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THIRTY-FIFTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF KENTUCKY

FOR THE YEAR 1922

Lexington, Ky.

PART I.

Bul 239-240
Rept 1922
Circ 28-30

THIRTY-FIFTH ANNUAL REPORT

OF THE

KENTUCKY AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR 1922

PART I.

Report of the Director
Meteorological Observations

LETTER OF TRANSMITTAL

To His Excellency, Hon. Edwin P. Morrow, 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, 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, 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 Thirty-Fifth Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,

THOMAS COOPER, Director.

January 1, 1923.

UNIVERSITY OF KENTUCKY

Lexington, Ky.

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L. P. Benjamin, Asst. Bacteriologist
A. L. Meader, Asst. Chemist
Ethel L. Hopphan, Asst. Bact.
Ralph F. Schneider, Chemist.

*Assigned by U. S. Dept. of Agriculture.
**On sabbatical leave.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION.

In Account with the United States Appropriations, 1921-22:

	Hatch Fund	Adams Fund
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ending June 30, 1922, 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	$15,000.00	$14,995.80
Labor		4.20
Publications		
Postage and stationery		
Freight and express		
Heat, light, water and power		
Chemicals and laboratory supplies		
Seeds, plants and sundry supplies		
Fertilizers		
Feeding stuffs		
Library		
Tools, machinery and appliances		
Furniture and fixtures		
Scientific apparatus and specimens		
Live stock		
Traveling expenses		
Contingent expenses		
Buildings and land		
Balance		
Total	$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, 1922; 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 $15,000.000 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, leaving balances of nothing and nothing.

And we further certify that the expenditures have been solely for the purposes 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: Wellington Patrick,
F. M. McKee,
Auditors.

(Seal)
Attest: Teresa Buchignani,
Custodian.

ANNUAL REPORT

of the

DIRECTOR OF THE

KENTUCKY AGRICULTURAL EXPERIMENT STATION

For the Year 1922.

The past year has been one of fruitful progress in the work of the Experiment Station. Certain investigations of great importance to the agriculture of the state have reached a point where they may be developed in terms of farm practise thru the efforts of the Extension Division of the College of Agriculture. Other investigations have made satisfactory progress and will soon be ready for dissemination. Correspondence and observation indicate that the farmers of the state are relying more upon the results of experimental work and that there is a growing conviction among them that increased use must be made of the new facts developed by the Experiment Station if they are to prosper to the greatest extent.

This chronicle of the year's activities of the Experiment Station is necessarily brief and at the best may only serve to call attention to the more important investigations in progress and to the services rendered. A formal report does not portray the unceasing calls upon an Experiment Station for all kinds of information nor the use and effect of the dissemination of information. Certain practises, originally developed thru the investigations of the Experiment Station, have become so assimilated that they are accepted as having always been in use. This, perhaps, is the best criterion of the usefulness of the Experiment Station and its appeal to the farmer.

New knowledge is a purchasable commodity. A state may determine the extent to which it will invest in the development of the new fields of information and consequently the progress that it will make. Agriculture repays many fold any sum expended in research bearing upon the industry.

The Kentucky Agricultural Experiment Station requires additional funds that it may be of greater service to the agriculture of the state. During the past year, it has been impossible owing to lack of funds to develop promising fields of investigation which probably would mean increased returns of thousands of dollars annually to the tobacco growers of the state. Research that bears particularly upon certain important phases of the live stock breeding industry should be materially strengthened. Much work remains to be done in the study of soil problems. The field of animal industry requires an increase in the studies that bear upon economical production. Marketing, farm management and the economic aspect of relation of farm and other industry require study that farmers may be informed as to the best methods of marketing their products, the effective means of organization and how best to organize the farm for profit.

New Projects. The following is a list of the projects upon which work has been initiated this year:

A comparison of the common grains in supplementing sour skim milk in the ration for laying hens.

Improvement of orchard grass (*Cynodon dactylon*).

A study of red clover failures.

Improvement of red clover.

Investigation of the methods of marketing Kentucky strawberries.

Investigation of methods and costs of marketing live stock.

Establishment of Hopkinsville experiment soil field to determine the cause of low wheat yields in Christian County and counties of similar soil conditions.

Changes in Staff. The personnel of the Experiment Station, other than clerical assistants, is shown by departments on page 7 of this report. The appointments and resignations for the year are as follows:

Appointments:

Harry Allen, assistant chemist, department of fertilizer control, to chemist in that department. May 1.

Lelah Gault, assistant chemist, department of fertilizer control. May 1.

E. A. Caslick, assistant, department of veterinary science. August 16.

A. Lloyd Meader, assistant chemist, department public service laboratories. September 1.

Miss Ethel L. Hopphan, assistant bacteriologist, department public service laboratories. September 1.

Max Braithwaite, inspector, department of entomology and botany. September 6.

Ralph F. Schneider, chemist, department of public service laboratories. September 8.

Resignations:

R. H. Ridgell, chemist, department of fertilizer control. March 1.

John S. Yankey, Jr., seed inspector, department of entomology and botany. August 17.

In the department of public service laboratories:

C. G. Fuss, chemist. June 1.

John Gaub, assistant chemist. February 14.

John B. Nelson, assistant bacteriologist. September 30.

Ralph F. Schneider, chemist. December 31.

Prizes, Fair Exhibits. Among the live stock exhibits made by the Experiment Station, the following prizes were awarded:

BLUE GRASS FAIR.

Sheep—

Aged Cheviot ram	2d
Aged Cheviot ewe	1st and 3d
Yearling Cheviot ewe	4th
Cheviot ewe lamb	3d and 4th
Cheviot flock	2d
Yearling Hampshire ram	2d

Beef Cattle, Steer Classes—

Junior yearling	1st and 3d
Senior calves	2d and 3d
Junior calves	1st and 2d
Herd of three	1st and 3d
Best 3 head by one sire	1st

KENTUCKY STATE FAIR

Beef Cattle, Steer Classes—

Herefords—

Junior yearling	2d and 4th
Senior calves	2d and 4th
Junior calves	1st
Herd of three	2d and 3d

Aberdeen—Angus—

Junior yearling	2d and 3d
Senior calves	3d
Herd of three	2d and 3d

Shorthorns—

Junior yearling	2d and 4th
Senior calves	4th
Junior calves	5th
Herd of three	1st and 3d

Grades and Crossbred—

Junior yearling	4th
Herd of three	4th

INTERNATIONAL LIVE STOCK EXPOSITION

Sheep—

Hampshire yearling wether	1st, 2d and champion
Cheviot yearling wether	1st and champion
Southdown wether lamb	4th
Rambouillet yearling wether	5th

Publications. The publications of the Experiment Station for the year are as follows:

Bulletins:

No.

239. Vitality of Spermatozoa. W. S. Anderson. January, 1922.
240. Land Prices and Land Speculation in the Bluegrass Region of Kentucky. G. W. Forster. January, 1922.
241. The White Flies of Hothouses. April, 1922.
Asterochiton abutilonea. H. Garman.
Asterochiton vaporariorum. H. H. Jewett.
242. Feeding Steers having Access to Barn and Range vs. Steers Confined to Barn. E. S. Good. June, 1922.
243. Breeding Experiments with Kentucky Mountain Ewes. L. J. Horlacher and E. S. Good. July, 1922.
244. Sterility in Relation to Animal Breeding. W. S. Anderson. December, 1922.
245. Analyses of Commercial Fertilizers. H. E. Curtis, H. R. Allen and Lelah Gault. December, 1922.

Circulars:

28. Strains of Standup White Burley Tobacco Resistant to Root-Rot. W. D. Valleau and E. J. Kinney. January, 1922.
29. Self-Fertility in Red Clover. E. N. Fergus. December, 1922.
30. Discussions and demonstrations on breeding problems. W. S. Anderson, W. W. Dimock, E. S. Good and Cassius Way. December, 1922.

Reports:

Thirty-Fourth Annual Report of the Experiment Station —1921. Thomas P. Cooper.

Scientific Papers (In print):

The hydrogen ion concentration of horse semen. D. J. Healy and W. S. Anderson. The Cornell Veterinarian. January, 1922.

Calcium in egg-shell formation. G. D. Buckner, J. H. Martin, W. C. Pierce and A. M. Peter. Journal of Biological Chemistry. Vol. 51, No. 1. March, 1922.

The function of grit in the gizzard of the chicken. G. D. Buckner and J. H. Martin. Poultry Science. Vol. 1, No. 4. April-May, 1922

The Clark hydrogen-electrode vessel and soil measurements. D. J. Healy and P. E. Karraker. Soil Science. Vol. 13, No. 5.

The role of manganese in plants. J. S. McHargue. Journal of American Chem. Soc. Vol. 44, No. 7. July, 1922.

A Kentucky chemist of the old school. A. M. Peter. Paper for Ky. Academy of Science. May, 1922. Abstract in Science. Vol. 56, No. 1438. July 21, 1922.

Chemical analyses of soil (of Logan County, Ky.) and the maintenance of fertility. S. D. Averitt and A. M. Peter. Soil Survey of Logan County, Kentucky, Advance Sheets—Field operations of the Bur. of Soils, 1919. Washington, 1922.

The mineral content of the normal white rat during growth. G. D. Buckner and A. M. Peter. Journ. Biological Chemistry. Vol. 54, No. 1. September, 1922.

Note on the use of the Mohr pipette. W. D. Iler. Journ. Indus. and Eng. Chemistry. Vol. 14, No. 10. October 1922.

The effect of certain calcium compounds on the yield and calcium content of certain crops. O. M. Shedd. Soil Science. Vol. 14, No. 4. October, 1922.

A rapid method for the analysis of dolomite and magnesian limestone. S. D. Averitt. Journ. Industrial and Engineering Chemistry. Vol. 14, No. 12. December, 1922.

The effect of paradichlorobenzene on the viability of stored seeds. H. Garman. Seed World. February 17, 1922.

Germination of scarified hard seeds. H. Garman. Seed World. October 20, 1922.

A study of the breeding methods of a successful Kentucky sheepman. L. J. Horlacher. Breeders' Gazette, July 6, 1922.

A study of spring lamb production in Kentucky. L. J. Horlacher. Breeders' Gazette, February 9, 1922.

Growth of a dairy herd. J. J. Hooper. Jersey Bulletin, December 13, 1922.

Time aborted calf is carried by dam. J. J. Hooper and J. W. Nutter. Hoard's Dairyman, October 13, 1922.

Fresh-water Coelenterata in Kentucky. H. Garman. Science, Vol. 56, No. 1458. December 8, 1922.

Genetics in relation to animal breeding. W. S. Anderson. (Read at a meeting of Kentucky Breeders, March, 1922.) In Circular 30, December, 1922.

Infectious abortion in mares. E. S. Good. (Read at a meeting of Kentucky Breeders. March, 1922.) In Circular 30, December, 1922.

Report of progress of work on sterility. W. W. Dimock. (Read at a meeting of Kentucky Breeders, March, 1922) in Circular 30, December, 1922.

The following papers have been prepared this year, but have not yet appeared in print:

The iron and manganese content of certain species of seeds. J. S. McHargue. Accepted by the Journal of Agricultural Research for the February 3, 1923, number.

The effect of different concentrations of manganese sulfate on the growth of plants in acid and neutral soils, and the necessity for manganese as a plant nutrient. J. S. McHargue. Accepted by the Journal of Agricultural Research for the May 26, 1923, number.

An improved method for the determination of nicotin in tobacco and tobacco extracts. O. M. Shedd. Accepted by the Journal of Agricultural Research.

Chemical analyses of the soils of Muhlenberg County, Kentucky. S. D. Averitt. For the Bureau of Soils report of the soil survey of Muhlenberg County.

Calcium metabolism in the laying hen. G. D. Buckner, J. H. Martin and A. M. Peter. To be issued as a Station bulletin.

Effect of calcium on the protein metabolism of the laying hen. G. D. Buckner, J. H. Martin and A. M. Peter.

The rate of expansion of a dairy herd. J. J. Hooper. Read at annual meeting of Kentucky Veterinary Medical Association. July 7, 1922.

Infectious abortion in live stock. E. S. Good. Read at meeting of the Association of Southern Agricultural Workers. February, 1922.

Breeds of Sheep for the South. L. J. Horlacher. Read at meeting of the Association of Southern Agricultural Workers. February, 1922.

Sterility in its bearing on horse breeding. W. S. Anderson. Read at annual meeting Kentucky Veterinary Medical Association. July, 1922.

Results of investigations of sterility in males. W. S. Anderson. Read at meeting of American Society of Animal Production, Chicago. December 1, 1922.

Influence of great sires on their breeds. W. S. Anderson. Read at meeting of the Genetic Section of the American Society of Animal Production. December 1, 1922.

(1) Yeast bread as compared to baking powder bread in nutritive value. (2) Experiments in bread making. Lelah V. Gault. For "Home Economics."

An important period in the life-history of two bacterial organisms causing leaf-spots on tobacco. W. D. Valleau. For Phytopathology.

An unusual skin disease of swine. A. J. Steiner and T. P. Polk. For North American Veterinarian.

Infectious necrotic enteritis. W. W. Dimock, D. J. Healy and G. L. Hoeft. For North American Veterinarian.

Infectious necrotic enteritis in swine. W. W. Dimock, Ethel Snyder and D. J. Healy.

Library. From 8711 volumes the accessions have grown to 8926, an increase of 215 volumes during the year. The periodicals subscribed for number 132 domestic and 38 foreign, or a total of 170.

PROGRESS OF WORK FOR THE YEAR.

Much of the progress in the several lines of work is due to the efficient administration and attention of the following heads of departments:

George Roberts, Head, Department of Agronomy.
E. S. Good, Chairman, Animal Husbandry Group.
A. M. Peter, Head, Department of Chemistry.
H. Garman, Head, Department of Entomology and Botany.
W. D. Nicholls, Head, Department of Farm Economics.
J. D. Turner, Head, Department of Feed Control.
H. E. Curtis, Head, Department of Fertilizer Control.
C. W. Mathews, Head, Department of Horticulture.
W. W. Dimock, Head, Department of Veterinary Science.
L. A. Brown, Head, Department of Public Service Laboratories.

The following presentation of typical pieces of interesting and important work indicates the development and progress of the institution and gives the results less formally than they are recorded in scientific papers.

Farm Management Study in the Purchase Region of Western Kentucky. A study was made in the Purchase Region to determine the fundamental factors for profitable farming. This included a complete business analysis for the year 1921 of 115 farms in Calloway, Marshall, McCracken, Graves, Bal-

lard and Carlisle Counties. The net earnings of the operators of these farms averaged minus $113, that is, the average farm failed by that amount to pay interest on the investment leaving nothing as a compensation for the operator's work. These figures represent a year of severe depression, but a significant point brought out by the study was that a few farmers made some money in spite of the general depression. Thus the ten most profitable farms made earnings which averaged $841.

A study of the exceptionally profitable farms indicates that the principal factors responsible for their success were that the labor and teams were handled so as to secure maximum efficiency; crops were limited to an acreage that could be cultivated well at a moderate cash outlay; the tobacco produced was of high quality; a greater proportion of these farms was in grass and more live stock was kept than on the average farm in the section.

Standard Grades for Tobacco. During the year almost 100 warehousemen, dealers, manufacturers and others interested in the tobacco business have been interviewed and information sought regarding tobacco grades, the principles involved, the factors to be considered and their relative importance, the difficulties to be overcome and other points. In addition, standard grades for tobacco have been discussed with several hundred farmers in order to obtain their views. Samples of tobacco have been assembled and these have formed the basis for further study of standard grades.

The Burley Tobacco Growers' Cooperative Association formulated definite grades early in the year for its use in receiving and marketing the tobacco delivered to it by its members. This system of grades has been studied very carefully, both by examination and comparison of samples of all the different grades and by obtaining the views of growers and persons in the tobacco business regarding them.

It is desirable that a tobacco grading system be as simple as possible and at the same time furnish a satisfactory basis for the receipt and sale of tobacco. The results of the study

of the Association's grades indicate that they meet these requirements. The grades recognize the fundamental differences in tobacco and at the same time are easily understood by growers, graders, buyers and others. It seems highly desirable that the grades be not too difficult for the average grower to understand, since uniformity in the grades depends so largely upon proper sorting by growers at stripping time. It is not necessary that the growers know all the subdivisions of the grading system, but they should be acquainted with the main classes or families so as to be able to sort their tobacco into uniform lots. Because of the satisfactory way in which the Burley grades are serving their purpose, it was recommended to the United States Department of Agriculture, in cooperation with which this study has been carried on, that they be adopted as the grades under the United States warehouse act.

The study has included western Kentucky types of tobacco as well as Burley. The principles are the same as in the case of Burley tobacco, but some variation must be made in order to meet the particular requirements of the western types. The establishment of the Dark Tobacco Growers' Cooperative Marketing Association is resulting in the formulation of association grades for the western types. Conferences have been held with members of the committee engaged in this work and the fitness of the grades adopted will be studied in the same way as the burley grades have been considered.

Rotation Experiments with Burley Tobacco. In the tobacco rotation, tobacco grown after orchard grass in a four-year rotation of (1) wheat, (2) clover and orchard grass, (3) orchard grass, (4) tobacco, has given considerably better quality of leaf than where tobacco follows corn and other crops. In addition, the average yields have been better. In the three-year rotations, the tobacco grown after a redtop sod is decidedly superior to that grown after wheat or rape. In fact, there seems to be no doubt that the chance of getting a good yield of good quality leaf is best on sod land.

Fertilizer Experiments on Burley Tobacco. The nitrogen tests on tobacco were continued in 1922. The tobacco was grown in a rotation of wheat, clover, corn and tobacco, ten to twelve tons of manure being used on the corn. Nitrogen fertilizers of several kinds in varying amounts failed to give an increase in yield in 1921. The 1922 crop is not stripped, but judging from appearances, the fertilizer has not been of benefit. In the permanent fertilizer tests on tobacco, nitrogen has given a substantial increase. No manure or crop residues are returned there, however. This shows that commercial nitrogen may give responses under such conditions, while on land well manured and where crop residues are returned, the use of commercial nitrogen may give no increase in yield.

Strains of Standup White Burley Tobacco Resistant to Root-Rot. Tests of strains of tobacco resistant to root-rot caused by *Thielavia basicola*, Zopf., have been continued on the Experiment Station farm and on approximately 200 farms in the Burley section. These strains have been derived directly by selection from the commonly grown varieties of Standup White Burley originated from a small lot of seed sent to Mr. B. L. Kelly of Lancaster, Kentucky, by the Experiment Station about fifteen years ago. Comparative tests of the resistant strains and the most widely grown standup varieties on diseased land indicate that all of the latter are susceptible to root-rot. A single local variety of tobacco grown near Georgetown, Kentucky, was found to be resistant, but the plant type was not desirable.

Aside from increased growth on diseased land, the use of resistant strains has reduced the cost of resetting. Practically no resetting was necessary in the resistant strains grown on several diseased fields whereas the resetting necessary in the common varieties ranged from 5 to 50 per cent and in one case an entire field of nine acres was disked and reset except five rows of a resistant strain.

The quality of the best resistant strains appears to be as good as the best standup Burley varieties commonly grown.

and has the added advantage of a higher degree of uniformity. This has greatly facilitated rapid uniform grading. In several instances, growers who tested the Experiment Station resistant tobacco last year planted their entire crop with it this year. One seedsman who tested the tobacco last year raised seed and sold over 200 ounces. At least four seedsmen have raised a quantity of seed the past season. Over 300 pounds of seed of Kentucky Agricultural Experiment Station resistant tobacco are on the market at present.

Further selections have been made, some of which appear to be more promising than those being tested. A thousand samples of seed of one of the Kentucky Experiment Station resistant strains have been prepared for distribution in 1923 in order to further test the value of this strain. An extensive survey of the prevalence of root-rot in the Burley section the past season indicated that it was causing damage in 60 per cent of the plantings.

Susceptibility of Varieties of Black Tobacco to Root-Rot. Tests of nine varieties of dark tobacco were conducted at the Experiment Station the past summer. These included Dark G (a resistant dark strain obtained from White Burley), Madole (2 strains), Broadbent, Yellow Pryor, Greenwood (3 strains), One-Sucker, Little Hill, Kentucky Yellow, Lack's and Turkish. Dark G is very resistant, but is of questionable value. Kentucky Yellow showed a fair degree of resistance. Turkish proved practically immune, which is an important point as this tobacco is grown rather intensively in a small, rather isolated area near Vanceburg, Kentucky. The remainder were all slightly more resistant than the susceptible strains of Burley and had made considerable growth by fall. However, the yield was reduced fully 40 per cent as a result of the disease. One-Sucker appeared the most susceptible to root-rot.

Root-rot caused considerable injury thruout the black patch of western Kentucky and northern Tennessee this season, as evidenced by the very uneven stands obtained. Micro-

scopic examinations confirmed the field observations. Selection for resistance and hybridization to obtain resistant varieties have been begun on dark tobacco.

Mosaic Disease of Tobacco. Studies on overwintering of the mosaic disease of tobacco indicate clearly that this disease is carried in the root stocks of the bull-nettle (*Solanum carolinense*) and in the several species of ground-cherry (*Physalis sp.*) common in Kentucky. The mosaic disease has been transmitted successfully from these weeds to tobacco and tomato. Attempts to transmit the mosaic disease of the bean, red clover, soybean, and pokeweed to tobacco resulted in failure. An attempt to transmit leaf-roll of potato to tobacco was also a failure. On two occasions an attempt was made to transfer the so-called ring-spot disease of tobacco to tobacco. In both cases the disease resulted on a single leaf of one plant, out of about 50 inoculated. No other plants in a bed of several hundred plants showed any signs of the disease. The use of crude oil and gasoline as a spray to destroy bull-nettle and ground-cherry plants in the late summer resulted in failure as only the tops were killed while the root stocks again sent up new shoots before winter.

Quality of Tobacco in Relation to its Chemical Analysis. About 100 samples of White Burley and dark tobacco, selected by expert graders according to quality, have been analyzed, in continuation of an investigation begun last year. The findings show material differences in both nicotin content and nitrogen content of Burley wrappers, fillers and smokers and also of dark leaf, lugs and trash. The nicotin content of good hands of either kind of tobacco usually is larger than that of the common. The nitrogen content of good and of common types of the same grade, however, does not show as great differences as the nicotin content, suggesting that the common has nitrogen in other forms which perhaps make inferior tobacco.

The differences in nicotin content, especially in waste and very inferior tobacco are such that it would not be safe to base

the proportions of tobacco and water used in making an infusion for spraying upon the average percentage.

An improved method for determining nicotin in tobacco and tobacco extracts has been worked out and described in an article accepted for publication in the Journal of Agricultural Research.

Improvement of Orchard Grass. This is an important crop in Kentucky both for forage production and seed production. In fact, a few counties in Kentucky produce more than half of the crop of orchard grass seed in this country. As a pasture crop it is constantly finding greater favor with farmers for its productivity and longevity. Like all the grasses, it has been known for years that a great deal of variation occurs among the plants, but little work has been done anywhere toward separating the various strains and determining their relative value for different purposes and possibly different soils. Altho only a beginning has been made at this Experiment Station, enough plants have been grown to show tremendous variation in character of growth, vigor, etc., indicating that as the work progresses it will be possible to select superior strains.

Alfalfa. The alfalfa variety tests which were sown in 1920 have shown that the hardy strains of alfalfa, Grimm, Cossack, etc., stand the effects of late spring frosts much better than the common alfalfa. In 1921 two hard freezes occurred after alfalfa had made a heavy growth. The common was very badly hurt while the hardy strains were injured but slightly. The latter made a fair cutting of hay while with the common strains, growth was effectively checked. Even the second cutting of common was inferior to that from the hardy strains. The common strains recovered from the effects of the freezes eventually and the rest of the year and in 1922 made about the same yields as the hardy strains. The winters have been so mild recently that there has been no winter killing or even heaving of the common type. In spite of the greater frost resistance, yields during the two years do not

indicate any marked superiority for the hardy strains in Kentucky. It is interesting to note that the alfalfa on the Station farm, averaging all strains, made in 1922 over five tons of hay per acre in four cuttings. This despite the fact that during this year we experienced a drouth of great severity at Lexington which reduced corn yields more than half and tobacco yields almost half.

Hemp. The experiments in growing hemp on land not generally regarded as in fit condition for hemp were completed this year, but the data for the five years can not be summarized until the 1922 crop is "broken." Judging from appearances, the increase from the use of nitrates was just as great this year as in previous years. The tests have shown clearly that good hemp can be grown by the use of nitrogen fertilizers where without the fertilizers the crop would be too small to be profitable. An example of the benefits of nitrogen fertilizers in hemp was shown on a large scale on the farm of Mr. Banks Hudson of Danville, who grew 450 acres of hemp this year. Upon the advice of the Experiment Station, Mr. Hudson used 200 pounds of sulfate of ammonia per acre and estimated the increased yield as 300 pounds of fiber per acre.

Corn. Standard varieties of corn were compared to some local and imported varieties in variety tests both at the Station and in numerous cooperative tests. At the Station the very dry year made corn a very poor crop. Early varieties suffered least, as they matured before the drouth became so severe. Pride of Saline, a variety which has proved quite drouth-resistant in Kansas, gave the largest yield at the Station, followed closely by Reid's Yellow Dent, Iowa Silver Mine and Boone County White. Woodburn White Dent, Albemarle Prolific, and two local varieties gave low yields. Pride of Saline also made a good record in other parts of the state.

At the Station all varieties were tested at two rates of planting—7000 plants per acre (two plants per hill $3\frac{1}{2} \times 3\frac{1}{2}$ ft.) and 10,500 plants per acre (3 stalks per hill ($3\frac{1}{2} \times 3\frac{1}{2}$ ft.) In all cases the thinner planting gave the larger yield as may be

expected in such a dry year. This and previous tests show that on the average the thinner rate is much safer for the Bluegrass region at least. It is even possible that fewer plants may be better. An ear-to-row test of 100 ears of Boone County White was made to study in particular the relation of type of grain to vigor of plant and yield.

Corn Root-Rot. Further detailed studies of the extent of infection of corn seed with pathogenic organisms have been continued and confirm previous reports as to the extremely high degree of infection present. In addition to the organisms previously reported to be present in corn seeds, there may be added *Helminthosporium* sp. in from 25 to 50 per cent of the seeds examined, a species of *Macrosporium* in a small per cent of seeds, and what appears to be *Sclerotium sp.* from seeds of a few ears. A rather definite relationship exists between certain seed-coat discolorations following germination and the presence of certain organisms in the seed. It has been determined definitely by microscopic examination of prepared slides of apparently healthy corn seeds that fungus hyphae may be present between any of the seed-coat layers outside of the aleurone layer and in any portion of the seed-coats. Seeds which appear sterile when cultured in test tubes or petri plates have been found by microscopic examination to be infected. Tests the past three years have indicated that selection for so-called badly diseased ears and "disease free" ears have been of no avail in reducing or increasing the yield of corn whereas the past season selection of extremely smooth ears and extremely rough ears from a lot of 500 selected seed ears of Boone County White corn resulted in an increase of 39 per cent in favor of the smooth ears over the rough. The season was extremely dry.

Oats. A test is being made of several early varieties of oats in comparison with later varieties both to demonstrate the advantage of the early varieties for yield and to determine the best of the early varieties. Burt still leads in yield among the early sorts, altho Fulghum was a close second this year.

The Burt variety has some serious faults such as rather weak straw, a good many dark grains and lack of uniformity. Breeding work has been started in an effort to find pure lines of superior quality.

Wheat. Kentucky farmers have become much discouraged over the wheat situation, for the crop has been very poor for several successive years. Yet there is no other small grain crop that is as well adapted to this state as wheat and a small grain crop is almost necessary in seeding land to grass and clover. It seems that various diseases have been responsible for the poor results. This year the crop was greatly reduced by a disease which caused premature ripening. Straw broke badly and the grains were shrunken. *Helminthosporium sp.* and the wheat scab organism were consistently isolated from the broken joints. The Station has been testing numerous strains and varieties in an effort to find one that is more resistant to disease. Ashland, the new variety developed by the Station and which was so promising, seemed to be particularly badly affected by the premature ripening and gave poor results in many of the cooperative tests. Fulcaster has given the best results of the varieties tested during the past two years and a number of pedigree strains of this and of Currell's Prolific are being tested. Nitrate tests on wheat this year resulted in no increase in yield when applied in the fall and a decreased yield when applied in the spring. The spring application stimulated a rank growth which invited disease attacks.

Seed Infection in Small Grains. Studies have been carried on to determine the extent of seed infection in seeds of the small grains as there is considerable indication that root diseases are a serious factor in the production of small grains in this state. Fifty-eight lots of seed (oats, barley and wheat) obtained from widely separated sections of the United States proved to be infected to a very high degree with seed-borne organisms as indicated by discoloration of the sheath shortly after germination and later rotting of the roots. The modi-

fied hot water treatment delayed development of the organisms in some cases but there was no indication that it killed them in any seeds.

Clover. In a study of clover on three widely differing soils it was found that stands of red and alsike clover on the most unproductive or "clover sick" soil were sufficient, thruout the first summer, for at least a fair yield but that the plants were so small that only a very careful search revealed them. The stand was greatly reduced on most soils during the second summer, however, practically all of the plants disappearing from the least productive soils. Root-rot was present to some extent on all the root systems which were examined, tho it was by far the most serious on those grown in the least productive soils. Such systems were practically destroyed by the end of the first summer, the plants living on new roots from or near the crowns. The tap-root systems of those plants on other soils functioned thruout the first and part of the second summer but were badly diseased or dead by the end of the second summer. The ability of a clover plant to persist after the decay of the tap-root apparently depends on its ability to produce new roots from the crown.

Some very significant results have been obtained in attempts to self-fertilize red clover. Previous attempts to accomplish this have resulted either in failure or where seeds have been obtained it has seemed very probable that they were the result of accidental cross-fertilization. A large number of plants have been handled in this work and seeds secured from a number of them. These were planted and gave rise to self-fertile plants again, some of them having the ability of seeding quite freely when selfed. The peculiarities in the growth of the plants, such as lack of chlorophyl, deformities, etc., as well as the striking uniformity in the progeny of selfed individuals certainly indicate that actual self-fertilization has occurred and that lines of self-fertile clover do exist. A preliminary report of this work has been prepared and will be

printed as a station circular. The discovery of self-fertile strains of clover should be of tremendous benefit in breeding up strains of clover of great vigor and disease-resistance.

Sweet Clover. Clipping tests on sweet clover to determine whether or not clipping will kill or injure it at various stages of growth, indicate, so far, that little or no injury results from clipping the first year. The plant has a crown during the first season and a new growth starts promptly even when the clover is cut very low. During the second year, we have been unable to get any new growth after clipping at any time or at any height where the stand was thick and vigorous. There seem to be no buds on the stalk near the base and of course the second year there is no crown from which the new shoots could spring. It is evident that the production of a seed crop after the growth has been cut for hay must depend upon leaving some of the lower branches of the sweet clover uncut. Where the stand is very thin, this might be possible. A series of clipping tests have been started in which the stand varies from very thin to very thick, the object being to ascertain if any kind of a stand can be clipped the second year and a seed crop produced later.

Soils. One very important feature in the results of the work on soils is the difference in the behavior of acid phosphate and rock phosphate on limed and unlimed ground on different soil types. The following data are presented to show the wide variation in the effect of these two forms of phosphate. For example, on the Mayfield experiment field, the rock phosphate is quite as effective as acid phosphate on both limed and unlimed soil, while on the Campbellsville field, the other extreme is found in that rock phosphate is very effective on unlimed soil and very ineffective on limed soil. An interesting observation is that as the experiments grow older the depressing effect of limestone on rock phosphate becomes greater where there is a depressing effect at all.

It is probable that the ideal condition for the use of rock phosphate is a neutral soil. In practise this would mean that

slight excess of finely ground limestone or burnt lime would be added to neutralize the soil and after the disappearance of the excess, the rock phosphate would be added. The use of rock phosphate and the proper return of manure and residues would probably thereafter provide sufficient calcium.

Below are given the yields from the various soil treatments under consideration:

Limestone was used in these experiments at the rate of two tons per acre per rotation. On all the fields except Campbellsville, acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1600 pounds per acre per rotation applied on corn ground. Rock phosphate was plowed under, while acid phosphate and limestone were disked in on plowed ground. The rates of phosphate applications are stated with yield data at Campbellsville.

Soil Type and Acidity of These Fields.

TYPE	Acidity=CaO Per 2 Mill. Lbs. Surface Soil (Hopkins)	Total Phosphorus Per 2 Mill. Lbs. Surface Soil
Greenville—Tilsit silt loam	60	660
Mayfield—Memphis silt loam (probably)	102	960
Russellville—Decatur silt loam	60	1040
Fariston—Silt loam (not mapped)	580	820
Campbellsville—Silt loam	72	1102

O=no treatment
L=limestone.
AP=acid phosphate.
RP=rock phosphate.
K=potassium salts.

Crop Yields Per Acre, Mayfield Soil Experiment Field.

	AP	RP	LAP	LRP	
Corn, bus.					
Ave. first rotation	24.2	26.5	34.6	36.1	
Ave. second rotation	31.7	35.2	44.7	43.8	O=29.1
Ave. 8 years	27.9	30.8	39.6	39.9	L=32.3
Soybean hay, lbs.					
Ave. first rotation	2365	2330	3578	3795	
Ave. second rotation	2072	2539	3285	3219	O=2049
Ave. 6 years	2186	2468	3382	3411	L=2791
Wheat, bus.					
Ave. first rotation	9.6	8.6	15.7	17.8	
Ave. second rotation	10.9	12.0	18.1	16.6	O= 8.2
Ave. 8 years	10.1	10.0	16.7	17.3	L=10.5
Clover, lbs.					
Ave. first rotation	457	710	3125	2811	
Ave. second rotation	1688	2590	4180	4301	O= 978
Ave. 7 years	699	1516	3577	3449	L=2458

Crop Yields Per Acre, Russellville Soil Experiment Field.

	AP	RP	LAP	LRP	LAPK	LRPK	RPK	
Corn, bus.								
Ave. 1st rotation	39.7	39.3	44.1	42.2	43.4	44.3	37.0	
Ave. 2nd rotation	39.4	38.2	42.6	39.6	42.1	40.4	36.5	
Ave. 8 years	39.7	38.9	43.0	40.7	42.8	42.0	37.3	O=34.9
								L=39.3
Soybean hay, lbs.								
Ave. 1st rotation	2890	2765	2945	2839	3073	2614	2900	
Ave. 2nd rotation	1977	2077	2302	2316	2390	2411	1996	O=1979
Ave. 8 years	2433	2421	2623	2577	2731	2512	2448	L=2574
Wheat, bus.								
Ave. 1st rotation	14.4	15.5	18.7	15.9	18.9	14.3	14.7	
Ave. 2nd rotation	12.4	15.0	17.4	16.0	19.6	16.3	14.0	O=10.7
Ave. 8 years	13.6	15.3	18.2	16.0	19.1	15.1	14.4	L=10.5
Clover, lbs.								
Ave. 1st rotation	2251	2600	3497	3356	3287	2970	2078	
Ave. 2nd rotation	3485	3680	3875	3735	3743	3295	3612	O=1578
Ave. 7 years	2603	2909	3605	3464	3417	3063	2516	L=2890

Crop Yields Per Acre, Greenville Experiment Field.

	AP	RP	LAP	LRP	RPK	LRPK	
Corn, bus.							
Ave. 1st rotation	31.6	31.5	41.5	36.7	35.3	41.1	
Ave. 2nd rotation	36.8	36.8	45.3	42.2	40.8	44.1	O=25.9
Ave. 9 years	34.1	33.8	41.5	37.8	38.1	41.8	L=31.9
Soybean hay, lbs.							
Ave. 1st rotation	2404	2664	3363	2920	2858	3300	
Ave. 2nd rotation	2295	2348	3286	2730	2706	2832	O=1704
Ave. 8 years	2349	2505	3324	2825	2782	3066	L=2265
Wheat, bus.							
Ave. 1st rotation	6.3	6.7	10.7	8.5	8.9	9.6	
Ave. 2nd rotation	13.5	14.6	18.2	14.4	16.0	15.7	O= 5.8
Ave. 8 years	9.0	9.7	13.5	10.6	11.5	11.9	L= 7.1
Clover, lbs.							
Ave. 1st rotation	2139	2367	2574	2274	2950	3179	
Ave. 2nd rotation	2707	2020	3377	2210	3487	2673	O= 783
Ave. 8 years	2352	2612	2875	2250	3152	2989	L=1684

Crop Yields Per Acre, Fariston Experiment Field.

	AP	RP	LAP	LRP	
Corn, bus. average 6 years	31.4	32.5	42.1	26.6	
Soybean hay, lbs. ave. 6 years	1843	2478	3108	2095	
Rye cover crop between beans and clover					O= 145
Clover, lbs. ave. 5 yrs.	823	922	1565	828	L= 465

Crop Yields Per Acre, Campbellsville Soil Experiment Field. Three-Year Rotation.

	Corn Ave. 2 yrs. Bus.	Wheat Ave. 2 yrs. Bus.	Clover Ave. 2 yrs. Lbs.
AP 300 lbs. per acre per rotation	28.6	4.7	1500
RP 600 lbs. per acre per rotation	32.4	5.8	2172
AP 600 lbs. per acre per rotation	34.7	6.7	1845
RP 1200 lbs. per acre per rotation	31.9	4.5	3096
AP 900 lbs. per acre per rotation	35.8	6.7	2418
RP 1800 lbs. per acre per rotation	35.9	6.1	3528
LAP 300 lbs. per acre per rotation	32.5	5.3	1872
LRP 600 lbs. per acre per rotation	30.6	5.3	1878
LAP 600 lbs. per acre per rotation	35.9	5.8	2225
LRP 1200 lbs. per acre per rotation	28.2	5.5	1963
LAP 900 lbs. per acre per rotation	38.6	8.2	3642
LRP 1800 lbs. per acre per rotation	32.3	5.1	2226
Checks	23.3	4.1	1210

The Rendering Available of Potash in Insoluble Silicates by the Action of Soil Bacteria. In this study, work has been continued upon the hydrogen ion concentration and biological reaction of the soil solution obtained by displacing it by means of alcohol from fresh soil of optimum moisture content. Samples taken from time to time on the Station farm and the Campbellsville and Berea experiment fields have been studied. During the period from March to June, 1922, the hydrogen ion concentration of the solution from the fresh soil diminished, but the content of both mineral matter and organic matter increased and the fermentation of peptone, urea and dextrose by the organisms present increased.

A chemical analysis was made of one lot of soil solution from soil of the Station farm. Of course it is not desired to base any conclusion upon a single example, but the findings in this analysis afford a very interesting and suggestive comparison with the average for natural drainage water from Fayette and Woodford Counties, taken from Table 1, Bulletin 237, as appears from the following tabulation:

	SOIL SOLUTION		NATURAL WATERS	
	Parts Per Million	Percentage of the Mineral Matter	Parts Per Million	Percentage of the Mineral Matter
CaO	225.7	33.2	65.8	33.4
K_2O	26.1	3.9	1.01	0.6
MgO	35.3	5.2	6.8	4.1
SO_3	37.92	5.6	10.6	6.3
Mn	a trace	.....	n. e.	.....
Total mineral matter	679.0	100.0	167.2	100.0

The sample of soil solution is more concentrated than the average natural drainage water. It is more concentrated than any of the samples reported in Bulletin 237. The percentage of K_2O in the total mineral matter of the soil solution, however, is six and a half times the average in the natural waters, altho the proportions of CaO, MgO and SO_3 are similar in the two.

Sulfur in Plants and Soils. Experiments have been continued to compare Dr. J. G. Lipman's "bacsul phosphate" with acid phosphate and rock phosphate plus sulfur, with and without limestone. Four kinds of soil were used, two of them from the experiment fields in McCracken and Laurel Counties, the other two from Hardin and Floyd Counties. The results tend to confirm those obtained last year in showing decided benefit from bacsul phosphate in many of the treatments.

The Occurrence and Distribution of Manganese in Plants. Eighty sand cultures were made in 2-gallon jars of manganese-free sand, with and without added manganese, all other conditions being identical. The plants used were radish, Alaska pea, Canada field pea, cowpea, lettuce, tomato, spinach, carrot, onion, pole bean, bush bean, cabbage, wheat, oats, clover, velvet bean and tobacco. Four jars of each kind of plant were grown, two with manganese and two without. The water content of the sand was controlled by frequent weighings and addition of distilled water when needed. All plants were allowed to remain until those which received manganese either had reached maturity or had begun to fructify. All plants from which manganese was withheld showed conspicuous signs of the need of this element as compared with the corresponding plants which received manganese. Need for manganese was indicated by stunted growth, lack of chlorophyl and dying back of young shoots and, finally, of the whole plant. Practically all the plants which received no manganese had died, without fructification, before the corresponding ones with manganese had reached maturity. The material has been harvested and some of it analyzed. The analyses show only a trace of manganese in the plants from which manganese was withheld, whereas those which grew in the presence of manganese contain a normal amount of that element, thus showing that these experiments had been controlled to the extent that manganese became a limiting factor for growth. The conclusion seems inevitable that manganese is necessary for the growth of these plants, because where it was

withheld only a stunted growth was obtained and only a trace was found in the tissues, whereas when manganese was added, all other conditions being the same, normal growth followed and a normal amount of manganese was found in the tissues.

Manganese and iron determinations have been made in about 60 different kinds of seeds. The results show that in the cereals tested the manganese content is equal to the iron content or greater than the iron content, whereas in the legumes tested, the manganese content is less than the iron content. An examination has been begun of the soils of the state for manganese and iron for the purpose of ascertaining if a correlation exists between the iron and manganese content of different types of soil. An examination has also been begun of animal tissues for manganese. So far the determination has been made only on the brain and lung of sheep, more being found in the brain than in the lung, but in neither was the percentage as large as usually found in dry vegetable matter.

Comparative Tests of Certified Strains of Seed Potatoes. Fifty separate lots of certified Early Ohio seed from Minnesota, five of Irish Cobbler from Minnesota, one from Ottawa, Canada, one from Kentucky, and three other strains were tested in the field for relative yield and freedom from disease. A strain of Irish Cobbler obtained from Minnesota in 1921 as certified stock was used as a check at frequent intervals throughout the plot.

Sixty per cent of the certified Early Ohio strains produced yields equal to or better than the Irish Cobbler check rows. This result is of significance to our potato growers located near the Cincinnati markets which prefer a pink potato like the Early Ohio. The growers in this section were becoming discouraged by the low yields obtained with the Early Ohio and have been questioning whether they would not be forced to abandon this variety in favor of some white variety, regardless of the market preferences. The results in this test suggest that the low yields with Early Ohio probably have been due to the use of inferior, diseased seed stock and that by

securing the best strains of certified seed they may continue to grow successfully this variety which their market distinctly prefers.

Of the fifty strains of Early Ohio tested the yield ranged from 8.1 pounds to 41.6 pounds per row, the latter being equivalent to nearly 200 bushels per acre. The average of the highest twelve strains was 27.8 pounds; of the second twelve, 22.4 pounds; of the third twelve, 18.8 pounds; and of the lowest yielding fourteen strains, 15.2 pounds per row. The average of the Irish Cobbler checks planted every third row was 20 pounds.

The yields of the strains appear to be in inverse proportion to the amount of degeneration diseases present. A few strains showed nearly 100 per cent of "spindling sprout." Mosaic was not found in any of these strains but was present in typical mottled form on an unselected row of Aroma in the same field.

The five Minnesota certified Cobbler strains ranged in yields from 30.3 to 14.1 pounds per row. Moser's strain of Irish Cobbler from Jefferson County yielded 35.8 pounds. The same strain grown in Minnesota the previous year and then returned to Kentucky, yielded 26.7 pounds, while a Minnesota strain of Cobbler in an adjoining plot in Minnesota in 1921 and again in Kentucky in 1922 yielded 28.7 pounds per row. Again the yields appeared to be very closely correlated with per cent of degeneration diseases present.

The elimination of degeneration diseases appears to be the most important problem in northern grown certified stock for use in the South. These results confirm previous results as to the value of fall grown Kentucky potatoes compared with northern certified stock for seed.

Mosaic Disease of Potatoes. In the spring of 1921, one hundred tubers each were selected from various strains and varieties of potatoes (some of them certified seed stock) including four strains of Cobbler, one of Early Ohio, one of Triumph, one Bull Moose, one Carman No. 3, and two of Green Mountain.

A single seed piece cut from each tuber was planted in a hill in early April and the remainder of each tuber, all being carefully numbered, placed in cold storage for summer planting for the second crop. Exact records were kept of growth and yield. Every hill showing signs of mosaic infection (varying from a trace to 95 per cent) was noted and the corresponding numbered seed piece held in storage was eliminated, the remainder being planted in July for the second crop.

No mosaic appeared in any of the several hills planted from each tuber of the selected stock. Again a single tuber from each hill was planted in the spring of 1922 and like records obtained. No mosaic appeared in any of these spring planted hills. The remainder of the apparently mosaic-free stock was held in storage and planted in July of this year for the second crop. Considerable leaf roll and a few plants of low vitality appeared in this second crop. It appeared, however, that mosaic had been completely eliminated in two seasons from seed stocks which at the beginning had been infected in varying degrees from 2 to 95 per cent.

Lettuce Variety Tests. A strain of Grand Rapids, called No. 10, was selected in 1921 and has been found more uniform and vigorous than the ordinary Grand Rapids obtained from seedsmen. The selections from heading varieties have not shown as marked improvement as was desired. The Hanson and New York or Wonderful have been found the most reliable heading sorts up to the present either for garden or greenhouse.

Lettuce Root-Rot and Tipburn. Several lots of apparently normal lettuce seeds have been tested for seed-borne organisms. In some lots nearly every seed appeared to be infected with *Macrosporium sp.* as indicated by the outgrowth of this organism from surface sterilized seeds grown on a sterile moist blotter. Other lots of seed appeared to be free from any infection when tested under these conditions but when microtome sections of the seeds were made and properly stained, very small stands of a fungus could be seen lying between the seed-coat

layers. These were much smaller than those of *Macrosporium sp.* The later are large and dark colored and easily observed if the seed-coat layers are torn apart. It is believed that this unidentified organism may be the cause of lettuce root-rot and that tipburn is a secondary effect of this trouble. The remedy has not been determined.

Orchard Tests and Practises. *Apples.* For the first time since it was planted in 1914, the young apple orchard on the Experiment Station farm has yielded a small amount of fruit from a majority of the permanent trees. The orchard was kept under cultivation thru the early summer and a cover crop of rye and vetch sown in the fall.

In the spring of 1920 systematic method of pruning was begun in this orchard, which has now continued for three seasons. The permanent rows have been given light pruning consisting almost exclusively of thinning out weak or badly placed branches. In contrast to this plan the "filler" rows (same varieties as the permanent rows) have been pruned with moderate severity, both by thinning out and by cutting back the previous season's growth about one-half.

The two methods of pruning have resulted in a marked contrast in relative abundance of bloom last spring and a distinctly larger crop of fruit on the lightly pruned trees as follows:

Blooming Record 1922.
Number of Varieties and Strains.

	Permanent Trees	Filler Trees
Full of bloom	17.5 per cent of all	4.2 per cent of all
Moderate bloom	17.9 per cent of all	7.4 per cent of all
Scanty bloom	21.2 per cent of all	23.8 per cent of all
No blooms	43.4 per cent of all	64.6 per cent of all

Most of the crabapples produced an abundance of blossoms with the more severe pruning.

Roman Stem, Oldenburg, Romanite, Winter Banana and King David gave a moderate bloom under severe pruning.

The lightly pruned trees of the permanent rows produced probably an average of 50 per cent more fruit than the heavily pruned filler trees.

The beginning of fruit bearing has revealed the fact that was suspected before, that a number of varieties constituting perhaps 5 per cent or more are not true to name. It is planned to top graft such trees from year to year as their identity is revealed.

Pears. The pear orchard tho decimated by blight, as was expected when planted, has borne a small crop on many varieties. The behavior of the Douglass pear, introduced ten or more years ago, with strong claims for size, quality and immunity to blight, has been particularly interesting. So far as could be discovered no blight appeared upon this variety tho severely blighted trees surround it. The trees were quite heavily loaded for their size, the fruit was slightly under medium size, its flesh free from "grit cells" and of good tho not high quality. The distinct blush claimed in the originator's description was entirely lacking in our fruit. If the freedom from blight shown in our specimens of this variety proves to be a permanent character, it seems likely to become a valuable addition to our list of pears, most of which are so badly affected with blight that pear culture in Kentucky has become almost a lost art.

Peaches. The peach orchard which was badly broken by the storm of sleet two years ago, nevertheless produced a fair crop of fruit in 1922.

The use of paradichlorobenzene for control of the peach borer has proved highly effective with nearly 100 per cent elimination of the borers. In using the ordinary method of control by digging with knives and probing with wires, it is doubtful if we could have secured better than 90 per cent elimination.

The lime-sulfur-glue formula as a substitute for the standard self-boiled lime-sulfur has proved an effective fungicide on peaches for controlling peach scab and brown rot; it is more uniform in composition and easily prepared.

Mexican Bean Beetle. An occurrence of special concern to the Station and to truck farmers in the state is the recent introduction of the Mexican bean beetle in southern Kentucky. It was reported in June from Monticello and Coopersville and has since spread northward and westward toward central Kentucky. It may prove only a temporary extension of its habit and a cold winter may destroy it, but nothing can be predicted as to its future in the state. Dusting with arsenate of lime and hydrated lime has been found effective against it (1 part of the former to 9 parts of the latter).

The Feeding of Skim-milk and Semisolid Buttermilk to Poultry. The second year's work with White Wyandottes to compare the feeding of milk, with and without a dry mash, substantially agrees with the first year's results. From the first two years' work the following conclusions have been drawn:

(1) When sour skim-milk or semisolid butermilk is fed as a source of protein to hens of the general purpose breeds, it is not necessary to feed a dry mash in addition to the grain ration.

(2) The addition of sour skim-milk, semisolid buttermilk or meat scrap to ration consisting of a grain mixture and a mash of ground grains and wheat byproducts more than doubled the winter egg production.

(3) Wyandotte hens averaging 155.5 eggs consumed sour skim-milk at the rate of a gallon per day to 32 hens, when no water or dry mash was given them. The average consumption of grain was 67 pounds per bird a year. The following table gives the results of the first two years' work. The third year's work is under way.

RATION*	AVERAGE PRODUCTION		
	1920-21 Pullets	1921-22 Pullets	1921-22 Yr. Hens
Mash plus meat scrap	119 eggs	150.5 eggs	113.2 eggs
Mash plus skim milk	127 eggs	145 eggs	
Skim milk, no mash	140 eggs	155.5 eggs	106.7 eggs
Mash plus semisolid		144 eggs	
Semisolid, no mash		152 eggs	

*All pens received the grain mixture morning and evening.

Effect of Artificial Illumination on Egg Production. The results of three years' trial of the effect on egg production of lengthening the day by the use of electric lights, are in substantial agreement. In the third year of the trial, 70 pullets under light averaged 3.1 more winter eggs per bird than those without light. The average for the three years shows an increase in winter egg production of 5.5 eggs per pullet. The yearling egg production is substantially the same from the pens with and without light. The increased winter production is much more pronounced with the yearling hens. The 29 hens under light averaged 18 more eggs per bird during the four winter months than the 29 hens without light. The average for the three years shows a much more pronounced increase in the winter egg production from hens under light than from pullets.

Feeding Tests with Dairy Cows. Experiments in feeding dairy cows include a test of the value of velvet-bean feed. Up to the present, the results indicate that this feed can be used with dairy cows in Kentucky and at a reasonable cost, but it must be mixed with more palatable feeds, such as corn meal and wheat bran.

Growth or Expansion that May Reasonably be Expected in a Herd of Cows. One of the problems of the constructive breeder of live stock is to build and maintain his herd so that it will increase not only in numbers but also in production and in quality.

The Jersey herd at the Kentucky Experiment Station was selected as an example of what may occur in the hands of a breeder who is endeavoring to build a fine herd from a few good foundation animals. This herd has existed for twenty-six years, having been founded in 1896 with fourteen selected cows. A review of the growth of this herd is as follows:

The herd was founded with fourteen cows in 1896 and in 1912 contained twenty-nine females descended from the fourteen original cows. Eleven of the fourteen foundation cows failed to produce offspring, particularly heifers, to breed on and have disappeared from the herd in the sixteen years, leaving only three of the cows responsible for the herd growth. The herd in 1922 contained thirty-seven females, all descendants of the twenty-nine females of 1912.

During the twenty-six years, an effort has been made to enlarge and improve the herd by retaining the best heifers, the bull calves being sold. The herd growth was not rapid, having been held in check by such difficulties as deaths, accidents, tuberculosis, infertility, defects such as sway backs and loss of quarters of udders, making it necessary to cull individuals. These difficulties are met by all breeders of live stock.

During the first sixteen years, the females worthy of retention slightly more than doubled the number of the foundation cows, while during the next ten years the herd increased from twenty-nine to thirty-seven females. During twenty-six years, the herd increased from the fourteen foundation cows to a herd of thirty-seven females. Dollie's Valentine was one of the foundation cows and her offspring are the backbone of this herd. Today, twenty-six of the thirty-seven females trace to her.

Length of Abortion Period with Subsequent Calf. It has been stated that an aborting cow will carry each succeeding calf a longer period until finally a calf is carried for the full period. A tabulation of all the abortions that have occurred in twenty-six years in a certain herd was made and studied. This tabulation included twenty-two dairy cows that aborted

forty-eight out of one hundred and twenty-one calves. From the study it was found that sometimes the cows aborted sooner the second time than they did the first time; sometimes each calf was carried an equal length of time and in a few cases the second calf or subsequent calves were carried longer than earlier ones. There seems to be no rule as to the length of time an aborting cow will carry each succeeding calf, as the following table attests:

Cow	First Calf Days	Second Calf Days	Third Calf Days	Fourth Calf Days	Fifth Calf Days	Sixth Calf Days	Seventh Calf Days	Eighth Calf Days	Ninth Calf Days
E. M.	185	263	N	N	N	113	N	N	N
B. L. L.	166	N	N	N	N				
J. P. R.	N	152	N	170	135	143			
A. M.	N	164	248						
K. C. 2d	220	204							
D.	176	183	N	195	221				
M. K.	N	270	*	204	208				
Emv.	N	N	158	N	N				
G. P.	218	215							
V. A.	N	N	N	N	N	N	N	210	N
C. M.	180	N	N	N	N	N	N	N	N
H. P. V.	N	161	254	198					
J. B. P.	N	250	N	167	207	N	255		
D. R. Dk.	N	156	N	N	N				
B. C.	N	N	N	N	N	N	253	234	249
H. L. V.	224	135							
C. B.	N	N	N	N	183	N			
P. L. D.	215	N	N	179	N	N			
P. S. M.	140	212	213						
J. Lal.	N	N	182	123					
F. D.	N	202	N	N	N	N			
L. V.	N	N	N	N	N	N	N	N	176

*Aborted.
(N=normal calf; figures give days aborted calf was carried.)

Horse Breeding. Attention has been given to a further study of horse semen in which germ cells were active in contrast with semen in which the germ cells were sluggish or inactive. The difference in the hydrogen ion concentration of normal and abnormal semen found previously was confirmed. Some evidence that rest partially restores the normal hydrogen ion concentration has been obtained. Investigations were made into the causes and remedies of sterile stallions whose semen contains pus cells. A number of stallions sterile or parti-

ally so were found with a discharge of pus with the semen. A study of the technique of breeding was made and a basis for future investigations was found.

Infectious Abortion in Mares. During the year, 648 mares in twenty-seven different herds were immunized against the disease of infectious abortion with perfect results as far as can be determined. In the immunization of mares, we have used four doses of vaccine seven days apart.

Sterility in Mares. Bacteriological examination has been made of 200 living mares. Thirteen have been killed and the reproductive organs studied both bacteriologically and pathologically. In addition, a bacteriological study has been made of four fetuses and six colts that died within the first two weeks of life, most of them within the first two or three days.

The results of the bacteriological study of the 200 mares show that 102 of them were free from micro-organisms as determined by cultures taken from the uterus thru the os uteri. Many of the mares from which the bacteriological findings were negative were so-called maiden mares, a few were young mares that had been bred one or two seasons but failed to conceive and the remainder were older mares barren from causes other than a general infection of the reproductive organs.

Of the 98 mares showing infection, as determined by cultural methods and clinical study, 40 showed a streptococcus. From 11 of the 40, a streptococcus was isolated in pure culture, the remaining 29 showed a streptococcus in combination with one or more other kinds of micro-organisms. The various combinations in which the streptococcus was found and the number of times each occurred are indicated in the following list:

Streptococcus genitalium nocens in pure culture, 11.
Streptococcus and B. coli, 1.
Streptococcus, B. coli and Micrococcus pyogenes albus, 4.
Streptococcus and unidentified rod of colon-typhoid group with wrinkled colony, 1.
Streptococcus and chromogenic cocci, 4.
Streptococcus and three or more of the following organisms, B. coli, M. aureus, M. roseus, rod with wrinkled colony and M. simplex, 6.

The streptococcus isolated from the uteri of 40 mares and designated Streptococcus genitalium nocens has been found also in the semen of stallions, in aborted fetuses, in colts born dead and in colts that have died in the first few days of life. The streptococci are hemolytic and do not stain by Gram's method. In the water of condensation where they grow most abundantly they occur in long tangled chains consisting of hundreds of elements. Their action on carbohydrates is the same as that of streptococcus pyogenes as described by Holman, in that they ferment lactose and salicin but do not ferment mannit. A small quantity (one-fourth c.c. from the water of condensation) of a 24-hour culture, when injected intravenously, kills a large rabbit in from 18 to 24 hours.

