C. After this period the results are noted and the tubes allowed to stand in the refrigerator over night. The next morning the results are finally recorded.

Where a number of tests are run at the same time the labor of pipetting may be reduced still further by first mixing the blood corpuscles and haemolysin in the proper proportions. As shown in tables 4 and 5 it would be necessary to add 0.75 c. c. of the mixture to each tube.

Table 4 and Figure 5 show the results of testing a cow which proves to be infected with contagious abortion. The control tube No. 1 shows complete haemolysis, while tubes 2, 3 and 4 show no haemolysis. Thus, the abortion amboceptors *were* present in the cow's blood for they have united with the bacteria and absorbed all the complement.

Tubes 5, 6, 7 and 8 are controls. Only one set of such controls need to be run with each lot of tests made on the same day. Tube 5 shows that the dose of antigen without serum will not prevent haemolysis. Tube 6 shows that double the dose of antigen will

*If the serum of more than one cow is to be tested, the pipette must be thoroughly cleaned after each sample. For the method of doing this, see page 318.

not interfere with haemolysis. Tube 7 is a control for the haemolytic system in order to be sure that sufficient complement and haemolysin are present. Tube 8 is a control without complement. It is usually not necessary to use tube 8 as the same control has been used in titrating the haemolysin. (Cf. table 2.)

Table 5 and figure 6 show the result of testing a cow not infected with the abortion organism. Here all four tubes show complete haemolysis proving that no abortion amboceptors were present in the cow's serum. The bacteriolytic system lacking the specificic amboceptors, failed to fix the complement. The complement was thus free when the haemolysin and corpuscles were added and in consequence the latter were dissolved.

As shown in figures 5 and 6, the result of the test is manifested by a distinct reaction in the test tubes. The difference in the appearance of the tubes with infected and non-infected cows is very marked. When the complement is fixed, indicating an infected cow, the corpuscles all settle to the bottom leaving the liquid above water clear or perhaps slightly yellow from the serum and antigen. When the complement is not fixed, as in figure 6, the tubes will have a transparent wine red color without any sediment* on the bottom.

The series of three tubes, viz., Nos. 2, 3 and 4, gives some idea of the titre of the cow's serum with respect to abortion amboceptors. In many cases the complement will be completely fixed in all three tubes showing that the titre lies beyond the last tube. If more tubes are used containing decreasing amounts of serum, a point is finally reached where the complement is no longer fixed. The smallest amount of serum showing complete fixation represents the titre of the cow's serum. In routine examination, we do not use a higher dilution than 0.02 c. c. (tube 4). If the complement is completely fixed in this tube, we indicate that the titre is less than 0.02 c. c., written <0.02 (cf. tables 6-10). If tube 4 shows faint traces of haemolysis, not over 10 per cent., the titre

*The action of the Haemolytic system is to dissolve the stroma of the corpuscles and thus set free the haemoglobin. A portion of the undissolved cell walls of the corpuscles may settle to the bottom, forming a very thin layer of sediment.

Figure 5.—Photograph of the complement fixation test with the blood of an infected cow. Tube No. 1 is a control containing no antigen. Tubes 2, 3, and 4 show fixation of the complement (no haemolysis). Compare Table 4, tubes Nos. 1, 2, 3, and 4.

Figure 6.—Photograph of the complement fixation test with the blood of a normal (uninfected) cow. Complete haemolysis in all four tubes. Compare Table 5.

TABLE 4

TABLE 4.
Complement Fixation Test.
Cow showing reaction.

Tube No.	Serum of suspected cow.	NaCl. 0.9%.	Complement. (Diluted 1 to 3. Titre 0.03.)	Antigen. (Titre 0.05.)	Haemolysin. (Diluted 1 to 50. Titre 0.05.)	Sheep's Corpuscles. 2%.	Results.
	c.c.	c.c.	c.c.	c.c.	c. c.	c. c.	
				Incubated 1 hr. at 37°C.		Incubated 2 hrs. at 37°C.	
1	0.2	1.5	0.045	.....	0.25	0.5	Complete haemolysis.
2	0.1	"	"	0.25	"	"	No "
3	0.05	"	"	.25	"	"	"
4	0.02	"	"	.25	"	"	"
5	.....	"	"	.25	"	"	Complete "
6	.....	"	"	.5	"	"	" "
7	.....	"	"	.....	"	"	" "
8	.....	"	.....	.....	"	"	No "

TABLE 5.

Complement Fixation Test.

Cow showing no reaction.

Tube No.	Serum of suspected cow.	NaCl. 0.9%.	Complement. (Diluted 1 to 3. Titre 0.03.)	Antigen. (Titre 0.05.)	Incubated 1 hr. at 37°C. Haemolysin. (Diluted 1 to 50. Titre 0.05.)	Sheep's Corpuscles. 2%.	Incubated 2 hrs. at 37°C. Results.
	c.c.	c.c.	c.c.	c.c.	c.c.	c. c.	
1	0.2	1.5	0.045	.....	0.25	0.5	Complete haemolysis.
2	.1	"	"	0.25	"	"	"
3	.05	"	"	"	"	"	"
4	.02	"	"	"	"	"	"

is recorded as equal to 0.02 c. c. (= 0.02). If tube 4 shows complete or nearly complete haemolysis while tube 3 shows either no haemolysis or only a slight trace, the titre is regarded as equal to 0.05 c. c. In this way it is possible to approximate the titre of the cow's serum with regard to abortion amboceptors.

As noted earlier, McFadyean and Stockman were the first to propose the use of complement fixation in the diagnosis of infectious abortion. At practically the same time and independently Holth used the same method. Since that time the work of Holth and particularly that of Wall has greatly extended our knowledge of this method and its limitations. The work of these men is referred to so frequently in these pages that it does not seem necessary to review* their results in detail here.**

We have now examined in considerable detail several methods for the diagnosis of infectious abortion. The microscopical and bacteriological methods have long been used in a number of laboratories. The inadequacy of these methods, especially with cows which have not aborted, has been pointed out. (p. 310.) The use of "Abortin" has not been attended with any measure of success in the reports so far received. On the other hand, both agglutination and complement fixation have given very good results in the hands of those who have given them a thorough trial. Following the suggestion of Holth and Wall the logical course appears to demand the use of both these methods and to *regard a cow as certainly infected, only when both tests show positive reactions.*

The agglutinins and the complement binding amboceptors are probably entirely separate and distinct antibodies. Either one

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*The writer has recently reviewed these papers in Science, N. S. Vol. XXXV, 1912.

**Since the preparation of this manuscript, the writer has seen the recent article by W. P. Larson on "The Complement Fixation Reaction in the Diagnosis of Contagious Abortion of Cattle." Journ. Infect. Dis. Vol. 10, pp. 178-185, 1912. A summary of this work was published by Dr. Russell in Science (N. S. XXXIV, p. 494). The technic is similar to that used by Holth and Wall. The results indicate that "The Complement Fixation reaction is a reliable and accurate method of diagnosis."

Meissner in Germany (Berl. Tierärzt. Woch. Bd. 28, No. 18, p. 316, 1912) has also confirmed the experience of other investigators regarding the reliability of agglutination and complement fixation in diagnosing this disease.

of these two substances if present in a considerable quantity is a specific test for infection by the abortion bacillus. If both tests are used, one serves to check the other. When both tests show a positive reaction we are safe in concluding that the animal has been infected with the abortion organism.

In our tests, we have regarded an animal as "reacting" only when 0.05 c. c. or less of her serum completely agglutinated 1 c. c. of our standard suspension (cf. p. 317), and in addition when 0.1 c. c. or less of her serum showed complete fixation of the complement. Adopting Wall's suggestion, a reaction is then indicated as follows:

Agglutination $\leqq$ 0.05

Complement Fixation $\leqq$ 0.1

As stated before it is entirely possible for an animal to be infected with this organism and still carry her calf to full term. Further, after an animal has been infected she gradually acquires some measure of immunity. It is impossible by these blood tests to distinguish between animals which have an active infection and those which have become immune.

What the tests do show is this, that the reacting animals either are, or have been infected with the abortion organism within the past eight or twelve months. No other claim can be made for these tests. It would be very desirable if we could distinguish between cows which have a virulent infection and those which have acquired immunity. At present, however, this is impossible. As will be pointed out later (cf. p. 360) this is not such a serious objection in practice. It is still possible to pick out the non-infected and hence, susceptible animals. The isolation of these will do much towards successfully combating the disease in a herd.

SPECIFICITY OF THE TEST.

A question which naturally arises is with regard to the specificity of these tests. Will the serum from an animal suffering from any other disease show a reaction with the abortion antigen? This is a most important question, and upon its answer depends the value of the tests. The writer has carried out a number of experiments in this direction.

The serum of a large number of normal animals, including horses, sheep, swine, rabbits and guinea pigs, has been tested with no evidence of any reaction. In addition, the serum from horses, rabbits and guinea pigs which have been inoculated with this organism, all show very marked reactions. Further, the serum of a sheep immunized to various strains of coli bacteria and the serum of hogs immune to hog cholera have been tested without showing any trace of reaction.

Wall has investigated the specificity of these reactions very thoroughly. He gives the results of agglutination and complement fixation tests, using abortion antigen and various kinds of immune sera. Twenty-six sera were tested in this manner. No one of these showed a reaction, as defined above, towards the abortion antigen. In five cases a weak agglutination was observed and in four other cases a weak complement fixation. No one of the twenty-six sera showed both agglutination and complement fixation.

Wall also carried out the same tests, using an abortion immune serum (horse) and as antigen, cultures of various kinds of bacteria. Eighteen such cultures were tested. In two cases, viz., with B. paracoli and B. typhosus a weak reaction was obtained. In the other tests there were no traces of either agglutination or complement fixation. Wall explains these two reactions by stating that the horses used for paracoli and typhoid sera stood in stalls adjoining the horse inoculated with abortion bacilli. It is thus quite probable that the latter horse became slightly infected with the paracoli and typhoid bacilli.

From these experiments it appears safe to state that a positive agglutination and complement fixation reaction can only mean that the animal furnishing the serum has been infected with the abortion organism.

RESULT OF TESTS.

During the past few months the writer has tested several hundred cows by agglutination and complement fixation methods. The results of testing a few herds are shown in the following tables.

TABLE 6

Herd No. 1.

Cow No.	Result of Test.	Agglutination Titre.	Complement Fixation Titre.	Age.	No. of Years in Herd.	No. of Calves.*	Abortions and Dates.	Remarks.
1	Reaction	$\equiv$0.01	$<$0.02	3 yrs.	3 yrs.	2	Feb. 1911	
2	"	$\equiv$0.02	$\equiv$0.05	7 "	7 "	6	April 1907	5 calves since abortion.
3	"	$\equiv$0.02	$\equiv$0.02	8 "	8 "	6		
4	"	$\equiv$0.02	$<$0.02	4 "	4 "	3		
5	"	$\equiv$0.005	$<$0.02	5 "	5 "	4	Apr. 1911-Feb. 1912.	
6	"	$\equiv$0.01	$<$0.02	6 "	6 "	4		
7	"	$\equiv$0.05	$\equiv$0.05	10 "	10 "	9	Nov. 1911	
8	"	$\equiv$0.02	$<$0.02	4 "	4 "	3		
9	"	$\equiv$0.05	$\equiv$0.05	16 "	16 "	?	June 1911	Purchased 1896,
10	No reaction	$\equiv$0	$\equiv$0	6 "	6 "	4	Feb. 1910-Oct. 1911.	Aborted twins in 1911.
11	Reaction	$\equiv$0.002	$<$0.02	10 "	10 "	8		
12	"	$\equiv$0.01	$\equiv$0.05	4 "	4 "	1	....	Difficult to breed.
13	"	$\equiv$0.02	$<$0.02	4 "	4 "	3	April 1910	
14	"	$\equiv$0.02	$\equiv$0.02	14 "	14 "	10	March 1912	
15	"	$\equiv$0.01	$\equiv$0.05	6 "	6 "	5		
16	"	$\equiv$0.02	$\equiv$0.05	3 "	3 "	1		
17	"	$\equiv$0.01	$<$0.02	4 "	4 "	2	March 1911	
18	"	$\equiv$0.02	$<$0.02	6 "	6 "	4		

19	"	=0.005	=0.05	3 "	3 "	2	Nov. 1910-Oct. 1911	
20	"	=0.02	=0.02	3 "	3 "	2		
21	No reaction	=0	=0	4 "	4 "	2		
22	Reaction	=0.02	=0.05	8 "	8 "	5	Jan. 1909	3 calves since abortion.
23	"	=0.01	<0.02	6 "	6 "	4		Last calf came 3 weeks before term.
24	"	<0.002	<0.02	5 "	5 "	3		
25	"	=0.01	<0.02	3 "	3 "	1	Jan. 1912	Aborted her first calf.
26	"	<0.002	<0.02	?	4 mos.	?	?	Purchased 1911.
27	No reaction	=0.05	=0	8 "	4 "	?	?	Purchased 1911.
28	" "	=0	=0	?	4 "	?	?	Purchased 1911.
29	" "	=0	=0	7 "	4 "	?	?	Purchased 1911.
30	" "	=0	=0	6 "	4 "	?	?	Purchased 1911.
31	Reaction	=0.05	=0.1	5 "	4 "	?	April 1912	Purchased 1911.
32	No reaction	=0	=0	12 "	6 "	?	?	Purchased 1911.
33	" "	=0	=0	?	4 "	?	?	Purchased 1911.
34	" "	=0	=0	?	3 "	?	?	Purchased 1911.
35	" "	=0	=0	?	3 "	?	?	Purchased 1911.
36	Reaction	=0.01	=0.02	2 "	2 yrs.	1	May 1912	Aborted her first calf three months after the test.
37	No reaction	=0	=0	2 "	2 "	0	....	Heifer due to calve July, '12
38	" "	=0	=0	18 mos.	18 mos.	0	....	Heifer, not bred.
39	" "	=0	=0	1 yr.	1 yr.	0	....	Heifer, not bred.
40	" "	=0	=0	1 "	1 "	0	....	Heifer, not bred.
41	" "	=0	=0	.....	.....	.....	....	Young calf.
42	" "	=0	=0	.....	.....	.....	....	Young calf.
43	Reaction	=0.05	=0.02	.....	.....	.....	....	Young calf.
44	No reaction	=0	=0	.....	.....	.....	....	Young calf.
45	" "	=0	=0	.....	.....	.....	....	Young calf.
46	" "	=0	=0	.....	.....	.....	....	Young calf.

*This includes the number of pregnancies, whether terminated by normal calving or by abortion.

Table 6 shows the result of testing a herd which has been very badly infected with abortion for a number of years. A number of the aborting cows have been sold from time to time so that the table gives no adequate idea of the actual number of abortions in the herd. The cows have been arranged in the table in the following manner: Numbers 1 to 25 inclusive are cows which have been in the herd for two years or longer. Most of these have been raised from calves. Numbers 26 to 35 inclusive were purchased in the fall of 1911, about four months before the tests. Numbers 36 to 40 inclusive are heifers, while 41 to 47 are young calves from 3 to 8 months old.

From this table, we may note the following points:

1. Of the 25 cows (Nos. 1 to 26) which have been in the herd for more than two years, 23, or 92 per cent. show a reaction.

2. Of the ten cows (Nos. 26 to 36) purchased in the fall of 1911, only two show a reaction. One of these (No. 31) aborted two months after the test. The abortion bacilli were isolated from the placenta and foetus.

3. Of the eleven heifers and calves (Nos. 36 to 47) only two (Nos. 36 and 43) show a reaction. Of these No. 43 has not been bred.*

4. Of the 21 animals (Nos. 26 to 47) which include the recently purchased cows and the young stock, only four, or nineteen per cent. show a reaction. This is in marked contrast to the 92 per cent. of reactions shown by the cows which have been in the herd for a longer time. It should be stated that the heifers and young stock are kept separate from the older cows. There is not, however, a strict isolation.

5. Of the 23 reacting cows in the older part of the herd, eight or 34.8 per cent. have aborted within a year of the test. In addition to this, three more have aborted at earlier periods and at least three others have shown some irregularity in calving or breeding. In fact a great deal of difficulty is being experienced in breeding most of these cows. Many of them return to the bull six or eight times before conception.

*Since the above manuscript was prepared, Heifer No. 36 has aborted. The abortion bacilli were obtained and grown in pure culture from various portions of the afterbirth.

6. Of the two cows in the older part of the herd which show no reaction (Nos. 10 and 21), No. 21 has never aborted. No. 10 on the other hand, has aborted twice. This would appear to discredit the tests. However, the following facts are to be considered: If her abortion in 1910 was due to the Bang bacillus and no new infection has occurred, her blood might no longer show the specific antibodies* In the spring of 1911 she gave birth to a normal calf at full term. In October, 1911, she aborted twins. It is quite possible that this second abortion was due to the multiple pregnancy and not to the abortion germ. Professor Good made a careful bacteriological examination of these two foeti without finding the abortion organism.

7. It will be noted that among the first twenty-six cows there are a number which show reactions but which have never aborted. This is in entire accord with what might be expected if the cows acquire immunity after an attack. The disease always requires considerable time after the infection before an abortion occurs. The English Abortion Committee found the average time between infection and abortion to be about 125 days. If the cow received only a small amount of the infectious material at a time, she could probably develop immune bodies fast enough to protect her against subsequent infections. As has been stated before, these tests cannot distinguish between immune animals and those actively infected. It is not unreasonable to regard those animals which show a reaction but which bear their calves at full term as immune, for the time at least, to ordinary infections with this germ.

Table 7 shows the results of testing a herd which has not been badly infected with abortion during recent years. Four or five years ago, there were a number of abortions in this herd. From that time until recently, very few abortions have occurred. Within the last few months several cows have aborted.

The following points may be noted from this table:

1. Of the 47 animals (Nos. 1 to 48) of breeding age, seven, or 15 per cent. have aborted within the year preceeding the test. Three others have aborted at earlier periods.

*This statement is based upon Wall's evidence that in six months to a year after a single infection the reaction disappears.

TABLE 7.
Herd No. 2.

Cow No.	Result of Test.	Agglutination Titre.	Complement Fixation Titre.	Age.	No. of Years in Herd.	Abortions and Dates.	Remarks.
1	Reaction	$=0.005$	$=0.02$	5 yrs.	4 yrs.	.....	Difficulty in breeding.
2	No reaction	$=0$	$=0$	8 "	3 "		
3	" "	$=0$	$=0$	3 "	3 "		
4	Reaction	$=0.002$	<0.02	6 "	4 "	Feb. 1912.	
5	No reaction	$=0$	$=0$	3 "	3 "		
6	Reaction	$=0.01$	$=0.1$	13 "	4 "		
7	"	$=0.02$	$=0.1$	5 "	5 "		
8	"	<0.002	<0.02	10 "	4 "	July 1910.	
9	No reaction	$=0$	$=0.1$*	6 "	3 "		
10	Reaction	$=0.01$	$=0.1$	13 "	6 "	Dec. 1911.	
11	"	$=0.005$	$=0.02$	4 "	4 "		
12	"	$=0.002$	<0.02	8 "	4 "		
13	No reaction	$=0.05$	$=0$	4 "	3 "		
14	" "	$=0.05$	$=0$	11 "	6 "	Feb. 1909.	
15	Reaction	$=0.005$	<0.02	17 "	5 "		
16	"	<0.002	<0.02	10 "	3 "	Jan. 1911—Mar. 1912.	
17	No reaction	$=0$	$=0$	4 "	3 "		
18	Reaction	$=0.01$	<0.02	5 "	5 "	.....	Difficulty in breeding.
19	"	<0.002	<0.02	14 "	8 "		
20	No reaction	<0.02	$=0$	4 "	3 "		
21	Reaction	$=0.02$	$=0.05$	5 "	5 "	Dec. 1911.	
22	No reaction	$=0$	$=0$	14 "	4 "		

17	No reaction	$=0$	$=0$	4	"	5	"	..... Difficulty in breeding.
18	Reaction	$=0.01$	<0.02	5	"	5	"	.....
19	"	<0.002	<0.02	14	"	8	"	
20	No reaction	$=0.02$	$=0$	4	"	3	"	
21	Reaction	$=0.02$	$=0.05$	5	"	5	"	Dec. 1911.
22	No reaction	$=0$	$=0$	14	"	4	"	
23	" "	$=0$	$=0$	4	"	4	"	June 1911.
24	" "	$=0$	$=0$	7	"	3	"	
25	" "	$=0$	$=0$	9	"	3	"	
26	" "	$=0$	$=0$	8	"	4	"	Jan. 1909.
27	" "	$=0$	$=0$	10	"	4	"	
28	Reaction	$=0.002$	<0.02	4	"	3	"	Feb. 1912.
29	No reaction	$=0.05$	$=0$	4	"	3	"	
30	Reaction	<0.002	<0.02	4	"	4	"	
31	"	$=0.05$	$=0.02$	3	"	3	"	
32	No reaction	$=0$	$=0$	4	"	4	"	Jan. 1912.
33	" "	$=0.05$	$=0$	4	"	3	"	
34	" "	$=0.05$	$=0$	3	"	3	"	
35	" "	$=0$	$=0$	8	"	20	mos.	
36	" "	$=0.05$	$=0$	8	"	20	"	Jan. 1912.
37	" "	$=0$	$=0$	8	"	20	"	
38	" "	$=0$	$=0$	7	"	2	yrs.	
39	" "	$=0$	$=0$	6	"	2	"	
40	" "	$=0$	$=0$	8	"	20	mos.	
41	" "	$=0$	$=0$	9	"	2	yrs.	
42	" "	$=0.05$	$=0$	8	"	20	mos.	
43	" "	$=0$	$=0$	?		10	"	
44	" "	$=0$	$=0$	5	"	1	yr.	
45	" "	$=0$	$=0$	?		2	yrs.	
46	" "	$=0$	$=0$	4	"	1	yr.	
47	" "	$=0$	$=0$	5	"	1	yr.	
48	" "	$=0$	$=0$	8	mos.	8	mos.	..... Young calf.
49	" "	$=0$	$=0$	8	"	8	"	..... Young calf.
50	" "	$=0$	$=0$	6	"	6	"	..... Young calf.
51	" "	$=0$	$=0$	.....		.....		..... Young calf.
52	" "	$=0$	$=0$	.....		.....		..... Young calf.
53	" "	$=0$	$=0$	.....		.....		..... Young calf.
54	" "	$=0$	$=0$	.....		.....		..... Young calf.

*Weak.

TABLE 8.
Herd No. 3.

Cow No.	Result of Test.	Agglutination Titre.	Complement Fixation Titre.	Age.	No. of Years in Herd.	Abortions and Dates.	Remarks.
1	Reaction	<0.002	<0.02	9 yrs.	9 yrs.		
2	"	<0.002	<0.02	4 "	4 "		
3	No reaction	$=0$	$=0$	5 "	5 "		
4	"	$=0.02$	$=0$	9 "	9 "		
5	Reaction	<0.002	<0.02	5 "	5 "		
6	No reaction	$=0.05$	$=0$	9 "	9 "		
7	Reaction	<0.002	<0.02	6 "	6 "		
8	"	$=0.02$	$=0.05$	11 "	8 "	1909.	
9	"	$=0.01$	<0.02	16 "	9 "		
10	"	$=0.005$	$=0.05$	5 "	5 "		
11	No reaction	$=0.05$	$=0$	9 "	5 "		
12	"	$=0.05$	$=0$	6 "	6 "		
13	Reaction	$=0.02$	$=0.05$	6 "	6 "		
14	"	$=0.01$	<0.02	5 "	5 "		
15	No reaction	$=0.05$	$=0$	3 "	3 "		
16	"	$=0.05$	$=0$	6 "	6 "		
17	Reaction	$=0.005$	$=0.02$	6 "	6 "		
18	No reaction	$=0.02$	$=0$	3 "	3 "		
19	Reaction	$=0.002$	<0.02	3 "	3 "		

18	No reaction	=0.02						
19	Reaction	=0.002	<0.02	3 "	3 "			
20	"	<0.002	<0.02	6 "	6 "			
21	"	<0.002	<0.02	3 "	3 "	Oct. 1911.		
22	"	=0.01	=0.05	7 "	7 "			
23	No reaction	=0.05	=0	7 "	7 "	1909.		
24	Reaction	=0.005	=0.02	5 "	4 mos.			
25	"	=0.005	=0.02	5 "	2 yrs.	April 1912.		
26	No reaction	=0	=0	?	4 mos.			
27	Reaction	<0.002	<0.02	2 "	2 yrs.	April 1912.		
28	No reaction	=0	=0	2 "	2 "			
29	" "	=0	=0	2 "	2 "	.....	Carrying first calf.	
30	" "	=0	=0	2 "	2 "	.....	Heifer, not bred.	
31	Reaction	=0.02	=0.02	1 yr.	1 yr.	.....	Heifer, not bred.	
32	No reaction	=0.05	=0	1 "	1 "	.....	Heifer, not bred.	
33	Reaction	=0.005	<0.02	1 "	1 "	.....	Heifer, not bred.	
34	"	=0.01	=0.02	1 "	1 "	.....	Heifer, not bred.	
35	"	=0.01	<0.02	1 "	1 "	.....	Heifer, not bred.	
36	"	=0.002	<0.02	1 "	1 "	.....	Heifer, not bred.	
37	"	=0.005	=0.02	1 "	1 "	.....	Young calf.	
38	"	=0.05	=0.05	.....	.....	.....	Young calf.	
39	No reaction	=0	=0	.....	.....	.....	Young calf.	
40	" "	=0.05	=0	.....	.....	.....	Young calf.	
41	" "	=0	=0	.....	.....	.....	Young calf.	
42	" "	=0	=0	.....	.....	.....		

TABLE 9.
Herd No. 4.

Cow No.	Result of Test.	Agglutination Titre.	Complement Fixation Titre.	Abortions with Dates.	Remarks.
1	No reaction	$=0$	$=0$		
2	"	$=0.05$	$=0$		
3	Reaction	$=0.005$	$=0.02$		
4	No reaction	$=0.02$	$=0$		
5	Reaction	<0.002	<0.02	Oct. 1911.	
6	"	$=0.01$	<0.02		
7	"	$=0.005$	<0.02	Oct. 1911.	
8	"	<0.002	<0.02	Sept. 1911.	
9	"	$=0.005$	<0.02		
10	No reaction	$=0$	$=0$		
11	Reaction	$=0.005$	$=0.02$		
12	"	<0.002	<0.02		
13	No reaction	$=0$	$=0$		
14	Reaction	$=0.01$	$=0.05$		
15	"	$=0.01$	<0.02		
16	"	$=0.002$	<0.02	Fall of 1911.	
17	"	<0.002	<0.02		
18	"	$=0.005$	<0.02	1910 and 1911.....	Living calf 1912.
19	No reaction	$=0$	$=0$		

20	Reaction	<0.002	$=0.02$		
21	"	<0.002	<0.02	March 1912.	
22	"	$=0.005$	$=0.02$	Nov. 1911.	
23	No reaction	$=0$	$=0$		
24	" "	$=0.02$	$=0$		
25	Reaction	$=0.005$	<0.02	Fall of 1911.	
26	No reaction	$=0.05$	$=0$		
27	Reaction	$=0.002$	<0.02	April 1912.	
28	"	$=0.02$	<0.02		
29	No reaction	$=0.02$	$=0$		
30	Reaction	$=0.01$	<0.02	Fall of 1911.	
31	"	<0.002	$=0.02$		
32	"	$=0.005$	$=0.02$	April 1912.	
33	No reaction	$=0$	$=0$	Dec. 1911.	
34	Reaction	$=0.005$	<0.02	Jan. 1912.	
35	No reaction	$=0$	$=0$		
36	Reaction	$=0.01$	$=0.05$		
37	No reaction	$=0$	$=0$		
38	Reaction	$=0.005$	<0.02		
39	"	<0.002	<0.02		

2. Of these same 47 animals, sixteen or 34 per cent. show a reaction with the tests applied.

3. Of the 34 animals (Nos. 1 to 35) which have been in the herd for more than two years, sixteen, or 47 per cent. show a reaction while of the 13 adult animals (Nos. 35 to 48) which have been purchased within the past two years, none show a reaction. None of the young stock (Nos. 48 to 55) show a reaction. Of the herd, as a whole, less than 30 per cent. react with these tests.

4. Of the eight animals which have aborted within the year preceeding the test, three, or 37.5 per cent. show no reaction. This appears to be a rather large percentage and argues against the reliability of the test. As has been stated elsewhere it is not to be forgotten that abortion may occur from other causes and naturally the percentage of such abortions will be higher in a herd which has not been badly infected with the disease. The owner stated before the test that he believed one of these abortions (No. 36) was due to injuries.

Herd No. 3 (Table 8) was badly infected with abortion three years ago. Since that time, but little trouble has been experienced until the last few months. Practicaly all the cows which aborted in 1908-9, have been disposed of. The majority of the animals in this herd have been raised from calves, only a few have been purchased.

Table 8, showing the results of examining this herd, is arranged in the same manner as tables 6 and 7. We may note the following points:

1. Of the 23 cows (Nos. 1 to 24) which have been in the herd for more than two years, fourteen or 60.8 per cent. show a reaction. Of these only one (No. 21) has aborted within the past year. It will be noted that the majority of these cows have been in the herd five years or more and consequently went through the former epidemic of abortion. Whether the antibodies have remained in the blood of these cows or whether they have been infected more recently cannot be determined at present.

2. Seven cows (Nos. 24 to 31) have been in the herd two years or less. Of these, three or 43 per cent. show a reaction and two of these reactors have aborted within the month preceeding the test.

3. Of the seven yearling heifers (Nos. 31 to 38), six, or 85.7 per cent show a reaction. This is a very large percentage and would indicate that the disease is now present in the herd in a virulent form. It will be of interest to note the results after these heifers have been bred.

4. Of the five young calves (Nos. 38 to 43) only one shows a reaction.

5. The total number of abortions in this herd (three within the past year) are too few to permit definite conclusions. However, it is worth noting that two of these abortions or 66 per cent. have occurred among animals which have been in the herd less than two years. It would seem that for some reason the young heifers have been subjected to conditions more favorable for infection than the older cows. Of the four two-year-old animals (Nos. 27 to 31) only one (No. 27) shows a reaction and she has aborted.

Table No. 9 shows the result of examining a dairy herd which has been troubled with abortion very seriously during the past year. Data regarding the age and number of years the cows have been in the herd were not secured. All cows examined were in milk.

The following points may be noted from this table:

1. Of the 39 cows tested, twenty-six or 66.7 per cent. reacted to the tests for infectious abortion.

2. Thirteen of the 39 cows, or 33.3 per cent. have aborted within the past year.

3. Of the 26 reacting cows, twelve or 46.2 per cent. have aborted within the year.

4. Of the 13 non-reacting cows, one or 7.6 per cent. aborted.

5. Of the 13 cows which aborted, twelve or 92.3 per cent. showed a reaction.

We have examined a large number of other cows but it is perhaps sufficient to give the detailed data on these four herds at present. The remaining data, and other that will accumulate will be presented in a future paper when the exact meaning of these reactions will be discussed more fully. It may be stated here that of 576 animals tested up to the time of writing, 258 or 44.8 per cent. have shown a reaction. This includes animals of all ages, some from herds badly infected and some from herds almost free

TABLE 10.
Summary of Herd Tests.

Herd No.	No. of Cows.*	Total Abortions within the year preceding the test.		Cows Showing a Reaction.		Aborting Cows Showing Reaction.			Aborting Cows Showing No Reaction.			
		No.	Percent of Herd.	No.	Percent of Herd.	No.	Percent of all Reacting Cows.	Percent of all Aborting Cows.	Percent of Herd.	No.	Percent of Non-reacting Cows.	Percent of all Aborting Cows.	Percent of Herd.
1	36	11	30.5	26	72.2	10	38.5	90.9	27.8	1	10.0	9.1	2.8
2	47	8	17.0	16	34.0	5	31.2	62.5	10.6	3	9.7	37.5	6.4
3	29	3	10.3	17	58.6	3	17.6	100.0	10.3	0	0	0	0
4	39	13	33.3	26	66.7	12	46.2	92.3	30.8	1	7.7	7.7	2.6
Total	151	35	23.1	85	56.3	30	35.3	85.7	19.9	5	7.6	14.3	3.3

*Only adult cows which have had at least one calf are included in this table.

from the disease. The data are not at hand to show how many of these animals have aborted.

Certain of the results of the examination of these four herds are summarized in table 10.

It should be noted that in this table only adult cows, which have terminated at least one pregnancy, are considered. This includes heifers which have aborted their first calf. The total number of cows in these four herds is too small to draw definite conclusions regarding average percentages. It will be of interest however, to briefly call attention to the following points:

1. Of the 151 cows, 23.1 per cent. aborted in the year preceding the test, while 56.3 per cent. showed a reaction.

2. Of the cows which aborted, 85.7 per cent. showed a reaction. Three of the herds show that 90 per cent. or more, of the aborting cows react to these tests. Wall found that in badly infected herds over 91 per cent. of the aborting animals reacted. In herds where little trouble had been experienced, the percentage was much lower, viz., 40 per cent.* It has been noted (page 347) that herd No. 2 was not badly infected with this disease.

3. Column 14 shows that an average of about three per cent. of the cows aborted without showing a reaction. It may perhaps be considered that about three per cent. of a herd may abort from other causes than the infectious disease. In the herds considered nearly 20 per cent. (Column 10) of the animals examined aborted from this disease.

COMPARISON OF AGGLUTINATION AND COMPLEMENT FIXATION.

In tables 6, 7, 8 and 9, the agglutination and complement fixation titres of 181 animals are given. It will be noted that in general there is an agreement between these two tests. In the great majority of cases, showing "No reaction" there is neither agglutination nor complement fixation. There are, however, a number of animals (17) which show agglutination in the dilution of 1 to 20 (0.05 c. c. serum) but which show no complement fixation. A much smaller number (6) show agglutination in the

*Wall, Sven.—Loc. cit. Table 10, page 136.

*Only adult cows which have had at least one calf are included in this table.

dilution 1 to 50 (0.02 c. c. serum) and no complement fixation. In these herds there are no cows showing agglutination with 0.01 c. c. of serum (1 to 100) which do not also show fixation of the complement. In other herds, however, the writer has found two cows which agglutinate in the dilution of 1 to 100 but show no complement fixation. From this it appears very probable that the blood of some normal cows can agglutinate the abortion bacilli in the dilution of 1 to 20 and perhaps 1 to 50. It is certainly very rare for cows to show agglutination in dilutions of 1 to 100 or above, unless they have been infected.

On the other hand there is only one case out of these 181 where the blood shows fixation of the complement, but no agglutination. (Table 7, cow No. 9.) If we may regard the agreement of these two tests as the proper basis for determining a reaction it is clear that the complement fixation test is the more reliable of the two.

Agglutination in the dilution of 1 to 100 and higher may be regarded as practically specific. However, it will be seen from the tables that many cows show a reaction as defined in this paper but yet agglutinate in the dilution of only 1 to 50 or even 1 to 20. From the present data it does not seem practicable to use the agglutination method alone. If this could be done it would greatly simplify the labor of diagnosis in this disease. This matter will be discussed in greater detail in a later paper.

It will also be seen from the tables that in general a high agglutination titre is followed by a high complement fixation titre, and visa versa. However, this is not always the case. A number of cows show agglutination in the dilution of only 1 to 50 or 1 to 100 and yet show complete fixation of the complement in the last tube used (0.02 c. c. serum). For this and other reasons it is probable that entirely different antibodies are responsible for these two phenomena. By using both tests one serves to check the other and greatly lessens the probability of an error.

PRACTICAL SUGGESTIONS.

There is at present no known specific remedy for infectious abortion in cattle. There are a number of so-called "cures" upon the market. The majority of these have as their basis a carbolic

acid solution. Carbolic acid has frequently been proposed as a remedy for this disease and many breeders have used it with apparently excellent success. On the other hand the writer has talked with a number of breeders who have had no success whatever with it. The difficulty in obtaining crucial evidence as to the effectiveness of this or any other remedy for this disease, lies in the fact that many cows undoubtedly acquire a measure of immunity after one or two attacks. Some cows apparently become immune without aborting. It is the history of the disease in the great majority of herds, that after reaching its height it gradually subsides of its own accord, until only a few slips occur each year or it may disappear entirely. It has usually been the case that carbolic acid has not been administered until the disease was very severe in the herd. The subsidence of the disease which sometimes follows may or may not be due to the remedy.

The writer does not wish it to be understood that he opposes the use of carbolic acid in this disease. To his mind there is at present, no evidence as to whether it is or is not a specific remedy. Since no specific cure is known it is perhaps well to continue its use "on faith," as it were.

Besides the internal administration of carbolic acid, either in the food or injected subcutaneously, the methods which have proved most effective against this disease have been, the isolation of the aborting animals, the disinfection of stables, the irrigation and disinfection of the vagina of the cows and the sheath of the bull before serving.

The diagnostic methods given in this paper will undoubtedly be of great aid in isolating infected animals. By their use it is possible to pick out the infected animals before they abort or even those infected cows which will not abort. Proper methods of isolation and disinfection will then do much toward preventing the spread of the infection to healthy animals.

Perhaps these methods will prove most useful in herds where the disease has just been introduced. In herds where abortions have not occurred for several years or at least only rarely, the owner should take particular pains to prevent its introduction. Every case of abortion should be regarded as suspicious until proven otherwise. If a slip occurs the cow should be isolated at once

from the rest of the herd. The foetus, afterbirth and all soiled bedding should be burned or deeply buried. The stall and adjoining portions of the stable should be thoroughly cleaned and disinfected.

The next step should be to obtain a sample of the cow's blood and send it to the Experiment Station for testing. If the cow shows no reaction the abortion was not due to the infectious disease and the cow may be returned to the herd. On the other hand, if she shows a reaction, she should be kept isolated for several months at least. Further, if she shows a reaction, the blood of every other cow in the herd should be tested as soon as possible. In such a herd, any cows which show a reaction will be very likely to abort. Consequently all reacting cows should be isolated at once. By the rigid isolation of these infected cows the disease can be prevented from reaching the remainder of the herd.

In herds where the disease has already obtained a serious footing, the problem of isolation becomes more difficult. In such herds the reacting animals will be of at least two classes, viz., those which have acquired some immunity and will not abort and those which have an active infection and will probably abort their next calf. On the other hand, the *non-reacting cows have not been infected and are the ones most susceptible to the disease.* In such herds the method of isolation should be to remove the *non-reacting cows* to a newly built stable if possible. They should at least be placed in a stable in which cows have not been kept for some years. Every possible means should be taken to prevent the introduction of infectious material from the diseased herd. A clean bull must be used for these cows. All heifers and purchased cows must be tested before admitting them to the clean herd. All cows in the new herd should be tested at intervals to see that none have become infected.

Such methods of "New herd building" as briefly outlined, have been successfully used in the eradication of tuberculosis. It is believed that in connection with these tests, such methods can be applied to this disease. If the infection can be prevented from reaching the healthy herd the disease will gradually die out. It is possible that after two or three years it will no longer be necessary to maintain such strict isolation.

In herds, where for practical reasons, it is impossible to employ such an extensive isolation, it is possible that some protection may be given the non-infected animals by placing them in one end of the barn, while all reacting cows are placed at the other. A temporary partition could be erected and separate pastures provided.

Since it requires several years to obtain definite experimental proof of the effectiveness of such methods, we can, at present, do no more than express our belief in their efficiency. In the course of time we hope to report the results of a number of definite experiments along these lines.

In the meantime the Experiment Station offers its services and advice to any breeders who may wish to put these methods into practice. More detailed directions for drawing the blood samples and appropriate sterile vials will be sent to any breeder in the State who may wish to have his cows tested.* We are interested in testing these methods further on a practical basis and will be glad to correspond with breeders or veterinarians who may be interested.

SUMMARY.

1. Recent investigations have shown that infectious abortion of cows in this country is undoubtedly caused by the same organism as that found in Europe. The disease is very widely spread and is causing much more loss than is usually recognized.

2. The disease is transmitted from one cow to another in several ways. Perhaps the two most important methods are by means of the bull and through the alimentary canal. It is certain that many animals become infected in many other ways than by the bull.

3. Not every cow which has been infected will abort. There are two possible reasons for this. First, the abortion is only a symptom of the disease. If the infection, which is located in the uterus, is not very severe, the calf may be born at full term. Second, the cows undoubtedly acquire some measure of immunity after one or two attacks. If the first infection is not too severe a cow may become immune without aborting.

*Whenever it is possible, it will be better to have the blood samples drawn by a competent veterinarian.

4. There are no well marked symptoms by which the disease can be recognized before the abortion occurs. In some cases the swelling of the udder and vulva indicate the approaching abortion. The same symptoms may occur in cases of accidental abortion.

5. After the abortion it is often possible to identify the abortion bacilli, if present, by the microscopical examination of material from the foetus or afterbirth. This method, however, is not always reliable.

6. Likewise, by means of appropriate methods it is often possible to grow the abortion bacilli in the laboratory. However, this organism is very difficult to grow under laboratory conditions. In many cases the bacteria can be identified in smear preparations and it will still be impossible to obtain a growth by any of the methods used.

7. While in many cases the disease can be diagnosed by means of microscopical and bacteriological examinations these methods can be used only after the animal has aborted. The problem of diagnosis has not been solved until it is possible to distinguish infected animals before the act of abortion. Further, many infected animals do not abort, although they may play an important part in spreading the disease. Three methods have been proposed for the diagnosis of this disease in animals which have not aborted.