In the other 58 mares found to have a uterine infection, no one particular micro-organism seemed to predominate. The micro-organisms isolated from the fetuses and colts include B. coli, M. pyogenes albus, B. viscosum equi, a number of colon-typhoid bacilli and a non-hemolytic streptococcus. The results do not indicate any direct relationship between the bacteriological findings of the mares and those of the colts and fetuses.

The isolation of B. viscosum equi from one of the colts is of particular interest, inasmuch as it has never before been reported found in this country. In the Journal of Comparative Pathology and Therapeutics, (vol. 32, September, 1919) Maynusson reports that he isolated it from 30 per cent of the cases of joint ill studied in Sweden.

The work in pathology on the reproductive organs has not yet been worked out as completely as the bacteriological findings. However, the nature of the inflammatory processes as seen in cases of vaginitis, cervicitis and metritis can be classified on a clinical pathological basis so that they quite consistently conform to the bacteriological findings.

Size, Sex and Weight of Pigs per Litter. A preliminary report of the investigations relative to size of litter, weight and sex of pigs from sows on the Experiment Station farm shows the following:

Average number of pigs per litter:
Duroc 9.2; Berkshire 8.8; Hampshire 8.7; Poland China 10.
Average weight of sow pigs at birth:
Duroc 2.35 pounds; Berkshire 2.66 pounds; Hampshire 2.52 pounds; Poland China 2.14 pounds.
Average weight of boar pigs at birth:
Duroc 2.34 pounds; Berkshire 2.7 pounds; Hampshire 2.58 pounds; Poland China 2.9 pounds.
Total number of sow pigs of all breeds, 186; total number of boar pigs of all breeds, 181.

Abortion in Swine. A study has been made of a number of herds of swine in which there was contagious abortion. Observations were confined to 15 herds in the field where abortion occurred under natural conditions. The number of brood sows in the different herds ranged from 7 to 100, and the percentage aborting in each herd varied greatly. In one of the smaller herds, all the sows (8) aborted, the owner reporting that one had aborted five times. In some of the large herds (100) only a few abortions occurred, therefore, the number of abortions in the different herds ranged from 5 to 100 per cent, the high percentage always occurring in the small herds.

The diagnosis of infectious abortion was made on the clinical evidence that sows in the herd actually aborted and was confirmed by the blood test which, in every instance, gave a positive reaction to the agglutination test for abortion and in many cases the herd boar also gave a reaction. The microorganism causing abortion in sows was isolated from material from one herd only.

Efforts were directed towards control of the disease, particularly with reference to the value of abortion bacterin. The first steps in the control of the disease were to isolate all aborting sows for thirty days or until all evidence of the after effects of abortion had disappeared and to wait at least sixty days before breeding them. All aborting sows of inferior quality and giving a positive reaction to the agglutination test were to be eliminated from the herd as brood sows. The same recommendation was made in the case of boars. However, as many of the boars showing a reaction were valuable

animals and as in no instance could any particular boar be incriminated as being responsible for the spread of the infection, the majority of them were retained in the herds and used for breeding.

Of the fifteen herds in which abortion was diagnosed, the sows and boars in fourteen herds were vaccinated. In most cases, the sows had not been bred before vaccination, tho in some of the large herds a few were pregnant at the time of vaccination. The results following vaccination were on the whole fairly satisfactory, yet in no way conclusive as to the necessity or value of vaccination of sows against abortion. In all herds where vaccination was carried out, the sows and boars received at least three, sometimes four, injections of the bacterin. The injections were made at intervals of seven days and the vaccine was increased in strength, the second injection being twice and the third, three times the strength of the first. The results as observed in two or three herds well illustrate the results on all herds. In herd No. 7, sixty sows were vaccinated, the majority of the sows vaccinated having normal healthy litters of pigs. The remainder of the herd being in advanced pregnancy and three sows not vaccinated, aborted. In herd No. 3, approximately 100 sows were vaccinated. Among them were a number of gilts that had not been bred at the time of vaccination. These were bred later and two of them were reported as having aborted. In herd No. 6, many of the sows were pregnant at the time of vaccination. Two of these sows aborted following the second injection of the bacterin, and one, following the third injection. No further abortions have been reported from this herd. In herd No. 5, four sows aborted, three giving a positive reaction to the agglutination test, the fourth giving a reaction designated as suspicious. Of two boars in this herd, one gave a very high reaction, the other being marked suspicious. Three of the sows aborting were bred to the boar that gave the high reaction to the agglutination test. None of the animals in this herd were vaccinated. Three gilts and one sow bred to the same boar for farrowing in the spring of 1922, aborted

from forty to eighty days after breeding. The sow and the three gilts were bred again to the same boar, the sow aborting three times and the gilts twice. Three months following the last abortion, the sow and the gilts were again bred to the same boar and all gave birth to normal litters of pigs. The results in the last herd mentioned would seem to indicate that swine do not become resistant to abortion infection following one abortion, as is generally believed, but do become resistant after the second and third abortions. Further, if herd No. 5 can be taken as a fair check on the herds which were vaccinated, then vaccination as a preventive for this disease would seem to be well worth the trouble and expense involved in its administration.

Effect of Stale Buttermilk on Growing Pigs. Two experiments were conducted to ascertain if buttermilk could become too stale for hog feed. It was found that buttermilk exposed to the sun's rays all day for twenty-five to thirty days during the summer did not materially affect the hogs' appetite for the milk, altho on account of its odor it was very disagreeable for the feeder to handle. This odor would at first lead one to believe it to be that of decomposition in which it would be alkaline in reaction. On the contrary it was found on testing with standard alkali that it was more acid than fresh buttermilk, the samples of fresh buttermilk averaging .108% lactic acid, whereas the stale buttermilk averaged .954% lactic acid. The bacterial count increased from 7,500,000 per c. c. in the fresh buttermilk to 124,900,000 per c. c. in the stale buttermilk.

Corn supplemented with stale buttermilk produced an average daily gain in the first experiment of 1.38 pounds per pig and in the second experiment, 1.43 pounds per pig.

The feeding of stale buttermilk to hogs, in preference to fresh buttermilk, is not advocated. The continuation of the experiment was due to some reports that stale buttermilk had a bad effect on the pigs. From the results of these experiments, the trouble reported must have been due to some cause other than the stale buttermilk.

Hogging Down Experiments. The results for this year show that the number of pounds of pork produced per acre was below normal, due to the low yield of corn and beans because of the drouth during the late summer. Again the lot in which corn was hogged down and tankage self-fed proved to be the most profitable. Our experiments in cooperation with the Bureau of Animal Industry showed that the hogging down of corn with the soybeans planted in the row did not produce soft pork.

Steer Feeding. An experiment was conducted the object of which was to obtain some data on the comparative gains and profits made by steers that were fed silage thruout the entire feeding period and steers that had clover hay substituted for silage near the end of the feeding period.

Steers fed corn, cottonseed meal, corn silage (86 days) clover hay (37 days) and straw made an average daily gain of 2.57 pounds on an average daily ration of 10.71 pounds shelled corn, 2.71 pounds cottonseed meal, 40.79 pounds silage, 11.36 pounds clover hay and .10 pound of straw. The profit per steer, not including pork, was $5.63. Including pork, the profit was $8.40.

Steers fed silage thruout the entire period and no clover hay made an average daily gain of 2.72 pounds on an average daily ration of 10.52 pounds shelled corn, 2.71 pounds cottonseed meal, 37.30 pounds silage and .64 pound straw. The profit per steer, not including pork, was $8.60. Including pork, the profit was $11.37.

During the ten days in which clover hay was being substituted for silage, the steers lost 24.5 pounds per head. The necessary margin where clover hay was substituted for silage was $1.23. The necessary margin where silage was fed straight thru was only $0.93, a difference of 30 cents. Steers receiving clover hay were slightly fatter than those receiving no hay.

Laboratory and Field Diagnosis of Animal Diseases. Of the numerous conditions encountered in this work, two in

particular are worthy of mention, one in cattle and the other in dogs. In a number of instances a disease among cattle has been found which, in its clinical manifestations and pathological lesions, resembles hemorrhagic septicemia but differs in that the causative agent has never been isolated or the disease transmitted thru animal inoculations. The disease in dogs is commonly called "fright disease," and reports indicate that it has been very prevalent not only in this state but in those states south and east of Kentucky. The disease is characterized by periodic attacks and during the acute stages the symptoms are suggestive of rabies, which accounts for the fact that many dogs have been killed. The mortality of this disease apparently runs high, but is difficult to estimate because of the number of animals destroyed. After working with considerable material from affected dogs and those dead from the disease, no conclusion has been reached as to its etiology. However, from clinical cases, considerable information has been obtained relative to symptoms and treatment. Very favorable results have been derived when animals were placed on light diet and given vermifuges and oil.

Biological Products. The distribution of biological products for the year included approximately one million (939,750) cubic centimeters of anti-hog-cholera serum and 35,530 cubic centimeters of anti-hog-cholera virus, 12,755 doses of roup and chicken pox vaccine and 8,770 doses of blackleg vaccine. The distribution of blackleg vaccine has been discontinued. This product has been furnished the Experiment Station by the Bureau of Animal Industry of the United States Department of Agriculture for distribution in this state, but owing to a provision of the Agricultural Appropriation Act, its preparation and distribution by the Bureau ceased July first of this year which consequently affected its supply and distribution by this Station.

A method of preparation of roup and chicken pox vaccine has been worked out by this Station which is a combination of methods and known as the "Kentucky modified form." This

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form of preparing roup and chicken pox vaccine consists in the use of the bacterial vaccine combined with the vaccine prepared from the scabs collected from the combs and wattles and the exudate from the eyes, nose and throat. This material is dried, pulverized and mixed with normal salt solution in the proportion of one gram to 100 cubic centimeters of normal salt solution. To this amount is added 100 cubic centimeters of the bacterial vaccine, making a total of 200 cubic centimeters which is sufficient to vaccinate 200 birds. By using the bacterial vaccine in combination with the scabs and exudate, two doses instead of one can be made from the same amount of dried scabs. The results as shown by reports indicate that it is decidedly more effective than the bacterial vaccine and equally as effective as the vaccine prepared from the scabs.

Botulinus Antitoxin. Botulism made its appearance during the fall months on various farms in the state and continued to occur during the winter and early spring of 1922. The disease was observed in horses, mules, cattle, swine, sheep and poultry. The majority of cases occurred following the feeding of corn, corn stover or oat hay, and in the case of smaller animals, of spoiled canned goods. In the case of sheep, the disease usually developed after feeding off the ground or following salting on the ground. On one farm where six head of horses and mules were lost, the cause was traced to oat hay. All horses and mules eating the oat hay sickened and died, while other live stock on the farm receiving other kinds of forage remained well. In a number of flocks of chickens where losses were severe, spoiled canned goods was responsible for the deaths. One outbreak in chickens was apparently the result of soil infection, as it was learned that none of the poultry on this farm had had access to spoiled food.

During the lambing season last spring, a large number of sheep thruout the state became affected and died from some disease. Inasmuch as most of the sheep lost were pregnant ewes, the disease was thought to be associated with advanced

pregnancy. Investigation, however, revealed the fact that rams and non-pregnant ewes were likewise affected. A number of herds were investigated during the course of the disease and complete histories obtained. An important fact was brought to light that in every herd the sheep affected had been taken off pasture and placed on dry feed preparatory to lambing. It was also disclosed that these sheep had either been fed salt or some form of grain feed off the ground. Organs and blood of the dead animals were cultured for micro-organisms and experimental animals were inoculated with the blood, all with negative results. Since the disease closely resembled botulism, both clinically and pathologically, sick sheep in various stages of the disease were injected experimentally with botulinus antitoxin which in most cases proved beneficial. Following this, a number of herds were treated in which not only a large percentage of the sick recovered, but others injected with botulinus antitoxin failed to contract the disease. After making a careful study of the conditions, it seemed that the toxin must have been formed outside the body in the feed or soil and was taken in with the feed, tho this was not definitely determined. Nearly ten thousand cubic centimeters of botulinus antitoxin have been distributed during the year.

Seed Inspection. The demand for tests of ordinary seeds is growing steadily, showing an increase each year. There is also a great demand during December, January and February for the cleaning and testing of tobacco seeds as the figures given below will show:

Number of miscellaneous seed samples received	3455
Number of samples tested for germination	3172
Number of special duplicate germination tests	670
Total number of germination tests	3842
Number of miscellaneous samples tested for purity	1991
Total number of tests of all sorts	5833

The figures given above include 569 tobacco samples, 310 of which were cleaned only; 244 cleaned and tested and 15 tested for germination only.

Nursery Inspection. Ninety-five nursery establishments were inspected. Some San Jose scale was detected but only in small numbers. In some cases all infested plants were destroyed. Where it was not possible to destroy all exposed to infestation, they will be fumigated before being used.

Creamery and Tester's License. Licenses have been issued to 38 creameries, ice cream factories and milk plants located in Kentucky and to 15 firms located in Ohio, Indiana, Illinois, West Virginia and Tennessee. In addition to the above, 24 licenses have been issued to independent buyers of butter fat. On January 1, 1922, there were 427 licensed cream stations in the state. Fifty-nine new stations were licensed during the first six months. Of the 489 licenses which expired June 30, only 359 were renewed. Forty new stations have been licensed since July 1, making a total of 399 at the close of the year. The number of transfer licenses granted during the year was 46. Tester's licenses were issued to 147 new operators and permits to 229. There are at present 409 licensed testers in Kentucky and 21 operators pending examination.

Creamery and cream station inspection has decreased due to the fact that fewer stations are in operation. Two hundred and twenty-two stations were visited in 110 towns and 55 counties. The percentage of stations not accessible by railroad increased from 40 to 44 per cent since 1921, and as funds available for inspection were limited, many of these inland points were not inspected. Twelve special investigations were made during the year, station shortage or over-reading of tests being the grounds on which complaints were registered. The names of two testers were reported to the Examining Board with the recommendation that the licenses of these operators be revoked for failure to comply with the requirements of the law. Samples from cans of cream being shipped direct to creameries were secured in 63 instances during the six months of inspection. A comparison between our tests of these samples and the tests actually received by the shipper reveals differ-

ences ranging from 7 points low to 5½ points high. Adjustments to patrons were made in a number of instances by creameries whose tests were found to have been inaccurate.

The decrease in number of cream stations has resulted in fewer operators being employed. Only 23 tester's license examinations were given in 1922 and of these 6 were held at Lexington, 8 at Louisville, 5 at Cincinnati, 2 at Henderson, 1 at Owensboro and 1 at Paducah. Two hundred and ninety-one testers were notified for these examinations and 153 appeared. Eight-five per cent of those present obtained a passing grade of 75 or higher. The percentage of attendance was 52.5, but the greater number of those absent had stopped testing before the examination was held. Operators who failed to appear and who did not give a satisfactory excuse were not allowed to continue testing.

A total of 10,975 pieces of glassware were inspected for accuracy, forty-five pieces being rejected as inaccurate. A few illegal weights were found during the course of cream station inspection and small quantities of untested glassware, but these were promptly removed from the stations when the creameries were notified.

The fees received for the creamery and tester's license work amounted to $3,875.67, the expenditures being as follows:

Salaries	$2,816.67	
Postage and stationery	110.74	
Freight and express	.74	
Laboratory supplies	3.75	
Sundry supplies	15.05	
Furniture and fixtures	7.00	
Travel	950.34	
Contingent	40.50	
		$3,944.79

Public Service Laboratories. During the period covered by this report, there has been a general increase in the service rendered in almost every line of the work of these laboratories. The records show that one thousand and three individual physicians have submitted specimens for examination, an increase

of about 50 per cent. In addition specimens have been submitted by a large number of city and county health departments.

In the bacteriological laboratory, a total of 28,630 specimens have been handled, an increase of more than three thousand specimens over last year. These include 15,256 specimens for Wassermann test, examinations for tuberculosis, diphtheria, typhoid, malaria, hookworm, etc., etc.

The food and drug laboratory examined 1,962 samples of food and drugs, of which 917 were official food samples and 133 official drug samples.

A large number of special investigations have been made of samples of various kinds. Often these involved feeding experiments or inoculation of small animals to reach a satisfactory determination.

In addition to this work, 32,278 outfits have been sterilized, assembled and shipped to physicians, health departments, private citizens, etc.

Feed Control. The principal task of the Department of Feed Control is to protect the public from the imposition of poor and adulterated feeds and to require manufacturers so to label feeds that the purchaser may have accurate knowledge of the character of the feeds he purchases. Inspections have been made at practically every point in the state where feeding stuffs are used. Eleven hundred and thirty-six samples of feed have been analyzed and the results reported to those immediately concerned. Nine cases for violations have been instituted in the federal courts and two in the state courts. Official tags were issued covering 247,275 tons of feed for the year.

Fertilizer Control. A total of 885 brands of fertilizer were registered for the year. Nearly all of these registered brands have been analyzed and in addition analyses have been made of 711 samples collected by our inspectors or sent in by farmers. These analyses have been tabulated and published in Bulletin 245 of the Experiment Station. During the year,

3,510,000 blank fertilizer tags have been issued and stamp sales numbered 1,387,908, the latter representing 85,201¼ tons of fertilizer.

Air and Soil Temperatures. During the past year complete records have been kept of air and soil temperatures, the latter at 3 inches and 18 inches daily and 36 inches weekly. Thermographs suitably exposed on the Experiment Station farm were relied upon for a continuous record, but were checked frequently with mercury thermometers.

The soil thermographs were located in a field of red clover until the 44th week, when they were moved to a plot free of vegetation for the remainder of the period. It will be observed that the soil temperatures at 3 inches exceeded or equaled the air temperatures from the 25th to the 35th week. As the clover was cut for hay during the 24th week, this may have permitted the higher temperature at the 3-inch soil depth. However, the second growth of clover, tho rather thin in cover, had reached 6-8 inches by the 29th week without affecting this relation. The time at which this temperature again dropped lower than the air temperature is identical with the first heavy rain which fell after the early summer. As the summer had been very dry, this may indicate that the soil moisture was a more important factor than the vegetative covering in this relationship. The average weekly temperatures are shown in the following table:

Average Weekly Air and Soil Temperatures (F) on Experiment Station Farm, Lexington, Kentucky, 1922.

Week number Beginning Jan. 1	Air	Soil 3″	Soil 18″	Soil* 36″
1	34.9	34.3	39.6	.....
2	31.9	33.6	39.3	42.0
3	35.4	32.2	38.1	40.1
4	28.1	28.7	36.2	39.2
5	38.1	30.9	35.5	38.3
6	39.0	37.3	37.2	39.2
7	30.9	34.0	39.4	40.3
8	45.7	44.9	42.5	39.2
9	33.6	33.5	39.6	42.8
10	43.6	41.6	40.4	42.8
11	49.8	47.0	45.1	41.9
12	48.1	45.1	44.2	44.6
13	55.9	53.8	49.9	46.4
14	63.1	58.4	52.1	48.2
15	62.2	60.4	56.6	53.6
16	54.4	55.6	56.0	54.5
17	52.2	53.1	52.4	51.8
18	63.0	58.1	54.4	51.8
19	69.8	64.1	58.6	54.5
20	65.1	61.7	58.9	56.3
21	71.9	66.8	60.3	57.2
22	68.7	65.5	61.9	58.2
23	74.2	70.4	64.0	63.0
24	77.6	73.6	67.5	63.5
25	74.2	75.9	69.4	69.5
26	79.0	79.0	71.4	67.1
27	70.5	72.7	70.2	68.4
28	78.3	79.2	72.5	70.7
29	76.4	78.7	73.9	71.6
30	80.2	81.6	75.1	71.2
31	75.1	77.6	75.0	72.7
32	74.1	77.6	74.3	75.2
33	79.6	80.5	75.4	75.2
34	75.5	77.3	75.1	73.4
35	75.7	75.6	72.7	73.4
36	79.5	77.9	75.2	71.6
37	71.0	71.6	72.1	71.6
38	69.7	67.7	69.1	69.8
39	68.6	66.7	66.9	68.0
40	72.4	69.1	68.0	68.0
41	56.3	57.9	62.2	65.5
42	55.9	56.3	58.3	61.6
43	55.5	53.0	55.5	58.1
44	61.7	58.0	56.6	59.4
45	51.5	51.9	55.1	58.6
46	52.9	51.6	53.4	56.3
47	38.5	40.6	49.1	55.0
48	39.4	37.1	44.4	49.1
49	47.1	46.8	47.3	48.6
50	32.4	35.0	43.7	48.6
51	30.9	30.5	39.6	42.8
52	43.4	37.9	41.1	42.8

Dec. Nov. Oct. Sept. Aug. July June May April Mar. Feb. January

*Temperatures at 36″ are those for Monday of each week.

METEOROLOGICAL SUMMARIES
For the Year 1922
Compiled from the records of the U. S. Weather Bureau Station, Lexington, Kentucky.

ANNUAL METEOROLOGICAL SUMMARY

| Month | Temperature, Degrees Fahrenheit | | | | | | Relative Humidity, Per cent 7 a. m. | Precipitation, in Inches | | | Per cent of Sunshine | Wind | | | Number of Days | | | | | |

MONTHLY AND ANNUAL MEAN TEMPERATURE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	S.pt.	Oct.	Nov.	Dec.	Ann.
1872												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						
1887											44	35	
1888	21	36	41	56	63	72	76	74	63	51	46	37	54.0
1889	37	22	43	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	27	54.4
1894	38	34	49	54	62	75	76	76	71	58	41	37	55.9
1895	28	22	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	27	56.3
1901	34	29	44	49	63	74	80	74	67	58	40	31	53.6
1902	22	25	45	53	68	71	77	74	67	59	53	34	54.8
1903	32	26	50	53	68	68	77	74	70	57	40	28	54.4
1904	30	31	46	48	64	72	74	74	69	57	44	24	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	22	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
1913	42	33	44	53	65	73	78	77	69	56	49	28	56.5
1914	37	29	40	54	66	76	78	75	67	59	46	30	54.6
1915	22	40	36	59	62	70	74	70	70	60	49	36	54.8
1916	40	33	41	52	67	69	78	76	67	58	47	34	55.2
1917	25	32	44	54	57	70	74	74	67	50	44	25	52.3
1918	20	38	49	52	69	72	73	79	62	61	44	43	55.2
1919	37	36	46	54	62	76	79	74	72	64	45	31	56.3
1920	30	23	45	50	62	71	74	72	70	62	43	36	54.1
1921	37	38	55	58	65	76	80	75	73	57	48	39	58.4
1922	33	38	47	57	68	75	76	75	73	61	47	39	58.1

TEMPERATURE EXTREMES

Month	Highest	Year	Day	Lowest	Year	Day
January	72	1906	21	-14	1918	12
February	75	1918	28	-20	1899	13
March	85	1910	24	- 1	1873	4
April	88	1915	25	15	1875	18
May	93	1911	28	30	1876	1
June	99	1914	27	40	1910	3
July	102	1901	22	51	1891	9
August	100	1918	6	46	1915	31
September	98	1899	6	32	1899	20
October	89	1919	2	21	1873	29
November	78	1895	7	2	1872	29
December	71	1875	31	-9	1917	10

MONTHLY AND ANNUAL PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
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						
1887											3.02	2.71	
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	1.89	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	5.63	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
1913	10.35	2.61	6.04	2.41	4.32	3.29	2.43	1.00	1.76	3.40	4.00	2.74	44.35
1914	2.50	3.87	2.24	2.23	1.65	4.77	2.63	4.69	1.82	5.22	1.62	4.40	37.74
1915	4.38	1.12	1.49	0.65	7.23	3.20	5.72	6.03	3.74	0.81	3.90	6.67	44.94
1916	5.65	3.40	3.30	1.01	2.92	5.33	1.72	2.34	2.75	2.04	1.25	3.63	35.34
1917	5.67	2.12	5.48	3.97	3.51	3.54	2.80	1.94	2.46	2.36	1.03	1.97	36.85
1918	4.46	1.92	1.55	2.09	4.13	3.61	2.01	2.68	1.41	4.57	2.24	4.83	35.50
1919	2.48	1.61	3.71	3.51	6.38	4.49	2.28	2.39	1.12	7.95	8.50	6.70	51.12
1920	5.26	2.11	4.62	6.42	2.51	2.39	1.73	6.71	4.88	2.75	2.22	1.40	43.00
1921	3.24	2.62	5.06	3.28	1.60	2.16	1.04	3.88	5.10	2.46	6.89	5.74	43.07
1922	1.87	3.12	7.75	4.46	3.10	2.44	2.13	2.20	5.99	1.25	0.88	5.67	40.86

EXTREMES OF PRECIPITATION AND WIND

MONTH	PRECIPITATION			WIND			
	Greatest in 24 hours	Year	Day	Max. Vel.	Dir.	Year	Day
January	3.50	1913	11	60	sw	1891*	1
February	3.04	1909	23-24	60	sw	1890*	25
March	3.61	1913	25-26	68	sw	1919	17
April	3.24	1909	29-30	64	sw	1909	29
May	2.61	1898	6-7	60	nw	1889*	12
June	4.45	1898	26-27	60	n	1890*	29
July	4.02	1875	11-12	58	nw	1915	30
August	2.98	1915	1-2	72	s	1918	6
September	5.45	1922	3	68	w	1889	8
October	2.32	1893	3-4	50	nw	1904*	21
November	3.95	1919	25-26	62	s	1895*	26
December	3.63	1919	6	60	sw	1895*	26

*Also in subsequent years.

THIRTY-FIFTH ANNUAL REPORT

Of The

Kentucky Agricultural Experiment Station

FOR THE YEAR 1922

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Kentucky
Agicultural Experiment Station

University of Kentucky

VITALITY OF SPERMATOZOA

BULLETIN NO. 239

(Research Bulletin)

Lexington, Ky.
January, 1922

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BULLETIN NO. 239

(Research Bulletin)

Vitality of Spermatozoa

By

W. S. ANDERSON

I. The Vitality of the Spermatozoa of Some Domestic Animals.

INTRODUCTION.

Kentucky has been noted for its blooded stock ever since the importation of Shorthorn cattle in 1817 and the importation of jack stock, swine and cattle by Henry Clay a few years later. The American saddle and show horse originated in Kentucky and the breeders of Kentucky exercised a major influence in founding and developing the Standard-bred, or trotting horse. No other state has made greater contributions to the evolution of the Thorobred Horse than has Kentucky. Some of the finest and best-equipped farms of the State are now devoted exclusively to breeding purebred horses, cattle, hogs or sheep.

The paramount problem of animal breeding is to get the females bred to produce. A very serious financial loss is sustained each year by our breeders because from 30 to 60 per cent. of mares and a considerable number of the most valuable females of other breeds fail to produce.

In 1913 a study of some of the problems of animal breeding was begun by the Kentucky Experiment Station. The investigations had not progressed very far until it became apparent that the vitality of the spermatozoa was one of the important phases of the investigation. As a result considerable time has been devoted to a study of the vitality of the male sex cells, not only of domestic animals but also of some of the lower forms of animal life.

The investigation concerning the behavior of spermatozoa has been made for two purposes. One purpose has been to add, if possible, to our knowledge of the male sex cells; the other is that this knowledge may throw some light upon the problems of the horse, hog and cattle breeder. It is the purpose of this bulletin to report some of the work done to this date.

THE SEMEN

The Origin of the Semen. The spermatozoa of mammals are transferred from the male gonads to the genitalia of the female by means of a liquid called semen. The sperm as matured in the testes are washed out of the tubules into the duct leading to the epididymis and vas deferens by a small quantity of a liquid of a whitish or milky appearance. The liquid carries them into the vas deferens. At the time of ejaculation, the fluids secreted by the prostate gland and Cowper's glands are mixed with those held in the seminal vesicles and the vas deferens, and the discharge is known as semen. Thus, the semen is a combination of the secretions of various glands, and is the medium in which the sex cells of the male are stored and in which they are conveyed to the womb of the female.

The Importance of the Semen. The writer has found that the vitality of the spermatozoa can be injured by any radical change in the medium which contains them. Perhaps, it is correct to refer to normal semen as that semen which has the best physical and chemical constitution possible for the welfare of the sperm cells. Abnormal semen is a semen which lowers the vigor of the sperm in any way whatever. In our investigations, semen has been obtained in which the sperm cells were without life, and

other samples showed various degrees of vigor from the quiescent state of some to the very active condition of normal sex cells.

The Chemical Composition of Semen. Slowtzoff[1] reports that human semen consists of approximately 90 per cent of water and 10 per cent of solids. Marshall[2] states that in the solids there is 2.3 per cent proteins, and that in the ash potassium, sodium, calcium, magnesium, prosphorus, iron and sulfur have been found.

Dr. A. M. Peter[3] reports that normal horse semen is 97.62 per cent water and 2.38 per cent solids, and that nitrogen and phosphorus in considerable quantities are present in the solids and that of the total solids more than 60 per cent is protein.

THE SPERMATOZOA

The only contribution which a stallion, or any male animal, makes to one of his offspring is a sex cell known as a spermatozoon. All the hereditary material which the male hands on to any decendant must be included in the one sex cell of his which finds and fuses with the egg of the female. The spermatozoa have two distinct functions to play in the process of reproduction. One office is to initiate development in the egg; the other value of the spermatozoa is to carry to the egg the hereditary contribution of the male to the new organism that is to develop from the fertilized egg.

Morphology of Spermatozoa. The spermatozoon of the stallion, when fully mature, consists of a head, middle piece and tail. The sperm moves by the vibratory motion of the tail and its function ends when the sperm is brought into contact with the egg; it does not always penetrate the egg but may be left behind when the head enters the cell wall of the egg.

The head of the spermatozoon of the stallion, which is somewhat similar to the sperm of most domestic animals, is oblong, or pear-shaped, and appears blunt at the end. When stained it

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[1] Slowtzoff, 1902, Zeitschrift. Phys. Chem.
[2] Marshall, 1910, Physiology of Reproduction.
[3] Anderson, Peter & Healy, 1921, Journal American Veterinary Medical Association, December, 1921, pp. 291-297.

is found to consist of chromatin, or material carrying the hereditary factors, with little or no cytoplasm, or food material.

The head is 3 microns in length and one and one-half microns in width while the tail is 24 microns in length. Fig. 2.

The spermatozoa of bulls are similar in outline to those of the horse, but are larger. The head is pear-shaped and blunt. The measurements are: 5 microns for length of head, 2 microns in width, and 32 microns for the length of tail. Fig. 3.

The spermatozoa of the rooster are shown as a contrast to those of mammals. The head is long and round but it is blunt. It is 12 microns in length and 1 micron in width while the tail is 40 microns in length. The tail even under a power of over a thousand diameters is hair-like in width and does not show any distinct middle piece or connecting piece, nor can a distinct end piece so often described by authors be seen. Fig. 4.

The spermatozoon of man is not very different from that of the horse, except that the head is more ovoid. The head is oval or pear-shaped, and blunt. There is no acrosome, or stylet, for the purpose of penetrating the egg, as has been described by some authors. There is, however a connecting piece or middle piece. The measurements are: length of head 3 microns, width of head 2 microns, length of tail 24 microns. The connecting piece is approximately 3 microns in length. When stained with gentian violet the head shows two distinct parts. The anterior division composing about two-thirds of the head is light, while the posterior portion is dark. The anterior end is known as the perforatorium and is the part of the spermatozoon which first enters the egg. Fig. 1.

The measurements as given above and the diagrammatic drawings of the various spermatozoa shown in the figures were made from the broad view of the heads. The heads of spermatozoa are slightly flat so that there is another view that would make the head appear not as large by about one-half a micron as the broad view.

Origin of the Spermatozoa. The function of the reproductive glands or testicles, is to mature the spermatozoa. This the testicles do in very large numbers. The process of production of

germ cells is called "maturation." When the sexual maturity of an animal is complete the reproductive glands begin to mature sex cells by transforming one gland cell into four sex cells. As a preparation for the maturation process a gland cell enlarges, or grows to a greater size than the other gland cells. This is its method of storing food for the processes, or divisions, that are to follow. It divides into two equal halves, separating itself as it does so from the other gland cells. Both the new cells immediately divide again, one-half of the bodies carrying the hereditary factors going into each of the new cells. The four new cells are attached to a nurse cell, called a Sertoli cell, to which they cling until the head, middle piece and tail are fully developed. They then drop away from the nurse cell into the tubule, or small passage, of the testicle and with many others similarly produced are sent on to the vas deferens.

Little or no activity is manifested by the spermatozoa as they pass down the tubules of the testicles or as they go on thru the epididymis and sperm cord.

Number of Spermatozoa. It will be observed that one testicle cell goes thru a process of maturation and produces four functional sex cells. The discharge of a vigorous stallion may contain more than two hundred million spermatozoa and he can make such a rich discharge every day or twice a day for a considerable period. The sex cells are matured very rapidly and in very great numbers. Millions of testicle cells must be constantly going thru the process of converting themselves into spermatozoa during the breeding season. The testicles retain their normal size by replacing the lost cells by the ordinary process of cell growth.

Motility of Spermatozoa. The spermatozoa are immobile, or at least manifest but little activity, while in the tubules, cords and seminal vesicles. It requires the contributions from the accessory sex glands, Cowper's and the prostate, added to that of the seminal vesicles during the act of ejaculation to activate them. The normal secretions of the mucus membrane of the womb have the activating effect; and the same result can be obtained by means of a physiological salt solution.

The natural rate of movement of spermatozoa is rapid and is against the current. If in the semen on a microscope slide, a current is set up, the vigorous sperm immediately change their seeming wandering movements to a direction opposite to the current or "upstream." This is nature's provision to secure the passage of the sperm cells thru the uterus and tubes against the current flow of the natural secretions on the membranes.

Some investigators suggest that one function of the semen is to furnish food for the spermatozoa. When the maturation process is complete and the sperm cells are freed from the nurse cells of Sertoli, it is not probable that they receive, or can make use of, any food during the remainder of their life history.

By experimental work reported in this bulletin it has been found that the addition of very slight amounts of acids or alcohols to the semen of mammals injures the spermatozoa. It seems reasonable to assume that the chemical constitution of the semen of sterile males may be, in some cases, the cause of injury to the spermatozoa.

EXPERIMENTAL WORK

The Normal Activity of the Spermatozoa of the Stallion. In the routine of horse breeding it is easy to procure semen as the stallion completes his work. The condition of the sperm cells is determined by the vigor of action, or rate of movement. A small portion of the liquid is placed on a glass slide and the movement of the reproductive cells is studied under the microscope. By using a No. 10 eye piece and a 16 mm. objective a magnification of about 100 diameters is obtained. This magnification affords an excellent field for observing the vigor of the cells.

The Normal Field. It may be said that semen from an animal in full sexual vigor will show a field full of sperm all of which will be active. The eye soon becomes accustomed to the observation and can tell immediately if the rate of movement is as rapid as it should be. It has been estimated that the maximum rate of progress across a field is between 3 and 4 mm. per minute. There is in practis no accurate method of determining the absolute rate of travel, nor is such determination necessary. The essential facts to be ascertained by the observer are the compara-

tive number of sperm in the semen and if all of them are moving with normal vigor.

The number in the field of good specimens is very much greater than a layman would suppose possible. The semen of Etawah, a Standardbred horse, for example, is so crowded with sperm that there appears to be no appreciable space between them. The field reminds the observer of a school of tiny fish feeding in the aquarium of a fish hatchery.

The Abnormal Field. The presence of any inactive sperm is a cause for suspicion. Males have been under observation a part of whose sex cells were inactive, or dead. When the number of dead cells from a male reaches any considerable proportion it is invariably an indication that a large percentage of the females mated to him will not conceive.

The presence of inactive or dead cells in semen is an indication, also, of a lack of vigor in the live ones. The weakness may manifest itself in a sluggish movement, or it may make itself apparent by a premature ending of motility. A male producing such a specimen of semen is either sterile or approaching that condition.

There is a class of males whose semen shows an abundance of sperm, but all of them are inactive. It is, of course, impossible for such males to procure offspring.

Another abnormal field is one in which no spermatozoa, dead or alive, are to be seen. In this investigation a much larger percentage of males were found in this sterile condition than would have been expected.

As the previous paragraphs indicate, a sire's ability to produce offspring can be judged very accurately by examining drops of semen with a microscope. Early in the investigation it seemed worth while to subject normal semen to certain tests in the laboratory.

THE LENGTH OF LIFE OF THE SPERMATOZOA OF THE HORSE.

To discover the life history of the sperm in the semen after ejaculation, samples were procured on the breeding farms, a drop at once examined to determine its condition and the liquid semen

placed in a sterile glass tube and taken to the laboratory, the time of mating being noted so that all subsequent observations could be dated from the time of ejaculation.

For the purposes of this bulletin the tables are omitted and the average results of 24 specimens of normal horse semen given for length of life under laboratory conditions.

1. Semen containing vigorous spermatozoa, kept in glass test tubes at a temperature of 22° C., shows loss of movement in two hours and a progressive loss until all are dead at the end of six hours on the average.

2. Other portions of semen kept in the incubator at 38° C. show loss of movement in somewhat less than two hours and total loss of movement in four hours on the average.

Under normal laboratory conditions semen cannot be kept an indefinite time as is supposed to be possible. The loss of vigor is distinct after the lapse of two hours; and it is probable that the ability of the sperm cells to fertilize eggs is lost before the decrease in vigor can be discovered by the observer.

An interesting result was obtained by contrasting the length of the duration of activity at the average laboratory temperature of 22° C. and that of an incubator at 38° C. or about animal heat. When the temperature is kept at 38° C. movement of the spermatozoa did not extend beyond four hours, or two hours less than at the temperature of 22° C. The reason for this difference is the more rapid multiplication of bacteria at 38° C. than at 22° C. Counts made of the bacteria after three hours at the higher temperature have run as high as 5,500,000 per c. c.

It is supposed that semen can be carried in a thermos bottle at 38° C. for many miles and used effectively. The writer has had inquiries as to the method of transporting it for hundreds of miles and even from one continent to another. It must be used, if used at all, very quickly after it has been ejaculated by a stallion. Perhaps 25 or 30 minutes is the utmost time it can with safety be kept and used.

This will be apparent when it is remembered that the albuminous character of the liquid semen makes it an ideal medium for the growth of bacteria, and there is no known way of procuring

semen from a stallion that is not more or less contaminated by certain forms of bacteria that in six or eight hours give the distinct odor of putrefaction. All movement ceases before the first odor of putrefaction can be detected.

3. To test the effect of light upon the life of the spermatozoa samples of semen were divided into two portions, one of which was kept in the laboratory exposed to the light, while the other portion was kept in a dark incubator. The temperature of the incubator was regulated so that it corresponded exactly with the room temperature which was in this case 21° C. In all the trials of this nature the progressive loss of life was the same in the semen kept in darkness as that kept in light. The experiments prove that light has no perceptible effect upon the life of the sex cells.

The opinion held by most breeders is that light is injurious to the sperm cells, and that semen must be protected from the light if injury is not to result. Our work shows conclusively that light has no appreciable effect.

4. To determine the effect of sunlight on the movement of Spermatozoa the test on a sample of semen is given. This is typical of all other trials.

10:00 A. M. Semen placed in sunlight, temperature 38° C.
10:10 A. M. All sperm active.
10:20 A. M. All sperm very active.
10:30 A. M. All sperm very active.
10:40 A. M. ¼ sperm inactive. ¾ very active.
10:50 A. M. ¼ sperm inactive. ¾ very active.
11:00 A. M. ½ sperm inactive. ½ very active.
11:10 A. M. 2/3 sperm inactive. 1/3 very active.
11:20 A. M. 2/3 sperm inactive. 1/3 verty active.
11:30 A. M. Very little activity.
11:40 A. M. No activity.

Sunlight appears to have a stimulating effect upon the spermatozoa and the movement as a result of the sun's rays seems to be more vigorous. The increased vigor however results in lessening the time of the activity. Movement of the sperm cells ceases in less than two hours when the semen is kept in sunlight

at a temperature of 38° C. whereas they live four hours at the same temperature in either the light of the laboratory or the darkness of an incubator.

5. The following tests were made to determine the effect of extreme temperature on the life of the spermatozoa in semen procured at 10 A. M. and taken to the laboratory at 11 A. M.

A—11:05 A. M. Semen raised in test tube to 40° C. All active.

11:10 A. M. Semen raised in test tube to 43° C. All active.

11:18 A. M. Semen raised in test tube to 44° C. A few not active.

11:28 A. M. Semen raised in test tube to 46° C. Slight activity.

11:35 A. M. Semen held in test tube to 46° C. No activity.

B—11:42½ A. M.	Semen raised to 46°	All active
11:47½		All active
11:55		About 10% inactive
12.05		About 15% inactive
12:15		About 25% inactive
12:25		About 95% inactive
12:30		About 95% inactive
12:35		All inactive

In testing semen for the resisting power of the sperm to extreme temperature two types of experiments were performed, as indicated by A and B above. In A the semen was gradually increased in temperature to 46° C. or approximately 115° F. No inactivity was noted below the temperature of 44° C.

In B the semen was raised to 46° C. at once and held at that temperature. In twelve and one-half minutes inactive sperm were seen and in approximately 50 minutes all became quiescent.

From these observations on the persistence of the life of the sperm it will be seen that some of them can live in temperatures as high as 46° C. for some time and a very few as long as 45 or 50 minutes.

6. To test the effect of extreme cold, semen in test tube was lowered to 0° C. and held.

11:00 A. M.	All active
11:10	All active
11:20	25% inactive.
11:30	50% inactive
11:40	50% inactive
11:50	75% inactive
12:00	75% inactive
12:10	95% inactive
12:20	98% inactive
12:30	Some evidence of life.
12:40	Slight evidence of life.
12:50	No activity.

It takes over one hour and forty minutes at 0° C. to render spermatozoa inactive.

7. To test the effect of freezing on the spermatozoa, a test-tube containing semen was placed in a mixture of salt and ice and slides examined after ice began to form in the tube. There was some movement of the cells as long as any unfrozen semen could be obtained. After the semen was frozen solid it was allowed to melt at room temperature; but there was no activity shown by the cells. By placing the test tube in warm water the temperature was raised to 35° C. and then to 40° C. but no evidence of motility was obtained.

The semen was then divided into two portions. Into one a physiological salt solution was poured, while the other portion received a 1 per cent potassium iodide solution. No evidence of life was found in either portion of semen.

It appears that the sperm cell of the horse will exhibit activity in great extremes of temperature, from 0° C. to 46° C; but when made quiescent by heat or cold there is no way known to the writer of starting movement again.

THE LENGTH OF LIFE OF THE SPERMATOZOA OF THE ROOSTER.

A vigorous White Wyandotte cock was used in a pen of birds during the breeding season of 1921 for the purpose of de-

termining his ability to fertilize eggs. He fertilized 85 per cent of all the eggs tested from his pen of hens.

At 7:30 A. M., June 8th, he was destroyed and his testicles and cords carefully removed from his body. From one testicle was taken a small amount of liquid. The milky appearing liquid contained inactive spermatozoa in very great numbers. Activity was aroused by diluting on the slide the liquid from the testicle by a physiological salt solution. Other trials showed that the inactive sperm from the testicles could be activated by diluting with water.

Examination of sperm cords of other birds during the breeding season shows that as the spermatozoa of the rooster approach the outlet of the cord some motility can be observed, but that in the main the semen must in the course of nature come in contact with the secretions of the vagina of the female bird to be fully activated.

To determine the length of life of the spermatozoa of the rooster destroyed at 7:30 the following tests were made:

A—At 10:00 A. M. the liquid semen of one cord was pressed ont and placed in 2 c. c. of physiological salt solution.

10:00 A. M.	All the sperm were active.
10:30	All the sperm were active.
11:00	All the sperm were active.
12:00	All the sperm were active.
2:30 P. M.	Diminished activity.
3:30	Greatly diminished activity.
5:00	Little evidence of activity.

At 9 A. M. of the following day, a drop of the solution showed marked degeneration of the sperm. The flagellum had disappeared and the head was greatly swollen. At 9 A. M. of the third day the degeneration of the sperm was complete.

B.—One testicle of the rooster used in A was placed, at 9 A. M. of the day it was released from his body, in a physiological solution of salt and transferred immediately to the ice box.

At 9 A. M. of the third day, the sperm had degenerated.

It will be noted that the duration of life of the sperm cells of a rooster is not different from that of the horse.

The semen procured from boars and bulls has been tested for the duration of life in the sperm cells and found to resemble very closely that of the horse.

THE EFFECT OF ACIDS ON THE SEPERMATOZOA OF MAMMALS.

In the progress the investigation semen has been procured from stallions, boars and bulls at various times in which the spermatozoa exhibited all the different degrees of movement from the most vigorous action to the absence of all movement. We have had the opportunity to observe the activity of the sperm cells of a large number of males and to ascertain the power of these males to produce impregnation in the females to which they were mated. It may be stated as a general rule that any given male will lack the power of impregnation if the spermatozoa in his semen are wanting to any considerable extent in activity or vigor of movement.

Trials were made in the laboratory by the use of small quantities of acids added to semen containing vigorous sperm, to bring about a lack of vigor in the cells. It was found that every degree of abnormality could be produced from slight to fatal injury.

A typical example is:

Normal semen treated with .36% solution of HC1. No activity of sperm.

Normal semen treated with .18% solution of HC1. No activity of sperm.

Normal semen treated with .09% solution of HC1. No activity of sperm.

Normal semen treated with .045% solution of HC1. No activity of sperm.

Normal semen treated with .0225% solution of HC1. Slight activity.

Normal semen treated with .01125% solution of HC1. More activity.

Normal semen treated with .00565% solution of HC1. Almost normal activity.

In the above treatment of semen with acid, a measured quantity of HC1 was added to a measured quantity of semen.

The percentage was calculated as tho a c. c. of semen were equal to a c. c. of distilled water. Later Healy and Anderson[3] found that semen is buffered against acids and alkalies to a certain extent, so that the percentages of free acid as given above are not absolute. A slightly smaller percentage of free acid, due to the buffer effect of the semen, should be kept in mind as the results of this experiment are interpreted.

In addition to HC1, as given above, H_2SO_4 and HNO_3 were tried with like results. A .045% solution of either H_2SO_4 or HNO_3 was a sufficient concentration of the acids to destroy all evidence of activity on the part of vigorous spermatozoa. $C_2H_4O_2$ and C_6H_5OH gave the same results when brought in contact with the sperm cells in the same degree of concentration.

It is remarkable how little resistance the sperm of mammals have to acids. There is no difference which the writer has been able to discover between the strengths of acid dilutions necessary to destroy the sperm of horses, hogs, bulls, rabbits, guinea-pigs and rats and even that of the rooster made active in physiological salt solution.

THE EFFECT OF POTASSIUM PERMANGANATE ON SPERMATOZOA.

Normal semen of the horse treated with 1.0% $KMnO_4$. No activity of sperm.

Normal semen of the horse treated with .5% $KMnO_4$. No activity of sperm.

Normal semen of the horse treated with .25% $KMnO_4$. No activity of sperm.

Normal semen of the horse treated with .0675% $KMnO_4$. No activity of sperm.

Normal semen of the horst treated with .0675% $KMnO_4$. Slight activity sperm.

Normal semen of the horse treated with .03375% $KMnO_4$. More activity.

Normal semen of the horse treated with .016875% $KMnO_4$. Almost normal activity.

[3]Healy, D. J., and Anderson, W. S., loc. cit.

THE EFFECT OF ETHYL ALCOHOL ON SPERMATOZOA.

Normal semen of the horse treated with 1.0% C_2H_5OH.
No activity.

Normal semen of the horse treated with .5% C_2H_5OH.
No activity.

Normal semen of the horse treated with .25% C_2H_5OH.
Slight activity.

Normal semen of the horse treated with .125% C_2H_5OH.
Almost normal activity.

As in the case of acid the percentage of the solution was calculated by considering one c. c. of semen as equal to a c. c. of distilled water.

A very weak dilution of $KMnO_4$, or .0675 per cent is sufficient to fatally injure the sperm. It requires a much greater concentration of C_2H_5OH, or .25%, to cause as serious an injury.

DIFFERENCE IN VIGOR OF SPERMATOZOA.

One of the most interesting features of the investigation has been the difference in the vigor of individual cells. Fields have been under observation when the concentration of some chemical substance had quieted all but one or two spermatozoa. These would be moving about with rapidity, going over and around the dead cells as tho they themselves were unaffected by the hostile chemical. The same difference is seen in individual behavior of the cells when semen is subjected to the different temperatures or in tests for length of life. Some few vigorous ones always show considerable vigor after the vast majority have succumbed to the adverse environment.

The same phenomenon is observed in examining the genitalia of bred females. Often when the great majority of the male sex cells have ceased to move on the mucous membrane an occasional sperm is found with considerable vigor of movement.

It has not been determined whether the most vigorous spermatozoa are due to age or to inherent vigor; nor has it been determined what difference, if any, there would be in organisms arising from eggs fertilized by the most vigorous sperm and those fertilized by the weakest.

HYDROGEN ION CONCENTRATION OF HORSE SEMEN.

There are stallions whose semen invariably contains a large number of inactive sperm cells. In some samples of abnormal semen more than one-half the spermatozoa are quiescent. The stud records of these horses show them to be partially sterile as the ones under observation impregnate from 20 to 40 per cent of the mares mated to them.

Such a large number of abnormal specimens of semen have been obtained that it occurred to the writer that there might be some difference in the acid or alkali concentration of normal and abnormal semen.

The proposition was placed before Dr. D. J. Healy of this Station and he kindly consented to determine the hydrogen ion concentration of a number of samples of normal and abnormal horse semen.

Horse semen is neutral, as far as any test with litmus paper can be made, and no difference can be seen in normal and abnormal semen by the use of litmus paper. Dr. Healy says in reporting the result of the hydrogen ion measurement:

"Living cells require the maintenance of a strictly limited hydrogen ion concentration in their environment. Enzymes are extraordinarily sensitive to minute changes in the hydrogen ion concentration of the medium in which they are working. Fortunately, protoplasm contains salts of carbonic and phosphoric acids which act as 'buffers' checking changes in hydrogen ion concentration, the bicarbonate acting by releasing or absorbing CO_2, while the phosphates readily change from mono — to di-phosphate and vice versa.

"Two methods are available for the measurement of hydrogen ion concentration in solution—the colormetric and the electrometric.

"The apparatus used in this investigation consisted of the Clark hydrogen ion apparatus supplied by Leeds and Northrup Company, a portable lamp and scale galvanometer, a Leeds and Northrup type K potentiometer and a standard Weston cell, Model 4."

The Semen used. The semen used for the investigation was procured from stallions in service. All the stallions whose semen was found to be normal—that is, full of very active spermatozoa, as shown by the microscope—have excellent records in the stud for getting a high percentage of their mares in foal. On the other hand, the semen which showed a large percentage of dead cells came from stallions that impregnated a smaller percentage of their mares.

Manner of Obtaining Semen. The semen was collected as the stallion made a service. As he came down a sterile, stoppered funnel was used to catch the semen which was transferred to a sterile bottle and taken as quickly as possible to the laboratory. About an hour, on the average, elapsed after collecting the semen before the measurement was made.

As soon as the semen was obtained, an examination was made of a drop under the microscope and it was re-examined after arriving at the laboratory. The following results were obtained in making the measurements of normal horse semen.

Table 1. Normal Semen.

Stallion	Time	Reading	Temp.	pH Value
1. Etawah	10.11	.7335 volts	26.5° C.	7.43*
2. Huon	9.47	.7230 volts	23.5° C.	7.44
3. Uncle	10.03	.7255 volts	23.5° C.	7.47
4. Rapid Water	11.13	.7080 volts	19.5° C.	7.14*
9. Prince Palatine	9.20	.7010 volts	23.5° C.	6.94*
12. Fritter Gold	9.38	.7325 volts	22.0° C.	7.51*
14. Fair Play	11.40	.7180 volts	29.0° C.	7.24
			Average	7.31

The range of the seven specimens of normal horse semen is from pH 6.94 to 7.51 or an average of pH 7.31. This finding may be compared to the pH value of blood which is pH 7.40, almost identical with that of semen.

*Correcion for flushing out hydrogen vessel with CO_2-free water, .125 pH has been deducted.

Table 2. Semen containing non-motile Spermatozoa.

Stallion	Time	Reading	Temp.	pH Value
5th.	8.50	.7280 volts	19.5° C.	7.49*
6th.	9.17	.7320 volts	19.5° C.	7.55*
7th.	9.07	.7280 volts	22.5° C.	7.55
8th.	9.23	.7300 volts	22.5° C.	7.58
13th.	9.47	.7480 volts	22.5° C.	7.76*
			Average	7.58

The range of the abnormal semen is from pH 7.49 to pH 7.76, while the average is pH 7.58 as contrasted with pH 7.31 for normal semen. The difference, therefore, is .27 of a pH value.

We realize that not enough work has yet been done to draw any very definite conclusion. It does not seem possible that a slight difference of .27 of a pH value can be the cause of the sperm cells loosing the ability to move, but earlier experiments show that they are very sensitive in the presence of some acids.

To determine if the hydrogen ion concentration of semen is readily altered we made this experiment. To a 10 c. c. portion of semen of pH 7.56, 0.5 c. c. N/10 HC1 was added. Then the hydrogen ion concentration was measured. The acid added made a reduction from pH 7.56 to pH 7. CO_2 free water of pH 5.6, with the same treatment is reduced to pH 2.25. In view of the quantity of an acid or an alkali necessary to produce a marked change in semen it may be possible that .27 of a pH value is enough to affect the life of the sperm cells.

"It appears that a hydrogen ion concentration of about pH 7.5 indicates a critical condition of the equilibrum of the electrolytes present in horse semen.

A preliminary chemical analyses of portions of the above semen, normal and abnormal, were made by Dr. A. M. Peter, Head of the Chemistry Department, Kentucky Experiment Station, with the following results:

*Correction for CO_2-free water (.125 pH) deducted.

Table 3. Chemical Analyses of Semen

Per cent by weight	Normal	Abnormal
Total solids, dried at 105°C.	2.38	3.49
Ash	0.78	0.60
Total nitrogen (N)	0.241	0.366
Total phosphorus (P)	1.017	0.028
Per cent ash in total solids	32.8	17.2
Per cent phosphorus in total solids	0.7	0.8
Per cent nitrogen in total solids	9.9	9.5

The proportion of total solids is distinctly larger in the abnormal semen than in the normal; the proportion of ash in the total solids of the abnormal semen, however, is markedly less than in the normal. The proportions of nitrogen and phosphorus in the total solids are sensibly the same in both. More analyses will be necessary to determine whether these differences are significant.

LIFE OF THE SPERMATOZOA IN THE WOMB.

Perhaps, no phase of breeding is as little understood as the time elapsing from breeding mammals to the time when actual fertilization takes place. If, for example, the egg of the female is not liberated for 24, 48 or 72 hours after insemination, will the spermatozoa remain motile and be capable of fusing with it?

It is the common opinion of breeders that the sperm live many days in the womb and tubes of the female. It is reported that live spermatozoa have been found in the organs of females twelve or fourteen days after mating, but the writer does not believe that their life extends beyond 48 hours.

Lewis[4] reports that out of 25 sows bred and destroyed in order to discover the length of time live sperm could be found in the womb and tubes: "In only three sows in the experiments of 1908-1910 could live sperm cells be found at a greater length of time than twenty hours after breeding. In two cases live cells were found after a lapse of more than forty hours, and in one case after a lapse of twenty-two and one-half hours."

[4] 1911, The Vitality of Reproductive Cells. L. L. Lewis—Bulletin No. 96, Oklahoma Experiment Station.

EXPERIMENTS WITH HENS.

In 1919, with the assistance of J. H. Martin, of this station, a number of hens were isolated for a period of 24 days. The hens were hand mated with a vigorous cock and destroyed after periods verying from six hours as a minimum up to forty-eight as a maximum.

All the hens destroyed at the end of the six and eight hour periods showed live sperm. None of the spermatozoa had progressed farther than one-third the length of the oviduct. We were unable to find any sperm cells, dead or alive, after a lapse of fifteen hours.

EXPERIMENTS WITH MARES.

During the breeding season of 1921, four mares* were secured for experiment.

No. 1. May 25—Mated twice to a vigorous young stallion. Last service at 5 P. M. Two capsules of semen were caught and inserted into the womb.

May 26. Mare destroyed 16 hours after mating. The organs were scraped and slides prepared of the scrapings for the microscope. No sperm cells were found from scrapings of the womb or horns. One spermatozoon was found in the right tube but it had lost its power of movement. Womb and horns appeared to be normal.

No. 2. June 10—Mare was mated at 9 A. M.
Mare was destroyed at 2 P. M.

Inactive spermatozoa were found in the womb and horns. No motile sperm were observed. The womb and horns were inflamed and the mucous lining was very greatly congested.

No. 3. June 20—Mare was mated at 9:45 A. M.
At 3 P. M. mare was destroyed.
At 3:30 P. M. examination was made by scraping the mucus, with the following results.

* These mares were donated to the Kentucky Agricultural Experiment Station by the Patchen Wilkes Stock Farm.

Inactive sperm found at vulva
Inactive sperm found in vagina.
Active sperm found at os.
Active sperm found in womb close to os.
Active sperm found in center of womb.
Active sperm found in womb at horns.
Active sperm found in right horn.
Active sperm found in center of right horn.
Active sperm found at entrance to right tube.
Active sperm found in left horn.
Active sperm found at entrance of left tube.

At 5 P. M. the sperm cells were vigorous in all parts of the organs examined.

No. 4. Mare No. 4 has an overgrown os and could not be used to test the length of life of the sperm. She is reserved for other work.

It appears that the womb and secretions of only one mare, No. 3, were friendly to the life of the sperm cells. The mare was bred at 9:45 A. M. and at 5 P. M., or 7¼ hours after mating, the cells were still moving with considerable vigor.

This fact becomes interesting when it is remembered that six hours is the average life of the sex cells when kept in the most favorable laboratory condition. It would seem that the fluids of the genitalia when normal have a tendency to prolong the life of the cells. From our work and that of Lewis, already referred to, it seems reasonable to assume that fertilization in mammals takes place in the vast majority of cases within twelve hours after insemination. Rare cases may extend the time to thirty-six or forty-eight hours. The spermatozoa after the first twelve hours of life on the mucus membrane of the womb and tubes are liable to become entangled on the surface and to be absorbed.

It would be of very great value to the horse breeder could the limits of fertilization after insemination be known, because mares have an extended heat period of from three to nine days.

Lewis[5] reports that the average time for sows to ovulate is thirty hours after the beginning of the heat period. If a mare

[5] Lewis, L. L., loc cit.

is bred at the beginning of her heat period and does not ovulate until six or eight days later there will be slight or no chance for her to become pregnant. If the spermatozoa lived in the womb indefinitely there would be no concern as to the time she shed her ovum as compared to the time of insemination.

Summary

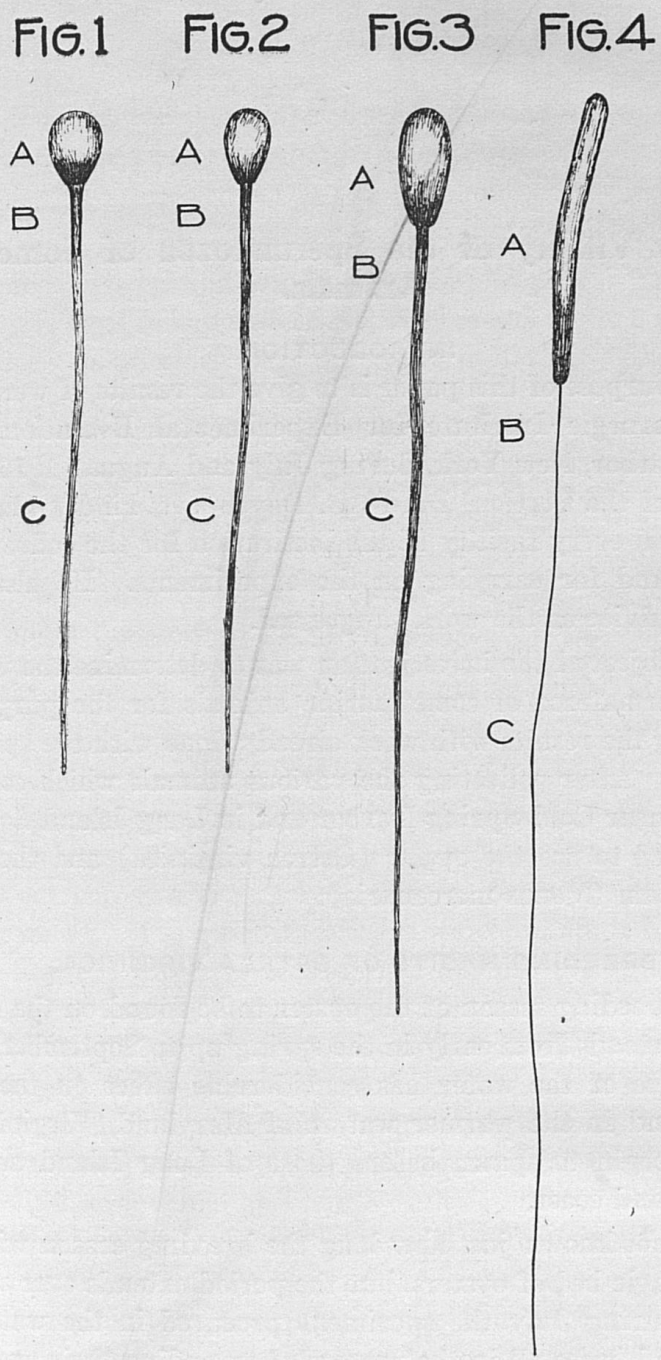
1. Spermatozoa of mammals show activity under laboratory conditions for about 6 or 8 hours.

2. Spermatozoa are not especially sensitive to change of temperature and are not immediately injured by sunlight.

3. Spermatozoa are easily injured by acids and alcohols but are not so easily injured by alkalies.

4. Spermatozoa show activity longer in the uterus than under laboratory conditions.

5. The hydrogen ion concentration of the semen appears to have an influence on the activity of the spermatozoa.



EXPLANATION OF FIGURES.

Figure 1. Spermatozoon of the human.
Figure 2. Spermatozoon of the horse.
Figure 3. Spermatozoon of the bull.
Figure 4. Spermatozoon of the rooster.

A, head. B, connecting piece. C, tail. Under a magnification of three thousand diameters no distinct connecting piece can be seen in the tail of the spermatozoon of the rooster.

The stains were made by Miss A. Harms and the measurements and drawings by Miss Virginia Anderson.

II. The Vitality of the Spermatozoa of Some Sea Animals.

INTRODUCTION

The purpose of this paper is to give the results of work done at the Carnegie Institute for Experimental Evolution, Cold Spring Harbor, New York, during July and August, 1916. The Director of the Station, Dr. C. B. Davenport, kindly placed at my disposal every facility of the institution for the collection of material and for carrying on the experiments. He also gave valuable advice as the work progressed.

The object of the investigation was to determine the vitality of the spermatozoa of some marine animals for the purpose of comparing the results with work already done with the sperm of mammals. After collecting the various animals which could be procured near Cold Spring Harbor and in Long Island Sound it was decided to use the oyster (Ostrea virginica) and the Hard Shelled Clam (Venus mercenaria).

BREEDING HABITS OF OSTREA VIRGINICA.

The breeding season of the oyster to be found on the Atlantic coast extends from early in the spring up to September. The temperature of the water has considerable effect on the time. Those found in the warmer waters of Maryland, Virginia and Carolina begin to spawn before those of Long Island and the New England coast.

It is not known just how long the breeding season will last for any single bed of oysters, but the period extends over several weeks. During July the specimens procured in the waters of Long Island, were all in the process of extruding their eggs and sperm. The process continued into August. Not until August 6 was an oyster found which had completely finished the spawning process, and only a very few sterile ones were found up to the 15th of August, when the work ceased. By the middle of

August it was evident that the process of spawning was well advanced and would be completed in a few days.

SEXES.

There are in European waters oysters which possess both ovaries and testicles and are truly hermaphroditic. The sperms fertilize the eggs in the mantle chamber of the mother where the development takes place until the young oyster can begin its free swimming career.

The Atlantic coast oysters (Ostrea virginica) on the American side are male and female. There is no way by examining the shell to distinguish the sexes. When opened the appearance of the two sexes is identical. The only way to distinguish the male from the female is by examining the products of the gonads under the microscope. The gonads of the female produce eggs only, while sperm alone is found in the sex glands of the male.

GERM CELLS.

The eggs are small, pear-shaped bodies, containing a rather large germinative vesicle. The eggs when mature are extruded into the water as the oyster lies on the bottom. The process is a gradual one going on from day to day for perhaps as long as six or eight weeks. The quantity of eggs which an adult female can shed in any one breeding season runs up into the millions, perhaps going as high as seventy-five million. The well-developed female will begin to mature eggs by or before the time she is one year old, and the process continues each season of her life, the length of which is several years under natural conditions.

The male oyster sheds his milt, or seminal fluid, into the water as it is swept thru his mantle cavity in the same way as the eggs of the female are shed. There is no concerted effort, or sexual excitement, on the part of the sexes, to exude eggs and milt at the same time and place as we find in fish. The eggs leave the female, to be washed about by the currents of the water which receives them, and in a few hours perish unless the water is also bearing active sperm. The meeting of the eggs and sperm is an accidental occurrence. As a mater of fact, but a small percentage of the eggs are ever fertilized, and few of those fertilized ever reach the sessile period of their development.

There is no way to estimate the number of spermatozoa which the average male oyster exudes during the breeding season, but the number will go well up into the billions. The sperm is in form of the usual type, consisting of a head, middle piece and tail. Fig. 1.

FERTILIZATION AND DEVELOPMENT.

By placing eggs and sperm together on a drop slide I was able to watch some of the early developing stages. Sperm would become attached to the eggs in a few seconds or, at most, minutes after bringing them in contact in the same fluid. Almost immediately, the eggs begin to change. The egg loses its pear shape and becomes spherical, while the germinative vesicle disappears and the polar body is extruded. In from two to three hours after fertilization the embryo has reached the 16-cell stage and from this on development is very rapid, so that in four or five hours the cilia thrown out enable the little animal to swim at will. This it continues to do for from 5 to 10 days, by which time the shell makes its appearance and it sinks to the bottom and attaches itself to the most convenient object to be found; should it find none and sink into the mud or sea ooze, it soon perishes.

MOTILITY OF THE SPERMATOZOA.

There is little, if any, activity of the oyster sperm in the gonads of the male. There is a slight movement in the milt, or semen, secured at the organ of extrusion, but the semen is so viscid that but little movement is found. The instant the seminal fluid is diluted with sea water the very greatest activity begins. Nature has fashioned the spermatozoon of the oyster to live and display its activity in sea waters. In sea waters fertilization takes place.

EFFECT OF CHEMICAL SOLUTIONS.

When a drop of seminal fluid is placed on a microscope-slide and examined the sperm are seen to be immotile. Motility begins the moment the semen is diluted with sea water. A smear

of the semen can be made, and by placing a drop of sea water in contact with one edge of it on the slide, the activating influence of the water can be watched as it gradually diffuses over the sperm. Fresh water and distilled water do not have any activating effect on the sperm.

The purpose in the following experiments was to determine which of the salts contained in normal sea water, is the cause of movement in the sperm. Sea water contains .35% $MgCl_2$, .17% $MgSO^4$, .14% KCl, and 2.61% NaCl. Solutions were used in distilled water representing the concentration of each salt as it is found in sea water.

Oyster sperm in distilled water. No activity.
Oyster sperm in fresh water. No activity.
Oyster sperm in .35% $MgCl_2$ distilled water. No activity.
Oyster sperm in .17% $MgSO_4$ distilled water. No activity.
Oyster sperm in .14% KCl distilled water. No activity.
Oyster sperm in 2.61% NaCl distilled water. Normal activity.

It is the NaCl which causes the dormant sperm to begin the movement necessary to enable the sperm to find the egg in sea water and fuse with it. This, of course, is what would be expected under the circumstances because the NaCl is found in sea water in much greater quantity than any of the other chemical compounds.

Various combinations of $MgCl_2$, $MgSO_4$, and KCl, were tried but no concentration of the three or of any two of them had the slightest effect on the sperm.

The tabulation below is the result of a series of observations to determine the minimum and the maximum concentration of NaCl in which the sperm will exhibit movements.

Oyster sperm in .50% NaCl. No activity.
Oyster sperm in .91% NaCl. Slight activity.
Oyster sperm in 1.35% NaCl. Greater activity.
Oyster sperm in 1.80% NaCl. Less than normal activity.
Oyster sperm in 2.00% NaCl. Appears to be normal activity.

Oyster sperm in 2.25% NaCl. Appears to be normal activity.
Oyster sperm in 2.61% NaCl. Normal activity.
Oyster sperm in 3.00% NaCl. Normal activity.
Oyster sperm in 3.50% NaCl. Close to normal activity.
Oyster sperm in 4.00% NaCl. Less than normal activity.
Oyster sperm in 4.50% NaCl. Slight activity.
Oyster sperm in 5.00% NaCl. Slight tremor just for an instant.
Oyster sperm in 6.00% NaCl. No activity.
Oyster sperm in 10.00% NaCl. No activity.

From the above tabulation it will be seen that the concentration of the sea water may vary over a wide range and yet not destroy the sperm. The amount of NaCl may vary from 1.80% or 2% to 3% or 3.50%, which is a much larger range than is found on the coast of the Atlantic, and it explains the reason why oysters can breed in rivers some distance back from the great body of salt water.

LENGTH OF ACTIVITY.

Spermatozoa placed in filtered sea water retained their vigor of movement from 8 A. M. to 3 P. M. After 7 hours the speed of their movements diminished rapidly. In no case was any active sperm found 24 hours after placing the seminal fluid in sea water. It is the opinion of the writer that when the sperm is shed into the medium about the oyster, fertilization takes place in a few minutes, if at all, or at most takes place in an hour or two. Should the sperm in this short time not find the egg, it perhaps looses its vigor so that it is not able to enter the egg when found.

To determine if sunlight has any bad effect on the sperm, seminal fliud in filtered sea water was, on different days, exposed to the direct rays of the sun. It could not be seen that the direct rays of the sun had any effect whatever. This is what would be expected when it is remembered that at low tide some oyster beds are not more than from 12 to 36 inches under the surface of the water and the direct rays of the sun can reach them.

THE EFFECT OF ALKALIES ON SPERMATOZOA.

When 1 cc of N/10, NaOH or KOH was added to 1 cc of sea water containing normal spermatozoa there was little decrease in the vigor of movement; 2 cc of either solution added to 1 cc of sea water diminishes the activity of the sperm to a much greater degree. The greater concentrations of alkalies do not seem harmful except as they reduce the concentration of NaCl in the sea water, rendering it too dilute to activate fully the sperm.

To determine the quantity of Na_2CO_3 necessary to injure the sperm, solutions were made by dissolving known weights of Na_2CO_3 in known weights of sea water.

Oyster spermatozoa treated with 1. % solution of Na_2CO_3 normal activity.

Oyster spermatozoa treated with 2. % solution of Na_2CO_3 normal activity.

Oyster spermatozoa treated with 3% solution of Na_2CO_3 normal activity.

Oyster spermatozoa treated with 3.5% solution of Na_2CO_3 normal activity.

Oyster spermatozoa treated with 4. % solution of Na_2CO_3 less than normal activity.

Oyster spermatozoa treated with 4.5% solution of Na_2CO_3 less than normal activity.

Oyster spermatozoa treated with 5. % solution of Na_2CO_3 much less than normal activity.

Oyster spermatozoa treated with 7. % solution of Na_2CO_3 no activity.

Oyster spermatozoa treated with 10. % solution of Na_2CO_3 no activity.

Not until 4% Na_2CO_3 in sea water is reached can there be a detection of the effect. In a 5% concentration there is a degree of activity not very different from the normal. Above this concentration the effect is appreciable until a 7% concentration results in no activity.

ALCOHOL.

The action of alcohol on the oyster spermatozoa gave unexpected results. The writer had found, as has been reported in detail in part I of this bulletin that 1% solution of C_2H_5OH will injure the sperm of mammals.

In working with oyster sperm it was necessary to make the solution in filtered sea water, or in distilled water containing 2.61% NaCl.

Solutions of sea water and alcohol gave the following results:

Oyster spermatozoa treated with .5% solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 1. % solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 1. % solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 2. % solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 5. % solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 7.5% solution C_2H_5OH normal activity.

Oyster spermatozoa treated with 10. % solution C_5H_2OH normal activity.

Oyster spermatozoa treated with 15. % solution C_2H_5OH some activity.

Oyster spermatozoa treated with 17. % solution C_2H_5OH slight activity.

Oyster spermatozoa treated with 20. % solution C_2H_5OH no activity.

The effect of alcohol in the more concentrated solutions was to stimulate the sperm cells to greater activity and then to hasten their death. While no observable effect upon them could be seen from the less concentrated solutions fertilization was never observed with any percentage of alcohol present. The presence of a small amount, too little to be detected by the behavior of the germ cells themselves, always interfered with the fertilization or

segmentation of the eggs. One can only judge of fertilization by the process of the development of the eggs in solution with the spermatozoa.

EFFECT OF ACID.

To determine the effect of acid on the sperm active in filtered sea water, a known percentage of the acid was added and the results noted as follows:

Oyster spermatozoa treated with .36% solution of HCl no activity.

Oyster spermatozoa treated with .18% solution of HCl no activity.

Oyster spermatozoa treated with .009% solution of HCl no activity.

Oyster spermatozoa treated with .045% solution of HCl no activity.

Oyster spermatozoa treated with .0225% solution of HCl slight activity.

Oyster spermatozoa treated with .01125% solution of HCl more activity.

Oyster spermatozoa treated with .00565% solution of HCl normal activity.

It is apparent from the above tabulation that an almost imperceptible amount of acid is injurious to the sperm of the oyster.

It will be noted that oyster spermatozoa, which have sea water as their natural medium, are as susceptible to the influence of acids as the spermatozoa of mammals. To save space the tabulation of the results with HCl only are given. The acids HNO_3, H_2SO_4 and $HC_2H_3O_2$ were tried with results similar to those given for HCl. A .045% solution of any of the acids made active cells inactive.

VENUS MERCENARIA.

To make a record of the peculiar character of the spermatozoa of the hard shell clam (Venus mercenaria) the following observations are given:

The breeding habits of the hard shell clam (Venus mercenaria) are identical with those of the oyster. The eggs are pear shaped like those of the oyster and the star fish.

The morphology of the sperm is the greatest point of difference. There is no resemblance of the spermatozoa of the Venus mercenaria to those of the Ostrea virginica or to any sperm of mammal, fish or insect examined by the writer. The spermatozoon of the hard shell clam under a magnification of 215 diameters has the appearance of a horn with the tip sawed off. There is no evidence of a tail. When examined under a power of 430 diameters the head gave the same appearance as with the lower power and occasionally the lashing of the flagellum could be seen.

Stains were made with Wright's blood stain, Janus blue and other stains and then examination made with the oil immersion objective. By this means the exact forms of the head and tail were revealed. Fig. 3.

The head is the shape of a horn with the tip of the horn blunt. The tail is attached to the center of the large end of the head and is very fine and long, much longer than the flagellum of any other sperm examined. It is unusual because of its extreme fineness. Under the high power used, after staining, it is hair like in its appearance.

The "head" end of the sperm is blunt, the cylindrical part is curved like a horn, while the larger end of the head is about twice the diameter of the smaller end. The sperm moves in a circular manner always keeping the concave part of the sperm head on the inside of the circle. Dilute solutions of the seminal liquid were prepared for the purpose of studying the movement, and the circular form represents the normal activity. The flagellum appears never to be curved in opposition to the curvature of the head but always with it. No sperm were observed in which the convexity of the tail did not correspond to the convexity of the head, giving the whole sperm, head and tail, the appearance of one continuous curve.

The lashing of the tail carries the head in a spiral or circular direction. The rate of movement is less than the movements of sperms which have shorter tails.

It requires sea water to give movement to the spermatozoa of clams and their behavior in the presence of various chemicals

is similar to the behavior of the sperm of oysters. Perhaps alcohol has a slightly greater influence on them than on the spermatozoa of the oyster, while the sperm of the clam can stand a somewhat greater degree of acidity than the oyster spermatozoa.

The spermatozoa of the clam very soon become attached to the eggs when brought in contact in a drop slide. The act of penetration was not observed.

NASSA OBSOLETA.

For the sake of comparison the spermatozoa of the mud snail (Nassa obsoleta) were examined. This snail lives in sea water as a normal medium, but at low tide can live as the oyster and clam, out of it for a time. It differs in its breeding habits, as copulation takes place and the semen of the male is by means of an intromittent organ, placed within the body of the female where the eggs are fertilized. They are, after fertilization, deposited by the female on grass or other convenient objects.

The process of copulation prevents the sperm from coming into contact with the sea water, and their life history is different from those sperm that do live in the sea. In form the spermatozoon of Nassa obsoleta is not greatly different from the standard mammalian kinds. It is composed of a flat head, middle piece and tail. The tail is longer than that of the oyster spermatozoon; otherwise there is no apparent difference. Fig. 2.

The spermatozoa of the mud snail are injured by small amounts of acids and alcohols, like the spermatozoa of mammals. They are not motile in sea water for the reason, evidently, that copulation takes place and the seminal fluid does not come in contact with the salt water of the sea. Unlike the oyster and clam sperm they are very active in the semen in which they are ejected by the male.

SUMMARY.

1. The spermatozoa of Ostrea vinginica and Venus mercenaria are immotile in the sex glands and the seminal fluid.
2. Fresh or distilled water has no influence on them.
3. The NaCl in sea water causes them to become active and

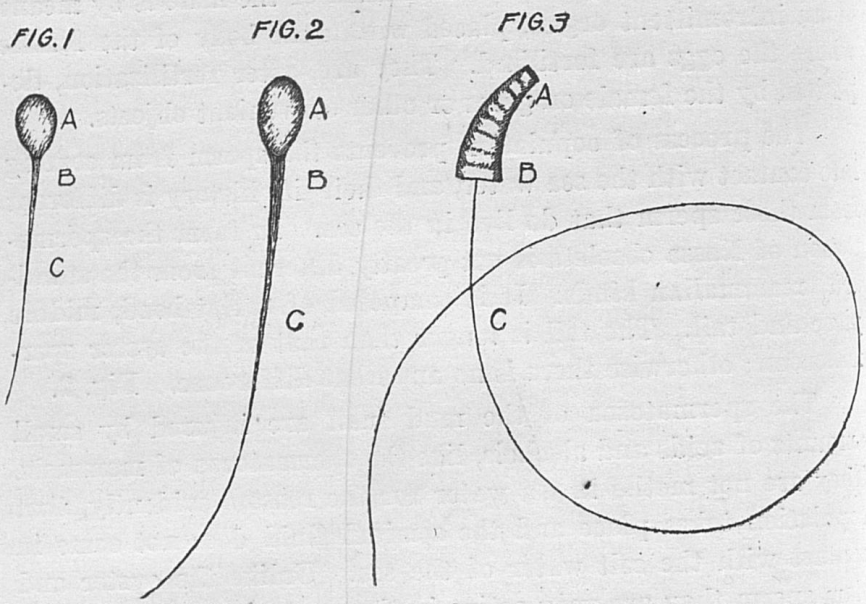
normal activity is manifested in solutions of NaCl varying from 2 to 3.5%.

4. The dilute solutions of alkalies are not apparently injurious to the spermatozoa.

5. The spermatozoa live and exhibit very great activity in 10 and even 15% solutions of alcohol.

6. Very dilute solutions of acid are injurious to the spermatozoa.

7. The spermatozoa of Nassa obsoleta resemble the spermatozoa of mammals rather than the spermatozoa of the oyster and clam.



EXPLANATION OF FIGURES.

Fig. 1. Diagrammatic representation of spermatozoon of Ostrea virginica. A, head. B, middle piece. C, tail.

Fig. 2. Spermatozoon of Nassa obsoleta. A, Head. B. middle piece. C, tail.

Fig. 3. Spermatozoon of Venus mercenaria. A and B, the horn-like head. C, the very long tail curved to correspond with the curve of the head.

Kentucky
Agricultural Experiment Station

University of Kentucky

LAND PRICES AND LAND SPECULATION IN THE BLUEGRASS REGION OF KENTUCKY.

BULLETIN NO. 240.

(Research Bulletin)

Lexington, Ky.

January, 1922

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BULLETIN NO. 240

(Research Bulletin)

Land Prices and Land Speculation in the Bluegrass Region of Kentucky.

By G. W. FORSTER*

THE PURPOSE

In recent years public attention has been directed toward the question of land values and land prices.[1] The focusing of attention on this question has been due, in part, to the rapid increase in land prices which has taken place during the last 20 years and, in part, to the recent speculative buying and selling which has occurred in many parts of the country. When it is considered how closely related the question of land values is to the many and difficult agricultural problems, such as tenancy, absentee landlordism, agricultural taxation, agricultural credit, cost of production and intensity of culture, it seems natural enough that the public should be interested. The relationship of land values to important social and economic problems bearing primarily upon agriculture, but at the same time affecting the whole body politic, furnishes at once the need and the justification of careful studies in this field.

This investigation, however, was not undertaken for the purpose of showing the relationship of land values to agricultural problems in general. Its scope is restricted to the study of

*Resigned to become Assistant Chief of the Office of Farm Management and Farm Economics, U. S. Department of Agriculture.

[1] In this bulletin the term "land prices" is used when the change in the price of land is one accompanying movements of the general price level. The term "land values" means changes in the value of land in relation to other commondities. It is conceivable that land prices might be increasing while land values as expressed in purchasing power might be falling. This distinction between land prices and land values is made for the purpose of exposition.

the economic and social forces and conditions which tend to influence the prices paid for farm land in a specific region at a time of active speculation, and to consider the probable effect of the rapid increase in land prices on agricultural production and on the economic and social status of the farming classes.[2]

DESCRIPTION OF THE AREA

The area to which this investigation applies is what is known as the Bluegrass Region of Kentucky. The part of the area studied includes the counties of Bourbon, Clark, Fayette, Jessamine, Madison, Scott and Woodford. These counties, the heart of the Bluegrass Region, constitute a very productive agricultural area with soil and climate especially favorable to agriculture. (See Figure 1)

The leading crops of the area are corn, oats, wheat, rye and tobacco. The two cereals, rye and barley, which were formerly of considerable importance in this region, have declined greatly since 1840. The oat crop was of much more importance in 1860 than it is today. At one time hemp was an important crop, but the introduction of white Burley tobacco, which proved to be more profitable, has greatly reduced the production of hemp. The relative importance of these crops is shown in Table 1.

White Burley tobacco is the most important money crop of the region. This crop has shown a most remarkable increase since 1880, both as to value and acreage. The reason for this popularity is its profitableness, because of the fact that the soil and climate are especially adapted to its production, and because it is a crop which furnishes fairly steady employment thruout the year.[3]

Owing to the excellent pastures, live-stock enterprises have always occupied an important place in the farming of this region. Beef cattle, tho not produced in as large numbers as formerly, are still of importance. Dairy cattle have shown a

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[2] Acknowledgment is due to Dr. L. C. Gray, Chief of the Division of Land Economics, Office of Farm Management and Farm Economics, U. S. Dept. of Agriculture, for valuable assistance in the preparation of the material presented in this bulletin.

Credit is due to Jesse W. Tapp, Junior Agricultural Economist, Office of Farm Management and Farm Economics, U. S. Dept. of Agriculure, who aided in gathering and tabulating the data.

[3] See United States Department of Agriculture Bulletin No. 482,

slight increase. The swine industry formerly was much more important than it is today, but during recent years this industry has shown a tendency to revive, more attention being given to the production of purebred stock. Sheep have continued fairly constant in number.

The transportation facilities of the region are well developt. Lexington, the largest city in the area, is served by three railway systems, which connect the region with the large western markets and with the Atlantic and Gulf ports. The city of Lexington is connected with the county seats of Scott, Bourbon, Jessamine and Woodford by both railway and electric trolley lines, and by rail with the county seats of Madison and Clark. (See Figure 1)

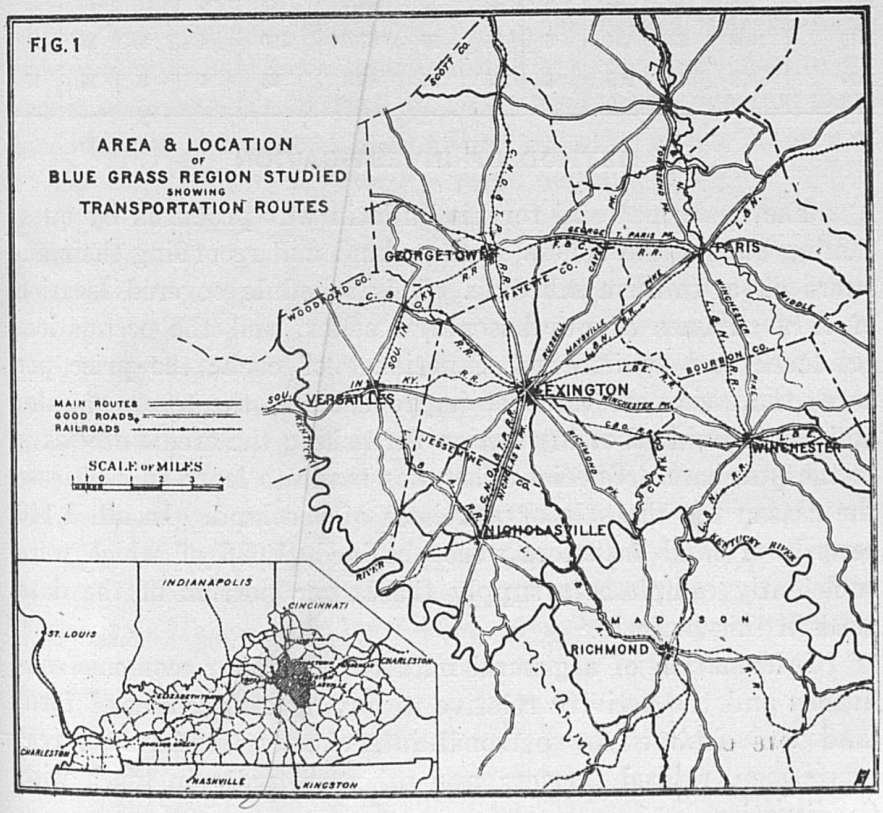


Table I.—Production of the principal crops and number of the principal classes of live stock for the counties of Clark, Fayette, Woodford, Madison, Scott, Jessamine and Bourbon, from 1850 to 1920 (U. S. Census).

Year	Crops (000 omitted)								Live Stock (000 omitted)			
	Corn, Bu.	Oats, Bu.	Wheat, Bu.	Rye, Bu.	Potatoes, Bu.	Hay, Tons	Tobacco, Lbs.	Hemp, Lbs.	Dairy Cows, No.	Other Cattle, No.	Sheep, No.	Swine, No.
1850	1222	143	49	14	24	2	27	3013	4	10	20	36
1860	1126	155	176	26	26	3	23	1665	4	10	13	28
1870	828	90	67	40	23	3	10	1510	3	10	8	18
1880	892	42	264	16	23	3	33	1121	3	10	24	19
1890	974	89	246	11	49	10	3006	2289	4	10	19	19
1900	766	29	303	6	18	10	4972	1145	4	11	16	15
1910	1008	23	194	6	55	10	6707	530	4	9	18	11
1920	878	18	209	6	165	26	8434	28	4	9	16	17

METHOD OF INVESTIGATION

The basic material for his bulletin was procured by questioning buyers and sellers of farm land and recording their answers on a uniform schedule. This schedule covered location of farm; names of purchaser and seller, and the occupation, residence and agricultural experience of each; the price per acre; the estimated value of improvements; the terms of sale; and the individual or institution furnishing the credit necessary to the purchase. Special effort was made to learn in each case the reason for the sale or purchase of the land. In all, 1,146 records of land transfers were obtained, 1,086 of which were sufficiently complete to supply the larger portion of the data used in this bulletin.[4]

Information of a general nature concerning economic conditions and the activity relative to buying and selling of farm land was obtained by personal interviews with farmers, real estate men, retired farmers, and others actually in touch with the situation.

Data on net rents from farm lands were obtained from 150 landlords who rent their farms on a cash, share, or share-cash basis. Additional data concerning farm income were obtained by survey of 52 farms. Farm management data on the cost of, and income from, tobacco were procured from the studies conducted on 81 farms in this region. (Kentucky Bulletin 229.) Additional data relating to the region were taken from the United States Census.

THE TREND OF LAND PRICES[5]

There was a time when free agricultural land of a good quality was very abundant in this country. Indeed, so vast was the area of our public lands that the supply seemed practically inexhaustible; nevertheless, the settlement of our public domain was so rapid that by 1890 good free lands in the humid regions of the United States had been practically all taken up. Soon after the passing of most of our public domain into private hands and more than keeping pace with the increase in our population, farm lands showed a strong tendency to increase in price. From 1850 to 1890 the average price of farm lands increased from $11.14 to $21.31 per acre, or an increase of 91 per cent. However, the too rapid settlement of our public lands and consequent overproduction of agricultural products, with a general downward movement of prices of commodities, resulted in the agricultural depression of the early nineties. Consequently, land prices did not increase during the decade from 1890 to 1900; in fact, they receded slightly.[6] From 1900 to the present time, however, there has been a phenomenal increase in prices of farm land. For the United States as a whole, the increase has been 257 per cent, while in some states, notably Iowa, the increase has been as great as 407.6 per cent.

The commodity price index numbers shown in Fig. 2 were computed from the Bureau of Labor Statistics, Juergen's Index Series, and Hansen's Index Series. These three series of index numbers were converted into a continuous series from 1801 to 1920, base 1913 = 100.

Logarithmic scale has been used in all the charts in this bulletin in order to show the proper relationship between the curves. When two or more curves are plotted on a logarithmic

[5] Farm land with improvements.
[6] See Figure 2.

FIG. 2. TREND OF COMMODITY PRICES, LAND VALUES AND POPULATION, UNITED STATES, 1800-1920.

scale they may be compared directly with each other. For example, if two curves move together, it means that the percentage increase or decrease of one is equal to the percentage increase or decrease of the other, irrespective of their position on the chart.

TREND OF LAND PRICES IN KENTUCKY

The rise of land prices in Kentucky has been somewhat similar to, altho not quite as marked as, the general rise for the United States as a whole. From 1850 to 1890 the average price of farm land in Kentucky increased from $9.15 to $16.17 per acre, or an increase of 76 per cent. During the years from 1860 to 1900, land in the state showed a slight tendency to increase in price, the percentage increase for this period being 14.2 per cent.

From 1900 to 1920 the increase in common with other parts of the country has been phenomenal. For this period the increase per acre has been $43.01, or 247 per cent. (Table II).

Table II.—Average price per acre of farm land with improvements, for seven counties in Central Kentucky, from 1880 to 1920.[1]

COUNTY	1880	1890	1900	1910	1920
Bourbon	$58.61	$65.06	$72.39	$104.36	$270.31
Clark	31.61	47.90	50.83	83.58	171.55
Fayette	76.16	88.59	84.88	137.55	314.12
Jessamine	46.05	50.55	50.59	85.38	208.37
Madison	25.37	29.21	29.40	51.38	113.61
Scott	36.96	44.12	45.60	68.60	160.70
Woodford	47.87	59.82	59.08	95.16	217.28
Average	$41.67	$53.26	$54.41	$89.44	$200.25
Increase over preceding period	$16.24	$11.59	$1.15	$35.03	$110.81
Index. (Average price 1880)	100.00	128.00	130.00	214.00	481.00
Average for Kentucky	$13.92	$16.17	$17.38	$28.64	$60.39
Increase over preceding period	$2.76	$2.25	$1.21	$11.26	$31.75
Index. (Average price 1880)	100.00	116.00	125.00	206.00	434.00

[1]Census data.

FIG. 2. TREND OF COMMODITY PRICES, LAND VALUES AND POPULATION, UNITED STATES,

FIG. 3. TREND OF LAND PRICES, 1850-1920.

The relation of land prices in Fayette and the six contiguous counties covered by this investigation to the land prices of the state and to the nation is shown in Figure 3. From 1850 to 1890 land prices in this region increased from $34.09 per acre to $53.26 per acre. From 1890 to 1900 there was hardly any advance in the price of farm lands. During the last 20 years land prices have increased rapidly, reaching $200.25 per acre in 1920.

EVIDENCE OF ACTIVITY IN BUYING AND SELLING FARM LAND

As in many other sections of the United States, there occurred in the counties of Central Kentucky a period of extreme activity in the buying and selling of farm land. This activity was occasioned by the rapid rise in price of agricultural commodities generally, but more especially of White Burley tobacco. Under such conditions, given a rich agricultural region capable of producing a crop returning large profits, land prices naturally would be expected to advance. The data presented in table III show that sales increased 40 per cent between 1918 and 1920. Farm sales recorded in 1920 constitute 19.7 per cent of the total farms in the region. These data do not include resales or intermediate sales. When this is considered, it is evident the activity was far from being a superficial phenomenon.

Additional evidence could be marshalled if a complete study were made of the increase in the number of farms advertised for sale by the leading daily papers of the region. In normal times farm sale advertisements are not numerous. For one week in July, 1913, one of the leading daily papers did not carry a single line of advertisement involving farms above three and one-half acres. For the corresponding week in 1919, the same paper carried 77 inches of farm "ads" (at the rate of 14 lines to the inch) besides a page display advertisement of an auction sale of farm land.

FIG. 3. TREND OF LAND PRICES, 1850-1920.

Table III.—Number of farm sales recorded in the office of the county clerk for seven counties in Central Kentucy from 1918-1920.

COUNTY	Number of farms.			Per Cent Increase Over 1918
	1918[1]	1919[2]	1920[3]	
Bourbon	243	257	306	26
Clark	258	285	458	77
Fayette	312	440	525	68
Jessamine	196	149	200	2
Madison	461	378	545	18
Scott	337	383	402	19
Woodford	179	326	353	97
Total	1986	2218	2789	40

[1] September 1, 1917, to September 1, 1918.
[2] July 1, 1918, to July 1, 1919.
[3] July 1, 1919, to July 1, 1920.

PRICES PAID FOR LAND

In Table IV data are presented showing the prices received for 930 farms sold between January 1, 1917, and May 1, 1920. Land prices in these counties showed a marked increase for the years 1918, 1919 and 1920, as compared with 1917. For example, in 1918, prices showed an increase of $18.10 per acre over those of 1917; in 1919 there was an increase of $91.00 per acre; and for 1920, $118.10 per acre, over the prices of 1917. In this connection it is worth while to observe that but few farms sold for over $800.00 per acre, and out of 940 sales, only one farm sold for as much as $1,000 per acre. From reports in circulation at the time, the impression was likely to be gained that land was selling at much higher prices than these data indicate. It is believed, however, that the data presented are sufficiently extensive to give a correct impression of the condition in regard to the range in prices and the relative number of sales made at each price.

Table IV.—Average selling price per acre of farm land with improvements in 930 sales in seven counties of Central Kentucky.

COUNTY	1917		1918		1919		1920	
	No. of records.	Value per acre.	No. of records.	Value per acre.	No. of records.	Value per acre.	No. of records.	Value per acre.
Bourbon	15	$163.35	26	$180.90	44	$250.15	42	$332.28
Clark	1	112.42	7	178.19	40	267.14	52	272.45
Fayette	11	195.50	47	199.50	139	306.75	48	380.00
Jessamine	4	120.30	11	152.35	43	242.41	66	244.46
Madison	2	149.68	14	122.00	32	143.79	42	176.86
Scott	2	167.91	30	162.18	42	248.95	28	245.64
Woodford	3	164.92	17	192.50	47	222.09	75	251.08
Ave. value	38	$170.50	152	$188.60	387	$261.50	353	$288.60
Increase over preceding year				$18.10		$72.90		$27.10
Per cent of increase over 1917 prices				10.6		53.3		69.2

Table V.—Range in price per acre of farm land.

VALUE PER ACRE	1918		1919		1920	
	No. of farms.	Per cent of farms.	No. of farms.	Per cent of farms.	No. of farms.	Per cent of farms.
Under $100	18	12.0	18	4.8	15	4.2
$100—under $200	67	44.7	64	17.2	69	19.2
$200—under $300	46	30.7	135	36.2	101	28.2
$300—under $400	17	11.3	91	24.4	87	24.2
$400—under $500	2	1.3	36	9.7	53	14.8
$500—under $600			14	3.8	18	5.0
$600—under $700			9	2.4	10	2.8
$700—under $800			2	.5	3	.8
$800 and over			4	1.0	3	.8
Totals	150	100.0	373	100.	359	100.

THE BUYERS AND SELLERS OF FARM LAND

Frequently the statement is made that the buying and selling of farm land is done by professional traders or speculators, realtors, merchants, doctors, lawyers, teachers, or other non-farming, city-dwelling individuals, whose knowledge of farm land is necessarily limited and whose interests are not primarily associated with the business of farming. While there is an element of truth in such a statement, it is evident, if the data presented in Table VI be correct, that those most active in the buying and selling of farm land were not non-farmers, but farmers.[7]

Table VI.—Distribution of 940 farms bought and sold by farmers and non-farmers.

CLASS OF PURCHASERS	Farms Purchased		Purchasers		Farms Sold		Sellers	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Farmers[1]	791	84.1	725	87.7	748	79.6	556	84.6
Non-farmers	149	15.9	102	12.3	192	20.4	101	15.4
Totals	940	100.0	827	100.0	940	100.0	657	100.0

[1] Includes retired farmers.

While it seems true that non-farmers were active in buying and selling farm land, they did not, so far as direct sale or purchase was concerned, play such an important role as might be supposed. Their influence was exerted rather in an indirect way, as agents of the sales and purchases.

In this connection attention is called to the data presented in Table VII.[8]

It seems that the majority of those buying and selling farm land during the period under consideration were experienced landowners and in no sense can it be said that the buying and selling of farm land was principally done by a non-landowning class.

[7] In a recent study of farm land values in Iowa (U. S. D. A. Bul. No. 874), it was found that farmers constitued 71.7 per cent of the buyers and 71.5 per cent of the sellers.

[8] To faciliate the presentation of the data, the buyers and sellers were divided into two groups, the grouping being based on their experience as landowners. For example, in Group 1 were placed all those who became landowners during the period studied, while in the second group were placed those individuals who became landowners prior to the active period.

Table VII.—Average age, average age at first attainment of ownership, and average number years of ownership, of 721 buyers and 512 sellers classified according to farmers and non-farmers.

CLASS	Group I. First experience as owners.[1]						Group II. More than one year as owners.[2]									
	Purchasers			Sellers			Purchasers						Sellers			
	Number	Per cent	Ave. age	Number	Per cent	Ave. age	Number	Per cent	Ave. age	Ave. No. of years ownership	Ave. age at beginning of ownership.	Number	Per cent	Ave. age	Ave. No. of years ownership	Ave. age at beginning of ownership.
Farmers	125	84.6	39.1	48	82.8	42.6	509	88.8	45.6	16.0	29.6	402	88.6	49.6	21.3	28.4
Non-farmers	23	15.4	37.	10	17.2	39.8	64	11.2	45.7	10.98	34.7	52	11.4	47.7	12.9	34.8
Totals	148	100.0	38.9	58	100.0	42.6	573	100.0	45.6	15.34	30.13	454	100.0	49.4	20.36	29.1

[1] Individuals becoming owners for the first time during period studied.
[2] Individuals who became owners prior to the period studied.

Table VIII.—Classification of 721 purchasers and 512 sellers according to whether they became owners thru tenancy or became owners directly.

The Road to Ownership.	Group I. First experinece as owners.[1]						Group II. More than one year as owners.[2]					
	Buyers			Sellers			Buyers			Sellers		
	Number	Per cent	Per cent of total purchasers.	Number	Per cent	Per cent of total sellers	Number	Per cent	Per cent of total purchasers.	Number	Per cent	Per cent of total sellers
Owners thru tenancy.												
1. Farmers	96	64.9	13.4	26	44.9	5.1	265	46.2	37.	167	36.8	32.4
2. Non-farmers	3	2.0	.4	1	1.7	.2	9	1.6	1.	6	1.3	1.2
Sub-total	99	66.9	13.8	27	46.6	5.3	274	47.8	38.	173	38.1	33.6
Owners direct.												
1. Farmers	29	19.6	4.1	22	37.9	4.3	244	42.6	33.7	235	51.8	46.
2. Non-farmers	20	13.5	2.8	9	15.5	1.8	55	9.6	7.6	46	10.1	9.
Sub-total	49	33.1	6.9	31	53.4	6.1	299	52.2	41.3	281	61.9	55.
Total	148	100.0	20.7	58	100.0	11.4	573	100.0	79.3	454	100.	88.6

[1] Individuals becoming owners for the first time during the period studied

[2] Individuals who became owners previous to the period studied.

It appears, also, that a considerable proportion of those active in buying and selling farm land had been tenants prior to becoming landowners. Thus, in Group 1, Table VIII, 66.9 per cent of the purchasers and 47 per cent of the sellers had been tenants prior to acquiring the ownership of farm land. In the case of those who had acquired farm land prior to the period studied, as illustrated in Group II, Table VIII, 47.8 per cent of

the purchasers and 38.1 per cent of the sellers had been tenants before acquiring ownership. It is worthy of consideration that even some of the buyers and sellers classed as non-farmers were not without farm experience, as some individuals in this class became owners of farm land thru tenancy.[9]

To what extent were the conditions favorable for tenants to become landowning farmers? The data presented in Table VIII may help to answer this question. Out of the total of 721 purchasers, 13.8 per cent were tenants who were buying land for the first time. Of 86 living on farms, 74 were buying for the purpose of production. If we may consider that these 74 tenants buying for production were really trying to become landowning farmers, then only 10.3 per cent of the total purchasers of farm land were tenants becoming, or attempting to become, landowning farmers. Taking the data as a whole, it does not appear that tenants were becoming landowning farmers at a rate which could be considered encouraging, and it is doubtful if the number of tenants becoming landowning farmers during this period has affected materially the present situation relative to tenancy. Perhaps this may be more readily understood by observing the ratio of tenants to owners.

In 1880 there were 29 tenants for every 100 owners.[10] This ratio increased to 86 tenants per 100 owners in 1920. The trend of the curve (Fig. 3) from 1880 to 1910, if extended, would indicate what was to be expected in 1920. That it approximated what would be expected indicates strongly that the activity did not impede or favor the acquisition of land by tenants. (Table IX)

[9] Non-farmers, so-called, were those who at the time these data were gathered were not making farming their principal occupation, but rather were engaged primarily in some other business.

[10] These data include croppers. In this region a cropper is one who works tobacco land for a share of the crop. He is not a tenant as that word ordinarily is understood. He is rather a farm laborer who takes a part of the tobacco crop as pay for his labor. The increase in tenancy as indicated by the census data is due to a large extent to the rapid expansion of the tobacco area. Compare tables I and IX.

Table IX.—Number of owners, tenants, per cent of tenancy, and number of tenants per 100 owners from 1880 to 1920.

COUNTY	1880			1890			1900			1910			1920		
	Owners	Tenants	Per cent tenancy	Owners	Tenants	Per cent tenancy	Owners	Tenants	Per cent tenancy	Owners	Tenants	Per cent tenancy	Owners	Tenants	Per cent tenancy
Bourbon	722	210	22.5	728	320	30.5	753	670	47.1	726	670	48.0	812	1074	56.9
Clark	988	226	18.6	918	271	22.8	971	402	29.3	943	573	37.8	953	703	42.4
Fayette	733	338	31.5	634	431	40.5	691	554	44.5	745	660	47.0	905	1073	54.2
Jessamine	701	195	21.8	677	254	27.3	670	283	29.4	802	483	37.6	764	770	50.2
Madison	1660	388	18.9	1808	538	22.9	2047	694	25.3	2333	1437	38.1	2284	1274	35.8
Scott	1053	284	21.2	1008	533	34.6	1097	824	42.9	1099	815	42.6	1295	891	40.8
Woodford	445	216	32.7	422	252	37.4	543	510	48.4	532	601	53.0	576	775	57.4
Totals	6302	1857	22.8	6195	2599	29.5	6772	3937	36.8	7180	5239	42.2	7589	6560	46.4
Tenants per 100 owners		29			42			58			73			86	

THE MOTIVES OF SALE AND PURCHASE

Inspection of the data presented in Tables X and XI, indicates in a rather striking manner that speculation was an important feature of the activity. It is evident that farmers, as a class, were less active in speculative purchases than non-farmers, provided that speculative activity is measured by the per cent of total purchases.[11] For example, about 31 per cent of the purchases made by farmers could be designated as speculative purchases, while about 62 per cent of the purchases made by non-farmers fell into this class. It should be remembered, however, that the total speculative purchases made by farmers exceeded in number the total speculative purchases made by non-farmers.

Table X.—Number of farms purchased and number of individuals purchasing for certain specified reasons, classified according to farmers and non-farmers.

Reason for Purchase.	Farmers				Non-farmers				Total			
	No. of purchases.	No. of purchasers.	Per cent of purchases.	Per cent of purchasers.	No. of purchases.	No. of purchasers.	Per cent of purchases.	Per cent of purchasers.	No. of purchases.	No. of purchasers.	Per cent of purchases.	Per cent of purchasers.
Production	493	476	62.3	65.6	43	34	28.9	33.3	536	510	57.0	61.67
Speculation	186	144	23.5	19.8	92	63	61.7	61.8	278	207	29.6	25.03
Production and speculation mixed	80	81	10.1	11.0	.....	.....	.....	.....	80	81	8.5	9.79
Investment	13	13	1.6	1.9	8	4	5.4	3.9	21	17	2.3	2.06
Adding to estate	10	7	1.3	1.0	6	1	4.0	1.0	16	8	1.6	.97
Miscellaneous	2	3	.3	.5	.....	.....	.....	.....	2	3	.2	.36
Not specified	7	1	.9	.2	.....	.....	.....	.....	7	1	.8	.12
Total	791	725	100.0	100.0	149	102	100.0	100.0	940	827	100.0	100.0

[11] Purchases or sales were not designated as speculative unless the land had been purchased with the express purpose of reselling at a profit. Sales made by individuals who had owned the land for a period of years or before the period of activity, were not classed as speculative sales.

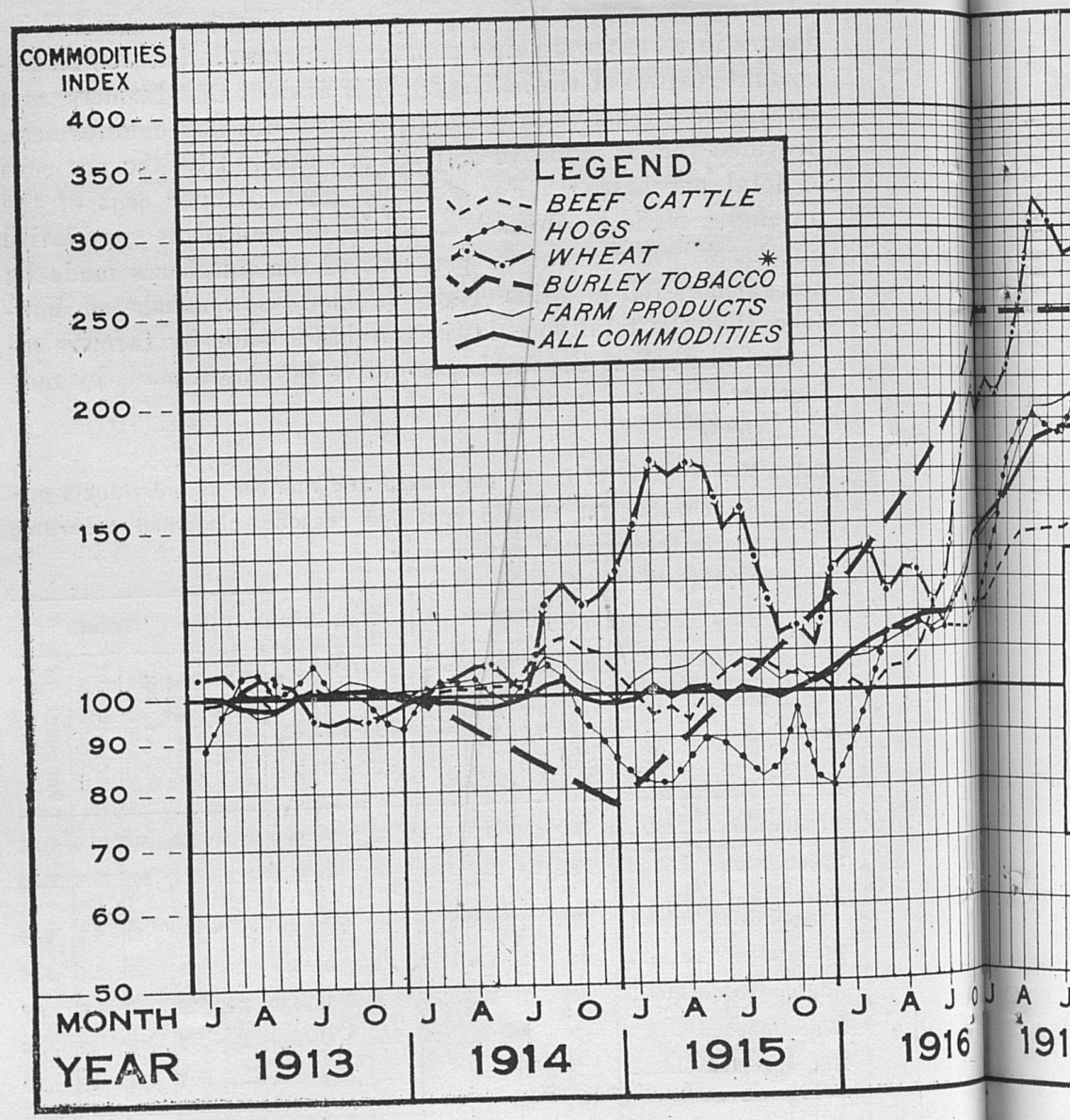
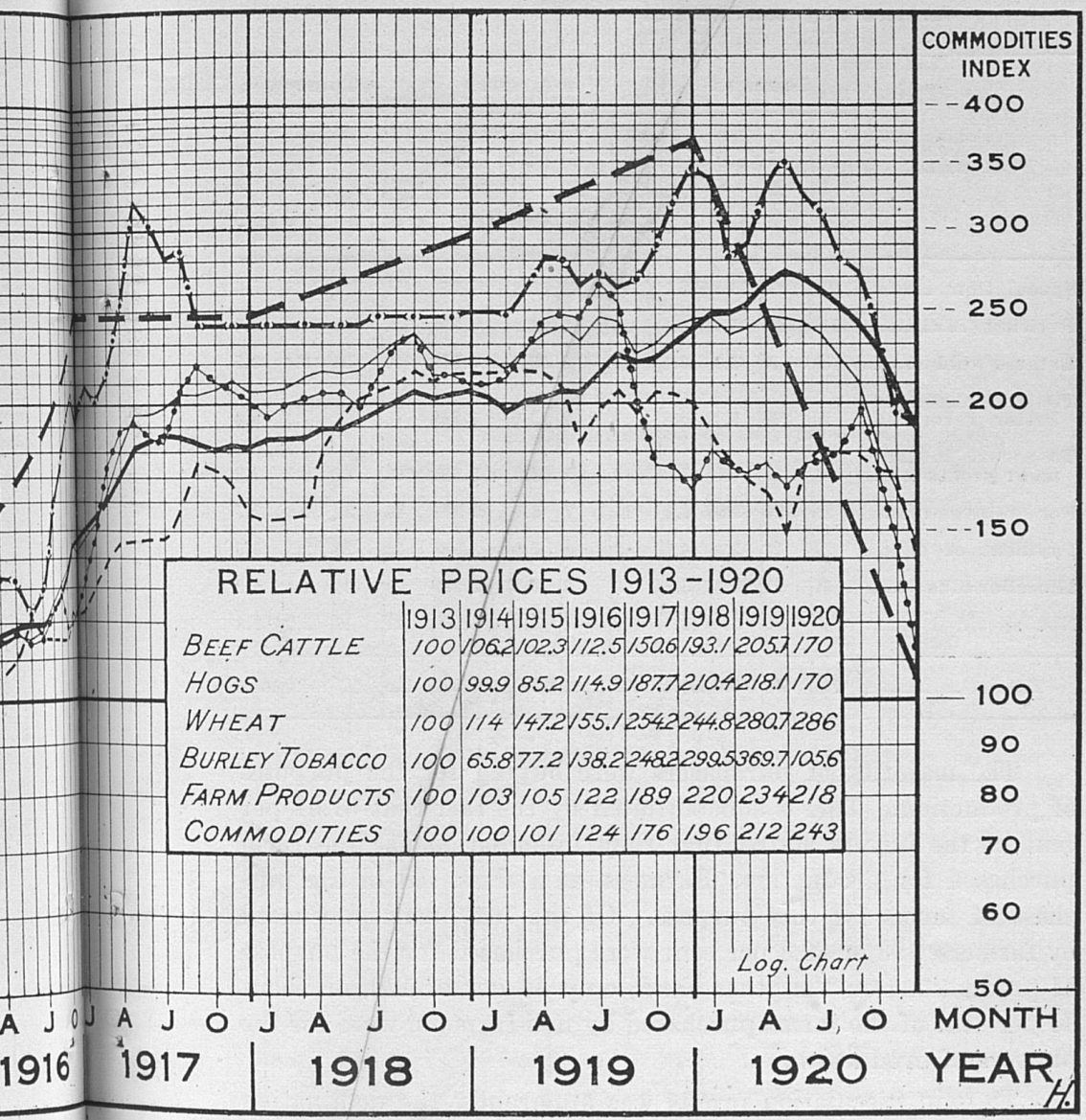


FIG. 4 TREND OF PRICES OF BEEF CATTLE, HOGS, WHEAT, TOBACCO, FARM PRODUCTS, A
INDEX, EQUAL 100.

*Wholesale price indices as of the Department of Labor, except Burley tobacco, which is based



RELATIVE PRICES 1913-1920

	1913	1914	1915	1916	1917	1918	1919	1920
Beef Cattle	100	106.2	102.3	112.5	150.6	193.1	205.7	170
Hogs	100	99.9	85.2	114.9	187.7	210.4	218.1	170
Wheat	100	114	147.2	155.1	254.2	244.8	280.7	286
Burley Tobacco	100	65.8	77.2	138.2	248.2	299.5	369.7	105.6
Farm Products	100	103	105	122	189	220	234	218
Commodities	100	100	101	124	176	196	212	243

CO, FARM PRODUCTS, AND ALL COMMODITIES. UNITED STATES 1913-1920. BUREAU OF LABOR INDEX, EQUAL 100.

tobacco, which is based on reports from Lexington, Winchester, Richmond and Paris markets.

Table XI.—Number of farms sold and the number of individuals selling for certain specified reasons classified according to farmers and non-farmers.