8. McFaydean and Stockman first proposed the use of a substance similar to tuberculin and mallein. They called this "Abortin." Tests of this method both in England and in Austria have not proven satisfactory. The difference between the temperature reaction of some non-infected and some infected animals is not sufficient to be of diagnostic value. Further, some animals which reacted to other tests failed to react to the abortin test, and *visa versa*.

9. The method of agglutination has been tested by a number of investigators. In a majority of tests it has proven satisfactory. When used alone it cannot always be relied upon. The blood of some non-infected animals will agglutinate the abortion bacilli in dilutions as high as 1 to 50. On the other hand the blood of some infected cows will not agglutinate these bacilli in dilutions higher than 1 to 20. Agglutination in dilutions of 1 to 100 and higher may be regarded as practically certain evidence of infec-

tion. Of the cows which agglutinate between 1 to 20 and 1 to 100 some may be infected and others not. (Compare tables 6 to 10.)

10. The third method of diagnosis is that of complement fixation. This is a more reliable test than either of the preceeding. The technic of the test is somewhat complicated and consequently difficult to use. From the evidence so far accumulated, it appears that animals which show a distinct reaction with this test may be regarded as having been infected with the abortion organism.

11. Following the suggestion of Wall, both the agglutination and complement fixation tests have been used on all cows examined. No cow has been regarded as certainly infected unless she reacted to both tests. In general, as shown in tables 6 to 10, the results of the two tests agree. In some cases, however, cows will show agglutination with 0.05 or 0.02 c. c. of serum but show no fixation of the complement. While the complement fixation test appears to be the more specific, the agglutination serves as a check upon the results. It is possible that after the accumulation of sufficient data the present methods can be somewhat simplified. Until that time, it will be more accurate to use both tests and to regard an animal as "reacting" only when she shows both agglutination and fixation of the complement.

12. These tests will not distinguish between cows which have become immune to the disease and those which have an active infection. Consequently all reacting cows will not abort. It may be said that *all reacting cows are or have been infected. Non-reacting cows are not infected and are not immune.* It is these latter cows which are most susceptible to the disease. Experience has shown that in badly infected herds most of the abortions occur among the heifers and the newly purchased cows.

13. The detailed results of testing four herds (181 animals) are given in tables 6 to 9 inclusive. Some of these results are summarized in table 10. From an examination of these tables it is seen that in general the results of the tests agree with the conditions found in the herds. Somewhat less than half of the reacting adult animals have aborted. Of the remainder of these reacting cows, some have probably become immune, in others the infection was not severe enough to cause an abortion, while still others will yet abort. Five of the thirty-four aborting cows showed no re-

action. These abortions were probably due to some other cause than the infectious disease. The number of tests reported is too small to draw conclusions concerning average percentages.

14. One of the most successful methods of controlling abortion in a herd has been the isolation of the aborting cows. By the use of the methods described in this bulletin the cows may be isolated before they abort. It is further possible to isolate those infected animals which may not abort but which may serve to spread the disease. It is believed that these methods will be of great aid in stamping out this disease, especially in herds where it has recently been introduced. If every purchased cow were tested before admitting her to a healthy herd, the introduction of the disease could be prevented. Since some cows may be infected and still carry their calves to full term, the presence of a living calf is not sufficient evidence that the cow is not infected.

* * * *

During the summer of 1911, the writer visited a number of European laboratories. In particular, several weeks were spent in laboratories of Professor Dr. C. O. Jensen and of Professor Dr. B. Bang, in Copenhagen, Denmark. To these gentlemen, and also to Dr. Halfdan Holth, assistant in Professor Jensen's laboratory, and to Dr. Oluf Bang, the writer wishes to express his sincere thanks for the many courtesies received. Before leaving this country the writer carried out a number of preliminary experiments on the use of complement fixation and satisfied himself of its applicability to the diagnosis of this disease. Since visiting the Danish laboratories a number of points in the technic of these tests have been modified to conform with those used in Professor Jensen's laboratory. In most instances due credit for these modifications have been given in the body of this paper.

The writer is further indebted to his assistant Mr. G. C. Routt for carrying out much of the routine work in these tests; to Professor E. S. Good for introductions to breeders in this state; to Professor L. E. Nollau for the photographs for figures 5 and 6; and also to those breeders who have kindly placed their herds at our disposal for these experimental tests.

NOTE.—While the proof of this bulletin was being paged, Dr. Graham called the writer's attention to an article by McFadyean and Stockman, which had just reached our library. (The Agglutination Test in the Diagnosis of Bovine Contagious Abortion.—Journ. of Comp. Path. and Therap. vol. XXV, pt. 1, pp. 22-39, 1912.) In this article the results of tests on nearly 700 animals are given. Of these 535 were steers, bulls and calves, which *a priori*, were assumed to be non-infected. Of this latter number only nine showed agglutination in the dilution of 1 to 50; four, in the dilution of 1 to 100 and only one gave complete agglutination in the dilution of 1 to 200. Of 127 animals which had either aborted or came from infected herds, 62 (nearly 50 per cent.) gave some agglutination, although only 38 agglutinated in the dilution of 1 to 100 or more.

The results of this paper are in entire accord with the results of the present investigation. However, it is believed as pointed out on page 358 of this bulletin, that a much more reliable diagnosis, especially in doubtful cases, can be made by the use of complement fixation in addition to the agglutination.

KENTUCKY

Agricultural Experiment Station

OF THE

STATE UNIVERSITY

BULLETIN No. 167

Forage Poisoning or so-called Cerebro-Spinal Meningitis in Horses, Cattle and Mules

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LEXINGTON, KENTUCKY
September, 1912.
(367)

Kentucky Agricultural Experiment Station

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Correspondents will please notify the Director of changes in their postoffice address, or of any failure to receive Bulletins.

Address

KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Kentucky.

BULLETIN No. 167

Forage Poison in Horses, Cattle and Mules So-called Cerebro-Spinal Meningitis and Commonly Termed "Staggers."

BY
ROBERT GRAHAM.

During the fall and winter months of 1911 and 1912, letters were frequently received by the Experiment Station describing a peculiar and strange malady affecting horses, cattle and mules. Newspapers over the State frequently commented on the loss sustained by certain men in their community from a so-called "mysterious disease." An investigation and personal observation of this outbreak in Kentucky, in Mercer, Shelby, Fayette and Boyle counties, furnished conclusive evidence that the disease in question was forage poisoning, also called epizootic cerebro-spinal meningitis, and commonly termed "blind staggers," traceable in a majority of cases to unsound corn, fodder or fermented ensilage.

OCCURRENCE.

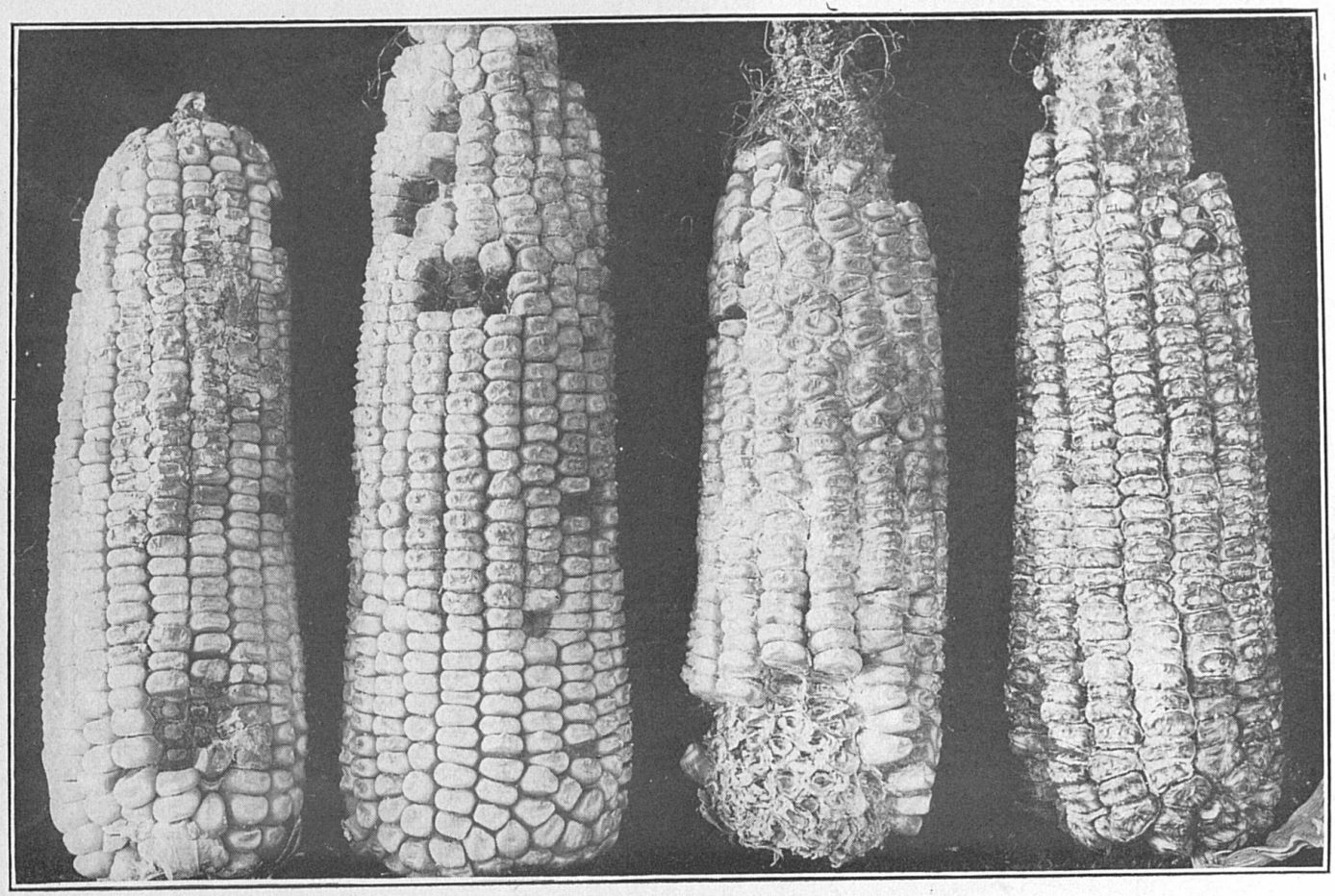
The disease assumed an epizootic form and occurred well scattered over the State, the heaviest losses being recorded in Kenton, Marion, Henderson, Boyle, Fayette, Warren, Scott, Mason, Marshall, Boone, Pulaski, Shelby, McCracken, Graves, Montgomery, Jefferson and Fleming counties. It attacked horses more than cattle, and cattle were more susceptible than mules. In one outbreak horses and cattle suffered on the same farm. The disease, however, more frequently affected but one species of animal and from one-tenth to three-fourths of the

animals in the herd. This was misleading to the farmer in that all the animals were receiving rations of the same food and water and living under practically the same surroundings. It can hardly be attributed to poisonous plants, for under such circumstances, a greater number of animals, kept under the same conditions, would have been affected.

In one outbreak one animal succumbed, though no further trouble occurred for one month, when five cows showed symptoms of the disease within four days, which strongly indicates that these five animals were exposed to the causative agent of the disease, at practically the same time. In the same herd, and under the same environment, the remaining twenty cows showed no evidence of ill health, though the feed was changed subsequent to the second outbreak. It attacked animals of all ages, varying from very young stock (not including sucklings) to aged and worn-out animals, showing no preference for working horses and mules, as compared with the idle in the stall, field or pasture. One attack with complete recovery does not confer immunity. It was more prevalent in fresh cows than in dry, due no doubt, to the quantity of feed consumed, but even this phase of the disease was not constant. It occurred on farms or in rural districts much more frequently than in cities, though city horses were attacked. It was not confined to any particular type of soil, occurring in low, wet lands, as well as in the hills and dryer districts; also on rich, productive land, as well as stony, gravelly, depleted areas.

It has been observed by veterinarians and stockmen that these outbreaks in Kentucky follow wet seasons, especially when preceded by a drouth, which causes a damp, sultry atmosphere, as was the case in Kentucky during the rainy fall months after the dry summer of 1911. Such climatic conditions are most favorable for the multiplication of molds which sometimes inhabit the grasses, corn stalk and corn kernels. While a majority of the cases have appeared when moldy corn, moldy corn fodder or moldy ensilage were fed, it is well to bear in mind that in damp seasons, as the fall of 1911, the grasses may also be contaminated and convey the destructive

No. 3—Corn as it was taken from crib. This was being fed exclusively at the time of one outbreak.



No. 3—Corn as it was taken from crib. This was being fed exclusively at the time of one outbreak.

agent when consumed by grazing animals. Water is a very important factor in spreading this contagion, as it has been shown experimentally that the consumption of water subsequent to its passage through moldy vegetation produced disease and thus contaminated water might naturally play an important role in transmitting the contagion in the low bottom lands, or even in high lands, where surface drainage gains entrance to deep wells or springs which furnish water to animals.

To control this disease and prevent the unaffected animals from contracting it, has been demonstrated possible in Kentucky, by discontinuing the feeding of moldy forage. This is not a curative step with animals showing symptoms, as a large percentage of the cases have been fatal even when receiving skillful medical attention. Very few cases have occurred after a complete change of feed was made. On one farm a complete change of feed was recommended to check the disease, and six cases appeared almost sitmultaneously between the fourth and seventh days following the change, but no further cases were reported, and it is safe to conclude that the infection gained entrance prior to the change of feed, after which time the disease had been incubating in the cases noted.

HISTORY.

The first description offered of this disease in the United States, was given by Professor Large, of New York, in 1850. Since that time, it has been described or referred to in a majority of the States under various titles, as "meningitis," "epizootic cerebro-spinal meningitis," "cryptogamic poisoning," "blind staggers," "mad staggers," "meningo-encephalitis," "encephalitis," etc., by such investigators as Haslem, Moore, Kinsely, Buckley, Pearson, Stange, Buchanan, Dalrymple, Nelson, Brimball, Wilson, Milks, and others. The majority of them conclude that the disease is produced by fermented, moldy vegetation or improperly cured or spoiled foodstuffs (corn, ensilage, fodder and grasses) which were infected with certain parasitic fungi, while others claim it is independent of the feed and of bacterial origin. The specific cause is not

agreed upon, but that it is closely associated with moldy feed is seldom questioned.

CAUSE.

A disease closely simulating this affection clinically has been recorded on the Continent and is known as Borna's Disease, due to a minute organism (streptococcus), and described by Dr. Ostertag, of Germany. He reproduced the disease by inoculation experiments on animals and they evidenced practically the same clinical symptoms that writers detail in this country under the aforementioned names.

The bacteriology of such outbreaks in this country has been studied by Wilson and Brimball, who describe a specific organism as the cause, as did Prof. Harrison, of Ontario Agricultural College, attributing it to a coccus isolated from the meningeal fluids. Dr. Milks, of Louisiana, was unable to isolate the organism described by these investigators, and states, after a thorough investigation, that "No micro-organism has been encountered that would account for the disease," nor could just conclusion be drawn from his studies that it was due to contaminated feed, but he recommends a complete change of food and water in outbreaks, to curtail the losses.

Dr. Haslam writes*: "Of the bacteria found upon the corn, one species (belonging to the Ærogenes group) is usually fatal to horses and rabbits when injected into their veins. It does not develop in the blood and often entirely disappears from it if the animal does not die for some time. Bacteria which have been heated to boiling for half an hour are just as injurious as the living ones. This bacterium is always present in the excrement of the corn ear worm and exists in large quantities in the so-called worm dust of corn."

Forage poisoning in this country has been referred to by

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*Bulletin 173, Meningo-Encephalitis, Kansas Experiment Station.

some as identical to pellagra*, but it seems that the evidence is not sufficient to substantiate their identity. No doubt, in many cases the phenomenon reminds one of that disease, but this outbreak showed but little similarity. It is very likely that as we gain more definite knowledge of the true pathology of cerebro-spinal meningitis in domestic animals, we shall recognize several species of fungi which infest vegetation as causing, directly or indirectly, one form of clinical cerebro-spinal meningitis, as Aspergillus glaucus (Mayo); Aspergillus flavus, niger; Rhizopus nigricans, Mucco rhizopodo formis and Fusarium, sp. (Schoenleber and Haslam); Monascus purpurens, Went (Strange and Buchanan). The nomenclature of such outbreaks associated with or which can be traced to spoiled vegetation should be confined to forage poisoning or cryptogamic poisoning, until some definite etiological factor can be proven.

MOLDS ATTACKING KENTUCKY CORN.

**Dr. H. Garman, of the Kentucky Agricultural Experiment Station, has recognized Trichothecium roseum, Aspergillus sp. Fusarium sp. Diplodia zeæ and several others, from corn which was being fed to animals previous to these outbreaks. He also states that the corn worm (Chloridea obsoleta) is prevalent in many fields in the State. With this information the following summary is quoted from Professor Haslam, of Kansas:

"1. Feeding horses upon immature corn badly infected with molds and worm dirt, with its accompanying bacteria, produces the typical disease of staggers.

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*The Journal of American Medical Association, July 6, 1912, pp. 33-35, "A Plea for an Earlier Diagnosis of Pellagra," by M. L. Ravitch.

**Bulletin No. 159, Kentucky Agricultural Experiment Station, A Preliminary Study of Kentucky Localities in which Pellagra is Prevalent, having Reference to the Condition of the Corn Crop and to the Possible Presence of an Insect or other Agent by which the Disease Spreads.

2. The extract of such corn is rapidly fatal to rabbits.

3. Aspergillus flavus, Aspergillus niger and Rhizopus nigricans have been found abundantly on corn only in localities which lose horses from staggers."

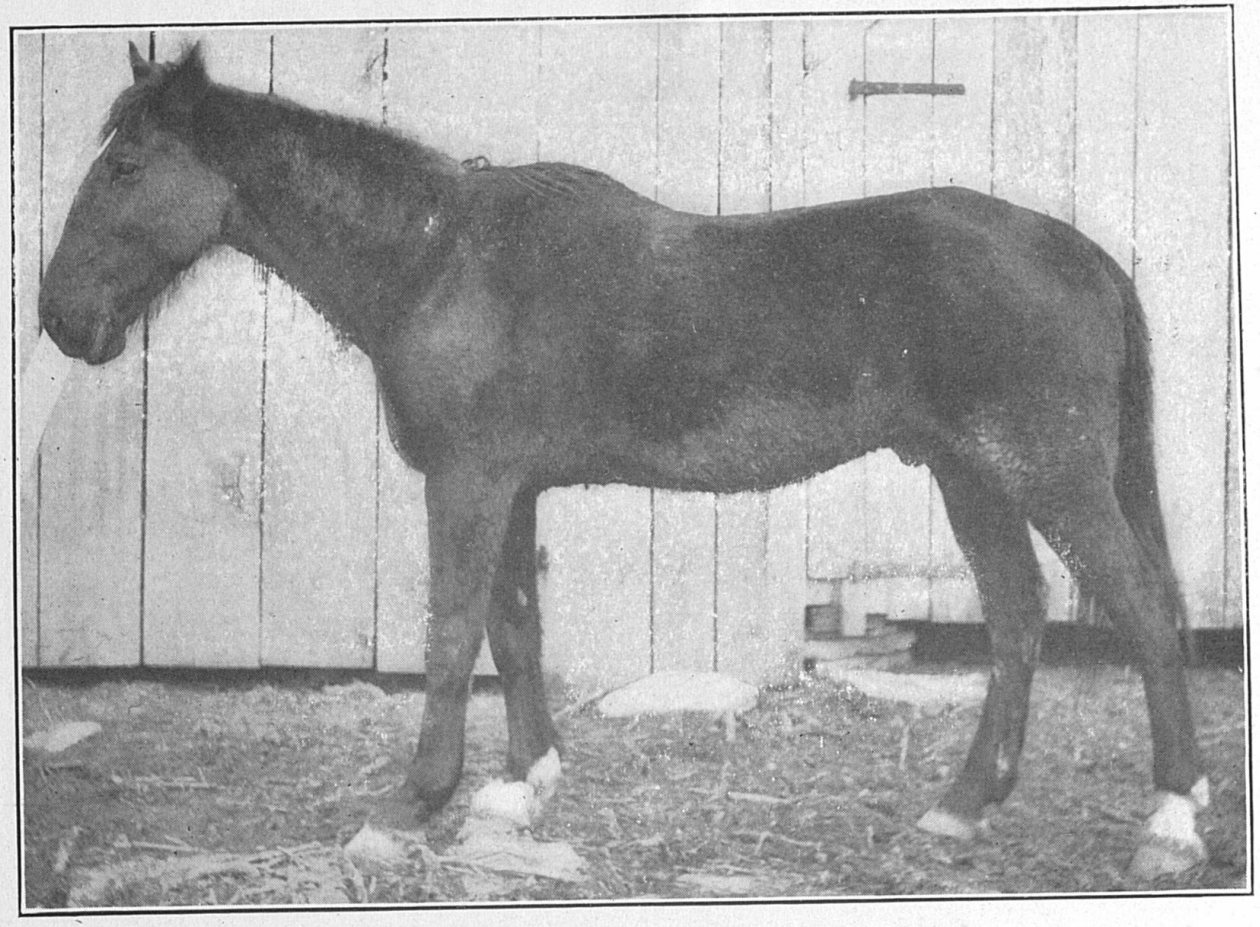
The presence of two of these molds described as the caustive factor in other States and found by Doctor Garman on the corn in Kentucky, combined with the fact that the disease was soon checked by discontinuing the moldy feed, is very strong evidence that these fungi played an important, if not a specific role in this disease. No feeding experiments were conducted at the Experiment Station to prove that Aspergillus sp. or Fusarium sp. with its accompanying bacteria, were responsible for the outbreak, but the aforementioned experimental evidence, that these fungi proved fatal in Kansas, together with the fact that losses were checked when inferior vegetation was discontinued points strongly to the fungus theory in the Kentucky outbreak. Some State Experiment Stations have conducted experiments by feeding horses, sheep and cattle on moldy feed, with negative results, but the influence of the time of the year, the locality and the season undoubtedly explains why loss does not always follow the use of moldy feeds.

Dr. Klimmer, of Berlin, one of the leading German veterinary authorities, in commenting upon such negative results, issues a warning against the use of such feed, saying that "the frequent losses of stock following the use of moldy feed renders it very probable that the experiments were not sufficiently extensive from which to draw conclusions."

TYPES OF THE DISEASE.

That the symptoms and course of the disease are not uniform in their intensity is very evident from reports and observations in this outbreak. Animals in the same locality and same herd show general symptoms which vary greatly in the degree manifested. It was often observed in cattle that the first animal affected in the herd died much sooner than animals subsequently attacked. In this regard it resembled an infectious disease, as the last animals attacked did, in many

No. 4—Note the braced position and dull expression. This animal when walking showed an irregular gait, and walked directly into fences, buildings, etc.



No. 4—Note the braced position and dull expression. This animal when walking showed an irregular gait, and walked directly into fences, buildings, etc.

cases, recover. Some made a complete recovery from a mild or chronic form of the disease, only to succumb in a few days or a few weeks' time on a recontraction of the disease, showing that one attack confers no resistance to a second one.

So varying has been the course of the disease that it might be described as occurring in two and perhaps three types; the acute, or rapidly fatal; the sub-acute, which generally ends in death, and the chronic, or milder form, from which the animal under proper care and treatment, may recover.

THE ACUTE TYPE.

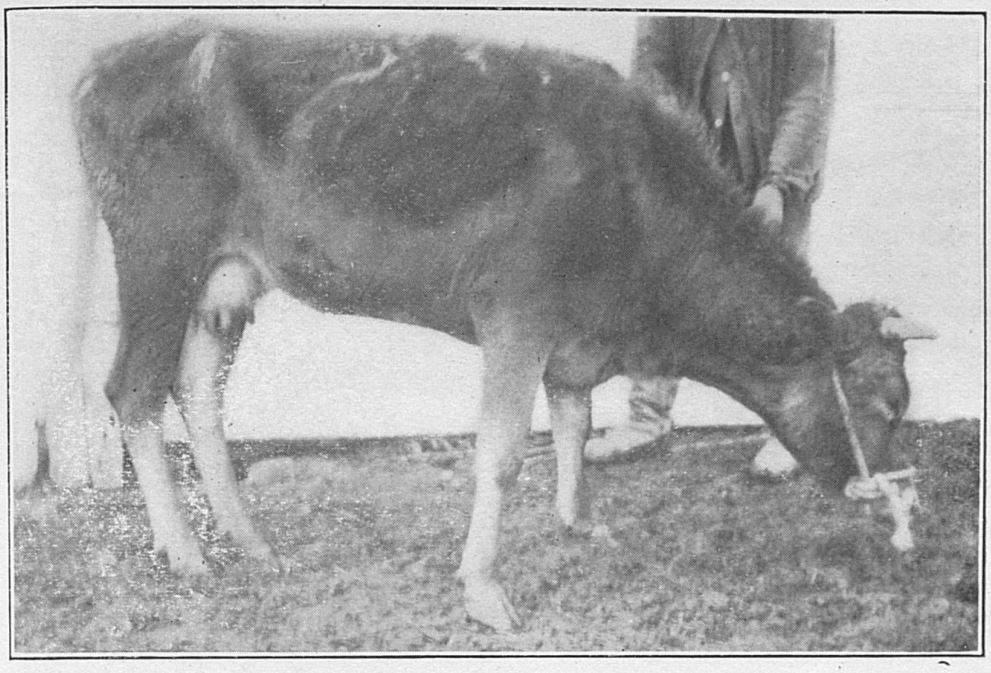
This form of the disease has been more prevalent than any other, especially in horses and mules. Animals so affected succumb in from two to three days from the time the first clinical symptoms were manifested. So suddenly have some of the cases developed that practically no premonitory symptoms were noted by the owner. Animals were frequently found dead in the morning that evidenced no symptoms of ill health to the owner on the previous day. Horses were attacked at work in the field and died within a few hours. In one case, at Mt. Sterling, Ky., an apparently healthy horse was driven to town and on the road home was seized with convulsions and succumbed almost immediately. The per-acute types of the disease have been mistaken for acute poisoning and numerous samples of stomach contents from such animals have been received by Dr. A. M. Peter, Chief Chemist at the Experiment Station, for chemical tests and examination. Such animals were probably uneasy and nervous prior to convulsions, but such symptoms, not being very pronounced, could easily have been overlooked, until the animal fell, suffering with acute convulsions which ended in death.

THE SUBACUTE TYPE.

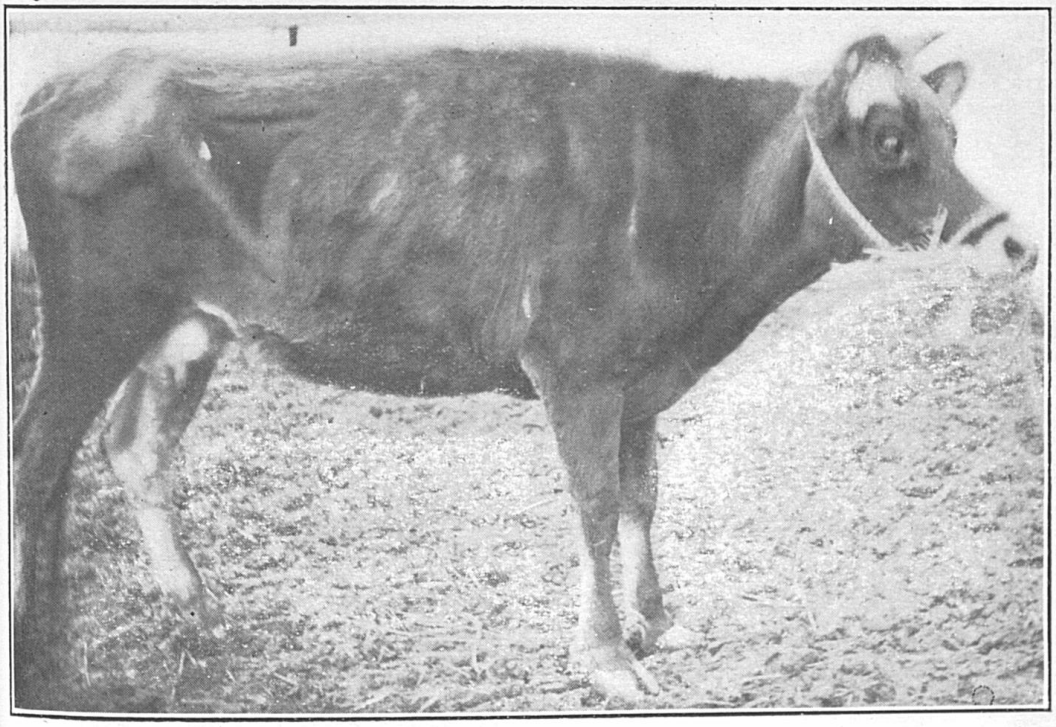
The symptoms of a majority of the acute cases were of a longer standing (12 to 72 hours), while sub-acute cases were of 3 to 9 days' duration. The first thing noticed was an irreg-

ularity in the gait of the animal, possibly in one or both hind legs, and gradually becoming more pronounced. This condition was usually accompanied by stupor. If the animal was at rest, the first symptom most frequently observed was a sleepy, dull disposition, with the head hung low and the eyes almost closed, as if asleep. This condition was often followed or alternated with excitement. Sometimes the animal seemed restless and preferred to walk, generally moving with an irregular and unsteady gait, in a circle, either to the right or left. When standing, as the disease advanced, the muscles of the face were drawn, and irregular jerking of the neck, body and rump muscles was observed, which symptoms were later followed by muscular weakness, the animal remaining in epileptoid tremor. In this stage the animal presented an excited attitude, the eyes showed an anxious expression and the animal walked directly into objects. When in the stall, the animal often stood in a braced position against the manger. There was generally paralysis of the pharyngeal muscles, making deglutition difficult or impossible. This was not constant, for some animals would eat and drink with ease between spasms. A majority of cases, however, partially masticated the feed, but made no attempt to swallow. Animals were observed carrying hay between the lips just as it was picked from the manger, but, in the semi-conscious state, did not masticate it. The symptoms of excitement alternated with stupor. During severe convulsions, the animal may fall. When down, it may remain quiet as if asleep, or die in convulsions.

The temperature varied from subnormal to 105 (normal in horses and mules 99.5—101.3, cows 100.4—102.2) and the disease was more serious in this outbreak when the animal showed evidence of a subnormal temperature than when the temperature registered above normal. In some cases the poll was warmer than other parts of the body, but not without exception. The appetite was, generally speaking, absent and the animal rapidly became emaciated. The body excretions (urine and feces) were scanty and, in cases of a week's standing, nasal mucous collected about the nostrils. The nasal discharge was slimy and of a foul odor, as was the saliva and



No. 1—Derangement of the central nervous system is shown in stupidity, paralysis of the muscles of deglutition, grinding of the teeth and somnolence—characteristic of the subacute type.



No. 2—This animal showed first symptom one week previous to time picture was made. She was exceedingly nervous and walked from one end of the pasture to the other in an excited manner. When standing she suffered muscular tremors. When food was offered, she would prehend the food but neglect to masticate or swallow. The above picture illustrates the semiconscious state and shows hay in the mouth.

partially masticated food in the mouth. The mucous membranes of the nasal cavities and mouth presented a yellowish, but sometimes bluish tinge. The conjunctiva was a pale yellow with few scattered petechiæ. Animals sweat profusely during convulsions in some cases.

Respirations during convulsions were increased to 40—60 per minute (normal 12—18 per minute in horse and mule, cow 10—30). In pronounced cases the nostrils were much distended. During profound stupor this characteristic was not so marked and in some cases there was a subnormal number of respiratory movements. The pulse was accelerated but frequently small and imperceptible.

The symptoms of the chronic form are mild, such as loss of appetite, dullness, slight incoordination in walking, followed by recovery in two or three days.

The following questions were sent to the graduate veterinarians of this State:

1. Have you observed a disease which resembles forage poisoning, cerebro spinal-meningitis, cryptogamic poisoning or blind staggers, and under what name do you describe the affection in your locality?

2. How many cases have you had in cows; horses; mules; hogs?

3. How many cases of recovery have you had in cows; horses; mules; hogs; after they showed symptoms of the disease?

4. Were all the outbreaks under your observation receiving corn or corn fodder? If not, do you remember what kind of feed was given the animals? Was the corn fed inferior and overgrown with mold?

5. Have you observed outbreaks where all the animals (one species) were affected fatally? How many in the herd? Have you observed it affecting two species of animal receiving the same feed on the same farm?

6. Have the outbreaks you have noticed been acute or chronic forms of the disease?

7. How long did it take the disease to run its course?

8. What was the first symptom observed?

9. Have the animals under your observation affected with the disease in the chronic form been, without exception, able to eat and drink?

10. If so, what was the mortality in the animals that were able to eat and drink when affected.

11. In your general practice, do you distinguish a case of forage poisoning (fungi poisoning) from cerebro-spinal meningitis? If so, what is the point of difference in diagnosis?

12. What treatment has given you the best results?

13. Will you describe the symptoms you have observed in animals affected with this malady? If you are accustomed to differentiating "forage poisoning" and cerebro-spinal meningitis, what are the symptoms observed by which you differentiate these diseases?

14. Have you found any constant post-mortem lesions?

Doctors Miller, Land, Shannon, Lang, Hobbs, Youngblood, Casey, Gray, Mumma, Moody, Gough, Crisler, Tibbals, Fischer, Sutherland, Robinson, Stamper, Purdy, Mussellman, Pontius and others furnished the data for the following tabulation, which indicates to some extent the mortality of this outbreak. Other information gained through the above men, in answer to the above questions, has been incorporated in the bulletin so as to render the information of a more general nature to the stockman and farmer.

The author wishes at this place to express his appreciation of the information given by these gentlemen.

COUNTY	Cows Affected	Deaths	Horses Affected	Deaths	Mules Affected	Deaths	PRINCIPAL FEED
Boone	..	..	1	1	..	..	Moldy corn and corn fodder.
Boyle	11	10	65	52	19	19	Mold corn, corn fodder and ensilage.
Fayette	12	9	40	29	15	10	Moldy corn and fodder.
Fleming	3	3	30	17	..	..	Moldy corn, grass. No fodder.
Graves	2	..	60	31	5	5	Moldy corn and corn fodder.
Henderson	15	8	38	24	6	2	Moldy corn and corn fodder.
Jefferson	30	22	150	144	50	50	Moldy grass, hay, corn, sugar cane, and corn fodder.
Marion	..	..	3	3	..	..	Moldy corn and corn fodder.
Marshall	1	0	20	15	..	..	Moldy corn and hay stalk field.
Mason	..	..	11	9	..	..	Moldy corn and fodder.
McCracken	4	4	50	30	1	1	Moldy corn and oats.
M'tgomery	15	13	31	28	..	..	Moldy corn and timothy hay.
Pulaski	24	21	26	18	6	5	Corn fodder, musty hay, some grass and no grain.
Scott	4	2	27	14	3	3	Moldy corn fodder and ensilage.
Shelby	7	5	48	43	4	0	Moldy corn.
Warren	6	3	12	7	6	4	Moldy corn.
Total	134	100	612	465	115	99	

It can be seen from the foregoing tabulation, which gives only the statistics of a part of the State, that Kentucky has recently sustained a heavy loss from this disease. With the exception of one or two authentic cases, when the disease occurred corn was the principal food. This is strong evidence that moldy corn was the cause of these losses, and in other cases the feed was musty and inferior. It is well known that the corn in 1911 was very inferior and, in all cases investigated where animals died, we have found it to be moldy. In horses on pasture the grasses might also have been fermented and overgrown with molds, thus being capable of causing death by any poisonous or noxious substance which might have been formed from improper curing.

POST-MORTEM LESIONS.

For the number of cases observed by the different veterinarians, but few detailed post-mortems were held. The

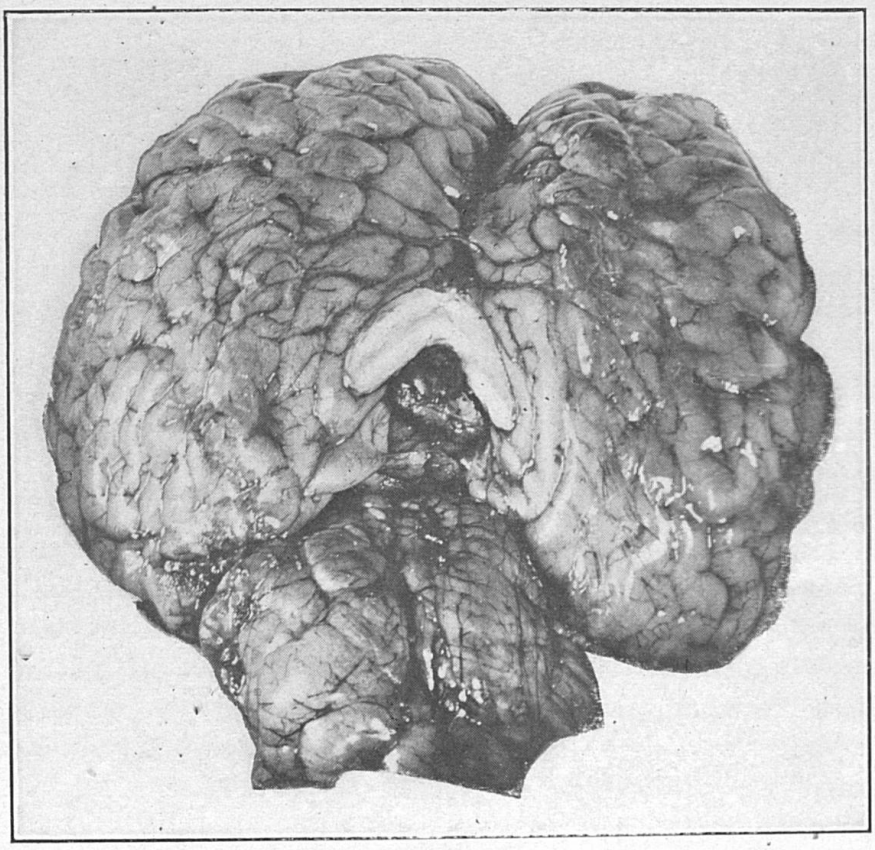
heads of four horses, two cows and one mule were received and a careful bacteriological examination of the brains of these heads was made by Professor E. S. Good and the writer, with no encouragement as to settling the etiology of the disease, from a bacteriological standpoint. In all these cases, with the exception of one cow, the meninges showed marked congestion, the inner covering being, in most cases dark, either in circumscribed or diffuse areas. In two cases there were blood clots at the base of the brain and from their appearance we judged them to be of an ante-mortem variety. In the cerebral area of a mule, one horse and two cows' brains there were areas of softening, which marked a distinct change from the remaining portions, by a yellowish color, and showed no areas of congestion. No fluid was observed under or within the meninges, but in one case (horse) there was a yellowish, clear fluid between the convolutions of the brain. Petechiæ were scattered in the white and gray substances and the ventricles contained small clots of blood in each case examined. The nasal septum showed congestion. The most consistent lesion, from our experience, is a congestion of the meninges of the brain.

H. J. Milks writes as follows:*

"In our investigations the post-mortem lesions were based upon five cases. In all cases the blood vessels of the meninges of the brain showed congestion. Otherwise the brain substance and cord appeared normal. Cross sections of the brain and medulla showed much ecchymosis and extravasation of blood. In some cases there was fluid beneath the dura; in others only a slight amount. No softening or other microscopic lesion could be detected.

The blood was usually dark and did not clot readily. Heart was usually normal, but frequently contained antemortem clots. The lungs were normal, except for a slight hypostatic congestion on the under side. The digestive tract was apparently normal, except that the posterior end usually contained much dry fecal matter. In one case there was

*H. J. Milks, Louisiana Bulletin No. 106. A preliminary report on the So-called Cerebro-spinal Meningitis of Horses.



No. 5—Note the injection of blood vessels and depression in right cerebral hemisphere.

marked congestion of the last fourteen feet of the small intestine. In another case there was slight congestion. However, this condition did not show from the exterior and may have been overlooked in other cases.

The liver usually contained much blood, spleen normal in size and appearance and might contain much blood or be very dry. The kidneys showed a slight congestion, but were otherwise normal in appearance. The bladder usually contained apparently normal urine.

Microscopic examinations were made of the brains and kidneys of two horses and the liver, spleen and intestines of one. Briefly stated, there was shrinkage of certain of the cells of the nervous tissue of the brain and inflammatory conditions, especially around the blood vessels. The blood vessels also contained much blood. The kidneys and liver showed some granular degeneration and congestion. In one case the blood vessels of the kidneys showed a similar condition to those of the brain. The spleen appeared normal, except for the large number of white blood cells."

PREVENTION AND CURE.