REASON FOR SALE	Farmers				Non-farmers				Total			
	No. of sales.	No. of sellers.	Per cent of sales.	Per cent of sellers.	No. of sales.	No. of sellers.	Per cent of sales.	Per cent of sellers.	No. of sales.	No. of sellers.	Per cent of sales.	Per cent of sellers.
Speculation	374	250	50.2	45.0	97	64	50.6	63.366	471	314	50.1	47.6
Retiring	117	100	15.7	18.0	5	5	2.6	4.950	122	105	13.0	16.0
Estates sold	38	17	5.1	3.1	52	6	27.1	5.940	90	23	9.6	3.5
To buy larger or better farm	66	60	8.4	10.8	2	2	1.0	1.980	68	62	7.2	9.4
To secure investment profits	54	39	7.2	7.0	9	9	4.7	8.910	63	48	6.7	7.3
For reinvestment	29	24	3.9	4.3	11	7	5.7	6.938	40	31	4.3	4.7
Payment of debt	24	23	3.2	4.1	2	1	1.0	.990	26	24	2.8	3.5
Miscellaneous	31	31	4.3	5.6	8	3	4.2	2.970	39	34	4.1	5.2
Not specified	15	12	2.0	2.1	6	4	3.1	3.960	21	16	2.2	2.8
Totals	748	556	100.0	100.0	192	101	100.0	100.004	940	657	100.0	100.0

The majority of purchasers were buying for the purposes of production. This is substantiated by the fact that 61.67 per cent of the buyers stated that they intended to use the farm purchased for production. Farmers, as a class, led in the purchase of farms for this purpose. Of the 791 farms purchased by farmers, 493 or 62.3 per cent were purchased for the purpose of production; on the other hand, only 43 out of 149, or about 30 per cent of the farms purchased by non-farmers, were for the purpose of production.

To gain speculation profits was apparently the dominating motive which impelled sellers to action, as 50.1 per cent of the total sales were made for this purpose. The farmers and non-farmers were engaged to about the same extent in this kind of activity. It should be pointed out, however, that the number of farms purchased for speculation by farmers far exceed in num-

ber those purchased by non-farmers. It should also be stated that in addition to purely speculative transactions there were others which were speculative in character. This apparently was true in some cases where farm land had been sold for the purpose of securing investment profit. In this same category, undoubtedly, should be placed some of the sales which were made to liquidate for reinvestment in some other business.

TERMS OF SALE

In the event that a period of rapidly increasing land prices be followed by a period of falling prices of agricultural commodities, those who buy on a narrow cash margin are likely to find themselves in a more precarious condition than those who pay a substantial portion of the purchase price in cash. In order to determine the proportion of the purchasers paying cash as compared with those who were paying part cash, data were gathered showing the terms of sale in the case of 842 transfers of land.

Table XII.—Per cent of purchase price paid in cash and length of deferred payments.

Length of deferred payments.	Amount paid in cash						Total	
	25 per cent	33 1-3 per cent	50 per cent	50-75 per cent	75-100 per cent	100 per cent	Number	Per cent
All cash	.....	.....	.....	.....	.....	176	176	20.9
1 year	1	3	14	7	6	.....	31	3.7
1–2 years	7	218	76	32	6	.....	339	40.3
1–2–3 years	8	195	23	7	2	.....	235	27.9
1–2–3–4 years	5	15	13	8	1	.....	42	5.0
Over 4 years	3	11	5	.....	.....	.....	19	2.2
Totals	24	442	131	54	15	176	842	100.0
Per cent	2.9	52.5	15.5	6.4	1.8	20.9	100	

AMOUNT PAID IN CASH

The data regarding cash payment are shown in Table XII. The per cent of the purchase price paid in cash varied from 25

per cent to 100 per cent. In many cases initial cash payments as low as 10 per cent were made, with the understanding that in addition to this 10 per cent, 23 1-3 per cent was to be paid on March first, or on taking possession of the farm. Fifty-two per cent of the sales involved a cash payment of 33 1-3 per cent of the purchase price. Sales which involved the payment of one-half of the purchase price amounted to 15 per cent of all the sales. Full cash payments were made in 176 transfers, or 20.9 per cent of all the sales.[12]

AMOUNT OF INDEBTEDNESS

It is evident from these data that a considerable indebtedness has been incurred. The most common terms of sale were 33⅓ per cent of the purchase price in cash, with the balance due in one and two, or one, two, three and four years. Deferred payments extended to four years in only 42 cases, and over four years in 19 cases. This indebtedness was to be paid in equal annual installments plus the accrued interest at 6 per cent. In most cases the deed was so worded that if the purchaser failed to meet any one of these annual payments with interest due at the time specified, all payments became due and collectible at once. It should not be inferred, however, that extension of time might not be granted to the purchasers. In fact, it is the custom in the region, wherever possible, to extend a number of years in which the debt may be paid off.

Practically all the lien notes were held by the sellers, banks or trust companies. A few notes were held by retired farmers. Banks were not advancing money to the purchaser for the purpose of meeting his annual payments unless a substantial portion of the purchase price had been paid in cash. In case one-half or more of the purchase price had been paid in cash, the bankers indicated a willingness to advance money to the purchaser for the purpose of meeting his annual payments. It appears doubtful if the bankers would be willing to advance money if only one-third or less of the purchase price had been paid in cash. This being the case, over 55 per cent of those purchasing farm

[12] Doubtless in some of these cases, a part of the purchase price was borrowed.

lands will not be able to get money from the banks in case they are not able to make their annual payments.

FACTORS INFLUENCING THE PRICE OF LAND

Earnings from Farm Land as a Factor Influencing the Price

One of the most common reasons advanced to account for the high land prices was that farm earnings, due to high prices received for farm products generally and tobacco in particular, had reached a point which justified the prices paid. Investigation shows that farm earnings did increase during the war period. As evidence of this, figures are presented in Table XIII showing the net rent received by 150 farmers who were renting their entire farms out to tenants. The average rate of return on the estimated value of the capital invested in real estate for 80 share-rented farms was 9.44 per cent, while the average net rent was $22.55 per acre. The majority of these 80 farms were returning a rate of return above the average.

The average net rent per acre for 45 farms rented on the cash basis in 1919 was $10.31, and $12.77 per acre for 19 farms in 1920. In the case of these cash-rented farms the average rate of return for the capital invested in real estate was 4.42 per cent in 1919 and 4.65 per cent in 1920. Thirty-two of the 45 farms returned a rate in excess of 4 per cent. As for farms rented for cash in 1920, only four returned a rate of less than 3 per cent, while fifteen returned a rate in excess of 4 per cent. As would be expected, the rate of net returns and the net rent per acre were less in the case of cash or share-cash-rented farms than those for share-rented farms. The difference is due in part to the fact that farmers who rent their farms for cash are relieved of a considerable portion of the risk normally involved in share renting, and in part to the increase in the prices of agricultural commodities.[13]

The data presented above are substantiated by the farm earnings on 52 farms, as determined by a careful analysis of the entire farm business. In 1919 these farms returned a rate of 8.45 per cent on the capital invested. While the average net re-

[13] It is interesting to note that in 516 cash-rented farms in 1919 in this region the average cash rent was $8.62 and the rate of return on capital in land was 4.34 per cent (census data).

Table XIII.—Rates of interest received on capital invested in farms, rented on share, share-cash and cash basis.

INTEREST ON CAPITAL.	Share—1919			Cash—1919			Share-cash—1919				Cash—1920			
	Number	Average rent	Average net rent per acre	Average rate, per cent	Number	Average rent	Average net rent per acre	Average rate, per cent	Number	Average rent	Average net rent per acre	Average rate, per cent	Number	Average rent	Average net rent per acre	Average rate, per cent
Under 3 per cent	3	$1,400	$3.23	1.18	13	$1,378	$5.69	2.29	1	$935	$5.50	2.	4	$3,727	$9.24	2.42
3 per cent—under 6	6	2,803	13.05	3.60	20	3,909	9.04	4.08					9	3,640	11.70	4.21
6 per cent—under 9	21	7,195	21.16	7.8	8	5,602	19.59	7.82	4	3,466	13.28	6.9	3	7,584	15.23	6.44
9 per cent—under 12	21	5,977	22.55	10.02									1	1,300	43.33	14.45
12 per cent—under 15	10	7,734	35.15	13.65	1	2,500	31.25	12.5								
15 per cent—under 18	8	7,213	31.91	15.65	1	1,311	45.70	15.9								
18 per cent—under 21	4	3,421	39.32	19.45												
21 per cent—under 24	3	3,843	26.87	22.66												
Over 24 per cent	4	7,331	150.00	35.17	2	731	81.24	28.5	1	9,754	107.20	28.6	2	2,975	126.59	26.3
Totals	80	$6,088	$22.55	9.44	45	$3,250	$10.31	4.42	6	$4,092	$18.09	8.7	19	$4,088	$12.77	4.65

turn per acre was $29, 55 per cent of the farms were above the average, both as to the rate of return on the capital and the net return per acre.

On the whole it may be inferred that agricultural production in this region was exceptionally profitable during 1919 and 1920 and this undoubtedly had a great influence on the prices paid for farm land. The danger lies in taking the income for any one or even two years as a basis for ascertaining the price which should be paid for farm land.

Generally speaking, the net rent attributable to the land is what determines its value. If the net rent is low, the value tends to be low. If the net rent is high, the value tends to be high, provided that the rate of interest at which the net rent is capitalized remains the same. It is sometimes said that the capital value of a piece of land is found by capitalizing the net rent at a normal rate of interest.[14] In determining the capital value of land, however, the probable future rents must be considered and it is not wise to say that the value of a piece of land is determined by the returns for a single year, unless it is certain that the return is a normal one and probably will continue to be received for an indefinite period.

Table XIV.—Average net returns[1] per acre, and average rate of return on capital invested in farming on 115 farms in Scott and Madison Counties in 1913.

Net return per acre.	No. of Rec.	Acres	Av. net return per acre	Av. rate of return per cent
Less than $5	59	377.02	$2.21	3.36
$5—$10	32	399.46	7.07	6.24
$10—$15	12	332.33	11.62	9.75
$15—$20	9	140.00	17.61	10.73
Over $20	3	57.66	30.69	12.10
Average	115	351.71	$5.27	4.13

[1] Net returns were calculated by deducting the estimated value of the farm labor from the farm income.

[14] To find the present capital value of an acre of land divide the net rent by the rate of interest.

That the returns from farming in this region were not as large in years prior to the period of activity is substantiated by the data presented in Table XIV. The average net return on the total capital invested in the farm business in the case of 115 farms was $5.27 per acre, while the average rate of return was 4.13 per cent. Seventy-nine per cent of the farms rented less than 10 dollars, net, per acre. Such facts ought to be considered in attempting to arrive at a fair price for farm lands.

The Influence of Tobacco Prices on the Prices Paid for Farm Lands

As already pointed out, one of the most important factors influencing prices paid for farm land was the remarkable profit secured from tobacco during the seasons of 1918 and 1919, owing to unusually high prices. The average farm price on December 1, 1913, for White Burley tobacco was 12.3[15] cents per pound. The 1919 crop sold for an average price of 45.48 cents per pound,[16] thus showing an increase of 269 per cent since 1913.

During the same period the cost of producing tobacco did not increase as rapidly as did the price. The cost of producing a pound of White Burley tobacco in this region in 1913 was 12.7 cents,[17] while the cost of production in 1919 was 26 cents.[18] Thus while there was an increase of 269 per cent in the price of tobacco there was only an increase of 104 per cent in the cost of production.[19] That the price of tobacco increased faster than did the cost of production is evidenced by the large profits which were realized from the production of tobacco during the two or three years preceding 1920. This is shown in Table XV. Such profits, however, were not realized for the 1920 crop. (See Table XVI).

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[15] Yearbook U. S. D. A., 1913.
[16] Average price on Lexington, Winchester, Paris and Richmond markets.
[17] U. S. Dept., Bulletin 482, page 25.
[18] Kentucky Bulletin 229, page 173.
[19] It should be pointed out that these two sets of data are not strictly comparable, owing to the different methods of obtaining them. They are, nevertheless, highly suggestive, and indicate that the cost of production lagged behind the price of tobacco.

Table XV.—Net gain per acre received from land in tobacco on 81 farms in the Bluegrass Region, with range in acreage, average receipts, expenses and gain per farm for 1919.

Range in Tobacco Acreage	Average acres of tobacco per farm.	No. of farms.	Per cent of farm acreage in tobacco.	Average receipts per farm.	Average Expense per farm[1]	Average gain per farm.	Average net gain per acre 1919.
Under 5 acres	3.05	32	3.5	$1,562.50	$540.00	$1,022.50	$335.50
5–10 acres	7.4	27	11.93	4,245.00	1,324.00	2,921.00	395.00
10–15 acres	12.3	17	13.22	9,055.00	2,398.00	6,657.00	540.00
15–20 acres	17.1	2	6.98	17,614.39	3,443.78	14,170.61	829.00
Over 20 acres	28.06	3	7.57	20,851.41	6,126.94	14,720.47	525.00
Average	7.72	81	8.0	$5,140.00	$1,470.00	$3,670.00	$476.00

[1] Includes every expense except land rent.

Table XVI.—Net loss per acre from land in tobacco on 74 farms in the Bluegrass Region, with range in acreage, average receipts, expenses and loss per farm for 1920 crop.

Range in Tobacco Acreage.	Av. acreage of tobacco per farm.	No. of farms.	Average receipts per farm.	Average expense per farm.[1]	Average loss per farm.	Average net loss per acre 1920.
Under 5	3.06	27	$340.65	$596.89	$256.24	$83.74
5–10	7.06	27	1,087.11	1,323.91	236.80	33.54
10–15	11.69	13	1,895.40	2,218.92	323.52	27.67
15–20	15.17	3	1,788.14	2,562.44	774.30	51.04
Over 20	22.98	4	3,870.77	4,491.97	621.20	27.03
Average	7.6	74	$1,135.64	$1,437.34	$301.70	$39.70

[1] Includes all expenses except land rent.

The Inflation of the Currency and Its Effect on Land Prices

A prevalent opinion was that the rapid advance in land prices was due in part, if not entirely, to the depreciation in the purchasing power of the dollar. It should be understood, how-

ever, that the value of a piece of land is dependent largely upon the net earnings which can be attributed to it. The magnitude of these earnings is dependent upon two things, (1) the cost of production and (2) the prices paid for the commodities produced. The purchasing power of such net income is determined by the general price level.[20] If the price of a farm product should be doubled because of inflation and, at the same time, the cost of production should also double, then the net earnings will be doubled. If, however, the cost of production does not increase as rapidly as the rise in prices of commodities produced, then the net earnings attributable to the land will be more than doubled. On the other hand, if the cost of production increased more rapidly than the prices, the net earnings will be less than double.

A third factor to be considered is the rate of interest at which the net earnings attributable to land are to be capitalized. If the net earnings of a piece of land remain the same, an advance in the interest rate means a lower capital value, while lowering the interest rate means a higher capital value for the land. If, during a period of inflation, the rate of interest at which the net earnings are capitalized increases, this would tend to lower the capital value. Farmers have shown a strong tendency to be willing to accept a rate of interest lower than a current rate, believing that the difference in the two rates would be made up by the increases in the value of the land, by residential advantages and by other benefits. The willingness on the part of farmers to accept a low rate of interest has tended to make the price of land higher than the economic rent alone would seem to justify.

Persons who purchased land during this period believing that its value varied inversely with the purchasing power of the dollar, may find that they have invested their money unwisely. While it is true that during a period of inflation prices of farm products are likely to advance more rapidly than the cost of production, thus making payment of debt easier, it is equally true that during a period of deflation prices are likely to fall

[20] Purchasing power of net incomes could be determined by dividing such incomes by the index of the prices of all commodities.

more rapidly than the cost of production, thus making the payment of debts difficult and sometimes impossible.

Land Speculation in Relation to Land Prices

There seems to be a common belief that in some way speculative buying and selling has an effect on the prices paid for land. This belief no doubt is attributable to the fact that high prices are usually accompanied by land speculation. Speculation must, however, be looked upon, in a large measure, as an effect rather than a cause of high prices. It is true, of course, that people will yield to illusions created by certain shrewd and cunning promoters and to the extent that this is true speculation must be considered a cause of high prices. In the main, however, it would appear that people were moved to buy because they believed that the earnings of the land justified the prices paid.

Miscellaneous Causes

The counties of central Kentucky always have been looked upon by farmers living in the eastern tier of counties as a highly desirable place in which to live. It was natural enough then, when coal, oil and other minerals were discovered in these outlaying counties, that farmers should begin to move to the Bluegrass Region. Many of these farmers, well supplied with money, were quite willing to pay good prices for land about which they had heard so much and which they desired so intensely. The buying of farm land by these persons exerted an appreciable influence on the prices paid for land.

Thruout its history the Bluegrass Region has been occupied by farmers who attached a great deal of significance to land ownership, aside from its income-producing power. The result of this has been the formation of several large and many small estates. The building up of these has in the past exerted an influence on the prices of land. The feeling exists, as strong as ever, that to own land in this region carries certain social advantages. This doubtless played its part in influencing the prices of farm land, especially where the hope was held out that land acquired could be paid for out of the earnings of tobacco

in a relatively short time. Such factors, however, are hard to determine and their influence is difficult of measurement, yet their presence helps to explain why high prices were paid for farm land.

THE EFFECTS OF THE LAND BOOM

A full presentation of the effects of the recent activity in the Bluegrass Region of Kentucky can not be given at this time because several years must elapse before all the effects are fully registered on the prosperity of the region and the status of the agricultural workers. It is essential, however, to a study of this nature, to present at least such effects as thus far have been registered, in order that the situation may be properly understood.

FINANCIAL LOSSES INCURRED

It is now obvious that some unwise purchases were made during the period and in order to determine to what extent this was the case, data were gathered regarding 146 persons, all of whom were in financial difficulties. In obtaining these data, no attempt at a complete canvass of the situation was made. These 146 men are considered to be representative of others in a similar position. Bankers and others in close touch with the situation express the opinion that at least fifty per cent of those who bought land just prior to 1920 are in financial difficulties, and approximately ninety per cent of those who bought in 1920.

The data presented in Table XVI give an idea of the nature of the action which was taken in regard to those who were unable to meet their deferred payments. Thirty-eight of the 146 voluntarily deeded back the farm to the former owner, thus incurring cash losses which averaged $9,356. It should be remembered that some buyers had made improvements in the way of erecting buildings, the value of which should be added to the cash payment to determine the total financial loss.

Table XVII.—Action taken in the case of 146 purchasers who were unable to meet their payments on March 1, 1921.

Action	No. of farms.	Average size (acres)	Average purchase price	Average of cash payment	Average amt. of indebtedness	No. of years allowed to pay out					
						1	2	3	4	5	6
Group I—First experience as owners (Individuals becoming owners for the first time.)											
Cancellation	19	90	$19,476	$5,678	$13,798	1	9	4	2	2	1
Time extended	37	70	18,318	7,285	11,033	4	13	14	4	2	.....
Sued	1	81	34,000	10,000	24,000	.....	1	.....	.....	.....	.....
Sold Farm	3	84	24,999	11,450	13,549	.....	2	1	.....	.....	.....
Miscellaneous	2	48	9,656	3,031	6,625	.....	1	1	.....	.....	.....
Action pending	6	104	24,818	8,524	16,294	2	1	3	.....	.....	.....
Total or average	68	79	$19,486	$7,044	$12,442	7	27	23	6	4	1
Group II.—More than one year as owners.											
Cancellation	19	133	$38,814	$13,034	$25,780	1	5	11	1	.....	1
Time extended	24	91	28,672	10,324	18,348	2	11	8	2	1	.....
Sued	3	175	30,947	6,250	24,697	.....	1	1	.....	1	.....
Sold Farm	6	103	32,630	7,122	25,508	.....	2	.....	3	1	.....
Action pending	12	131	39,295	15,019	24,276	1	6	2	2	.....	1
Total or average	64	116	$34,152	$11,518	$22,634	4	25	22	8	3	2
Group III. Experience as to ownership not specified.											
Time extended	4	102	$30,995	$12,268	$18,727	1	.....	3	.....	.....	.....
Sued	2	70	26,848	8,783	18,065	.....	.....	2	.....	.....	.....
Sold Farm	4	119	33,653	9,006	24,647	.....	2	.....	1	1	.....
Action pending	4	38	11,713	4,450	7,263	.....	1	3	.....	.....	.....
Total or average	14	84	$25,652	$8,603	$17,048	1	3	8	1	1	.....
Summary.											
Cancellation	38	111	$29,145	$9,356	$19,789	2	14	15	3	2	2
Time extended	65	80	22,921	8,714	14,207	7	24	25	6	3	0
Sued	6	124	30,089	7,719	22,370	0	2	3	.....	1	0
Sold Farm	13	103	31,184	8,700	22,484	0	6	1	4	2	0
Miscellaneous	2	48	9,656	3,031	6,625	.....	1	1	.....	.....	0
Action pending	22	107	30,331	11,325	19,006	3	8	8	2	.....	1
Total (average)	146	95	$26,506	$9,155	$17,356	12	55	53	15	8	3

Table XVIII.—Farm income of 176 farmers operating under normal conditions.[1]

SIZE OF FARM.	No. of records.	Farm Income.		
		Average.	Range.	Per cent over average.
Less than 100 acres	16	$1,045	—$298 to $3,100	37.5
100-200 acres	45	1,448	—748 to 3,591	42.2
200-300 acres	50	2,185	151 to 4,951	40.6
300-400 acres	26	2,325	—202 to 6,219	46.1
Over 400 acres	39	5,080	538 to 15,908	30.8

[1] Data obtained in connection with Farm Management Survey conducted in 1914.

If the purchaser was able to pay the interest, or the interest and part of the principal, the seller was inclined to allow an extension of time. This extension of time was usually for one year, but in a few cases an indefinite period was granted provided the purchaser could meet his interest payments promptly. Of the 146 cases, 44.5 per cent represented buyers who were being given extensions of time. These had made an average cash payment of $8,714, with an average indebtedness of $14,207. In 54 out of these 65 cases, the indebtedness was to be paid off in three years or less.

A few purchasers were trying to sell their farms in an attempt to meet their financial obligations. Most of these attempts, however, resulted in failure, because there was no market for the land at prices high enough to bring even sufficient funds to liquidate the deferred payments.

Suit against purchasers for failure to meet deferred payments was not generally instituted. Suit was brought only in cases in which the purchaser refused to do anything regarding the payment of interest or principal, or had other property which could be attached.

In addition to cases of cancellations, extension of time, farms sold and individuals being sued, a number of cases of purchasers in financial difficulties, on which no action had been taken, were still pending.

Table XIX.—Interest on deferred payments at 6 per cent for 113 individuals in financial difficulties.

SIZE OF FARM.	No. of records.	Interest on Deferred Payments at 6 per cent.		
		Average.	Range.	Pre cent over average.
Less than 100 acres	75	$609	$60-$2,100	43
100-200 acres	31	1,487	240- 3,080	42
200-300 acres	4	2,095	1,542- 2,883	50
300-400 acres	3	1,860	1,206- 2,723	67

The income-producing power of those in financial difficulty is not known and for that reason their ability to meet their financial obligations can only be conjectured. However, some idea as to whether or not these individuals will be able to pay for their farms may be gained by studying the data presented in Tables XVIII and XIX.[21]

Assuming that the data presented in these tables are comparable, it would seem that the majority of the purchasers would be able to pay the interest on their indebtedness and, to some extent, liquidate the principal. If, however, the majority are to pay for their farms, the number of years in which payment may be made must be extended.

[21] Farm income, as determined from farm management survey records, is the difference beween receipts and expenses, with due regard to accruals and deferrd charges as ordinarily understood in business practis. The receipts consist of the actual cash received for products sold from the farm, the value of services rendered and the money value of increase in inventory. The expenses consist of all cash payments actually made belonging to the year's business (allowing for those costs of the year's business which may not have been paid but stood as charges at the end of the year), for the value of the services of the members of the family other than the operator himself, for depreciation of buildings and equipment and the decrease, if any, in the money value of the inventory. In this connection it should be pointed out that the farmer's own labor and interest on the value of the farm property are not included in the expenses. The farm income represents a fund for current family use which the farmer cannot overdraw without impairing his capital. It should be understood, also, that because of interest on indebtedness and because an ample part of the farm income is often in goods rather than in cash and the current financial needs of the business must be paid out of this income, it does not represent a sum altogether available for living expenses or paying debts. It is rather the gross profit of the farm as a business.

It is true, of course, that some of the purchasers will be able to pay off their indebtedness in the time stated in the agreement. However, whether or not the majority of the purchasers will be able to pay for their farms will depend to a large extent upon the economic conditions as they affect agriculture. The data presented in Table XVIII represent normal conditions. This should be understood clearly in making comparisons of the data presented in Tables XVIII and XIX.

The material presented in Table XX furnishes information relative to the progress made by tenants in their attempt to become permanent landowning farmers. It has been pointed out that the data available indicate that there is no sound reason for believing that tenants made any progress in becoming landowning farmers. This contention is substantiated by the cases under consideration. Of 146 cases, 44 were tenants just before their purchase. The records show that 16 of these voluntarily gave up their farms, suffering an average cash loss of $5,678; 26 had to be given an extension of time, while two sold their farms because they were unable to meet their payments.

LIBERAL CREDIT SYSTEM

It has been said that the present situation could be relieved materially if a more liberal credit system were established, which would permit individuals to buy land on a larger margin of credit than is permitted by existing agencies, including the Federal Farm Loan System. The establishment of such a credit system doubtless would help individuals possessing exceptional ability. There is reason to believe, however, that a liberal credit system thru which loans could be produced at a lower rate than that charged by existing credit agencies would stimulate the demand for land to such an extent that it would be over-capitalized. Everything considered, it would appear that an improved credit system, however useful as an emergency measure, would not furnish a remedy for the present situation nor would it prevent the recurrence of high land prices. The solution of the present difficulties would seem to lie in the utilization of the

Table XX.—Agricultural experience, occupation and residence, and reason for purchasing of 146 individuals who were unable to meet their payments on March 1, 1921.

ACTION.	No. of records.	Agr. Experience.			Occupation, Farmers.	Reason for Purchase.		
		Av. age.	Tenant.	Non-tenant.		Production.	Speculation.	Not Specified.
FIRST EXPERIENCE AS OWNERS								
Cancellation	19	37	16	3	19	18	....	1
Time extended	37	40	26	11	37	36	1	....
Sued	1	42	....	1	1	1	....	....
Action pending	6	46	....	6	6	4	1	1
Sold farm	3	36	2	1	3	2	1	....
Action miscellaneous	2	48	....	2	2	2	....	....
Sub-total	68	40	44	24	68	63	3	2
MORE THAN ONE YEAR AS OWNERS.								
Cancellation	19	49	....	19	19	7	11	1
Time extended	24	47	1	23	24	17	7	....
Sued	3	44	....	3	3	1	1	1
Action pending	12	42	3	9	12	9	3	....
Sold farm	6	48	....	6	6	5	1	....
Sub-total	64	46	4	60	64	39	23	2
EXPERIENCE AS TO OWNERSHIP NOT SPECIFIED.								
Time extended	4	48	1	3	4	3	....	1
Sued	2	45	1	1	2	....	....	2
Action pending	4	50	1	3	4	2	1	1
Sold farm	4	39	....	4	4	2	2	....
Sub-total	14	46	3	11	14	7	3	4
Total	146	43	51	95	146	109	29	8

existing credit agencies rather than in the establishment of a new system. In those cases where the individuals have paid a large part of the purchase price in cash and are able to meet their interest payments, together with small payments on the principal, it would seem advisable to extend the number of years in which these deferred payments could be made.

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THE WHITE FLIES OF HOTHOUSES

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BULLETIN NO. 241

(RESEARCH BULLETIN)

THE WHITE FLIES OF HOTHOUSES

Asterochiton Abutilonea*

By H. GARMAN

Asterochiton Vaporariorum

By H. H. JEWETT

During the past fifteen years gardeners and florists in Kentucky have become familiar with very small, white, sucking insects appearing in great numbers on leaves of plants grown under glass and becoming a very serious pest, difficult to destroy and, at their worst, rendering unsightly and valueless most of the plants in a house. The exact date of their appearance in Kentucky as hothouse insects cannot now be determined. It is probable that one of our two species was introduced with infested plants from time to time before our attention was drawn to it. In 1908 and 1909 it appeared in destructive numbers in one of the Station hothouses and some attention was then given to the life history and habits. It was found that not one but two species were working on hothouse plants, sometimes one, sometimes the other predominating, but because of their small size passing with practical men and others not very familiar with insects as one species. At first a species with banded wings was most numerous; later this insect became less common and another with pure white wings predominated, tho the species with banded wings (*Asterochiton abutilonea*) could be found at all times with the other (*A. vaporariorum*) in small numbers.

*Drawings and figures by and under the direction of H. Garman, Head of the Department of Entomology and Botany.

Details of the investigation on **Asterochiton vaporariorum** carried out by H. H. Jewett, research Assistant Entomologist, Department of Entomology and Botany.

The two insects belong to the same family as the notorious citrus fly (*Dialeurodes citri*) of orange trees in Florida and other southern states, and injure the plants in exactly the same way. In fact they are so much like the southern fly and so very small that ordinary observers would not recognize them as different. The adults, tho small, quickly attract attention because of their constant flitting about when plants are disturbed; they puncture the plants, but probably three-fourths or more of the injury is done by the singular scale-like young which, after a brief preliminary stage during which they have legs and creep about, settle down on the surfaces of the leaves, hundreds of them on a plant. One of the illustrations of *A. abutilonea* shows how thickly plants become covered with the young.

The banded-wing white fly of our hothouses is probably a native insect, occurring out-of-doors on a common weed known as velvet leaf (*Abutilon theophrasti*), but deserts this for other plants; and indoors it feeds on almost anything available, showing, however, a fondness for the leguminous plants. It was first observed on a Florida plant (*Sesbania macrocarpa*) grown from seed in the hothouse. It could not have been brought from the south, as no other southern plants were at the time grown in the house. Its invasion of hothouses is thus due to the presence of its favorite weed in the vicinity during the fall months when ventilators must be kept open, a fact suggesting an obvious preventive treatment.

The eggs of this species were observed in the Insectary in September, 1908, and recently hatched young obtained from them on the twenty-second of the month, minute objects with short, jointed legs, moving slowly over the leaves like the young of San Jose scale. The eggs are placed on the leaves somewhat irregularly, at times in perfect circles, again a few together, frequently scattered singly. Fresh eggs laid February 1, 1909, were pale yellowish, or greenish, glossy and, unlike those of *A. vaporariorum*, remained pallid, tho assuming finally a slight pinkish appearance, until hatched. They are to be distinguished, also, from those of *A. vaporariorum* by the stalk for attachment

to the leaf tapering somewhat gradually into the body of the egg, and when attached the eggs are inclined with one side to the leaf, whereas in *A. vaporariorum* they stand erect or nearly so. The eggs measure 0.12 mm. in length and 0.10 mm. in diameter. Those laid February 1 did not hatch until February 12, but it was thought probable that the low temperature at which the house was kept delayed the development. Eggs were obtained again April 1, and hatched on the thirteenth of this month, the two observations together giving a period of about twelve days.

The young of *A. abutilonea* measure 0.37 mm. to 0.52 mm. in length, are translucent whitish, with a yellow spot on each side behind the middle of the body. As the insect settles down on the leaf it begins to secrete from close-placed round pores at its sides a marginal fringe which finally becomes the side wall of the pupa case. With growth other secretions appear at the dorsal edge of the body forming finally a fringe of translucent setae, and the whole central dorsal region of the integument becomes black, a feature by which it can be distinguished at a glance from *A. vaporariorum*.

A pupa case from red clover measures 0.86 mm. long and 0.50 mm. in width; the long marginal setae measure 0.34 mm. and short ones 0.14 mm. The central region is uneven and black, the operculum yellow.

Adults emerge as in the related species from a dorsal cleft extending from the front margin to the middle of the body, thence outward on each side to the margin. This opening closes after the winged fly comes forth and the case again looks like a perfect insect. Adults emerging January 22, 1909, stood erect on the cleft as they worked their way out, with their wings rolled into pads at the sides of the body. At this stage they were pure white, with the eyes red. Fifteen minutes after freeing themselves the wings were fully expanded, but still white. As the crust of the body became rigid after emerging the characteristic black markings appeared. Mature flies, as represented in the figures, have zig-zag cross bands on the front wings, the hind wings being unmarked, and an elongate mark

at the base. The double eyes are black to ordinary inspection, but under a hand magnifier, dark red, the two parts separated by a narow white bridge, the dorsal division the smaller, the facets in sixes surounding an unpigmented central region. Ocelli are apparent on the head between the compound eyes. The claws of the feet are rather strongly divergent, acute, with a series of long hairs along one side. The median pulvillar structure is as long as the claws, slender, acute, but expanded and obliquely cut off at the tip. The terminal claspers of the male are broad, knife-like, acute; the median appendage is slender, curved, tapering, the tip somewhat hooked.

The white species (*A. vaporariorum*), to which most attention has been given may be recognized when mature, at once, under a magnifier, by being pure white, the only duskiness of consequence being a black tip of the rostrum, this feature, however, being present in *A. abutilonea*. The egg of *A. vaporariorum* is attached by a slender stalk and widens perceptibly at the base, thence contracting to the tip. It stands erect on the leaf instead of inclining toward it, and gradually assumes a decided purple hue before the young hatch.

A peculiar feature of both species, which is present also in other members of the family we have studied, is a powdery coat with which the whole body and wings are dusted. This powder produces the white hue of the insects, the real color beneath being honey-yellow, in great part. The purpose of this coating evidently is to protect the flies against moisture. Small insects like this but with smooth bodies sometimes become fatally stranded in droplets of water collecting on the leaves they frequent. The source of the waxy powder is extensive glandular developments of somites in the ventral side of the abdomen. Four of the basal somites of the male are thus modified, while two are present in the female. These remarkable structures are suggestive of the wax glands on the ventral side of the abdomen of the honey bee. The wax secreted is clawed off and transferred to the body and wings by the feet, somewhat as it

is in the bee in making honeycomb. The figures represent the structures in *A. abutilonea,* but serve well for the glands on the body of the related insect.

The sexes of the insects are readily recognizable by these glands, but there are other features by which any one may tell them apart. The male has three conspicuous appendages at the tip of the abdomen, which are represented in figures 4, 5 and 6. The appendages on the female are less evident and are commonly turned upward and inward, out of the way. The male appendages of *A. vaporariorum* are less slender than those of *A. abutilonea* and the tips of the claspers are edged beneath, those of the male of the other species being plain in this region.

The following account of the transformations of *A. vaporariorum* is not presented as a completed work. The study was undertaken in the hope that some means might be found to destroy the insects in all their stages without doing harm to the plants. The adult flies can be destroyed readily enough, by some of the means suggested, but young are constantly hatching when a house has become thickly infested, and repeated fumigations are required to keep the flies from reinfesting the plants.

Two facts of primary importance in dealing with the insects have been learned in the course of our observations. *A. abutilonea* is an out-of-door insect, invading hothouses when given opportunity in the fall of the year. *A. vaporariorum* is practically a hothouse pest, and perishes in winter out-of-doors. Therefore, only when the native insect is permitted to become established in hothouses in the fall is it calculated to do mischief, and only when *A. vaporariorum* is brought in on plants. Knowing the source from which the insects come, there should be no great difficulty in preventing infestation of hothouses.

Asterochiton Vaporariorum

HABITS AND LIFE HISTORY

Few adults were to be found in the Insectary at the time this work was assigned in the latter part of January, 1914. The Insectary had been fumigated a few days previous to the assignment and but few immature individuals escaped the treatment. It has been found, however, that thru the cold winter months of this season, the insect was not as numerous as in the warmer months. The insect increases slowly thru the months of January, February, March and April, but after that time there is a very marked increase up to the colder weather in the fall.

DISSEMINATION AND HIBERNATION OF THE INSECT

The adults begin to appear outside the greenhouse about the first of May and may be found there until the heavy frosts in the fall. They do not fly to any great distances, and then in an irregular manner, but no doubt a few escape from the greenhouse by flying. A number of adults are sometimes taken out of the greenhouses on rubbish and on plants that are to be transplanted. The wind is a very important factor for carrying the adults short distances and is a chief agency for disseminating the insect. In the latter part of the summer, the insect may be found at considerable distances from greenhouses.

This species does not live outside of greenhouses, according to observations made during the winter season, and careful search did not result in the finding of the insect in any of its stages at that time. Hardy plants, bearing leaves on which were all stages of the insect, were placed outside the Insectary to determine the effect of cold on the insect. In a few days all the leaves were examined and all stages of the insect were found to be dead.

FOOD PLANTS

The insect is a very general feeder on greenhouse plants and it can live on a large number of plants outside of greenhouses during the summer months. Immature stages of the insect were found on the following plants, and no doubt there

are many more on which it feeds: Bean, white lupine, Canfield pea, soybean, cowpea, sweet pea, bur clover, red clover, sweet clover, alfalfa, Lespedeza, hairy vetch, redbud, honey-locust, black locust, yellow-wood, rose, tobacco, potato, tomato, *Solanum nigrum,* muskmelon, cucumber, *Amaranthus spinosus,* lettuce, *Lactuca canadensis,* Chrysanthemum, *Ambrosia artemisiaefolia, aster,* Taraxacum, sp, Convolvulus sp, morning-glory, Ploygonum sp, Avalis, Geranium, *Lepidium virginicum, Malva rotundifolia, Sida spinosa,* Hibiscus sp, and Berberis.

FOOD PREFERENCES AND FEEDING HABITS

The insect, tho a very general feeder, prefers certain plants as food, noticeably, tomato, cucumber and muskmelon. These plants become literally covered with the insect in all its stages if remedial measures are neglected. The plants are greatly weakened and injured by its attacks. The excretions of the larvae, together with any excess moisture in the greenhouse, encourage fungus growth which, tho it may kill some of the larvae, hinders the respiration of the leaves and causes them to wither and die. Both the larvae and adults get their food by sucking juices from the plant, so that in hot weather especially, plants are likely to wilt. The adults prefer the young plants or growing tips on which to feed, and they collect on these in large numbers rather than on old plants or old leaves. On an old plant, all stages of the insect can be found. Adults do not feed readily on leaves on which are "red spiders" or plant lice.

MATING OF ADULTS

Adults of both sexes collect on the under surfaces of the leaves and remain there most of the time unless disturbed. Mating takes place freely when the adults are not confined too closely, but isolated pairs do not mate readily. Preliminary to copulation, a number of males frequently surround a female or there may be one at each side of her. The males are the active sex and stroke the head and antennae of the female with their antennae for some time, accompanying this activity with wing movements. One or more males may be seen performing these

movements at the sides of a female. Presumably fertilized females were often observed to brush the males aside when the males came near them. In copulating, the female raises the abdomen and the male clasps her with his clasping organs from beneath. The copulating pair remain joined together on the average for about five minutes, but the time may be lengthened or shortened. Females were not observed to copulate more than once during the whole period of egg laying.

OBSERVATIONS ON EGG DEPOSITION

Place and Manner of Egg Deposition.—Very few eggs are placed upon the upper surfaces of the leaves, but overcrowding on the under surfaces no doubt tends to cause more deposition on other surfaces of plants. Counts of eggs distributed on different surfaces of plants in May, June and July, are given below:

May, 1914,	Upper surface of leaves	56
	Under surface of leaves	3594
	Stems	20
June, 1914,	Upper surface of leaves	131
	Under surface of leaves	7060
	Stems	28
July, 1914,	Upper surface of leaves	131
	Under surface of leaves	5280
	Stems	31

The eggs are deposited in an irregular manner on the surfaces of the leaves or in the form of circles and parts of circles. When depositing the eggs in the form of a circle, the female inserts her beak into the leaf tissue and using the beak as a pivot swings around and deposits the eggs one at a time. The time during which the female keeps the beak inserted in the leaf varies considerably. In cases observed, this lasted as long as 12 hours and without doubt is often prolonged. The largest number of eggs found in any circle was 29, and of 3670 eggs counted in May, 1914, 864 were arranged in circles or parts of circles and 2806 were scattered over the surface of the plant. The tendency to deposit eggs in circles is greater where the plant sur-

faces are smooth. The actual time taken to deposit the egg is short, the average being three seconds. The female depositing the egg bends the abdomen under the body and places the end firmly against the support and then on raising the abdomen leaves the egg fastened to the leaf. The space between eggs in circles is small.

Number of Eggs Deposited by a Single Female.—The females do not begin depositing eggs immediately after emerging from the pupa cases but feed for a few hours to one or more days. This is true for both the females that are fertilized and those that are not. The number of eggs deposited by nine fertilized females ranged from 28 to 121 and the number of eggs deposited by eight unfertilized females ranged from 46 to 91. The largest number of eggs deposited by one of these 17 females in a single day was nine, the daily average being 3 or 4. The individual egg-laying records follow:

Fertilized Females:

Fertilized 2/ 9/14, deposited 110 eggs, died 3/20/14.
Fertilized 2/10/14, deposited 80 eggs, died 3/18/14.
Fertilized 2/18/14, deposited 121 eggs, died 3/28/14.
Fertilized 2/28/14, deposited 74 eggs, died 4/ 1/14.
Fertilized 3/19/14, deposited 85 eggs, died 4/20/14.
Fertilized 4/10/14, deposited 71 eggs, died 5/14/14.
Fertilized 5/ 9/14, deposited 54 eggs, died 5/30/14.
Fertilized 6/18/14, deposited 28 eggs, died 6/29/14.
Fertilized 6/23/14, deposited 40 eggs, died 7/ 9/14.

Average 74

Unfertilized Females:

Emerged from pupa case 2/28/14, deposited 71 eggs, died 3/26/14.
Emerged from pupa case 3/21/14, deposited 91 eggs, died 4/24/14.
Emerged from pupa case 3/23/14, deposited 83 eggs, died 4/25/14.
Emerged from pupa case 4/ 7/17, deposited 87 eggs, died 5/ 6/14.
Emerged from pupa case 4/20/14, deposited 81 eggs, died 5/19/14.
Emerged from pupa case 4/23/14, deposited 96 eggs, died 5/19/14.
Emerged from pupa case 4/23/14, deposited 56 eggs, died 5/16/14.
Emerged from pupa case 5/ 9/14, deposited 46 eggs, died 5/31/14.

Average 76

HATCHING OF THE EGGS

When freshly laid, the egg is white or white with a yellowish-green cast. It begins to darken in two or three days and at the time of hatching is nearly black or dark brown. A number of eggs were discovered while the young were hatching from them. The first evidence of hatching is the rupturing of the case from the apex to the base. The young larva forces its way out of the case, ventral side to the slit. It first appears rather rounded in shape, but gradually flattens out as it crawls on to the leaf. The empty case collapses and bends over on itself. The egg stage lasts from 6 to 13 days, according to temperature conditions. Under prolonged low temperature, the maximum period may be slightly increased. Eggs on leaves that die do not hatch unless the egg period is nearly completed.

MOVEMENTS OF THE LARVAE

The newly hatched larvae do not fasten themselves permanently to the leaf immediately on hatching, but wander about on the leaf in an irregular path for some time. This migratory period usually ends after a few hours to a day. No instance was observed in which a larva crawled from one leaf to another, and this could hardly take place unless the leaves were in very close contact. The larva is easily turned aside by hairs or other obstacles. Larvae travel at the rate of about one to two mm. a minute, seldom more and even less. In one case observed, the larva required twenty minutes to travel 1 mm. The larva seldom gets farther away from the egg case than 10 to 15 mm. Very little activity was noted for the larvae after they became fastened permanently in the leaf. A slight turning on its axis, using the beak as a pivot, and a somewhat more pronounced movement of the caudal part of the body in the shedding of the skin, were the movements observed after the larva had secured itself to the leaf.

This motion of the caudal part of the body was simply an up and down movement. Voiding of excrement was evident in the viscid material collected in drops at the caudal end of the body. The larval skin breaks loose from the body near the anterior

end and is gradually worked off over the abdomen by the aid of the up and down movements of the abdomen. It sometimes requires as much as 15 to 20 hours to accomplish this act, or even more. After the skin is removed, the body spreads out flat on the surface of the leaf. Sometimes when the skin is not completely removed, the body becomes constricted at that point.

EMERGENCE OF THE ADULT

The adult escapes thru a T-shaped opening on the dorsal side of the pupa case. This opening is made by a slit which begins at the anterior end of the case and extends thru the mid-dorsal region to the base of the abdomen where it joins a transverse slit which extends down the sides of the case. The time necessary for the young insect to escape is about 35 minutes, that is after the opening has been made. The newly escaped insect remains on the pupa case in a nearly perpendicular position until the appendages assume their natural shape and color and the wings expand into their normal form. Waxy secretions found on the older adults are not present at the time of emergence.

LENGTH OF LIFE OF THE ADULT

Adults live for a considerable length of time as indicated by those confined in breeding jars. Very few dead specimens can be found in the greenhouse in the colder months and but slightly more in the hot months. Breeding jar experiments indicate a longer life period by a few days in the colder months. The longest life period recorded was 46 days and in general the period lies within 30 to 40 days. Adults confined in jars without food do not live long. In April, 1914, on different days, 447 adults were confined in jars without food; they commenced to die at the end of 18 hours and were all dead at the end of 54 hours. Other observers record periods as long as three days.

PROPORTION OF MALES AND FEMALES

Unfertilized females readily deposit eggs and there is no appreciable difference in the number deposited by unfertilized and fertilized females. An unfertilized female's eggs pro-

duce all males, but a fertilized female's eggs do not produce all females. During March, April and May, 1914, eight unfertilized females deposited 611 eggs; these produced only males. C. B. Williams, 1917, in his paper, "Sex Ratios and Parthenogenesis" Jour. Genetics, Vol. VI, No. 4, p. 266, states in his summary:

"*Aleurodes vaporariorum* has two races, one of which, found in England, produces females parthenogenetically; the other, found in the United States, produces males. A colony of what is apparently the male-producing race has been found in England."

Records of the progeny of fertilized females show that nearly 40 per cent are males and 60 per cent females; a record of 170 individuals reared shows 105 females and 65 males. During May, 1914, 818 adults were collected from plants in the greenhouse; of these, 549 were females and 270 males. However, in March, 1914, the proportions were reversed; out of 362 adults collected, 212 were males and 150 were females.

LENGTH OF A BROOD AND OF THE LARVAL AND PUPAL PERIODS

The time necessary to complete all the stages of the brood varies considerably according to the season. In winter more time is necessary to complete a brood than in summer; in fact, the shortening of the brood in summer is quite appreciable. The average length of a brood, determined from 174 rearings, is 31.87 days. The time necessary to complete a brood varies from 21 to 41 days. By allowing a few days for fertilization of the females, this would give a generation in a little more than five weeks thru the year.

Larval Periods.—The larva of the white fly moults three times before entering upon the pupal stage. These stages may be lengthened or shortened by temperature conditions. In the summary of rearings of 174 individuals in table 4, the first larval instar averages 4.74 days, the second 4.26 days, the third 4.14 days; the first varies from 2 to 8 days, the second varies from 2 to 8 days, and the third varies from 2 to 6 days.

Pupal Period.—The pupal period spoken of here is the stage from the third moult of the larva to the emergence of the adult, but during the first part of this period the growth is still continuing and this, therefore, should be called the fourth larval period. However, there is no fourth shedding of the skin. The pupal period, as noted in summary of rearings, table 4, averages 9.15 days, with variations from 6 to 13 days. No doubt the maximum period would be increased under prolonged lower temperatures. These averages were made from rearings in February, March, April, May, June and July of 1914.

RECORD OF REARINGS. 1914

TABLE 1. Nine Females that had Copulated

Incubation Period of Egg	Larval Instars 1	Larval Instars 2	Larval Instars 3	Pupal Instar	Length of Brood	Number Reared	Sex
Average	days 9.42	days 4.82	days 4.24	days 4.13	days 31.74	61	Females
Range	6-13	2-8	2-8	6-13	21-41		
Average	8.39	4.31	3.91	4.13	9.05	29.79	38	Males
Range	6-12	2-8	2-8	3-6	7-13	21-40		

TABLE 2. Six Females that had not Copulated

Incubation Period of Egg	Larval Instars 1	Larval Instars 2	Larval Instars 3	Pupal Instar	Length of Brood	Number Reared	Sex
Average	days 10.29	days 4.85	days 4.32	days 4.05	days 9.14	days 32.65	55	Males
Range	9-12	3-7	3-6	3-5	7-11	29-36		

TABLE 3. One Female that had Copulated

Incubation Period of Egg	Larval Instars 1	Larval Instars 2	Larval Instars 3	Pupal Instar	Length of Brood	Number Reared	Sex
Average	days 10.15	days 5.00	days 4.60	days 4.25	days 9.30	days 33.30	20	Males
Range	10-12	3-6	3-6	4-5	8-12	31-36		

TABLE 4. Summary

Incubation Period of Egg	Larval Instars 1	Larval Instars 2	Larval Instars 3	Pupal Instar	Length of Brood	Number Reared	Sex
Average	days 9.56	days 4.74	days 4.26	days 4.14	days 9.15	days 31.87	174	Females & Males
Range	6-13	2-8	2-8	2-6	6-13	21-41		

Explanation of Tables of Rearings

Table 1. The rearings presented in this table were made from eggs deposited in February, March, April, May, June and July by 9 females that had copulated.

Table 2. The rearings presented in this table were made from eggs deposited in March, April and May by 6 females that had not copulated. These females were taken as they emerged from the pupa cases and were then isolated in breeding jars.

Table 3. The rearings presented in this table were made from eggs deposited March 2-8, by a female that had copulated, but because the progeny were all males the records were kept separate.

Table 4. This table presents a summary of the rearings of tables 1, 2 and 3.

THE STAGES OF THE INSECT

The Egg.—The egg is ovoid in shape, somewhat elongated, pointed at the apex and slightly flattened or concave on the side. It is small and not readily noticed without the aid of a lense. It varies from .2 to .5 mm. in length and has a diameter slightly less than .1 mm. at the thickest part. The surface is smooth and has no markings. It is white with a yellowish-green cast when freshly laid. Each egg is fastened to the leaf with a small, slender stem, which extends from the base of the egg.

The Larva.—The larva moults three times and with each moult there is an increase in size. The color is light green. In the first instar, the larva is nearly oval in outline with the abdomen slightly tapering. A pair of eyes, the antennae, the mouth parts, the legs and the segmentation are readily observed on the ventral side; a pair of eyes, the vasiform orifice and the segmentation are readily observed on the dorsal side. The dorsal segmentation is more pronounced in the abdominal region. In the second and third instars, the body is more elliptical than in the first stage and the antennae and legs are more nearly atrophied; otherwise, there are no very marked differences except in size. The average length of the larvae at the end of the first instar is .285 mm.; at the end of the second instar, .375 mm., and at the end of the third instar, .519 mm.

The Pupa.—The pupa is yellowish-green in color and is oval to elliptical in outline. The empty case is white, and it remains attached to the leaf for a long time. The pupa is

slightly convex, thicker than the larva and averages .75 mm. long by slightly less and .5 mm. wide. The dorsum bears a number of glass-like rods or waxen secretions of two sizes. The short, rather blunt rods are submarginal, with their bases nearly in alignment, and in general they curve down over the margin. The larger and longer rods usually are arranged in seven pairs, tho the number may vary, as is the case with the shorter rods. The longer rods are arranged within the shorter rods on the dorsum; one pair close to the cephalic margin, one pair a short distance back of the first on the cephalic region, a pair on the thoracic region, two pairs on the abdominal region, a pair on the caudal margin and a pair on the caudo-lateral margin. This arrangement of rods is an aid in determining this species of *Asterochiton*. The eyes appear as reddish spots in mature pupae.

The Adult.—The adult white flies are small, four-winged insects provided with sucking mouth-parts. The wings and body become covered with a powdery waxen secretion soon after the adults emerge from the pupa cases. The male is smaller than the female, with the abdomen more pointed. Each wing has a single median vein with a slight branch at the base of the vein in the fore wing. The fore wings are larger than the hind wings. The body, legs and antennae are yellowish, wings white, the tip of the beak black, and the eyes reddish or reddish-brown. The average length of the female from the anterior end to the end of the wing is 1.48 mm., the average wing expanse, 2.48 mm.

PARASITES OF THE WHITE FLY

Encarsia pergandiella.—During the four years covered by these observations, parasites have not been present at any time in sufficient numbers to aid materially in controlling the white fly. A Hymenopterous parasite was collected in November, 1914, which was determined as being *Encarsia pergandiella*. This parasite disappeared after about six weeks. About four per cent of the pupae were parasited at that time. The parasite deposits its eggs in both the pupae and larvae, and it is very active in hunting the immature stages in which to deposit its eggs. Two females, on November 24, 1914, a. m., were observed

to thrust their ovipositors into ten different larvae and pupae. These larvae and pupae were isolated and on December 3, 1914, a. m., seven adult parasites emerged from the cases.

Fungus.—The viscid nature of the excrement of the larvae together with warm, damp weather encourages fungus growths. Frequently, a dark, sooty fungus makes its appearance among the larvae and pupae and many of them are killed by it. This fungus no doubt at times does some good, but it is likely to interfere with the respiration of the leaves of the plant and cause them to die. The fungus was not identified.

REMEDIES

A number of experiments were made at the Station Insectary during the time the study of the white fly was in progress, in an attempt to find an effective remedy; both fumigants and contact insecticides were used. Potted tomato plants were used in all the experiments. A statement of methods, experimental data, discussion, and recommendations follows:

FUMIGANTS

Potassium Cyanide.—Potassium cyanide was used in the first test of hydrocyanic acid gas as a fumigant. The cyanide was 98 per cent pure and was "fumigation cyanide." The old formula: 1 part cyanide, 1 part acid and 4 parts water, was used. The sulfuric acid was a good grade of commercial acid.

The cyanide was first carefully weiged out, and the water and acid measured, then the acid was poured into the water in a small crock. The plants were then placed in the fumigation box, and the cyanide was put into the diluted acid and the box door closed. The foliage of the plants was dry when fumigated and the earth in the pots free from excess moisture. The weights of the cyanide used in these experiments varied from 5 to 10 milligrams per cubic foot of content of the box. Duration of exposure was three hours, 15 hours and 15.5 hours. When the fumigation was completed, the plants were removed from the fumigation box and were kept isolated in one part of the Insectary until the results of the fumigation were recorded. The fumigation box has a capacity of 50 cubic feet and was practically air-tight.

Sodium Cyanide.—Sodium cyanide was used in a few tests of hydrocyanic acid gas as a fumigant. The cyanide was designated as 129 per cent, with 51 per cent cyanogen, and was a brand used for fumigation. The sodium cyanide was used according to the following formula: 1 part sodium cyanide 1½ parts of a good grade commercial sulfuric acid and 2 parts water. In the experiments with sodium cyanide, 5.4, 6.2 and 6.9 milligrams of the cyanide were used per cubic foot. The general plan of these experiments was the same as that for potassium cyanide. The fumigation box had a capacity of 25 cubic feet.

Para-dichlorobenzene.—Para-dichlorobenzene was used alone as a fumigant and in combination with other chemicals. In preparation for fumigation, the para-dichlorobenzene was crushed into particles about the size of coarse salt. When used alone, it was spread evenly over the bottom of a shallow glass dish of about 12 inches in diameter and in this condition was placed in the fumigation box. Four and six ounces of the fumigant to a box of 25 cubic feet capacity were used in the experiments, the test lasting fifteen hours. After the fumigation the plants were isolated and the results of the fumigation recorded. All tests of para-dichlorobenzene and combinations with it were made in a box of 25 cubic feet capacity.

Para-dichlorobenzene and Acetone.—Two ounces of para-dichlorobenzene were put into two ounces of acetone and the combination was emptied into a flat dish in the fumigation box. The plants were then placed in the box and the tests were continued for 2, 4, 8 and 12 hours respectively. At the end of the tests the plants were isolated as in the other experiments.

Para-dichlorobenzene and Carbon Tetrachlorid.—Two ounces of para-dichlorobenzene were put into a dish containing two ounces of carbon tetrachlorid and the combination was placed in the fumigation box. The plants were fumigated for 2, 4, 8 and 12 hours respectively. They were then removed from the fumigation box, and the effects of the fumigation recorded.

CONTACT SPRAYS

Kerosene Emulsion.—The kerosene emulsion was made according to the standard formula: kerosene 2 gallons, whale-oil soap ½ pound and water 1 gallon. The spray was made by mixing one part of the emulsion with 11, 12, 13, 14 and 15 parts of water, respectively. The plant to be sprayed was placed on a large sheet of paper and after the spraying such adults as remained fastened to the paper were counted and the number added to the number of dead adults on the plant. The adults alive on the plant after the spray had dried were collected and counted and an estimate of the adults killed was found. The plant was kept isolated until all the data had been recorded.

Whale-oil Soap.—Whale-oil soap spray was made by dissolving 1 ounce of the soap in 1 gallon of water or 1.5 or 2 ounces to each gallon for the stronger sprays. The spraying and subsequent treatment of the plants was the same as for the kerosene emulsion spray.

Schnarr's Insecticide.—A spray was made of this emulsion by using 1 part of the emulsion to 30, 40, 50 and 60 parts of water, respectively. The spraying was conducted in the same manner as that for the kerosene emulsion. The plants were kept isolated until all observations had been recorded.