The high death rate recorded in the recent outbreak in Kentucky shows that no medicine can be depended on to cure. If treatment is given early some of the animals can be saved by administering purgatives. Various worthless empiric remedies are used which merit no attention. Purgation is the most successful line of treatment, though, in many cases, death occurs before the ordinary purgatives have time to produce peristalsis. Arecoline (1 to 2 gr.) or eserine (1 to 2 gr.) and pilocarpine (1 to 2 gr.), subcutaneously, or barium chloride (10 to 20 gr.) intravenously should have the preference when an immediate brisk action of the bowels is desired. By the above treatment, action is, by no means, insured. The ordinary purgatives, such as aloes, calomel, oils and magnesium sulphate may be used, but the physiological action is not acquired in time to save the animal. Drs. Miller and Lang, both of Louisville, record slight

success in treating this disease by intravenous injections of a solution of potassium permanganate. When the animal is unable to swallow, as is often the condition, there is danger of producing aspiration pneumonia in administering a medicine by the mouth. The stomach tube, however, may be employed to avoid this complication. Morphine, bromides, chloral, etc., are often employed to quiet an enraged animal. In cases of long standing, when the animal is weak, chances of recovery may be increased by the use of slings and liberal doses of stimulants, such as alcoholic spirits or nux vomica. When the animal is convalescent, potassium iodine in drachm doses is recommended. To check the flow of blood to the brain and establish normal blood pressure, ice or cold applications may be applied to the region of the poll. Aconite, ergot or veratrum viride may be used for the same purpose. Blood letting is recommended by some and condemned by others, and this treatment depends a great deal upon the stage of the disease in which it is practiced.

Affected animals should be removed to a clean, dry, well ventilated, airy stall. A complete change of feed is of paramount importance, and when made the disease was checked and proved to be a real benefit in chronic cases, aside from preventing development of new cases. The animal should be tied in a well bedded box stall to avoid any injury being inflicted upon himself during convulsions, which may appear at any stage of the disease, without warning, and which may be accompanied by violence. The owner should not unduly expose himself, in controlling or quieting the animal during such moments, as the gentlest family horse may assume a vicious attitude. Stalls for violent animals should, if possible, be padded and kept scrupulously clean. Disinfectants should frequently be sprayed on the floor and wall. A solution consisting of 6 ounces of chloride of lime to one gallon of water; liquor creosolis compositus or carbolic acid in 5 per cent solution in water is recommended for this purpose.

It is very evident that the best method of combating this disease lies in prevention. Moldy, improperly cured, fermented or damaged feed should not be fed to animals. If nec-

essary it should be given sparingly and mixed with some other feed of good quality. Good results can be obtained in preventing this disease, by floating the feed. All corn which was fed during the winter of 1911 and 1912 at Elmendorf, one of the largest stock farms in the United States, was ordered floated by Dr. Hagyard, to avoid this disease. The damaged corn rises to the surface and is skimmed off; the sound kernels sink and can be fed to horses, cattle and mules with safety. Dr. Hagyard has, by this simple method of prevention, avoided a single case in the Elmendorf herds, and it is to be recommended as an easy, effective method of preventing or checking this disease.

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KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE

STATE UNIVERSITY

BULLETIN No. 168

COMMERCIAL FERTILIZERS

LEXINGTON, KENTUCKY
DECEMBER 31, 1912

385

Kentucky Agricultural Experiment Station

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The Bulletins of the Station will be mailed free to any citizen of Kentucky who sends his name and address to the Station for that purpose.

Correspondents will please notify the Director of changes in their postoffice address, or of any failure to receive Bulletins.

Address
KENTUCKY AGRICULTURAL EXPERIMENT STATION
Lexington, Kentucky.

BULLETIN No. 168

Analyses of Commercial Fertilizers

The matter of plant food is all important in purchasing fertilizers. When a farmer buys a ton of an average commercial fertilizer he buys in reality only about 300 pounds of actual plant food. If he buys a cheap fertilizer he gets less than this amount. If he buys a high grade fertilizer he may receive as much as 600 pounds. It costs as much to mix a ton of fertilizer containing 300 pounds of plant food as it does one containing 600 pounds. The cost of sacking, hauling, and freighting is the same. Therefore, it is evident that the manufacturer can sell the plant food in a high grade fertilizer cheaper per pound than he can the plant food in a low grade fertilizer. In other words the higher the grade the cheaper can the plant food be bought. Farmers are advised therefore to purchase only high grade fertilizers.

Attention is called to those brands which have less than two per cent. of ammonia or potash. Less than two per cent. of either of these ingredients is too small a quantity where such ingredients are needed, and where not needed it is useless to purchase them. It is an utter waste of money to purchase potash or ammonia in fertilizers containing less than one per cent. of these ingredients.

Number of Brands. There were 672 different brands of commercial fertilizers registered during the year 1912. Of these different brands, 393 were complete fertilizers, or fertilizers containing all three of the essential ingredients namely: phosphoric acid, nitrogen and potash (non acidulated bone and potash mixtures are not counted in this

item); 79 acid phosphates or superphosphates, 11 nitrogenous superphosphates, 104 acid phosphates and potash mixtures, 79 bones, tankage and non-acidulated bone and potash mixtures; 4 potash salts, and 2 samples of nitrate of soda. Samples of these various brands sent by manufacturers have been analyzed, as well as samples collected by deputy inspectors and those sent by farmers, and the results are given in the tables which follow.

Results of Analyses. The results of these analyses show that in most cases the samples analyzed have come fully up to the guarantee, or, where there is a slight deficiency in one ingredient, it has been made up by an excess in one or both of the other ingredients. But in a few instances, the deficiency in one ingredient, while fully made up by an excess of the other ingredients, is still too low to be considered acceptable, this being due to bad mixing at the factory. In a few instances, there seems to be an inclination on the part of the manufacturer to guarantee higher percentages than their goods contain. Especially is this the case in a number of instances with respect to the guaranty on total phosphoric acid, where it is four or five per cent. higher than the guaranty on available phosphoric acid. In most of these the analysis shows that while the available phosphoric acid guaranteed is present, the insoluble and total phosphoric acid are both deficient. In some cases, however, the deficiency in insoluble phosphoric acid is made up by an excess of available phosphoric acid which is to be preferred, but in such cases the total phosphoric acid is not deficient. Although the insoluble phosphoric acid is of little value, at the same time we feel inclined to call special attention to these guarantees and hope that all persons who purchase fertilizers will carefully study the bulletins and see how the guarantees have compared with our analyses with respect to the available and total phosphoric acid. Some manufacturers also have used muriate of potash in making fertilizers in which the potash was guaranteed from sulphate.

Method of Reporting Results. The following changes

have been made in the method of reporting results. First: Nitrogen is separated into the various forms in which it occurs, namely, nitrogen in nitrates, nitrogen in ammonia salts and organic nitrogen. Second: In case of bones, the bone phosphate of lime equivalent is given and the percentage of fineness is shown also, fine bone being that which passes through a sieve with meshes one-twenty-fifth inch square, and medium bone that which passes through a sieve with meshes one-sixth inch square, but not including the fine bone. Third: The analyses are grouped under tables, the classification being based upon the nature of the fertilizer, as follows:

Table 1. Complete fertilizers.
Table 2. Bones, tankage and mixtures of bone and potash.
Table 3. Acid phosphates.
Table 4. Acid phosphate and potash mixtures.
Table 5. Nitrogenous superphosphates.
Table 6. Potash Salts.
Table 7. Nitrate of soda.

Free Analysis of Fertilizers. It is hoped that farmers who purchase fertilizers in quantity, at least, will take advantage of Section 8 of the fertilizer law, and send a sample to the Station for free analysis.

Essentials in Taking a Sample. 1. Take it at the time of purchase, and if possible in the presence of agent or seller. 2. Take a sample from not less than two bags, and from one additional bag for every ten purchased; mix these samples carefully and take at least a pint of this mixed sample, put into a fruit jar, seal, box and express to J. H. Kastle, Director, Lexington, Ky. 3. Take the sample in the presence of at least one witness, and have the witness sign the required certificate. 4. The certificate for free analysis to be sent *by mail,* and should be in accordance with the law as given in section 8.

If the sample is taken in accordance with the above directions it may be sent by express, and the charges will be paid by the Station.

Blank certificates will be furnished free upon application

to the Station. The section of the fertilizer law describing the manner in which samples are to be taken for free analysis is also printed on the certificate.

Values Used. In calculating the relative value per ton, the following values have been used:

Soluble and reverted phosphoric acid in mixed fertilizers	6 c lb.
Soluble and reverted phosphoric acid in plain acid phosphates	5 c lb.
Insoluble phosphoric acid in mixed fertilizers	2 c lb.
Phosphoric acid in fine bone	4 c lb.
Phosphoric acid in medium bone	3 c lb.
Nitrogen in all fertilizers	17½c lb.
Potash in all fertilizers, from sulphate	6 c lb.
Potash in all fertilizers, from muriate	5 c lb.

The term "Potash from muriate" does not indicate necessarily that the manufacturers used muriate of potash in furnishing the potash; they may have used sulphate of potash, or other salts of potash, but in all fertilizers where the term "Potash from muriate" is used there is enough chlorine present to combine with the potash, either from salt in the tankage used, or the potash salts used as muriate, kainit, carnallite, etc. As the objection to the use of muriate of potash arises from the chlorine present in this salt, it likewise follows that chlorine in a fertilizer is objectionable, whether put in with the potash or otherwise. The using of sulphate of potash where there is chlorine present in other ingredients of the fertilizer will not obviate the injurious effect of the chlorine, and therefore we take this method of showing chlorine present by designating the potash as "from muriate."

Explanation of the Table. In the table of analyses, following the name of each brand will be found the analysis of the sample furnished by the manufacturer at the time the fertilizer was entered for sale and which was accompanied by an affidavit giving the guaranteed analysis. This is the analysis that is marked "manufacturer" in the column head-

ed "From Whom Obtained." If any other analyses of the same brand have been made, they will be found following this analysis. These samples have been collected by deputy inspectors or sent in by farmers. The manufacturer's guarantee is printed last in *italic* figures.

The figures in the table which are set in bold face type are those results which, in the judgment of the Director, were too low to be acceptable.

The names of the manufacturers are arranged in alphabetical order, and all the analyses of the same brand have been grouped together.

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	A. D. Adair and McCarty Bros., E. Chattanooga. Tenn.	
39071	David Harum Extra High Grade Guano	Manufacturer
39124		D. M. Brakefield, Adairville
39072	Adair's Soluble Pacific Guano	Manufacturer
39125		D. M. Brakefield, Adairville
39073	Adair's Standard Tobacco Grower	Manufacturer
39126		D. M. Brakefield, Adairville
39087	High Grade Special Tobacco Grower	Manufacturer
39088	Big Leaf Tobacco Producer	Manufacturer
39109	Furman High Grade Fertilizer	Manufacturer
	The American Agr'l Chemical Co., Cincinnati, Ohio.	
38566	Complete Fertilizer	Manufacturer
39128		Hines, Lowry & Co., Science Hill
39413		Coomer & Gowan, Sparksville
38568	High Grade Tobacco and Truck Fertilizer	Manufacturer
39130		J. B. Taylor, Lewisport
39415		J. H. Dodson, Maysville
38569	Special Potato and Vegetable Manure	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
10.69	1.12	11.81	0.88		1.95	2.83	3.44	4.61		$27.80	39071
10.37	0.31	10.68	0.79		2.28	3.07	3.73	4.25		27.56	39124
10.00						*3.29*	*4.00*	*4.00*		*27.52*	
9.97	0.83	10.80	0.86		0.70	1.56	1.89	2.06		19.81	39072
11.08	0.74	11.82	0.92		0.68	1.60	1.94	1.88		21.08	39125
10.00						*1.65*	*2.00*	*2.00*		*19.78*	
8.31	0.68	8.99	0.73		0.83	1.56	1.89	1.74		17.44	39073
8.79	0.45	9.24	0.88		0.67	1.55	1.88	2.09		18.25	39126
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
7.75	0.84	8.59	0.71		0.89	1.60	1.94	7.19		22.43	39087
8.00						*1.65*	*2.00*	*6.00*		*21.38*	
7.28	1.66	8.94				1.08	1.31	6.42		19.60	39088
7.00						*0.82*	*1.00*	*5.00*		*16.27*	
11.06	0.93	11.99	0.80		0.78	1.58	1.92	2.37		21.54	39109
10.00						*1.65*	*2.00*	*2.00*		*19.78*	
10.27	1.70	11.97		1.11	0.68	1.79	2.17	2.31		21.58	38566
11.21	0.99	12.20		1.52	0.70	2.22	2.70	3.06		24.67	39128
11.45	2.04	13.49		0.90	0.68	1.58	1.92	2.16		22.25	39413
10.00	*2.00*	*12.00*				*1.65*	*2.00*	*2.00*		*20.58*	
8.92	1.22	10.14		0.87	0.89	1.76	2.14	5.11		22.46	38568
8.11	1.95	10.06				1.56	1.89	5.43		21.40	39130
9.02	1.08	10.10		1.26	0.56	1.82	2.21	0.72	4.67	23.94	39415
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*5.00*		*21.18*	
5.29	0.94	6.23				0.97	1.18	9.70		19.83	38569
5.00	*2.00*	*7.00*				*0.82*	*1.00*	*10.00*		*19.67*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co.,	
38570	Kentucky and Tennessee Special Manure	Manufacturer
39131		J. B. G. Higgs, Elizabethtown
39416		F. C. Parrish, Horse Cave
	The American Agr'l Chemical Co., Bradley Fertilizer Works, Cincinnati, Ohio.	
38573	B. D. Sea Fowl Guano	Manufacturer
38574	Potato and Root Fertilizer	Manufacturer
38575	Corn and Wheat Phosphate	Manufacturer
39133		J. B. Taylor, Lewisport
39419		Coomer & Gowan, Sparksville
38576	Dissolved Bone with Potash	Manufacturer
38577	Niagara Phosphate	Manufacturer
	The American Agr'l Chemical Co., Cleveland Dryer Works, Cincinnati, Ohio.	
38582	Phospho Bone	Manufacturer
38583	Potato and Tobacco Fertilizer	Manufacturer
39421		J. H. Dodson, Maysville
38584	Ohio Seed Maker with Potash	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.19	1.40	9.59		1.15	1.36	2.51	3.05	5.74		$24 92	38570
8.02	1.29	9.31		1.17	1.23	2.40	2.91	6 25		24 79	39131
8.28	2.08	10.36		0.32	2.27	2.59	3.14	0.80	4.78	26 38	39416
8.00	*2.00*	*10.00*				*2.47*	*3.00*	*6.00*		*25.05*	
9.15	1.24	10.39		0.86	1.27	2.13	2 59	1.84		20.78	38573
8.00	*2.00*	*10.00*				*2.06*	*2.50*	*1.50*		*19.11*	
8.68	1.47	10 15		0.20	0.92	1.12	1.36	3.69		19.36	38574
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*16.27*	
10 28	1.73	12.01				0.98	1.19	1.31		17.77	38575
9.59	2.27	11.86				0.96	1 17	1.16		16.94	39133
9.54	2.98	12.52				1.14	1.38	1.40		18.03	39419
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*1.00*		*16.67*	
8.40	1.68	10.08		0.21	1.02	1.23	1.49	2.62		17.68	38576
8.00	*2 00*	*10.00*				*1.03*	*1.25*	*2.00*		*16.01*	
6.89	1.28	8.17				1.01	1.23	1.43		13.75	38577
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
10.02	1.77	11.79				0.90	1.09	1.28		17.16	38582
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*1.00*		*16.67*	
8 39	1 62	10.01				1.03	1 25	3.39		17.72	38583
7 94	2.64	10.58		0.21	0.81	1 02	1.24	3 25		17.41	39421
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*16.27*	
8.23	1 82	10.05		0.60	1.26	1.86	2.26	2.46		19 58	38584
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co., Bowker Fertilizer Works, Cincinnati, Ohio.	
38589	Bowker's Harvest Bone	Manufacturer .....
39139		Dunagan & Kirtley, Horse Cave.....
38591	Bowker's Fish Guano	Manufacturer .....
39141		Hines, Lowry & Co., Science Hill.....
38592	Bowker's Grain and Grass Grower	Manufacturer .....
39142		W. L. Anderson, Caneyville.....
39426		C. P. Clark, Owensboro.....
38593	Bowker's Kentucky Special...	Manufacturer .....
39143		Dunagan & Kirtley, Horse Cave.....
39427		Marcum, Gooch & Payne, Eubank...
38594	Bowker's Tobacco Grower....	Manufacturer .....
39144		Dunagan & Kirtley, Horse Cave.....
39428		T. E. Richeson, Campbellsville.....
38595	Bowker's 10% Manure.....	Manufacturer .....
39145		McCarley Hardware Co., Pembroke...
38598	Bowker's High Grade Fertilizer	Manufacturer .....
39147		Browning, McReynolds & Co., Lewisb'g
39429		T. E. Richeson, Campbellsville.....
	The American Agr'l Chemical Co., Michigan Carbon Works, Cincinnati, Ohio.	
38601	Red Line Complete Manure..	Manufacturer .....
39150		P. K. Hubbard, Munfordville.....
39432		A. A. Cross, Benton .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
8.44	1.70	10.14		0.21	0.82	1.03	1.25	1 64		$16.06	38589
10.05	1.85	11.90				0.98	1.19	1.58		17.81	39139
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*1.00*		*14.07*	
8.24	1.47	9.71		0.27	0.79	1.06	1.29	3.21		17.40	38591
7.28	1.71	8.99		0.41	0.52	0.93	1.13	2.72		15.40	39141
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*3.00*		*16.07*	
8.33	1.82	10.15		0.66	1.12	1.78	2.16	2 45		19.41	38592
6.92	2.22	9.14		0.65	1.00	1.65	2.00	2.27		17.24	39142
7.12	3.12	10.24		0.72	1.09	1.81	2.20	2.26		18.39	39426
8.00	*1.50*	*9.50*				*1.65*	*2.00*	*2.00*		*17.98*	
8.02	1.44	9.46		0.25	1.09	1.34	1.63	4 42		19.31	38593
8.12	1.71	9.83		0.41	1.12	1.53	1.86	4.20		19.98	39143
8.03	1.33	9.36		0.79	0.55	1.34	1.63	3 96		18.82	39427
8.00	*1.50*	*9 50*				*1.23*	*1.50*	*4.00*		*18.51*	
8.59	1.61	10.20		0.72	1 12	1.84	2.23		5.46	23.94	38594
7.32	2.14	9.46		1.01	0.81	1.82	2.21	2.18	3 20	22.03	39144
8.06	2.13	10.19		0.74	0.96	1.70	2.06	4.08	1.00	21.75	39428
8.00	*1.50*	*9.50*				*1.65*	*2.00*		*5.00*	*21.98*	
4 80	1.35	6.15		0.24	0.77	1.01	1.23	10.77		20.61	38595
5.83	1.19	7.02				1.10	1 34	10.55		21.88	39145
5.00	*1.50*	*6.50*				*0.82*	*1.00*	*10.00*		*19.47*	
8.80	1.36	10.16		1 56	1.02	2.58	3.13		6.00	27.33	38598
8.54	1.08	9.62		1.70	0.85	2.55	3.10	0.78	5.65	27.17	39147
8.14	1.28	9.42		1.52	0.66	2.18	2.65	2.24	3.39	24.22	39429
8.00	*1.50*	*9.50*				*2.47*	*3.00*		*6.00*	*26.05*	
7.48	0.82	8.30		0.21	0.82	1.03	1.25	1.49		14 41	38601
6.63	1.52	8.15				0.92	1.12	1.19		12.98	39150
7.00	1.07	8.07				0.85	1.03	1.12		12.93	39432
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co., Michigan Carbon Works,	
38603	Red Line Tobacco Manure ...	Manufacturer .....
39151		Bradford Brothers, Glasgow.....
38604	A-1 Potash Fertilizer	Manufacturer .....
39152		Woodson Lewis, Greensburg.....
39434		Norris & Lockett Co., Henderson.....
38605	Red Line Crop Grower.....	Manufacturer .....
39435		F. C. Parrish, Horse Cave.....
38606	Homestead Bone Black Fertilizer	Manufacturer .....
39153		E. S. Ferrell & Son, Buffalo.....
39436		J. C. DeHaven, Hardinsburg .....
38607	Homestead Potato and Tobacco Special	Manufacturer .....
39154		N. F. Hill, Bowling Green .....
39437		R. H. Kemp, Marion.....
38608	Homestead 10% Potash Manure	Manufacturer .....
39155		Bradford Brothers, Glasgow .....
38610	Homestead Tobacco Grower..	Manufacturer .....
39156		Young, Conway & Co., Morganfield...
39439		F. C. Parrish, Horse Cave.....
	The American Agr'l Chemical Co., North Western Fertilizing Co., Cincinnati, Ohio.	
38611	Horseshoe Brand 3-8-6 Fertilizer	Manufacturer .....
39157		Woodson Lewis, Greensburg.....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.54	1.30	9.84		0.25	0.78	1.03	1.25	3.44		$17.82	38603
8.16	1.59	9.75		0.22	0.67	0.89	1.08	3.21		16 76	39151
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*2.00*		*16.27*	
8.32	1.50	9.82		0.27	0.76	1.03	1.25	3.44		17.63	38604
7.40	1.28	8.68		0.46	0.57	1.03	1.25	3.43		16.43	39152
7.67	2.18	9.85				0.96	1.17	3.29		16.72	39434
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*16.27*	
8.47	1.36	9.83		0.66	1.17	1.83	2.22	2.45		19.57	38605
9.37	1.75	11.12		0.79	0.84	1.63	1 98	2.35		20.00	39435
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
9.02	1.06	10.08		0.93	1.19	2.12	2.57	1.87		20.55	38606
8.44	1.20	9.64		1.08	1.08	2.16	2.62	1.85		20.02	39153
8.66	1.44	10.10		0.86	1.15	2.01	2.44	1.32		19.33	39436
8.00	*2.00*	*10.00*				*2.06*	*2.50*	*1.50*		*19.11*	
8 64	1.53	10.17		0.97	0.85	1.82	2.21	5.22		22.57	38607
7.83	1.85	9.68		0.65	1.07	1.72	2.09	5.10		21.26	39154
8.41	1.98	10.39				1.84	2.23	4.60		21.92	39437
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*5.00*		*21.18*	
5.00	0.99	5.99				0.95	1.15	9.42		19.15	38608
5.00	1.48	6.48				0.81	0.98	10.61		20.04	39155
5.00	*2.00*	*7.00*				*0.82*	*1.00*	*10.00*		*19.67*	
10.60	1.21	11.81		1.46	1.63	3.09	3.75	3.51		28.23	38610
9.62	1.52	11.14		1.92	1.06	2.98	3.62	3.79		26.37	39156
9.76	3.09	12.85		2.16	0.56	2.72	3.30	4.30		26.77	39439
10.00	*1.00*	*11.00*				*2.88*	*3.50*	*3.50*		*25.98*	
8.57	1.17	9.74		1.25	1.31	2 56	3.11	5.98		25.69	38611
8.13	1.30	9.43		1.28	1.27	2.55	3 10	5.66		24.87	39157
8.00	*2.00*	*10.00*				*2.47*	*3.00*	*6.00*		*25.05*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co., North Western Fertilizing Co.,	
38612	Horseshoe Brand Tobacco Grower	Manufacturer
39158		E. S. Ferrell & Son, Buffalo
38613	Horseshoe Brand Special Onion and Vegetable Manure.	Manufacturer.
38614	Horseshoe Brand Challenge Corn Grower	Manufacturer
39440		Grayson County Supply Co., Leitchfield
38615	Horseshoe Brand Ky. Tobacco Grower	Manufacturer
39159		Hatter Hardware Co., Franklin
38616	Horseshoe Brand Corn and Wheat Grower	Manufacturer.
39160		E. S. Ferrell & Son, Buffalo
39441		E. P. Barnes & Bro., Beaver Dam
38617	Horseshoe Brand Acidulated Bone and Potash	Manufacturer
38618	Horseshoe Brand Potash Manure	Manufacturer
39442		John R. Nelson, Eubank
38619	Horseshoe Brand Dark Tobacco Grower	Manufacturer
39161		E. S. Ferrell & Son, Buffalo

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.66	1.28	9.94		0.95	0.87	1.82	2.21	5.22		$22 49	38612
8 30	1.45	9.75				1.62	1.97	5.52		21.73	39158
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*5.00*		*21.18*	
5.15	0.91	6.06				0.94	1.14	10.22		20.05	38613
5.00	*2.00*	*7.00*				*0.82*	*1.00*	*10.00*		*19.67*	
9.41	1.06	10.47		0.91	1.19	2.10	2.55	1.92		20.98	38614
8.63	2.13	10.76		0.83	1.26	2.09	2.54	1.84		20.37	39440
8.00	*2.00*	*10.00*				*2.06*	*2.50*	*1.50*		*19.11*	
8.29	1.47	9.76		0.66	1.21	1.87	2.27	2.36		19.45	38615
7.87	1.40	9.27		0.72	0.87	1.59	1.93	2.30		17.87	39159
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
8.45	1.53	9.98		0.65	1.14	1.79	2.17	2 46		19.48	38616
8.76	0.98	9.74		0.65	0.96	1.61	1.95	2.28		18.82	39160
7.70	2.50	10.20		0.59	1.01	1.60	1.94	2.47		18.31	39441
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
10.43	1.59	12.02				0.99	1.20	1.21		17.84	38617
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*1.00*		*16.67*	
8.17	1.61	9.78		0.25	0.82	1.07	1.30	3.43		17.62	38618
7.59	1.82	9.41		0.34	0.70	1.04	1.26	3.07		16.55	39442
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*16.27*	
7.09	1.17	8.26		0.20	0.81	1.01	1.23	1.55		14 07	38619
7.42	1.40	8.82		0.38	0.56	0.94	1.14	1.16		13.91	39161
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co., Packers Fertilizer Association, Cincinnati, Ohio.	
38628	Boar's Head Brand Faultless Grain Grower	Manufacturer
38630	Boar's Head Brand Ammoniated Bone and Potash	Manufacturer
38631	Boar's Head Brand Sure Growth Potash Manure	Manufacturer
38632	Boar's Head Brand Special Tobacco Grower	Manufacturer
38633	Boar's Head Brand Corn and Wheat Grower	Manufacturer
39447		J. H. Wyan, London
38634	Boar's Head Brand World of Good Superphosphate	Manufacturer
38635	Boar's Head Brand High Grade Vegetable Fertilizer	Manufacturer
39448		J. H. Wyan, London
	The Armour Fertilizer Works, Chicago, Ill.	
38961	Ammoniated Bone with Potash	Manufacturer
38963	Bone, Blood and Potash	Manufacturer
39167		Simpson County Hardw'e Co., Franklin

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
7.34	1.10	8.44				0.92	1.12	1.46		$13.93	38628
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
9.77	1.89	11.90				0.92	1.12	1.38		17.08	38630
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*1.00*		*16.67*	
8.05	1.70	9.75		0.24	0.83	1.07	1 30	3 33		17.42	38631
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*16.27*	
8.54	1.49	10 03		0.59	1.18	1.77	2.15	2.36		19.41	38632
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
8.57	1.50	10.07		0.58	1.20	1.78	2.16	2.37		19.48	38633
7.97	2.44	10.41		0.77	1.04	1.81	2.20	2.17		19.05	39447
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
9.47	1.10	10.57		0.83	1.23	2 06	2.50	1 82		20.83	38634
8.00	*2.00*	*10.00*				*2.06*	*2.50*	*1.50*		*19.11*	
9.15	1.25	10 40		0 86	0.94	1.80	2.19	5 04		22.82	38635
8.16	2.46	10.62		0.69	1.12	1.81	2.20	0.76	3.58	22.17	39448
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*5.00*		*21.18*	
6.97	9.36	16 33		1.50	1.24	2.74	3 33	0.64	1.77	24.45	38961
6.00	*1.00*	*7.00*				*2.47*	*3.00*		*2.00*	*18.65*	
8.69	0 87	9 56	0.26	2 22	1.89	4 37	5 31		8.55	36 34	38963
8.0[illegible]	2 55	10.63		1.21	1.29	2 50	3 04	2.78	2.96	25.80	39167
8.00	*1.00*	*9.00*				*4.12*	*5.00*		*7.00*	*32.82*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Armour Fertilizer Works,	
38964	Armour's Champion	Manufacturer .....
39450		Simpson County Hardw'e Co., Franklin
38966	Corn and Wheat Grower.....	Manufacturer .....
39452		Simpson County Hardw'e Co., Franklin
38967	Dark Tobacco Special	Manufacturer .....
39168		Herbert Bowles, Glasgow .....
39453		Finley Hardware Co., Madisonville...
38968	Grain Grower	Manufacturer .....
39169		E. S. Ferrell & Son, Buffalo.....
39454		Barren County Grocery & Hardware Co., Glasgow.....
38969	High Grade Potato Grower...	Manufacturer .....
39170		Todd County Hardware Co., Elkton...
39455		Finley Hardware Co., Madisonville...
38971	Record Brand	Manufacturer .....
38974	Tobacco Grower	Manufacturer .....
39173		E. S. Ferrell & Son, Buffalo.....
38975	Wheat, Corn and Oats Special	Manufacturer .....
39174		E. S. Ferrell & Son, Buffalo.....
39459		Barren County Grocery& Hardware Co., Glasgow .....
38976	Wheat Special No. 2.....	Manufacturer .....
38977	White Burley and Black Tobacco	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.40	2.59	11.99		1.27	1.02	2.29	2.78		3.03	$23.98	38964
10.48	2.27	12.75	0.31		1.17	1.48	1.80	0.52	1.16	20.68	39450
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*2.00*	*20.58*	
8.82	5.88	14.70				1.07	1.30	4.21		20.98	38966
7.59	0.71	8.30				0.91	1.10	0.86	3.75	17.94	39452
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
8.04	6.01	14.05		1.07	0.85	1.92	2.33		4.14	27.74	38967
5.88	2.24	8.12	0.22		1.66	1.88	2.28	1.10	4.19	20.67	39168
6.86	2.89	9.75				1.57	1.91	0.74	2.24	18.32	39453
7.00	*1.00*	*8.00*				*1.65*	*2.00*		*4.00*	*18.98*	
9.12	5.58	14.70		1.03	0.86	1.89	2.29	2.33		22.59	38968
9.71	6.39	16.10				1.47	1.78	0.54	1.94	22.23	39169
7.59	2.26	9.85				1.03	1.25		1.36	15.25	39454
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
9.00	3.57	12.57	0.23		1.62	1.85	2.25		10.53	31.35	38969
8.45	0.36	8.81				1.35	1.64	0.98	9.50	27.39	39170
6.90	2.72	9.62	0.25		1.40	1.65	2.00	1.58	4.33	21.93	39455
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*27.78*	
10.84	4.79	15.63				1.07	1.30	1.27		19.95	38971
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*16.27*	
8.99	5.32	14.31	0.23	0.27	1.43	1.93	2.34		5.55	26.34	38974
8.30	7.51	15.81				1.46	1.77	0.92	4.60	24.51	39173
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
7.79	9.14	16.93		0.48	0.62	1.10	1.34	0.68	0.56	18.21	38975
7.48	10.94	18.42				0.88	1.07	0.90		17.34	39174
7.13	1.63	8.76				0.84	1.02		1.12	13.49	39459
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
10.95	4.26	15.21				1.10	1.34	0.60	1.56	21.16	38976
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*17.27*	
9.39	3.45	12.84	0.20	1.40	1.57	3.17	3.85	0.66	3.67	28.81	38977
8.00	*1.00*	*9.00*				*2.88*	*3.50*		*4.00*	*24.88*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
39336	**The Armour Fertilizer Works,** Armour's Bone Meal and Potash	Manufacturer
39117	**Baugh & Sons Co., Norfolk, Va.** Baugh's Animal Base and Potash Compound	Manufacturer
39090	**C. S. Brent, Lexington, Ky.** Brent's Grain Grower	Manufacturer
39091	Brent's Tobacco and Hemp Special	Manufacturer
38507	**Central Manufacturing Co., Lockland, Ohio.** Equity Clay Land Wheat Special	Manufaucturer
39177		Whitely & Eskridge, Leitchfield
39464		J. J. Eskridge & Co., Leitchfield
38508	Equity Wheat Grower	Manufacturer
39178		D. C. Jacobs, Princeton
39465		J. J. Eskridge & Co., Leitchfield
38510	Equity Crop Maker	Manufacturer
39179		D. E. Patterson, Hodgenville
39466		R. H. Chrisman, Berea
38511	Equity Home Mixture	Manufacturer
39467		J. J. Eskridge & Co., Leitchfield
38512	Equity Pota-Bacco Special	Manufacturer
39180		D. C. Jacobs, Princeton

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
10.16	8.53	18.69				1.19	1.44		3.72	$24.23	39336
10.00	*6.00*	*16.00*				*1.23*	*1.50*		*3.00*	*22.31*	
7.98	1.82	9.80				1.60	1.94	2.18		18.09	39117
8.00						*1.65*	*2.00*	*2.00*		*11.38*	
8.66	2.19	10.85	0.33		1.51	1.84	2.23	0.86	1.09	19.88	39090
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
4.78	0.77	5.55	2.89		1.13	4.02	4.88	1.54	10.07	33.74	39091
5.00						*4.00*	*4.86*		*10.00*	*32.00*	
11.10	1.62	12.72				1.10	1.34	2.01		19.83	38507
10.61	2.01	12.62				1 04	1.26	1.79		18.96	39177
9.31	2.19	11.50	0.37		0.99	1 36	1 65	1.70		18.51	39464
10.00	*1.50*	*11.50*				*0.82*	*1.00*	*1.00*		*16.47*	
7.86	2 12	9.98				1.15	1.40	3.12		17.43	38508
8.72	1.40	10.12				1.12	1 36	3.85		18.79	39178
8.01	1.25	9.26				0.84	1.02	3.57		16 62	39465
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*3.50*		*16.37*	
8.60	1.54	10.14				1.47	1.78	3.02		19.11	38510
8.09	2.01	10.10				1.52	1.85	2.83		18.66	39179
8.93	1.95	10.88	0.24		1.22	1.46	1.77	2.76		19.37	39466
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
8.24	2.19	10.43				2.23	2.71	3.18		21.76	38511
8.93	1.21	10.14				1.71	2.08	3 53		20.70	39467
8.00	*1.50*	*9.50*				*2.06*	*2.50*	*3.00*		*20.41*	
9.31	1.72	11.03				1.58	1.92	4.93		22.32	38512
8.89	2.19	11.08				1.74	2.11	5.95		23.59	39180
9.00	*1.50*	*10.50*				*1.65*	*2.00*	*5.00*		*22.18*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Central Manufacturing Co.,	
38513	Equity High Grade Truck Food	Manufacturer
	The Cincinnati Phosphate Co., Cincinnati, Ohio.	
39046	High Grade Manure	Manufacturer
39047	Grain and Grass Grower	Manufacturer
39051	Tobacco, Potato and Beet Grower	Manufacturer
39054	Bone and Phosphate Mixture Wheat Special	Manufacturer
39055	Truck and Tobacco Fertilizer	Manufacturer
	Continental Fertilizer Co., Nashville, Tenn.	
38895	Bear Special Corn and Wheat Grower	Manufacturer
39183		H. A. McElroy, Bowling Green
38896	Bear Special Tobacco Grower	Manufacturer
39184		J. H. Brown, Cloverport
38897	Bear Grain Grower	Manufacturer
38898	Bear Grain Special	Manufacturer
38899	Bear Slaughter House Bone	Manufacturer
39185		Farmers Exchange, Leitchfield

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
6 85	2.11	8.96				2.53	3.07	8.32		$26.24	38513
6.00	*1.50*	*7.50*				*2.06*	*2.50*	*8.00*		*23.01*	
8.97	1.10	10.07	0.51		0.83	1.34	1.63	2.94		18.83	39046
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
9.02	1.36	10.38	0.43		0 58	1.01	1.23	2.19		17.09	39047
8.00	*1.00*	*9.00*				0.82	*1.00*	*2.00*		*14.87*	
8.32	0.94	9.26				0.80	0 97	4.46		17 62	39051
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.86*	
8.72	7.93	16.65	0.56		1 47	2.03	2.46	1.18		21.92	39054
10.00	*6.00*	*16.00*				*1.65*	*2.00*	*1.00*		*21.18*	
6.06	1.89	7.95		0.72	1.26	1.97	2.39	6 70	1.22	23.09	39055
6.00	*1.00*	*7.00*				*1.65*	*2.00*		*6.00*	*20.58*	
8.30	0.94	9 24				0.97	1.18	0.48	0.89	15.29	38895
7.37	1.02	8 39				1.31	1.59		1.71	15.89	39183
7.00	*2.00*	*9.00*				*0 82*	*1.00*		*1.00*	*13.27*	
9 03	0.88	9 91				1.00	1.21	0.70	1.33	16.99	38896
7.61	0.98	8.59	0.33		0.67	1.00	1.21	1.14	0.93	15.28	39184
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*1.50*	*15 07*	
8.89	0.52	9.41				0.49	0.59		4.33	17.80	38897
8.00	*2.00*	*10.00*				*0.41*	*0.50*		*4.00*	*16.64*	
11.21	1.34	12.55				1.12	1.36		2.50	20.91	38898
10.00	*2.00*	*12.00*				*0.82*	*1.00*		*2.00*	*18.07*	
8.78	2.01	10.79				1.69	2.05		2.48	20.24	38899
8.71	0.89	9.60	0.30		1.05	1.35	1.64		3.91	20.23	39185
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Continental Fertilizer Co.,	
38900	Bear Beef, Blood and Bone..	Manufacturer
39186		Farmers Exchange, Leitchfield
38901	Bear High Grade Tobacco and Potato Grower	Manufacturer
39187		H. A. McElroy, Bowling Green
38902	Bear Potato Grower	Manufacturer
38903	Bear Tobacco Grower	Manufacturer
39188		W. F. Grainger, Franklin
38904	Bear Truck Grower	Manufacturer
	The Currie Fertilizer Co., Louisville, Ky.	
39389	Currie's Corn and Wheat Special	Manufacturer
39390	Currie's Soluble Bone	Manufacturer
	Duncan and Brother, LaGrange, Ky.	
39096	Tiger Brand Potato Grower..	Manufacturer
39189		Manufacturer's Warehouse
39097	Tiger Brand Grain Grower	Manufacturer
39190		Manufacturer's Warehouse
39469		Manufacturer's Warehouse
39122	Tiger Brand Tobacco Grower	Manufacturer
39191		Manufacturer's Warehouse

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
11.17	1 82	12.99				1 79	2.17	0.78	2.00	$23.58	38900
11.58	0 42	12.00	0.25		0 97	1 22	1.48	2.61		20 95	39186
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
7.79	1.48	9.27				1.76	2.14		4.97	22.06	38901
8.96	1.44	10 40	1.28		0.75	2.03	2.46		4.15	23.42	39187
7.00	*2.00*	*9.00*				*1.65*	*2.00*		*4.00*	*19.78*	
8.54	1.72	10.26	1.57		1.36	2.93	3 56		8.16	30.99	38902
8.00	*2.00*	*10.00*				*2.47*	*3.00*		*6.00*	*26.25*	
8 62	1 91	10.53	1.60		1.32	2.92	3.54		8.10	31 04	38903
7.92	1 86	9.78	0.39		1.76	2.15	2.61	1.24	4.77	24 73	39188
8.00	*2.00*	*10.00*				*2.47*	*3.00*		*6.00*	*26.25*	
8.76	0.88	9.64	1.51		0.36	1.87	2.27		11 32	30.99	38904
8:00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*28.18*	
10.77	6.88	17.65	0.50		0.54	1.04	1.26	1.45		20 76	39389
10.00						*0.82*	*1.00*	*1.00*		*15.87*	
10.73	5.65	16.38		0.65	0.64	1.29	1.57	2.79		22.45	39390
10.00						*1.03*	*1.25*	*1.50*		*17.11*	
8 56	0.50	9.06	1.03		0.97	2 00	2 43		8.87	28.11	39096
7.70	0.40	8.10	1.07		1.01	2 08	2 53		6 87	24.92	39189
8.00	*1 00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.85*	
14 34	0 80	15.14	0.22		0 84	1.06	1.29		1 89	23 51	39097
11 59	0 65	12.24	0 35		0.79	1.14	1.38		1 49	19.95	39190
11.90	0 47	12.37	0.51		0.90	1 41	1.71		1.68	21 43	39469
12.00	*2.00*	*14.00*				*0.82*	*1.00*		*1.00*	*19.27*	
8.57	2.45	11 02	0.72		1.28	2.00	2 43		5.74	25 15	39122
7.73	0 96	8.69	1.02		1.06	2 08	2 53		6.48	24.72	39191
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*6.00*	*23.38*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Empire Guano Co., Nashville, Tennessee.	
38516	Climax Wheat Grower.....	Manufacturer.....
38517	Favorite Manure	Manufacturer.....
38518	Special Grain Grower	Manufacturer.....
38519	Blood, Bone and Potash.....	Manufacturer.....
38520	Red Banner Special	Manufacturer.....
38521	Red Banner Tobacco Grower.	Manufacturer.....
38522	High Grade Tobacco Grower..	Manufacturer.....
39192		J. L. Durham, Greensburg .....
38523	High Grade Tobacco Special..	Manufacturer.....
38524	Climax Tobacco Grower.....	Manufacturer.....
38525	XXX Tobacco Special.....	Manufacturer.....
38526	Special Corn Grower.....	Manufacturer.....
38535	Wheat and Corn Grower.....	Manufacturer .....
	Evansville Packing Co., Evansville, Ind.	
39018	Tobacco Special	Manufacturer.....
39194		Allen & Chandler Bros., Blackford...

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
11.35	2.04	13.39		1.27	0.65	1.92	2.33	1.66	3.02	$26.44	38516
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*24.18*	
11.40	2.36	13.76		0.27	0.78	1.05	1.27	1.26	1.95	21.90	38517
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*3.00*	*20.07*	
11.74	3.84	15.58		0.25	0.83	1.08	1.31	0.82	0.70	21.07	38518
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*1.00*	*17.67*	
9.51	6.20	15.71		1.28	0.64	1.92	2.33	1.32	1.40	23.61	38519
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
10.91	3.89	14.80		1.31	0.58	1.89	2.29	1.10	1.65	24.35	38520
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
9.11	6.57	15.68		1.32	0.63	1.95	2.37	1.30	1.48	23.47	38521
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
8.97	6.01	14.98		1.24	0.66	1.90	2.31	1.68	2.62	24.63	38522
8.62	4.78	13.40				1.48	1.80	4.16	1.38	23.25	39192
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*4.00*	*21.78*	
8.79	2.84	11.63		1.21	0.52	1.73	2.10	2.44	6.32	27.77	38523
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*8.00*	*26.58*	
10.93	1.99	12.92		1.25	0.57	1.82	2.21	1.50	3.36	25 82	38524
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*24.18*	
8.59	1.70	10.29		1.26	0.51	1.77	2.15	2.76	7.78	29.29	38525
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*10.00*	*28.98*	
9.23	5.66	14.89		0.27	0.78	1.05	1.27	1.46	2.03	20.92	38526
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*3.00*	*17.67*	
12.63	6.11	18.74		0.34	0.32	0.57	0.69		1.87	21.84	38535
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17.44*	
11.87	0.73	12.60	0.87		3.06	3.93	4.77	1.14	3.11	33.16	39018
10.91	0.99	11.90	0.96		2.17	3.13	3.80	1.04	3.41	29.57	39194
10.00	*2.00*	*12.00*				*3.29*	*4.00*		*4.00*	*29.12*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Evansville Packing Co.,	
39020	Half and Half Mixture.....	Manufacturer .....
39021	Special 10% Potash	Manufacturer .....
39195		F. A. Yost Co., Hopkinsville.....
39022	Potato aand Tobacco Grower.	Manufacturer .....
39196		Eldred Hardware Co., Princeton.....
39023	Beef, Blood and Bone.....	Manufacturer .....
39197		J. C. DeHaven, Hardinsburg.....
39024	Harvest King	Manufacturer .....
39025	Bone and Potash.....	Manufacturer .....
	Federal Chemical Co., Louisville, Ky.	
38731	Daybreak Standard Corn and Wheat Grower	Manufacturer .....
38732	Daybreak High Grade Fertilizer	Manufacturer .....
38733	Daybreak Favorite	Manufacturer .....
38734	Daybreak Special Tobacco Grower	Manufacturer .....
39198		F. A. Yost Co., Hopkinsville.....
38735	Daybreak Vegetable Grower..	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
12 56	0.62	13.18	0.73		2.27	3.00	3.64	0.70	2.01	$28.93	39020
10.00	*2.00*	*12.00*				*2.47*	*3.00*	*2.00*		*23.45*	
5.93	0.27	6.20				0.66	0.80	0.98	9.03	21 36	39021
6.37	0.40	6.77	0.24		0.59	0.83	1.01		10.16	22.90	39195
5.00	*1.00*	*6.00*				*0.82*	*1.00*		*10.00*	*21.27*	
8.07	2.15	10.22				1.51	1.83		5.85	22.85	39022
7.88	2.89	10.77				1.48	1.80		5.64	22.57	39196
8.00	*2 00*	*10.00*				*1.65*	*2.00*		*5.00*	*22.18*	
8.30	2.83	11.13				1.36	1.65		2.73	19.13	39023
7.65	2 80	10.45				1.56	1.89		1.92	18.06	39197
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	
8.87	1.89	10.76				1.17	1.42	1 22	1.03	17.96	39024
8.00	*2.00*	*10.00*				*1.00*	*1.21*	*2.00*		*15.90*	
7.49	1.39	8.88				0.77	0.93	0.99		13 24	39025
7.00	*2.00*	*9.00*				*0.82*	*1.00*	*1.00*		*13.07*	
10.38	5.62	16.00		0.37	1.55	1.92	2.33	0.68	2.34	24 92	38731
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
12.03	2.00	14.03		0.39	1.72	2.11	2.56	0.54	2.53	26.21	38732
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
13.06	1.99	15.05				1.27	1.54	0.62	3.47	25.74	38733
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*21.27*	
9 85	4.11	13.96		0.32	1.44	1 76	2.14	1.06	6 05	27.94	38734
7.98	5 80	13.78	0.28		0.98	1.26	1.53		6.90	24.59	39198
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*6.00*	*22.71*	
9.99	3 03	13.02		0.46	1.73	2.19	2 66	1 10	5.13	28 13	38735
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*22.98*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co.,	
38736	Daybreak Standard Crop and Tobacco Grower	Manufacturer
39199		J. B. Hamilton, Edmonton
39470		J. R. Sower Hardware Co., Frankfort
38737	Daybreak Special Manure	Manufacturer
38738	Grigsby's Special Wheat Grower	Manufacturer
39200		Grigsby and Co., Bardstown
39471		Grigsby and Co., Bardstown
38739	Daybreak Wheat and Corn Special	Manufacturer
39201		A. H. Miller Implement Co., Elizabethtown
39472		J. R. Sower Hardware Co., Frankfort
38740	Daybreak Corn and Clover Grower	Manufacturer
38741	Daybreak Grain Grower	Manufacturer
38742	Daybreak Potato and Tobacco Grower	Manufacturer
38755	Daybreak Beef, Blood and Bone	Manufacturer
39476		Grayson County Supply Co., Leitchfield
38756	Daybreak Champion Mixture.	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
10.09	6.87	16.96		0.22	1.06	1.28	1.55		5.19	$25.57	38736
8.46	2.86	11.32				0.94	1.14		4.57	20.06	39199
8.29	2.78	11.07	0.22		0.57	0.79	0.96	4.41		18.24	39470
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*18.87*	
13.11	1.58	14.69		0.28	1.15	1.43	1.74		2.97	24.93	38737
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	
13.18	1.52	14.70		0.28	1.18	1.46	1.77	0.68	2.34	25.03	38738
10.35	1.78	12.13				0.78	0.95		1.55	17.72	39200
10.71	3.06	13.77				0.72	0.87	0.82	1.10	18.73	39471
10.00	*2 00*	*12.00*				*0.82*	*1.00*		*2.00*	*18.07*	
13.43	4.93	18.36				0.78	0.95		1.78	22.96	38739
11.34	2.15	13.49				0.69	0.84	0.76	0.90	18.73	39201
11.08	2.36	13.44				0.63	0.76	0.96	0.48	17.99	39472
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17 44*	
11.07	5.86	16.93		0.27	1.17	1.44	1.75	0.60	1.99	23.65	38740
9.00	*4.00*	*13.00*				*0.82*	*1.00*		*1.00*	*16.47*	
11.40	7.19	18.59				0.98	1.19	0.58	1.80	22.73	38741
9.00	*4.00*	*13.00*				*0.41*	*0.50*		*1.50*	*15.64*	
9.60	2.19	11.79		0.46	1.47	1.93	2.34	1.40	8.07	30.24	38742
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*7.50*	*25.98*	
11.90	1.86	13.76		0.38	1.61	1.99	2.42		3.24	25.88	38755
11.23	2.40	13 63	0.29		1.44	1.73	2.10	1.84		22.34	39476
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
13.16	0.54	13 70	0.53		0.38	0.91	1.10		4.94	25.12	38756
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*3.50*	*20.44*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
38960	**Federal Chemical Co.,** Daybreak High Grade Truck and Tobacco Grower	Manufacturer .....
	Fox Chemical Co., Branch Federal Chemical Co., Louisville, Ky.	
38757 39203	Fox Wheat and Corn Manure.	Manufacturer ..... Harrison Austin, Beaver Dam.....
38758	Fox Tobacco Grower	Manufacturer .....
38759	Fox Wheat and Corn Grower.	Manufacturer .....
38760 39477	Fox Formula	Manufacturer ..... M. L. Spurling, Campbellsville.....
38761 39204	Fox Special Tobacco Grower..	Manufacturer ..... Harrison Austin, Beaver Dam.....
38762	Fox Vegetable Grower	Manufacturer .....
38763 39478	Fox Crop and Tobacco Grower	Manufacturer ..... M. L. Spurling, Campbellsville.....
38764	Fox Early Harvest	Manufacturer .....
38765	Fox Ten One Ten	Manufacturer .....
38766	Fox High Grade Tobacco Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.66	0.60	10.26	2.66		0.32	2.98	3.62	0.88	7.12	$31.68	38960
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*6.00*	*27.05*	
9.88	5.34	15.22		0.46	1.70	2.16	2.62	0.76	2.04	24.77	38757
10.43	2.22	12.65	0.91		0.55	1.46	1.77	1.64	0.49	20.75	39203
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
10.26	5.52	15.78		0.45	1.50	1.95	2.37	0.84	1.90	24 47	38758
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
11.75	1.89	13.64		0.45	1.75	2.20	2.67		2.95	26.10	38759
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
13.65	1.75	15.40		0.28	0.98	1.26	1.53		4.18	26.51	38760
12.37	0.66	13.03				0.86	1.04	2.86		20.97	39477
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*21.27*	
10.04	3.06	13.10		0.45	1.62	2.07	2.51	1.00	5.17	27.72	38761
8.68	1.21	9.89	1.21		0.51	1.72	2.09	0.60	4.93	23.44	39204
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*22.98*	
10.01	3.10	13.11		0.45	1.68	2.13	2.59	1.12	4.98	27.81	38762
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*22.98*	
9.87	6 77	16.64		0.28	1.04	1.32	1.60	0.64	4.14	24.78	38763
9.47	0.47	9.94				0.89	1.08	0.76	3.11	19.16	39478
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*18.87*	
12.42	2.00	14.42		0.31	0.95	1.26	1.53		3.16	23.90	38764
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	
9.43	1.62	11.05	0.73		0.76	1.49	1.81	0.94	10.19	30.36	38765
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*10.00*	*28.47*	
10.16	0.05	10.21	1.55	0.51	1.62	3.68	4.47	1.00	4.53	31.53	38766
8.00	*4.00*	*12.00*				*3.29*	*4.00*		*4.00*	*27.52*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Fox Chemical Co.,	
38767	Fox Wheat and Grain Special	Manufacturer
38768	Fox Bone, Blood and Potash	Manufacturer
39205		Harrison Austin, Beaver Dam
39479		M. L. Spurling, Campbellsville
38769	Fox Grain Grower	Manufacturer
38770	Fox Grain Special	Manufacturer
38771	Fox Potato and Tobacco Grower	Manufacturer
39112	Fox Ideal Fertilizer	Manufacturer
	Globe Fertilizer Co., Branch Federal Chemical Co., Louisville, Ky.	
38785	Eagle Wheat and Corn Grower	Manufacturer
39209		W. E. Gravely, Brodhead
39482		W. E. Gravely, Brodhead
38786	Big Four Tobacco Grower	Manufacturer
39210		H. W. McCandless, Munfordville
38787	Globe Wheat Grower	Manufacturer
39483		J. I. Rice, Adairville
38788	Braden Formula	Manufacturer
39484		W. E. Gravely, Brodhead

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
14.38	1 02	15.40		0.31	1.11	1.42	1.72		2.67	$25.84	38767
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*20 07*	
14.12	4.50	18.62				0.82	1.00		1.88	23.87	38768
12.47	1.56	14.03				0.48	0.58		1.22	18.72	39205
11.91	0.89	12.80				0.48	0.58	0.58	0.83	17.91	39479
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17.44*	
11.37	5.42	16.79		0.28	1.15	1.43	1.74	0.54	2.03	23.80	38769
9.00	*4.00*	*13.00*				*0.82*	*1.00*		*1.00*	*16.47*	
11.26	7.74	19.00				0.78	0.95		2.41	22.23	38770
9.00	*4.00*	*13.00*				*0.41*	*0.50*		*1.50*	*15.64*	
10.14	1.68	11.82		0.45	1.61	2.06	2.50	1.18	7.41	30.12	38771
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*7.50*	*25.98*	
10.86	2.55	13.41				0.76	0.92	3.35		20.06	39112
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*2.50*	*19.24*	
10.96	4.21	15.17		0.46	1.77	2.23	2.71	0.70	2.86	26.77	38785
9.36	1.73	11.09	0.68		0.69	1.37	1.66		2.42	19.62	39209
9.95	5.01	14.96	0.37		1.14	1.51	1.83	2.34		21.57	39482
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
10.11	5.29	15.40		0.45	1.60	2.05	2.49	0.56	2.26	23.90	38786
8.82	9.34	18.16	0.67		0.94	1.61	1.95		2.23	22.64	39210
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
11.74	1.87	13.61		0.46	1.59	2.05	2.49	0.76	2 23	25.46	38787
10.87	1.50	12.37	0.50		1.32	1.82	2.21	2.30		22.31	39483
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21 78*	
12.78	2.42	15.20		0.27	1.04	1.33	1.61		4.09	25.88	38788
12.40	3.72	16.12				0.80	0.97	2.94		22.11	39484
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*21.27*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Globe Fertilizer Co.,	
38789	Kentucky Standard Tobacco Grower	Manufacturer
39211		H. W. McCandless, Munfordville
39337		S. L. Edwards & Son, Walton
38790	Globe Soluble Vegetable Manure	Manufacturer
38791	Universal Crop and Tobacco Grower	Manufacturer
39212		W. E. Gravely, Brodhead
38792	Progress Corn and Wheat Grower	Manufacturer
39213		J. B. Benjamine, Providence
39338		S. L. Edwards & Son, Walton
38793	Globe Blood, Bone and Tobacco Mixture	Manufacturer
38794	Globe Special Potato Grower	Manufacturer
38795	Globe High Grade Tobacco Grower	Manufacturer
39214		C. B. Holman, Trenton
38796	Globe Potato Grower	Manufacturer
38797	Globe Wheat and Grain Special	Manufacturer
39485		W. E. Gravely, Brodhead

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.81	3.21	13.02		0.39	1.67	2.06	2.50	0.98	5.13	$27.40	38789
10.11	5.19	15.30	0.68		1.00	1.68	2.04		4.33	25.29	39211
9.14	1.11	10.25	0.98		0.73	1.71	2.08	0.74	4.39	23.41	39337
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*22.98*	
9.93	3.34	13.27		0.44	1.57	2.01	2.44	0.88	5.10	27.30	38790
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*22.98*	
10.24	6.53	16.77		0.25	1.17	1.42	1.72		4.56	25.34	38791
9.84	2.15	11.99	0.28		0.56	0.84	1.02		4.36	20.84	39212
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*18.87*	
13.59	1.42	15.01				1.33	1.61		3.20	25.38	38792
10.58	0.80	11.38				0.93	1.13	2.38		18.66	39213
11.15	1.54	12.69				0.79	0.96	2.74		19.51	39338
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	
10.14	7.14	17.28				0.97	1.18	0.94	4.30	24.53	38793
8.00	*4.00*	*12.00*				*0.41*	*0.50*		*4.00*	*17.44*	
7.81	1.22	9.03	0.88		1.78	2.66	3.23	0.94	5.81	27.08	38794
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*6.00*	*27.05*	
9.88	0.32	10.20	1.79	0.44	1.53	3.76	4.56	0.84	4.85	31.81	38795
7.35	0.59	7.94	1.24		2.07	3.31	4.02		5.40	27.13	39214
8.00	*4.00*	*12.00*				*3.29*	*4.00*		*4.00*	*27.52*	
10.39	0.06	10.45	1.64	0.41	1.69	3.74	4.54	0.80	4.21	31.43	38796
8.00	*4.00*	*12.00*				*3.29*	*4.00*		*4.00*	*27.52*	
14.23	1.53	15.76				1.38	1.68		2.48	25.50	38797
12.19	1.07	13.26				0.86	1.04	0.98	0.44	19.58	39485
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*20.07*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Globe Fertilizer Co.,	
38798	Globe Bone and Potash	Manufacturer .....
39215		Mr. Baxter, Nobob .....
38799	Globe Grain and Grass Grower	Manufacturer .....
38800	Globe Bone Dust	Manufacturer .....
39486		C. L. Dudley, Flemingsburg.....
38801	Globe Grain Grower	Manufacturer .....
39216		H. W. McCandless, Munfordville.....
38802	Globe Potato and Tobacco Grower	Manufacturer .....
38803	Globe Special Tobacco Grower	Manufacturer .....
38806	Globe Truck Grower	Manufacturer .....
38818	Globe High Grade Special....	Manufacturer .....
39222		C. B. Holman, Trenton.....
39113	Globe Good Luck Crop Grower	Manufacturer .....
	Grayson County Fertilizer Co., Leitchfield, Ky.	
38838	Grain Grower No. 2.....	Manufacturer .....
39223		Manufacturer's Warehouse .....
39490		Manufacturer's Warehouse .....
38839	Tobacco Grower No. 1.....	Manufacturer .....
39224		Manufacturer's Warehouse .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
13.28	5.29	18.57				0.85	1.03		1.87	$23.28	38798
11.96	1.12	13.08	0.22		0.46	0 68	0.83	0.54	0.86	18.75	39215
11.00	*4.00*	*15.00*				0.41	*0.50*		*1.00*	*17.44*	
13.33	5.29	18.62				0.88	1.07	0.50	1.24	23.19	38799
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17.44*	
11.29	6.18	17.47		0.27	1.15	1.42	1.72		2.61	24.12	38800
11.47	3.12	14 59				0.85	1.03	1.13		19.12	39486
9.00	*4.00*	*13.00*				*0.82*	*1.00*		*1.00*	*16.47*	
10.77	8.06	18.83				0.91	1.10	0.58	1.82	22.09	38801
8.22	12.83	21.05				0.58	0.70	1.50	0.49	19.11	39216
9.00	*4.00*	*13.00*				*0.41*	*0.50*		*1.50*	*15.64*	
10.48	1.56	12.04		0.45	1.63	2.08	2.53	1.32	6.96	30.15	38802
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*7.50*	*25.98*	
9.58	0.11	9.69	1.41	0.32	1.13	2.86	3.47	1.32	9.45	34.21	38803
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*10.00*	*31.85*	
10.57	4.41	14.98		0.22	0.79	1.01	1.23	1.04	8.15	28.84	38806
8.00	*4.00*	*12.00*				*0.41*	*0.50*		*8.00*	*22.24*	
12.84	0.24	13.08	9.59		0.26	0 85	1.03	0.74	6.40	26.91	38818
12.66	0.47	13.13				0.51	0.62		3.34	21.18	39222
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*22.24*	
10.73	2.66	13.39				0.85	1.03	3.21		20.13	39113
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*2.50*	*19.24*	
8.26	0.59	8.85	1.21			1.21	1.47	5.59		19.98	38838
9.88	0.77	10.65	0.68			0.68	0.83	0.70	3.14	19.02	39223
6.94	1.05	7.99				0.21	0.25	1.75		11.24	39490
8.00						*1.03*	*1.25*	*5.00*		*18.21*	
8.28	0.66	8.94	1.18			1.18	1.43	5.44		19.77	38839
10.10	0.55	10.65	0.91			0.91	1.10	4.13		19.66	39224
8.00						*1.03*	*1.25*	*6.00*		*19.21*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Great Southern Phosphate Co., Mt. Pleasant, Tenn.	
38677	Great Southern Tobacco Grower	Manufacturer
38678	Farmers Champion	Manufacturer
38680	Universal Tobacco Grower	Manufacturer
39225		L. F. Grissom & Co., Lynnville
38683	Great Southern Potato Special	Manufacturer
38685	Great Southern Tobacco Special	Manufacturer
38686	Great Southern Corn Special	Manufacturer
38687	Great Southern Superior Tobacco Grower	Manufacturer
	Grigsby & Company, Bardstown, Ky.	
39086	Grigsby's Special Wheat Grower	Manufacturer
	The Groves Company, Cincinnati, Ohio.	
38640	Complete Grain Grower	Manufacturer
39230		T. W. Denney, Science Hill
38641	Corn and Tobacco Grower	Manufacturer
39231		Haselden Brothers, Lancaster

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.20	8.92	18.12				0.85	1.03		4.08	$22 49	38677
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*4.00*	*18.07*	
11.73	1.98	13.71		0.28	1.44	1.72	2.09	2.32		23.21	38678
10.00	*2.00*	*12.00*				*1.65*	*2.00*	*2.00*		*20 58*	
9.32	6.78	16.10				1.72	2.09		6.57	27.79	38680
9.05	5.04	14.09				2.01	2.44	1.44	1.94	23.69	39225
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*6.00*	*23.38*	
8.47	6.17	14.64		1.46	1.04	2.50	3.04	1.26	4.75	28.34	38683
7.00	*2.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.05*	
9.29	3.63	12.92		1.18	1.65	1.83	2.22	1.18	9.71	31.84	38685
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*28.18*	
8.75	9.02	17.77		0.25	1.31	1.56	1.89	1.99		21.56	38686
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
8.13	8.23	16.36		0.28	1.42	1.70	2.06		4.01	23.81	38687
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*4.00*	*20.98*	
10.95	1.45	12.40	0.45		0.61	1.06	1.29		2.17	20.03	39086
10.00	*2.00*	*12.00*				*0.82*	*1.00*		*2.00*	*18.07*	
8.39	0.89	9.28	0.21		0.55	0.76	0.92	2.18		15.27	38640
7.73	1 25	8.98	0.21		0.61	0.82	1.00	2 04		14.69	39230
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*2.00*		*15.27*	
8.50	1.05	9.55	0.40		0.46	0.86	1.04	4.43		18.06	38641
8.92	1.44	10.36	0.20		0.59	0.79	0.96	4.50		18.55	39231
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*4.00*		*17.27*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Groves Company,	
38642 39491	Favorite Fertilizer	Manufacturer ..... Haselden Brothers, Lancaster.....
38643	10% Potash Fertilizer	Manufacturer .....
38644	Special Truck Manure	Manufacturer .....
38647	Special Onion and Truck Manure	Manufacturer .....
	Hirsh, Stein & Co., Chicago, Ill.	
38650 39232	Calumet Brand Grain Grower	Manufacturer ..... L. C. Goering, Hawesville .....
38651 39233 39494	Calumet Brand Wheat, Corn and Oats Special	Manufacturer ..... J. B. Taylor, Lewisport..... Buky, Patterson & Jeffries, Shepherdsville .....
38652 39234	Calumet Brand Tobacco Fertilizer	Manufacturer ..... C. R. Newcom, Marion .....
38653 39235	Calumet Brand Ky. Tobacco Grower	Manufacturer ..... J. B. Taylor, Lewisport .....
38654	Calumet Brand Special Potato, Tobacco and Onion Grower ..	Manufacturer .....
38655	Calumet Brand Special 10% Potash Manure	Manufacturer .....

Complete Fertilizers.

Phosphoric Acid.			Nitrogen.				Equivalent to Ammonia.	Potash.		Estimated Value Per Ton.	Station Number
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.31	1.95	10.26	0.58		1.10	1.68	2.04	2.30		$18.93	38642
8.05	1.38	9.43				1.60	1.94	2.09		17.90	39491
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
6.47	1.05	7.52	0.42		0.40	0.82	1.00	10.69		21.74	38643
5.00	*2.00*	*7.00*				*0.82*	*1.00*	*10.00*		*19.67*	
8.74	1.62	10.36		0.71	0.99	1.70	2.06	1.54	6.68	26.65	38644
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*8.00*	*25.78*	
10.29	0.73	11.02	0.26	1.17	1.13	2.56	3.11	10.21		31.81	38647
9.00	*2.00*	*11.00*				*2.47*	*3.00*	*10.00*		*30.25*	
7.91	1.42	9.33		0.46	1.24	1.70	2.06	2.31		18.32	38650
9.41	0.74	10.15		0.55	1.05	1.60	1.94	2.48		19.67	39232
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
9.45	0.54	9.99				0.91	1.10	4.71		19.46	38651
8.58	0.51	9.09				0.76	0.92	4.53		17.69	39233
9.15	1.19	10.34				0.77	0.93	4.56		18.72	39494
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
8.11	0.80	8.91		0.39	0.74	1.13	1.37	3.19		17.20	38652
8.84	0.77	9.61				0.77	0.93	2.37		15.99	39234
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.87*	
8.75	1.08	9.83		0.70	1.14	1.84	2.23	0.74	4.74	23.80	38653
9.18	0.97	10.15				1.64	1.99	1.14	4.12	23.23	39235
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
9.07	0.61	9.68		1.11	0.84	1.95	2.37	3.64	7.18	30.21	38654
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*27.78*	
5.35	0.92	6.27				0.98	1.19	10.43		20.65	38655
5.00	*1.00*	*6.00*				*0.82*	*1.00*	*10.00*		*19.27*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Hirsh, Stein & Co.,	
38656	Calumet Brand Ammoniated Dissolved Pure Bone and Potash	Manufacturer
38657	Calumet Brand High Grade Garden and Vegetable Grower	Manufacturer
39236		D. C. Edwards, London
38658	Calumet Brand Bone Phosphate and Potash	Manufacturer
38863	Calumet Brand High Grade Bone, Blood and Potash	Manufacturer
39496		J. B. Taylor & Sons, Lewisport
38864	Calumet Brand Bone, Blood and Potash	Manufacturer
39238		C. R. Newcom, Marion
38865	Calumet Brand High Grade Bone Phosphate and Potash	Manufacturer
39239		Farmers Exchange, Leitchfield
39497		Hutcheson Bros., Auburn
38866	Calumet Brand Bone Black Grain Grower	Manufacturer
39240		Jas. Person & Co., Franklin
39498		Jas. Person & Co., Franklin
	Hopkins Fertilizer Company, New Albany, Indiana.	
39004	Old Time Half and Half	Manufacturer
39243		F. A. Yost Co., Hopkinsville

Complete Fertilizers.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
10.03	1.38	11.41		1.18	0.74	1.92	2.33	2.84		$22.15	38656
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*20.18*	
8.84	1.64	10.48		0.83	1.49	2.32	2.82	7.13		26.52	38657
10.01	1.44	11.45		0.44	1.87	2.31	2.80	2.22	5.41	29.39	39236
8.00	*1.00*	*9.00*				*2.06*	*2.50*	*6.00*		*23.21*	
10.92	0.68	11.60				0.46	0.56	2.37		17.35	38658
10.00	*1.00*	*11.00*				*0.41*	*0.50*	*2.00*		*15.84*	
10.95	0.38	11.33				0.97	1.18	5.59		22.28	38863
11.73	0.89	12.62				0.88	1.07	4.88		22.40	39496
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*5.00*		*20.27*	
10.61	0.32	10.93				0.95	1.15	2.71		18.90	38864
10.34	0.85	11.19				0.87	1.06	2.50		18.30	39238
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*17.27*	
10.15	0.61	10.76				0.00		5.70		18.12	38865
10.13	1.22	11.35				0.47	0.57	4.67		18.97	39239
10.39	0.70	11.09				0.46	0.56	4.95		19.31	39497
10.00	*1.00*	*11.00*				*0.41*	*0.50*	*5.00*		*18.84*	
9.19	1.61	10.80		0.67	1.43	2.10	2.55	1.95		20.97	38866
8.32	1.75	10.07		0.56	1.43	1.99	2.42	1.91		19.56	39240
8.83	1.73	10.56				1.82	2.21	2.29		19.95	39498
8.00	*1.00*	*9.00*				*2.06*	*2.50*	*1.50*		*18.71*	
8.06	5.72	13.78				2.34	2.84	1.78	0.89	22.89	39004
9.72	6.35	16.07				1.71	2.08	1.60		21.79	39243
6.00	*6.00*	*12.00*				*2.00*	*2.43*	*2.00*		*18.60*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Hopkins Fertilizer Co.,	
39005	Old Time Kentucky and Indiana Special	Manufacturer
39006	Old Time Potato and Tobacco Grower	Manufacturer
39244		A. W. Pickerill, Hodgenville
39007	Old Time Tobacco Grower	Manufacturer
39245		O. A. Lutes & Co., Shepherdsville
39008	Old Time Truck Grower	Manufacturer
39246		A. W. Pickerill, Hodgenville
39009	Old Time Blood and Bone	Manufacturer
39247		C. R. Barnes, Bardstown
39010	Old Time Ammoniated Potash Mixture	Manufacturer
39011	Old Time Wheat and Corn Grower	Manufacturer
39248		O. A. Lutes & Co., Shepherdsville
39508		O. A. Lutes & Co., Shepherdsville
39012	Old Time Bone and Potash	Manufacturer
39249		A. W. Pickerill, Hodgenville
	International Agr'l Corporation, (Buffalo Fert. Works) Cincinnati, Ohio.	
39343	General Favorite	Manufacturer
39344	Ideal Wheat and Corn	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.63	0.51	10.14	0.85		1.48	2.33	2.83		9.40	$31.20	39005
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*8.00*	*28.25*	
9.74	0.54	10.28	0.94		1.83	2.77	3.36		6.57	29 49	39006
9.61	0.59	10.20	0.31	0.79	1.17	2.27	2.76		6.02	26.94	39244
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.85*	
9.68	0.10	9.78	0.29		1.58	1.87	2.27		4 71	23.86	39007
8.45	0.64	9.09	1.25	0.22	0.53	2.00	2.43		3.97	22 16	39215
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*20.58*	
7.56	0.06	7.62	0.54		1.30	1.84	2.23		9.89	27.40	39008
6.01	0.40	6.41		0.92	1.01	1.93	2.34		8.58	24.43	39246
6.00	*1.00*	*7.00*				*1.65*	*2.00*		*8.00*	*22.98*	
9.40	0.22	9.62				1.68	2.04	2.31		19.56	39009
8.86	0.50	9.36		0.76	0.78	1.54	1.87	2.35		18.57	39247
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
11.14	0.47	11.61				0.60	0.73	4.86		20 52	39010
10.00	*1.00*	*11.00*				*0.41*	*0.50*	*4.00*		*17.84*	
11.84	0.40	12.24				0.63	0.76	2.74	0.77	20 24	39011
10.61	0.71	11.32	0.47		0.21	0.68	0.83	3.00		18.39	39248
10.43	0.55	10 98				0.56	0.68	2.42		17.12	39508
10.00	*1.00*	*11.00*				*0.41*	*0.50*	*2.00*		*15.84*	
8.43	0.11	8.54				0.78	0.95	3.03		15.92	39012
7.53	0.69	8.22				0.91	1.10	1.92		14.43	39249
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
9.16	1.24	10.40				1 11	1.35	2.95		18.33	39343
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
9.66	0.87	10.53		0.37	1.21	1.58	1.92	5.97		23.44	39344
9.00	*1.00*	*10.00*				*1.65*	*2.00*	*5.00*		*21.98*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
39345	**International Agr'l Corporation,** Truck and Potato Special....	Manufacturer.....
39346	Tobacco and Garden King....	Manufacturer.....
39347	Ideal Tobacco Grower	Manufacturer.....
39349	Millers Wheat and Corn Grower	Manufacturer.....
39505		I. K. Miller & Sons, Campbellsville..
39357	Dickinson's Special Manure..	Manufacturer.....
	The Jarecki Chemical Co., Cincinnati, Ohio.	
39035	Lake Erie Guano with Phosphate and Potash	Manufacturer.....
39511		Willis Ballard, Bardstown.....
39036	Number One Formula.....	Manufacturer.....
39252		Terrell Brothers, Bedford.....
39040	Raw Bone and Phosphate Mixture	Manufacturer.....
39253		W. T. Kirkman, Elkton.....
39041	Fish Phosphate and Potash Tobacco and Potato Food...	Manufacturer.....
39043	Tobacco and Truck Grower ..	Manufacturer.....
39254		W. T. Kirkman, Elkton.....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.34	0.65	9.99		0.38	1.35	1.73	2.10	10.96		$28.49	39345
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*10.00*		*25.78*	
10.06	1.35	11.41		0.83	1.56	2.39	2.90	1.34	5.49	28.91	39346
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*7.00*	*27.05*	
9.85	0.87	10.72	1.08	0.76	1.24	3.08	3.74	1.44	5.47	30.95	39347
8.00	*1.00*	*9.00*				*3.29*	*4.00*		*7.00*	*29.92*	
10.01	2.23	12.24				1.99	2.42	2.77		22.64	39349
8.15	3.45	11.60				2.23	2.71	2.42		21.39	39505
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*20.18*	
7.58	2.68	10 26				1.73	2.10	4.31		20.54	39357
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
8.63	1.12	9.75	0.53		0.77	1.30	1.58	2.90		18.26	39035
7.24	1.25	8.49				1.41	1.71	2.91		17.04	39511
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
9.26	0.94	10.20	0.38		0.57	0.95	1.15	2.28		17.10	39036
8.89	1.72	10.61	0.37		0.44	0 81	0.98	1.97		16.17	39252
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.87*	
8.90	7.75	16.65	0.66		1.52	2.18	2.65	1.37		22.78	39040
10.52	6.76	17.28		0.58	1.08	1.66	2.02	1.17		22.30	39253
10.00	*6.00*	*16.00*				*1.65*	*2.00*	*1.00*		*21.18*	
8.18	0.96	9.14				0.86	1.04	4.49		17.70	39041
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
6.14	1.57	7.71		0.73	1.14	1.87	2.27	6.92	1.24	22.96	39043
7.02	0.71	7.73		0.45	1.07	1.52	1.85	1.20	5.15	21.40	39254
6.00	*1.00*	*7.00*				*1.65*	*2.00*		*6.00*	*20.58*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Jarecki Chemical Co.,	
39044	Indian Brand Tobacco and Potato Fertilizer	Manufacturer
39045	Indian Brand Gilead Phosphate	Manufacturer
	Jones Fertilizer Company, Louisville, Ky.	
38931	Jones Corn and Wheat Grower	Manufacturer
38932	Jones Reliable	Manufacturer
38933	Jones Special Tobacco Grower	Manufacturer
39339		J. W. Webb & Son, Vanceburg
38934	Jones Grain Grower	Manufacturer
38935	Jones Grain Special	Manufacturer
38936	Jones Slaughter House Bone	Manufacturer
38937	Jones Miami Valley Phosphate	Manufacturer
38938	Jones Tobacco and Potato Grower	Manufacturer
39255		Evans, Goodman & Maxe, Glasgow
38939	Jones Potato Grower	Manufacturer
39340		J. B. Sanders, Dry Ridge
38940	Jones Truck Grower	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.14	0.93	10.07		1.68	0.96	2.64	3.20	0.94	5.57	28 . 20	39044
9.00	*1.00*	*10.00*				*2.47*	*3.00*		*5.00*	*$25.85*	
8.43	1.33	9.76	0.41		0.55	0.96	1.17	3.28		17.29	39045
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*3.00*		*15.87*	
7.90	0.83	8.73				0.97	1.18	0.60	0.89	14.39	38931
7.00	*2.00*	*9.00*				*0.82*	*1.00*		*1.00*	*13.27*	
9.11	0.96	10.07				0.98	1.19	0.64	1.33	16.92	38932
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*1.50*	*15.07*	
9.18	1.11	10.29				1.00	1.21	0.66	1.22	17.08	38933
8.34	1.07	9.41				1.04	1.26	1.42	0.57	16.18	39339
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*1.50*	*15.07*	
8.62	0.55	9.97				0.47	0.57		4.27	18.33	38934
8.00	*2.00*	*10.00*				*0.41*	*0.50*		*4.00*	*16.64*	
11.67	1.40	13.07				0.97	1.18		2.13	20.52	38935
10.00	*2.00*	*12.00*				*0.82*	*1.00*		*2.00*	*18.07*	
8.67	2.04	10.71				1.84	2.23		2.50	20.66	38936
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	
10.90	2.28	13.18				1.86	2.26	0.56	2.27	23.78	38937
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
8.26	1.35	9.61				1.83	2.22		4.74	22.55	38938
8.97	1.10	10.07	0.82		0.71	1.53	1.86		4.15	21.54	39255
7.00	*2.00*	*9.00*				*1.65*	*2.00*		*4.00*	*19.78*	
8.32	1.84	10.16	1.30		1.52	2.82	3 42		7.64	29.76	38939
7.69	2.61	10.30	1.13		1.13	2.26	2.74		6.31	25.75	39340
8.00	*2.00*	*10.00*				*2.47*	*3.00*		*6.00*	*26.25*	
8.73	1.02	9.75	1.20		0.55	1.75	2.12		10.97	30.18	38940
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*28.18*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Kaufman Fertilizer Co., Cincinnati, Ohio.	
38873	Potato and Truck Special.....	Manufacturer .....
39000		Frank Ochsner, St. Matthews.....
39083		Frank Meisner, Jr., St. Matthews ...
39084		John C. Fenley, St. Matthews.....
39085		Henry Hahn, St. Matthews .....
39056	Corn, Wheat and Oats Grower	Manufacturer .....
39057	Harvest King	Manufacturer .....
39256		Likens & Wenchell, Caneyville.....
39058	Golden Rule	Manufacturer .....
39059	Special Potato and Tobacco Fertilizer	Manufacturer .....
39060	Half and Half	Manufacturer .....
39064	Kentucky Tobacco Grower...	Manufacturer .....
	Kentucky Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.	
38819	O. K. Golden Leaf Tobacco Grower	Manufacturer .....
39257		J. B. Hatcher, Glasgow Junction.....
38820	O. K. High Grade Mixture...	Manufacturer .....
39516		Payne & Brown, Temple Hill .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.97	1.01	9 98		2.18	0.63	2.81	3.41		6.32	$28.58	38873
8.73	0.84	9.57	0.51	0 55	1.11	2.17	2.63	0.90	4.67	24.92	39000
9.53	0.59	10.12	0.86	0.51	0.84	2 21	2.68	0.74	5.00	26.16	39083
9.34	0.32	9.66	0.88	0 55	0.88	2.31	2.80	0.76	6 31	27.76	39084
8.90	0.55	9.45	0.91	0.60	0.88	2.39	2.90	0.76	6.06	27.30	39085
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.85*	
8.49	1.66	10.15	0.57		0.76	1.33	1.61	2.85		18.36	39056
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
9.01	1.34	10.35	0.38		0.52	0.90	1.09	2.22		16.72	39057
9.24	1.01	10 25	0.21		0.53	0.79	0.96	1.80		16.06	39256
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.87*	
8.51	0.85	9.36				0.81	0.98	4.71		18.10	39058
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
6.54	1.13	7.67		0.66	1.08	1.74	2.11	5.92	2.40	23.19	39059
6.00	*1.00*	*7.00*				*1.65*	*2.00*		*6.00*	*20.58*	
8.71	7.76	16.47	0.66		1.48	2.14	2.60	1.45		22 49	39060
10.00	*6.00*	*16.00*				*1.65*	*2.00*	*1.00*		*21.18*	
9.93	0.55	10.48	0.33		0.60	0.93	1.13	2.20		17.60	39064
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.87*	
10.34	5 48	15.82		0.41	1.66	2.07	2.51	0.64	2.22	25.16	38819
7.79	1.15	8.94	0.69		0.83	1.52	1.85		2.95	18.67	39257
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
13 17	2.18	15.35		0.25	1.03	1.28	1.55	0.62	3.60	26.09	38820
14.80	2.49	17.29	0.29		0.31	0.60	0.73	3.34		24.20	39516
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*21.27*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Kentucky Fertilizer Co.,	
38821	O. K. Tobacco and Vegetable Grower	Manufacturer
39258		W. A. Ogilvie, Benton
38822	O. K. Crop and Tobacco Grower	Manufacturer
38823	O. K. Corn and Wheat Grower	Manufacturer
38824	O. K. Grain Grower	Manufacturer
38825	O. K. Corn, Wheat and Oats Grower	Manufacturer
39517		Payne & Brown, Temple Hill
38828	O. K. Complete Manure	Manufacturer
39259		J. B. Hatcher, Glasgow Junction
39519		Payne & Brown, Temple Hill
38829	O. K. 20% Fertilizer	Manufacturer
38837	O. K. Special Crop Grower	Manufacturer
	Louisville Fertilizer Co., Louisville, Ky.	
38880	Eagle Special Corn and Wheat Grower	Manufacturer
39265		Smith, Riley & Co., Barbourville
39521		D. S. Smith, Livermore
38881	Eagle Special Tobacco Grower	Manufacturer
39266		D. S. Smith, Livermore