TABLE 5. Potassium Cyanide, 1-2-4 formula. 1914-1915

No. of Experiments	Temperature F. Degrees	Duration of Test. Hours	Wt. of Cyanide per cu. ft. milligrams	Effect on Plants	Per Cent Dead at End of Test, Average				Range in Per Cent of Adults Dead
					Eggs	Larvae	Pupae	Adults	
3	67-68	3	5	no injury	1.4	34.7	23.8	92.8	85-98
checks	do.	do.	0	do.	1.7	4.5	6.3	none	
1	54.5	15.5	5	do.	0.8	38.1	28.9	89.5	
check	do.	do.	0	do.	0.5	3.6	5.8	none	
3	68-69.8	3	6	do.	1.7	33.2	41.4	95.8	90-100
checks	do.	do.	0	do.	1.3	4.9	7.6	none	
1	68	15	6	do.	1.4	47.7	40.1	98.8	
check	do.	do.	0	do.	1.9	4.5	7.6	none	
3	64.5-72	3	7	do.	1.8	70.7	47.8	99.3	98-100
checks	do.	do.	0	do.	1.1	3.5	6.8	none	
1	66	15	7	do.	1.6	68.9	43.5	100	
check	do.	do.	0	do.	1.7	4.8	6.8	none	
2	59	3	8	do.	1.1	78.3	45.2	99.5	99-100
checks	do.	do.	0	do.	1.2	4.3	8.3	none	
2	57-69.8	15	8	do.	1.9	86.2	37.3	100	
checks	do	do.	0	do.	1.7	5.7	7.4	none	
3	64.5-68	3	9	do.	3.1	88.9	70.8	100	
checks	do.	do.	0	do.	1.5	3.8	7.4	none	
1	57	15.5	9	do.	4.2	94.0	71.1	100	
check	do.	do.	0	do.	0.6	5.2	6.5	none	
3	59-68	3	10	slight injury	2.5	91.2	82.0	100	
checks	do.	do.	0	no injury	1.2	4.9	8.8	none	
2	59-62.5	15	10	slight injury	1.8	94.0	65.5	100	
checks	do.	do.	0	no injury	1.9	5.8	9.3	none	

TABLE 6. Sodium Cyanide. 1919-1920

No. of Experiments	Temperature F. Degrees	Duration of Test, Hours	Wt. of Cyanide Per Cu. Ft. Milligrams	Effect on Plants	Per Cent Dead at End of Test, Average		
					Larvae	Pupae	Adults
1	64.5	3	5.4	no injury	65	45	100
4	50-80	15	do.	do.	68	39.5	100
checks	do.	do.	0	do.	3.4	5.8	none
6	51-75	15	6.2	slight injury	82.1	51.5	100
checks	do.	do.	0	no injury	3.8	7.5	none
2	50-68	3	6.9	moderate injury	84	67.5	100
2	60-66	15	do.	slight injury	90	75	100
check	do.	do.	0	no injury	5.5	10.5	none

TABLE 7. Para-dichlorobenzene. 1919

No. of Experiments	Temperature F. Degrees	Duration of Test, Hours	Wt. of Para-dichloro-benzene Per 25 Cu. Ft. Ounces	Effect on Plants	Per Cent Dead at End of Test		
					Larvae	Pupae	Adults
1	70	15	4	no injury	77.3	40.1	100
check	do.	do.	0	do.	2.4	4.3	none
1	75	15	6	leaves injured	91.3	75.0	100
check	do.	do.	0	no injury	2.4	4.3	none

TABLE 8. Para-dichlorobenzene and Acetone. 1919

No. of Experiments	Temperature F. Degrees	Duration of Test, Hours	Amount of Each used, Ounces	Effect on Plants	Per Cent Dead at End of Test		
					Larvae	Pupae	Adults
1	77	2	2	no injury	1.8	3.6	00
1	do.	4	do.	do.	30.2	14.3	100
1	do.	8	do.	do.	64.5	18.0	100
1	do.	12	do.	tips of leaves killed	66.3	20.2	100
1	do.	do.	0	no injury	2.3	6.5	none
check	do.						

TABLE 9. Para-dichlorobenzene and Carbon Tetrachloride. 1919

No. of Experiments	Temperature F. Degrees	Duration of Test, Hours	Amount of Each used, Ounces	Effect on Plants	Per Cent Dead at End of Test, Average		
					Larvae	Pupae	Adults
2	74-79.7	2	2	no injury	0.9	3.0	00
2	do.	4	do.	do.	5.3	2.9	100
2	do.	8	do.	considerable injury	8.9	3.4	100
2	do.	12	do.	do.	26.9	6.5	100
2	do.	do.	0	no injury	1.7	2.7	none
checks	do.						

TABLE 10. Kerosene Emulsion. 1915

TABLE 10. Kerosene Emulsion. 1915

No. of Experiments	Temperature F. Degrees	Dilution	Effect on Plants	Per Cent Dead at End of Test, Average				Range in Per Cent of Adults Dead
				Eggs	Larvae	Pupae	Adults	
5	69.8	1-11	leaves spotted, slightly burned	1.6	82.5	48.7	73	65-80
checks	do.	0	no injury	1.5	5.6	8.9	none	
4	77	1-12	leaves spotted, slightly burned	1.6	74.9	48.0	63.7	55-70
checks	do.	0	no injury	1.6	3.5	9.6	none	
5	87	1-13	leaves spotted and burned	1.4	63.4	44.8	69	65-75
checks	do.	0	no injury	1.8	4.8	8.5	none	
5	87	1-14	leaves spotted and burned	1.6	67.6	42.7	67	60-75
checks	do.	0	no injury	1.1	6.8	9.4	none	
5	86	1-15	very slight injury	1.5	45.9	28.0	64	60-70
checks	do.	0	no injury	1.6	3.9	8.3	none	

TABLE II. Scharr's Insecticide. 1915

No. of Experiments	Temperature F. Degrees	Dilution	Effect on Plants	Per Cent Dead at End of Test, Average				Range in Per Cent of Adults Dead
				Eggs	Larvae	Pupae	Adults	
2	72	1-60	no injury	2.7	77.9	60.4	72.5	70-75
checks	do.	0	do.	1.5	3.9	7.4	none	
2	61-66	1-50	no injury	2.9	87.5	25.9	72.5	70-75
checks	do.	0	do.	1.8	5.4	7.1	none	
2	77-82.5	1-40	slight injury	2.5	83.3	42.2	66.6	55-70
checks	do.	0	no injury	2.4	5.5	7.1	none	
2	92	1-30	severe injury	6.4	94.0	50.0	75	
checks	do.	0	no injury	1.6	5.3	8.1	none	

TABLE 12. Whale-Oil Soap. 1915 -

No. of Experiments	Temperature F. Degrees	Wt. of Soap to 1 Gal. Water, Ounces	Effect on Plants	Per Cent Dead at End of Test, Average				Range in Per Cent of Adults Dead
				Eggs	Larvae	Pupae	Adults	
5	75	1	no injury	1.9	75.5	38.8	70	60-80
checks	do.	0	do.	1.9	4.4	6.8	none	
5	64	1.5	no injury	1.7	85.7	44.4	71	65-75
checks	do.	0	do.	1.8	5.4	8.7	none	
5	68.5	2	no injury	1.1	89.2	60.5	71	65-75
checks	do.	0	do.	1.6	5.3	9.0	none	

DISCUSSION OF THE EXPERIMENTAL DATA

Table 5.—It will be seen from this table that no injury resulted to the plants when from 5 to 9 milligrams of the cyanide per cubic foot were used at 3 and 15.5 hours' exposure; but, that slight injury did result from the use of 10 milligrams of cyanide per cubic foot at 3 and 15 hours' exposure. The fumigation had practically no effect upon the viability of the eggs in any test. Five milligrams of the cyanide per cubic foot killed a good per cent of the adults but had little effect upon the larvae and pupae. When 9 milligrams of the cyanide per cubic foot were used, a moderate per cent of both larvae and pupae were killed; the 3-hour exposure was very nearly as effective as the 15.5-hour exposure.

Table 6.—This table gives the results of a few experiments with sodium cyanide. There was no injury to the plants when 5.4 milligrams of cyanide per cubic foot were used. Only a moderate per cent of the larvae and pupae were killed. With 6.2 milligrams of the cyanide per cubic foot at 15 hours' exposure, there was very slight injury to the plants, but the plants were young and tender. When 6.9 milligrams of cyanide per cubic foot were used, there was some injury to the tips and edges of the leaves.

Table 7.—Two tests of para-dichlorobenzene as a fumigant were made, each test lasting 15 hours. When four ounces of para-dichlorobenzene to 25 cubic feet were used, the plant was not injured, but when six ounces were used the leaves of the plant were injured. Fumigation with four ounces of the fumigant killed a good many of both larvae and pupae and all the adults. The eggs were not injured.

Table 8.—Four tests were made with para-dichlorobenzene and acetone, using two ounces of each in combination. The adults were killed at four or more hours' exposure, but larvae and pupae were not greatly affected. Twelve hour exposures killed the tips of the leaves of the plants.

Table 9.—Para-dichlorobenzene and carbon tetrachlorid in a combination of two ounces each was not a satisfactory fumi-

gant. The adults were killed at four hours or more exposure, but the larvae and pupae were scarcely affected. The plants were injured at 8 hours' exposure.

Table 10.—Several tests were made of dilutions of kerosene emulsion. All the tests recorded in the table show that the leaves of the plants were injured. The spray did not affect the eggs in any test. Dilutions of 1 part of the emulsion to 11 or 12 of water kill a good per cent of the larvae, but kill a too small per cent of the pupae.

Table 11.—Schnarr's Insecticide at dilutions of 1 part of the emulsion to 50 or 60 parts of water did not injure the plants and show a fair control of both larvae and pupae. The eggs were very slightly affected, if at all, by these dilutions.

Table 12.—Whale-oil soap did not injure the plants in any of the tests that were made. The eggs were not affected by the spray, and only such adults as were hit by the spray were killed. Seventy-five to eighty-nine per cent of the larvae and 38 to 60 per cent of the pupae were killed by the spray.

TESTS OF OTHER INSECTICIDES

Tobacco Extracts.—"Black-leaf-40" and "Nico-fume" are not satisfactory remedies for the white fly. Sprays made from these extracts were not as effective as plain soap solutions. The "Nico-fume" used as a fumigant at the rate of 3 ounces to 1,000 cubic feet killed from 96 to 100 per cent of the adults, but the immature stages of the insect were only slightly affected.

Soluble Sulfur.—Sprays made of soluble sulfur were not effective remedies when used at strength of one pound of the soluble sulfur to 45 or 50 gallons of water. Some of the plants were injured in each test.

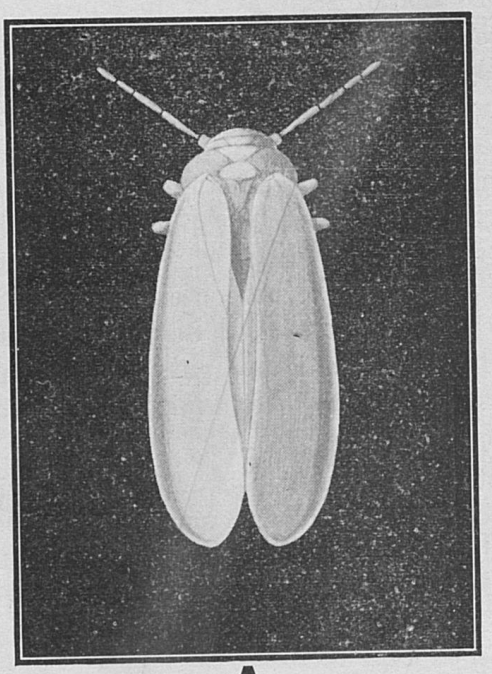
Lime-sulfur Solution.—This solution was not an effective remedy for the fly. When used in proportion of 1 to 30 or greater, injury resulted to the plants.

RECOMMENDATIONS

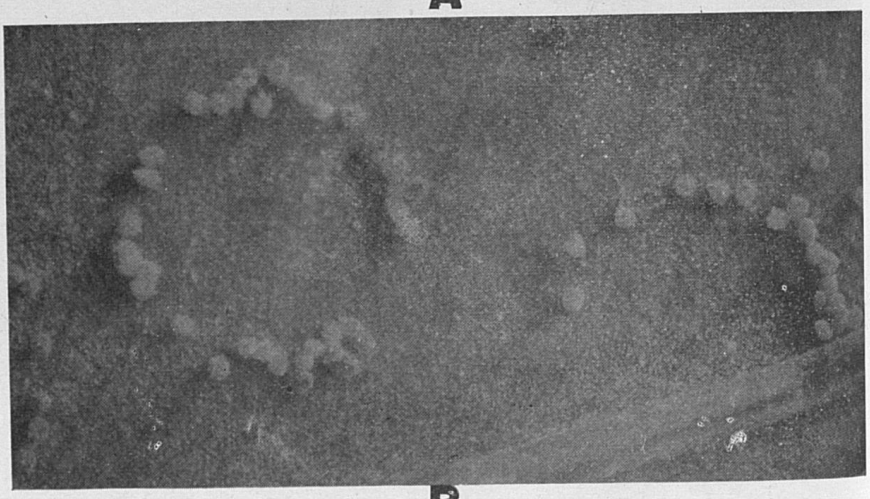
Hydrocyanic acid gas is a satisfactory fumigant for freeing hothouses of the white fly. The eggs of this insect are not affected greatly by fumigations at strengths that do not injure

the plants, so that it is necessary to repeat the fumigation in about 10 days; two or three fumigations should rid the hothouse entirely of this pest. In an air-tight box, 8 or 9 milligrams of potassium cyanide per cubit foot did not injure tomato plants at 15 hours' exposure. The sodium cyanide should be used in amounts a third less than those recommended for potassium cyanide. Sodium cyanide has very largely replaced potassium cyanide as a fumigant. Slightly larger amounts of cyanide can be used in a hothouse because it is not air-tight, but it must be remembered that different plants are not all affected alike by hydrocyanic acid gas. A preliminary test or two in a hothouse will help in determining the proper amount of cyanide to use.

It is not always practicable to fumigate with hydrocyanic acid gas, and in such cases frequent sprayings with soap solutions, made by dissolving one or two ounces of soap in a gallon of water, will do much to keep this insect under control.



A



B

Fig. 1. A, the adult hothouse white fly (*Asterochiton vaporariorum*) greatly magnified. B, showing the manner of placing the eggs on leaves.

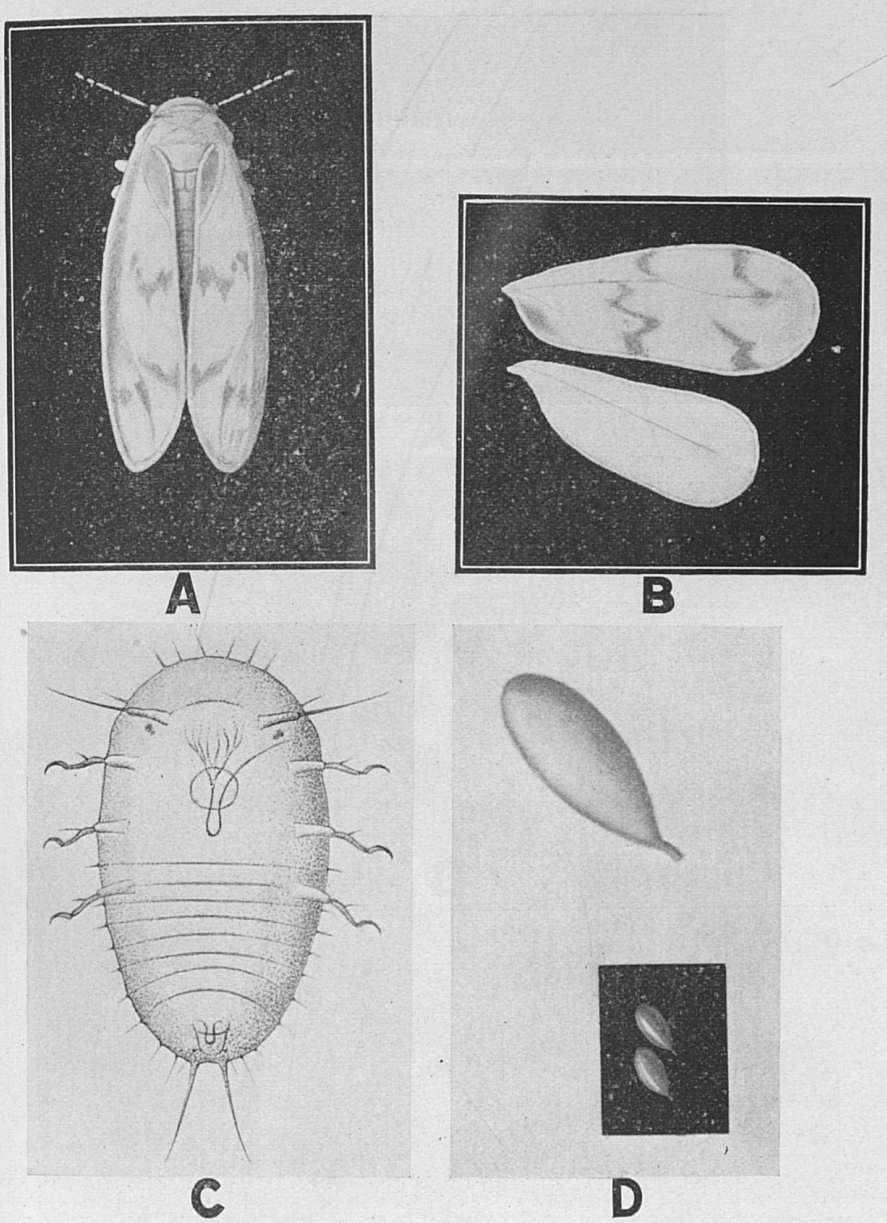


Fig. 2. A, the banded-winged hothouse white fly (*Asterochiton abutilonea*) greatly magnified. B, surface views of front and hind wings. C, the young recently hatched. D, the eggs, one above more highly magnified.

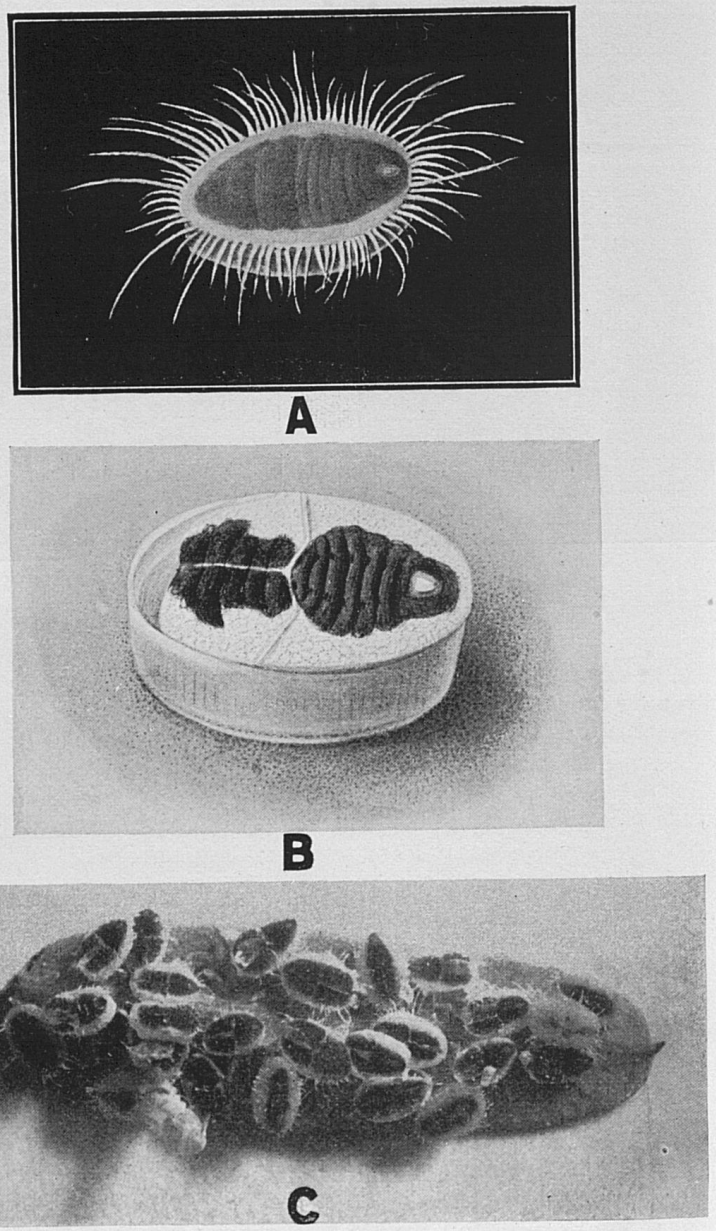


Fig. 3. A, the young of *A. abutilonea*, showing marginal setae. B, the pupa case after the adult has emerged. C, showing young thickly crowded on leaflet of *Sesbania macrocarpa*. All highly magnified.

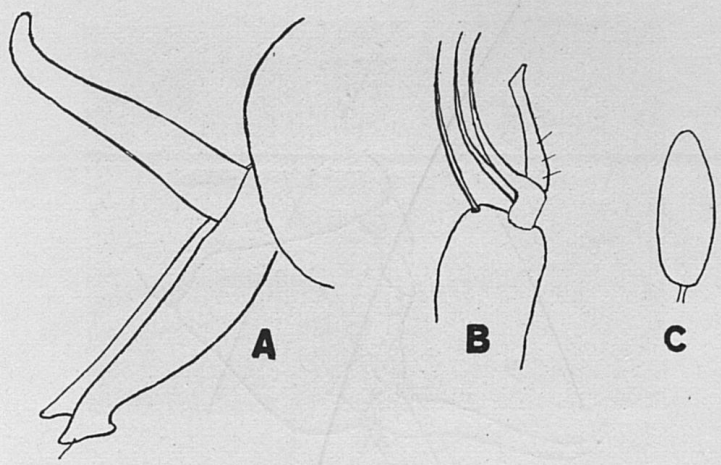


Fig. 4. A, abdominal appendages of the male *A. vaporariorum*. B, the tarsal claw of the same. C, the egg of same. Highly magnified.

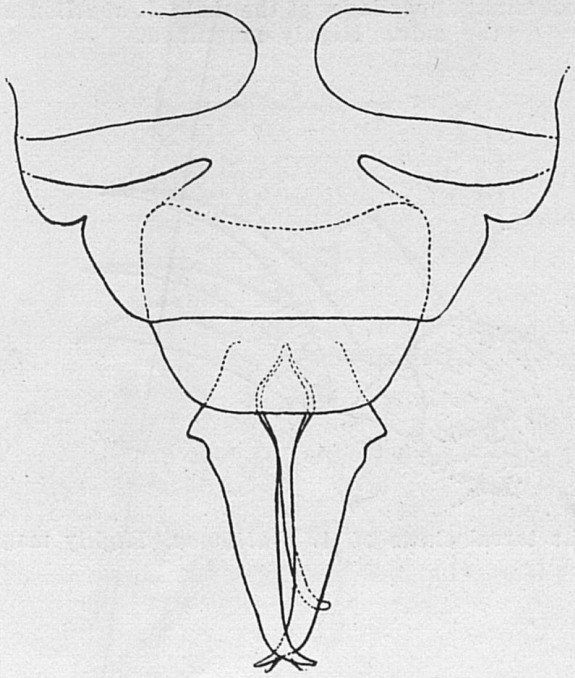


Fig. 5. The abdominal appendages of the male *A. abutilonea* seen from beneath. Highly magnified.

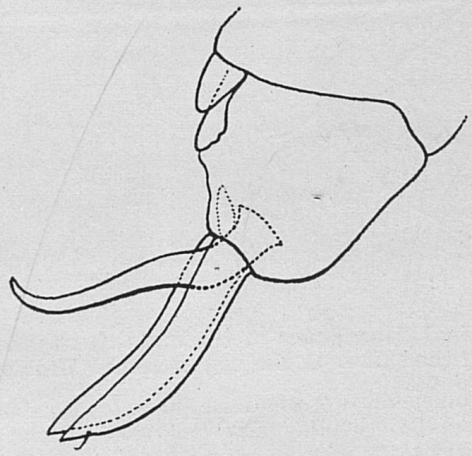


Fig. 6. The abdominal appendages of the male *A. abutilonea* seen from the side. Highly magnified.

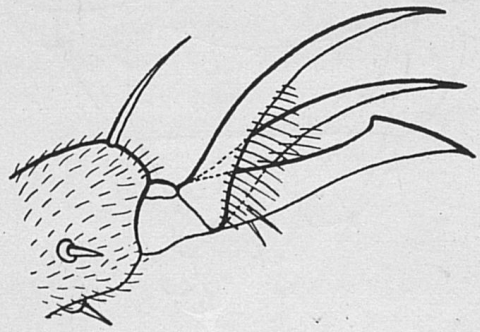


Fig. 7. The tarsal claws of *A. abutilonea.* Highly magnified.

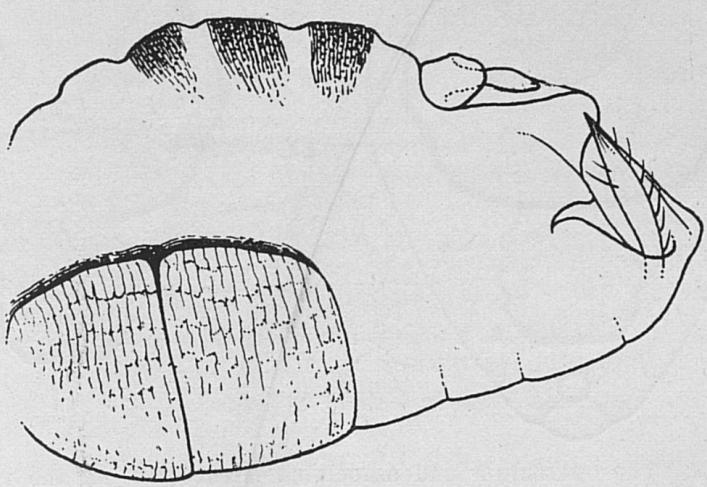


Fig. 8. The abdomen of the female *A. abutilonea*, showing the extensive glands on two of the basal segments. Seen from the side. Highly magnified.

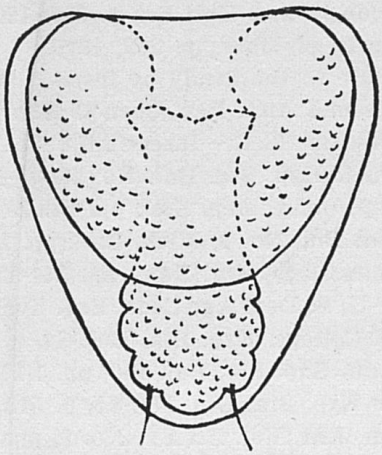


Fig. 9. The operculum and associated structures of the young *A. vaporariorum*. Highly magnified.

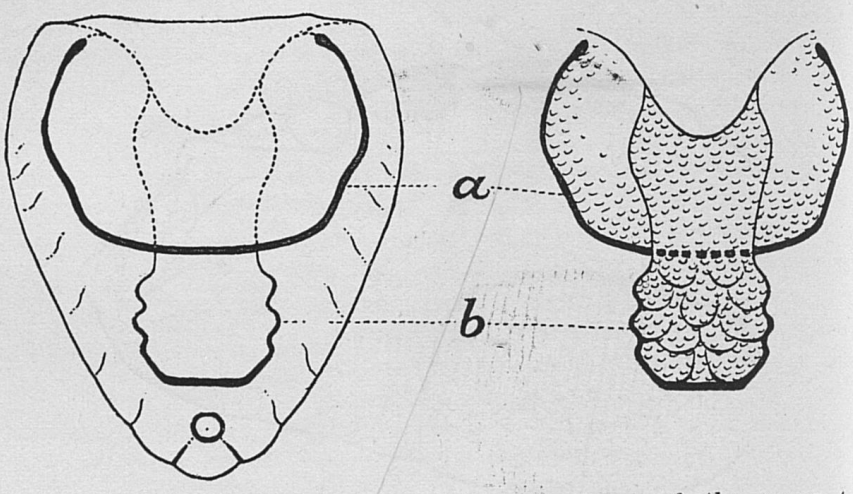


Fig. 10. The operculum and associated structures of the young *A. abutilonea*. Highly magnified.

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Kentucky
Agricultural Experiment Station
University of Kentucky

Feeding Steers Having Access to Barn and Range
vs.
Steers Confined to Barn

BULLETIN NO. 242

Lexington, Ky.
June, 1922
(113)

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BULLETIN NO. 242

Feeding Steers Having Access to Barn and Range vs. Steers Confined to Barn

By
E. S. GOOD

INTRODUCTION

It is well understood that one of the main factors to be considered in the feeding of steers is the fertilizer produced in the form of manure. It is estimated that about 85 per cent of the fertilizing constituents of a feed stuff are recovered in the solid and liquid manure. If the steer is allowed range, a considerable part of the fertilizing constituents may be lost by rains washing the manure into streams or by its being tramped into mud. This is especially true if the steer is confined in a small open lot. If steers are allowed the run of one certain pasture, this field becomes very fertile to the detriment of other fields on the farm. Even in the field where such cattle run, a part of the manure is deposited where not needed, such as in valleys and fence corners.

Manure is of great value in adding humus and fertility to the soil and communities that have paid special attention to its production and conservation have become outstanding ones as to richness of soil and farm wealth. A good illustration of this is Lancaster County, Pennsylvania, where some sixty thousand steers are fed annually and nearly all confined under cover. This county ranks among the very first in the United States in agricultural wealth and prosperity. It is one of the large tobacco-producing counties in the United States producing as

much as forty million pounds in some years. Sections of the county are also extensively engaged in truck gardening.

A number of feeders of steers in the western part of Kentucky, especially in Warren County, have for the past fifteen years been confining their steers under cover while fattening them for market. The main purpose of this procedure was to save as much of the manure as possible and to conserve its fertilizing constituents by protecting it from the rains. Then, too, the thoro tramping of the manure by the steers made it very compact and thus put it into a state where little fermentation took place, under which conditions it did not need to be hauled at once to the fields but could be moved during the slack season of work. The farms where such a system was followed always were found to be fertile. The fertility of depleted farms, also, was built up by this procedure, resulting in an increase in production of crops as well as of value per acre from year to year.

It was thought by some feeders, however, that although more manure would be conserved by confining steers under cover, the gains on steers would not be as large, when they were confined, as would be the case if the steers were allowed range, especially range with pasture, in addition to the run of the barn. It was to obtain experimental data along this line as well as to compare the amount of manure produced by the two systems of handling steers that the following experiments, the results of which are recorded in this bulletin, were planned and conducted.

PLAN

For the purpose of conducting the experiments as outlined in this bulletin, a barn 32 x 50 feet was built, having at one end a covered barnyard 25 feet in depth. This barnyard was covered with a shed-like roof and the sides were fenced in. This construction admitted a great deal of sunlight and air. (See cut, p. 135) Two feed mangers running thru the center of the barn were connected with an 18-inch feed alley, the bottoms of the mangers being 30 inches and the tops 43 inches above the ground

floor. This height eliminated the necessity of raising the mangers as the manure accumulated and also prevented the hogs running after the steers from getting into the mangers. As steers could not eat conveniently from this trough when there was no manure in the barn, logs were placed before the mangers so that the steers could raise themselves by putting their front feet on them while eating. Racks for hay and straw were situated on the sides of the barn. Fresh water was supplied in a concrete tank inside the barn. The water was pumped to this tank from a spring by means of a small gasoline engine. The barn and covered barnyard were kept well bedded with wheat straw.

Steers should not be crowded if confined to a barn. They should have at least 60 square feet of floor space per steer.

In this investigation three consecutive experiments were conducted. The first was run November 15, 1915 to April 24, 1916 (161 days); the second from November 27, 1916 to April 23, 1917 (147 days); and the third from November 15, 1917 to April 4, 1918 (140 days). In each of these experiments, twenty steers were divided into two lots of ten each, numbered Lot 5 and Lot 6, these lots being as nearly alike as possible in size, condition, quality and breeding. Also, in each experiment, the two lots received the same feeds and were otherwise handled the same, except that Lot 6 was kept confined to one-half of the barn and covered yard and Lot 5 allowed the run of the other half of the barn and a twenty-acre bluegrass pasture.

DESCRIPTION OF THE STEERS

The steers in these trials were selected from a large number of native steers which had been purchased by a dealer during the late summer and early fall months and run on a bluegrass pasture on his farm located about six miles from the Experiment Station. They were mostly grade Shorthorns with a few Hereford and Angus grades. They were selected as to uniformity of weight, age, quality, condition and thrift. Two-year-old steers were used.

METHOD OF VALUING THE CATTLE

The initial value of the cattle was based upon the purchase price, which was about the average price paid for feeder cattle in this State at the time of purchase. At the end of the feeding period, the cattle were valued by a committee of experts.

WEIGHTS

Before the experiment was begun, a sufficient length of time was allowed the steers to regain shrinks caused by driving them from the place of purchase to the Experiment Station feed lots. Each steer in the experiment was identified by a numbered brass tag on a strap fastened around the neck.

Each animal was weighed in the morning of three consecutive days at the beginning and end of the experiment. The averages of the three weights at the beginning and end of the feeding period were taken as the initial and final weights, respectively. It was our aim to weigh each lot as a group every two weeks and individually every thirty days, weather permitting. As the steers had to be driven one-half mile to be weighed, it was not practicable to do this at the end of certain periods on account of stormy weather. The steers were not allowed the morning feed and water was kept from them for twelve hours before weighing.

METHOD OF FEEDING

The steers were fed twice a day, at 7 a. m. and 4 p. m. The cottonseed meal was spread on and mixed with the silage, as was the corn when fed. The straw was fed in racks. Salt was kept before the cattle at all times.

FEEDS USED

Rations fed in these trials consisted of various combinations of the following feeds: Corn, cottonseed meal, wheat straw, oat straw, bluegrass chaff, corn stover and soybean straw. The same combination of feeds was not used in any two experiments, but the same with both lots in each year's experiment. Corn stover was fed only the first few days of the experiment,

until the cattle gained a fill and could be placed on full feed. Feeds used each year are given below:

First Experiment (November 15, 1915-April 24, 1916): Cottonseed meal, broken ear corn, shelled corn, sorghum silage, corn stover and oat straw.

Second Experiment (November 27, 1916-April 23, 1917): Cottonseed meal, sorghum silage, wheat straw and bluegrass chaff.

Third Experiment (November 15, 1917-April 4, 1918): Cottonseed meal, sorghum silage, corn silage, wheat straw, soybean straw and corn the last ninety days.

METHOD OF STARTING THESE CATTLE ON FEED

The cattle were given a preliminary feed of cottonseed meal, corn silage, corn stover and straw for several days before starting on the experiments. This was done in order to regain the shrink and get the cattle accustomed to the feeds used in the experiments.

When the experiments started, the steers were given one-half pound of cottonseed meal, 20 pounds silage, 6 pounds hay and about all the straw and stover they would eat. When corn was fed in the experiments, the steers were started on 2½ pounds per day and gradually increased so that when they were marketed they were getting nearly a full feed. Silage was increased to a full feed by the end of the first week, and cottonseed meal was increased to a full feed by the end of the first thirty days.

HOGS

Hogs followed the cattle in the two experiments when corn was fed. The first year two 95-pound pigs were allowed to run with each lot of cattle. A sufficient amount of tankage to balance the ration was fed these hogs.

The third year two 200-pound pigs were allowed to follow each lot of steers. No tankage was fed during this year and the pigs received only the droppings from the cattle.

FIRST EXPERIMENT IN FEEDING STEERS HAVING ACCESS TO BARN AND RANGE VS. STEERS CONFINED TO BARN

The tables given show comparative data on the amount of feed eaten, the rapidity and cost of gains, the finish on cattle, the profit, and the manure saved by steers confined in a barn with a covered barnyard as compared with steers allowed the run of a barn and the range of a twenty-acre bluegrass pasture.

TABLE I. Average Amount of Feed Consumed Daily Per Head by Periods.

November 15, 1915-April 24, 1916 (161 days)

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (31 days)		
Cottonseed meal	1.40 lbs.	1.40 lbs.
Shelled corn	7.45 "	7.45 "
Sorghum silage	25.40 "	30.32 "
Corn stover	8.26 "	8.26 "
Oat straw	1.61 "	1.93 "
Second Period (31 days)		
Cottonseed meal	3.41 "	3.39 "
Shelled corn	9.90 "	9.90 "
Sorghum silage	39.67 "	45.48 "
Oat straw	3.80 "	2.93 "
Third Period (31 days)		
Cottonseed meal	3.50 "	3.50 "
Shelled corn	10.00 "	10.00 "
Sorghum silage	40.00 "	44.56 "
Oat straw	5.48 "	3.13 "
Fourth Period (29 days)		
Cottonseed meal	3.52 "	3.52 "
Shelled corn	10.93 "	10.93 "
Sorghum silage	36.24 "	43.82 "
Oat straw	3.60 "	3.33 "
Fifth Period (39 days)		
Cottonseed meal	3.78 "	3.78 "
Shelled corn	17.82 "	17.82 "
Sorghum silage	30.07 "	30.07 "
Oat straw	.87 "	1.18 "

It will be noted that the amounts of corn and cottonseed meal consumed were almost exactly the same in the two lots during the five feeding periods. The steers in Lot 6 consumed considerably more silage in every period except the last, but they ate less straw, especially in the second and third periods. The steers in Lot 5 had their appetite for succulent feed partly satisfied by the pasture, which accounts for the smaller amount of silage eaten by them.

Corn stover was fed during the first period while the steers were becoming accustomed to cottonseed meal and silage.

TABLE II. Average Daily Gain Per Steer by Periods.
November 15, 1915-April 24, 1916.

	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (31 days)	2.45 lbs.	3.45 lbs.
Second Period (31 days)	1.80 "	1.48 "
Third Period (31 days)	.16 "	.83 "
Fourth Period (29 days)	2.18 "	2.10 "
Fifth Period (39 days)	2.40 "	2.41 "
Total gain per steer	294.00 "	334.00 "
Average daily gain for entire period	1.82 "	2.07 "

Table II shows that good gains were made by both lots during the first, fourth, and fifth periods, but that poor gains were made in both lots during the second and third periods. The greatest differences in gains in the two lots were in the first period, in which Lot 6 made one pound more gain per day per steer than did Lot 5, and in the third period, in which Lot 6 gained .67 pounds more than Lot 5. The total gain per steer was 294 pounds for Lot 5 and 334 pounds for Lot 6, which is a difference of 40 pounds per steer in favor of the steers which were confined.

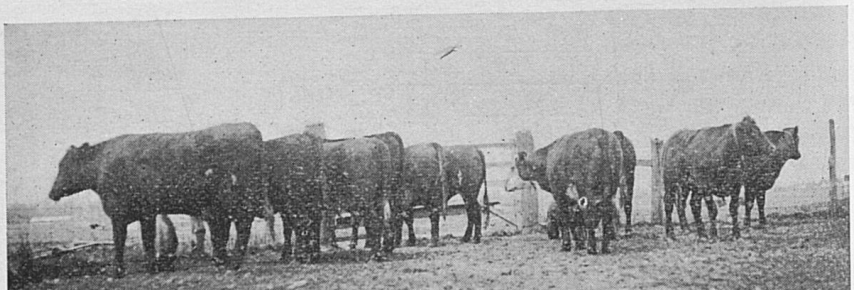
The average daily gain for the whole time for each steer was 1.82 pounds for Lot 5 and 2.07 pounds for Lot 6—a difference of .25 of a pound in favor of the steers which were confined.

TABLE III. Average Amount of Feed Consumed Per Pound Gain and Cost Per 100 Pounds Gain.

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
Feed per pound gain:		
Cottonseed meal	1.73 lbs.	1.52 lbs.
Shelled corn	6.33 "	5.57 "
Sorghum silage	18.64 "	18.48 "
Corn stover	.87 "	.76 "
Oat straw	1.62 "	1.17 "
Cost per 100 pounds gain	$14.81 "	$12.47

It will be noted from Table III that less corn and cottonseed meal were required for a pound of gain in Lot 6 than in Lot 5. The amount of silage required per pound gain was about the same in both lots, while the amount of straw was somewhat more in Lot 5.

The cost per hundred pounds gain was $14.81 for Lot 5 and $12.47 for Lot 6, a difference of $2.34 per hundredweight in favor of the steers which were confined.



Lot 5. (Allowed Range) At the end of the experiment, April 24, 1916.



Lot 6. (Confined to Barn) At the end of the experiment, April 24, 1916.

TABLE IV. Summary of First Experiment.
November 15, 1915-April 24, 1916 (161 days)

	Lot. 5 Steers Allowed Range		Lot 6 Steers Confined to Barn	
Number of steers	10		10	
Initial weight of lot	9960	lbs.	10020	lbs.
Initial weight per steer	996	"	1002	"
Final weight of lot	12900	"	13360	"
Final weight per steer	1290	"	1336	"
Total gain of lot	2940	"	3340	"
Average daily gain per steer	1.82	"	2.07	"
Total feed consumed:				
Shelled corn	18598	"	18598	"
Cottonseed meal	5076.25	"	5068.25	"
Sorghum silage	54815	"	61755	"
Corn stover	2560	"	2560	"
Oat straw	4763	"	3913	"
Average daily feed consumed per steer:				
Shelled corn	11.55	"	11.55	"
Cottonseed meal	3.15	"	3.14	"
Sorghum silage	34.04	"	38.35	"
Corn stover (31 days)	8.26	"	8.26	"
Oat straw	2.95	"	2.43	"
Cost of feeds	$408.86		$416.70	
Pasture	26.83			
Cost of cattle at $7.25 per cwt.	722.10		726.45	
Total cost	1,157.79		1,143.15	
Cost per cwt. gain	14.81		12.47	
Pork produced	528	lbs.	380	lbs.
Cost of tankage fed hogs	$1.22		$1.22	
Value of pork produced at $9.00 per cwt.	47.52		34.20	
Net value of pork produced	46.30		32.98	
Necessary selling price pork included	8.61		8.30	
Necessary selling price pork not included	8.97		8.55	
Value of steers per cwt.	8.73		8.98	
Profit per steer incl. pork	1.46		8.95	
Manure saved per steer	2.47	tons	3.80	tons

Feed prices used: Shelled corn, 70c per bu.; cottonseed meal, $30 per ton; corn stover, $3.00 per ton; oat straw, $6.00 per ton; pasture for Lot 5, 50c per steer per month; sorghum silage, $3.00 per ton.

SUMMARY OF FIRST EXPERIMENT

A summary of the data obtained with the two lots of cattle is shown in Table IV. No charge was made for straw used for bedding nor for labor of feeding, neither is any credit given for manure produced by the cattle, it being considered that the value of the manure will much more than offset these two items.

Two hogs were run after each lot of steers. A small amount of tankage was fed the hogs in addition to the corn obtained from the droppings, but the cost of tankage fed was deducted from the value of pork produced before the latter was credited to receipts from the cattle.

It will be noted from Table IV that the steers confined made larger daily gains at less cost than did the steers running out. The difference in the daily gain was .25 pound per steer and the difference in the cost of gains was $2.34 per hundredweight in favor of Lot 6.

The necessary selling price required to come out even for Lot 5, with pork included, was $8.61 per hundredweight, while the valuation as made by committee of experts was $8.73 per hundredweight, making a net profit of $1.46 per steer. In Lot 6, the necessary selling price to come out even was $8.30 per hundredweight, the valuation was $8.98 per hundredweight and the net profit per steer was $8.95. This was a difference in net profit of $7.49 per steer in favor of the Lot 6 which was confined.

It is to be noted that in the financial results of this experiment, the fact was not taken into account that about .53 per cent more manure was saved where the steers were confined than where they ran out on pasture.

SECOND EXPERIMENT IN FEEDING STEERS HAVING ACCESS TO BARN AND RANGE VS. STEERS CONFINED TO BARN.

This experiment was conducted like the previous one with the exception that a different combination of feeds was used. No corn was used in the ration in this experiment. Lot 5 was allowed

the run of a barn and a twenty-acre bluegrass pasture. Lot 6 was confined to a barn and covered lot.

The steers received wheat straw during the first period while they were being placed on a full feed of cottonseed meal and silage. The ration used during the remainder of the experiment consisted of cottonseed meal, silage and bluegrass chaff. The two lots of steers were fed all the roughage they would eat without waste.

TABLE V. Average Amount of Feed Consumed Daily Per Head by Fattening Steers, by Periods.

November 27, 1916-April 23, 1917 (147 days).

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (29 days)		
Cottonseed meal	1.17 lbs.	1.15 lbs.
Sorghum silage	31.90 "	31.72 "
Wheat straw	5.86 "	11.54 "
Bluegrass chaff	3.81 "	5.62 "
Second Period (28 days)		
Cottonseed meal	2.14 "	2.14 "
Sorghum silage	49.28 "	49.28 "
Bluegrass chaff	6.00 "	6.00 "
Third Period (28 days)		
Cottonseed meal	3.35 "	3.35 "
Sorghum silage	49.91 "	49.91 "
Bluegrass chaff	6.00 "	6.00 "
Fourth Period (28 days)		
Cottonseed meal	4.27 "	4.27 "
Sorghum silage	47.73 "	50.01 "
Bluegrass chaff	4.82 "	5.04 "
Fifth Period (34 days)		
Cottonseed meal	5.33 "	5.76 "
Sorghum silage	38.80 "	49.83 "
Bluegrass chaff	3.35 "	4.64 "

It will be noted that during the first month there was little difference in the consumption of cottonseed meal and silage in the two lots, but there was quite a difference in the amount of

straw and bluegrass chaff eaten. This probably was because the steers in Lot 5 were getting a considerable amount of grass at this time and did not require so much roughage.

During the second and third periods the amount of feed eaten by the two lots was exactly the same, while in the last two periods Lot 6 consumed more roughage than did Lot 5.

Cottonseed meal was increased gradually during the entire 147 days. The average daily ration of cottonseed meal was practically the same for both lots except in the fifth period in which Lot 6 consumed .43 of a pound more per steer, daily, than Lot 5. This was because a steer in Lot 5 was off feed for a few days. The amount of silage remained about the same after a full feed was reached until the last period, when Lot 6 ate more silage than Lot 5. This was due to a steer of Lot 5 going off feed for a few days and also because fresh grass was beginning to appear, which the steers relished. The amount of bluegrass chaff eaten reached a maximum in the second and third periods and gradually decreased thereafter.

TABLE VI. Average Daily Gain Per Steer by Periods. November 27, 1916-April 23, 1917 (147 days).

MONTHS	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (29 days)	1.60 lbs.	.93 lbs.
Second Period (28 days)	.98 "	1.18 "
Third Period (28 days)	1.14 "	1.54 "
Fourth Period (28 days)	1.25 "	1.50 "
Fifth Period (34 days)	1.05 "	1.57 "
Total gain per steer	177.00 "	198.20 "
Average daily gain for entire period	1.20 "	1.35 "

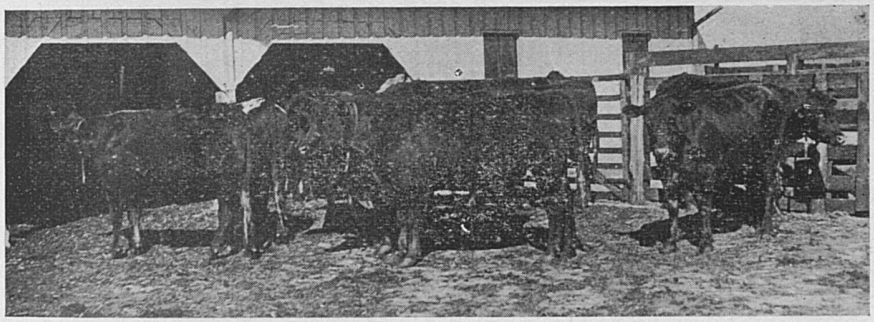
It will be seen from Table VI that the steers which were confined made better gains during the last four periods than did those running on pasture. They seemed to be a little slow in getting started, however, and fell considerably behind Lot 5 in the first 29 days.

The total gain per steer for the entire 147 days was 177 pounds for Lot 5 and 198.2 pounds for Lot 6—a difference of

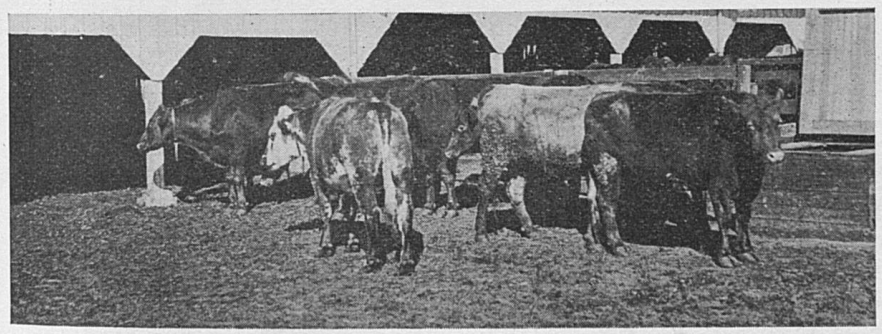
21.2 pounds per steer in favor of the steers confined. The average daily gain was 1.20 pounds per steer in Lot 5 and 1.35 pounds per steer in Lot 6, a difference of .15 of a pound in favor of Lot 6.

TABLE VII. Average Amount of Feed Consumed Per Pound Gain and Cost Per 100 Pounds Gain.

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
Feed per pound gain:		
Cottonseed meal	2.80 lbs.	2.54 lbs.
Sorghum silage	36.30 "	34.49 "
Bluegrass chaff	3.98 "	4.09 "
Wheat straw	.96 "	1.69 "
Cost per 100 pounds gain	$18.07	$15.94



Lot 5. (Allowed Range) At the end of the experiment, April 23, 1917.



Lot 6. (Confined to Barn) At the end of the experiment, April 23, 1917.

We note from Table VII that the steers running on pasture required .26 of a pound more cottonseed meal and 1.81

pounds more silage per pound gain than did those in the closed lot. The amount of straw and bluegrass chaff consumed per pound gain was slightly less, however, in Lot 5, for this experiment.

The cost per hundred pounds gain was $18.07 for Lot 5 and $15.94 for Lot 6, a difference of $2.13 per hundredweight in favor of the steers confined.

TABLE VIII. Summary of Second Experiment.

November 27, 1916-April 23, 1917 (147 days).

	Lot. 5 Steers Allowed Range		Lot 6 Steers Confined to Barn	
Number of steers	10		10	
Initial weight of lot	10470	lbs.	10421	lbs.
Initial weight per steer	1047	"	1042.1	"
Final weight of lot	12240	"	12403	"
Final weight per steer	1224	"	1240	"
Total gain of lot	1770	"	1982	"
Average daily gain per steer	1.20	"	1.35	"
Total feed consumed:				
Cottonseed meal	4962.5	"	5030	"
Sorghum silage	64259.0	"	68375	"
Wheat straw	1702	"	3348	"
Bluegrass chaff	7056	"	8107	"
Average daily feed consumed per steer:				
Cottonseed meal	3.37	"	3.42	"
Sorghum silage	43.72	"	46.51	"
Wheat straw (29 days)	5.86	"	11.54	"
Bluegrass chaff	4.79	"	5.51	"
Cost of feeds	$295.50		$316.07	
Pasture	24.50			
Cost of cattle at $8.50 per cwt.	889.95		885.78	
Total cost	1,209.95		1,201.85	
Cost per cwt. gain	18.07		15.94	
Necessary selling price	9.88		9.69	
Value of steers per cwt.	10.00		10.00	
Profit per steer	1.40		3.81	
Manure produced per steer	2.29	tons	4.24	tons

Feed prices used: Cottonseed meal, $41.60 per ton; sorghum silage, $5.25 per ton; wheat straw, $7.00 per ton; bluegrass chaff, $5.00 per ton; pasture for Lot 5, 50c per steer per month.

Table VIII shows a summary of the results obtained with the two lots of cattle in the second experiment. It will be noted that these results are very similar to those secured in the first experiment in that the steers confined made a larger daily gain, a more economical gain, and there were 1.95 tons more manure per steer taken from the side of the barn where the steers were confined than from the side to which the steers had access as well as the run of the pasture. It seemed that there was not so much difference in the finish of the two lots this year, however, and they were valued at the same price by expert cattle men.

It was necessary for Lot 5 to sell at $9.88 per hundredweight in order to come out even. The valuation was $10.00 per hundredweight and the profit per steer was $1.40.

Lot 6 would have had to sell at $9.69 per hundredweight to come out even and the valuation was $10.00 per hundredweight, thus returning a net profit of $3.81 per steer. This gave a difference in net profit of $2.41 per steer in favor of the steers confined. The difference in net profit per steer between the two lots was smaller than that obtained the previous year, due to the fact that the finish of the two lots of steers was about the same.

As corn did not enter the ration in this experiment there were no hogs following the steers.

There were 1.95 tons more manure per steer secured from the half of the barn where the cattle were confined than from the half where the cattle were allowed to go on pasture at will.

THIRD EXPERIMENT IN FEEDING STEERS HAVING ACCESS TO BARN AND RANGE VS. STEERS CONFINED TO BARN.

In this experiment, conditions were the same as in the two previous ones. The combination of feeds was much the same with the exception that corn was introduced into the ration at the beginning of the fifty-sixth day, whereas, in the first experiment, corn was fed during the entire 161 days and in the second experiment no corn was fed at any time.

TABLE IX. Average Amount of Feed Consumed Daily per Head, by Periods.

November 15, 1917-April 4, 1918 (140 days).

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (35 days)		
Cottonseed meal	3.02 lbs.	3.02 lbs.
Sorghum silage	40.91 "	40.89 "
Corn stover	4.05 "	3.41 "
Wheat straw	2.69 "	1.52 "
Soybean straw	1.91 "	1.41 "
Second Period (21 days)		
Cottonseed meal	3.80 "	3.80 "
Shelled corn	.14 "	.14 "
Sorghum silage	49.47 "	49.47 "
Wheat straw	2.57 "	2.81 "
Soybean straw	2.38 "	2.38 "
Third Period (35 days)		
Cottonseed meal	3.92 "	3.92 "
Shelled corn	4.70 "	4.50 "
Sorghum silage	48.57 "	48.71 "
Wheat straw	1.87 "	2.16 "
Soybean straw	1.28 "	1.28 "
Fourth Period (28 days)		
Cottonseed meal	3.92 "	4.04 "
Shelled corn	7.95 "	8.17 "
Corn silage	38.17 "	39.92 "
Wheat straw	.32 "	.29 "
Fifth Period (21 days)		
Cottonseed meal	4.31 "	4.13 "
Shelled corn	10.84 "	10.18 "
Corn silage	32.00 "	31.52 "

It will be seen from Table IX that the amount of feed consumed in the two lots was almost the same thru the entire experiment. Steers in Lot 5 did not have quite as good an appetite as those in Lot 6 during the fourth period, but they consumed slightly more feed in the last period, which

raised their average and made the amount of feed eaten by the two lots during the last 56 days about equal.

No straw was eaten by either lot during the last period.

It must be remembered, however, that it was the aim to feed the same amount of corn and cottonseed meal to each lot and that any difference was due to a steer being off feed for a day or two when the amount of feed was reduced.

TABLE X. Average Daily Gain Per Steer by Periods. November 15, 1917-April 4, 1918 (140 days).

	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (35 days)	2.75 lbs.	2.30 lbs.
Second Period (21 days)	.19 "	1.55 "
Third Period (35 days)	1.43 "	1.27 "
Fourth Period (28 days)	2.00 "	1.90 "
Fifth Period (21 days)	1.32 "	1.78 "
Total gain per steer	234.00 "	248.00 "
Average daily gain for entire period	1.67 "	1.77 "

It will be seen from Table X that the steers running on pasture made somewhat larger gains during the first, third, and fourth periods than did those confined, but their gains being so very poor in the second period and somewhat off in the last period, they were not able to average up with Lot 6.

The total gain per steer for Lot 5 was 234 pounds, and the average daily gain per period was 1.67 pounds, being somewhat less than that for Lot 6, which was 248 pounds gain per steer and 1.77 pounds daily gain per period.

TABLE XI. Average Amount of Feed Consumed Per Pound Gain and Cost Per 100 Pound Gain

RATION Feed per pound gain:	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
Cottonseed meal	2.23 lbs.	2.10 lbs.
Shelled corn	2.34 "	2.26 "
Sorghum silage	17.39 "	16.36 "
Corn silage	7.86 "	7.58 "
Corn stover	.60 "	.48 "

TABLE IX. Average Amount of Feed Consumed Daily per Head, by Periods.

November 15, 1917-April 4, 1918 (140 days).

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (35 days)		
Cottonseed meal	3.02 lbs.	3.02 lbs.
Sorghum silage	40.91 "	40.89 "
Corn stover	4.05 "	3.41 "
Wheat straw	2.69 "	1.52 "
Soybean straw	1.91 "	1.41 "
Second Period (21 days)		
Cottonseed meal	3.80 "	3.80 "
Shelled corn	.14 "	.14 "
Sorghum silage	49.47 "	49.47 "
Wheat straw	2.57 "	2.81 "
Soybean straw	2.38 "	2.38 "
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Cottonseed meal	3.92 "	3.92 "
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It will be seen from Table IX that the amount of feed consumed in the two lots was almost the same thru the entire experiment. Steers in Lot 5 did not have quite as good an appetite as those in Lot 6 during the fourth period, but they consumed slightly more feed in the last period, which

raised their average and made the amount of feed eaten by the two lots during the last 56 days about equal.

No straw was eaten by either lot during the last period.

It must be remembered, however, that it was the aim to feed the same amount of corn and cottonseed meal to each lot and that any difference was due to a steer being off feed for a day or two when the amount of feed was reduced.

TABLE X. Average Daily Gain Per Steer by Periods. November 15, 1917-April 4, 1918 (140 days).

	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
First Period (35 days)	2.75 lbs.	2.30 lbs.
Second Period (21 days)	.19 "	1.55 "
Third Period (35 days)	1.43 "	1.27 "
Fourth Period (28 days)	2.00 "	1.90 "
Fifth Period (21 days)	1.32 "	1.78 "
Total gain per steer	234.00 "	248.00 "
Average daily gain for entire period	1.67 "	1.77 "

It will be seen from Table X that the steers running on pasture made somewhat larger gains during the first, third, and fourth periods than did those confined, but their gains being so very poor in the second period and somewhat off in the last period, they were not able to average up with Lot 6.

The total gain per steer for Lot 5 was 234 pounds, and the average daily gain per period was 1.67 pounds, being somewhat less than that for Lot 6, which was 248 pounds gain per steer and 1.77 pounds daily gain per period.