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.83	4.07	13.90		0.37	1.37	1.74	2.11	0.96	6.51	$28.29	38821
8.86	1.47	10.33	0.37		1.07	1.44	1.75	0.90	4.33	22.36	39258
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*6.00*	*22.71*	
10.18	6.63	16.81		0.25	1.08	1.33	1.61	0.70	4.16	25.22	38822
8 00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*18.87*	
13.52	1.47	14.99		0.29	1.23	1.52	1.85		3.09	25.84	38823
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	
13.24	5.38	18.62				0.83	1.01		1.87	23.19	38824
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17.44*	
12.71	5.28	17.99				0.91	1.10		1.73	22.63	38825
14.20	6.48	20 68				0.70	0.85	1.10		23.18	39517
11.00	*4.00*	*15 00*				*0.41*	*0.50*		*1.00*	*17.44*	
10.17	7.20	17.37		0.29	1.04	1.33	1.61	0.76	2.65	23.68	38828
7.75	5.15	12 90	0.35		0.64	0.99	1.20	3.46		18.29	39259
11.49	7.66	19.15				0.67	0.81	2.77		21.97	39519
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*2.50*	*17.07*	
10.05	0.31	10 36		0.46	1.62	2.08	2.53	1.48	10.48	33.52	38829
8.00	*4 00*	*12.00*				*1.65*	*2.00*		*10.00*	*28.98*	
13.19	0.40	13.59	0.52		0.44	0.96	1.17	0.60	4.32	25.13	38837
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*3.50*	*20.44*	
7.75	0.78	8.53				0.87	1.06	0.62	0.80	14.24	38880
7.42	0.74	8.16	0.23		0.58	0.81	0.98	1.14	1.82	15.36	39265
6.85	1.19	8.04				0.84	1.02		1.22	13.10	39521
7.00	*2.00*	*9.00*				*0.82*	*1.00*		*1.00*	*13.27*	
8.89	0.98	9.87				0.95	1.15	0.66	1.38	16.71	38881
8.59	8.15	16.74	0.23		0.72	0.95	1.15		1.57	18.78	39266
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*1.50*	*15.07*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Louisville Fertilizer Co.,	
38882	Eagle Soluble Bone	Manufacturer
38883	Eagle High Grade Tobacco and Potato Grower	Manufacturer
39267		Martin & Ford, Glasgow Junction
38884	Eagle Grain Grower	Manufacturer
39268		Martin & Ford, Glasgow Junction
38885	Eagle Slaughter House Bone.	Manufacturer
39269		Martin & Ford, Glasgow Junction
39522		N. A. Starr, Temple Hill
38886	Eagle Guano	Manufacturer
38887	Eagle Potato Grower	Manufacturer
38888	Eagle Tobacco Grower	Manufacturer
39270		Martin & Ford, Glasgow Junction
38889	Eagle Truck Grower	Manufacturer
	Morris & Co., Chicago, Ill.	
38690	Big Three	Manufacturer
39274		Redmond & Burba Co., Hodgenville
38691	Big Four	Manufacturer
39275		H. A. McElroy, Bowling Green
38692	Big Five	Manufacturer
39276		Grayson County Supply Co., Leitchfield
39525		Grayson County Supply Co., Leitchfield

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.25	0.82	10.07				1.00	1.21	0.54	1.41	$17.16	38882
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*1.50*	*15.07*	
7.81	1.52	9.33	0.21		1.62	1.83	2.22		4.85	22.21	38883
9.37	0.75	10.12	0.89		0.57	1.46	1.77		3.93	21.37	39267
7.00	*2.00*	*9.00*				*1.65*	*2.00*		*4.00*	*19.78*	
9.23	0.41	9.64				0.45	0.55		4.65	18.40	38884
9.57	0.46	10.03	0.23		0.27	0.50	0.61	2.60	0.42	16.51	39268
8.00	*2.00*	*10.00*				*0.41*	*0.50*		*4.00*	*16.64*	
9.05	1.66	10.71				1.74	2.11		2.42	20.51	38885
9.56	0.51	10.07	0.77		0.66	1.43	1.74		2.05	19.14	39269
9.88	1.19	11.07	0.23		0.97	1.20	1.46	2.36		18.90	39522
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	
10.96	2.00	12.96				1.94	2.36	0.62	2.34	24.17	38886
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
8.36	1.67	10.03	1.48		1.31	2.79	3.39		7.91	29.96	38887
8.00	*2.00*	*10.00*				*2.47*	*3.00*		*6.00*	*26.25*	
8.43	1 58	10.01	1.51		1.28	2.79	3.39		7.66	29.71	38888
9.32	0.85	10.17	1.55		0.63	2.18	2.65		5.39	25.62	39270
8.00	*2.00*	*10.00*				*2.47*	*3.00*		*6.00*	*26.25*	
8.55	0 65	9.20	1.44		0.40	1 84	2.23		11.23	30.44	38889
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*28.18*	
6 08	5.07	11.15				2.41	2.93	0.94	1.15	20.09	38690
8.93	2.35	11.28				2.78	3 37		2.23	24.07	39274
6.00	*4.00*	*10.00*				*2.47*	*3.00*		*2.00*	*19.85*	
8 74	5.62	14.36				3.84	4.66		4.42	31.48	38691
8.92	4.07	12 99				3.94	4.78		3.58	30.44	39275
7.00	*5.00*	*12.00*				*4.12*	*5.00*		*4.00*	*29.62*	
7.09	5.19	12.28				2.43	2.95	1.06	0.59	20.87	38692
9.85	3.00	12.85				2.23	2.71		1.58	22 73	39276
8.96	5.39	14 35				2.73	3 31		0.90	23.55	39525
6.00	*4.00*	*10.00*				*2.47*	*3.00*		*1.00*	*18.65*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Morris & Co.,	
38694	Big Seven-Special Bone Meal and Potash	Manufacturer
39527		Woodson Lewis, Greensburg
38695	Big Eight-Ammoniated Acid Phosphate and Potash	Manufacturer
39277		M. C. Marion & Son, Elizabethtown
38696	Big Nine-Prepared Manure with Phosphate and Potash	Manufacturer
39278		Redmon & Burba Co., Hodgenville
38697	Big Ten-Prepared Manure with Phosphate and Potash	Manufacturer
38698	Big Eleven-Bone Meal and Potash	Manufacturer
38699	Big Twelve-Prepared Manure with Phosphate and Potash	Manufacturer
39279		M. C. Marion & Son, Elizabethtown
39528		Grayson County Supply Co., Leitchfield
	Mt. Pleasant Fertilizer Co., Mt. Pleasant, Tenn.	
38661	Big Success Blood, Bone and Potash	Manufacturer
38663	Big Success Universal	Manufacturer
38664	Big Success Potato Special	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.24	6.90	16.14				1.17	1.42		2.51	$20.96	38694
7.74	9.17	16.91				1.36	1.65		3.44	21.85	39527
8.00	*8.00*	*16.00*				*1.23*	*1.50*		*3.00*	*20.71*	
7.05	0.97	8.02				0.75	0.91	1.00	0.43	13.00	38695
8.43	1.13	9.56				1.25	1.52	0.54	0.89	16.56	39277
7.00	*1.00*	*8.00*				*0.82*	*1.00*		*1.00*	*12.87*	
7.67	1.43	9.10				0.81	0.98	1.82	5.95	21.57	38696
9.70	0.89	10.59				1.40	1.70	0.94	6.86	26.07	39278
7.00	*2.00*	*9.00*				*0.82*	*1.00*		*7.00*	*20.47*	
8.90	1.59	10.49				1.63	1.98	1.32	1.49	20.14	38697
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	
7.46	8.55	16.01				0.97	1.18		10.49	28.36	38698
8.00	*8.00*	*16.00*				*0.82*	*1.00*		*10.00*	*27.67*	
6.76	2.29	9.05				0.70	0.85	1.86	1.94	15.67	38699
8.37	0.80	9.17				1.08	1.31		3.05	17.80	39279
10.60	1.28	11.88				0.83	1.01	0.62	1.94	19.09	39528
7.00	*2.00*	*9.00*				*0.82*	*1.00*		*3.00*	*15.67*	
10.46	5.20	15.66				0.87	1.06	0.86	5.97	25.70	38661
9.00	*2.00*	*11.00*				*0.82*	*1.00*		*7.00*	*22.87*	
7.89	9.57	17.46				0.87	1.06	3.88		20.23	38663
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*4.00*		*17.27*	
8.39	6.15	14.54		1.39	1.16	2.55	3.10	1.02	5.36	28.91	38664
7.00	*2.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.05*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Mt. Pleasant Fertilizer Co.,	
38666	Big Success Cantaloupe and Vegetable Special	Manufacturer
38667	Big Success Corn Special	Manufacturer
38669	Black Patch Grain and Seeding Down	Manufacturer
38670	Black Patch Farmers Friend	Manufacturer
38672	Black Patch Tobacco Special	Manufacturer
39283		Ware Brothers, Trenton
38673	Black Patch Best by Test	Manufacturer
38674	Black Patch Tobacco Grower	Manufacturer
39284		C. J. White, Princeton
38675	Tenn. and Ky. Tobacco Grower	Manufacturer
39285		Ware Brothers, Trenton
38676	Big Success Tobacco Grower	Manufacturer
	National Fertilizer Co., Nashville, Tenn.	
38710	Old Hickory Tobacco Grower	Manufacturer
38711	Old Hickory Corn and Wheat Guano	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
7.32	4.04	11.36		1.98	1.18	3.16	3.84	1.82	8.15	$33.06	38666
6.00	*2.00*	*8.00*				*3.29*	*4.00*		*10.00*	*31.52*	
8.65	8.78	17.43		0.28	1.33	1.61	1.95	2.33		21.86	38667
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
12.01	2 41	14.42		0.21	1.57	1.78	2.16	2.19		23.79	38669
10.00	*2.00*	*12.00*				*1.65*	*2.00*	*2.00*		*20.58*	
10.86	6.23	17.09				0.80	0.97	3.21		21.53	38670
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*3.00*		*18.67*	
9.26	3.66	12.92		1.21	0.59	1.80	2.19		9.96	30.82	38672
8.47	3.82	12.27		0.73	0.85	1.58	1.92	1.18	9.03	29.24	39283
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*18.18*	
12.80	0.37	13.17				1.66	2.02	6.08		27.40	38673
12.00	*2.00*	*14.00*				*1.65*	*2.00*	*6.00*		*26.98*	
9.20	8.71	17.91				0.89	1.08		3.92	22.34	38674
9.15	7.04	16.19				1.08	1.31	0.66	5.04	24.29	39284
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*4.00*	*18.07*	
9.31	7.41	16.75		0.27	1.34	1.61	1.95		4.22	24.87	38675
8.55	6.02	14.57		0.24	1.57	1.81	2.20	0 90	2.86	23.34	39285
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*4.00*	*20.98*	
9.32	1.49	10.81		2.12	1.08	3.20	3.88	1.34	9.04	35.17	38676
8.00	*2.00*	*10.00*				*3.29*	*4.00*		*10.00*	*33.92*	
11.91	0.85	12.76	0.71		1.11	1.82	2.21		2.29	23.75	38710
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*2.00*	*20.58*	
8.99	0.56	9.55				1.16	1.41	1.99		17 06	38711
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.89*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	National Fertilizer Co.,	
38715	Old Hickory Guano	Manufacturer .....
39287		E. S. Diuguid & Son, Murray.....
38717	Old Hickory Corn Grower....	Manufacturer .....
38718	Old Hickory Special High Grade Tobacco Grower	Manufacturer .....
38719	Old Hickory Special Tobacco Grower No. 2.....	Manufacturer .....
	Peruvian Guano Corporation, Charleston, S. C.	
39111	Peruvian Guano	Manufacturer .....
	The Queen City Fertilizer Co., Cincinnati, Ohio.	
39066	Miami Valley Grain Grower..	Manufacturer .....
39067	Valley Gem Phosphate	Manufacturer .....
39068	Big Bonanza Tobacco and Potato Grower	Manufacturer .....
39070	Lion Truck Grower	Manufacturer .....
	Read Phosphate Co., Nashville, Tenn.	
38548	Read's Standard Tobacco Grower	Manufacturer .....
39291		McCarley Hardware Co., Pembroke...

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
10.77	0.22	10.99	0.83		1.03	1.86	2.26	2.17		$21.69	38715
9.61	1.30	10.91				1.43	1 74	3.81		20.87	39287
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
12.67	0.36	13.03				1.02	1.24	1.05		19.96	38717
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*16.27*	
13.20	0.06	13.26	0.64		1.07	1.71	2.08	8.50		30.35	38718
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*8.00*	*27.78*	
10.45	0.20	10.65	0.73		1.07	1.80	2.19	5 19		24.11	38719
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
8.82	6.60	15.42	0.86	1.53	2.34	4.73	5.74	0.60	1.31	31.95	39111
8.00	*5.00*	*13.00*				*4.94*	*6.00*		*2.00*	*31.29*	
9.57	0.68	10.25	0.50		0.79	1.29	1.57	3.03		19.30	39066
8.00	*1.00*	*9.00*				*1.23*	*1.50*	*2.50*		*16.81*	
9.45	0.93	10.38	0.38		0.63	1.01	1.23	2.26		17.51	39067
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*2.00*		*14.87*	
8.60	0.78	9.38				0.82	1.00	4.52		18.02	39068
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*16.87*	
6.28	1.48	7.76	0.72		1.14	1.86	2.26	6.78	1.22	22.88	39070
6.00	*1.00*	*7.00*				*1.65*	*2.00*		*6.00*	*20.58*	
9.51	6.53	16.04		1.22	0.65	1.87	2.27	1.38	1.30	23.51	38548
6 68	2.03	8.71				1.61	1.95	0.68	2.67	18 35	39291
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Read Phosphate Co.,	
38549 39292	Read's High Grade Tobacco Grower	Manufacturer Hatter Hardware Co., Franklin
38550 39293	Read's High Grade Tobacco Special	Manufacturer McCarley Hardware Co., Pembroke
38551 39294	Read's Complete Tobacco Grower	Manufacturer R. P. Turney, Cerulean Springs
38552	Read's Red Diamond Tobacco Special	Manufacturer
38553	Read's Perfect Tobacco Fertilizer	Manufacturer
38554	Read's Special Potato Grower	Manufacturer
38555	Read's Red Diamond Special.	Manufacturer
38556 39295 39542	Read's Blood and Bone No. 1	Manufacturer W. T. Kirkman, Elkton Hatter Hardware Co., Franklin
38557	Read's Russell County Special	Manufacturer
38558	Read's Soluble Bone	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
9.30	5.62	14.92		1.28	0.64	1.92	2.33	1.74	2.68	$25.09	38549
6.03	4.12	10.15				1.55	1.88	1.52	3.17	19.64	39292
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*4.00*	*21.78*	
9.30	2.69	11.99		1.26	0.58	1.84	2.23	2.44	6.32	28 70	38550
6 81	2.38	9.19				1.59	1.93	0.86	8.20	25.39	39293
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*8.00*	*26.58*	
8.92	1.24	10.16		1.24	0.60	1.84	2.23	2.90	7.67	29.74	38551
8.96	2.46	11.42				1.57	1.91	7.82	4.09	29.96	39294
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*10.00*	*28.98*	
9.43	0.77	10.20		2.12	0.46	2.58	3.13	2.80	8.17	33.26	38552
8.00	*4.00*	*12.00*				*2.47*	*3 00*		*10.00*	*31.85*	
11.52	1.68	13.20		1.31	0.58	1.89	2.29	1.58	3.26	26.60	38553
10.00	*4 00*	*14.00*				*1.65*	*2.00*		*4.00*	*24.18*	
9.91	3.80	13.71		1.35	0.57	1.92	2.33	2.22	4.93	28.27	38554
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*6.00*	*24 18*	
12.56	1.08	13.64		2.19	0.51	2.70	3.28	1.24	2.44	29.12	38555
10.00	*4.00*	*14.00*				*2.47*	*3.00*		*3.00*	*25.85*	
8.98	6.23	15.21		1.29	0.69	1.98	2.40	1.20	1.53	23.24	38556
8.98	4.96	13.94				1.66	2.02	3.49		22.06	39295
8.95	5.41	14.36		0.20	1.15	1.35	1.64	2.05		19.68	39542
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*19.38*	
8.90	5.76	14.66		0.27	0.85	1.12	1.36	1.42	1.91	20.61	38557
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*3.00*	*17.67*	
9.38	7.11	16.49		0.33	0.77	1.10	1.34	1.10	1.13	20.41	38558
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*2.00*	*16.47*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Read Phosphate Co.,	
38559	Read's High Grade Ammoniated Dissolved Bone.....	Manufacturer .....
39543		Hatter Hardware Co., Franklin.....
38560	Read's Farmers Special Manure	Manufacturer. .....
39296		Barren County Grocery and Hardware Co., Glasgow .....
39544		Barren County Grocery and Hardware Co., Glasgow .....
38561	Read's Blood and Bone Special	Manufacturer .....
39297		E. L. Foulks, Hopkinsville.....
38562	Read's Wheat and Clover Grower	Manufacturer .....
38563	Read's Corn and Wheat Grower	Manufacturer .....
	Smith Agricultural Chemical Co., Columbus, Ohio.	
39078	Ohio Farmers Wheat Maker and Seeding Down	Manufacturer .....
39079	Ohio Farmers Corn, Oats and Wheat Fertilizer	Manufacturer .....
39080	Ohio Farmers Tobacco Grower	Manufacturer .....
39081	Ohio Farmers Potato and Tobacco Special	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
11.24	3.30	14.54		1.33	0.61	1.94	2.36	1.30	1.41	$24.59	38559
9.49	4.97	14.46		0.24	1.28	1.52	1.85	1.88		20.58	39543
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
11.37	2.55	13.92		0.24	0.83	1.07	1.30	1.32	2.13	22.29	38560
10.84	3.48	14.32		0.38	0.58	0.96	1.17	3.00		20.76	39296
9.67	5.16	14.83				0.84	1.02	2.77		19.37	39544
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*3.00*	*20.07*	
11.14	4.30	15.44		0.20	0.87	1.07	1.30	0.76	0.88	20.66	38561
11.53	3.52	15.05				0.95	1.15	1.24		19.82	39297
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*1.00*	*17.67*	
11.37	3.01	14.38		0.20	0.92	1.12	1.36	1.10	1.46	21.61	38562
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	
12.61	6.59	19.20		0.23	0.43	0.66	0.80		1.92	22.39	38563
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*17.44*	
9.21	0.84	10.05		0.51	0.36	0.87	1.06	2 38		16.82	39078
8.00						*0.82*	*1 00*	*2.00*		*14.47*	
8.68	0.89	9.57		1.12	0.45	1.57	1.91	2.53		18.81	39079
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
8.62	0.99	9.61		0.32	0.49	0.81	0.98	4.45		18.03	39080
8.00						*0.82*	*1.00*	*4.00*		*16.47*	
8.88	0.62	9.50		1.15	0.40	1.55	1.88	4.55		20.89	39081
8.00						*1.65*	*2.00*	*4.00*		*19.38*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Smith Agricultural Chemical Co.,	
39082	Abbott & Martin Harvest King	Manufacturer
	Smith Brothers, Louisville, Ky.	
38981	Special Tobacco Grower	Manufacturer
39298		Greenville Hardware and Grocery Co., Greenville
38982	Corn and Wheat Grower	Manufacturer
38983	Success Crop Grower	Manufacturer
38984	Standard Tobacco Grower	Manufacturer
38985	Kentucky Tobacco Grower	Manufacturer
38986	High Grade Potato Grower	Manufacturer
38987	Grain Special	Manufacturer
38988	Beef, Blood and Bone	Manufacturer
	Southern Seed Co., Louisville, Ky.	
39028	Elk Corn and Wheat Grower	Manufacturer
39300		E. S. Ferrell & Son, Buffalo
39029	Elk Grain Grower	Manufacturer
39301		B. F. Beard & Co., Hardinsburg
39548		B. F. Beard & Co., Hardinsburg

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.57	0.89	9.46		1.05	0.52	1 57	1.91	2.45		$18.59	39082
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
8.82	5.10	13.92	0.23	0.25	1.42	1.90	2.31		5.41	24.68	38981
9.22	0.38	9 60				1.65	2.00	0.74	3.97	22.49	39298
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
9.14	5.29	14.43		1.49	0.84	2.33	2.83	0.54	1.59	23.70	38982
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
8.11	9.19	17.30		0.47	0.62	1.09	1.32	0.46	0.76	18.60	38983
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
8.85	5.65	14.50		0.90	1.04	1.94	2.36		2.25	22.37	38984
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*2.00*	*18.18*	
8.34	5.98	14.32	0.20	0.91	0.86	1.97	2 39		3.97	24.06	38985
7.00	*1.00*	*8.00*				*1.65*	*2.00*		*4.00*	*19.38*	
8.68	3.33	12.01		1.11	1.60	2.71	3.29	0.82	6.35	29.68	38986
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.85*	
10.78	4.27	15.05				1.10	1.34	2.08		20.58	38987
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*17.27*	
9.16	2.80	11.96		1.30	0.98	2.28	2.77	0 60	2.32	23.47	38988
10.00	*1.00*	*11 00*				*1.65*	*2.00*		*2.00*	*20.58*	
7.06	1.70	8.76				0.93	1.13		1.01	13.62	39028
8.02	1.34	9.36	0.21		0.62	0.83	1 01		0.80	14.03	39300
7.00	*1.00*	*8.00*				*0.82*	*1.00*		*1.00*	*12.87*	
9.13	0.55	9.68	0.24		0.20	0.44	0.53		4.49	18.11	39029
9.09	0.73	9.82	0.27		0 24	0.51	0.62	3.54	0.48	17.11	39301
8 20	1.02	9.22	0.32		0.28	0.60	0.73		3.85	16.97	39548
8.00	*1.00*	*9.00*				*0.41*	*0 50*		*4.00*	*16.24*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Southern Seed Co.,	
39030	Elk Standard Guano	Manufacturer .....
39549		Hackney Brothers, London .....
39031	Atlas Tobacco Grower	Manufacturer .....
39302		Grigsby & Co., Bardstown .....
39032	Elk Special Tobacco Grower..	Manufacturer .....
39303		E. S. Ferrell & Son, Buffalo.....
39033	Elk Tobacco Grower.....	Manufacturer .....
39098	Elk High Grade Vegetable Grower	Manufacturer .....
	Swift & Co., Chicago, Ill.	
38845	Swift's Superphosphate	Manufacturer .....
39304		B. F. Beard & Co., Hardinsburg.....
39550		B. F. Beard & Co., Hardinsburg.....
38846	Swift's Onion, Potato and Tobacco Fertilizer	Manufacturer .....
39305		Green Brothers, Falls of Rough.....
38847	Swift's Champion Wheat and Corn Grower	Manufacturer .....
39551		C. E. Owen, Madisonville .....
38848	Swift's Complete Fertilizer...	Manufacturer .....
39306		Barren County Grocery and Hardware Co., Glasgow .....
39552		Barren County Grocery and Hardware Co., Glasgow .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.48	2.45	10.93	0 54		1.42	1.96	2.38		2.50	$21.02	39030
9.05	0.33	9.38	1.31		0.31	1.62	1.97	2.44		19.10	39549
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*2.00*	*18.18*	
7.42	0.41	7.83	1.12		0.32	1.44	1.75		9.25	25.20	39031
7.80	0.46	8.26	0.32		0.31	0.63	0.76	5.24	2.09	19.50	39302
7.00	*1.00*	*8.00*				*0.82*	*1.00*		*7.00*	*20.07*	
8.81	0.61	9.42	0.31		0.24	0.55	0.67		4.35	17.96	39032
7.76	0.91	8.67				0.49	0.59	3.92		15 31	39303
8.00	*1.00*	*9.00*				*0.41*	*0.50*		*4.00*	*16.24*	
8.45	1.75	10.20	1.48		0.96	2.44	2.96		6.05	26 64	39033
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*25.85*	
7.39	3.82	11.21	1.00		2.33	3.33	4.04		4.59	27.57	39098
8.00	*1.00*	*9.00*				*3.29*	*4.00*		*4.00*	*26.32*	
8.65	6.06	14.71	0 21		1.60	1.81	2.20	2.67		21.81	38845
7.71	2.73	10.44	0.38		1.16	1.54	1 87	2.34		18.07	39304
8.40	1.82	10.22				1.59	1.93	2.19		18.57	39550
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17 78*	
8.93	0.48	9.41	0.47		1.12	1.59	1.93	1.44	6.05	25.18	38846
7.88	1.62	9.50	0.65		1.03	1.68	2.04	1.04	5.40	23 51	39305
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*7.00*		*22.78*	
12.91	0.54	13.45	0.54		1.75	2.29	2.78	1.14	1.54	26.72	38847
11.88	2.96	14.84	0.63		1.02	1.65	2.00	2.06		23 28	39551
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*22.58*	
8.25	3.71	11.96	0.20		1.05	1.25	1.52	1.51		17.27	38848
7.89	1.34	9.23	0.42		0.61	1.03	1.25	1.23		14.85	39306
8.70	1.91	10.61	0.22		0.71	0 93	1.13	1.18		15.64	39552
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*13.87*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Swift & Co.,	
38849	Swift's Tobacco and Truck Grower	Manufacturer
39307		Barren County Grocery and Hardware Co., Glasgow
38850	Swift's Kentucky Tobacco Grower	Manufacturer
38851	Swift's Vegetable and Tobacco Grower	Manufacturer
39308		Barren County Grocery and Hardware Co., Glasgow
38852	Swift's Diamond A Fertilizer	Manufacturer
38853	Swift's Diamond B Fertilizer	Manufacturer
	Taylor & Powell Fertilizer Co., Springfield, Tenn.	
39387	Henry's Special Wheat Grower	Manufacturer
39388	W. & B. Wheat Formula	Manufacturer
39397	Downer's Wheat Special	Manufacturer
39099	No. 4 Tobacco Grower	Manufacturer
39315		Walter Pendleton, Pembroke
39100	No. 6 Tobacco Grower	*Manufacturer
39105	Grain Special	Manufacturer

*The Manufacturer failed to furnish sample as required by law.

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.77	3.02	12.79	0.22		1.00	1.22	1.48		4.73	$22.88	38849
7.78	1 93	9.71	0.23		0.67	0.90	1.09	0.66	3.63	18.52	39307
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*4.00*	*17.67*	
11.42	1 98	13.40	0.33		1.65	1.98	2.40	2 81		24.23	38850
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*20.18*	
8.72	0 83	9.55	0.37		2.50	2.87	3.48		12.12	35.38	38851
8.67	2.98	11.65	1.07		1.41	2.48	3.01	1.54	7.82	31 19	39308
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*10.00*	*30 65*	
9.60	0.50	10.10	1.22		1.29	2.51	3.05	3 76		24.27	38852
8.00	*1.00*	*9.00*				*2.47*	*3.00*	*3.00*		*21.65*	
9.49	1.95	11 44	0.20		2.58	2.78	3.37	6.33		28.23	38853
8.00	*1.00*	*9.00*				*2.47*	*3.00*	*5.00*		*23.65*	
10.70	7.85	18.55				1.07	1.30	0.44	2.22	22.93	39387
10.00						*0.82*	*1.00*	*3.00*		*17.87*	
8.74	9.29	18.03				1.75	2.12	0.80	1.19	22.57	39388
8.00						*1.65*	*2.00*		*2.00*	*17.78*	
11.64	3.95	15.59				1.83	2.22	0.84	2.93	26.32	39397
10.00						*1.65*	*2.00*		*4.00*	*22.58*	
9.97	0.98	10.95				2.17	2.63		2.85	23.37	39099
8.48	1.08	9 56	0.69		2.02	2.71	3.29	3 95		24.05	39315
8.00						*2.06*	*2.50*		*4.00*	*21.61*	
											39100
8.00						*2.06*	*2.50*		*6.00*	*24.01*	
12.67	6.35	19.02				0.92	1.12		2.09	23.47	39105
12.00						*0.82*	*1.00*		*2.00*	*19.67*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Tennessee Chemical Co., Nashville, Tenn.	
38914	Ox Special Corn and Wheat Grower	Manufacturer
39319		I. K. Miller & Sons, Campbellsville
39564		J. M. Johnson, Benton
38915	Ox Pride Tobacco Grower	Manufacturer
39320		J. C. Cowherd & Co., Greensburg
38916	Ox Grain Grower	Manufacturer
39321		I. K. Miller & Sons, Campbellsville
39565		R. E. Moore, Madisonville
38917	Ox Slaughter House Bone	Manufacturer
39322		W. F. Grainger, Franklin
39566		W. F. Grainger, Franklin
38918	Ox Ammoniated Bone	Manufacturer
38919	Ox Special Tobacco Guano	Manufacturer
39323		Sexton Brothers, Murray
38920	Ox High Grade Tobacco and Potato Grower	Manufacturer
39324		I. K. Miller & Sons, Campbellsville
38922	Ox Truck Grower	Manufacturer
39325		W. F. Grainger, Franklin
38923	Ox Special Tobacco Grower	Manufacturer
39326		S. O. Moody, Auburn

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
8.02	0.97	8.99				0.89	1.08		1.51	$14.94	38914
8.90	0.98	9.88	0.33		0.59	0.92	1.12	2.33		16.62	39319
9.09	1.62	10.71				0.66	0.80	1.56		15.42	39564
7.00	*2.00*	*9.00*				*0.82*	*1.00*		*1 00*	*13.27*	
9.29	1.06	10.35				0.99	1.20		2.06	17.51	38915
9.03	0.73	9.76	0.27		0.65	0.92	1.12	0.72	0.97	16 23	39320
8.00	*2.00*	*10.00*				*0.83*	*1.00*		*1.50*	*15.07*	
9.17	0.45	9.62				0.42	0.51		4.77	18.37	38916
8.22	0.77	8.99				0.51	0.62	3.89		15.85	39321
8.83	0 34	9.17				0.70	0.85	1.26	2.48	17.43	39561
8.00	*2.00*	*10.00*				*0.41*	*0.50*		*4.00*	*16.64*	
9.23	1.71	10.94				1.79	2.17		2.53	21.07	38917
9.30	0.46	9.76		0.63	0.79	1.42	1.72	0.64	1.61	18.88	39322
8.26	1.91	10.17				1.25	1.52	0.68	2 01	18.14	39566
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*18.58*	
10.71	2.18	12.89				1.95	2.37	0.62	2.47	24.13	38918
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
11.28	1.78	13 06				1.90	2.31	0.60	2.30	24.26	38919
9.19	1.34	10.53	0.28		1.36	1.64	1.99		2.07	19.79	39323
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
7.82	1.40	9.22				1.80	2.19		4.94	22.17	38920
8.98	0.80	9.78	0.45		0.92	1.37	1.66	3.63		19.53	39324
7.00	*2.00*	*9.00*				*1.65*	*2.00*		*4.00*	*19.78*	
8 88	1.03	9 91	1.39		0.36	1.75	2.12		11.10	30.52	38922
10.95	0.89	11.84	0.41		1.05	1.46	1.77	0.92	4.72	25 19	39325
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*10.00*	*28.18*	
9.51	2.33	11.84	1.64		0.21	1.85	2.25		11.30	32.38	38923
11.34	0.62	11.96		0.52	1.04	1.56	1.89	0.70	7.61	29 15	39326
10.00	*2.00*	*12.00*				*1.65*	*2.00*		*10.00*	*30.58*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Tennessee Chemical Co.,	
39089 39328	Ox High Grade Tobacco Grower	Manufacturer N. Wood, Trenton
	Tennessee Valley Fertilizer Co., Florence, Ala.	
38700	Three Link Guano	Manufacturer
38701	Monarch	Manufacturer
38702	Blood and Bone	Manufacturer
38703	Pride of Kentucky	Manufacturer
38704	Tiger Special Tobacco Grower	Manufacturer
	The T. J .Turley Co., Owensboro, Ky.	
38995 39569	Ideal Grain Grower	Manufacturer McAtee, Vickers Hardware Co., Russellville
38996	Ideal Tobacco Grower	Manufacturer
38997 39330	Ideal Truck and High Grade Tobacco Grower	Manufacturer McAtee, Vickers Hardware Co., Russellville
38999	Ideal Wheat Grower	Manufacturer

Complete Fertilizers.

Phosphoric Acid.			Nitrogen.				Equivalent to Ammonia.	Potash.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.10	1.30	9.40				1.74	2.11		5.50	$22.93	39089
8.33	2.51	10.84	0.31		1.36	1.67	2.03	0.70	3.28	21.49	39328
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
12.53	0.48	13.01	0.77		1.00	1.77	2.15	2.18		23.61	38700
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*20.18*	
10.44	0.36	10.80	0.63		1.16	1.79	2.17	2.19		21.13	38701
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
12.46	0.43	12.89				1.02	1.24	0.92		19.61	38702
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*16.27*	
12.32	0.33	12.65				1.01	1.23		4.18	23.47	38703
10.00	*1.00*	*11.00*				*0.82*	*1.00*		*4.00*	*20.07*	
9.97	0.36	10.33	0.64		1.05	1.69	2.05		4.37	23.26	38704
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*20.58*	
8.65	7.70	16.35	0.23		0.86	1.09	1.32	0.64	2.52	20.94	38995
8.47	1.22	9.69				0.98	1.19		2.85	17.50	39569
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*3.00*		*15.87*	
9.54	3.24	12.78		1.07	0.95	2.02	2.45		4.56	25.29	38996
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*20.58*	
10.22	1.29	11.51	0.23		1.60	1.83	2.22		8.23	29.07	38997
7.80	0.97	8.77	0.30	0.25	1.01	1.56	1.89		10.28	27.55	39330
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*27.78*	
9.26	5.58	14.84	0.32	0.83	0.75	1.90	2.31	0.58	1.70	22.61	38999
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Tuscarora Fertilizer Co., Chicago, Ill.	
38943	Dark Tobacco Grower	Manufacturer
38944	Ammoniated Phosphate	Manufacturer
38945	Big Four	Manufacturer
38946	Tuscarora Standard	Manufacturer
38947	Tuscarora Trucker	Manufacturer
38948	Wheat and Corn Grower	Manufacturer
39571		T. J. Alexander, Monticello
38949	Tobacco Special	Manufacturer
38957	Dickinson's Corn, Wheat and Oats Grower	Manufacturer
38958	Dickinson's Tobacco and Potato Grower	Manufacturer
38959	Dickinson's High Grade Potash Mixture	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
8.35	1.02	9.37				1.69	2.05		10.47	$28.91	38943
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*27.78*	
8.02	9.32	17.34	0.22	0.29	0.62	1.13	1.37	0.48	0.86	18.82	38944
7.00	*1.00*	*8.00*				*0.82*	*1.00*	*1.00*		*12.67*	
7.89	6.12	14.01		1.09	0.86	1.95	2.37		4.02	23.57	38945
7.00	*1.00*	*8.00*				*1.65*	*2.00*		*4.00*	*19.38*	
9.06	5.53	14.59		1.01	0.89	1.90	2.31		2.20	22.37	38946
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*2.00*	*17.78*	
9.05	0.96	10.01		2.23	2.04	4.27	5.18	8.73		34.92	38947
8.00	*1.00*	*9.00*				*4.12*	*5.00*	*7.00*		*31.42*	
9.42	2.55	11.97		1.14	1.21	2 35	2.85	2.89		23.44	38948
9.75	1.43	11.18				1.55	1.88	1.10	0.95	19.94	39571
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*20.18*	
8.94	5.09	14.03	0.43		1.50	1.93	2.34		5.10	25.65	38949
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
8.19	7 98	16.17	0.27		1.55	1.82	2.21		2.21	22.04	38957
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*17.78*	
10.34	9.59	19.93	0.24		1.28	1 52	1.85	3.43		25.69	38958
7.00	*1.00*	*8.00*				*1.65*	*2.00*		*4.00*	*19.38*	
8.56	3.09	11.65	0.29		1.58	1.87	2 27		11.30	31.62	38959
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*27.78*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Virginia-Carolina Chemical Co., Memphis, Tenn.	
38720	Beef, Blood and Bone Fertilizer	Manufacturer
39332		Olive & Walker, Marion
38721	Royal Blood, Bone and Potash	Manufacturer
38722	National Tobacco Fertilizer	Manufacturer
39333		Olive & Walker, Marion
38723	Royal Tobacco Fertilizer	Manufacturer
38724	Champion Corn and Wheat Grower	Manufacturer
39114	Scott's State Standard Guano	Manufacturer
39115	Royal Vegetable Fertilizer	Manufacturer
39356	Eureka Special Fertilizer	Manufacturer
	Virginia-Carolina Chemical Co., Cincinnati, Ohio.	
39361	Bright Leaf Tobacco and Truck Grower	Manufacturer
39362	Complete Fertilizer	Manufacturer
39363	Wheat, Corn and Tobacco Grower	Manufacturer
39574		R. H. Chrisman, Berea

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.		From Muriate.	From Sulphate.		
8.60	0.74	9.34				1.70	2.06	2.33		$19.37	38720
7.98	1.42	9.40				1.59	1.93	3.08		18.80	39332
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
9.09	0.64	9.73				1.61	1.95	2.44		19.25	38721
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
7.99	0.60	8.59				1.68	2 04	0.68	3.53	20.63	38722
8.14	0.71	8.85				1.51	1.83	0.60	3.07	19.62	39333
7.00	*2.00*	*9.00*				*1.65*	*2.00*		*4.00*	*19.78*	
8.70	0.77	9.47				1.85	2.25	0.70	4.03	22.77	38723
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*5.00*	*21.78*	
8.17	0.68	8.85				1.01	1.23	2.32		15.93	38724
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*2.00*		*15.27*	
7.71	0.47	8.18				1.68	2.04	2.21		17.53	39114
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*2.00*		*18.18*	
8.68	0.84	9.52		1.11	1.59	2.70	3 28	4.98		25.19	39115
8.00	*2.00*	*10.00*				*2.47*	*3 00*	*4.00*		*23.05*	
9.44	1.56	11.00				1.06	1.29	4.73		20.39	39356
10.00	*2.00*	*12.00*				*0.82*	*1.00*	*5.00*		*20.67*	
7.61	1.42	9.03	0.25	0.38	0.90	1.53	1.86	1.64	4.52	22.12	39361
6.00						*1.65*	*2.00*		*6.00*	*20.18*	
8.29	2.36	10.65	0.24	0.88	0.61	1.73	2 10	2.34		19.29	39362
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
8.50	1.38	9.88		0.59	0.43	1.02	1.24	3.80		18.22	39363
8.63	1.73	10.36		0.43	0.44	0 87	1.06	4.46		18.58	39574
8.00						*0.82*	*1.00*	*4.00*		*16.47*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Virginia-Carolina Chemical Co.,	
39364	Champion Corn and Wheat Grower	Manufacturer
39365	Standard Wheat Special	Manufacturer
39366	Star Brand Grain Grower	Manufacturer
39367	Royal Tobacco Fertilizer	Manufacturer
39368	National Tobacco Fertilizer	Manufacturer
39369	Beef, Blood and Bone	Manufacturer
39370	Royal Blood, Bone and Potash	Manufacturer
39575		R. H. Chrisman, Berea
39381	Royal Vegetable Fertilizer	Manufacturer
39382	Scott's State Standard Guano	Manufacturer
39383	Tip Top Tomato Grower	Manufacturer
39384	Diamond Potash Formula for Wheat and Corn	Manufacturer
39385	Game Cock Grain and Grass Grower	Manufacturer
39386	Game Cock Wheat and Corn Compound	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
9.78	1.24	11.02		0.38	0.52	0.90	1.09	2.16		$17.55	39364
8.00						*0.82*	*1.00*	*2.00*		*14.47*	
12.02	1.50	13.52		0.52	0.54	1.06	1.29	3.31		22.04	39365
11.00						*0.82*	*1.00*	*3.00*		*19.07*	
8.59	1.77	10.36		0.81	0.63	1.44	1.75	2.39		18.45	39366
8.00						*1.23*	*1.50*	*2.00*		*15.91*	
9.78	1.44	11.22		0.60	1.11	1.71	2.08	1.40	3.67	24.11	39367
8.00						*1.65*	*2.00*		*5.00*	*21.38*	
8.91	1.35	10.26		0.48	1.08	1.56	1.89	1.38	2.95	21 61	39368
7.00						*1.65*	*2.00*		*4.00*	*18.98*	
7.93	2.52	10.45	0.38	0.77	0.57	1.72	2.09	2.37		18.92	39369
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
8.03	2.60	10.63	0.26	0.88	0.62	1.76	2.14	2.39		19.23	39370
8.40	1.94	10.34		1.13	0.49	1.62	1.97	2.26		18.79	39575
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
8.54	1.29	9.83		2.27	0.56	2.83	3.44	3.98	0.64	25.43	39381
8.00						*2.47*	*3.00*	*4.00*		*22.25*	
8.18	2.55	10.73	0.28	0.81	0.61	1.70	2.06	2.27		19.06	39382
8.00						*1.65*	*2.00*	*2.00*		*17.38*	
7.71	0.96	8.67		2.92	0.73	3.65	4.43	1.34	4 61	29.28	39383
7.00						*3.29*	*4.00*		*5.00*	*25.92*	
9.67	1.33	11.00		0.34	0.37	0.71	0.86	5.09		19.71	39384
9.00						*0.41*	*0.50*	*5.00*		*17.24*	
10.77	1.42	12.19		0.60	0.30	0.90	1.09	3.03		19.67	39385
10.00						*0.82*	*1.00*	*3.00*		*17.87*	
11.02	1.35	12.37		0.62	0.34	0.96	1.17	2.11		19.23	39386
10.00						*0.82*	*1.00*	*2.00*		*16.87*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Wood, Stubbs & Co., Louisville, Ky.	
38840	Acme Brand Potato and Tobacco Fertilizer	Manufacturer
38841	Acme Brand High Grade Vegetable Fertilizer	Manufacturer
38842	Acme Brand Special Truckers Fertilizer	Manufacturer
38843	Acme Brand Blood, Bone and Potash	Manufacturer
38844	Acme Brand Wheat and Corn Fertilizer	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID.			NITROGEN.					POTASH.			
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
8.02	1.29	9.31	0.99		1.56	2.55	3.10		6.73	$27.15	38840
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*6.00*	*27.05*	
9.24	0.70	9.94	1.45	0.41	1.64	3.50	4.25	0.74	4.54	29.81	38841
8.00	*4.00*	*12.00*				*3.29*	*4 00*		*4.00*	*27.52*	
9.65	0.68	10.33		0.66	2.65	3.31	4.02	0.88	3.05	27.98	38842
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*2.00*	*22.25*	
11 63	2.08	13.71		0.44	1.63	2.07	2.51		3.16	25.83	38843
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*21.78*	
13.19	1.47	14.66		0.28	1.13	1.41	1.71		3.31	25.33	38844
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*18.87*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chemical Co., Cincinnati, Ohio.	
38571	Pure Ground Bone	Manufacturer .....
39417		W. M. Powell, Greenville .....
38572	Fine Raw Bone	Manufacturer .....
39132		E. L. Robertson, Glendeane .....
39418		E. P. Barnes & Bro., Beaver Dam ....
	The American Agr'l Chemical Co., Bowker Fertilizer Works, Cincinnati, Ohio.	
38596	Bowker's Pure Bone and Potash Mixture	Manufacturer .....
38597	Bowker's Pure Ground Bone..	Manufacturer .....
39146		Powell & Williams, Greenville .....
	The American Agr'l Chemical Co., Michigan Carbon Works, Cincinnati, Ohio.	
38609	Wolverine Pure Ground Bone	Manufacturer .....
39438		Woodson Lewis, Greensburg .....
	The American Agr'l Chemical Co., North Western Fertilizing Co., Cincinnati, Ohio.	
38624	Horseshoe Brand Pure Ground Bone	Manufacturer .....
39165		E. L. Robertson, Glendeane .....
	The American Agr'l Chemical Co., Packers Fertilizer Association, Cincinnati, Ohio.	
38636	Boar's Head Brand Chicago Bone Meal	Manufacturer .....

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
79	21	20.32	44.37	2.60	3.16			$24.50	38571
69	31	21.47	46.88	2 40	2.91			24.25	39417
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
67	33	22.44	49.01	3.38	4.19			28.30	38572
60	40	20.96	45.78	3.57	4.33			27.59	39132
61	39	22.82	49.84	3.70	4.49			29.43	39418
		22.00	*48.06*	*3.29*	*4.00*			*24.72*	
90	10	17.67	38.59	1.16	1.41	4.62		22.46	38596
		18.00	*39.31*	*0.82*	*1.00*	*3.00*		*16.67*	
77	23	20.20	44.12	2.61	3.17			29.66	38597
69	31	22.82	49.84	2.21	2.68			24.58	39146
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
77	23	20.91	45.64	2.58	3.13			24.80	38609
80	20	17.75	38.74	2.53	3.07			22.35	39438
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
80	20	20.68	45.16	2.63	3.19			24.92	38624
75	25	22.44	49.01	2.35	2.85			25.06	39165
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
80	20	20.20	44.12	2.67	3.24			24.70	38636
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	Fine Bone.
	The Armour Fertilizer Works, Chicago, Ill.		
38962	Armour's Bone Meal	Manufacturer	94
39166		Dickey & Martin, Munfordville	88
39449		Barren County Grocery and Hardware Co., Glasgow	87
38978	Mixed Bone and Potash	Manufacturer	91
39460		J. R. Johnson, Flippin	64
38979	Raw Bone Meal	Manufacturer	81
39175		Dickey & Martin, Munfordville	63
39461		The T. J. Turley Co., Owensboro	76
	Baugh & Sons Co., Norfolk, Va.		
39118	Baugh's Raw Bone Meal	Manufacturer	96
	Central Manufacturing Co., Lockland, Ohio.		
38514	Equity Bone Tankage and Potash	Manufacturer	79
39181		Whiteley & Eskridge, Leitchfield	52
39468		R. H. Chrisman, Berea	51
38515	Equity Raw Bone Meal	Manufacturer	70
39182		Lebanon Carriage & Implement Co., Lebanon	76
39092	Equity Ground Tankage	Manufacturer	70
	The Cincinnati Phosphate Co., Cincinnati, Ohio.		
39053	Ground Bone	Manufacturer	72

BONES, TANKAGE, &c.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
94	6	26.90	58.76	2.44	2.96			$29.74	38962
88	12	26.26	57.36	2.16	2.62			27.94	39166
87	13	28.12	61.41	1.96	2.38			28.63	39449
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
91	9	25.35	55.36	1.61	1.95		4.38	30.73	38978
64	36	19.74	43 11	0.91	1.10		4.97	23.52	39460
		18.00	*39.31*	*0.82*	*1.00*		*4.00*	*18.47*	
81	19	24.99	54.58	3 86	4.69			32.55	38979
63	37	22.77	49.73	3.54	4.30			28.92	39175
76	24	26 62	58.14	3.56	4.32			32.47	39461
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
96	4	21.22	46.35	3.50	4.25			29.06	39118
		21.50	*46.93*	*3.71*	*4.50*			*25.89*	
79	21	14.49	31.66	4.15	5.04	0.75		26.26	38514
52	48	14.87	32.47	3.88	4.71	2.21		26.25	39181
51	49	15 20	33.19	4.25	5.16	4.27		29.82	39468
		15.00	*32.76*	*3.71*	*4.50*	*2.00*		*23.99*	
70	30	22.31	48.73	3 63	4.41			29.22	38515
76	24	22 21	48.50	3.50	4.25			28.95	39182
		23.00	*50.24*	*2.88*	*3.50*			*23.88*	
70	30	11.42	24.95	6.40	7.77			30.85	39092
		11.44	*25.00*	*6.59*	*8.00*			*29.93*	
72	28	23.08	50.40	2.91	3.53			27.37	39053
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Continental Fertilizer Co., Nashville, Tenn.	
38905	Bear Bone Meal	Manufacturer
38906	Bear Raw Bone	Manufacturer
	The Empire Guano Company, Nashville, Tenn.	
38531	Raw Bone Meal	Manufacturer
38533	Pure Raw Bone Meal	Manufacturer
	Evansville Packing Co., Evansville, Ind.	
39019	Pure Raw Bone Meal	Manufacturer
	Federal Chemical Co., Louisville, Ky.	
38753	Daybreak Fine Raw Bone	Manufacturer
39475		Ollie Scott, Beaver Dam
38754	Daybreak Raw Bone	Manufacturer
	Fox Chemical Co., Branch Federal Chemical Co., Louisville, Ky.	
38783	Fox Ground Raw Bone	Manufacturer
39401		E. B. Riley, Olmstead
38784	Fox Raw Bone	Manufacturer

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
78	22	26.08	56.97	1.57	1.91			$25.21	38905
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
56	44	24.33	53.14	3.87	4.70			30.88	38906
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
34	66	22.75	49.68	3.55	4.31			27.63	38531
		20.00	*43.67*	*2.65*	*3.22*			*21.28*	
40	60	23.64	51.63	4.28	5.20			31.06	38533
		23.00	*50.24*	*3.71*	*4.50*			*26.79*	
37	63	23.23	50.74	4.26	5.17			30.56	39019
		23.00	*50.24*	*3.71*	*4.50*			*26.79*	
75	25	24.23	52.92	3.10	3.76			29.03	38753
87	13	21.80	47.61	2.57	3.12			25.88	39475
		24.00	*52.42*	*2.88*	*3.50*			*24.48*	
48	52	24.05	52.53	3.97	4.82			30.64	38754
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
75	25	24.58	53.67	3.18	3.86			29.56	38783
83	17	26.52	57.92	2.25	2.73			28.20	39401
		24.00	*52.42*	*2.88*	*3.50*			*24.48*	
36	64	23.64	51.63	3.93	4.77			29.65	38784
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Globe Fertilizer Co., Branch Federal Chemical Co., Louisville, Ky.	
38816	Acorn Raw Bone	Manufacturer
39488		W. E. Gravely, Brodhead
38817	Globe Raw Bone	Manufacturer
	The Groves Company, Cincinnati Ohio.	
38645	Pure Ground Bone	Manufacturer
38646	Pure Raw Bone	Manufacturer
39492		W. T. Kirkman, Elkton
38648	Pure Bone and Potash Mixture	Manufacturer
38649	Half and Half	Manufacturer
39493		W. T. Kirkman, Elkton
	Hirsh, Stein & Co., Chicago, Ill.	
38659	Calumet Brand Pure Raw Bone Meal	Manufacturer
39237		J. B. Taylor, Lewisport
39409		W. S. McGuffin, Hardin Springs
39495		L. C. Goering, Hawesville
38869	Calumet Brand Special Pure Bone Meal and Potash	Manufacturer
39242		Grayson County Supply Co., Leitchfield
39500		Hutcheson Bros., Auburn
38870	Calumet Brand Extra Bone Meal	Manufacturer

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
79	21	24.71	53.96	2.96	3.59			$29.09	38816
87	13	22.82	49.84	2.60	3.16			26.76	39483
		24.00	*52.42*	*2.88*	*3.50*			*24.48*	
33	67	23.84	52.06	4.09	4.97			30.20	38817
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
81	19	22.06	48.17	2.59	3.14			25.78	38645
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
59	41	22.03	48.11	3.78	4.59			29.05	38646
50	50	23.77	51.91	4.56	5.54			32.60	39492
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
90	10	22.49	49.12	1.14	1.38	6.14		27.73	38648
		20.00	*43.67*	*0.82*	*1.00*	*5.00*		*19.87*	
87	13	19.71	43.06	1.76	2.14	2.37		23.27	38649
80	20	18.13	39.59	1.66	2.02	2.26		21.85	39493
		16.00	*34.95*	*1.65*	*2.00*	*2.00*		*17.38*	
30	70	21.83	47.68	4.32	5.24			29.53	38659
25	75	21.34	46.60	3.96	4.81			27.73	39237
51	49	20.43	44.62	3.67	4.46			29.35	39409
29	71	23.05	50.35	3.77	4.58			28.36	39495
		20.00	*43.67*	*3.71*	*4.50*			*24.99*	
56	44	21.80	47.61	1.24	1.51	5.40		25.26	38869
50	50	21.68	47.36	1.06	1.29	4.60		23.48	39242
65	35	22.19	48.46	1.21	1.47	3.97		24.41	39500
		20.00	*43.67*	*0.82*	*1.00*	*4.00*		*18.87*	
60	40	30.04	65.60	2.09	2.54			28.95	38870
		28.00	*61.16*	*2.00*	*2.43*			*23.80*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Hirsh, Stein & Co.,	
38871	Calumet Brand Pure Bone Meal	Manufacturer
38872	Calumet Brand Special Pure Bone Meal	Manufacturer
39501		L. C. Goering, Hawesville
	Hopkins Fertilizer Co., New Albany, Indiana.	
39002	Old Time Pure Raw Bone	Manufacturer
39506		O. A. Lutes & Co., Shepherdsville
39003	Old Time Special Ground Bone	Manufacturer
39507		Wilson Supply Company, Bardstown
	International Agr'l Corporation (Buffalo Fert. Works) Cincinnati, Ohio.	
39348	Bone Meal	Manufacturer
39504		I. K. Miller & Sons, Campbellsville
	The Jarecki Chemical Co., Cincinnati, Ohio.	
39038	Pure Ground Bone	Manufacturer
	Jones Fertilizer Co., Louisville, Ky.	
38941	Jones Bone Meal	Manufacturer
39514		Will Copers, Mount Hermon
38942	Jones Raw Bone	Manufacturer
39515		Will Copers, Mount Hermon

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
80	20	24.15	52.75	2.71	3.29			$27.85	38871
		22.90	*50.00*	*2.47*	*3.00*			*22.39*	
60	40	33.44	73.04	1 81	2.20			30.42	38872
38	62	30.86	67 40	1 37	1 66			25 66	39501
		29.00	*63.34*	*0 82*	*1.00*			*20.27*	
44	56	22.70	49 58	3.84	4.66			29.06	39002
40	60	21.65	47.27	4 19	5 09			29.39	39506
		22.00	*48.06*	*3.50*	*4.25*			*25.45*	
50	50	21.70	47.39	2.65	3 22			24.47	39003
63	37	20.83	45 49	2.62	3 18			24.29	39507
		20.60	*43.67*	*2.47*	*3.00*			*20.65*	
80	20	22.62	49.40	2 69	3.27			26.61	39348
.75	25	24 81	54.18	2.72	3 30			28.13	39504
		22.00	*48.06*	*2.47*	*3.00*			*21.85*	
72	28	21.91	47.86	3.16	3 84			27.36	39038
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
75	25	25 68	56 08	1.66	2 02			25 07	38941
96	4	26.52	57 92	2.11	2 56			28 40	39514
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
66	34	24 15	52 75	3.86	4.69			31.19	38942
59	41	23.33	50.96	3.86	4 69			30.26	39515
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Kaufman Fertilizer Co., Cincinnati, Ohio.	
39065	Pure Bone	Manufacturer
	Kentucky Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.	
38835	O. K. Fine Raw Bone	Manufacturer
38836	O. K. Raw Bone	Manufacturer
	Louisville Fertilizer Co., Louisville, Ky.	
38879	Eagle Raw Bone Mixture	Manufacturer
38890	Eagle Bone Meal	Manufacturer
39271		D. L. D. Sandefur, Beaver Dam
38891	Eagle Raw Bone	Manufacturer
39208	Eagle Special Raw Bone	Manufacturer
	Morris & Co., Chicago, Ill.	
38688	Big One-Ground Raw Bone	Manufacturer
39523		Hatter Hardware Co., Franklin
38689	Big Two-Pure Bone Meal	Manufacturer
39524		Woodson Lewis, Greensburg
38693	Big Six-Special Bone Meal and Potash	Manufacturer
39526		Woodson Lewis, Greensburg

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
75	25	22.41	48 95	3 00	3 64			$27.31	39065
		20.00	*43.67*	*2.47*	*3.00*			*20.65*	
76	24	24.25	52.96	2.91	3 53			28 42	38835
		24 00	*52.42*	*2.88*	*3.50*			*24.48*	
40	60	23 92	52.25	4 03	4.89			30 38	38836
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
62	38	17.80	38 86	1.87	2 27		1.58	21.34	38879
		15.00	*32.76*	*1.65*	*2.00*		*1.00*	*15.98*	
78	22	25 60	55 91	1 63	1 98			25 07	38890
89	11	26 54	57.96	2.68	3.25			30 03	39271
		27.00	*58.96*	*1.65*	*2.00*			*21 98*	
55	45	24.33	53 14	3.96	4 81			31 13	38891
		22.00	*48 06*	*3.71*	*4.50*			*26.19*	
50	50	21.16	46 21	4.66	5.66			31.12	39208
		20 00	*43.67*	*3.71*	*4.50*			*24 99*	
70	30	25 50	55 68	3 22	3 91			30.14	38688
56	44	26 48	57.84	3.37	4 09			30 65	39523
		24.00	*52.42*	*3.29*	*4.00*			*25 92*	
89	11	28 98	63.28	1.90	2 31			29 19	38689
71	29	29 72	64 90	1.83	2 22			28 46	39524
		28 00	*61.16*	*2.06*	*2.50*			*24.01*	
90	10	16 73	36 55	0 56	0 68	0 94	1.73	18.03	38693
76	24	13 87	30.29	1.08	1.31	0.54	1.38	16 41	39526
		16.00	*34.95*	*0.41*	*0.50*		*2.00*	*13.44*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	National Fertilizer Co., Nashville, Tenn.	
39392	Old Hickory Brand Nitrogen, Bone and Potash	Manufacturer
39123		T. P. Johnson, Oak Grove
39532		F. A. Yost Co., Hopkinsville
39393	Old Hickory Brand Pure Raw Bone Meal	Manufacturer
	Pero & Stoecker, Louisville, Ky.	
39093	Pure Bone Meal	Manufacturer
39533		Watkins & Company, Elizabethtown
39094	Pure Animal Matter Corn and Wheat Grower	Manufacturer
39534		Watkins & Company, Elizabethtown
39095	Pure Animal Matter and Potash	Manufacturer
	Read Phosphate Co., Nashville, Tenn.	
38546	Read's Half and Half Raw Bone Meal and Acid Phosphate	Manufacturer
39541		J. I. Rice, Adairville
38547	Read's Raw Bone Meal	Manufacturer
38564	Read's Pure Raw Bone Meal	Manufacturer

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
90	10	23.97	52.36	2.43	2.95	3.39		$30.60	39392
91	9	20.96	45.78	2.52	3.06	2.61		27.82	39123
83	17	24.61	53.76	2.55	3.10	2.68		30.46	39532
		23.00	*50.24*	*2.47*	*3.00*	*3.00*		*25.45*	
42	58	23.94	52.28	3.65	4.43			29.15	39393
		22.00	*48.06*	*3.29*	*4.00*			*24.72*	
77	23	23.89	52.17	3.07	3.73			28.76	39093
75	25	24.79	54.15	3.25	3.95			29.97	39533
		22.00	*48.06*	*3.50*	*4.25*			*25.45*	
74	26	15.68	34.25	4.77	5.79			28.43	39094
69	31	20.55	44.87	4.00	4.86			29.15	39534
		10.00	*21.85*	*4.00*	*4.86*			*20.00*	
80	20	14.46	31.57	4.04	4.90	1.00	5.17	32.33	39095
		10.00	*21.85*	*4.00*	*4.86*		*4.00*	*24.80*	
50	50	21.12	46.13	2.46	2.99			23.40	38546
52	48	18.26	39.87	1.56	1.89			18.32	39541
		18.00	*39.31*	*2.06*	*2.50*			*18.01*	
30	70	23.16	50.57	3.73	4.53			28.35	38547
		20.00	*43.67*	*2.65*	*3.22*			*21.28*	
39	61	23.66	51.67	4.15	5.04			30.57	38564
		23.00	*50.24*	*3.71*	*4.50*			*26.79*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Smith Brothers, Louisville, Ky.	
38989	Pure Raw Bone Meal	Manufacturer
39299		Greenville Hardware and Grocery Co., Greenville
39546		Greenville Hardware and Grocery Co., Greenville
38992	Bone Meal	Manufacturer
38993	Pure Bone Meal with Potash	Manufacturer
	Swift & Company, Chicago, Ill.	
38857	Swift's Pure Raw Bone Meal	Manufacturer
39311		C. E. Owen, Madisonville
39555		Parrish & Hankins, Providence
38858	Swift's Pure Bone Meal	Manufacturer
39312		N. F. Hill, Bowling Green
39556		C. E. Owen, Madisonville
38859	Swift's Pure Bone Meal and Blood	Manufacturer
39557		Grayson County Supply Co., Leitchfield
38860	Swift's Pure Bone Meal and Potash	Manufacturer
39313		Forbes Manufactur'g Co., Hopkinsville
39558		Parrish & Hankins, Providence
38861	Swift's Ground Steamed Bone	Manufacturer
39314		N. F. Hill, Bowling Green
38862	Swift's Ground Beef Bone	Manufacturer

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
81	19	24.53	53.57	3.84	4.66			$32.14	38989
55	45	24.56	53.64	3.62	4.39			30.11	39299
63	37	25.47	55.63	3 94	4.78			32.28	39546
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
96	4	27.24	59.48	2.40	2.91			29.97	38992
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
97	3	25.37	55.41	1 60	1 94		4.32	30.93	38993
		18.00	*39.31*	*0.82*	*1.00*		*4.00*	*18.47*	
64	36	25.52	55.74	3.79	4.60			31.84	38857
75	25	23.51	51 35	3.98	4.83			31 56	39311
66	34	23.82	52 02	3.90	4.73			31 09	39555
		23.00	*50.24*	*3.71*	*4.50*			*26.79*	
76	24	25.86	56.48	2.64	3.20			28 69	38858
78	22	24.96	54.51	2 64	3.20			28 11	39312
78	22	25.62	55 96	2.29	2.78			27 38	39556
		24.00	*52.42*	*2.47*	*3.00*			*23.05*	
80	20	24.15	52.75	3.76	4.56			31.52	38859
73	27	22 75	49 68	3 64	4.42			29.71	39557
		23.00	*50.24*	*3.71*	*4.50*			*26.79*	
75	25	26.34	57 53	1.78	2.16	3 22		29.21	38860
86	14	26.78	58.48	2 16	2.62	2 34		30 57	39313
72	28	25.32	55.29	2 09	2 54	3.35		29 50	39558
		25.00	*54.59*	*1.85*	*2.25*	*3.00*		*24.48*	
81	19	21.04	45.96	1 80	2 19			22 33	38861
84	16	24.02	52 43	1 93	2.34			25 20	39314
		20.00	*43.67*	*1.65*	*2.00*			*17.78*	
77	23	29.00	63 34	2.22	2.70			29.63	38862
		27.00	*58.96*	*2.06*	*2.50*			*23.41*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Taylor & Powell Fertilizer Co., Springfield, Tenn.	
39102	Raw Bone Meal	Manufacturer
39410		G. H. Byars, Adairville
	Tennessee Chemical Co., Nashville, Tenn.	
38921	Ox Raw Bone with Potash	Manufacturer
39567		W. F. Grainger, Franklin
38924	Ox Bone Meal	Manufacturer
39327		Jas. I. Rice, Adairville
39568		W. F. Grainger, Franklin
38925	Ox Raw Bone	Manufacturer
39352	Ox Bone Meal Special	Manufacturer
	The T. J. Turley Co., Owensboro, Ky.	
38994	Ideal Half and Half	Manufacturer
38998	Ideal Bone Meal	Manufacturer
39331		McAtee, Vickers Hardware Co., Russellville
39570		Manufacturer's Warehouse
	Tuscarora Fertilizer Co., Chicago, Ill.	
38951	Bone Meal	Manufacturer
38952	Raw Bone Meal	Manufacturer
39572		T. J. Alexander, Monticello

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.						POTASH.			
Fine Bone.	Medium Bone.	Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	From Muriate.	From Sulphate	Estimated Value Per Ton.	Station Number.
48	52	23.03	50.29	3.89	4.72			$29.65	39102
47	53	22.49	49.12	4.00	4.86			31.45	39410
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
86	14	19.58	42.76	2.16	2.62		4.42	27.97	38921
69	31	20.91	45.65	1.74	2.11		3.56	25.79	39567
		20.00	*43.67*	*1.85*	*2.25*		*3.00*	*22.08*	
74	26	25.37	55.41	1.67	2.03			24.83	38924
94	6	26.72	58.37	2.35	2.85			29.9	39327
94	6	27.50	60.07	2.33	2.83			29.83	39568
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
60	40	24.40	53.28	3.84	4.66			31.01	38925
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	
88	12	25.17	54.97	2.55	3.10			28.46	39352
		24.00	*52.42*	*2.47*	*3.00*			*23.05*	
100		24.00	52.42	1.82	2.21		3.09	29.28	38994
		16.00	*34.95*	*1.23*	*1.50*		*2.00*	*16.30*	
96	4	26.94	58.84	2.46	2.99			29.93	38998
68	32	26.90	58.76	2.00	2.43			26.80	39331
89	11	26.78	58.48	2.64	3.20			30.07	39570
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
83	17	26.98	58.93	2.48	3.01			29.34	38951
		27.00	*58.96*	*1.65*	*2.00*			*21.98*	
76	24	24.73	54.01	3.86	4.69			32.10	38952
67	33	24.81	54.18	3.93	4.77			31.97	39572
		22.00	*48.06*	*3.71*	*4.50*			*26.19*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Virginia-Carolina Chemical Co., Memphis, Tenn.	
38729	Ground Animal Bone	Manufacturer .....
	Wood, Stubbs & Co., Louisville, Ky.	
39034	Acme Brand Raw Bone Meal..	Manufacturer .....

BONES, TANKAGE, &C.

PERCENTAGE OF FINENESS.		Total Phosphoric Acid.	Equivalent to Bone Phosphate.	Nitrogen.	Equivalent to Ammonia.	POTASH.		Estimated Value Per Ton.	Station Number.
Fine Bone.	Medium Bone.					From Muriate.	From Sulphate		
73	27	23 97	52 32	2 97	3 61			$28 28	38729
		20.00	*43 67*	*3.29*	*4.00*			*23.52*	
41	59	22.16	48 37	3 73	4 53			28 17	39034
		22.00	*48.06*	*3.29*	*4.00*			*24.72*	

TABLE III.—ACID PHOSPHATES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Estimated Value Per Ton.	Station Number.
			Available.	Insoluble.	Total.		
	A. D. Adair & McCarty Bros., E. Chattanooga, Tenn.						
39076	Adair's High Grade Dissolved Bone	Manufacturer	15 27 *14.00*	0 36	15.63	$15.27 *14.00*	39076
	The American Agr'l Chemical Co., Cincinnati, Ohio.						
39027	A. A. C. Acid Phosphate	Manufacturer	13 03 *12.00*	2 09 *1.50*	15 12 *13.50*	13 03 *12.00*	39027
39350	A. A. C. Co.'s 16% Acid Phosphate	Manufacturer	17 27 *16.00*	2.08 *1.00*	19 35 *17.00*	17.27 *16.00*	39350
	The American Agr'l Chemical Co., Bradley Fertilizer Works, Cincinnati, Ohio.						
38579	Soluble Dissolved Bone	Manufacturer	14.71 *14.00*	2.40 *2.00*	17 11 *16.00*	14.71 *14.00*	38579
	The American Agr'l Chemical Co., Cleveland Dryer Works, Cincinnati, Ohio.						
38580	Horse Head Phosphate	Manufacturer	10.58	1.39	11 97	10 58	38580
39134		J. B. G. Higgs, Elizabethtown	9.59 *10.00*	1.85 *2.00*	11.44 *12.00*	9 59 *10.00*	39134

38581	XXX Superphosphate	Manufacturer	14 34	2 31	16.65	14 34	38581
39135		J. B. G. Higgs, Elizabethtown..	14 53	2.45	16 98	14 53	39135
39420		J. M. Smith, Leitchfield	14 49	2.80	17 29	14 49	394 0
			14.00	*2.00*	*16.00*	*14.00*	
	The American Agr'l Chemical Co., Bowker Fertilizer Works, Cincinnati, Ohio.						
38586	Bowker's Soluble Bone	Manufacturer	14.72	2.03	16 75	14.72	38586
39136		Hines, Lowry & Co., Science Hill	15 64	2.36	18 00	15 64	39136
39422		Marcum, Gooch & Payne, Eubank	14.15	4.19	18 34	14.15	39422
			14.00	*1.50*	*15.50*	*14.00*	
38587	Bowkers Acid Phosphate.....	Manufacturer	14.12	2.14	16.26	14.12	38587
39137		Hines, Lowry & Co., Science Hill	12 02	2.04	14 06	12 02	39137
39423		Marcum, Gooch & Payne, Eubank	12.25	2.80	15 05	12 25	394?3
			12.00	*1 50*	*13.50*	*12.00*	
	The American Agr'l Chemical Co., Michigan Carbon Works, Cincinnati, Ohio.						
38599	Red Line Phosphate	Manufacturer	15 53	1 84	17.37	15.53	38599
39148		Hines, Lowry & Co., Science Hill	14 61	3 42	18 03	14 61	39148
39430		R. H. Kemp, Marion	14.46	2.70	17 16	14 46	39430
			14.00	*2.00*	*16.00*	*14.00*	
	The American Agr'l Chemical Co., North Western Fertilizing Co., Cincinnati, Ohio.						
38622	Horseshoe Brand Square Deal Phosphate	Manufacturer	15.30	1 86	17 16	15.30	38622
39163		J. F. Ramey, Eddyville.....	15.54	2 03	17.57	15.54	39163
			14.00	*2.00*	*16.00*	*14 00*	
38623	Horseshoe Brand Quick Acting Phosphate	Manufacturer	10.58	1 06	11 64	10.58	38623
39164		Watkins & Co., Elizabethtown.	11.29	2 03	13 32	11 29	39164
39445		Watkins & Co., Elizabethtown.	9 97	3 62	13.59	9 97	39445
			10.00	*2.00*	*12.00*	*10.00*	

TABLE III.—ACID PHOSPHATES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Estimated Value Per Ton.	Station Number.
			Available.	Insoluble.	Total.		
	The American Agr'l Chemical Co., Packers Fertilizer Association, Cincinnati, Ohio.						
38625	Boar's Head Brand Soluble Phosphate	Manufacturer	10.76	1 20	11.96	$10.76	38625
			10.00	*2.00*	*12.00*	*10.00*	
38626	Boar's Head Brand Gilt Edge Phosphate	Manufacturer	15.72	1 49	17.21	15 72	38626
			14.00	*2.00*	*16.00*	*14.00*	
	The Armour Fertilizer Works, Chicago, Ill.						
38965	Cereal Phosphate	Manufacturer	11 85	10 08	21 93	11 85	38965
39451		R. L. Mitchell, Liletown	9.73	2 94	12 67	9 73	39451
			10 00	*1.00*	*11.00*	*10.00*	
38973	Star Phosphate	Manufacturer	15.44	3 48	18 92	15 44	38973
39172		Forbes Mfg. Co., Hopkinsville	14.42	1 67	16 09	14 42	39172
39458		Forbes Mfg. Co., Hopkinsville	14 75	2.87	17 62	14 75	39458
			14.00	*1.00*	*15.00*	*14 00*	
38980	Armour's High Grade Phosphate	Manufacturer	17 34	0.13	17 47	17 34	38980
39462		J. W. Pfeffer, Uniontown	18.16	0.48	18 64	18 16	39462
			16.00			*16.00*	
	Central Manufacturing Co., Lock-						

	Central Manufacturing Co., Lockland, Ohio.						
38505	Equity Rock Phosphate	Manufacturer	14.15	1 28	15.43	14.15	38505
39176		Whitely & Eskridge, Leitchfield	14 49	1.63	16.12	14.49	39176
			14.00	*1.00*	*15.00*	*14.00*	
	The Cincinnati Phosphate Co., Cincinnati, Ohio.						
39050	Wheat Grower	Manufacturer	14.92	1.25	16 17	14.92	39050
			14.00	*1.00*	*15.00*	*14.00*	
	Continental Fertilizer Co., Nashville, Tenn.						
38892	Bear Phosphate	Manufacturer	13.75	0.48	14.23	13.75	38892
			12.00	*1.00*	*13.00*	*12.00*	
38893	Bear High Grade Dissolved Bone	Manufacturer	16.00	0.68	16 68	16.00	38893
			14.00	*1.00*	*15.00*	*14.00*	
	The Empire Guano Co., Nashville, Tenn.						
38529	Acid Phosphate	Manufacturer	14.13	8.57	22.70	14.13	38529
			12.00	*2.00*	*14.00*	*12.00*	
38530	High Grade Acid Phosphate..	Manufacturer	17.68	3.10	20.78	17.68	38530
			14.00	*2.00*	*16.00*	*14 00*	
38534	Climax Acid Phosphate.....	Manufacturer	18.67	0.23	18.90	18.67	38534
			16.00	*1.00*	*17.00*	*16.00*	
	Federal Chemical Co., Louisville, Ky.						
38749	Daybreak High Grade Acid Phosphate	Manufacturer	17.83	0 66	18.49	17 83	38749
39202		Plain Hardw'e Co., Madisonville	15.79	1.68	17.47	15.79	39202
			16.00	*2.00*	*18.00*	*16.00*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	Phosphoric Acid. Available.	Insoluble.	Total.	Estimated Value Per Ton.	Station Number.
	Federal Chemical Co.						
38750	Daybreak Royal Phosphate...	Manufacturer	16.63	3.31	19.94	$16 63	38750
39474		Ollie Scott, Beaver Dam.....	16.29	5.39	21.68	16.29	39474
			14.00	*2.00*	*16.00*	*14.00*	
38751	Daybreak Standard Phosphate	Manufacturer	14.00	7.06	21 06	14 00	38751
			12.00	*2.00*	*14.00*	*12.00*	
38752	Daybreak Star Phosphate....	Manufacturer	11.05	10.52	21 57	11.05	38752
			10.00	*2.00*	*12.00*	*10.00*	
	Fox Chemical Co., Branch Federal Chemical Co., Louisville, Ky.						
38779	Fox High Grade Acid Phosphate	Manufacturer	18 23	0.51	18.74	18.23	38779
39402		E. B. Riley, Olmstead.....	16.41	2.59	19.00	16.41	39402
			16.00	*2.00*	*18.00*	*16.00*	
38780	Fox Acid Phosphate	Manufacturer	17.16	3.06	20.22	17 16	38780
			14.00	*2.00*	*16.00*	*14.00*	
38781	Fox Standard Acid Phosphate	Manufacturer	15 06	6 55	21 61	15.06	38781
39207		Harrison Austin, Beaver Dam ..	13.29	1.82	15 11	13.29	39207
			12.00	*2.00*	*14.00*	*12.00*	
38782	Fox A. A. Acid Phosphate....	Manufacturer	11.82	9.50	21.32	11.82	38782
39481		A. B. Beale & Son, Murray ...	12.21	1 15	13.36	12 21	39481

38782	Fox A. A. Acid Phosphate....	Manufacturer	11.82	9.50	21.32	11.82	38782
39481		A. B. Beale & Son, Murray ...	12.21	1.15	13.36	12.21	39481
			10.00	*2.00*	*12.00*	*10.00*	
	Globe Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.						
38812	Globe High Grade Acid Phosphate	Manufacturer	18.56	0.57	19.13	18.56	38812
			16.00	*2.00*	*18.00*	*16.00*	
38813	Globe Acid Phosphate.....	Manufacturer	16.53	3.44	19.97	16.53	38813
			14.00	*2.00*	*16.00*	*14.00*	
38814	Globe Standard Acid Phosphate	Manufacturer	14.39	6.88	21.27	14.39	38814
			12.00	*2.00*	*14.00*	*12.00*	
38815	Globe AA Acid Phosphate....	Manufacturer	10.28	10.67	20.95	10.28	38815
39221		H. W. McCandless, Munfordville.	11.17	1.75	12.92	11.17	39221
			10.00	*2.00*	*12.00*	*10.00*	
	Grayson County Fertilizer Co., Leitchfield, Ky.						
39110	Dissolved Bone Phosphate....	Manufacturer	14.34	6.76	21.10	14.34	39110
			12.00	*2.00*	*14.00*	*12.00*	
	Great Southern Phosphate Co., Mt. Pleasant, Tenn.						
38682	Great Southern Acid Phosphate	Manufacturer	15.36	3.21	18.57	15.36	38682
			14.00	*2.00*	*16.00*	*14.00*	
38684	Great Southern Special Acid Phosphate	Manufacturer	16.65	0.61	17.26	16.65	38684
39226		S. E. Welch, Berea	18.37	0.96	19.33	18.37	39226
			16.00	*2.00*	*18.00*	*16.00*	

TABLE III.—ACID PHOSPHATES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	Estimated Value Per Ton.	Station Number.
	The Groves Company, Cincinnati, Ohio.						
38637	Monarch Brand	Manufacturer	15.45	2 22	17.67	$15 45	38637
39227		T. W. Denney, Science Hill....	14.60	2.87	17.47	14.60	39227
			14.00	*2.00*	*16.00*	*14.00*	
	Hopkins Fertilizer Co., New Albany, Ind.						
39014	Old Time High Grade Acid Phosphate	Manufacturer	16 36	0.27	16.63	16 36	39014
			14.00	*1.00*	*15.00*	*14.00*	
39015	Old Time Quick Action Phosphate	Manufacturer	12.26	0 11	12 37	12.26	39015
39251		O. A. Lutes & Co., Shepherdsville	10 39	0 94	11.33	10.39	39251
39510		O. A. Lutes & Co., Shepherdsville	11.00	0.87	11.87	11 00	39510
			10.00	*1.00*	*11.00*	*10.00*	
	International Agr'l Corporation (Buffalo Fert. Works) Cincinnati, Ohio.						
39341	Dissolved Phosphate	Manufacturer	15.68	0.59	16.27	15.68	39341
39502		I. K. Miller & Sons, Campbellsville	14.63	2.23	16 86	14.63	39502
			14.00	*1.00*	*15.00*	*14.00*	
	The Jarecki Chemical Co., Cincinnati, Ohio.						

	The Jarecki Chemical Co., Cincinnati, Ohio.						
39037	C. O. D. Phosphate.....	Manufacturer	14.71	1 30	16 01	14 71	39037
			14.00	*1.00*	*15.00*	*14.00*	
	Jones Fertilizer Co., Louisville, Ky.						
38926	Jones Phosphate	Manufacturer	13.81	0 85	14 66	13 81	38926
39512		Will Copers, Mount Hermon....	13.23	0 61	13 84	13 23	39512
			12.00	*1.00*	*13.00*	*12.00*	
38927	Jones High Grade Dissolved Bone	Manufacturer	15 72	1 01	16 73	15 72	38927
			14.00	*1.00*	*15.00*	*14.00*	
	Kaufman Fertilizer Co., Cincinnati, Ohio.						
39063	Dissolved Phosphate	Manufacturer	15 09	1 08	16.17	15 09	39063
			14.00	*1.00*	*15.00*	*14.00*	
	Kentucky Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.						
38832	O. K. Phosphate	Manufacturer	17.29	3 01	20 30	17.29	38832
			14.00	*2.00*	*16.00*	*14.00*	
38833	O. K. Standard Phosphate ...	Manufacturer	14.15	6 82	20.97	14 15	38833
39260		J. B. Hatcher, Glasgow Junction	13 31	1.28	14 59	13 31	39260
			12.00	*2.00*	*14.00*	*12.00*	
38834	O. K. Good Luck Phosphate...	Manufacturer	11 63	10 85	22.48	11 63	38834
39261		J. B. Hatcher, Glasgow Junction	11 04	1.43	12 47	11 04	39261
			10.00	*2.00*	*12.00*	*10.00*	
	Louisville Fertilizer Company, Louisville, Ky.						
38875	Eagle Phosphate	Manufacturer	13.40	0.73	14.13	13.40	38875
			12.00	*1.00*	*13.00*	*12.00*	

TABLE III.—ACID PHOSPHATES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	Estimated Value Per Ton.	Station Number.
	Louisville Fertilizer Co.						
38876	Eagle High Grade Dissolved Bone	Manufacturer	16 13	0.70	16.83	$16.13	38876
39262		D. L. D. Sandefur, Beaver Dam..	13.88	1.11	14.99	13 88	39262
			14.00	*1.00*	*15.00*	*14.00*	
	Mt. Pleasant Fertilizer Co., Mt. Pleasant, Tenn.						
38662	Big Success Mt. Pleasant Special Acid Phosphate	Manufacturer	15.66	3.72	19.38	15 66	38662
			14.00	*2.00*	*16.00*	*14.00*	
38665	Big Success High Grade Dissolved Bone	Manufacturer	16.82	0.70	17 52	16.82	38665
39281		Forbes Mfg. Co., Hopkinsville..	16 52	1.33	17.85	16.52	39281
			16.00	*2.00*	*18.00*	*16.00*	
38671	Black Patch Mt. Pleasant Soluble Bone	Manufacturer	12.42	7.42	19.84	12.42	38671
39531		T. H. Cochran & Co., Marion..	14.25	6.18	20.43	14.25	39531
			12.00	*2.00*	*14.00*	*12.00*	
	National Fertilizer Co., Nashville, Tenn.						
38716	Old Hickory Acid Phosphate	Manufacturer	13.25	0.56	13 81	13.25	38716
			12.00	*1.00*	*13.00*	*12.00*	
	Read Phosphate Co., Nashville, Tenn.						
38542	Read's Special High Grade						

	Read Phosphate Co., Nashville, Tenn.						
38542	Read's Special High Grade Acid Phosphate	Manufacturer	18.59	0.41	19.00	18.59	38542
39538		M. B. Hines, Science Hill	17.48	0.75	18.23	17.48	39538
			16.00	*1.00*	*17.00*	*16.00*	
38543	Read's High Grade Acid Phosphate	Manufacturer	17.61	3.51	21.12	17.61	38543
39539		M. B. Hines, Science Hill	15.48	2.19	17.67	15.48	39539
			14.00	*2.00*	*16.00*	*14.00*	
38544	Read's XXX Dissolved Bone..	Manufacturer	15.81	6.50	22.31	15.81	38544
39290		R. P. Turney, Cerulean Springs	14.58	2.15	16.73	14.58	39290
39540		Baker & Glasgow, Murray	13.92	5.84	19.76	13.92	39540
			13.00	*2.00*	*15.00*	*13.00*	
38545	Read's Quick Action Phosphate	Manufacturer	11.76	12.07	23.83	11.76	38545
			10.00	*2.00*	*12.00*	*10.00*	
	Smith Brothers, Louisville, Ky.						
38990	Soluble Phosphate	Manufacturer	15.47	3.58	19.05	15.47	38990
			14.00	*1.00*	*15.00*	*14.00*	
	Swift & Company, Chicago, Ill.						
38856	Swift's Garden City Phosphate	Manufacturer	14.90	1.75	16.65	14.90	38856
			14.00	*1.00*	*15.00*	*14.00*	
	Taylor & Powell Fertilizer Co., Springfield, Tenn.						
39106	13% Acid Phosphate	*Manufacturer					39106
			13.00			*13.00*	
39107	14% Acid Phosphate	*Manufacturer					39107
			14.00			*14.00*	
39108	16% Acid Phosphate.....	*Manufacturer					39108
			16.00			*16.00*	

*The Manufacturer failed to furnish sample as required by law.