TABLE XI. Average Amount of Feed Consumed Per Pound Gain and Cost Per 100 Pound Gain

RATION Feed per pound gain:	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
Cottonseed meal	2.23 lbs.	2.10 lbs.
Shelled corn	2.34 "	2.26 "
Sorghum silage	17.39 "	16.36 "
Corn silage	7.86 "	7.58 "
Corn stover	.60 "	.48 "

RATION	Lot. 5 Steers Allowed Range	Lot 6 Steers Confined to Barn
Soybean straw	.69 "	.62 "
Wheat straw	.95 "	.79 "
Cost per 100 pounds gain	$22.61	$20.30

It will be seen from Table XI that it required .13 of a pound more cottonseed meal, .08 of a pound more corn, 1.03 pounds more sorghum silage, .12 of a pound more corn stover, .07 of a pound more soybean straw and .16 of a pound more wheat straw, and .28 of a pound more corn silage to produce one pound of gain on the steers running on pasture than on those confined.

The cost per 100 pounds gain was $22.61 for steers on pasture and $20.30 for those confined, being $2.31 per steer in favor of the steers confined.



Lot 5. (Allowed Range) At the end of the experiment, April 4, 1918.



Lot 6. (Confined to Earn) At the end of the experiment, April 4, 1918.

TABLE XII. Summary of Third Experiment.
November 15, 1917-April 4, 1918 (140 days).

	Lot. 5 Steers Allowed Range		Lot 6 Steers Confined to Barn	
Number of steers	10		9	
Initial weight of lot	9125	lbs.	8218	lbs.
Average weight per steer	912	"	913	"
Final weight of lot	11466	"	10456	"
Average final weight per steer	1146	"	1161	"
Total gain of lot	2341	"	2238	"
Average gain per steer	234	"	248	"
Average daily gain per steer	1.67	"	1.77	"
Total feed consumed:				
Cottonseed meal	5236	"	4707	"
Shelled corn	5593	"	5072	"
Corn stover	1418	"	1076	"
Soybean straw	1619	"	1395	"
Wheat straw	2228	"	1765	"
Sorghum silage	40716	"	36632	"
Corn silage	18410	"	16965	"
Average daily feed consumed:				
Cottonseed meal	3.74	"	3.73	"
Shelled corn (last 85 days)	6.57	"	6.63	"
Corn stover (1st 6 days only)	23.63	"	19.92	"
Soybean straw (first 65 days only)	2.49	"	2.38	"
Wheat straw	1.59	"	1.40	"
Sorghum silage (90 days)	45.24	"	45.22	"
Corn silage (50 days)	36.82	"	37.70	"
Total cost of feeds	$504.47		$454.49	
Pasture	25.00			
Cost of cattle at $9.25 per cwt.	844.06		760.16	
Total cost	1,373.53		1,214.65	
Cost per cwt. gain	22.61		20.30	
Pork produced	30	lbs.	56	lbs.
Value of pork produced at $17 per cwt.	$5.10		$9.52	
Necessary selling price, pork inc.	11.93		11.52	
Necessary selling price, pork not inc.	11.97		11.61	
Value of steers per cwt.	12.95		13.30	
Profit per steer, including pork	11.56		20.50	
Manure produced per steer	1.76	tons	2.66	tons

Feed prices used: Cottonseed meal, $53.00 per ton; shelled corn, $1.25 per bu.; corn silage, $8.00 per ton; sorghum silage, $7.25 per ton; soybean straw, $8.00 per ton; wheat straw, $8.00 per ton; corn stover, $6.00 per ton; pasture for Lot 5, 50 cents per steer per month.

Table XII is a summary of the third experiment in this series and brings out practically the same results that had been obtained in the two previous experiments, namely, that the steers confined to the barn made more rapid gains at less cost per hundredweight, showed a better finish, and returned a larger net profit than did the steers allowed range. More manure also was conserved from the steers confined than from those allowed range.

Lot 5 made an average daily gain of 1.67 pounds per steer, the cost per hundredweight of which was $22.61; the selling price required to come out even, (pork credited) was $11.93 per hundredweight. This lot of steers was valued at $12.95 per hundredweight, returning a profit of $11.56 per steer. The manure produced was 1.76 tons per steer. Lot 6 made an average daily gain of 1.77 pounds per steer and each 100 pounds of gain cost $20.30. The required selling price (pork included) to break even was $11.52 per hundredweight. This lot of steers was valued at $13.30 per hundredweight, returning a net profit of $20.50 per steer. The manure produced by Lot 6 was 2.66 tons per steer or 51 per cent greater than by Lot 5.

SUMMARY

1. The three experiments show that the average daily gain per steer of the steers confined in the barn was .16 pounds greater than that made by the steers having access to barn and range.

2. The average cost per hundredweight gain was $2.26 less for the steers confined than for those allowed range.

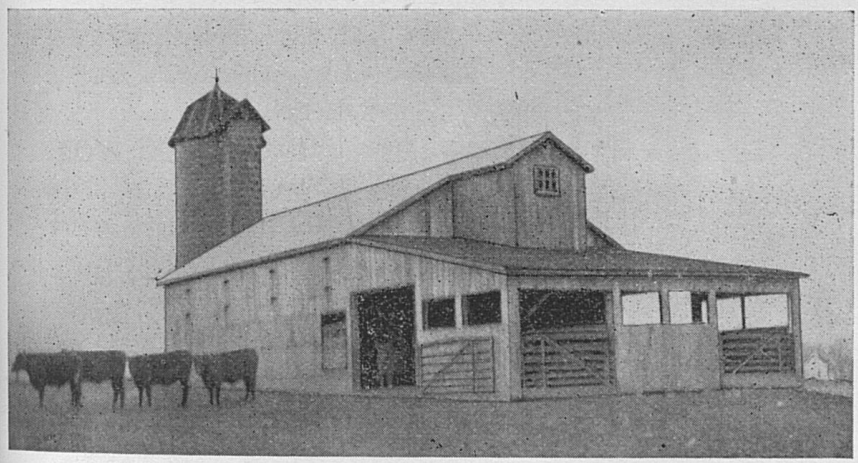
3. The average value of finished steers was 20 cents per hundredweight larger for those confined than for those with range.

4. The average net profit, including credit for pork produced, was $6.28 more per steer for those confined than for those having range.

5. The average amount of manure per steer taken from that part of the barn where the steers (Lot 6) were confined was 3.56 tons and from that part of the barn to which the steers (Lot 5) had access as well as the run of a twenty-acre pasture was 2.17 tons or 64 per cent more where the steers were confined.

ACKNOWLEDGMENT

The author acknowledges valuable assistance on the part of Mr. Morgan O. Hughes in planning the barn and experiments as outlined in this bulletin. Mr. Hughes was formerly an extensive feeder of steers under cover in Warren County, Kentucky, and is now connected with the Department of Farm Management and Markets of this Station.



Small steer-feeding barn used in this experiment.

Kentucky
Agricultural Experiment Station
University of Kentucky

BREEDING EXPERIMENTS WITH KENTUCKY MOUNTAIN EWES

BULLETIN NO. 243

Lexington, Ky.

July, 1922

(137)

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BULLETIN NO. 243

BREEDING EXPERIMENTS WITH KENTUCKY MOUNTAIN EWES

By L. J. HORLACHER and E. S. GOOD

Sheep from the mountain section of Kentucky play an important part in the sheep industry of the State. In former years, large numbers of native ewes were purchased for breeding, were used one or two years, and were then sent to market. This practis resulted in rapidly decreasing the numbers of these sheep, so that sheepmen are becoming interested in some method by which they can produce their own breeding ewes, using the native sheep as a foundation.

The best types of native ewes have many good qualities, foremost among which are their prolificacy and their mothering and milking qualities. The use of scrub rams on the native ewes has had a very deleterious effect on the conformation of their produce. The most pronounced defects of the native stock are: small size; late maturity; lack of symmetry and balance; poor fattening qualities; and coarse, light wool. The exact origin of these sheep is unknown, but they evidently are descendants of some of the British breeds of mutton sheep which were imported into this country at an early date.

OBJECT

Fully realizing the existence of these conditions the Animal Husbandry Department of the Kentucky Experiment Station, in the fall of 1915, began an experiment the object of which was the improvement of the Kentucky mountain ewe with the purpose of producing a superior general-utility farm ewe that would shear more wool of a finer quality and would produce a superior type of market lamb; also of obtaining data as to the

form, quality, finish and gains of lambs out of ewes sired by rams of the Rambouillet, Hampshire, Southdown and Cheviot breeds.

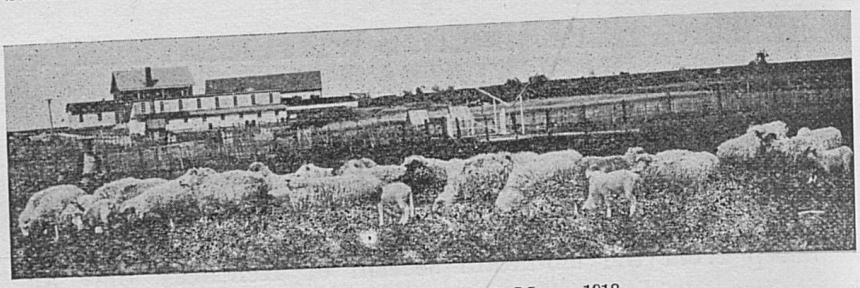

Fig. 1. The flock, May, 1918.

SHEEP USED

Thirty-two head of native ewes were purchased near London, Laurel County, Kentucky, in September, 1915. These ewes were yearlings and two-year-olds, typical of the mountain sheep and free from disease (Figs. 2, 3, 5).

For the introduction of Merino blood a yearling Rambouillet ram was purchased. This was a good, big, rugged ram, a trifle up-standing, but well covered with a fleece of good quality. He was bred to a part of the native ewes to produce the half-blood Rambouillet ewes which were in turn bred to mutton rams for the production of market lambs. The Rambouillet ram was used in 1915, 1916 and 1917 (Fig. 8).

A two-year-old Southdown ram was used in 1915. He was bred to a part of the mountain ewes. No Southdown was used in 1916. In 1917 another Southdown ram was used. In 1918 a

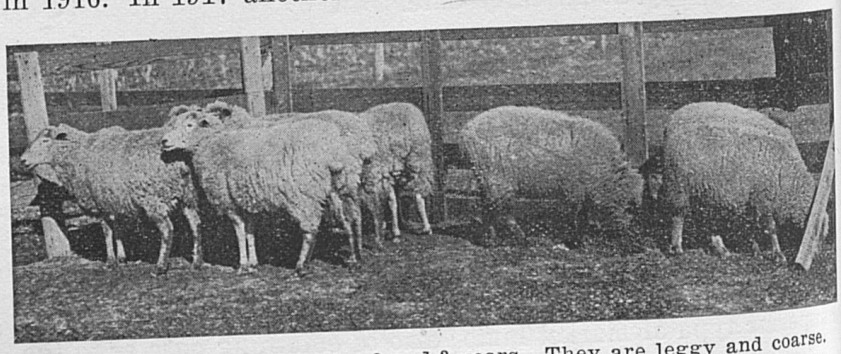

Fig. 2. Mountain ewes. Age 2 and 3 years. They are leggy and coarse.

yearling Southdown ram was purchased. This ram was used in 1918, 1919 and 1920 (Figs. 26-28).

Three Hampshire rams were used: the first in 1915, 1916, 1917 and 1918, the second in 1919, and the third in 1920 (Fig. 13).

In 1918 a Cheviot ram lamb was purchased. He was used in 1918, 1919 and 1920. A Cheviot ram lamb was used in 1920 (Fig. 37).

A scrub ram was used on a part of the ewes in 1916. (Fig. 4).

Several scrub lambs were dropt in the 1916 crop, as six of the ewes proved to be with lamb when purchased.

All ewes and lambs were numbered by the use of metal ear-tags.



Fig. 3. Mountain ewes, all over 4 years old. Weight 98 pounds. The wool is coarse and open; the heads and legs are bare. The ewe at the right has rubbed off the wool from the under side of her neck.

METHOD OF PROCEDURE

The general method of procedure was this: The Rambouillet, Hampshire, Southdown and Cheviot rams were bred to native mountain ewes. The half-blood Rambouillet ewes resulting from this first cross were bred to the rams of the three mutton breeds. The half-blood mutton ewes resulting from this second cross were then bred to other mutton rams of the same breed, thus preventing any mixture of Hampshire, Southdown or Cheviot blood.

The half-blood Hampshire ewes resulting from breeding the Hampshire ram to the mountain ewes were bred to a Hamp-

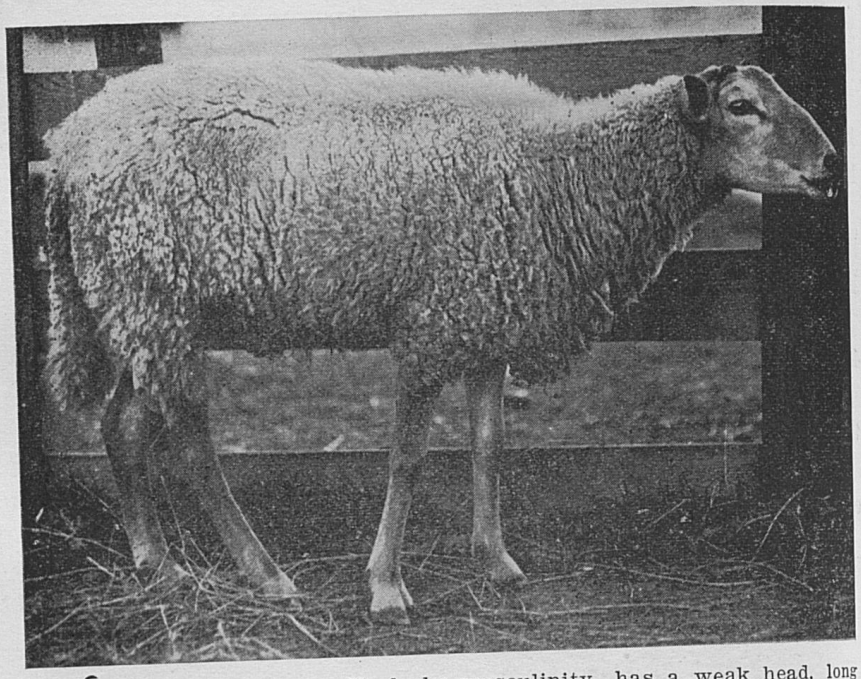

Fig. 4. Mountain ram. He lacks masculinity, has a weak head, long thin neck, long, bare, legs, coarse, light fleece, and has little meat on his body. He is especially lacking in vigor and vitality. Weight 90 pounds.

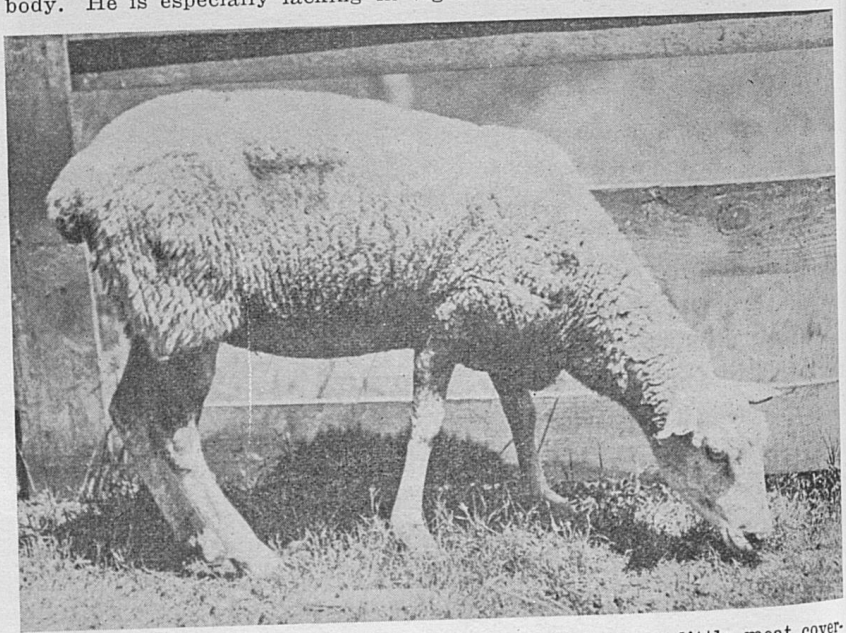

Fig. 5. Mountain ewe. A rugged ewe, but has very little meat covering and a light fleece.

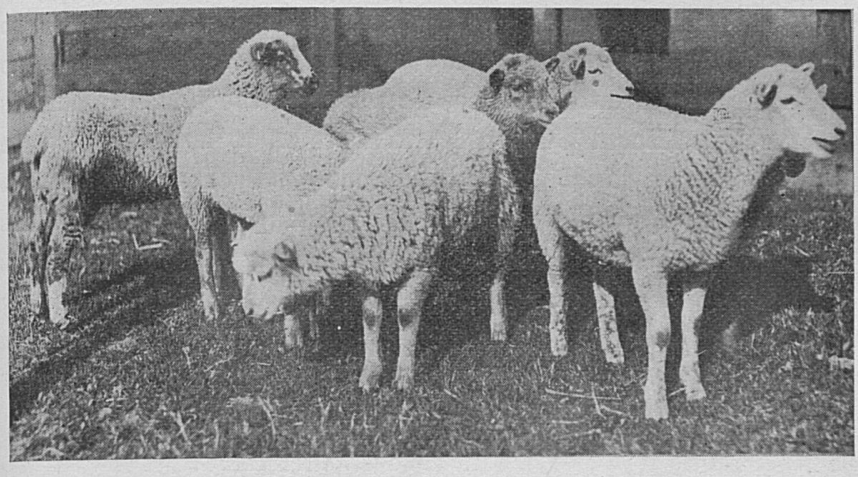

Fig. 6. Mountain lambs, age 3 months. Their heads are narrow, necks thin and long, bodies narrow and shallow. Their backs are weak and their legs long.

shire ram. This process was continued so that high-grade Hampshires were obtained. The same method was followed with the Southdown and the Cheviot rams.

In 1915 the breeding season began on October 11. The beginning date during the next four years was September 16. In 1920 the date was August 11. In each year the rams were allowed to run with the ewes for a period of 40 days, and at the end of that time they were taken away from the ewes. During the first four years the rams were turned with the ewes only at night. In 1919 and 1920, however, they were permitted to be with the ewes night and day.

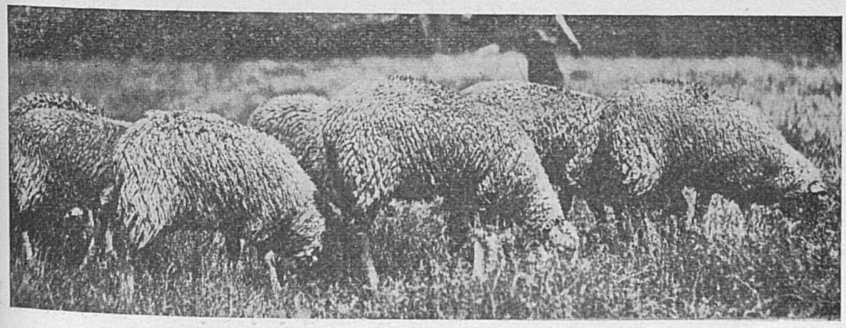

Fig. 7. Mountain lambs. Age 7 months. Lambs like these do not look well on the market.

The mountain sheep in their native haunts are permitted to roam around at will over the hills and valleys. Little or no extra feed is given to them at any time of the year. Conditions at the Experiment Station Farm were such, however, that the ewes had to be handled quite differently. Lack of pasture made it necessary to feed grain and hay during at least six months of the year. Because of the excessive danger from dogs the ewes were shut up each night throughout the year in either a barn or a small enclosure of slightly over one acre surrounded by a dog-proof fence. Thus grain was fed throughout the entire year to replace the pasture which could not be used at night.



Fig. 8. Rambouillet ram. Sheared 28 pounds as a yearling. He combines a heavy, dense fleece with meat-producing ability superior to that of the mountain ram. Weight 165 pounds.

EXPLANATION OF ABBREVIATIONS AND TERMS

Mt.	—Mountain, native or scrub.
R.	—Rambouillet.
H.	—Hampshire.
S.	—Southdown.
C.	—Cheviot.
R-Mt.	—Half-blood Rambouillet, result of breeding a Rambouillet ram to a mountain ewe.
H-Mt.	—Half-blood Hampshire, result of breeding a Hampshire ram to a mountain ewe.
S-Mt.	—Half-blood Southdown, result of breeding a Southdown ram to a mountain ewe.
C-Mt.	—Half-blood Cheviot, result of breeding a Cheviot ram to a mountain ewe.
H-(R-Mt.)	—Half-blood Hampshire, result of breeding a Hampshire ram to a R-Mt. ewe.
S-(R-Mt.)	—Half-blood Southdown, result of breeding a Southdown ram to a R-Mt. ewe.
C-(R-Mt.)	—Half-blood Southdown, result of breeding a Southram to a R-Mt. ewe.
H-(H-Mt.)	—Three-quarter-blood Hampshire, result of breeding a Hampshire ram to a H-Mt. ewe.
S-(S-Mt.)	—Three-quarter-blood Southdown, result of breeding a Southdown ram to a S-Mt. ewe.
C-(C-Mt.)	—Three-quarter-blood Cheviot, result of breeding a Cheviot ram to a C-Mt. ewe.
H-(H-(R-Mt.)	—Three-quarter-blood Hampshire, result of breeding a Hampshire ram to a H-(R-Mt.) ewe.
S-(S-(R-Mt.)	—Three-quarter-blood Southdown, result of breeding a Southdown ram to a S-(S-Mt.) ewe.
H-(H-(H-Mt.)	—Seven-eighths-blood Hampshire, result of breeding a Hampshire ram to a H-(H-Mt.) ewe.

Part I.

LAMB PRODUCTION

First Year, 1915-1916

On October 11, 1915, thirty mountain ewes were divided into three lots of ten each. The Southdown ram was placed with lot 1, the Hampshire ram with lot 2, and the Rambouillet ram with lot 3. The rams were turned with the ewes each night and taken away during the day. The breeding season continued over a period of forty days.

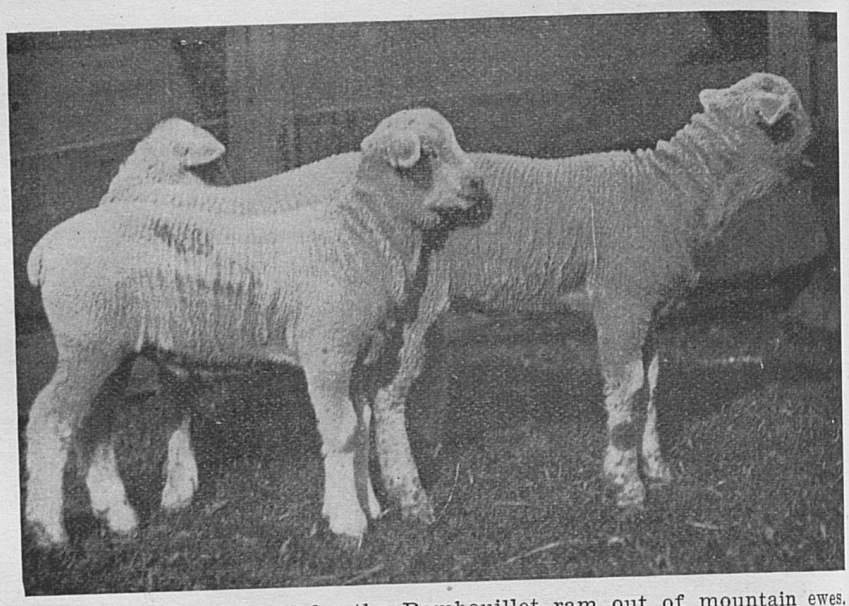

Fig. 9. Lambs sired by the Rambouillet ram out of mountain ewes. They are rangy, but have a good covering of meat.

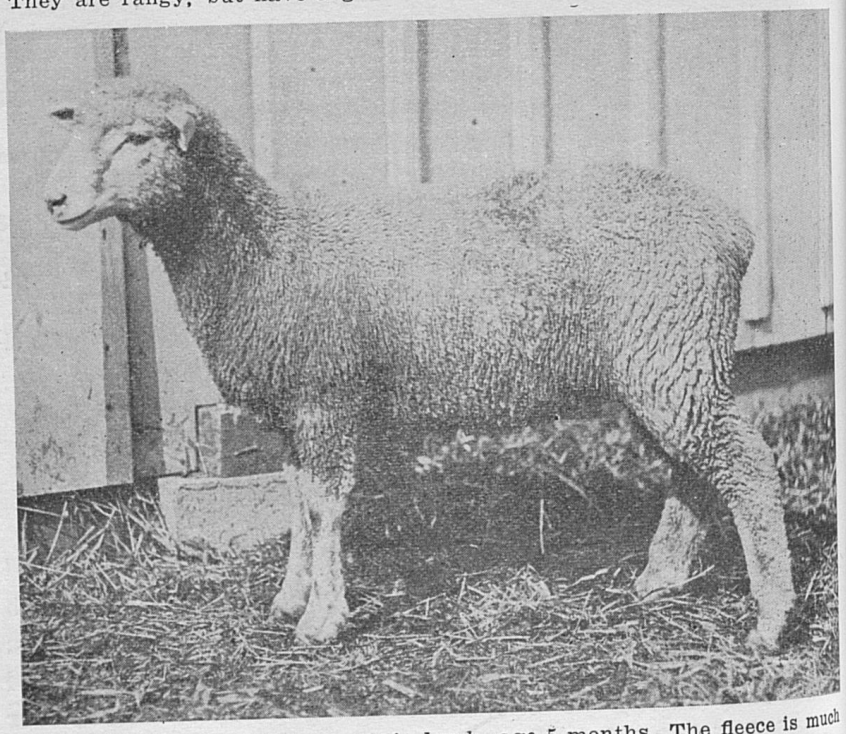

Fig. 10. Rambouillet-mountain lamb, age 5 months. The fleece is much denser than that of the mountain lamb.

Six of the ewes proved to be with lamb at the time of purchase, evidently to a very superior type of mountain ram.

On December 13 silage was introduced into the ration. At first only 8 pounds per day were fed, but this was increased gradually until each ewe was eating 1.5 pounds per day. After the bluegrass pasture became unfit for further use and the sheep were becoming accustomed to silage, grain was fed at the rate of 14 pounds to the 30 ewes per day. The grain mixture consisted of two parts of oats and one part of bran, by weight, and was fed only in the morning. At night 1 pound of clover hay per head was fed. Exercise was given the ewes by permitting them to run on a corn stubble field during good days.

Ewes with young lambs were fed 2 pounds of the grain mixture mentioned above, 2 pounds of corn silage, and mixed hay ad libitum. The ewes came into parturition with very little milk.

On April 1, 1916, the silage was removed from the ration. Bluegrass and rye pastures were substituted. Hay was discontinued April 18.

Table I shows the weights of the lambs at birth and at weaning time.

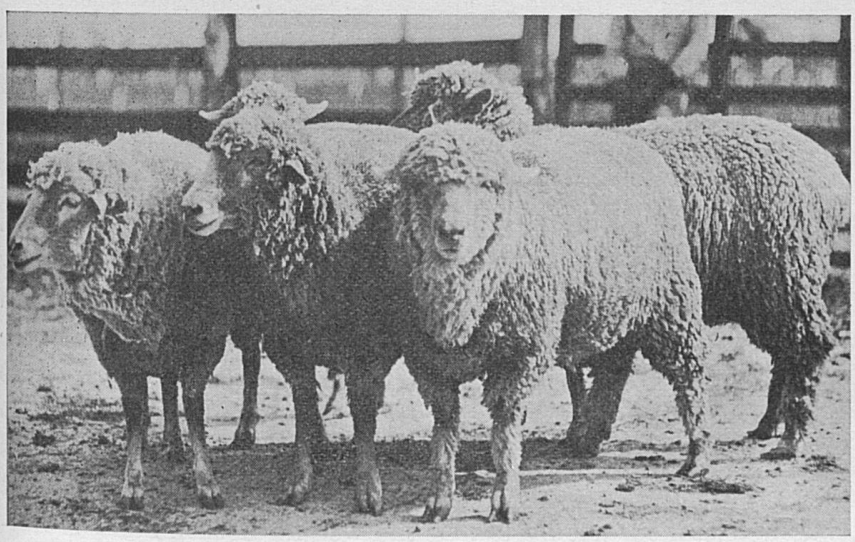

Fig. 11. Yearling Rambouillet-mountain ewes and wethers. These sheep are vigorous and hardy. They have more wool on their faces, legs and underlines than have the mountain sheep.

TABLE I

Weights of Lambs, First Year, 1915-1916

No. of lambs	Breeding	Ave. Wt. at birth	Ave. final weight (age 120 days)	Rank
9	R-Mt.	8.3 lbs.	73.5 lbs.	1
9	S-Mt.	6.66 lbs.	71.5 lbs.	2
6	H-Mt.	7.3 lbs.	70.0 lbs.	3
6	Mt.	7.5 lbs.	56.5 lbs.	4

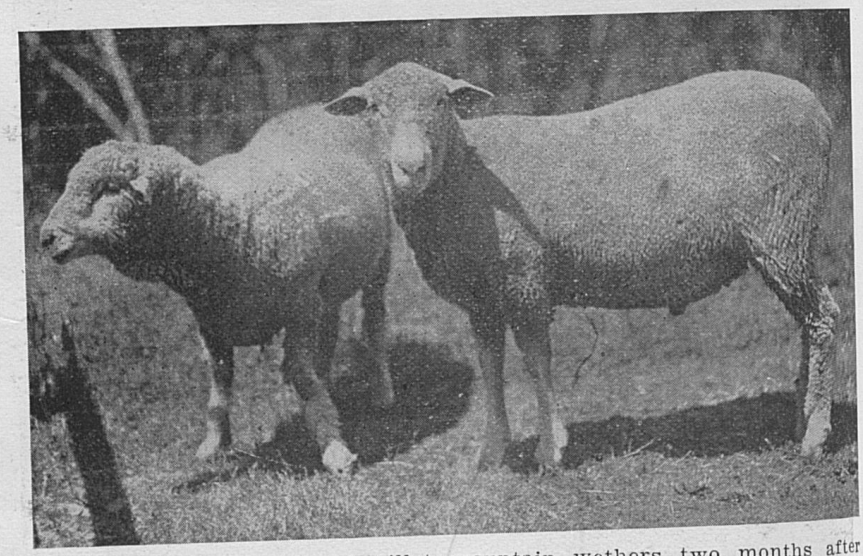

Fig. 12. Yearling Rambouillet mountain wethers two months after shearing. The bodies of these wethers are fairly well filled out and covered with meat.

Some of the lambs were sold on August 9. Those which were kept for experimental purposes were weaned on the same date. In Table I the average of the lambs is given as 120 days. Since the mountain lambs (Figs. 6, 7, 45-47) were 4 to 7 weeks older than any of the others and since the other lambs were dropt over a period of six weeks, the average final weight was determined, not by taking the weight of each lamb on August 9, but by taking the weight of each individual lamb the day

it was 120 days old and then averaging the weights of the lambs of each cross.

Table I shows no relationship between the birth weights and the final weights of the lambs. It happened that the R-Mt. lambs were the largest both at birth and at weaning time, but, on the other hand, the S-Mt. lambs were the lightest at birth and ranked second in weight at weaning time. There was very little difference in the final weights of any of the lambs sired by purebred rams. The scrub lambs not only weighed 13.5 pounds per head less than the lightest of those sired by one of the purebred rams, but they were much more narrow, leggy, and shallow bodied, and lacked meatiness and symmetry of build.



Fig. 13. Hampshire ram lamb, used 1915 to 1918. This ram weighed 230 pounds in breeding condition when two years old, and 260 pounds when four years old.

Second Year, 1916-1917

The breeding season began on September 16, 1916. The ewes and rams were handled as in the preceding year. Eight of the ewes were bred to the Hampshire ram, two to the Rambouillet and the remainder to a mountain ram purchased for $4.50 and weighing 90 pounds.

The rams were turned in with the ewes at night and taken away in the morning. The entire flock was very thrifty and in excellent condition.

The first lambs were dropt on February 6. They varied a great deal in color. The lambs from the scrub buck were yellowish-brown in color, with some white markings on the face and legs. Lambs sired by the Hampshire ram had black faces and ears, black and white markings on the body, and black or dark brown color on the legs. They had typical large dark-colored Hampshire ears. Lambs sired by the Rambouillet ram were of various colors. Some were dark brown, some light and almost

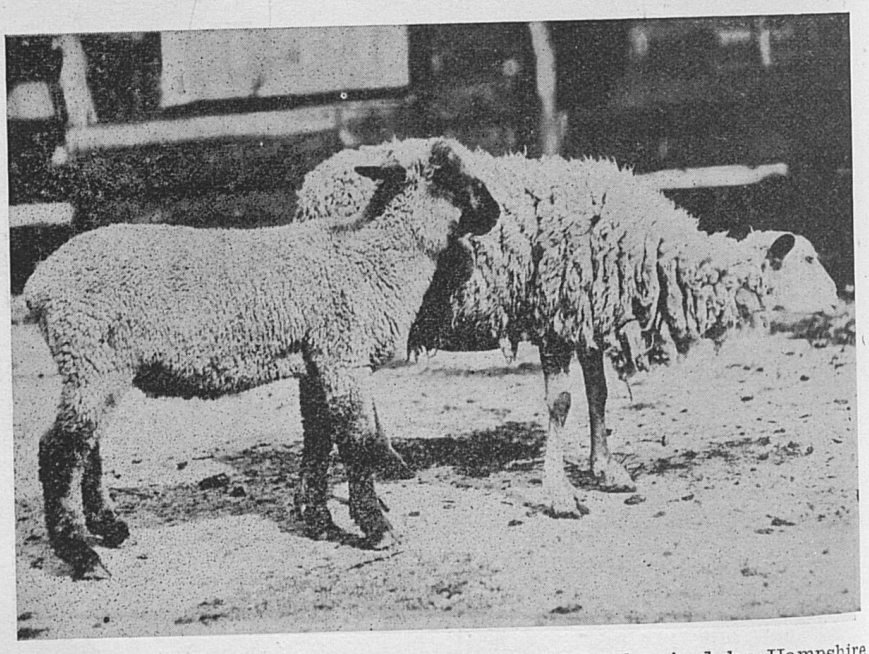

Fig. 14. Mountain ewe and her 50-day old lamb, sired by Hampshire ram. The lamb is much thicker and more blocky than its mother. It has a much denser fleece, more evenly distributed over the body. An early-maturing lamb.

white. They had heavy, dense, compact fleeces. All lambs were docked and all ram lambs were castrated when they were about 10 days of age.

On March 12 the lambs were given their first feed of grain. This consisted of a mixture of two parts of bran and one part of oats by weight. It was fed in a creep. One week later the ewes and lambs were turned on rye pasture. The lambs were weaned August 20.

Table II shows the weights of the lambs at birth and at weaning time.

TABLE II

Weight of Lambs, Second Year, 1916-1917

No. of lambs	Breeding	Ave. Wt. at birth	Ave. final weight (age 163 days)	Rank
3	R-Mt.	7.17 lbs.	93 lbs.	1
1	H-(H-Mt.)	8. lbs.	87 lbs.	2
19	H-Mt.	6.10 lbs.	75 lbs.	3
12	Mt.	7.43 lbs.	67 lbs.	4

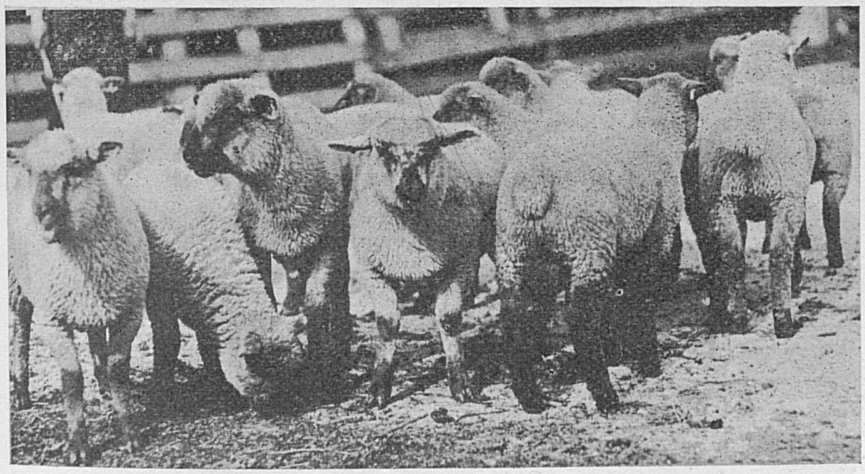

Fig. 15. Lambs sired by the Hampshire ram, out of mountain ewes, age 3 months. They are broader and thicker in front and are plumper and fuller behind than the mountain lambs.

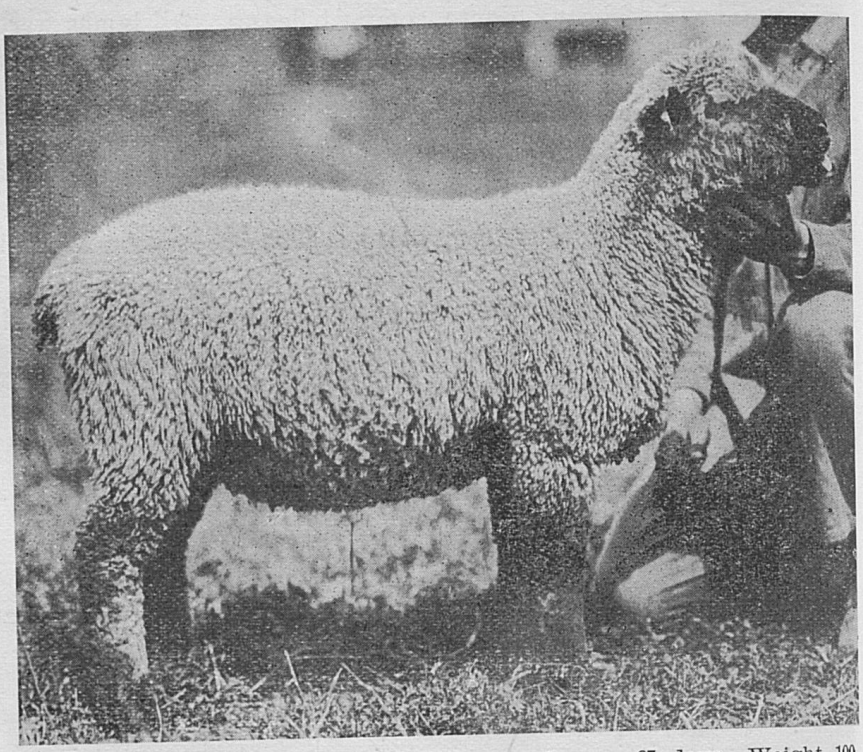

Fig. 16. Hampshire-mountain wether lamb, age 87 days. Weight 100 pounds. This lamb shows that the Hampshire cross lambs mature much earlier than the mountain lambs.

The final weights of the lambs in the second year were greater than those of the first year. However, the weights were taken when the lambs were 163 days old, as compared with 120 days in the preceding year. As in the first year's work,



Fig. 17. Hampshire-mountain lambs, age 6 months. These lambs are very uniform in size, form and fleece.

there was no relationship between the birth weight and the final weight.

As only one three-quarter Hampshire lamb is listed, nothing definite can be concluded as to its relative position when compared with the other crosses in which more individuals are concerned. Lambs sired by the Rambouillet ram ranked first, 6 pounds heavier than the three-quarter Hampshire lamb, which, in turn, was 12 pounds heavier than the H-Mt. lambs. The mountain lambs were 8 pounds per head lighter than the H-Mt. lambs.

With one exception all ewes bred to the Hampshire ram dropt twins. Two of the three R-Mt. lambs were twins. There were only three sets of twins among the mountain lambs.

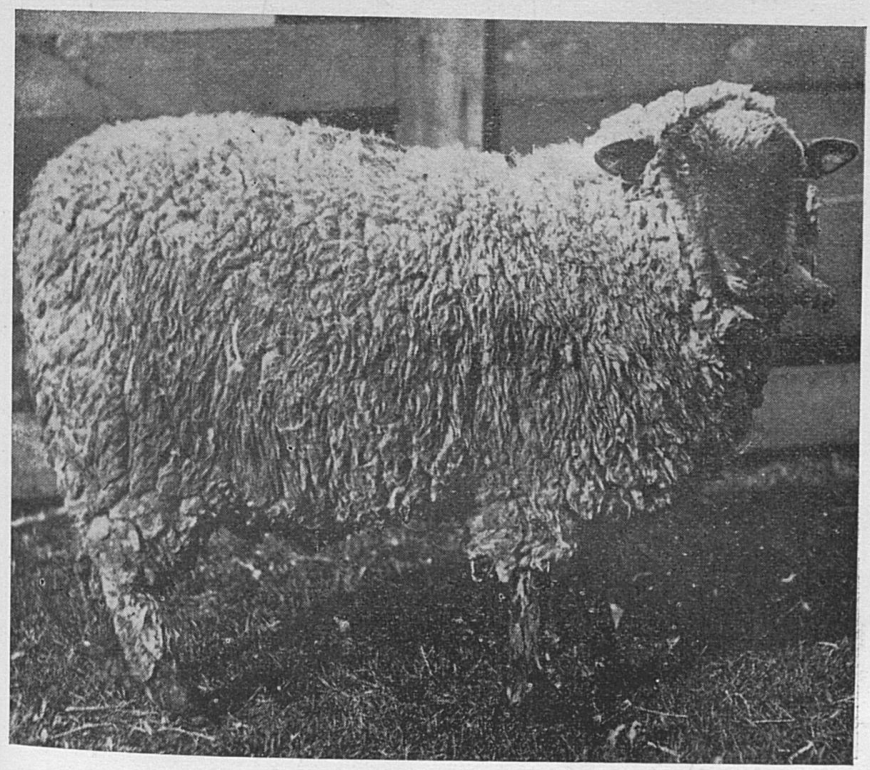

Fig. 18. Yearling Hampshire-mountain ewe. She is much more lowset and compact than the mountain ewes.

Third Year, 1917-1918

The breeding season of 1917 began on September 16. Lot 1, consisting of mountain and first-cross Hampshire and Rambouillet ewes, was bred to the Hampshire ram. Lot 2, consisting of first-cross Rambouillet ewes, was bred to the Southdown ram. The remaining mountain ewes were bred to the Rambouillet ram.

The rams were turned with the ewes at night and taken out in the morning. The ewes were given the run of an excellent bluegrass pasture and were fed half a pound per head of equal parts of oats and bran daily.

The winter was very severe, so that it was necessary to keep the ewes closely housed.

February was more mild. Lambing started on the 9th. The general method of handling was the same as in the two preceding years. The lambs were docked with hot pincers, with very successful results. All ram lambs were castrated when they were about two weeks of age. They were weaned on the fifth of September.

Table III shows the weights of the lambs at birth and at weaning time.

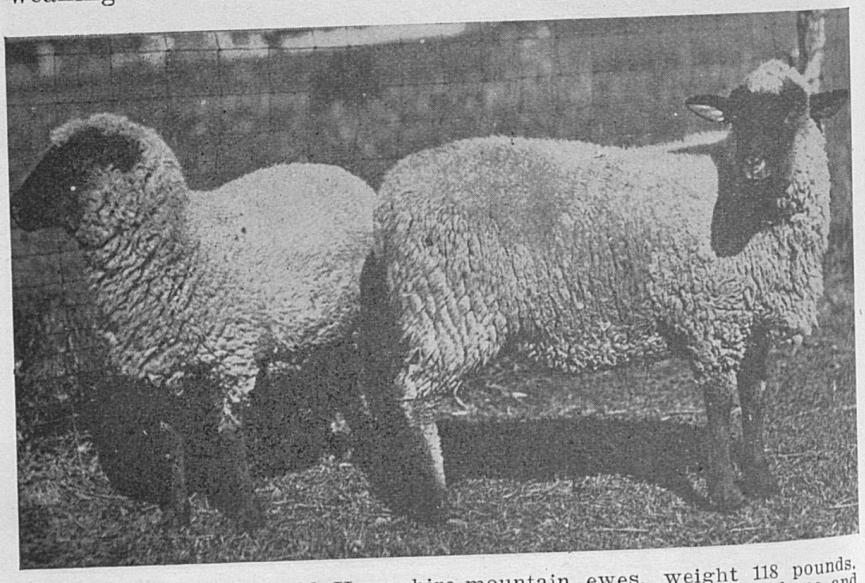

Fig. 19. Two-year-old Hampshire-mountain ewes, weight 118 pounds. These ewes are larger than the mountain ewes. They have more bone and substance. The black faces and legs show Hampshire breeding.

TABLE III

Weight of Lambs, Third Year, 1917-1918

No. of lambs	Breeding	Ave. wt. at birth	Ave. wt. July 1, 1918	Rank
6	H-Mt.	6.44	63.8	1
12	S-Mt.	6.54	58.8	2
12	R-Mt.	7.21	58.4	3
4	H-(R-Mt.)	6.5	55.5	4
2 (twins)	S-(R-Mt.)	6.5	49.5	5

The average age of all lambs on July 9 was approximately four months. The Rambouillet-mountain lambs dropt from first place, which they held in the first two years, to third place. The Hampshire cross on the mountain ewe led the list with an advantage of 5 pounds more than the Southdown-mountain cross, which was second. The second-cross Hampshire-Rambouillet-mountain ranked fourth and second-cross Southdown-Ram-



Fig. 20. Three-quarter Hampshire lambs, sired by the Hampshire ram, out of Hampshire mountain ewes. These lambs are more uniform than the H-Mt. lambs. They would attract a great deal of attention on the market.

bouillet-mountain lambs ranked at the bottom. These last two lambs, however, were twins.

Six of the ten Hampshire cross lambs, six of the fourteen Southdown cross lambs, and six of the twelve Rambouillet cross lambs were twins. The birth weights and final weights varied much as they did the first two years.

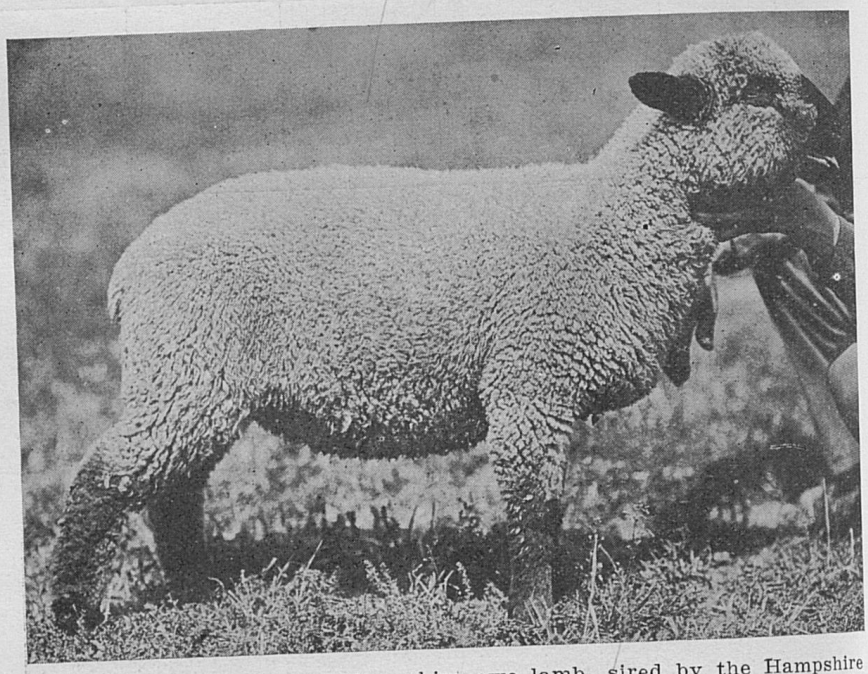

Fig. 21. Seven-eighths Hampshire ewe lamb, sired by the Hampshire ram, out of a three-quarter Hampshire ewe. She is slightly drooping in the rump, but otherwise very blocky and symmetrical.

Fourth Year, 1918-1919

In 1918, breeding began September 16. As in the previous years the ewes were divided into three lots. Lot 1 was bred to the Hampshire ram. The ewes were mountain, Hampshire-mountain, Hampshire-Rambouillet-mountain and Rambouillet-mountain. The remaining mountain ewes were placed in Lot 3 and bred to the Cheviot ram.

The rams were permitted to be with the ewes at night only. During the day the ewes were grazed on a rich bluegrass pasture, while at night they were kept in the barn. As the ewes

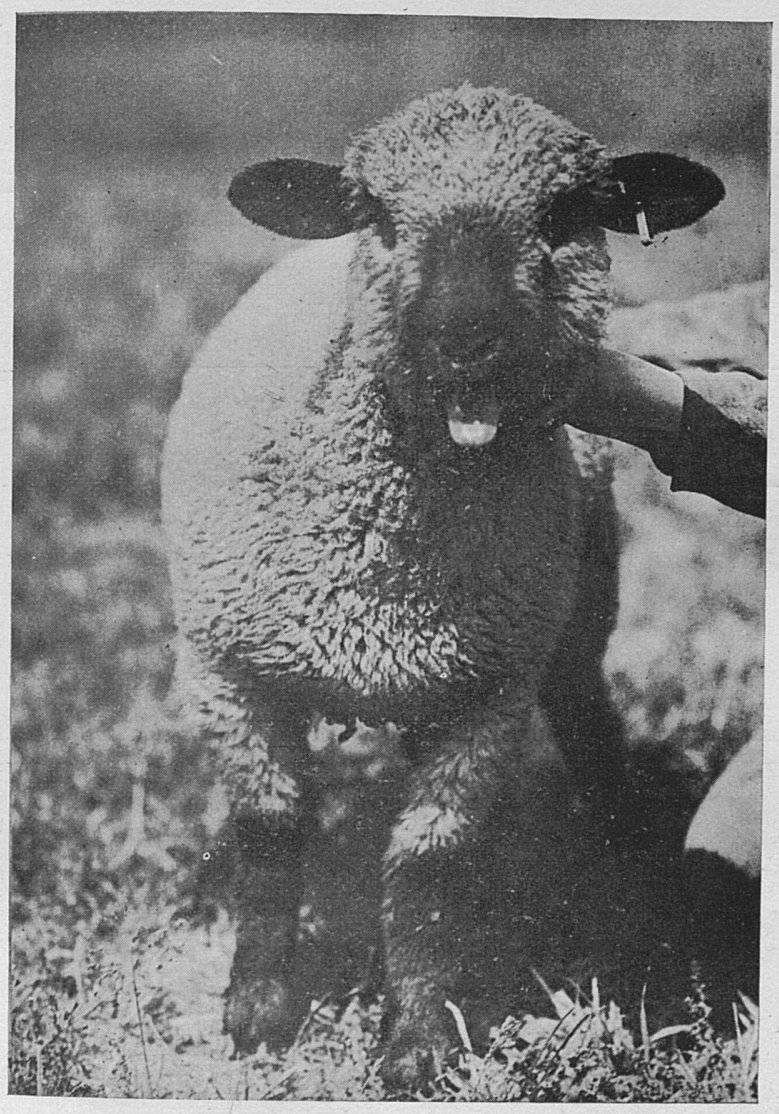

Fig. 22. Head of seven-eighths Hampshire ewe lamb shown in Fig. 21. It would be difficult to distinguish between this lamb and a pure bred Hampshire.

were very thin each was fed one pound of grain (10 parts oats and 1 part linseed oil meal) per day.

During October there was some slight digestive trouble among the ewes, causing a few of them to go blind for several days. The affected sheep were drenched with 140 cc. of a solu-

tion made up of one ounce of Epsom salts, 1/10 ounce gamboge and a little ginger. Every one recovered.

Beginning January 1, sorghum silage was fed to the ewes. This was continued for one month, and no bad effects were noted, altho a great deal of red mold was present in the silage.

Table IV gives the weights of the lambs at birth and at weaning time.

TABLE IV

Weights of Lambs, Fourth Year, 1918-1919

No. of lambs	Breeding	Ave. wt. at birth	Average final wt. (age 125 days).	Rank
2	H-(R-Mt.)	8.42 lbs.	66.75 lbs.	1
2 (twins.)	H-(H-(R-Mt.)	7.5 lbs.	64.75 lbs.	2
6	H-(H-Mt.)	6.38 lbs.	61.5 lbs.	3
7	H-(Mt.	6.32 lbs.	60. lbs.	4
2	S-(R-Mt.)	6.83 lbs.	57.5 lbs.	5
7	C-Mt.	8. lbs.	56.5 lbs.	6
18	S-Mt.	8.21 lbs.	53.5 lbs.	7

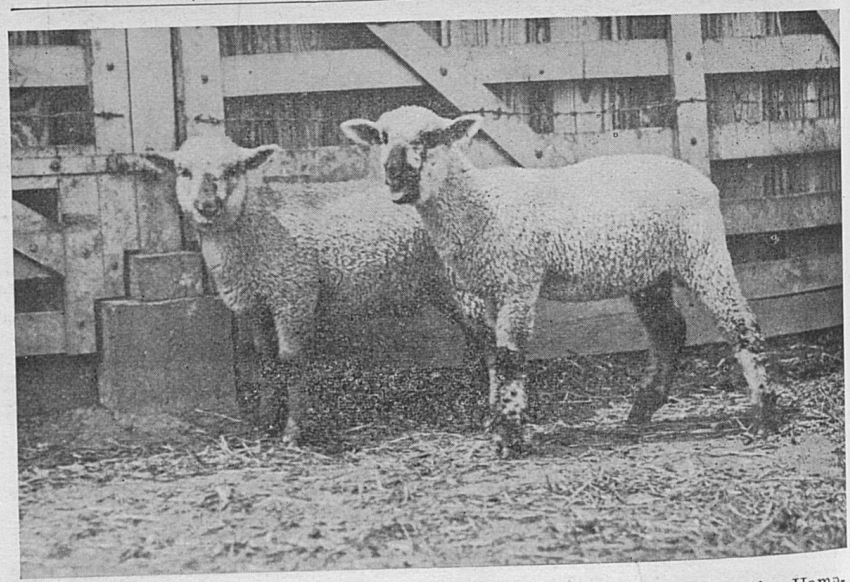

Fig. 23. Hampshire-Rambouillet-mountain lambs, sired by the Hampshire ram, out of a Rambouillet-mountain ewe, age 96 days. This cross does not reduce the length of leg, but it gives heavier lambs that are thicker than the mountain lambs. They gain very rapidly.

Three of the crosses were represented by only two lambs each, which is not a sufficient number to warrant definite conclusions as to their proper standing. The significant feature of this table is that the four leading crosses were all sired by the Hampshire ram, so that very probably the crosses represented by only two lambs each are approximately where they belong. Here, as before, there was no relationship between the birth weight and the final weight.

The H-(R-Mt.) lambs were lacking in uniformity of color. They had speckled faces and legs. They were upstanding and lacking in blockiness. Their faces, cheeks and legs were well covered with wool.

The H-(H-(R-Mt.) lambs showed more of the black color of the Hampshire, which gave the wool on top of the head a brown tinge. They were closer to the ground and had a fair covering of wool on the faces and legs.

The H-(H-Mt.) lambs showed many of the characteristics in color and markings of the Hampshire. The faces and legs

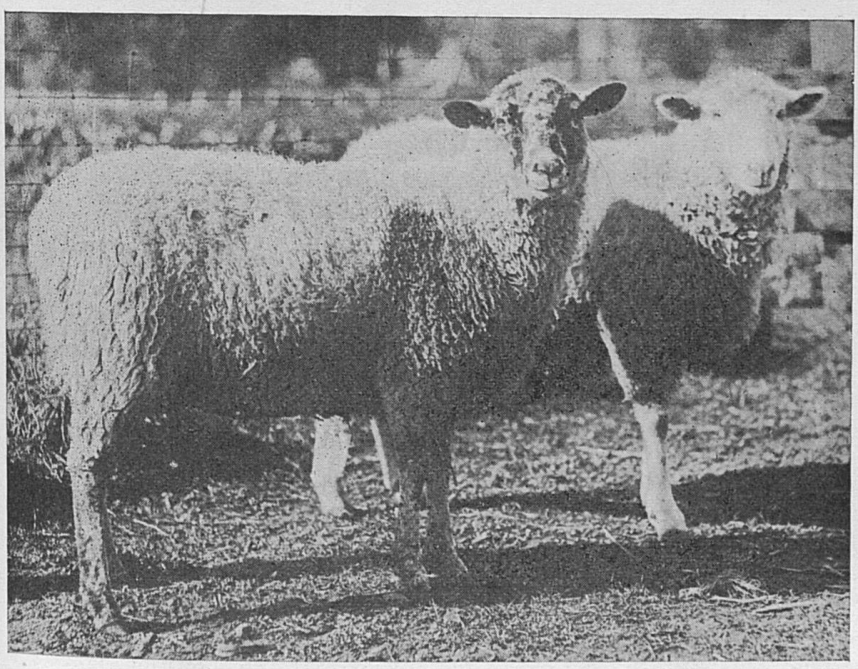

Fig. 24. Hampshire-Rambouillet-mountain yearling ewe and wether twins. The ewe proved to be an excellent breeder.

were of a uniform black color. The ears were large and heavy with the characteristic droop. Their bodies were much more smooth and compact and low-set than those of the first cross. One lamb had a covering of wool on the face and cheeks, while the wool on the others stopt at the eyes.

The H-Mt. lambs were leggy and loosely put together. The faces, legs and ears were either black or mottled.

The S-(R-Mt.) lambs were a little more leggy and rangy than were the S-Mt. lambs. Their color markings were mixed. They were well covered with medium dense wool over the face, cheeks, underline and legs.

The S-Mt. lambs were low-set, compact, blocky and smoothly built, more so than any of the other crosses. The color varied from light to dark gray. Most of them showed quite pronounced Southdown type. They were wooled down fairly well between the eyes, but had very little wool on the cheeks.