TABLE III.—ACID PHOSPHATES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	Estimated Value Per Ton.	Station Number.
	Tennessee Chemical Co., Nashville, Tenn.						
38907	Ox Phosphate	Manufacturer	13.62	0.47	14 09	$13 62	38907
39560		Sexton Brothers, Murray	12 99	2 36	15 35	12 99	39560
			12.00	*1.00*	*13.00*	*12.00*	
38908	Ox High Grade Dissolved Bone	Manufacturer	16 21	0.57	16.78	16.21	38908
39316		Sexton Brothers, Murray	14 97	0.48	15 45	14 97	39316
39561		Sexton Brothers, Murray	14 52	1 80	16 32	14 52	39561
			14.00	*1.00*	*15.00*	*14.00*	
38909	Ox Tennessee Best Acid Phosphate	Manufacturer	18.38	0.87	19.25	18 38	38909
			16.00	*1.00*	*17.00*	*16.00*	
	Tennessee Valley Fertilizer Co., Florence, Ala.						
38707	Tiger Dissolved Bone	Manufacturer	13 03	0 60	13.63	13 03	38707
39329		E. S. Diuguid & Son, Murray ..	11 60	1 01	12.61	11 60	39329
			12.00	*1.00*	*13.00*	*12.00*	
38708	Tiger High Grade Dissolved Bone	Manufacturer	17 05	0.19	17 24	17 05	38708
			14.00	*1.00*	*15.00*	*14.00*	
	Tuscarora Fertilizer Co., Chicago, Ill.						
38950	Acid Phosphate	Manufacturer	15.58	3.14	18.72	15.58	38950

	Tuscarora Fertilizer Co., Chicago, Ill.						
38950	Acid Phosphate	Manufacturer	15.58 *14.00*	3.14 *1.00*	18.72 *15.00*	15.58 *14.00*	38950
38953	Tuscarora Bone Phosphate	Manufacturer	11.71 *10.00*	10 72 *1.00*	22.43 *11.00*	11.71 *10.00*	38953
	Virginia-Carolina Chemical Co., Memphis, Tenn.						
38728	Capital Dissolved S. C. Bone	Manufacturer	13.22	0.40	13 62	13.22	38728
39335		Olive & Walker, Marion	13 35	1 57	14.92	13 35	39335
39577		E. B. Ferguson, Benton	12 45 *12.00*	2.44 *2.00*	14.89 *14.00*	12.45 *12.00*	39577
38730	Victor High Grade Acid Phosphate	Manufacturer	14.95 *14.00*	0.66 *2.00*	15.61 *16.00*	14.95 *14.00*	38730
39116	Victor High Grade Superphosphate	Manufacturer	16.21 *16.00*	1.13 *2.00*	17.34 *18.00*	16.21 *16.00*	39116
	Virginia-Carolina Chemical Co., Cincinnati, Ohio.						
39376	High Grade Acid Phosphate	Manufacturer	15 61 *14.00*	0.40	16.01	15.61 *14.00*	39376
39377	Victor High Grade Acid Phosphate	Manufacturer	16 23 *14.00*	0.55	16.78	16.23 *14.00*	39377
39378	Capital Dissolved D. C. Bone	Manufacturer	13.89 *12.00*	0.85	14.74	13.89 *12.00*	39378
39379	I. X. L. Acid Phosphate	Manufacturer	18.82	0.56	19.38	18.82	39379
39578		R. H. Chrisman, Berea	15.80 *16.00*	1.31	17.11	15.80 *16.00*	39578
39380	Victor High Grade Super Phosphate	Manufacturer	18.25 *16.00*	0.77	19.02	18.25 *16.00*	39380

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	POTASH. From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
	A. D. Adair & McCarty Bros., E. Chattanooga, Tenn.								
39074	Adair's High Grade Potash Compound	Manufacturer	9.61	0.78	10.39	4.50		$16.34	39074
			10.00			*4.00*		*16.00*	
39075	Adair's Formula	Manufacturer	10 35	0 33	10 68	2.10		14 65	39075
39411		I. B. Porter, Cadiz	9 35	0.73	10.08	2.01		13.52	39411
			10.00			*2.00*		*14.00*	
	The American Agr'l Chemical Co., Cincinnati, Ohio.								
38565	Ten Four Grade	Manufacturer	9 07	2.42	11 49	5.79		17 64	38565
39127		Hatter Hardware Co., Franklin.	9.69	1.95	11 64	5.21		17 62	39127
39412		Woodson Lewis, Greensburg	9 35	2 80	12 15	4.40		16.74	39412
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
38567	High Grade Bone and Potash.	Manufacturer	9 60	2.19	11.79	6.17		18 57	38567
39129		J. B. G. Higgs, Elizabethtown	10.70	2.97	13 67	4.89		18 92	39129
39414		Coomer & Gowan, Sparksville	9.98	2.45	12 43	5.41		18.37	39414
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	
	The American Agr'l Chemical Co., Bradley Fertilizer Works, Cincinnati, Ohio.								
38578	Alkaline Bone and Potash	Manufacturer	10.21	1.85	12 06	2.44		15.43	38578
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
	The American Agr'l Chemical Co., Cleveland Dryer Works, Cincinnati, Ohio.								

	The American Agr'l Chemical Co., Cleveland Dryer Works, Cincinnati, Ohio.								
38585	Soluble Bone and Potash....	Manufacturer	10.06	2.51	12.57	2.85		15 92	38585
			10.00	*2 00*	*12.00*	*2.00*		*14.80*	
	The American Agr'l Chemical Co., Bowker Fertilizer Works, Cincinnati, Ohio.								
38588	Bowker's Dissolved Bone and Potash	Manufacturer	10.25	2 09	12.34	2 42		15 56	38588
39138		Ben Harrison, Pageville	9.91	2 37	12 28	2 20		15 04	39138
39424		Coomer & Gowan, Sparksville .	9 60	3.00	12 60	2.03		14.75	39424
			10 00	*1.50*	*11.50*	*2.00*		*14 60*	
38590	Bowker's Potash Fertilizer...	Manufacturer	10 25	1.82	12.07	6 22		19.25	38590
39140		Ben Harrison, Pageville	9.95	1.98	11.93	4 91		17 64	39140
39425		Marcum, Gooch & Payne, Eubank	10 14	2 98	13 12	4.81		18 17	39425
			10.00	*1.50*	*11 50*	*5.00*		*17.60*	
	The American Agr'l Chemical Co., Michigan Carbon Works, Cincinnati, Ohio.								
38600	Red Line Phosphate with Potash	Manufacturer	10 86	1.75	12.61	2.47		16 20	38600
39149		Bradford Brothers, Glasgow ...	11 26	1 45	12 71	2.33		16.42	39149
39431		J. R. Davis & Bro., Campbellsville	9 01	3 09	12 10	2.10		14 15	39431
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38602	High Potash Phosphate.....	Manufacturer	10 32	1.54	11 86	6.31		19.31	38602
39433		A. B. Dodson, Flippin.....	9.45	3.21	12.66	5.20		17.82	39433
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	POTASH. From Muriate.	From Sulphate.	Estimated Value per Ton.	Station Number.
	The American Agr'l Chemical Co., North Western Fertilizing Co., Cincinnati, Ohio.								
38620	Horseshoe Brand 10-5 Potash Manure	Manufacturer	10.38	1.53	11.91	6.28		$19.35	38620
39162		E. S. Ferrell & Son, Buffalo	9.74	2.12	11.86	4.99		17.53	39162
39443		Watkins & Co., Elizabethtown	9.32	2.89	12.21	5.41		17.75	39443
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	
38221	Horseshoe Brand Bone and Potash	Manufacturer	11.02	1.50	12.52	2.83		16.65	38621
39444		Watkins & Co., Elizabethtown	9.31	2.19	11.50	2.41		14.46	39444
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
	The American Agr'l Chemical Co., Packers Fertilizer Association, Cincinnati, Ohio.								
38627	Boar's Head Brand Kentucky Potash Mixture	Manufacturer	11.07	1.49	12.56	2.53		16.41	38627
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38629	Boar's Head Brand Potash Phosphate Fertilizer	Manufacturer	10.54	1.53	12.07	6.37		19.63	38629
39446		J. H. Wyan, London	9.92	2.79	12.71	5.12		18.14	39446
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	
	The Armour Fertilizer Works, Chicago, Ill.								
38970	Phosphate and Potash	Manufacturer	11.60	2.13	13.73	1.82		18.50	38970

	The Armour Fertilizer Works, Chicago, Ill.								
38970	Phosphate and Potash	Manufacturer	11.60	9.13	20.73	1.99		19.56	38970
39171		Barren County Grocery & Hardware Co., Glasgow	10 43	3 51	13 94	1 58		15.50	39171
39456		R. L. Mitchell, Liletown	10 21	2.50	12.71	0 62	1.83	16.07	39456
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
38972	Soluble Phosphate and Potash	Manufacturer	12 30	8.11	20 41	3 80		21 80	38972
39457		R. L. Mitchell, Liletown	9.87	3.03	12 90	4.17		17.22	39457
			10 00	*1.00*	*11.00*	*4.00*		*16.40*	
39351	Armour's High Grade Phosphate and Potash	Manufacturer	12 14	1.15	13.29	2.00		17.03	39351
			12.00			*2.00*		*16.40*	
	Central Manufacturing Co., Lockland, Ohio.								
38506	Equity Oats Special	Manufacturer	10.07	1 02	11 09	3 18		15 67	38506
39463		J. J. Eskridge & Co., Leitchfield.	8 96	1.11	10.07	3.22		14.41	39463
			9.00	*1.00*	*10.00*	*3.00*		*14.20*	
38509	Equity Ohio Wonder	Manufacturer	12.07	1.43	13 50	5 34		20 39	38509
			12.00	*1 00*	*13.00*	*5.00*		*19.80*	
	The Cincinnati Phosphate Co., Cincinnati, Ohio.								
39048	Dissolved Phosphate and Potash	Manufacturer	9.29	1 80	11 09	5.56		17.43	39048
			10.00	*1.00*	*11.00*	*4.00*		*16.40*	
39049	Alkaline Phosphate	Manufacturer	11.12	1.20	12 32	2.87		16.69	39049
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
	Continental Fertilizer Co., Nashville, Tenn.								
38894	Bear Potash Mixture	Manufacturer	11.06	0.59	11.65	2.01		15.52	38894
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	POTASH. From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
	The Empire Guano Co., Nashville, Tenn.								
38527	Potash Mixture	Manufacturer	11.12	4.88	16 00	4.44		$19 73	38527
			10.00	*4.00*	*14.00*	*4.00*		*17.60*	
38528	Bone and Potash	Manufacturer	11.46	7 67	19.13	2.91		19.73	38528
39193		J. C. Cowherd & Co., Greensburg	10.80	7.45	18 25	2.16		18.10	39193
			10.00	*4.00*	*14.00*	*2.00*		*15.60*	
38532	Climax Potash Acid	Manufacturer	10.62	1.54	12 16	7 26		20.62	38532
			10.00	*4.00*	*14.00*	*6.00*		*19.60*	
38536	Climax Bone and Potash	Manufacturer	13 86	3.91	17.77	2.57		20.76	38536
			12.00	*4.00*	*16.00*	*2.00*		*18.00*	
	Evansville Packing Company, Evansville, Indiana.								
39026	Grain Grower	Manufacturer	10.48	0.88	11 36	3.96		16 89	39026
			10 00	*2.00*	*12.00*	*4.00*		*16.80*	
	Federal Chemical Company, Louisville, Ky.								
38745	Daybreak Bone and Potash	Manufacturer	13.56	8.12	21.68		3.00	23 12	38745
			10.00	*2.00*	*12.00*		*2.00*	*15.20*	
38746	Daybreak Potash Fertilizer	Manufacturer	11.68	7 62	19 30	0.72	5.02	23.81	38746
			9.00	*2.00*	*11.00*		*5.00*	*17.60*	
38747	Daybreak Potash Mixture	Manufacturer	12.20	7.14	19 34	0.70	4.74	23.89	38747
			10.00	*2.00*	*12.00*		*4.00*	*17.60*	

38747	Daybreak Potash Mixture	Manufacturer	12.20	7.14	19 34	0.70	4.74	23.89	38747
			10.00	*2.00*	*12.00*		*4.00*	*17.60*	
38748	Daybreak Phosphate and Potash	Manufacturer	14.05	4.97	19.02		3 33	22.85	38748
			12.00	*2.00*	*14.00*		*2.00*	*17.60*	
	Fox Chemical Co., Branch, Federal Chemical Co., Louisville, Ky.								
38774	Fox Alkaline Bone	Manufacturer	11.96	8.82	20.78		3.14	21 65	38774
39206		J. D. Osborn, Glasgow.....	10 45	1.38	11 83	2.16		15 25	39206
39480		A. B. Beale & Son, Murray	10.37	1.50	11 87	1.72		14.76	39480
			10.00	*2.00*	*12.00*		*2 00*	*15.20*	
38775	Fox Phospho-Potash	Manufacturer	11 87	7 93	19 80	0.70	5 19	24.34	38775
			9.00	*2.00*	*11 00*		*5.00*	*17.60*	
38776	Fox Bone Phosphate and Potash	Manufacturer	12.40	7 39	19 79	0 62	4.62	24.00	38776
39403		E. B. Riley, Olmstead	10 79	8.12	18 91	3.87		20 07	39403
			10.00	*2.00*	*12.00*		*4.00*	*17.60*	
38777	Fox Bone Phosphate	Manufacturer	14.73	4.64	19 37		3 11	23 27	38777
			12.00	*2.00*	*14 00*		*2.00*	*17.60*	
38778	Fox Bone and Potash	Manufacturer	12.48	9.55	22 03		2 30	21 56	38778
			9.00	*2.00*	*11.00*		*1.00*	*12 80*	
	Globe Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.								
38807	Globe Potash Special	Manufacturer	13 74	7 55	21 29		2.99	23 10	38807
39218		W. J. Pursley, Cadiz.....	11 31	3 37	14 68		1.95	17.26	39218
			10.00	*2.00*	*12.00*		*2.00*	*15.20*	
38808	Globe Potash Formula	Manufacturer	12 17	8 01	20 18	0.72	5 07	24 60	38808
39219		K. R. C. Woosley, Caneyville .	8.73	0.83	9.56		5.08	16 91	39219
			9.00	*2.00*	*11.00*		*5.00*	*17.60*	

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

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	Globe Fertilizer Co.								
38809	Globe Bone Phosphate and Potash	Manufacturer	12.27	7.37	19.64		4.82	$23 45	38809
39220		K. R. C. Woosley, Caneyville	10 78	1.01	11.79		5.57	20 02	39220
			10.00	*2.00*	*12.00*		*4.00*	*17.60*	
38810	Globe Potash Compound	Manufacturer	14.75	4 69	19 44		3 15	23 36	38810
			12.00	*2.00*	*14.00*		*2.00*	*17.60*	
38811	Big Four Phosphate	Manufacturer	12.63	10 07	22.70		2.14	21.78	38811
			9.00	*2.00*	*11.00*		*1.00*	*12.80*	
	Great Southern Phosphate Co., Mt. Pleasant, Tenn								
38679	Great Southern Wheat Special	Manufacturer	11.01	7.61	18.62	4.00		20 45	38679
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
38681	Ever Ready Wheat Grower	Manufacturer	10.90	9.04	19.94	2 04		18.74	38681
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
	The Groves Company, Cincinnati, Ohio.								
38638	Wheat and Oats	Manufacturer	10 15	1.49	11 64	2 36		15 14	38638
39228		T. W. Denney, Science Hill	10.03	1 42	11 45	1 93		14.54	39228
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38639	**Potash Mixture**	Manufacturer	10.43	1.89	12 32	5.57		18.85	38639
39229		T. W. Denney, Science Hill	9 52	2.09	11 61	4.82		17.08	39229

38639	**Potash Mixture**	Manufacturer	10.43	1.89	12 32	5.57	18.85	38639
39229		T. W. Denney, Science Hill	9 52	2.09	11 61	4.82	17.08	39229
			10.00	*2.00*	*12.00*	*5.00*	*17.80*	
	Hirsh, Stein & Company, Chicago, Ill.							
38867	Calumet Brand Phosphate and Potash	Manufacturer	10.48	0.57	11.05	2.62	15.43	38867
39241		Jas. Person & Co., Franklin	10.09	1.06	11.15	2.27	14.80	39241
			10.00	*1.00*	*11.00*	*2.00*	*14.40*	
38868	Calumet Brand High Grade Phosphate and Potash	Manufacturer	10.09	0.71	10 80	5.63	18.02	38868
39499		Hutcheson Bros., Auburn	12 23	1 25	13 48	4 88	20.16	39499
			10.00	*1.00*	*11.00*	*5.00*	*17.40*	
	Hopkins Fertilizer Co., New Albany, Ind.							
39013	Old Time Potash Mixture	Manufacturer	12 06	0 14	12 20	4 87	19.40	39013
39250		C. R. Barnes, Bardstown	10.93	0 51	11.44	3 68	17.00	39250
39509		Nelson Supply Co., Bardstown	11.27	0.92	12 19	4.07	17 96	39509
			10.00	*1.00*	*11.00*	*4.00*	*16.40*	
	International Agr'l Corporation (Buffalo Fert. Works) Cincinnati, Ohio.							
39342	Phosphate and Potash	Manufacturer	10.58	0.59	11 17	5.22	18.16	39342
39503		I. K. Miller & Sons, Campbellsville	9 22	1.34	10.56	4 33	15 98	39503
			10.00	*1.00*	*11.00*	*5.00*	*17.40*	
39353	Dickinson's Phosphate and Potash	Manufacturer	9 76	1.45	11 21	2.29	14.58	39353
			10.00	*1.00*	*11.00*	*2.00*	*14.40*	
39354	Dickinson's Standard Grain Grower	Manufacturer	9.60	1.39	10 99	7.20	19.28	39354
			10.00	*1.00*	*11.00*	*4.00*	*16.40*	

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	The Jarecki Chemical Co., Cincinnati, Ohio.								
39039	Square Brand Phosphate and Potash	Manufacturer	10.16	1.01	11 17	2.71		$15 30	39039
			10 00	*1.00*	*11.00*	*2.00*		*14.40*	
39042	Super Phosphate and Potash.	Manufacturer	9.84	1 38	11.22	5.54		17.90	39042
			10.00	*1.00*	*11.00*	*4.00*		*16.40*	
	Jones Fertilizer Company, Louisville, Ky.								
38928	Jones Potash Mixture	Manufacturer	11.24	0 50	11.74	1 84		15.53	38928
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38929	Jones Bone and Potash	Manufacturer	10 90	0.60	11.50	3 90		17 22	38929
39513		Will Copers, Mount Hermon	11 63	0.43	12 06	3.70		17 83	39513
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
38930	Jones Potash Formula	Manufacturer	11 34	0.66	12 00	4 75		18.62	38930
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	
	Kaufman Fertilizer Co., Cincinnati, Ohio.								
39061	Dissolved Bone and Potash	Manufacturer	9 81	0.94	10.75	5.68		17.83	39061
			10.00	*1.00*	*11.00*	*4.00*		*16.40*	
39062	Alkaline Bone and Potash	Manufacturer	10 02	0 89	10.91	2.66		15.04	39062
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	

39062	Alkaline Bone and Potash ...	Manufacturer	10 02	0 89	10.91	2.66		15.04	39062
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
	Kentucky Fertilizer Co., Branch Federal Chemical Co., Louisville, Ky.								
38830	O. K. Potash Special	Manufacturer	13 02	8 40	21 42		3 10	22 70	38830
39520		W. A. Ogilvie, Benton.....	11 66	7.50	19 16	3 72		20.71	39520
			10.00	*2.00*	*12.00*		*2.00*	*15.20*	
38831	O. K. Potash Manure	Manufacturer	10 81	8 25	19 06	0.64	5.24	23 20	38831
39272		John Leet, Campbellsville.....	9.92	3 16	13.08		4.51	18 57	39272
			9.00	*2.00*	*11.00*		*5.00*	*17.60*	
	Louisville Fertilizer Co., Louisville, Ky.								
38877	Eagle Potash Mixture	Manufacturer	10.87	0.66	11.53	1.91		15.21	38877
39263		Martin & Ford, Glasgow Junction	9 55	1.40	10.95	1 63		13 65	39263
			10.00	*2.00*	*12.00*	*2 00*		*14.80*	
38878	Eagle Bone and Potash Compound	Manufacturer	10 57	0 22	10 79	3.75		16.52	38878
39264		Will Webb, Tompkinsville	9 18	1 06	10 24	5 47		16 91	39264
			10.00	*2.00*	*12 00*	*4.00*		*16.80*	
39360	Eagle Potash Special	Manufacturer	12.52	0 79	13 31	1.16	0.76	17.41	39360
			12.00	*1.00*	*13.00*	*2.00*		*16.80*	
39391	Eagle Phosphate and Potash.	Manufacturer	10 71	0 51	11.22	5.45		18 50	39391
			10.00	*4.00*	*14.00*	*6 00*		*19 60*	
	Mt. Pleasant Fertilizer Co., Mt Pleasant, Tenn.								
38660	Big Success Banner Grair Grower	Manufacturer	10 96	8 83	19 79	2 02		18.70	38660
39280		Dickinson Bros., Glasgow	9 98	9.27	19 25	1.97		17 66	39280
39529		Forbes Mfg. Co., Hopkinsville.	9 64	8 44	18.08	3 12		18.07	39529
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	

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	Mt. Pleasant Fertilizer Co.								
38668	Black Patch Wheat Special...	Manufacturer	9.95	7.60	17.55	4.07		$19.05	38668
39282		Dickinson Bros., Glasgow.....	10.12	7.94	18.06	4.12		19.44	39282
39530		Forbes Mfg. Co., Hopkinsville.	10.24	8.48	18.72	3.86		19.54	39530
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
	National Fertilizer Co., Nashville, Tenn.								
39358	Old Hickory Millers Special Wheat Grower	Manufacturer	9.44	8.76	18.20	7.53		22.36	39358
			10.00	*1.00*	*11.00*	*5.00*		*17.40*	
39359	Old Hickory Diuguid Special Wheat Grower	Manufacturer	9.10	7.28	16.38	9.42		23.25	39359
			8.00	*1.00*	*9.00*	*2.00*		*12.00*	
38712	Old Hickory Anti Trust Bone and Potash	Manufacturer	11.39	0.51	11.90		3.65	18.25	38712
			10.00	*1.00*	*11.00*		*4.00*	*17.20*	
38713	Old Hickory Acid Phosphate and Potash	Manufacturer	10.58	0.36	10.94	1.79		14.63	38713
39286		E. S. Diuguid & Son, Murray...	9.71	1.43	11.14	2.24		14.46	39286
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
38714	Old Hickory Sadler's Formula	Manufacturer	13.84	0.03	13.87	2.37		18.99	38714
			12.00	*1.00*	*13.00*	*2.00*		*16.80*	
	The Queen City Fertilizer Co., Cincinnati, Ohio.								

	The Queen City Fertilizer Co., Cincinnati, Ohio.								
39069	Phosphate and Potash.....	Manufacturer	9.65	0.94	10.59	2.74		14.70	39069
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
	Read Phosphate Company, Nashville, Tenn.								
38537	Read's Special Wheat Grower	Manufacturer	10.86	1.56	12.42	6.86		20.51	38537
39535		Copenhagen & Carroll, Burnside	9.65	5.46	15.11	5.67		19.43	39535
			10.00	*4.00*	*14.00*	*6.00*		*19.60*	
38538	Read's High Grade Special Potash Mixture	Manufacturer	11.03	4.87	15.90	4.75		19.94	38538
39288		E. L. Foulks, Hopkinsville.....	10.96	3.53	14.49	4 33		18.89	39288
39536		Barren County Grocery & Hardware Co., Glasgow	9.66	5.53	15.19	3 87		17.67	39536
			10.00	*4.00*	*14.00*	*4.00*		*17.60*	
38539	Read's Alkaline Bone	Manufacturer	11.62	7.93	19.55	2.95		20.06	38539
39289		Baker & Glasgow, Murray	10.61	1.62	12.23	3 39		16 77	39289
39537		Hatter Hardware Co., Franklin	10.21	4.87	15.08	1.46		15.66	39537
			10.00	*4.00*	*14.00*	*2.00*		*15.60*	
38540	Read's High Grade Bone and Potash	Manufacturer	15.17	3.45	18.62	2.70		22.28	38540
			12.00	*4.00*	*16.00*	*2.00*		*18.00*	
38541	Read's High Grade Grain Special	Manufacturer	15.73	0.59	16.32	4.90	2.35	26.84	38541
			14.00	*3.00*	*17.00*	*5.00*		*23.00*	
	Smith Agricultural Chemical Co., Columbus, Ohio.								
39077	Ohio Farmers' Soluble Phosphate and Potash.....	Manufacturer	11 55	0 96	12 51	3.95		18.19	39077
39545		Staggs & McDaniel, Vanceburg.	9 21	1.05	10.26	1 94		13.41	39545
			10.00			*2.00*		*14.00*	

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	POTASH. From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
	Smith Brothers, Louisville, Ky.								
38991	Bone and Potash	Manufacturer	11.87	9.29	21.16	1.90		$19.86	38991
39547		Allensville Mercantile Co., Allensville	10 81	2.64	13 45	1.67		15.70	39547
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
	Swift & Company, Chicago, Ill.								
38854	Swift's High Grade Phosphate and Potash	Manufacturer	11.24	0.94	12.18	4.16		18 03	38854
39309		Barren County Grocery & Hardware Co., Glasgow	8 97	0.77	9.74	3 55		14 62	39309
39553		Barren County Grocery & Hardware Co., Glasgow	10 01	1 66	11 67	4 22		16.89	39553
			10 00	*1.00*	*11.00*	*4.00*		*16.40*	
38855	Swift's Special Phosphate and Potash	Manufacturer	10.73	1 02	11.75	2 33		15.62	38855
39310		Barren County Grocery & Hardware Co., Glasgow	9.95	0.75	10 70	1 90		14 14	39310
39554		C. E .Owen, Madisonville	10.48	1 31	11 79	1.88		14.98	39554
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
	Taylor & Powell Fertilizer Co., Springfield, Tenn.								
39103	10-4 Grower	Manufacturer	10 61	1 02	11.63		4 09	18.05	39103
			10.00				*4.00*	*16.80*	
39104	12-2 Grower	Manufacturer	13 99	5.52	19.51		1.80	21.16	38104
39559		Newton Walker, Adairville	11.60	6.80	18.40	0.94	0.76	18.49	39559

39104	12-2 Grower	Manufacturer	13 99	5.52	19.51		1.80	21.16	38104
39559		Newton Walker, Adairville	11.60	6.80	18.40	0.94	0.76	18.49	39559
			12.00				*2.00*	*16.80*	
	Tennessee Chemical Company, Nashville, Tenn.								
38910	Ox Potash Mixture	Manufacturer	10 88	0 79	11 67	1.86		15 24	38910
39317		W. F. Grainger, Franklin	9.48	3 00	12.48	1.85		14.43	39317
39562		W. F. Grainger, Franklin	11.26	1.62	12.88	0.52	1 00	15 88	39562
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38911	Ox Potash Formula	Manufacturer	10.95	0 73	11 68	3 96		17 39	38911
39318		W. F. Grainger, Franklin	10.19	0 94	11 13	3 68		16 29	39318
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
38912	Ox Alkaline Bone	Manufacturer	13.40	0 66	14.06	2 69		19.03	38912
			12 00	*2.00*	*14.00*	*2.00*		*17.20*	
38913	Ox High Grade Potash	Manufacturer	11 06	0.78	11.84	4 98		18 56	38913
39563		W. F. Grainger, Franklin	10 40	1 64	12.04	0 70	3 28	17.78	39563
			10.00	*2.00*	*12.00*	*5.00*		*17.80*	
39394	Ox Potash Formula	Manufacturer	10.66	0.28	10 94		4 10	17.82	39394
			10.00	*4.00*	*14.00*		*4.00*	*18.40*	
39395	Ox High Grade Potash	Manufacturer	10 77	0.17	10.94		5.07	19.07	39395
			10.00	*4.00*	*14.00*		*5.00*	*19.60*	
	Tennessee Valley Fertilizer Co., Florence, Ala.								
38705	Tiger Potash Guano	Manufacturer	11.60	1.02	12 62	2.13		16.45	38705
			10.00	*1.00*	*11.00*	*4.00*		*16.40*	
38706	Tiger Guano	Manufacturer	10 65	0.31	10.96	2.07		14.97	38706
			10 00	*1.00*	*11.00*	*2.00*		*14.40*	
38709	Tiger Bone and Potash	Manufacturer	8.73	0 56	9 29	2 28		12.98	38709
			8.00	*1.00*	*9.00*	*2.00*		*12.00*	

TABLE IV.—ACID PHOSPHATE AND POTASH MIXTURES.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID. Available.	Insoluble.	Total.	POTASH. From Muriate.	From Sulphate.	Estimated Value Per Ton.	Station Number.
	Tuscarora Fertilizer Co., Chicago, Ill.								
38954	Tuscarora Bone and Potash...	Manufacturer	11.74	9.55	21.29	1.95		$19.86	38954
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
38955	Dickinson's Potash and Phosphate Mixture	Manufacturer	11.67	6.12	17.79	2.77		19.22	38955
			10.00	*1.00*	*11.00*	*2.00*		*14.40*	
38956	Dickinson's Standard Grain Grower	Manufacturer	11.97	8.71	20.68		3.96	22.59	38956
39573		Dickinson Brothers, Glasgow .	9.11	1.96	11.07	3.19		14.90	39573
			10.00	*1.00*	*11.00*	*4.00*		*16.40*	
	Virginia-Carolina Chemical Co., Memphis, Tenn.								
38725	Royal Grain Grower.....	Manufacturer	10.54	1.19	11.73	4.08		17.21	38725
39576		E. B. Ferguson, Benton	10.38	1.36	11.74	3.93		16.93	39576
			10.00	*2.00*	*12.00*	*4.00*		*16.80*	
38726	Capital Bone and Potash Compound	Manufacturer	11.51	0.87	12.38	2.78		16.94	38726
39334		Dickinson Brothers, Glasgow .	11.15	1.47	12.62	2.19		16.16	39334
			10.00	*2.00*	*12.00*	*2.00*		*14.80*	
38727	Victor Bone and Potash.....	Manufacturer	15.59	0.99	16.58	3.53		22.64	38727
			15.00	*2.00*	*17.00*	*3.00*		*21.80*	
39355	Champion Bone and Potash Compound	Manufacturer	9.81	2.01	11.82	5.07		17.64	39355

39355	Champion Bone and Potash Compound	Manufacturer	9.81 *10.00*	2.01 *2.00*	11.82 *12.00*	5.07 *5.00*		17.64 *17.80*	39355
	Virginia-Carolina Chemical Co., Cincinnati, Ohio.								
39371	Acid and Potash King	Manufacturer	11.17 *10.00*	1.06	12.23	5.10 *4.00*		18.92 *16.00*	39371
39372	Royal Grain Grower	Manufacturer	11.06 *10.00*	1.15	12.21	5.24 *4.00*		18.97 *16.00*	39372
39373	Victor Bone and Potash Compound	Manufacturer	15.80 *15.00*	1.16	16.96	3.10 *3.00*		22.52 *21.00*	39373
39374	Grain Food	Manufacturer	10.32 *10.00*	1.28	11.60	2.44 *2.00*		15.33 *14.00*	39374
39375	Capital Bone and Potash Compound	Manufacturer	10.10 *10.00*	1.28	11.38	2.51 *2.00*		15.14 *14.00*	39375

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Cincinnati Phosphate Co., Cincinnati, Ohio.	
39052	"Bonus" A Humus Phosphate	Manufacturer
	Federal Chemical Company, Louisville, Ky.	
38743	Daybreak Harvest Home Bone Meal Mixture	Manufacturer
38744	Daybreak Harvest Bone	Manufacturer
39473		J. B. Smith, Sulphur Well
	Fox Chemical Co., Branch, Federal Chemical Co., Louisville. Ky.	
38772	Fox Half and Half Bone Meal Mixture	Manufacturer
39400		S. W. Cobb, Olmstead
38773	Fox Ammoniated Bone	Manufacturer
	Globe Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.	
38804	Golden Harvest Bone Meal Mixture	Manufacturer
39487		J. I. Rice, Adairville
38805	Golden Harvest Bone Meal	Manufacturer
39217		Evans, Goodman & Maxe, Glasgow
	Kentucky Fertilizer Co., Branch, Federal Chemical Co., Louisville, Ky.	
38826	O. K. Special Bone Meal Mixture	Manufacturer

NITROGENOUS SUPERPHOSPHATES.

PHOSPHORIC ACID.			NITROGEN.						
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.	Equivalent to Ammonia.	Estimated Value Per Ton.	Station Number.
14.45	1.68	16.13				0.48	0.58	$19.69	39052
12.00	*1.00*	*13.00*				*0.41*	*0.50*	*16.24*	
9.96	11.56	21.52	0.52		1.24	1.76	2.14	22.73	38743
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*21.78*	
12.20	1.15	13.35		0.60	2.12	2 72	3 30	24.62	38744
10 90	5.66	16 56	0.63		1.73	2.36	2.87	23 60	39473
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*22.25*	
10 65	11.79	22.44	0.29		1.38	1.67	2.03	23 35	38772
10.85	7.56	18.41				1.50	1.82	21.29	39400
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*21.78*	
12.17	1.12	13.29		0.79	1.99	2.78	3.37	24.78	38773
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*22.25*	
10.64	11.65	22.29	0.47		1.26	1.73	2.10	23.49	38804
11.82	8.07	19.89	0.51		1.11	1.62	1 97	23 08	39487
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*21.78*	
12.35	0.87	13.22		0 60	2.22	2 82	3.42	25 04	38805
9.60	3.42	13 02	0.76		1.33	2.09	2.54	20 21	39217
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*22.25*	
9.92	11.91	21.83	0.59		1.29	1.88	2.28	23.24	38826
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*21.78*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Kentucky Fertilizer Co.	
38827	O. K. Bone Meal Mixture.....	Manufacturer .....
39518		Payne & Brown, Temple Hill.....
	Taylor & Powell Fertilizer Co., Springfield, Tenn.	
39396	Half and Half	Manufacturer .....
39101	Half and Half	Manufacturer .....

NITROGENOUS SUPERPHOSPHATES.

PHOSPHORIC ACID.			NITROGEN.				Equivalent to Ammonia.	Estimated Value Per Ton.	Station Number.
Available.	Insoluble.	Total.	In Nitrates.	In Ammonia Salts.	Organic.	Total.			
12.02	1.15	13.17		0.58	2.13	2 71	3.29	$24.37	38827
10.68	5.70	16.38	0.65		1.66	2.31	2.80	23.19	39518
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*22.25*	
9.52	10.14	19.66				2.04	2.48	22.62	39396
10.00	*5.00*	*15.00*				*1.65*	*2.00*	*19.78*	
9.61	10.25	19.86				2.87	2.88	23.93	39101
10.00	*5.00*	*15.00*				*1.85*	*2.25*	*20.48*	

TABLE VI.—POTASH SALTS.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	POTASH. From Muriate.	POTASH. From Sulphate.	Estimated Value Per Ton.	Station Number.
	German Kali Works, Baltimore, Maryland.					
39119	Muriate of Potash	Manufacturer	52.55 *50.00*		$52.55 *50.00*	39119
39120	Sulphate of Potash.....	Manufacturer		50.30 *48.00*	60.36 *57.60*	39120
39121	Kainit	Manufacturer	13.72 *12.00*		13.72 *12.00*	39121
	Hopkins Fertilizer Co., New Albany, Ind.					
39017	Old Time Muriate of Potash.	Manufacturer	52.40 *50.00*		52.40 *50.00*	39017

TABLE VII.—NITRATE OF SODA.

TABLE VII.—NITRATE OF SODA.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	Nitrogen.	Equivalent to Ammonia.	Estimated Value Per Ton.	Station Number.
	Hopkins Fertilizer Co., New Albany, Ind.					
39016	Old Time Nitrate of Soda...	Manufacturer	15.72 *15.00*	19.08 *18.22*	$55.02 *52.50*	39016
	Nitrate Agencies Co., Chicago, Ill.					
38874	Nitrate of Soda	Manufacturer	15.21 *15.00*	18.47 *18.22*	53.24 *52.50*	38874

Dec. 31, 1912.

JOSEPH H. KASTLE, Director.
H. E. CURTIS, Chemist.

DIVISION OF CHEMISTRY

ANALYSES OF MINERAL AND POTABLE WATERS.

BY

A. M. PETER, S. D. AVERITT AND J. S. MCHARGUE.

BOURBON COUNTY.

LABORATORY NO. 36651—Water from an old well 40 feet deep and 18 to 20 feet across, at the old distillery of Peed & McClintock, Millersburg, Ky. The well was being cleaned out to supply Millersburg Institute. A plugged drill hole 2 inches in diameter was found at the bottom. When this plug was removed, water flowed out and when a 2-inch pipe was inserted the water rose 14 to 16 feet in the pipe. Sample somewhat turbid. Brought July 24, 1912, by E. S. Waddell, Millersburg, Ky.

ANALYSIS—One gallon contains 21.6 grains of solid matter (.371 gram per liter) composed of calcium carbonate, sodium chlorid and a very small quantity of magnesium carbonate, with traces of iron, silica, strontium and potassium sulfate. Nitrate nitrogen 0.1 part per million.

The analysis indicates that this is an ordinary well water. It would not be classed as a mineral water.

LABORATORY NO. 36707—Salt water sent by C. L. Murphy, Shawhan, Ky., from a well 140 feet deep bored two years ago. Sample cloudy, tasting of salt and containing a little whitish sediment. Received September 10, 1912.

ANALYSIS—One gallon contains 368.0 grains of mineral matter (6.302 grams per liter) composed mainly of sodium chlorid, some calcium sulfate, small amounts of calcium carbonate and magnesium carbonate and traces of iron, silica and strontium.

This is a moderately strong salt water.

BULLITT COUNTY.

LABORATORY NO. 36679—Magnesian water sent by J. T. Foster, 1203 W. Market St., Louisville, Ky., from a spring two miles Southeast of Belmont in Bullitt County, Ky. Received in August, 1912.

ANALYSIS—One gallon contains 189.6 grains of mineral matter (3.241 grams per liter) composed of calcium sulfate, magnesium sulfate, calcium carbonate, magnesium carbonate, ferrous carbonate and sodium chlorid, with traces of iron, silica, potassium and strontium sulfates.

It is an alkaline magnesian water containing a little iron and should have medicinal value.

CARTER COUNTY.

LABORATORY NO. 36826—Well water sent by the Olive Hill Fire Brick Company, Hitchins, Carter County, Ky. The well was driven last summer and is 23 feet deep. Sample colorless with slight sediment. Received about December 19, 1912.

ANALYSIS—

Total solid matter.....2.4 grains per gallon.
Ignited solid matter.....1.7 grains per gallon.
Organic and volatile matter .7 grain per gallon.

The solid matter consists of traces of sulfates, chlorids, calcium, magnesium and iron. There is a very small amount of clay in suspension. The water is slightly acid to litmus paper, due to the presence of ferrous sulfate. There are no nitrites, nitrates or free ammonia present.

It would be classed as a weak chalybeate water and is all right as a drinking water.

CLARK COUNTY.

LABORATORY NO. 36754—Water from a well 100 feet deep located one mile east of Winchester, Clark County, Ky., owned by the Ford Lumber Company of Winchester. To be tested for boiler purposes. Sample received October 23, 1912.

ANALYSIS—	Grains per gallon.	Parts per million
Total solid matter	29.6	508.
Ignited solid matter	25.7	440.
Organic and volatile matter	3.9	68.
Total alkalinity (as $CaCO_3$)	14.1	240.

The mineral matter consists of calcium carbonate, sodium chlorid, magnesium carbonate, a little calcium sulfate and traces of iron, lithium and silica.

It is a hard water, but may be used as a boiler water with attention to cleaning boilers.

DAVIESS COUNTY.

Two waters from the Owensboro Municipal Water Works sent by E. H. Breidenbach, Manager, Owensboro, Ky., to test the efficiency of the softening plant. Samples received May 10, 1912.

LABORATORY NO. 36585—The treated water. Samples colorless with practically no sediment.

LABORATORY NO. 36586—The untreated water. Sample colorless, but has a small sediment in bottom of jug.

LABORATORY NO. 36587—Sludge from the softening plant. Had the appearance of precipitated calcium carbonate.

	36585	36586
	Grains per gallon.	
Calcium carbonate ($CaCO_3$)	1.04	7.93
Calcium sulfate ($CaSO_4$)	1.90	1.90
Magnesium carbonate ($MgCO_3$)	1.26	4.75
Silica (SiO_2)	0.55	0.99
Sodium chlorid (NaCl)	0.96	0.96
Ferric oxide (Fe_2O_3) and alumina (Al_2O_3)	trace	0.09
Total	5.71	16.62
Total solids at 100° C.	7.17	17.92
Ignited solids	5.72	14.59

The analyses show that about seven-eighths of the lime originally present as the corbonate has been removed by the treatment. No lime present as the sulfate was removed. About seven-tenths of the magnesia was removed, about half the silica and practically all the iron. The water has been very much improved by the treatment.

LABORATORY No. 36587. The sludge consists largely of calcium carbonate and some magnesium carbonate, traces of iron and phosphorus pentoxide. 70.9 per cent of the sludge is water. Dried and applied to land it would correct acidity but has no other value as a fertilizer.

FAYETTE COUNTY.

LABORATORY No. 36523—Water from a well 84 feet deep near Lexington, Ky., sent by Jo. C. Van Meter, to be tested for domestic use. Sample a half gallon bottle of clear, colorless water with only a trace of sediment.

ANALYSIS—One gallon contains 36.2 grains of solid matter (.621 gram per liter) composed mainly of calcium carbonate and sodium chlorid with small amounts of magnesium carbonate and calcium sulfate. There are traces of iron, potassium sulfate, silica, zinc carbonate and lithium carbonate.

The sanitary tests show heavy nitrite nitrogen which renders the water questionable as a drinking water.