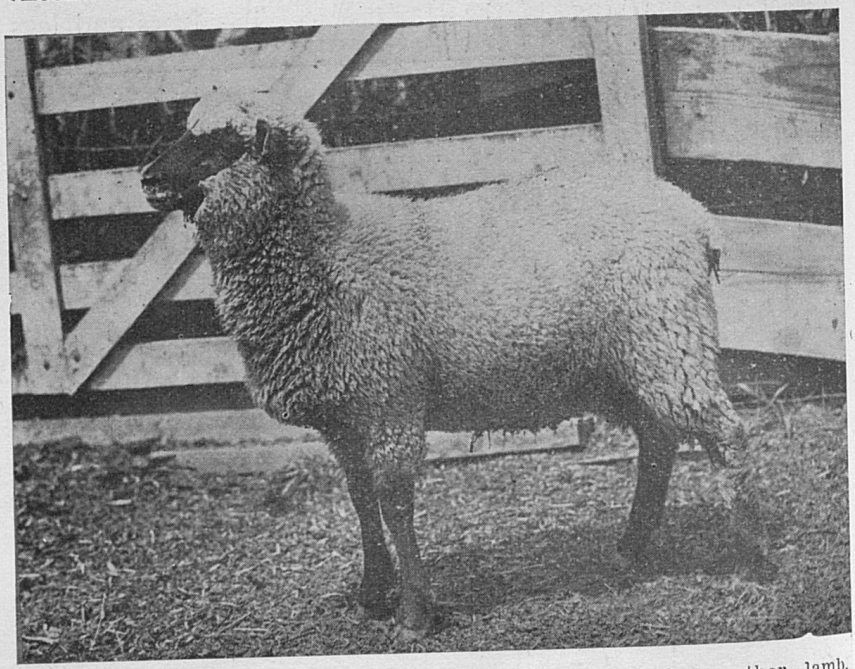

Fig. 25. Hampshire-Hampshire-Rambouillet-mountain wether lamb, sired by Hampshire ram, out of the brockle-face ewe shown in Fig. 24, age 5 months. As a market lamb this lamb is an improvement over the H-(R-Mt.) cross.

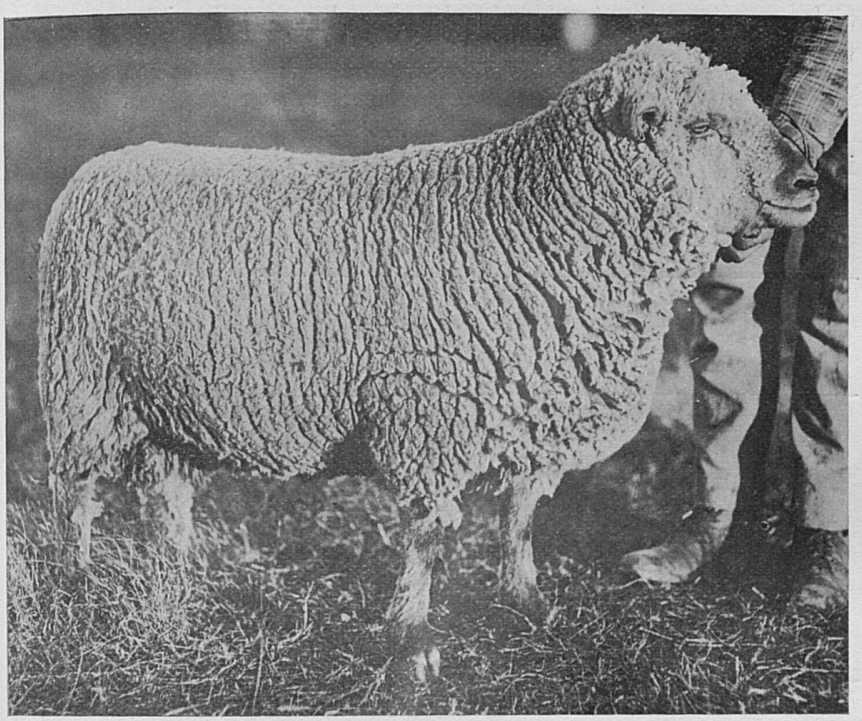

Fig. 26. First Southdown ram used. Two years old. He sired the largest lambs of any of the three Southdown rams used.

The C-Mt. lambs all appeared very much like the Cheviot. They had white faces, legs and ears, erect ears, and were alert in appearance. Their fleeces were open but of good length. A few of the wether lambs showed scurs, which were quite prominent in their sire.

Fifth Year, 1919-1920

The breeding season in 1919 began on September 16. Hampshire, Southdown and Cheviot rams were used. The rams were turned with the ewes on September 16 and were allowed to run with them continually for 40 days. The Hampshire ram proved to be very uncertain as a breeder, getting only two ewes with lamb.

Conditions during this year were very unsatisfactory. The sheep were too crowded and very little protein feed was available. The result was that a great many of the lambs came

either weak or dead. The lambs sired by the Cheviot were more vigorous at birth and nursed more quickly than did the lambs of any other cross.

Table V gives the weights of the lambs at birth and at weaning time.

TABLE V

Weight of Lambs, Fifth Year, 1919-1920

No. of lambs	Breeding	Ave. wt. at birth	Ave. final wt. (age 140 days)	Rank
1	H-(H-(R-Mt.)	8.75 lbs.	74 lbs.	1
4	C-(R-Mt.)	7.92 lbs.	73.5 lbs.	2
1	S-(S-(R-Mt.)	8.00 lbs.	70 lbs.	3
5	C-Mt.	7 lbs.	66.5 lbs.	4
12	S-Mt.	6.82 lbs.	60 lbs.	5
2 (twins)	H-(H-Mt.)	5.25 lbs.	55 lbs.	6
4	S-(S-Mt.)	7.33 lbs.	52.5 lbs.	7
2 (twins)	S-(R-Mt.)	7 lbs.	46 lbs.	8

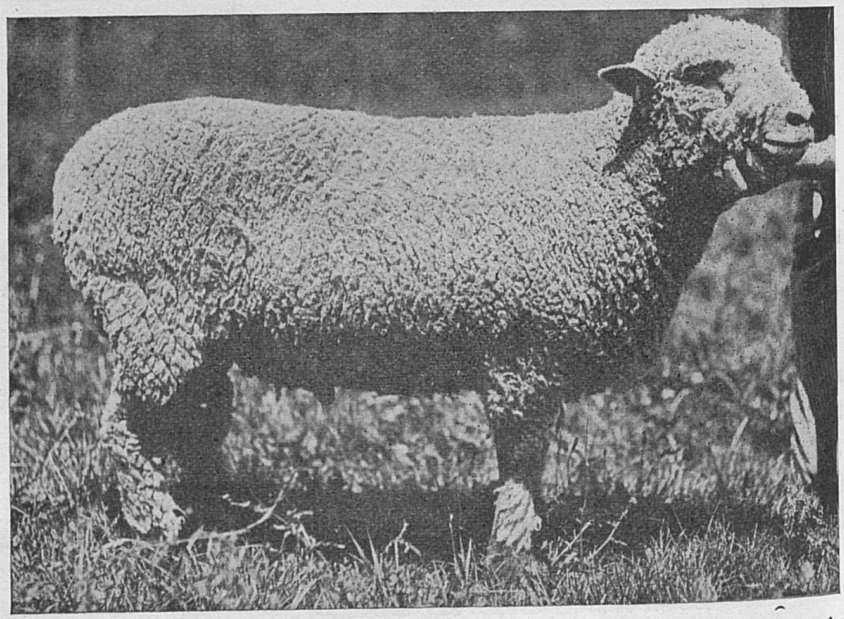

Fig. 27. Second Southdown ram used. Weight 102 pounds. The lambs sired by this ram were small.



Fig. 28. Third Southdown ram used, four years old. Weight 175 pounds Second prize as a lamb at the Tennessee State Fair. His lambs had plenty of quality but lacked size.

The age of all the lambs at the last weighing was 140 days. One three-quarter Hampshire lamb, H-(H-(R-Mt.), led the list with a half pound more than the four Cheviot-Rambouillet-mountain lambs. One three-quarter Southdown, S-(S-(R-Mt.), a lamb of remarkable squareness and blockiness of build and with plenty of quality, ranked third, followed by the five Chev-

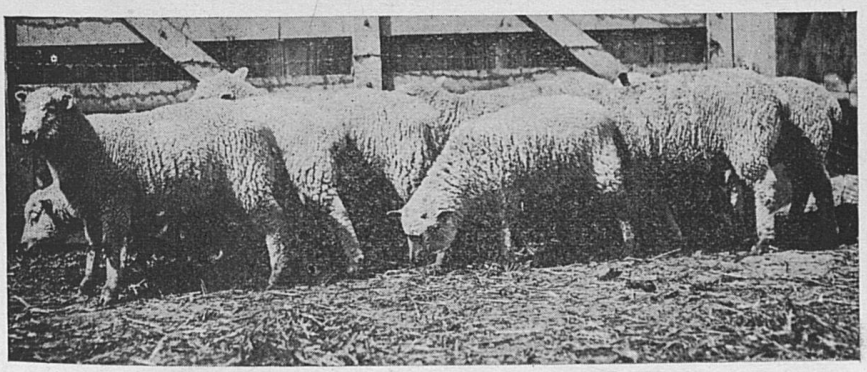

Fig. 29. Southdown-mountain lambs, age 107 days. Weight 57 pounds. They are much more uniform and more blocky than the mountain lambs. They are closer to the ground than the R.-Mt. or the H.-Mt. lambs.

iot-mountain lambs. Twelve Southdown-mountain lambs ranked fifth with an average of 60 pounds. Two Hampshire-Hampshire-mountain lambs were sixth, four Southdown-Southdown-mountain lambs seventh, and two Southdown-Rambouillet-mountain twins were at the bottom, twenty-eight pounds lighter per head than the leader. The nine grade Cheviot lambs ranked higher than did the seven grade Cheviots in 1919. The three grade Hampshire lambs ranked lower than did the seventeen grade Hampshires in 1919.

Sixth Year, 1920-1921

The breeding season in 1920 began on August 11. Hampshire, Southdown and Cheviot rams were used. The rams were allowed to remain with the ewes for forty-seven days. They

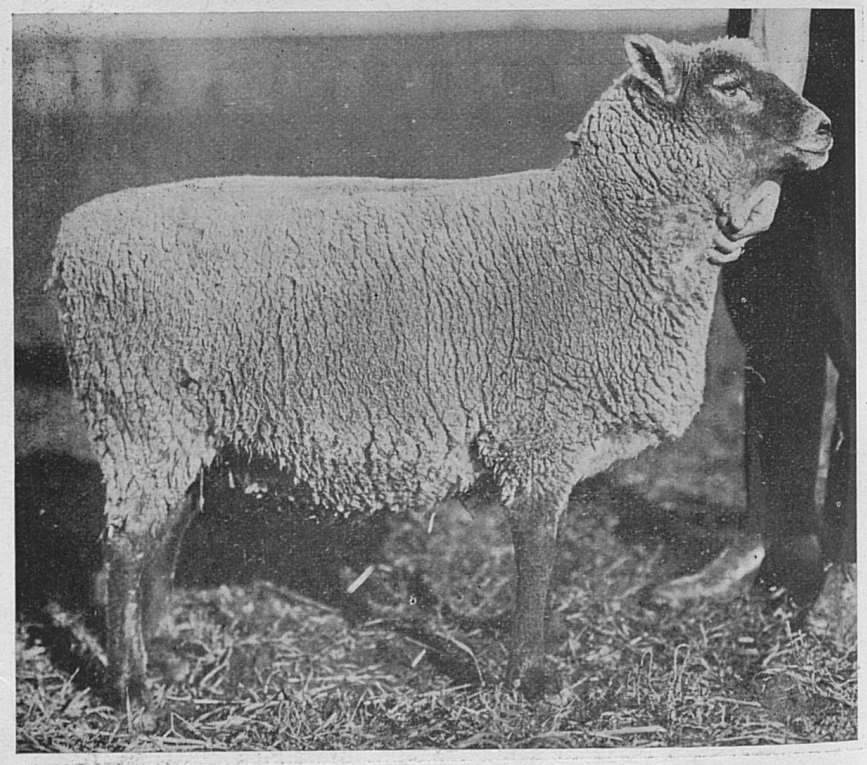

Fig. 30. Yearling Southdown-mountain wether. Weight 145 pounds. Dressed 64.4 per cent without a shrink. This wether fattened very easily. His head is small, short and wide and his body very thick, but he is peaked in the hind quarter. His legs are too long.

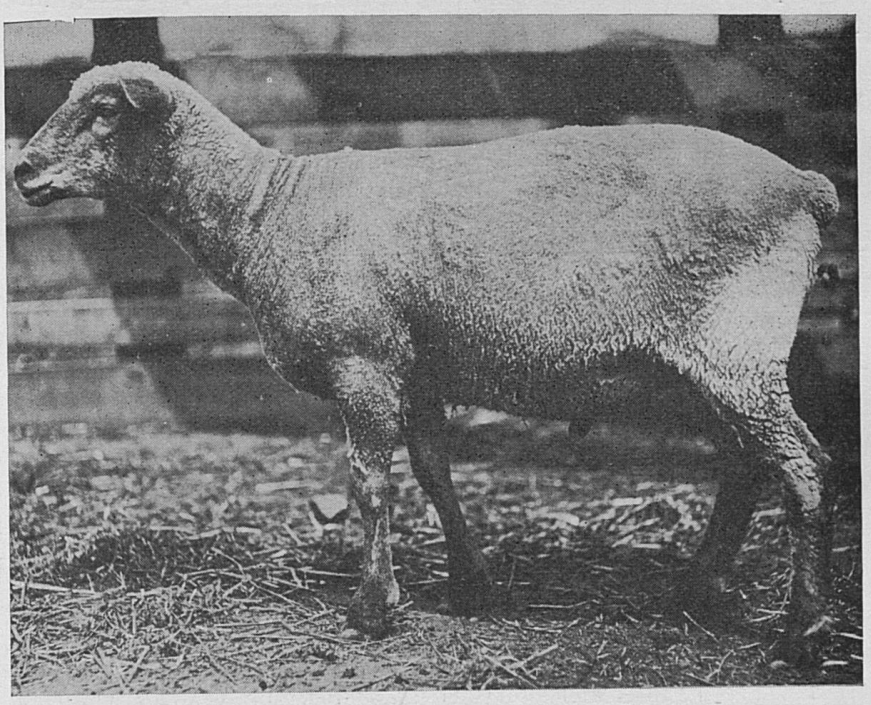

Fig. 31. Yearling Southdown-mountain wether, after shearing. Weight 110 pounds. This wether is more rangy than the one shown in Fig. 30. He is thickly covered with meat of good quality.

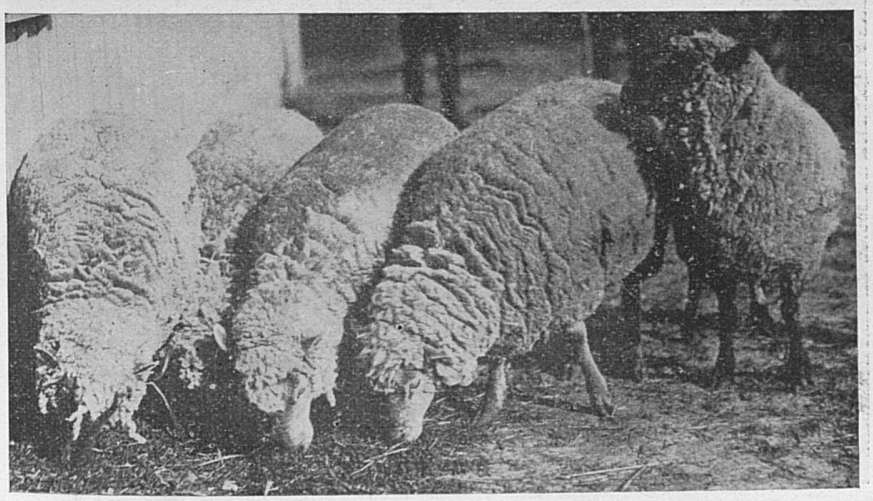

Fig. 32. Yearling Southdown-mountain ewes. Weight 100 pounds. Only a few of these ewes are larger than the mountain ewes. Their wool, however, is finer and denser.

were permitted to be with the ewes continuously during this time.

Table VI gives the weights of the lambs at birth and at weaning time.

TABLE VI

Weights of Lambs, Sixth Year, 1920-1921

No. of lambs	Breeding	Ave. wt. at birth	Ave. final weights (age 120 days).	Rank
1	H-Mt.	11.5 lbs.	100 lbs.	1
1	H-(H-(H-Mt.)	9.25 lbs.	81.5 lbs.	2
2 (twins)	H-(H-(R-Mt.)	8.0 lbs.	79 lbs.	3
4	H-(H-Mt.)	8.0 lbs.	70 lbs.	4
2	C-Mt.	10.25 lbs.	69 lbs.	5
5	C-(R-Mt.)	6.5 lbs.	66.5 lbs.	6
1	C-(C-Mt.)	7.25 lbs.	66 lbs.	7
4	S-(R-Mt.)	7.5 lbs.	64 lbs.	8
2 (twins)	S-(H-Mt.)	7.5 lbs.	63.5 lbs.	9
7	S-(S-Mt.)	7.5 lbs.	61.5 lbs.	10

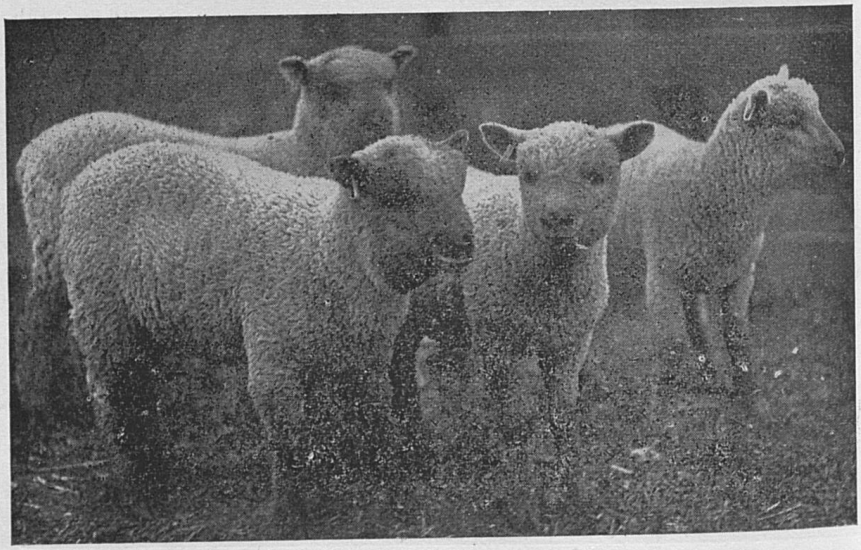

Fig. 33. Three-quarter Southdown lambs, sired by the Southdown ram, out of Southdown-mountain ewes.

The eight lambs in the four leading crosses were all sired by the Hampshire ram. This agrees with the figures given in Table IV, but the number of individuals represented here is small also. The heaviest lamb at birth was also the heaviest at 120 days of age but the remainder of the crosses show as much variaton as in any preceding year.

A half-blood Hampshire wether lamb ranked first, weighing 100 pounds, which was 18.5 pounds more than the weight of the seven-eights-blood Hampshire ewe lambs ranking second. The two lambs in the third place were twins, three-quarter-blood Hampshires with one Rambouillet cross. The four three-quarter-blood Hampshires which did not possess a Rambouillet cross were fourth, nine pounds lighter per head than those in third place. Only one other cross containing Hampshire blood was represented. Two twin lambs sired by the Southdown ram and out of a Hampshire-mountain ewe ranked ninth with a weight of 63.5 pounds.

The Cheviot and Southdown grades occupied the six bottom places. The Cheviot crosses ranked fifth, sixth and seventh, while the Southdown crosses ranked eighth, ninth and tenth.

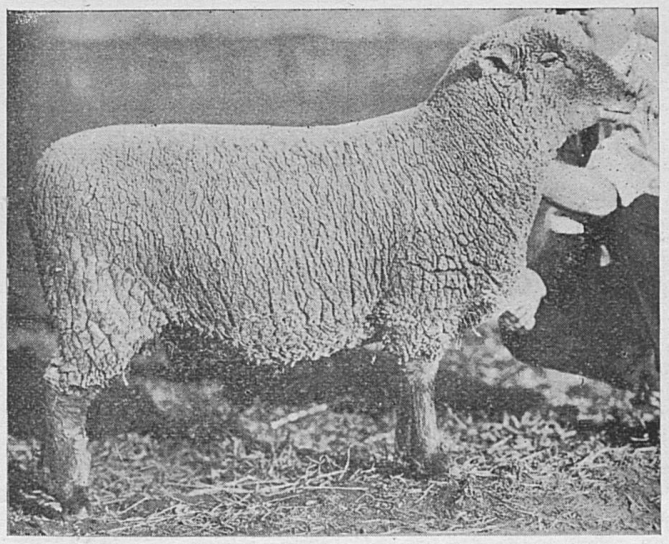

Fig. 34. Three-quarter Southdown yearling wether. Weight 135 pounds. He is closer to the ground and is more typically Southdown than the wethers shown in Figs. 30 and 31.

PERCENTAGE OF TWINS

Table VII shows the percentage of twins sired by rams of the different breeds.

TABLE VII

Breed of Ram	No. of lambs sired	No. of twin lambs	Percentage of twins	Rank
Hampshire	78	56	71.8	1
Cheviot	36	23	63.9	2
Southdown	102	45	44.1	3
Rambouillet	32	12	37.5	4
Mountain	19	6	31.5	5

The above figures cover the results of six years. They include not only lambs out of mountain ewes but also lambs out of



Fig. 35. Yearling Southdown-Rambouillet-mountain wether. This wether won third prize for the University of Kentucky in the carcass contest at the 1920 International Live Stock Exposition. He dressed 56.4 per cent without a shrink. His fleece weighed 9 pounds.

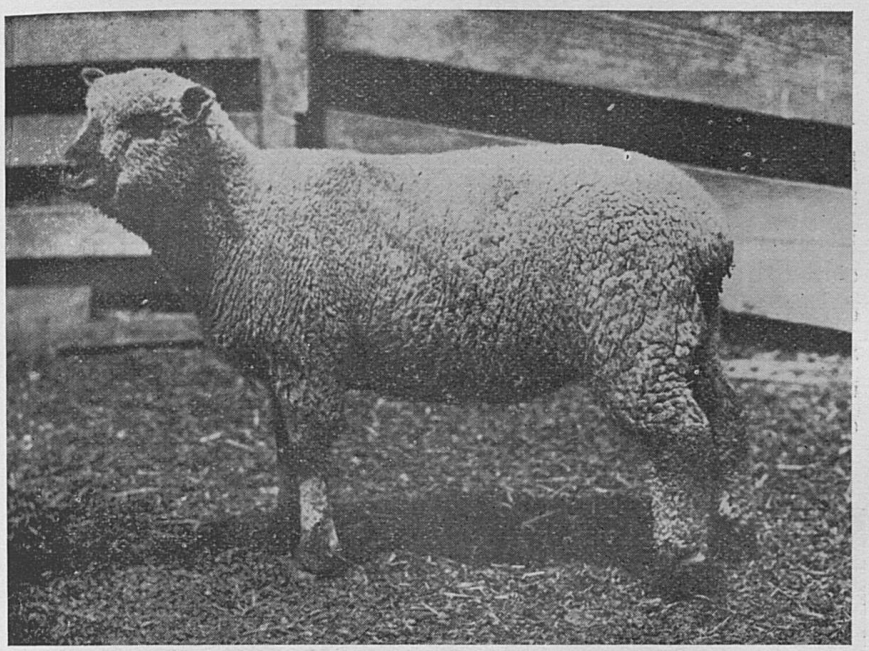

Fig. 36. Southdown-Southdown-Rambouillet-mountain wether lamb, out of a Southdown-Rambouillet-mountain ewe. Age 4½ months. A very compact small lamb.

grade ewes. The mountain ram, however, was bred only to mountain ewes.

The Hampshire ram sired the largest percentage of twins, followed in order by the Cheviot, Southdown, Rambouillet and mountain rams. While it may be desirable that sheep in the mountains should produce only a small percentage of twins, because of poor pastures and lack of proper handling facilities, yet for the production of spring lambs for market, especially in sections such as the Bluegrass region where grass and feed are plentiful, it is more profitable to produce a larger number of twins per ewe.

SLAUGHTER RECORDS

A few of the lambs were slaughtered in the meat laboratory. Unfortunately this laboratory was not in operation at the beginning of the experiment; consequently no records of the mountain lambs were obtained. However, records were kept of a few of the R-Mt., H-Mt. and S-Mt. lambs.

In every case the live weight, immediately before killing, was recorded. After the pelt, feet, head and viscera had been removed, the dressed carcass was weighed. The carcass was placed in the cooler where it remained for at least 24 hours in a temperature of from 33 to 37 degrees Fahrenheit. The carcass was then weighed again, this last weight being known as the cold dressed weight. This figure was used in determining the dressing percentage. The carcass shrank from one-half to two and one-half pounds during the process of cooling. The fatter carcasses shrank the less. Table VIII gives the slaughter records.

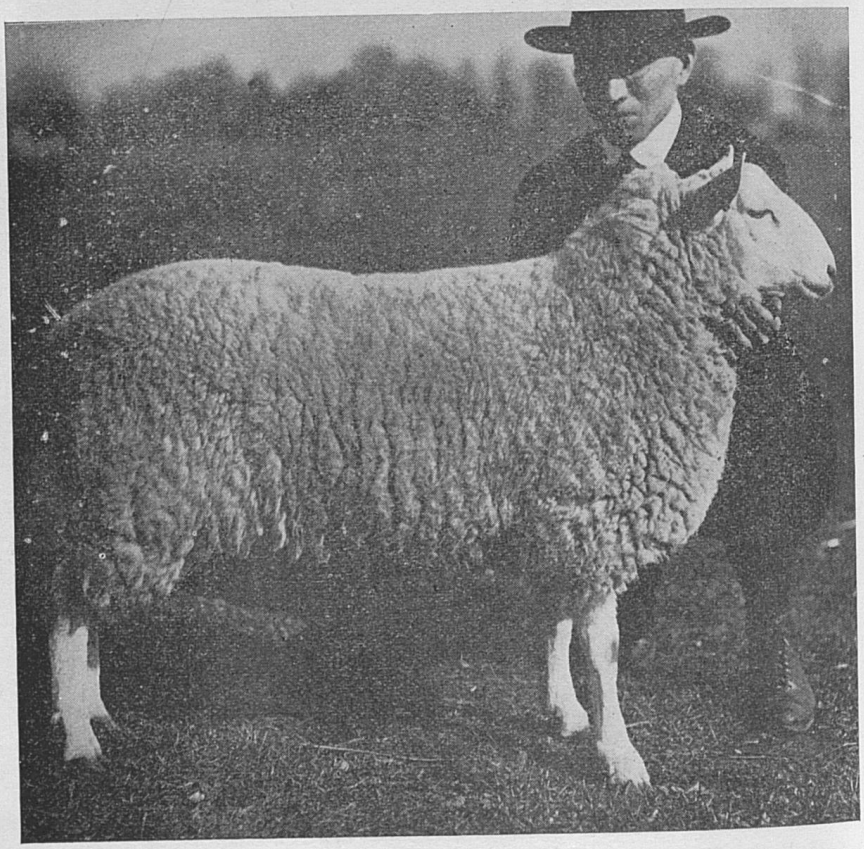

Fig. 37. Cheviot ram lamb, age 6 months. Weight when two years old, 145 pounds. He won fifth prize as a lamb at the Kentucky State Fair.

TABLE VIII

Slaughter Records

Breeding	Dressing Percentage	Percentage of marketable meat to weight of dressed carcass	Percentage weight of pelt to live weight
H-Mt.	50.15	89.98	12.25
S-Mt.	49.32	92.75	14.43
R-Mt.	48.70	92.99	19.73

All the carcasses were of good quality. There was an inverse relationship between the dressing percentage and the weight of the pelt. The H-Mt. lambs dressed the highest percentage and had the lightest pelts. The S-Mt. lambs were second in dressing percentage, with the second heaviest pelts, and the R-Mt. lambs were third with the lowest dressing percentage and the heaviest pelts. However, the percentage of marketable meat to the weight of the dressed carcass was greatest in the R-Mt lambs, second in the S-Mt. lambs, and least in the H-Mt. lambs. The marketable meat consisted of the carcass with the shanks, tail and kidney fat removed.

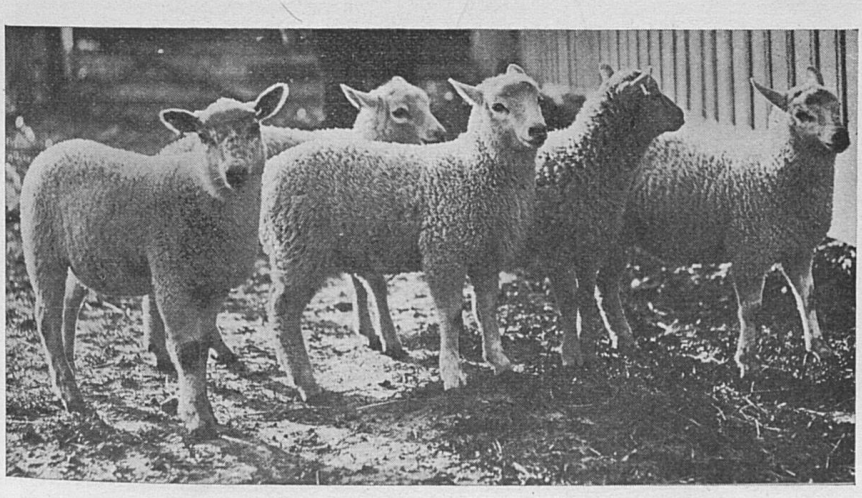

Fig. 38. Cheviot-mountain lambs, age 8 weeks. These lambs are very alert and hardy. They are much more uniform than the mountain lambs, and more thickly covered with meat of finer quality.

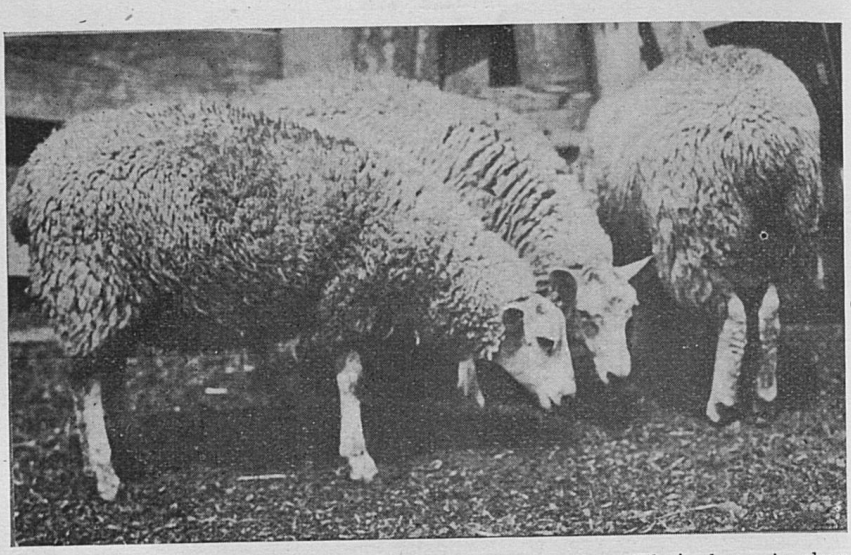

Fig. 39. Cheviot-mountain lambs, age 5 months. Their bone is clean and dense. Their wool is open and does not cover the head and legs as it does in the other crosses.

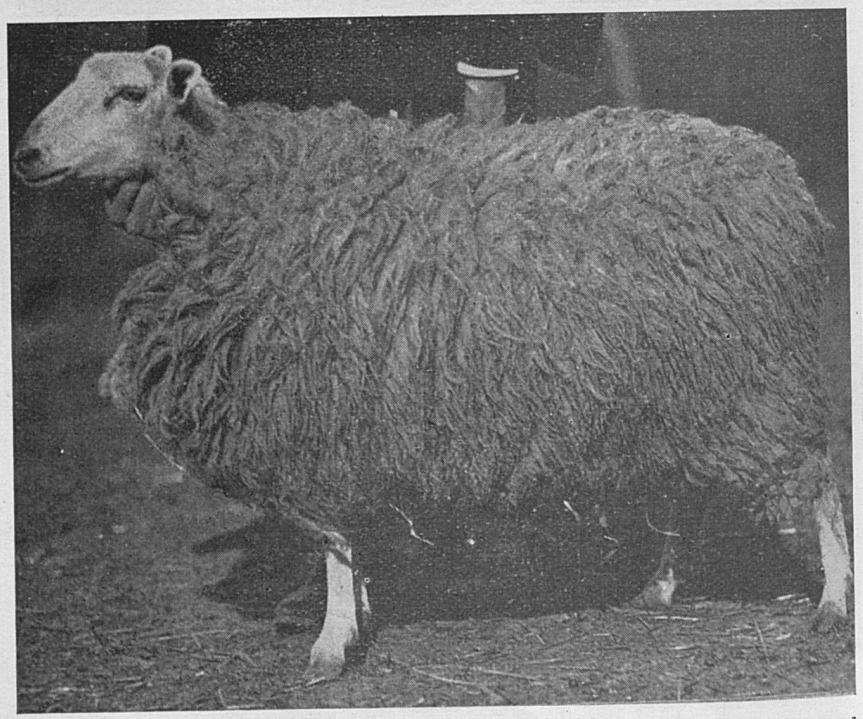

Fig. 40. Yearling Cheviot-mountain ewe. The fleece is coarse and long. Ewes of this breeding are very hardy.

Rambouillet Crosses

The Rambouillet ram transmitted his characteristics to his offspring more uniformly than did the rams of any other breed. The first-cross rams and ewes showed very pronounced Rambouillet characteristics. The hair on the face and legs usually was white, with sometimes a light tinge of brown, but never mottled. The fleeces were dense, compact and of good quality, grading three-eights and half-blood combing at the first shearing. After the first shearing, however, the wool was shorter, the class in the majority of cases changing from combing to clothing.

The general body formation was quite typical of the Rambouillet. The lambs showed a tendency to legginess and ranginess, which was not overcome as they matured. All the lambs showed a few wrinkles on the necks and the sides of the body. In some instances as the lambs matured all these wrinkles disappeared, while in others a slight dewlap or a small apron in front of the brisket remained.

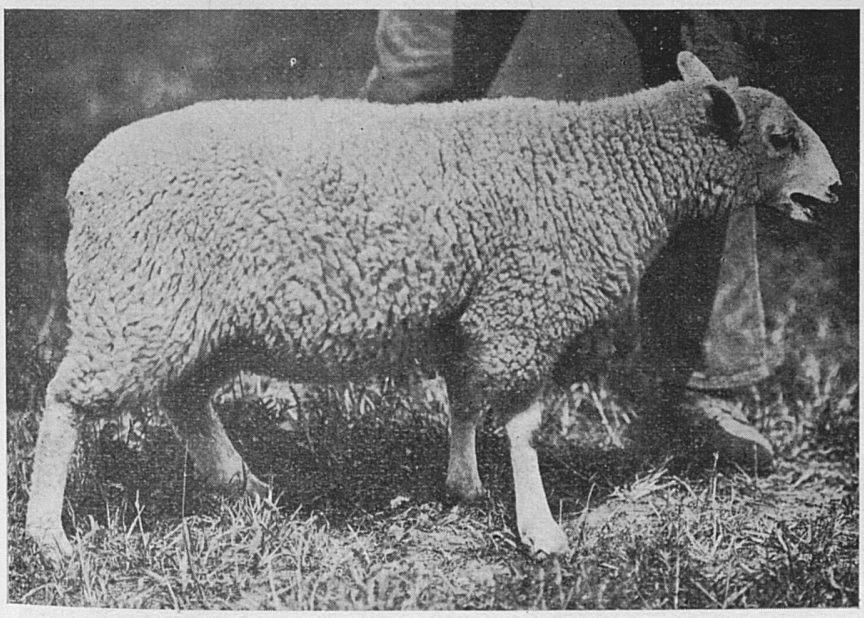

Fig. 41. Three-quarter Cheviot ewe lamb, sired by the Cheviot ram, out of the Cheviot-mountain ewe shown in Fig. 40. Her appearance is much more like that of the pure bred Cheviot. Her fleece is denser than that of her dam.

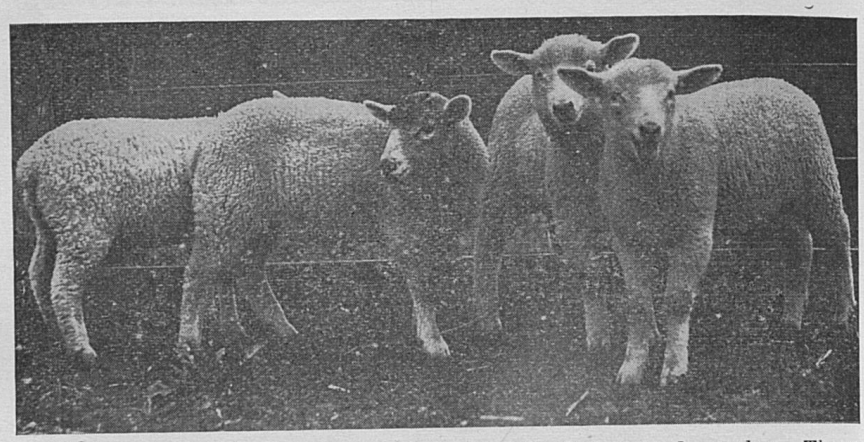

Fig. 42. Cheviot-Rambouillet-mountain lambs, age 8 weeks. These lambs grow more rapidly than those containing no Rambouillet blood.

The lambs of this cross were very hardy and vigorous. they gained rapidly. In two out of the three years in which the Rambouillet ram was used his lambs weighed more at weaning time than did any of the other crosses represented. In the third year, however, the lambs of this cross dropt to third place. The Rambouillet ram sired a smaller percentage of twins than the Hampshire, the Cheviot or the Southdown. (Figs 9-12.)



Fig. 43. Rear view of Cheviot-Rambouillet-mountain wether lambs. They have heavier, plumper legs-of-mutton than do the mountain lambs.



Fig. 44. Flock of grade Hampshire, Southdown and Rambouillet ewes, after shearing. Ewes of this type would be a credit to any farm. Compare with Figs. 2 and 3.

Hampshire Crosses

The Hampshire ram on the mountain ewe produced a larger proportion of twins than did any other cross. The lambs lacked uniformity in color markings, more so than those of any other cross. The faces and legs varied from mottled to solid

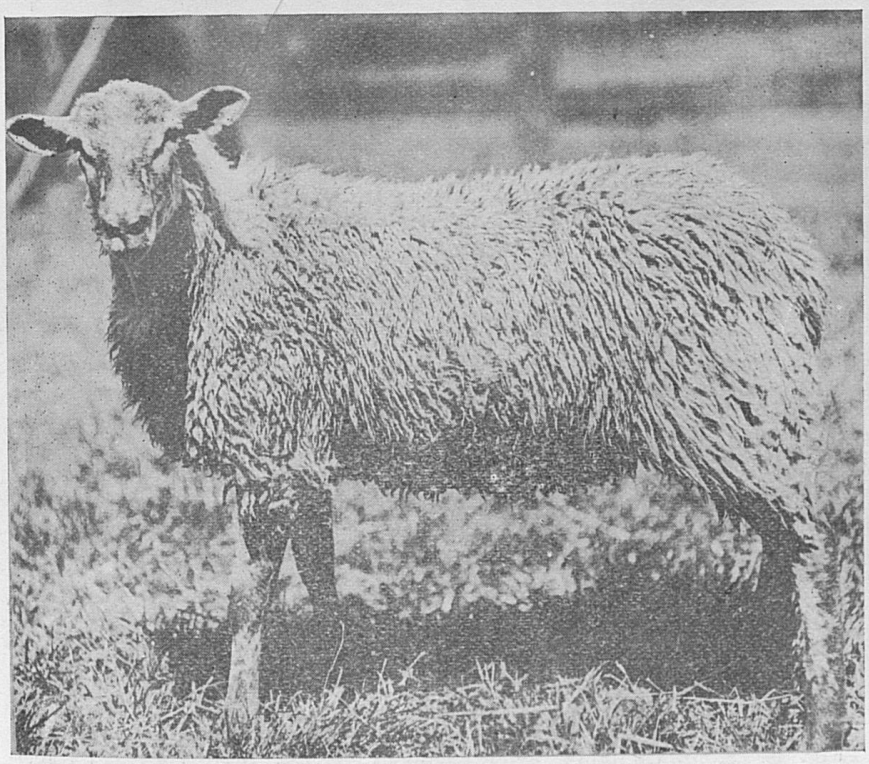

Fig. 45. Mountain lamb, before shearing. She is rangy; her legs are long; her body is shallow, and her wool coarse.

black. At birth a few of the lambs were black over their entire bodies, but their wool soon changed to white. The large head and large, drooping ear of the Hampshire were prominent characteristics.

As a whole, these lambs were somewhat leggy and rather loosely put together. They gained very rapidly and overcame to some extent their looseness of conformation as they grew older. (Figs 14-19: 48-50.)

The three-quarter Hampshires, H-(H-Mt.), showed very strongly the Hampshire characteristics. The body form, color and covering of wool were very typical. From the standpoint of the ideal market lamb they were a marked improvement over the half-blood Hampshires. (Fig. 20.)

The seven-eights Hampshires were again an improvement over the three-quarter bloods. Hampshire characteristics were very marked. (Figs, 21, 22.)

The Hampshire ram on the Rambouillet-mountain ewes produced lambs that gained more rapidly than did those out of the

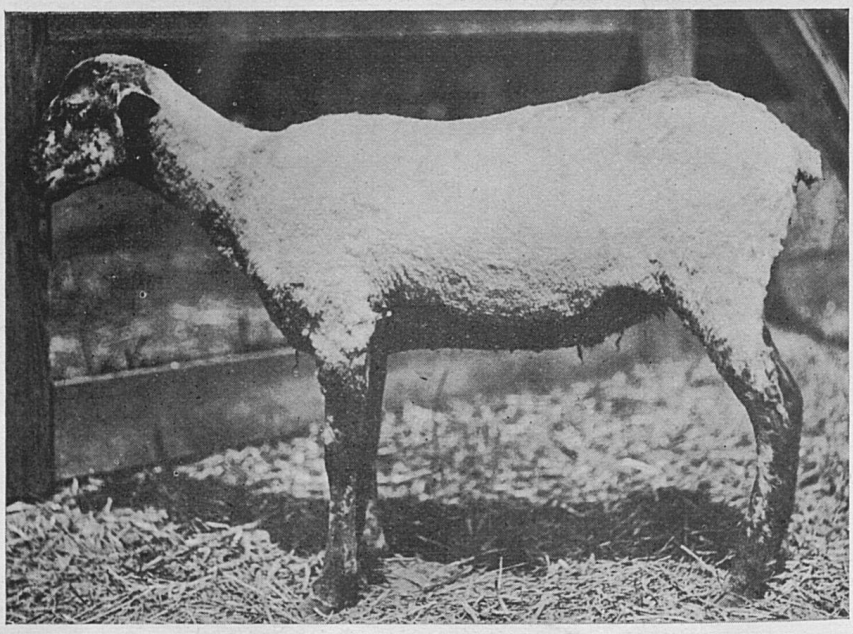

Fig. 46. Mountain lamb, after shearing. Her neck is long and thin; her back is swayed; her rump is short and steep; her legs are long, and she is thinly covered with flesh.

mountain ewes. They were a trifle more leggy, but were more compactly built and had much denser fleeces of finer quality. The face color ranged from solid white to solid black. (Figs. 23, 24.)

The ewes of the preceding cross, when bred to a Hampshire ram, produced three-quarter blood Hampshires that grew very rapidly. These lambs were much more uniform in color markings than were their dams, very little white appearing. The fleeces were a little more open, yet were more compact than those of lambs which contained no Rambouillet blood. (Fig 25.)

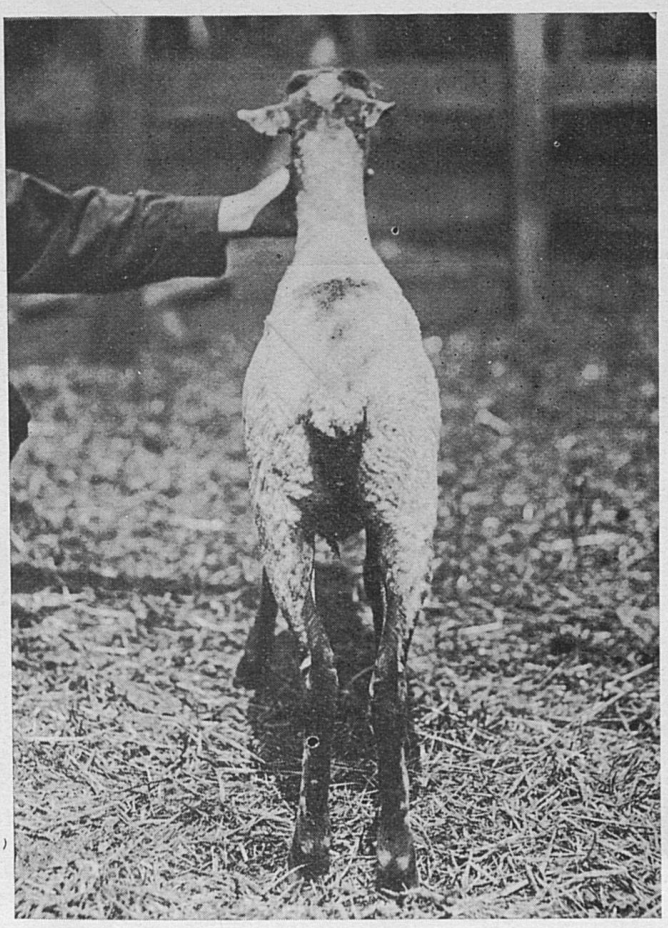

Fig. 47. Mountain lamb, after shearing. The body is extremely narrow; the leg-of-mutton is very light.

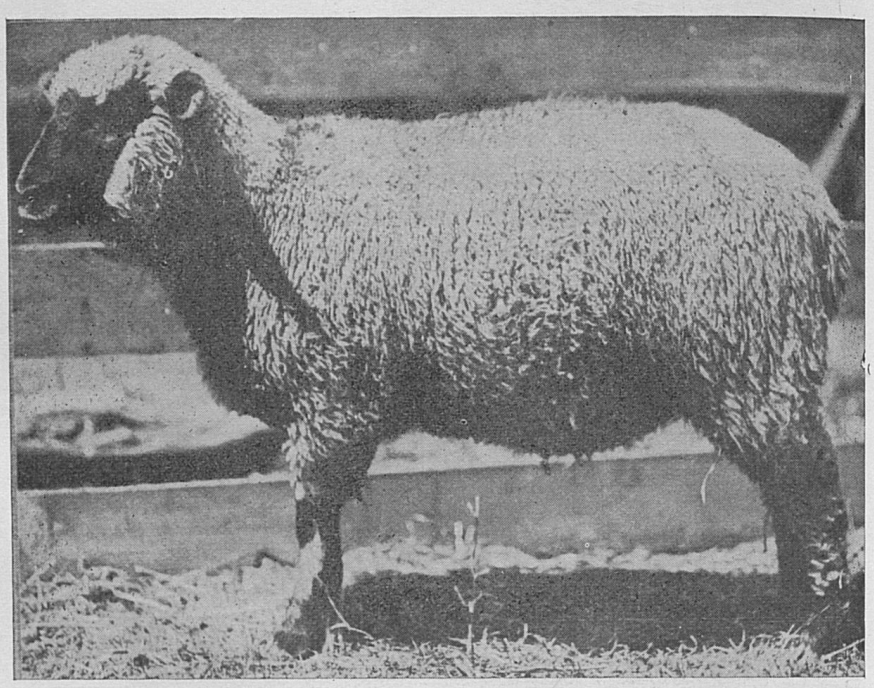

Fig. 48. Hampshire-mountain lamb, before shearing. This lamb is shorter, more compact and more blocky than the mountain lamb. His fleece is denser.

The Hampshire ram mated well with the mountain ewes. More satisfactory results were obtained, however, by first using the Rambouillet ram on the mountain ewe and then breeding the ewe lambs of that cross to the Hampshire ram.

Southdown Crosses

Quality was the outstanding characteristic of these lambs. They were not quite as hardy as the Rambouillet and Cheviot crosses. The color markings, as a rule, were very uniform, being mostly a greyish-brown, tho white markings and dark-brown faces sometimes occurred. The body form was quite typical of the Southdown. The lambs were low-set, blocky, squarely and compactly built, with smooth shoulders and large, plump legs. The wool was short, and coarser than that of the purebred Southdown. (Figs. 29-32; 51-53.)

The three-quarter blood Southdowns, S-(S-Mt.), showed Southdown characteristics more strongly. They were more uni-

form in their color markings and were more smoothly turned thruout. (Figs. 33, 34.) The Southdown on the Rambouillet-mountain ewes produced lambs that were small and well covered with a short fleece of fine quality. The faces and legs were a mottled gray in color. From the standpoint of growth this did not prove to be a good cross. The lambs, however, had excellent quality. The Department of Animal Husbandry showed a yearling wether of this breeding in the carcass contest at the 1920 Internatonal Live Stock Exposition. In a class of 23 yearlings this wether won third prize. He was the lightest yearling in the class, weighing only 117 pounds. Without a shrink he dressed 56.4 per cent. His carcass sold for 29 cents a pound. (Fig 35.) Lambs of this cross had plenty of quality but lacked growthiness.

Ewes of the above breeding when bred to Southdown rams produced three-quarter Southdowns, S-(S-(R-Mt.), which were

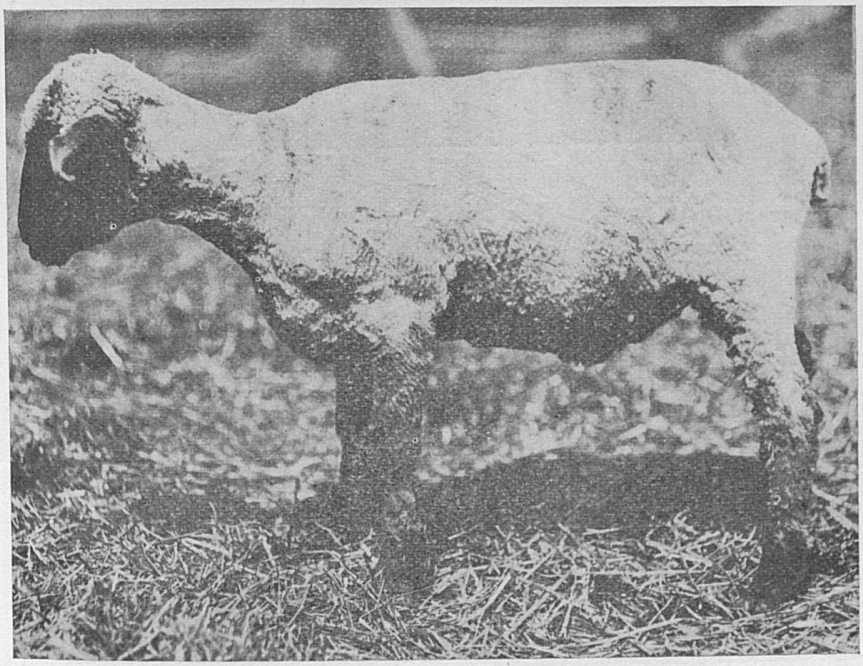

Fig. 49. Hampshire-mountain lamb, after shearing. His neck is thicker and shorter than that of the mountain lamb; his lines are straighter; his body is deeper, and he is more thickly covered with meat.

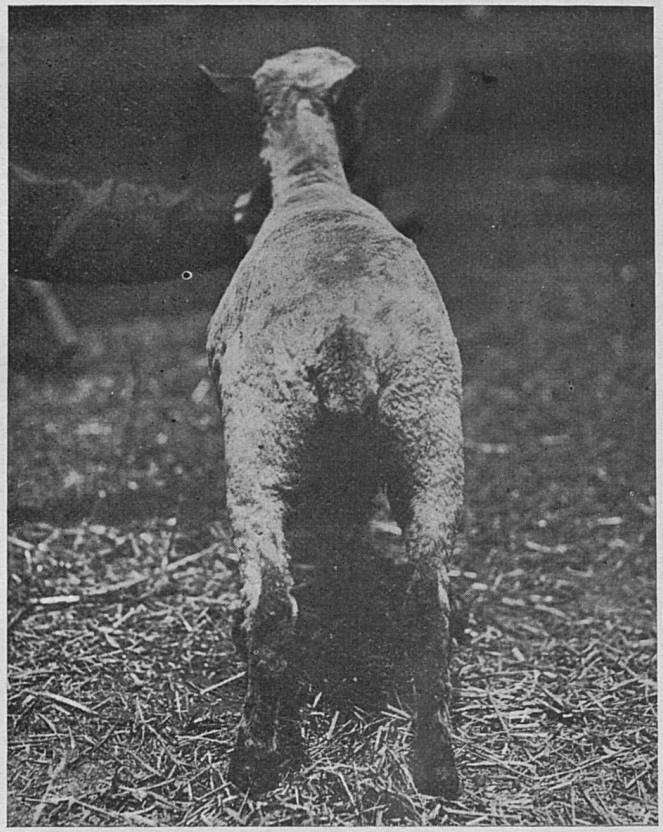

Fig. 50. Hampshire-mountain lamb, after shearing. His body is much thicker than that of the mountain lamb. His leg-of-mutton is much deeper and plumper.

more typically Southdown than were their dams. They had dark grayish-brown faces, were well covered with short, dense fleeces and were very smoothly turned. (Fig. 36.)

Cheviot Crosses

Vigor and activity were outstanding characteristics of the Cheviot crosses. The markings of the Cheviot were very evident. The faces and legs were white, with occasionally a few black spots. The fleeces were very much like those of the pure-bred Cheviot, but were perhaps just a trifle more open. In body form they were somewhat sharp on the top of the shoulder, but were thick and meaty, and remarkably straight on top. Pink noses occurred very frequently. (Figs 38-40; 54-56.)



Fig. 51. Southdown-mountain lamb, before shearing. This lamb is much more blocky and low-set than the mountain lamb. Her fleece is much denser.

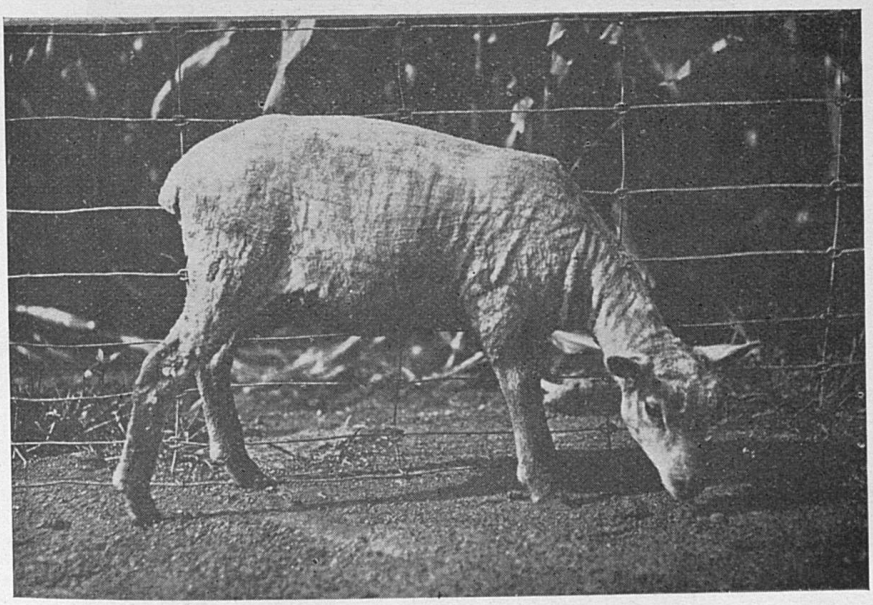

Fig. 52. Southdown-mountain lamb, after shearing. A much smoother, more evenly turned, more blocky lamb than the mountain lamb.

The three-quarter Cheviots, C-(C-Mt.), were more alert and stylish than were the half-bloods. Their ears were smaller and more erect. They were more meaty and more compactly built. (Fig. 41.)

The Cheviot ram bred to the Rambouillet-mountain ewes gave extremely rapid gaining lambs that were somewhat coarse but meaty. Their faces and legs were white. The wool extended somewhat over the sides of the face, was long, and of finer quality than that of the purebred Cheviot. (Figs. 42, 43.)

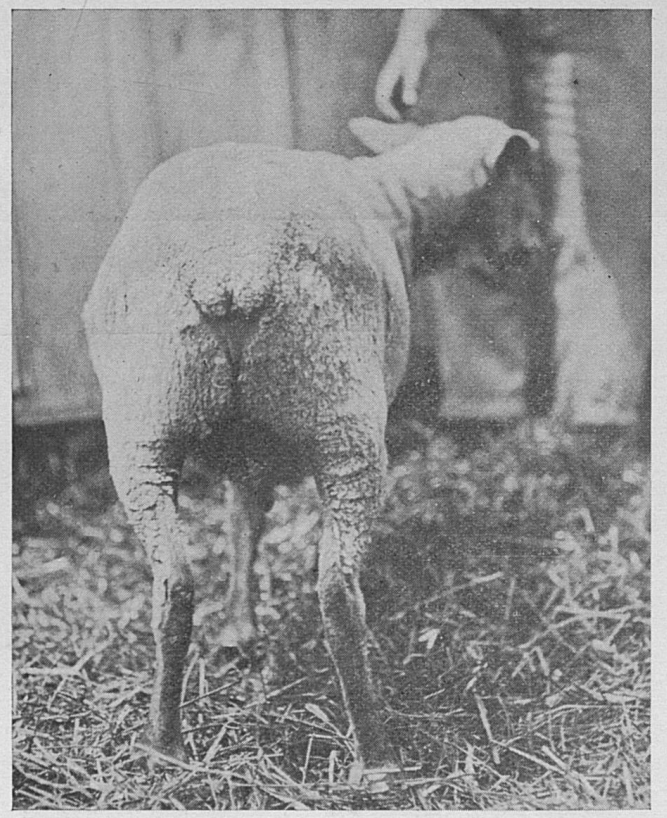

Fig. 53. Southdown-mountain yearling wether, after shearing. His leg-of-mutton is shallow, but it is plump and full.