LABORATORY NO. 36633—Salt water brought by Mrs. J. S. Dunn, Lexington, Ky. The well is 80 feet deep. Stock will not drink the water. Sample contained a good deal of sediment and smells of petroleum. Received about July 1, 1912.

ANALYSIS—One gallon contains 473. grains of solid matter (8.114 grams per liter) composed of sodium chlorid, some magnesium chlorid, a little calcium sulfate, calcium carbonate and potassium sulfate and traces of iodid, bromid, lithium, strontium and iron.

It is a salt water such as is often found by boring into the limestones about Lexington. These waters have some medicinal value. The smell of petroleum may have made it distasteful to live stock.

LABORATORY NO. 36634—Water sent by J. W. Pharis, Walnut Hill pike, Fayette County, Ky. The well is 107 feet deep, bored last year. Sample contained some sediment.

ANALYSIS—One gallon contains 40.6 grains of solid matter (.696 gram per liter) composed of calcium carbonate, calcium sulfate, magnesium carbonate and sodium chlorid, with traces of silica, iron, potassium sulfate, lithium carbonate and strontium carbonate.

LABORATORY NO. 36649. Well water brought by Mrs. F. L. Saunders from a well three miles from Lexington on the old Frankfort pike. It was bored several years ago and is 85 feet deep. Sample clear, colorless water with a little brownish sediment. Received July 18, 1912.

ANALYSIS—One gallon contains 12.5 grains of solid matter (.215 gram per liter) composed of calcium carbonate, with very small amounts of calcium sulfate, magnesium carbonate and sodium chlorid, with traces of iron, lithium and silica.

The sanitary examination shows only a faint trace of nitrite, a trace of chlorid, 3.2 parts nitrate nitrogen per million and no free ammonia.

It should be a good water for domestic use. Except for the presence of a trace of lithium, it is like the ordinary spring water of this county.

LABORATORY NO. 36763--Water sent by John W. Coleman, Lexington, Ky., from a well at his residence on the Newtown road about two and one-half miles north of Lexington. The well is 153 feet deep, the water standing at 113 feet. Sample colorless with a little light brown sediment Received October 26, 1912.

ANALYSIS—One gallon contains 94.4 grains of solid matter (1.618 gram per liter) composed of sodium chlorid and calcium carbonate with small amounts of magnesium carbonate, sodium carbonate and sodium sulfate and traces of iron, silica, sodium iodid, potassium sulfate, lithium and strontium carbonates.

The sanitary tests show traces of both nitrites and nitrates and a strong test for free ammonia.

LABORATORY NO. 36786—Water sent by Dr. A. L. Blanding, Lexington, Ky., from a well near Lexington. Sample colorless with very little sediment. Received November 19, 1912.

ANALYSIS—One gallon contains 87.3 grains of solid matter (1.498 gram per liter) composed of sodium chlorid with a little calcium carbonate, calcium sulfate and magnesium chlorid and traces of iron, zinc, strontium and silica. Tests for nitrates and nitrites gave negative results.

It is a weak salt water and should have some medicinal value.

FULTON COUNTY.

LABORATORY NO. 36676—Water from a bored well 143 feet deep at Fulton, Fulton County, Ky. The well is a year old. Sample slightly turbid water with a small yellow brown sediment. Brought by Mr. Pittman of the Experiment Station to see if its use as a drinking water shoud be continued. Analysis reported August 24, 1912.

Analysis—	Grains per gallon.	Parts per million.
Total solids at 100° C.	7.93	0.136
Ignited solids	6.12	.105
Chlorin		11.
Nitrate nitrogen		A trace.
Nitrites and free ammonia		None.
Lime, magnesia and sulfates		traces.

The analysis does not show anything objectionable.

GRANT COUNTY.

Laboratory No. 28-S. Mineral water sent by The Kentucky Carlsbad Springs Hotel Company, Dry Ridge, Ky., July 9, 1912.

Analysis	Grams per Liter.	Grains per gal.
Ferrous carbonate $FeCO_3$	.0102	0.59
Calcium carbonate $CaCO_3$	.1325	7.72
Strontium carbonate $SrCO_3$	.0083	.48
Magnesium carbonate $MgCO_3$	.1187	6.92
Sodium carbonate, anhydrous, Na_2CO_3	.3849	22.44
Lithium carbonate Li_2CO_3	.0046	.27
Sodium chlorid NaCl	2.9751	173.45
Sodium sulfate, anhydrous, Na_2SO_4	.1410	8.22
Potassium sulfate, K_2SO_4	.0915	5.33
Potassium iodid, KI	.0001	.01
Potassium bromid, KBr	.0018	.11
Sodium sulfid, Na_2S	.0133	.78
Sodium biborate, $Na_2B_4O_7$	.0081	.47
Silica, SiO_2	.0070	.41
Total	3.8971	227.20
Total solids at 100° C.	3.9500	230.29
Ignited solids	3.7830	220.55
Ferrous sulfid in sediment	.0347	2.02

There was a black sediment of ferrous sulfid in the carboy when received, which was determined separately. This was, no doubt, in solution when the water was first drawn.

The analysis shows that this is a good alkaline-saline sulfur water, or "black sulfur" water. (Analysis by H. D. Spears).

HANCOCK COUNTY.

LABORATORY No. 36744—Water from a public well on D. L. Wilson's farm, sent by G. Orville Patterson, Hawesville, Hancock County, Ky. Sample received October 2, 1912.

ANALYSIS—One gallon contains 66. grains of solid matter (1.131 gram per liter) composed mainly of sodium chlorid and sodium carbonate with traces of calcium carbonate, magnesium carbonate, sodium sulfate, iron, silica, sodium iodid and potassium chlorid.

It is an alkaline-saline water and should have some medicinal value in some forms of stomach trouble and as a diuretic.

HARRISON COUNTY.

LABORATORY No. 36562—Water sent by R. A. Bishop, Manager of the Ashbrook Distilling Company, Cynthiana, Ky. Sample clear. Received March 27, 1912.

ANALYSIS—	Grains per gallon.	Grams per liter.
Total solid matter at 100° C.	12.66	0.2170
Ignited solid matter	9.74	.1670
Calcium carbonate ($CaCO_3$)	5.02	.0860
Magnesium carbonate ($MgCO_3$)	.47	.0689
Calcium sulfate, anhydrous ($CaSO_4$)	4.02	.0070
Sodium chlorid (NaCl)	.41	.0077

In addition to the above there are traces of iron, silica and potassium sulfate.

HART COUNTY.

LABORATORY No. 36746—Water from a well recently bored near Horse Cave, Hart County, Ky., sent by J. A. Marcum of that place. Sample opalescent with some dirty white sediment. Received October 8, 1912.

ANALYSIS—One gallon contains 33.5 grains of solid matter (.574 gram per liter) composed of sodium chlorid and calcium sulfate with small amounts of calcium carbonate and magnesium carbonate and traces of iron, silica and potassium sulfate.

HENDERSON COUNTY.

LABORATORY NO. 36656—Water sent by D. E. McMullen, Robards, Henderson County, Ky. Sample received July 26, 1912. The well is in the town of Robards on East Main Street, about a block from the railroad depot. It was dug in March, 1912, is 43 feet deep and the water stands 32 feet in it. The water, after standing, deposits a moderately large amount of brown sediment.

ANALYSIS—One gallon contains 24.8 grains of solid matter (0.425 gram per liter) composed of calcium carbonate, magnesium carbonate, sodium chlorid and a little sodium carbonate, iron carbonate and traces of silica, potassium sulfate and strontium carbonate.

Sanitary tests show .1 part nitrate nitrogen per million and about .1 part nitrite nitrogen. The latter is an unfavorable indication, but the water had been standing too long for it to have its full significance.

The water is alkaline in reaction. It is a weak chalybeate water.

HOPKINS COUNTY.

LABORATORY NO. 21-S. Water from magnesia well No. 2, Dawson Springs, Ky., sent by H. H. Ramsey, July 23, 1912.

ANALYSIS—	Grams per liter.	Grains per gallon.
Ferrous carbonate, ($FeCO_3$)	.0101	0.59
Calcium carbonate, ($CaCO_3$)	.0220	1.28
Calcium sulfate, anhydrous ($CaSO_4$)	.2174	12.67
Magnesium sulfate, anhydrous ($MgSO_4$)	.1221	7.12
Potassum chlorid (KCl)	.0215	1.25
Sodium chlorid (NaCl)	.2658	15.15

Analysis—	Grams per liter.	Grains per gallon.
Sodium biborate	A trace	
Silica (SiO_2)	.0400	2.33
Total	.6989	40.74
Total solids by evaporation	.7460	43.49
Ignited solids	.6100	35.56

(Analysis by H. D. Spears).

Laboratory No. 23-S—Mineral water sent for analysis by E. P. Doom, Dawson Springs, Ky., September 30, 1912.

Analysis—	Grams per liter.	Grains per gallon.
Calcium carbonate ($CaCO_3$)	0.3922	22.87
Magnesium carbonate ($MgCO_3$)	.1239	7.22
Strontium carbonate	trace	trace
Calcium sulfate, anhydrous ($CaSO_4$)	1.2493	72.82
Magnesium sulfate, anhydrous ($MgSO_4$)	3.5643	207.80
Potassium sulfate (K_2SO_4)	.0330	1.92
Sodium sulfate, anhydrous (Na_2SO_4)	.4656	27.14
Lithium sulfate	trace	trace
Sodium chlorid (NaCl)	.1777	10.35
Silica (SiO_2)	.0154	.90
Total	6.0214	351.02
Total solids at 100° C.	6.8050	396.73
Ignited solids	5.8190	338.72

The analysis shows it is a good laxative water.
(Analysis by H. D. Spears.)

Laboratory No. 24-S—Mineral water sent for analysis by H. E. Redden, Dawson Springs, Ky., October 11, 1912.

Analysis—	Grams per liter.	Grains per gallon.
Ferrous carbonate ($FeCO_3$)	.0006	0.03
Calcium carbonate ($CaCO_3$)	.4489	26.17
Magnesium carbonate ($MgCO_3$)	.0132	0.77
Strontium carbonate	trace	trace
Calcium sulfate, anhydrous ($CaSO_4$)	1.3090	76.31

ANALYSIS—	Grams per liter	Grains per gallon.
Magnesium sulfate, anhydrous ($MgSO_4$)	2.7956	162.98
Potassium sulfate (K_2SO_4)	.0272	1.59
Sodium sulfate, anhydrous (Na_2SO_4)	.5634	32.85
Lithium sulfate	trace	trace
Sodium chlorid (NaCl)	.2037	11.88
Silica (SiO_2)	.0214	1.25
Total	5.3830	313.83
Total solids at 100° C.	5.8400	340.47
Ignited solids	5.0050	291.79

The analysis shows it is a good laxative water.

(Analysis by H. D. Spears).

JEFFERSON COUNTY.

LABORATORY No. 36616—Mineral water from "St. Patrick's well," Louisville, Ky., sent by Mr. Adam Vogt, 1382 S. Third Street, Louisville, Ky. The well is located in the rear of Mr. Vogt's residence, No. 1382 S. Third Street. According to a circular of Moody & Bremaker, the former proprietors, this water was struck March 17, 1886, at a depth of 1952 feet, in a white rock which appeared at about 1900 feet, the flow of water finally becoming so strong that boring had to be discontinued. Different veins of water were found at various depths for 1150 feet, but the well was securely cased down to 1200 feet to exclude them and from there on for 700 feet the rock was dry. The well has continued to flow steadily. The well was bored for gas but only a small quantity accompanies the water. The water has some reputation as a medicinal water, laxative in effect and beneficial in dyspepsia. It was marketed under the name of St. Patrick's Well Water. Sample a 5-gallon carboy of clear water. Taste saline and bitter with a peculiar flavor suggesting free iodin, but none could be detected by shaking with carbon bisulfid. Bromin was easily detected by shaking with carbon bisulfid and chlorin.

Analysis—	Grams per liter.	Grains per gallon.
Ferrous carbonate ($FeCO_3$)	.0128	0.75
Calcium carbonate ($CaCO_3$)	.2740	15.97
Strontium carbonate ($SrCO_3$)	.0498	2.91
Calcium sulfate, anhydrous ($CaSO_4$)	2.0507	119.55
Potassium sulfate (K_2SO_4)	.2580	15.04
Magnesium sulfate, anhydrous ($MgSO_4$)	.1278	7.45
Magnesium chlorid, anhydrous ($MgCl_2$)	1.0965	63.93
Sodium chlorid (NaCl)	13.0939	763.37
Lithium chlorid (LiCl)	.0540	3.15
Bromid	Notable quantity.	
Iodid	Marked trace.	
Silica (SiO_2)	.0074	.43
Total	17.0249	992.55
Total solids at 100° C.	18.14	1057.56
Ignited solids	16.46	959.62

A good salt water which should have value medicinally both for internal and external use. It resembles some of the foreign brines, such as certain of the sources at Homburg, Kissengen and Duerkheim which are valued both for bathing and for internal use.

Laboratory No. 36764—Magnesian water sent by J. T. Foster, Louisville, Jefferson County, Ky., from a spring seven miles south of Louisville, known as the Mitchell Deer Lick Spring. Sample colorless with some very light brown sediment Received October 29, 1912.

Analysis—One gallon contains 142.5 grains of mineral matter (2.442 grams per liter) composed of magnesium sulfate, calcium sulfate and sodium chlorid, with traces of iron, silica, potassium sulfate, lithium sulfate and strontium sulfate.

This is a moderately strong magnesian water and has some medicinal value.

JESSAMINE COUNTY.

LABORATORY NO. 36632—Well water sent by W. M. Wharton, Keene, Jesssamine County, Ky. Sample clear and colorless. Received June 27, 1912 from Mr. T. R. Bryant.

ANALYSIS—One gallon contains 39.1 grains of solid matter (.67 gram per liter) composed of sodium chlorid, sodium carbonate, calcium carbonate and magnesium carbonate and traces of iron, silica and potassium sulfate.

This is a slightly alkaline, weak saline water and would doubtless prove good for drinking and domestic use.

KNOX COUNTY.

LABORATORY NO. 36776—Sulfur water sent by S. B. Dishman, Barbourville, Knox County, Ky., from his farm near that place. Sample colorless with a little dark colored sediment. Received October 23, 1912.

ANALYSIS—One gallon contains 21.5 grains of solid matter (.37 gram per liter) composed of sodium carbonate, with small quantities of calcium carbonate and sodium sulfate and traces of iron, silica, sodium chlorid, potassium sulfate, lithium carbonate and magnesium carbonate. Hydrogen sulfid 0.29 grain per gallon (.005 gram per liter). Alkalinity calculated as sodium carbonate, 15.7 grains per gallon (.27 gram per liter).

This is an alkaline, very weak sulfur water and should have some medicinal value.

LAWRENCE COUNTY.

LABORATORY NO. 36490—Water from a well 75 feet deep near Louisa, Lawrence County, Ky., sent by A. J. Garred of that place. Sample contained some light brown ferruginous sediment. Received January 12, 1912.

ANALYSIS—One gallon contains 4.9 grams of solid matter (.085 gram per liter) composed of small quantities of calcium carbonate, magnesium carbonate and sodium chlorid. The

water also shows a distinct test for iron and the sediment consists of ferric hydroxid.

It is a weak chalybeate water.

LABORATORY NO. 46588—Water sent by C. M. Summers, Louisa, Lawrence County, Ky., for the Louisa Water & Improvement Company. Sample received May 8, 1912.

ANALYSIS—One gallon contains 199.3 grains of mineral matter (3.426 grams per liter) composed mainly of sodium chlorid with some calcium carbonate and sodium carbonate, and traces of iron, silica, potassium sulfate and zinc carbonate.

This is an alkaline salt water and should have some medicinal value. It would not be a good boiler water and would corrode iron pipes in which it stood.

LEE COUNTY.

LABORATORY NO. 36648—Well water from the mission school at Heidelberg, Lee County, Ky., sent by Dr. E. O. Guerrant, Wilmore, Ky. Sample clear and colorless with some light brown ferruginous sediment. Received June 27, 1912.

ANALYSIS—	Grains per gallon.	Grams per liter.
Total solid matter	4.5	0.078
Ignited solid matter	2.5	.042

Chlorids, sulfates, lime and magnesia traces. There is a small quantity of iron present in the form of ferrous carbonate.

The sanitary tests show no nitrite or nitrate nitrogen and only a trace of free ammonia.

It is a very weak chalybeate water and should be a good water for drinking and domestic use.

LINCOLN COUNTY.

LABORATORY NO. 36501—Water sent by Prof. F. P. Anderson for the Q. & C. Railway from a spring near McKinney, Lincoln County. Sample received about February 15, 1912.

ANALYSIS—	Grains per gallon.	Grams per liter.
Total solid matter	210.7	3.62
Ignited solids	185.6	3.19
Alkalinity, calculated as calcium carbonate ($CaCO_3$)	21.8	0.375
Total hydrogen sulfid, (H_2S)	1.3	0.022

The mineral matter consists of sodium chlorid, calcium carbonate, magnesium sulfate and sodium sulfate, with traces of iron, silica, potassium sulfate and lithium carbonate.

It is a good saline sulfur water of moderate strength, containing magnesium and sodium sulfates.

LABORATORY NO. 36716—Well water from McKinney Graded School, McKinney, Lincoln County, Ky., sent by Horace Caldwell. Sample milky looking, containing some sulfur. Reported September 30, 1912.

ANALYSIS—One gallon contains 97.3 grains of solid matter (1.668 gram per liter) composed mainly of sodium chlorid and calcium sulfate, moderate quantities of calcium carbonate and magnesium carbonate and traces of iron, silica, sodium sulfid, potassium sulfate and strontium. Total hydrogen sulfid, free and combined, 1.3 grain per gallon (.022 gram per liter.)

A saline sulfur water.

LOGAN COUNTY.

LABORATORY NO. 36503—Water sent by W. T. Duncan, Russellville, Logan County, Ky. Sample contained very little sediment.

ANALYSIS—One gallon contains 113.8 grains of solid matter (1.953 gram per liter) composed of magnesium sulfate, calcium carbonate and sodium sulfate, with traces of sodium chlorid, iron, potassium sulfate and lithium carbonate.

This is a magnesia water and should have medicinal properties.

LABORATORY NO. 36770—Salt-sulfur water sent by G. W. Evans, Oakville, Logan County, Ky. The well is on Mr. Evans' farm, six miles south of Russellville. It is 132 feet deep. A strong flow of fresh water was struck at 80 feet. At 90 feet strong sulfur water was struck and at 116 feet a pretty strong flow of natural gas which burned 8 or 10 feet high when ignited. Sample gave strong test for metallic sulfids. Received about November 1st, 1912.

ANALYSIS—One gallon contains 172. grains of mineral matter (2.95 grams per liter) composed of sodium chlorid, calcium sulfate, calcium carbonate, magnesium carbonate, magnesium sulfate, a little potassium sulfate and considerable sodium sulfid. The water contains, also, some free hydrogen sulfid, the total present, both free and combined, being 8.4 grains to the gallon (0.144 gram per liter).

It is a good salt sulfur water.

Two well waters sent by J. H. Follin, Oakville, Logan County, Ky. The wells are about fifty feet apart and each is about 80 feet deep. Both recently bored. Samples received December 12, 1912.

LABORATORY NO. 36811—Sulfur water labeled No. 1.

ANALYSIS—One gallon contains 29.8 grains of solid matter (.51 gram per liter) composed of sodium chlorid, calcium carbonate, magnesium carbonate and magnesium sulfate. There are traces of iron, silica, potassium sulfate, strontium sulfate and zinc carbonate. There is a trace of nitrite but no nitrate present and a trace of phosphate. There is also a little hydrogen sulfid present.

It would be classed as a weak alkaline sulfur water.

LABORATORY NO. 36812—Sulfur water, labeled No. 2. Gives a strong test for metallic sulfid.

ANALYSIS—	Grams per liter.	Grains per gallon.
Ferrous carbonate ($FeCO_3$)	.0109	0.63
Calcium carbonate ($CaCO_3$)	.2178	12.70
Magnesium carbonate ($MgCO_3$)	.0972	6.67

	Grams per liter.	Grains per gallon.
Magnesium sulfate, anhydrous ($MgSO_4$)	.4286	24.99
Potassium sulfate (K_2SO_4)	.0129	.75
Sodium Chlorid (NaCl)	.6005	36.01
Sodium sulfid (Na_2S)	.2184	12.73
Silica (SiO_2)	.0115	.67
Total	1.5978	95.15
Total solids, dried at 100° C.	1.844	107.51
Ignited Solids	1.566	91.30

It is a saline sulfur water, quite strong in metallic sulfid.

MARSHALL COUNTY.

LABORATORY No. 36682—Magnesian water sent by Drs. Stilley and Washburn, Benton, Marshall County, Ky. Dr. Stilley says it seems to have some purgative effect. Sample colorless with some white flocculent sediment. Received August 22, 1912.

ANALYSIS—One gallon contains 77.2 grains of solid matter (1.324 gram per liter) composed of calcium sulfate, magnesium sulfate and a small amount of sodium chlorid, with traces of iron and silica.

It is a weak magnesian water and the laxative effect claimed for it is due to the magnesium sulfate present.

McCRACKEN COUNTY.

LABORATORY No. 36743—Water sent by John T. Lamb, Paducah, McCracken County, Ky. Sample received September 16, 1912.

ANALYSIS—One gallon contains 29.5 grains of solid matter (.505 gram per liter) composed mainly of sodium chlorid, some sodium sulfate, small amounts of calcium and magnesium carbonates and traces of iron, strontium, silica and potassium sulfate.

MONTGOMERY COUNTY.

LABORATORY No. 36678—Spring water brought by E. H.

Moss, Mt. Sterling, Montgomery County, Ky. The spring is six miles south of Mt. Sterling. Sample colorless with a little light brown sediment. Analysis reported August 29, 1912.

ANALYSIS—One gallon contains 5.7 grains solid matter (.097 gram per liter) composed of very small quantities of ferrous carbonate, calcium sulfate, magnesium sulfate and traces of sodium chlorid and silica.

It seems to be a very pure spring water but could be said to have weak chalybeate properties.

NELSON COUNTY.

LABORATORY NO. 36654—Mineral water sent by Lacy McClaskey, Bloomfield, Nelson County, Ky. Sample is perfectly clear with no appreciable sediment. The water comes from a dug well walled up with stone. Received July 29, 1912.

ANALYSIS—One gallon contains 170.9 grains of mineral matter (2.93 grams per liter) composed mainly of sodium chlorid, with small quantities of calcium carbonate, magnesium carbonate and calcium sulfate and traces of iron, silica, sodium bromid and strontium carbonate.

It is a moderately strong saline water.

NICHOLAS COUNTY.

LABORATORY NO. 19-S—Blue Lick water, sent by the Blue Lick Springs Company, March 29th, 1912.

ANALYSIS—	Grams per liter.	Grains per gallon.
Ferrous carbonate ($FeCO_3$)	.0044	0.26
Calcium carbonate ($CaCO_3$)	.3011	17.55
Magnesium carbonate ($MgCO_3$)	.0248	1.45
Strontium carbonate	Decided test.	
Calcium sulfate, anhydrous ($CaSO_4$)	.6348	37.01
Magnesium sulfate, anhydrous ($MgSO_4$)	.1023	5.96
Magnesium chlorid, anhydrous ($MgCl_2$)	.4546	26.50
Potassium chlorid (KCl)	.4820	28.10

	Grams per liter.	Grains per gallon.
Sodium chlorid (NaCl)	7.1083	414.41
Sodium sulfid (Na_2S)	.0080	.47
Sodium metaborate	Decided test.	
Lithium chlorid	Decided test.	
Potassium bromid (KBr)	.0275	1.60
Potassium iodid (NaI)	.0004	.02
Silica (SiO_2)	.0190	1.11
Total	9.1672	534.44
Ignited solids	8.9730	521.16
Free hydrogen sulfid (H_2S)	.0296	1.72

(Analysis by H. D. Spears).

OHIO COUNTY.

LABORATORY No. 36681—Well water sent by J. B. Howard, Fordsville, Ohio County, Ky. Mr. Howard states the water has turned reddish in color in the last week. Has no bad taste or odor. Sample contained some sediment and trace of sulfur. Analysis reported August 29, 1912.

ANALYSIS—One gallon contains 132.1 grains of solid matter (2.264 grams per liter) composed of calcium sulfate, magnesium sulfate, calcium carbonate, sodium chlorid and ferrous sulfate, with traces of silica, strontium, lithium and potassium. The reddish color is due to the oxidation of ferrous sulfate.

It is a chalybeate water containing magnesia.

OLDHAM COUNTY.

LABORATORY No. 36652—Mineral water sent by Mrs. W. H. Matlack, 947 Brook Street, Louisville, Ky., from a well near Crestwood, Oldham County. Sample received July 23, 1912. The water is very slightly turbid, with small dirty brown sediment.

ANALYSIS—One gallon contains 109.5 grains of mineral matter (1.877 gram per liter) composed of calcium sulfate, sodium sulfate and magnesium sulfate, with small quantities

of calcium and magnesium carbonates and sodium chlorid and traces of iron, silica and strontium.

This is a slightly chalybeate magnesian water and should have medicinal value.

LABORATORY NO. 36680—Spring water sent by McGruder Bros., Goshen, Oldham County, Ky. Sample colorless with a very small sediment. Analysis reported August 29, 1912.

ANALYSIS—One gallon contains 12.2 grains of solid matter (.21 gram per liter) composed of calcium carbonate, a small amount of magnesium carbonate and traces of calcium sulfate, sodium chlorid, iron, lithium and silica.

Except for the trace of lithium it is like the average spring water of the bluegrass region.

RUSSELL COUNTY.

LABORATORY NO. 36683—Water from Russell Springs, Russell County, Ky., sent by J. P. Bicknell, Berea, Ky. Sample somewhat turbid. Received August 13, 1912.

ANALYSIS—One gallon contains 10.6 grains of solid matter (.182 gram per liter) composed mainly of calcium carbonate with traces of calcium sulfate, sodium chlorid, magnesium carbonate and potassium sulfate. The alkalinity is equivalent to 7. grains of calcium carbonate to the gallon.

It seems to be an ordinary spring water.

SCOTT COUNTY.

LABORATORY NO. 36603—Salt-sulfur water brought by Benj. F. Battenfield, 285 E. Fifth Street, Lexington, Ky., from a well in Scott County, seven miles north of Georgetown. The well was bored over a year ago, 114 feet deep. Sample two small bottles of cloudy water, one containing a great deal more sediment than the other. Sediment composed largely of clay, some sulfur and iron. The water gives a test for sulfids.

ANALYSIS—One gallon contains 1194 grains of mineral matter (20.47 grams per liter) composed mainly of sodium

chlorid, calcium chlorid and magnesium chlorid with small amounts of calcium carbonate and sodium sulfid. There is a small amount of hydrogen sulfid present.

It is a strong salt sulfur water.

LABORATORY NO. 36620—Sulfur water from an old well about 14 feet deep on Harkness' White Sulphur farm, adjoining the Catholic school property at White Sulphur, Scott County, Ky. Sample collected June 23, 1912. Clear when drawn, quite turbid when received.

ANALYSIS—	Grains per gallon.	Grams per liter.
Sodium chlorid ($NaCl$)	50.01	0.858
Calcium sulfate, anhydrous ($CaSO_4$)	3.08	.053
Calcium carbonate ($CaCO_3$)	7.83	.134
Magnesium carbonate ($MgCO_3$)	10.37	.178
Total	71.29	1.223
Free and combined hydrogen sulfid (H_2S)	0.48	.008
Total solid matter at 100° C.	72.68	1.246
Ignited solid matter	62.30	1.068

In addition to the above there are traces of iron, silica, potassium and lithium salts.

It is a weak saline sulfur water and should have some medicinal value.

TAYLOR COUNTY.

LABORATORY NO. 36777—Water sent by R. W. Hazelwood, M. D., Bengal, Taylor County, Ky., from a well he has just had dug on his farm. Sample received about the last of October, 1912.

ANALYSIS—One gallon contains 631.5 grains of mineral matter (10.832 grams per liter) composed of sodium chlorid, sodium sulfate, some calcium sulfate and magnesium sulfate, a little calcium carbonate and magnesium carbonate, a little potassium sulfate and marked traces of strontium, lithium, iron, alumina, zinc and arsenic. The water also gave decided tests for free ammonia and nitrites.

It is a strong saline water.

WARREN COUNTY.

LABORATORY No. 36666—Water sent by M. R. Graham, Bowling Green, Warren County, Ky., from a well 100 feet deep, four miles north of Bowling Green. Reported September 5, 1912.

ANALYSIS—One gallon contains 25.4 grains of solid matter (.436 gram per liter) composed mainly of calcium carbonate, with small quantities of magnesium carbonate and sodium chlorid and traces of iron, silica and potassium sulfate.

The sanitary tests show no free ammonia, only a trace of nitrite nitrogen and 11.2 parts of nitrate nitrogen per million.

WEBSTER COUNTY.

LABORATORY No. 36653—Well water sent July 25, 1912, by Mrs. Byrd Stodghill, Sebree, Webster County, Ky. (R. R. No. 2). The well is on the farm of Frank Oglesby, seven miles west of Sebree on Rural Route No. 2. It is 80 feet deep, situated in the yard near Mr. Oglesby's residence and was bored in the fall of 1911. Water is turbid with heavy dark brown sediment. (See No. 36769).

ANALYSIS—One gallon contains 371.6 grains of mineral matter (6.372 grams per liter) composed of ferrous and aluminum sulfates, calcium sulfate, magnesium sulfate and sodium sulfate, with a little sodium chlorid and traces of silica and strontium sulfate.

This is a sulfated chalybeate water, the iron being present as ferrous sulfate. It is decidedly acid, due to the ferrous and aluminium sulfates. Such waters are commonly known as "alum waters."

LABORATORY No. 36769—Well water sent by Dr. F. V. Winstead, Dixon, Webster County, Ky., from a well located near Sebree, known as the Oglesby well. Sample received October 22, 1912.

ANALYSIS—One gallon contains 374.8 grains of mineral matter (6.425 grams per liter) composed of calcium sulfate, magnesium sulfate, aluminum sulfate, and ferrous sulfate,

and a small amount of sodium chlorid with traces of potassium sulfate and silica.

The water is strongly acid in reaction due to the aluminum and ferrous sulfates.

This is the same water as No. 36653, sampled at a different time and examined by a different chemist.

WHITLEY COUNTY.

Two samples of mineral water sent by C. W. Denham, Williamsburg, Ky., with letter of June 18, 1912. Samples in 10-ounce bottles, by mail.

LABORATORY No. 36618—Labeled "No. 1, from a well about 85 feet deep." Contains considerable red sediment.

ANALYSIS—One gallon contains 27. grains of solid matter (.464 gram per liter) composed of sodium chlorid, ferrous carbonate and calcium sulfate with traces of magnesia and silica.

This is a chalybeate water and should have some medicinal value.

LABORATORY No. 36619—Labeled "No. 2 from a well about 60 feet deep." Contains a little black sediment. No smell of hydrogen sulfid when first opened.

ANALYSIS—One gallon contains 14.1 grains of solid matter (.242 gram per liter) composed of small quantities of sodium chlorid, ferrous carbonate, calcium sulfate and magnesia with traces of potash and silica.

It is a weak chalybeate water.

WOODFORD COUNTY.

LABORATORY No. 36708—Mineral water brought September 19, 1912, by Joe Graddy, Versailles, Ky., from a well 142 feet deep, bored about 7 years ago, situated on the Lexington and Frankfort pike about 5½ miles west of Versailles. The well has been cleaned out and the sample was taken fresh this morning with a sand pump. Sample turbid and

smelled slightly of hydrogen sulfid and gave a decided though not very strong test for metallic sulfid.

ANALYSIS—One gallon contains 525. grains of mineral matter (8.984 grams per liter) composed of sodium chlorid with some calcium sulfate, calcium chlorid, magnesium chlorid, calcium carbonate, sodium sulfid, potassium chlorid, strontium carbonate and sodium bromid. No nitrate or nitrite was detected. Total hydrogen sulfid, both free and combined, .075 grain per gallon (.0129 gram per liter).

It is a salt sulfur water, very much like water of the old Lower Blue Lick Spring.

METEOROLOGICAL SUMMARIES

FOR THE YEAR 1912.

Compiled from the records of the U. S. Weather Bureau Station in the main building of State University.

Monthly and Annual Mean Temperature.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annl
1872											37	27	
1873	30	35	42	53	66	74	75	74	67	53	40	39	54. 0
1874	36	38	44	46	66	77	78	75	71	57	45	38	56. 0
1875	27	29	42	49	64	72	76	71	64	52	43	43	52. 7
1876	41	39	41	52	65	72	77				44	35	
1887													
1888	31	36	41	56	63	72	76	74	63	51	46	37	54. 0
1889	37	32	46	55	63	69	75	72	65	52	43	50	55. 0
1890	44	45	39	56	63	77	76	71	67	56	49	37	56. 6
1891	37	41	40	57	62	76	73	73	72	55	43	43	56. 0
1892	28	41	39	54	63	76	75	75	68	57	41	33	54. 1
1893	23	36	43	57	61	72	79	74	70	57	43	37	54. 4
1894	38	34	49	54	62	75	76	76	71	58	41	37	55. 9
1895	28	23	43	56	62	75	73	76	73	52	45	37	53. 7
1896	34	35	38	62	71	72	75	75	67	54	48	38	55. 9
1897	30	37	48	53	59	72	76	74	72	64	46	37	55. 7
1898	38	36	49	50	65	74	76	76	72	56	43	33	55. 8
1899	34	24	42	56	67	75	77	77	68	61	48	33	55. 1
1900	36	31	39	55	66	72	77	79	73	65	45	37	56. 3
1901	34	29	44	49	63	74	80	74	67	58	40	31	53. 6
1902	32	25	45	53	68	71	77	74	67	59	53	34	54. 8
1903	32	36	50	53	68	68	77	74	70	57	40	28	54. 4
1904	30	31	46	48	64	72	74	74	69	57	44	34	53. 5
1905	24	25	49	54	66	72	75	74	68	55	44	35	53. 5
1906	37	32	36	57	64	72	74	76	71	55	45	36	54. 5
1907	40	32	52	45	59	69	76	73	68	53	42	37	53. 8
1908	33	33	50	55	65	72	76	75	72	58	48	38	56. 1
1909	37	41	43	54	62	73	73	74	66	53	53	28	54. 6
1910	32	31	54	54	59	69	75	73	70	60	40	29	53. 7
1911	38	40	43	52	70	74	76	76	72	58	40	41	56. 6
1912	23	28	39	57	65	69	75	72	70	59	44	36	53. 1

Monthly and Annual Precipitation.

1872											1.21	3.30	
1873	2.53	4.05	3.73	2.89	6.05	4.49	3.37	2.94	1.60	5.47	1.92	4.48	43.52
1874	5.41	4.89	5.90	6.81	0.79	3.55	6.26	1.57	2.89	0.92	4.27	3.83	47.09
1875	2.61	3.12	6.18	2.06	2.43	4.16	11.24	0.62	1.72	2.37	5.87	3.68	46.06
1876	6.06	1.66	3.63	4.20	2.16	4.13	3.84				3.02	2.71	
1887													
1888	4.39	2.93	5.82	3.17	3.29	2.97	4.21	8.76	1.22	3.02	5.15	1.88	46.81
1889	5.66	1.78	1.63	1.52	3.53	3.49	5.82	1.15	6.79	3.06	5.34	1.73	41.50
1890	5.34	8.13	9.91	3.59	4.71	7.43	3.14	7.32	1.82	2.38	3.54	4.05	61.36
1891	4.70	4.36	7.63	1.85	1.17	5.33	3.23	6.48	1.26	1.33	5.38	2.82	45.51
1892	2.35	3.10	4.01	6.57	5.32	3.81	6.22	3.28	4.10	0.45	3.72	3.03	45.96
1893	2.10	4.44	3.30	5.81	3.88	4.24	3.11	1.86	2.25	5.59	3.36	2.61	42.55
1894	3.58	3.33	2.13	4.19	3.81	4.44	0.87	3.67	4.05	1.40	1.38	3.45	36.32
1895	5.60	0.52	2.79	3.17	4.05	2.93	5.07	1.56	0.33	1.28	2.52	5.50	35.32
1896	1.25	3.15	5.41	0.40	3.20	3.74	10.39	3.37	4.25	1.27	4.30	2.56	43.29
1897	2.59	6.33	6.55	5.80	4.48	4.77	4.34	3.21	0.80	0.38	4 83	5.11	49.19
1898	9.56	2.20	8.18	3.29	6.13	7.94	5.72	2.99	3.55	5.27	2.89	2.80	60.52
1899	6.69	2.84	8.61	2.16	3.63	2.55	0.97	4.18	1.90	2.09	1.70	2.92	40.24
1900	2.13	3.17	1.98	1.23	3.54	2.19	2.80	5.75	1.85	0.79	6.38	1.86	33.67
1901	1.49	0.62	2.23	4.52	2.67	3.70	2.61	3.74	2.18	1.33	1.73	3.50	30.32
1902	4.77	0.90	2.92	1.27	2.43	5.19	2.33	1.89	2.60	2.11	3.09	6.60	36.10
1903	1.68	6.16	3.24	3.29	1.75	2.71	2.62	1.49	0.81	2.12	2.84	1.99	30.70
1904	1.92	2.38	4.75	3.08	2.60	2.51	3.13	2.44	1.71	0.57	0.53	3.10	28.72
1905	2.04	2.13	5.87	2.87	5.54	3.31	4.94	4.11	3.20	3.45	3.58	4.13	45.17
1906	2.29	1.84	6.45	1.11	3.15	4.68	3.89	4.92	5.03	0.74	3.95	4.54	42.59
1907	9.06	1.89	4.13	1.83	3.89	3 65	4.42	2.07	2.72	2.76	2.67	2.28	41.37
1908	1.85	4.81	8.17	4.99	4.20	2.12	3.60	2.98	0.38	0.72	1.65	2.13	37.60
1909	3.35	6.86	3.97	6.72	4.15	5.41	5.98	1.26	4.88	2.05	1.96	2.77	49.36
1910	4.46	4.11	0.46	4.22	6.24	5.92	7.66	4.15	7.92	1.67	1.72	2.81	51.34
1911	2.44	2.21	2.31	4.46	1.07	3.01	0.92	2.84	4.37	3.67	3.84	6.20	37.34
1912	1.78	2.50	4.36	6.89	5.11	2.15	4.70	3.23	2.09	0.51	1.02	3.66	38.00

Annual Meteorological Summary for the Year 1912

Month.	Temperature. Degrees Fahrenheit.							Moisture						Per cent of Sunshine.	Wind.					Number of Days.								
	Mean.			Extreme				Relative Humidity. Per cent. 7 a. m.	Precipitation. In Inches.				Total Snowfall, Ins.		Average Hourly Velocity.	Prevailing Direction.	Maximum For five mins.			Clear.	Partly Cloudy	Cloudy.	With trace of snow.	Thunderstorms.	Fog.	Freezing or below.	Temp. 90 or above.
	Maximum.	Minimum.	Monthly.	Maximum.	Date.	Minimum.	Date.		Total.	Maximum in 24 hours.	Date.	Days with .01 inch or more.					Velocity.	Direction.	Date.								
January	32	15	23	52	23	-11	16	82	1.78	0.78	18-19	12	12.2	43	12.1	W	46	W	4	11	3	17	13	0	7	29	0
February	36	19	28	58	21	-9	4	80	2.50	1.25	20-21	9	4.0	31	11.6	W	50	W	21	6	2	21	9	4	11	24	0
March	47	31	39	73	19	17	2	88	4.36	1.47	23-24	17	5.5	30	10.4	SE	38	SW	21	6	5	20	10	1	12	19	0
April	66	47	57	80	12	33	8	77	6.89	2.41	26-27	14	0	57	12.1	S	60	W	2	9	7	14	0	10	1	0	0
May	74	56	65	86	27	42	13	81	5.11	2.22	6-7	13	0	69	9.5	SW	36	S	28	13	5	13	0	11	1	0	0
June	79	60	69	87	27	46	8	78	2.15	0.55	17-18	10	0	67	8.1	SW	32	SW	16	7	9	14	0	12	3	0	0
July	84	67	75	93	15	60	20	86	4.70	1.77	17-18	11	0	68	7.8	SW	27	SW	21	5	11	15	0	15	1	0	2
August	81	64	72	88	17	51	5	86	3.23	0.85	8-9	15	0	59	8.6	SW	43	NW	29	7	13	11	0	10	3	0	0
September	79	60	70	91	11	41	30	85	2.09	0.65	3	9	0	70	7.8	SE	42	NW	3	15	8	7	0	3	6	0	4
October	70	48	59	85	9	35	25	78	0.51	0.29	18-19	3	0	69	9.0	S	35	S	31	15	10	6	0	0	2	0	0
November	54	35	44	72	11	20	28	75	1.02	0.62	6-7	5	0.2	50	12.0	W	41	NW	23	11	7	12	1	0	2	11	0
December	44	28	36	64	5	11	12	79	3.66	1.38	5	12	6.1	43	11.8	S	41	SE	5	12	3	16	6	0	4	24	0
Year	62	44	53	93	Jul. 15	-11	Jan. 16	81	38.00	2.41	Apr. 26-27	130	28.0	55	10.1	S	60	W	Apr. 2	117	83	166	39	66	53	107	6

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