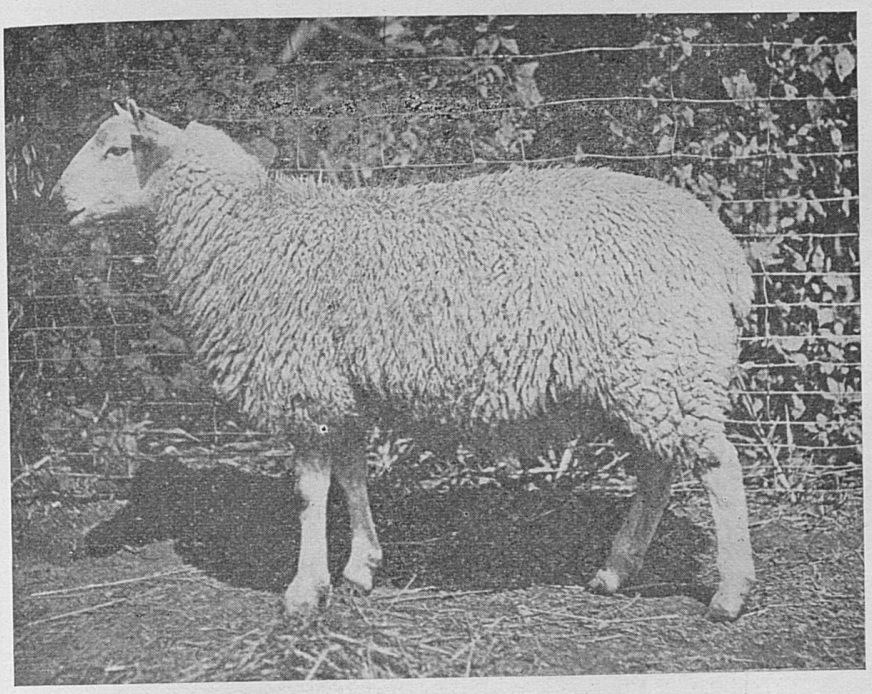

Fig. 54. Cheviot-mountain lamb, before shearing. This lamb is closer to the ground and is more blocky than the mountain lamb. The fleece is slightly more compact than that of the mountain lamb, but is more open than that of the Hampshire or Southdown cross.

Part II.

WOOL

The ewes used in this experiment possesst the light, open fleeces typical of the native mountain sheep. Their wool graded in the majority of cases as quarter and low quarter combing. A lack of wool extension over the face, legs and underline was predominant.

Eight of the mountain ewes were bare along the underline, four showed a light or medium covering, and eighteen were rather well covered. (Figs. 57, 65.)

In each of the six years shearing took place between April 15 and June 1, depending somewhat upon the season.

The following tables show the average weights and grades of the wool from the different crosses:

TABLE IX

Weight and Grade of Wool—Mountain

Year	Number of sheep	Ave. wt. of fleece	Grade
1916	31	5.00 lbs.	¼ and low ¼ combing and clothing
1917	28	5.43 lbs.	¼ and low ¼ combing and clothing
1918	27	5.08 lbs.	¼ and low ¼ combing and clothing
1919	27	4.98 lbs.	¼ and low ¼ combing and clothing
1920	22	3.98 lbs.	¼ and low ¼ combing and clothing
1921	9	6.00 lbs.	¼ and low ¼ combing and clothing
Ave.		5.00 lbs.	¼ and low ¼ combing and clothing

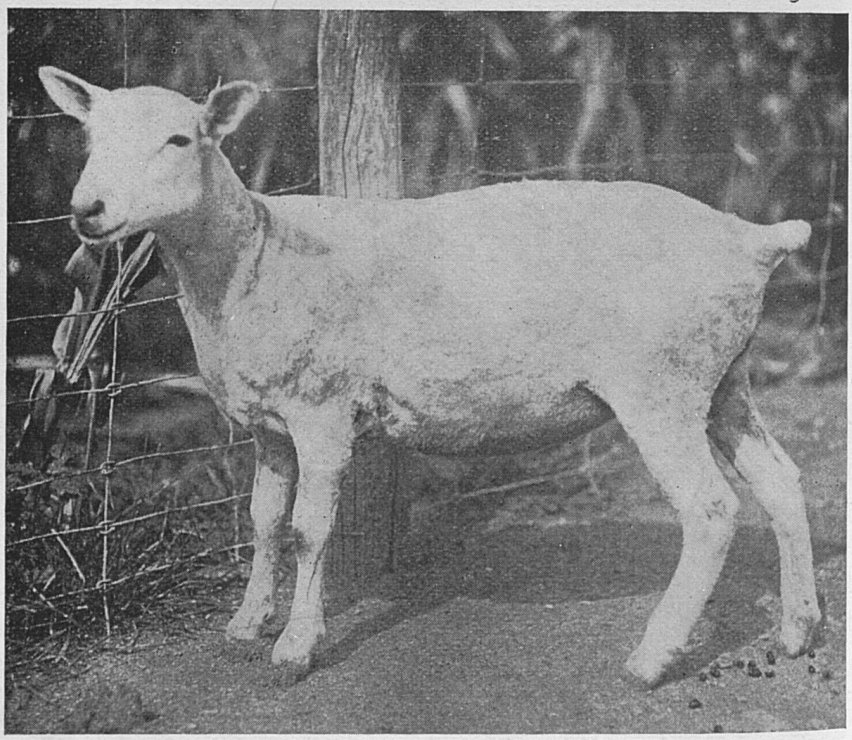

Fig. 55. Cheviot-mountain lamb, after shearing. The body is much deeper, more compact and more symmetrical than that of the mountain lamb. The hindquarters should be more heavily developt.

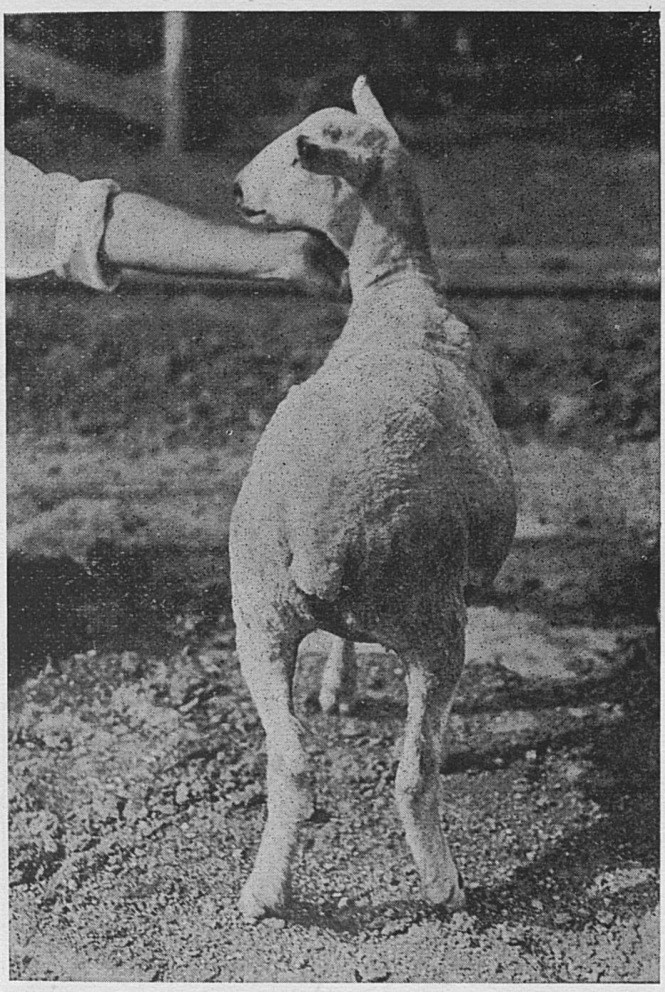

Fig. 56. Cheviot-mountain lamb, after shearing. The body is much thicker than that of the mountain lamb. The leg-of-mutton is plump but lacks depth.

TABLE X

Weight and Grade of Wool—Hampshire-Mountain (Figs. 59, 66)

Year	Number of sheep	Ave. wt. of fleece	Grade
1917	1	9 lbs.	¼ and ⅜ combing
1918	8	5.87 lbs.	¼ and ⅜ combing
1919	9	6.63 lbs.	¼ and ⅜ combing
1920	7	5.37 lbs.	¼ and ⅜ combing
1921	5	6.6 lbs.	¼ and ⅜ combing
Average		6.2 lbs.	¼ and ⅜ combing

TABLE XI

Weight and Grade of Wool—Rambouillet-Mountain (Figs. 58, 68)

Year	Number of sheep	Ave. wt. of fleece	Grade
1917	7	8.14 lbs.	⅜ and ½ blood combing and clothing
1918	5	7.90 lbs.	⅜ and ½ blood combing and clothing
1919	12	7.57 lbs.	⅜ and ½ blood combing and clothing
1920	13	6.05 lbs.	⅜ and ½ blood combing and clothing
1921	12	8.54 lbs.	⅜ and ½ blood combing and clothing
Average		7.52 lbs.	⅜ and ½ blood combing and clothing

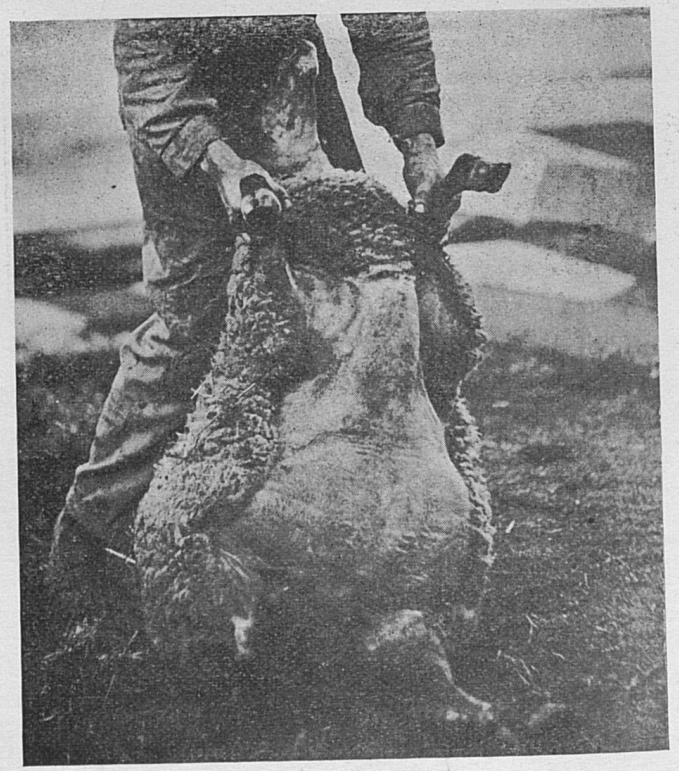

Fig. 57. Mountain ewe. Bare underline. Compare with Figs. 58, 59, 60 and 61.



Fig. 58. Rambouillet-mountain ewe. Well covered on legs and underline. Compare with Fig. 57.

TABLE XII

Weight and Grade of Wool—Southdown-Mountain (Figs. 60, 67)

Year	Number of sheep	Ave. wt. of fleece	Grade
1919	8	6.94 lbs.	¼ and ⅜ combing and clothing
1920	9	4.78 lbs.	¼ and ⅜ combing and clothing
1921	15	6.36 lbs.	¼ and ⅜ combing and clothing
Average		6.06 lbs.	¼ and ⅜ combing and clothing

TABLE XIII

Weight and Grade of Wool

Hampshire-Rambouillet-Mountain (Fig. 69)

Year	Number of sheep	Ave. wt. of fleece	Grade
1919	4	7.56 lbs.	¼ and ⅜ blood combing
1920	4	5.93 lbs.	¼ and ⅜ blood combing
1921	4	7.75 lbs.	¼ and ⅜ blood combing
Average		7.08 lbs.	¼ and ⅜ blood combing



Fig. 59. Hampshire-mountain ewe. Well covered on legs and underline. Compare with Fig. 57.



Fig. 60. Southdown-mountain ewe. Well covered on legs and underline. Compare with Fig. 57.

TABLE XIV

Weight and Grade of Wool
Southdown-Rambouillet-Mountain

Year	Number of sheep	Ave. wt. of fleece	Grade
1919	1	5.5 lbs.	⅜ combing
1920	2	6.1 lbs.	½ clothing ⅜ combing
1921	3	5.58 lbs.	⅜ clothing ½ combing
Average		5.74 lbs.	⅜ and ½ combing and clothing

TABLE XV.

Weight and Grade of Wool—Cheviot-Mountain

Year	Number of sheep	Ave. wt. of fleece	Grade
1920	1	6 lbs.	¼ combing
1921	3	6 lbs.	¼ and ⅜ combing
Average		6 lbs.	¼ and ⅜ combing



Fig. 61. Cheviot-mountain ewe. Well covered on underline. Clean legs and head. Compare with Fig. 57. The extension of wool in this cross is less than in any other cross.

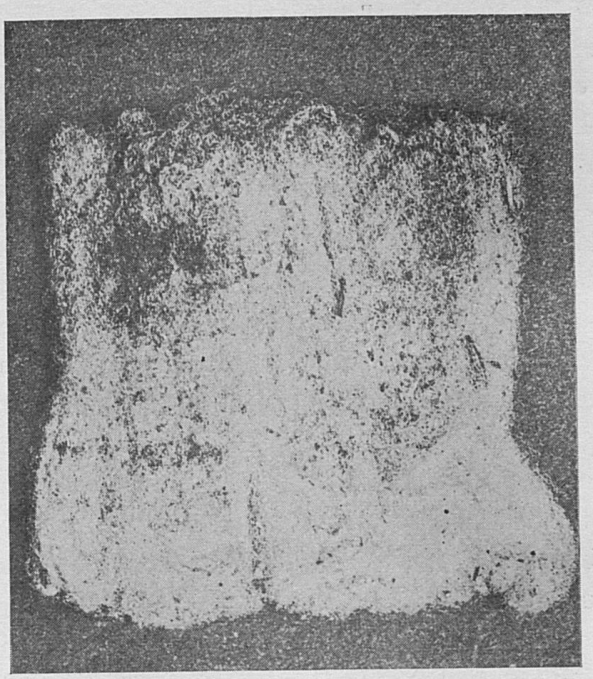

Fig. 62. Wool from the Rambouillet ram, natural size.

TABLE XVI

Summary

Weights and Grades of Wool

Breeding	Ave. Wt. of fleece	Grade
R-Mt.	7.52 lbs.	⅜ and ½ combing and clothing
H-(R-Mt).	7.08 lbs.	¼ and ⅜ combing and clothing
H-Mt.	6.2 lbs.	¼ and ⅜ combing
S-Mt.	6.06 lbs.	¼ and ⅜ combing and clothing
C-Mt.	6.00 lbs.	¼ and ⅜ combing
S-(R-Mt.)	5.74 lbs.	⅜ and ½ combing and clothing
Mt.	5.00 lbs.	¼ and low ¼ combing and clothing

Altho the sheep were sheared each year between April 15 and June 1, there was quite a variation in the weights of the fleeces from one year to the next. During the six years covered by this experiment the average weights of the fleeces from the mountain sheep varied from 3.98 pounds to 6 pounds. One reason for this weight of 6 pounds in 1921 was that the ewes were culled in the summer of 1920 and only nine of the best mountain ewes were kept in the flock. It is seen from the tables that five out of the seven crosses represented produced more wool in 1921 than in 1920; that one produced the same, and that one produced less. During the winter of 1919-1920 very little clover hay or protein feed of any kind was fed to the ewes and they came thru the winter in rather thin condition. In fact, some of them lost weight. During the winter of 1920-1921 plenty of clover hay was available at all times and the ewes came thru in excellent shape, every ewe making a good gain.

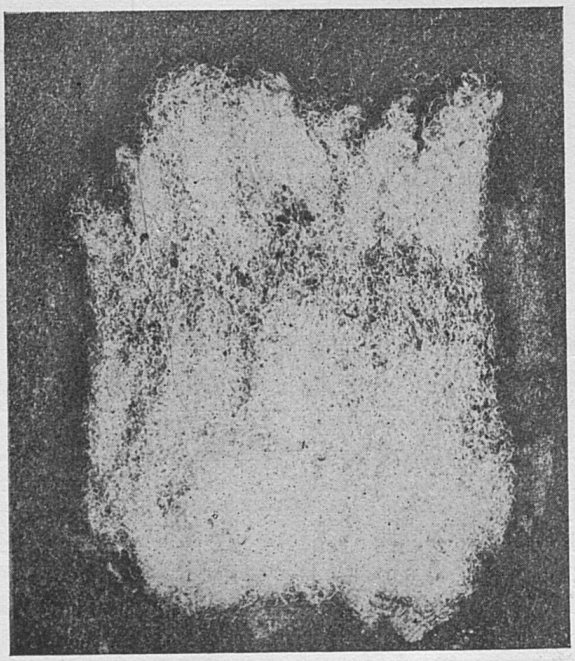

Fig. 63. Wool from the Southdown ram, natural size.

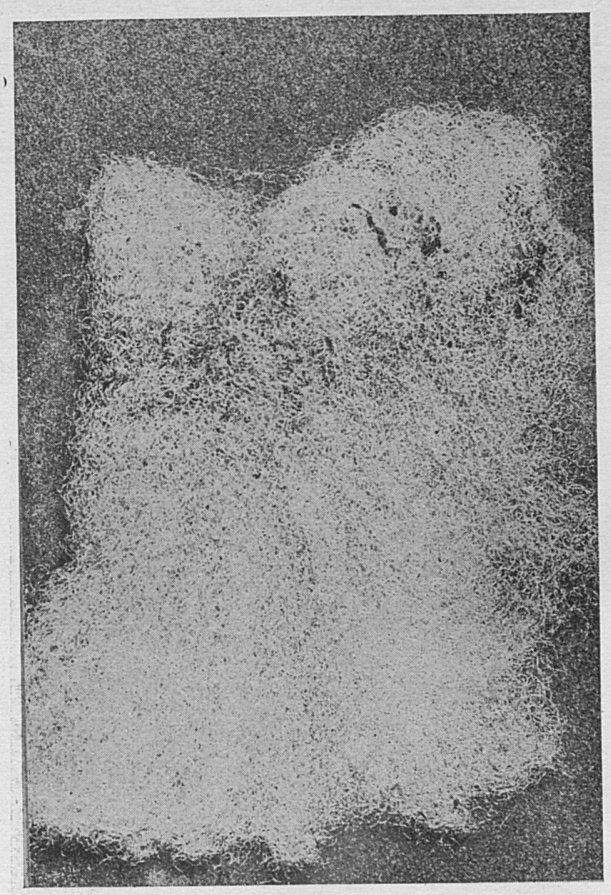

Fig. 64. Wool from the Hampshire ram, natural size.

These results indicate that feeding is an important factor in determining the weight of the fleece.

Table XVI shows that the fleeces from the mountain sheep weighed less and graded lower than those of any of the crosses. With but two exceptions this was true during every year of the experiment. In 1921 the average weight of wool produced by nine mountain ewes was the same as that of the three C-Mt. ewes and was .42 pound more than that of the three S-(R-Mt.) ewes. This was because the mountain ewes were culled in 1920 and only the best nine ewes were kept, whereas no attempt had been made to cull the C-Mt. and the S-(R-Mt.) ewes.

The wool from the R-Mt. and the S-(R-Mt.) ewes was sufficiently long at the first shearing to be classed as combing (2½ inches or more in length) but at each of the succeeding shearings the majority of the fleeces were shorter than 2½ inches and therefore were of clothing length. Figure 35 shows the fleece of a yearling S-(R-Mt.) wether. This fleece was five inches in length and graded high three-eights combing. Commercially, it was the most desirable fleece produced by any sheep during the six years of the experiment. This is the same wether which was mentioned as having won third prize in the yearling wether class in the carcass contest at the 1920 International Live Stock Exposition.

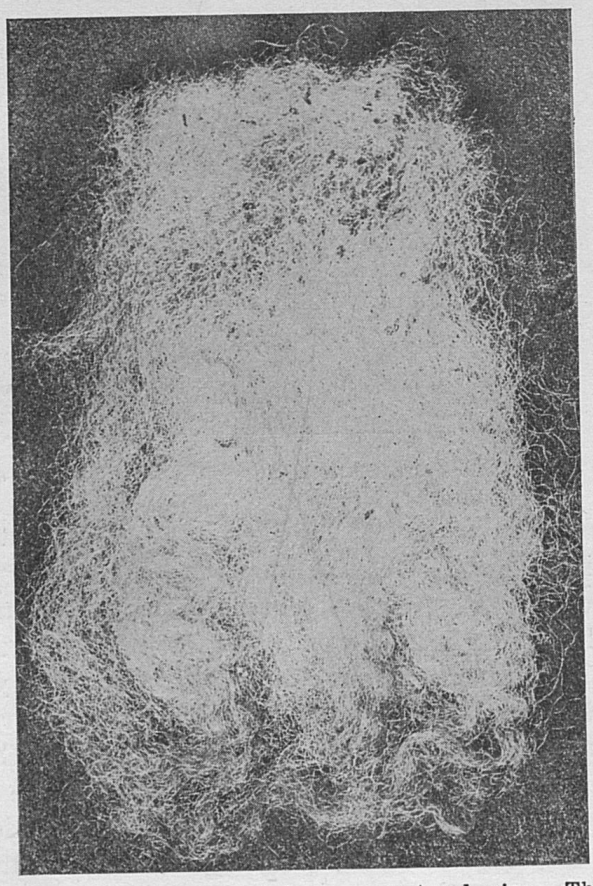

Fig. 65. Wool from a mountain ewe, natural size. This fleece is coarser than any of the crosses.

The Hampshire and Cheviot crosses produced coarser wool than that of the Southdown and Rambouillet crosses, but it was longer and very seldom was classed as clothing in length. Practically thirty per cent of the S-Mt. wool was of clothing length after the first shearing.

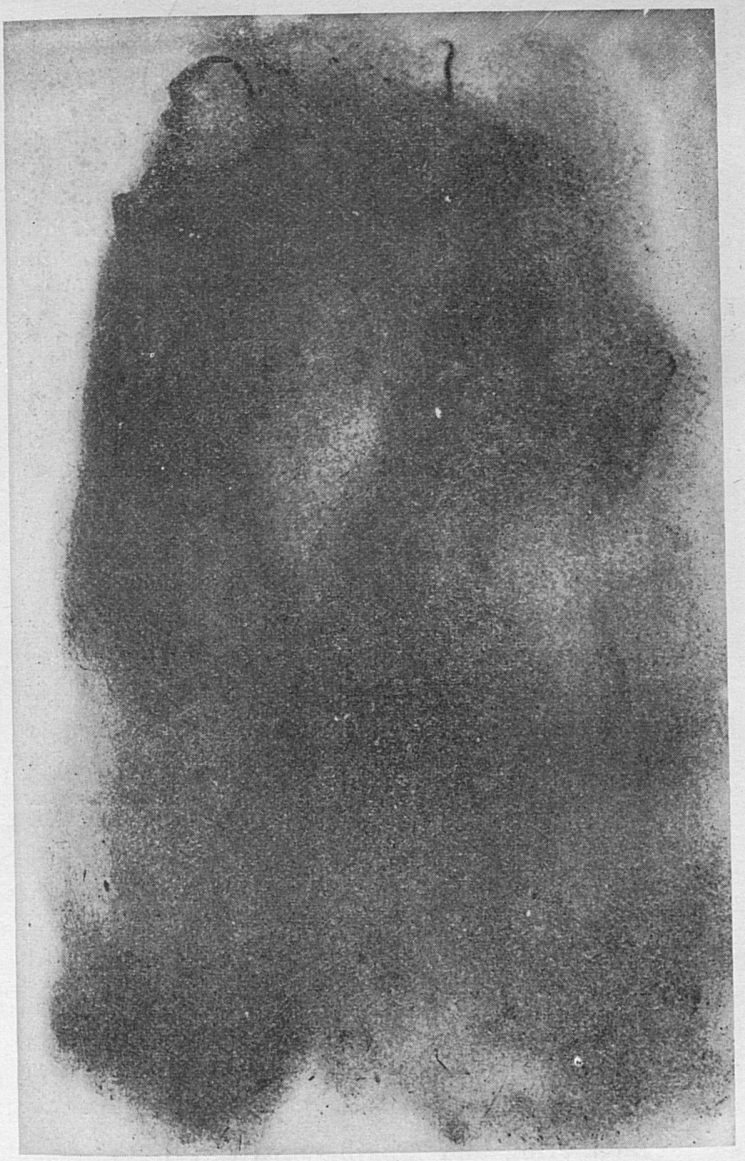

Fig. 66. Wool from a Hampshire-mountain ewe, natural size. It is longer, finer and heavier than that from the mountain ewe.

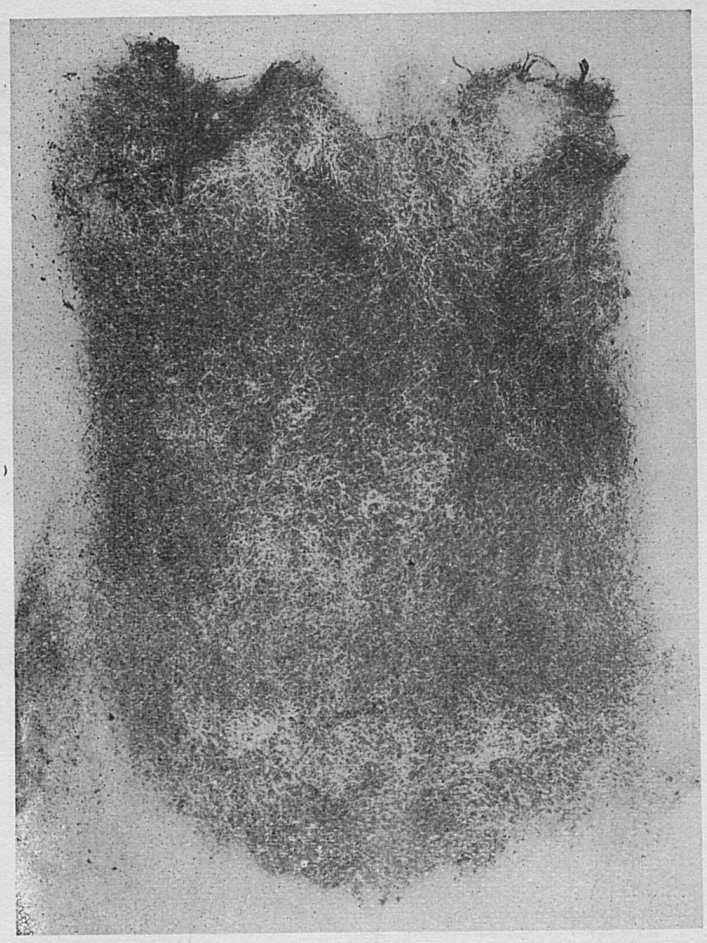

Fig. 67. Wool from a Southdown-mountain ewe, natural size. It is finer and heavier than that from the mountain ewe, but not as long.

SUMMARY AND CONCLUSIONS

1. The Rambouillet should be given careful consideration by Kentucky sheep men when considering the blood to choose in building up farm flocks. This was found to be the most satisfactory cross for improving the mountain ewes. The ewe lambs saved from this cross gained rapidly and develop into ewes possessing to a greater extent than any other cross the hardiness, the prolificacy, the early breeding and the mothering and milking qualities of the mountain ewes. They produced heavier, finer and more valuable

fleeces. When bred to purebred mutton rams they produced market lambs of better quality and type than the lambs from the mountain ewes.

2. The grade Hampshire lambs gained rapidly and were ready for market at an earlier age than any others. They lacked the quality of the Southdown and Cheviot grades. The grade Hampshire ewes had plenty of size and were good mothers.

3. The Southdown grades possesst excellent quality and good mutton form, but they gained slowly and required a longer time to reach marketable weight than the grade Hampshires, Cheviots and Rambouillets. The grade Southdown ewes were too small.

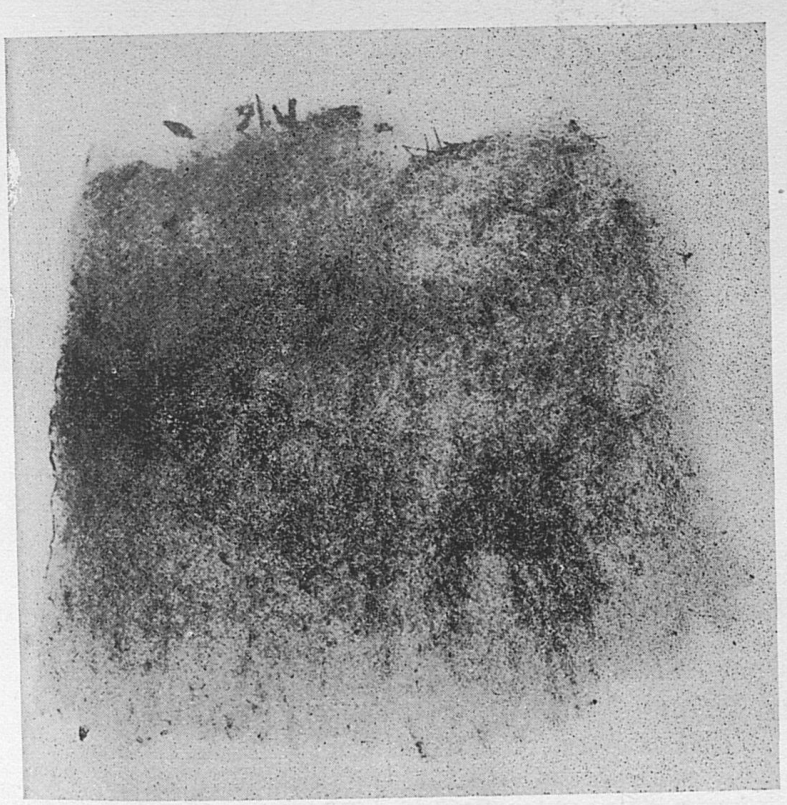

Fig. 68. Wool from a Rambouillet-mountain ewe. Much finer and heavier than that from the mountain ewe or any other cross, but shorter.

4. The Cheviot grades grew more rapidly than the Southdown grades. They had finer quality than the Hampshire and Rambouillet grades. The grade Cheviot ewes were vigorous and were good mothers. They were very similar to the mountain sheep in appearance.

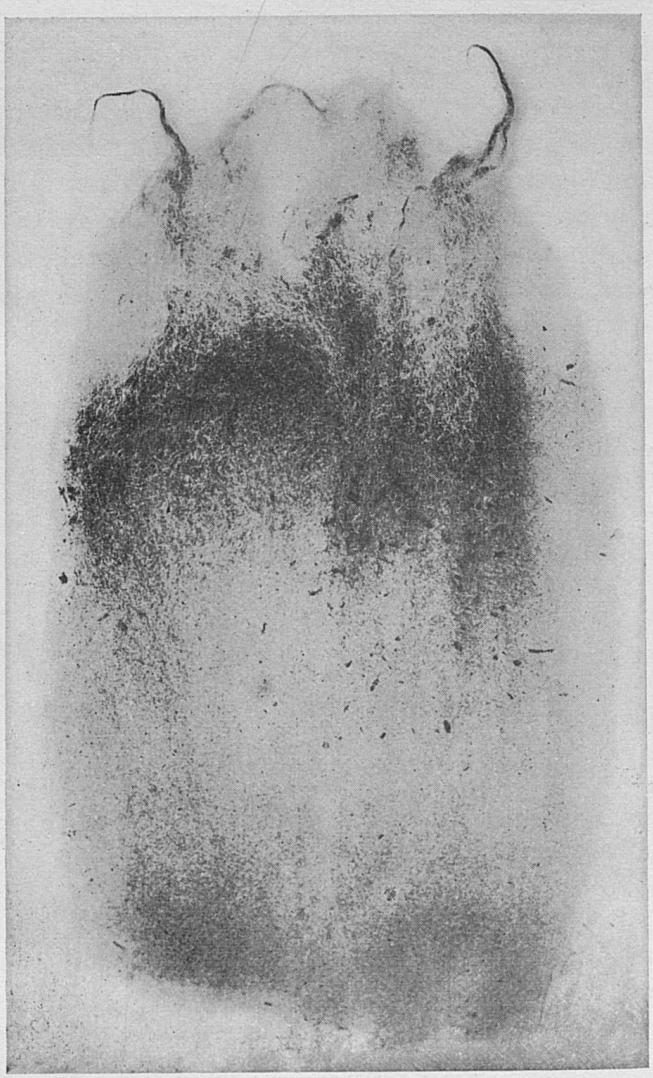

Fig. 69. Wool from a Hampshire-Rambouillet-mountain ewe. This wool is longer, finer and heavier than that of the mountain ewe; finer and heavier than that of the H.-Mt. cross; longer, coarser and lighter than that of the R.-Mt. cross. Commercially it is a very desirable type of wool.

5. The average mountain ewe produced 5 pounds of low-grade wool. The purebred rams increased the weight of the fleece .74 pound to 2.52 pounds and in practically every instance improved the quality.
6. Rams of the four breeds used sired lambs that were more meaty, grew more rapidly, were of finer quality, and dressed out a higher percentage than lambs sired by scrub rams.
7. Lambs sired by the purebred rams topped the Louisville and Cincinnati markets. The largest lambs, therefore, returned the most money per head.
8. The Hampshire ram sired a larger percentage of twins than any of the other rams. The Cheviot ranked second, Southdown third, Rambouillet fourth, and mountain last.

Acknowledgments

Acknowledgments for assistance in this work are due to Mark J. Smith, L. B. Mann and T. G. Yaxis, all of whom formerly were members of the Animal Husbandry Department.

Kentucky
Agricultural Experiment Station

University of Kentucky

STERILITY IN RELATION TO ANIMAL BREEDING

BULLETIN NO. 244
(Research Bulletin)

Lexington, Ky.

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(201)

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BULLETIN NO. 244

(Research Bulletin)

Sterility in Relation to Animal Breeding

BY W. S. ANDERSON

INTRODUCTION

In building the breeds of domestic live stock almost all breeders have had the progress of their work retarded by sterility. Breeders have not only seen some of their best animals cast off as worthless because of sterility but they have seen an entire bloodline of a breed disappear because of the prevalence of sterile animals in the strain.

Sterility is met in all breeds of live stock at the present time; and it seems that the better bred a breed becomes the more numerous are the sterile animals found in it. A small per cent of the males of all breeds are sterile. A much larger per cent of females are barren. Often the female fails to produce for one or two seasons and then becomes productive again, while there are others which produce regularly for a certan length of time and then are permanently barren. A few females are sterile from birth and never can be made to produce at all owing to some congenital defect; but the number is not large enough to give any great concern.

The dairy cattle breeders who push their cows for record productions of milk and butter fat have difficulty in getting some of their best matrons to breed regularly. Hog breeders find some of their best breed and best show-ring specimens sterile. Some of the very heaviest laying hens produce only a small per cent of fertile eggs. Horse breeders, however, have the greatest trouble with sterility. An occasional stallion is sterile or partially so, while almost half the brood mares are barren for any given season or permanently nonproducers.

A considerable proportion of the farms within a radius of twenty-five miles of the Kentucky Experiment Station are devoted to one of the three breeds of light horses or to some other breed of registered stock. In cooperation with many of these breeding establishments a study of breeding has been made for the last nine years. Instead of depending on laboratory animals for material, free access to the males and females has been given the investigator by the owners of the stock farms. In this way animals sterile, or temporarily so, have been studied in a normal environment and under conditions which were as favorable for reproduction as any farm can give.

The purpose of this bulletin is to give a report of the work done to date on the nature and causes of sterility in the higher forms of domestic animals which have been studied. It has been prepared, not as a bulletin for general distribution, but for the use of those live stock breeders, who are interested in the production of blooded stock and for the use of those who are attempting to solve some of the problems of breeding. The very nature of the subject is such that it does not lend itself to a popular discussion. To be of value it is necessary to go into details and to use plain terms in describing those details; for these reasons it will be largely restricted in its use to those who are interested in breeding problems.

I. Sterile Males

Opinion of Breeders. The common opinion of breeders is that if a male is in good physical condition and can make a service he is fertile. One of the first results obtained by this study is that the outward perfection of the animal is no criterion by which to judge his breeding ability.

In horse breeding so many mares are barren for a year or two that even the record of a stallion in the stud is not always to be relied upon as a measure of his sexual potency.

Method of Determining Sterility in Males. Fortunately, the method of determining the breeding condition of males is not a difficult one. Normal semen contains innumerable sex cells, the spermatozoa, which may be observed by means of the

microscope. The presence of very active spermatozoa in great numbers is essential to fertility. If a sample of semen can be obtained as a male completes a service, a drop can be placed on a slide and the spermatozoa examined directly. In the bulletin "Vitality of the Spermatozoa"[1] the writer has shown the character of the fields to be found in making such examinations. If the field, under lenses which magnify about one hundred diameters, is full of active, swiftly moving spermatozoa, it is almost absolute evidence of fertility. When such a field is found there is only one other test to make to be sure the male is not at fault. That test is to keep the semen, or part of it, at a room temperature of from 65 to 75 degrees Fahrenheit for two or three hours. The vigor of the sex cells should be noticed at intervals of fifteen minutes. Should the spermatozoa retain their vigor of movement for two hours or more it is positive evidence that the male is sexually potent.

Doubtful condition, sterility or partial sterility, results from too few a number of spermatozoa. As a rule, if the number of sperm cells is greatly reduced the vitality will be lowered also. Another border line condition is the inactivity of the sex cells or of the greater number of them. Sometimes approximately one-half are dead or inactive. The absence of all spermatozoa is proof of sterility.

EXAMPLES OF STERILITY IN MALES

In the course of the investigation which has been made for the past nine years during the breeding season, many examples of sterile males have been found. A description of some of these is given in the belief that a study of the individual cases will be instructive.

1. *A Standardbred Stallion.* The stallion was making a season at the stud of his owner and had seventy mares booked. In the routine of miscroscopic examinations being made on this farm of the stallions the first sample of his semen examined showed no sperm cells. Examinations on the following days confirmed the first examination.

[1] 1922, Anderson, W. S., Bulletin No. 239, Ky. Exp. Station.

Apparently he was in perfect health. He carried all the flesh needed. The usual feeds for horses were given him and he had several miles exercise each day.

To learn what results had followed his work in the stud up to the time he was found sterile, an examination of the stud records was made. The first twenty-six mares to which he had been bred, or all which had gone long enough, had been back and rebred. The first sixteen had been bred to him three times each, at three successive heat-periods. While his stud service book showed this record, he had not been under suspicion when found sterile. He was in the hands of experienced horsemen, men who had given their entire time to horse breeding. The stallion was kept under observation the remainder of the season and was mated to fifty mares. At times a few feeble sperm cells were seen in his semen, but at no time did they approach one per cent of the number found in normal semen. The spermatozoa observed were perfect in physical conformation but had little or no vitality. In February of the next year a sample of semen showed enough live sperm cells to offer hope that he was returning to breeding condition, but the improvement disappeared with a few services in the new season. He was mated to twenty mares the second season, or to a total of seventy in the two years. The record books of the farm show that he did not sire a foal in the two seasons.

2. *A Standardbred Stallion.* Our attention was called to this stallion in the fall of the year after he had made two seasons. The first season he was bred to thirty mares and the second to seventy. There had been the usual returns for remating each season. Suspicion was aroused when the owners of all the thirty mares bred the previous year reported that they were barren. In November a report was asked from the owners of the seventy mares served the second spring. Something over thirty out of the seventy reported their mares were probably in foal. The results the following spring showed them to be in error, as not a mare produced a foal to his service. In the two years the stallion was mated to one hundred mares and did not get a single foal.

When called into conference we suggested a mating to secure semen. In the semen thus obtained no sperm cells were found. Forty-eight hours later another sample of semen was procured and examined but no sex cells were to be seen. The quantity of semen and the color of it would not have aroused suspicion. The stallion was then castrated and the cords and testicles turned over to us for examination. The testicles were normal and producing normal sex cells. There was, however, in each cord a center of inflammation which had closed the passageway and the secretions of the testicles, in which the sex cells float, had no outlet to the seminal vesicles.

The semen of the stallion was abundant and natural in appearance. The semen, of course, was secreted by the accessory sex glands and had no product of the testicles in it. He was, however, a very nervous horse and had to be kept on a wood floor as he would dig out with his front feet to a considerable depth the dirt in his stall. There had been some skin trouble of an eruptive nature after the end of the second season in the stud, a few weeks before we examined him. Perhaps this was due, as well as his restless disposition, to the efforts of the system to absorb the pus formed in the epididymis and cords. At any rate, castration seemed to relieve him entirely and he became a quiet, dependable gelding.

Every effort was made to study the history of this stallion to discover, if possible, if there had been any disease or other irregularity to cause the inflammation which resulted in closing the spermatic cords, but no reason could be found for the condition. A thoro examination of the organs before castration gave no reason to assume that the irritation had been caused by an external injury to the parts.

The epididymis of both testes was distended with pus and dead spermatozoa. The testicles appeared to be functioning by maturing spermatozoa which in due time reached the epididymis, there to be destroyed by mingling with the products of the inflamed organ.

3. *A Thoroughbred Stallion.* This stallion is one of the noted sires of thoroughbred horses and was kept at the time of

the observation to be mated to a few select mares of his owner. The first examination was made in April at the suggestion of the veterinarian who had the horse under his supervision. He had been mated and remated to a number of mares, with no evidence of impregnation. The microscope showed that he had only a few germ cells and they were of low vitality. He was examined often enough to confirm the first examination. The stallion was relieved of all stud duty for two weeks. His grain ration of oats only was changed to include hot mashes of bran at night. Green stuff was fed also, and a tonic given him.

At the end of two weeks the germ cells were abundant and of normal vigor. He was remated to all mares previously bred to him and the remainder booked to him; and he impregnated ninety-one per cent, a greater per cent than most stallions.

He is a good example of a male temporarily out of breeding condition. The change of food and the use of tonics may not have been the cause of his recovery. He might have regained his potency without treatment, or he might have grown continually worse until permanent impotency set in.

It is mere speculation to suggest the possible causes of the temporary derangement of the sexual functions. Some work done by us[1] on the hydrogen ion concentration of horse semen indicates that it may be due to an exhaustion of certain mineral elements in the animal metabolism. This hypothesis seems to be sustained by the quick responses which this stallion and others have made to a tonic containing phosphorus.

4. *A Thoroughbred Stallion.* This horse was a four-year-old stallion which had been raced as a two and three-year-old. There was no apparent reason why he should not have been sexually normal.

After he was bred to a number of mares in the early part of his first season in the stud it was found that his mares returned to be remated. The specimens of semen obtained for examination showed a very small number of sperm cells, and their vitality was very low. The best treatment which could be given the stallion did not make any change in the number or vigor of

[1] 1921. Anderson, Healy & Peter, Journal of the American Veterinary Medical Assn., No. 3, page 291.

the germ cells. The mares were bred to other stallions and he was rested until the next February.

The sample of semen obtained at the first mating in February showed some improvement in the number of sperm cells, but it seemed very doubtful if he would be successful in the stud. Being a stallion of excellent breeding his owner took the risk of mating him to some of his mares. After a few matings his semen showed only a very few sperm cells in a field and these were not vigorous in their movement. As time went by all the mares returned and had to be remated to other stallions. No treatment had any appreciable effect on this stallion and he had to be discarded.

5. *A Standardbred Horse.* The stallion in this case had been raced in his three-year-old form and placed in the stud the next year. He was making a normal season when it was noticed that more mares were returning about June 10-15 than should have been expected. A sample of his semen showed a sufficient number of sperm cells altho they were lacking in vigor of movement.

A very large number of small, sphere-like bodies were also present. As the writer had not before seen these bodies in the semen the sample was taken to the laboratory of bacteriology at the Experiment Station and there examined. It was agreed that the bodies were broken-down leucocytes or pus cells.

On the third day after the first sample of semen was secured the stallion discharged a considerable quantity of pus with the semen. From that time on the number of pus cells diminished but never during that season entirely disappeared. They became so few in number, however, that the number of sperm cells became normal and their vigor seemed to be undiminished. Except for the few mares mated to him when his semen showed the greatest amount of pus, there were no unusual returns; and the following season his mares produced the number of foals expected.

Examinations made the next season of his semen showed a few pus cells but not enough to affect adversely the number or the activity of the sperm cells. The third year after the dis-

order was discovered his semen still showed the presence of a small number of pus cells.

Examinations of his testicles on different occasions were made but we were never able to detect the presence of any inflammation. The stallion served promptly and in the usual way. There was, of course, some center of irritation, perhaps within the genito-urinary tract. No evidence, however, of it could be detected except by means of the microscopic examination of the semen; or at the times when considerable masses of pus were expelled with the semen.

The case is typical of a class, disordered by inflamed glands or an inflamed center in the genito-urinary canal.

6. *A Thoroughbred Stallion.* When this stallion was observed he was beginning the second season in the stud. He had been mated to thirty mares the previous season and only one proved to be in foal.

The statement was made to us by his owner that in making one of his first services he fell and severely injured a vertebra of his tail. After this injury he did not, it was reported, serve close. He would barely enter and discharge close to the vulva.

When he was allowed to serve a mare in our presence the story told of his service the previous season was confirmed. He had formed the habit of entering but a short distance, discharging and, of course, drawing out the discharge as he came down. The semen was found to be without fault. The barren mares, a great loss to the farm, were caused by his not giving a better service. Semen deposited just within the lips of the vagina will be wasted on the withdrawal. Frequently stallions are guilty of this fault and when it happens the service should not be counted but the mare remated.

7. *A Thoroughbred Stallion.* This stallion was found in the midst of a stud season with no mares seemingly settled from his efforts up to that time. In an endeavor to procure a sample of his semen he was given the opportunity to serve a mare. After repeated attempts and failures it was noticed that he was wasting a drop or two of semen, some of which was caught. The microscopic examination showed the number and vigor of germ

cells in it to be normal. When this was discovered the problem was simplified to one of getting him to make a proper discharge.

The feed given him up to this time had been crushed oats and hay. His exercise was taken early in the morning under saddle and he was ridden some eight or nine miles. The problem was to discover, if possible, the reason why he could not complete the service at the first effort. The writer advanced the theory that with oats only as a grain diet and so much exercise the glands were not secreting enough liquid semen to make the discharge possible when bred to one mare a day. The microscope showed that the testicles were functioning properly for there was a good supply of vigorous germ cells. It seemed that if the prostate gland and seminal vesicles were congested with semen he could not fail to discharge, and that his failure must be because of a lack of semen.

To encourage greater activity on the part of the prostate and Cooper's glands the diet was supplemented by giving a hot bran mash at night and by adding eighteen raw eggs a day to his ration. He was given exercise in the morning and rested until the afternoon, when he was mated. The change of time for breeding to the afternoon when his muscles had had time to completely relax, with the more stimulating diets, completely changed the stallion. He very soon was able to make the service at the first attempt. A large per cent of the mares mated to him after this became pregnant and produced vigorous foals the next year, many of which have since become successful racehorses. His case is interesting because he represents a nervous class of horses. Stud duty is exacting to them and easily exhausts their energy unless every condition otherwise is favorable. In the case under consideration the restricted diet and the unusual amount of exercise unfitted the animal for breeding purposes. When his diet was changed, his exercise lessened and a period of relaxation allowed before he was called upon to do his work, it changed him from an impotent to a potent stallion.

8. *A Standardbred Horse.* Perhaps the most unusual behavior of any male examined was that of this stallion. He is an

undersized horse and has trouble in serving large mares. It has been found necessary to catch semen as he comes down and artificially inseminate the mare, because he discharges just within the lips of the vulva and the semen is practically all withdrawn as he comes down.

The writer was present on an afternoon when he was attempting a service. He did not seem greatly interested and the groom remarked that he would come down without serving, as was his regular habit; and he had to go back usually before he completed the act. However, as he came away a fair supply of semen, some five cubic centimeters, was caught. There was no question in the minds of all concerned that the service had been made. Before the semen was injected an examination of it was made with the microscope. There were no sperm cells in it. This caused all the more surprise as the stallion is noted for the number and the vigor of his germ cells.

Immediately arrangements were made to breed him the next morning to the same mare. He behaved in the same way as the afternoon before. The semen secured had no germ cells. He was held near the mare while the slide was being prepared and the condition of the semen determined. He was ready to serve in a very few minutes and made the complete service in a satisfactory way, the semen from the full service being crowded with germ cells of the greatest vitality.

It appears that in dropping the small amount of semen, the stallion had a partial emission. Only that quantity of liquid secreted by the glands close to the opening of the urethra was discharged. The part of the semen held by the deeper reservoirs and containing the germ cells was not discharged until the final service.

The groom of the stallion stated that many services and discharges like the two just described had been made that season by him. There is no doubt that many horses make false services as this one did, and the mares are sent away as bred when no sperm cells have been imparted by the male.

9. *A Standardbred Stallion.* This stallion is one of the noted sires of his breed and had had very heavy stud service. In his

work he is slow. He is quiet and deliberate, but works without undue delay. His semen is very thin and more like water in appearance than it is like the semen of stallions. It lacks the milky color and the stringy tendency which is usually found in the semen of stallions.

While the color and physical condition of his semen were not as expected, the semen contained a sufficient number of sperm cells, all of which showed great activity. His record in the number of foals produced to his service is surpassed by few sires. He is recorded here to show that there are very great differences in the physical appearance of the semen of stallions and that the eye unaided cannot be trusted to judge the value of a discharge.

11. *A Thoroughbred Stallion.* It was found at the beginning of a breeding season that this stallion had failed to impregnate twenty out of twenty-five mares bred to him the previous year. The discovery led the owner to consult us. The first examination showed large quantities of pus in the semen. The discharge resembled more a pus discharge than it resembled normal horse semen. Floating in the pus-laden semen were immense numbers of live germ cells. Laboratory examination of the discharge and subsequent ones showed that the spermatozoa quickly lost their vigor. Careful examination of the horse located the seat of the trouble in one of the seminal vesicles. His testicles, epididymis and vas deferens gave no evidence of abnormality. It appears that these organs were functioning in the usual expected way, but that the partial if not total sterility was due to a seminal vesicle or some other organ discharging large quantities of pus into the semen at the time of ejaculation. The toxic effect of the pus no doubt robbed the sperm of their normal vigor and their ability to produce impregnation.

12. *A Thoroughbred Stallion.* Another unusual case came to light during the season of 1922. The result of this stallion's service in the stud during 1921 was disappointing as he did not have half as many mares in foal as he should have had. The few examinations which had been made of him in 1921 revealed nothing of a suspicious character.

When it was learned that he had failed so largely in 1921 we began to give him careful attention. We found that he was making only a partial discharge. The small quantity of semen ejected came evidently from some accessory sex gland and was without sperm cells. We found that he would go back at once and give a complete discharge. The semen from the second discharge was normal and contained large numbers of active sperm cells. The method was then regularly used of giving two services with only a few minutes intervening.

13. *A Valuable Jack.* This jack was purchased in Missouri and brought to Kentucky where he made a few successful seasons. He then had a rather mild attack of orchitis or inflamed testicles. After recovery he continued stud duty successfully for the next season but just at its close he had a second attack of orchitis. He was mated to a number of jennets during midsummer and fall, after the recovery from the second attack. In the following spring he was bred to twenty-five mares before it became apparent that he was sterile and a sample of his semen was obtained for examination.

The semen had no sex cells but the slide was a mass of pus cells. Examinations on other days found masses of pus discharged in the semen. In the meanwhile a third attack of orchitis was experienced by him. From this he seemed to make a complete recovery as he had done twice before. By this is meant that a physical examination made by a veterinary surgeon disclosed no physical defect or abnormality. From July, 1918, when he recovered from the second attack of the disease, until January 1, 1920, there had been no produce from his service, which included the jennets and twenty-five or thirty mares of the season of 1919. He was not used during the season of 1920 except to secure semen.

The value of the history of this jack is the fact that he made a complete recovery from one onset of the disease, but was made sterile by the return of the trouble. Another value is that while there were no outward signs of physical abnormality he was completely sterile. If placed in the sale ring on his appearance he could have passed as sound.

It should be noted that he served promptly, with no undue labor and without any evidence of discomfort. The clots of pus passed in the semen would not have been detected had no samples of the semen been taken for examination.

Everything which the veterinarian in charge knew to do was done for this jack but at the last examination, September 1, 1920, there was no improvement. The infection must have become so severe as to have permanently injured the sperm-forming cells of the testicles. No opportunity has yet been given the writer to castrate and examine the reproductive gland of a sterile male made so by orchitis.

Orchitis is of frequent occurrence in horses and jacks. It seems that most animals, at least, can resist one attack of the disease but there is very great danger of sterility when there are recurrences of the trouble.

In 1911 a case of orchitis was examined by an Experiment Station worker* and it was found that on lancing the testicle the discharge containned not only a bacillus which caused a green growth on agar but also a bacillus which was the same as that which causes infectious abortion in mares.

14. *A Jack Four Years Old.* This jack had a severe attack of orchitis. At the time of examination there was a somewhat swollen scrotum and testicles tho it had been months since the attack of orchitis. The jack was used on ten mares during the season, none of which produced to his service. The jack was given good care until the following season. By that time the swelling had entirely disappeared and he made a normal season getting an average number of foals. He is a good example of temporary sterility. The inflammation of the reproductive glands evidently rendered them unable to mature normal sex cells during the first season after the attack of orchitis, but when all swelling had subsided the gonads were able to function again.

15. *A Jersey Bull.* When attention was called to this animal he had failed to produce a calf in twenty months altho he was mated to a number of cows. An attempt to secure semen failed because he was unable to complete the act of mating.

*1912. Good, E. S., Bulletin No. 165, p. 290. Ky. Expt. Station.

When he was slaughtered his reproductive organs were secured for examination. Scrapings from the testicles failed to show spermatozoa. Dr. Graham of the Kentucky Experiment Station made examination of the gonads and pronounced the cause of sterility to be premature senility, or fibroid degeneration. It was found, also, that the inability to serve was due to a severe inflammation of the intromittant organ. There seemed no connection between the fibrosis which rendered the gonads useless and the inflammation which made him unable to serve.

16. *A Hereford Bull.* The bull had been sold to go from Kentucky to Iowa. In that state he was used in a registered herd. There was complaint that he was unable to settle his females. When his new owner was convinced that he was a non-producer he reported that fact to the firm who bred him.

The firm refunded his purchase price and ordered him returned. He was given a chance in their own herd, but failed to sire a calf.

But one sample of his semen was obtained. It contained well-formed sperms but they were inactive. The bull was shipped to the market and no opportunity was given to examine his organs.

17. *A Shorthorn Bull.* The bull was used in a herd of thirty registered cows and heifers. Some of the females bred to him produced calves but a large per cent were barren. The longer he was used the greater was the number of cows that proved barren to his service.

One sample only of his semen was examined and it had a sufficient number of germ cells, but there was no evidence of life. The bull went to the shambles and no opportunity was offered to examine his gonads.

18. *A Mature Boar.* This animal had been fitted and successfully shown until he was mature. When first used as a breeding male very few sows produced to his services and the litters were not large.

It seems that no pigs were farrowed by the sows bred to him during his second season in the stud. During his third season

opportunity for examination was given. The way in which he served and the appearance of the semen would not have aroused any suspicion of his fertility. Large numbers of sperm cells were in the semen, and slides mounted at once showed considerable movement of sperm, but a movement much less than normal. Another evidence of their low vitality was that motility ceased in a few minutes when they should have been active from four to six hours.

This boar was given tonics and compelled to take exercise but he made no improvement. As a last resort he was turned out on a farm with a small herd of sows and allowed to run at will with them over the fields. None of the sows produced to his service. Each examination made of his semen showed that the sperms were gradually decreasing in vigor altho the numbers were in no way diminished. This progressive loss of vitality continued until finally no evidence of life could be found in his spermatozoa. When it was discovered that the semen had an abundance of sperm cells without life the boar was castrated and the glands made available for examination.

The glands appeared to be normal. Portions were prepared for section but a change in the personnel of the laboratory at that time caused a loss of samples.

The animal showed a progressive change in the vigor of his sex cells going, under our observation, from the ability to sire an occasional pig to total sterility and to the stage in which all sperm were inactive. At all stages the animal's germ cells were of the usual size and form. He was active and served readily. No observer of his work could have detected anything wrong with him.

19. *A Duroc-Jersey Boar.* This was a young boar that on account of his conformation and pedigree was sold for a good price to head a purebred herd. None of the sows bred to him produced. The persons concerned shipped him to the Kentucky Agricultural Experiment Station where he could be examined.

Samples of his semen contained no germ cells. He served promptly and the semen gave no evidence of any irregularity, but the mounted slides showed no sperms. He was castrated

by Dr. G. L. Hoeft of the Kentucky Experiment Station and the cords and testicles examined. The cords were in good condition but the liquid in them as well as scrapings from the testicles had no sperm cells. Dr. Hoeft prepared portions of the glands and made sections which showed the cause of the animal's sterility to be fibroid degeneration. That is, the fibrous, or connective, tissue of the testicles had developed to an abnormal extent thereby destroying the sperm-forming parts of the glands. There are reasons to believe that fibroid degeneration is the cause of sterility in many cases when the animal discharges no germ cells.

DISCUSSION

It is apparent that a sterile male may defeat the efforts of a breeder over a considerable period before it can be certainly determined by him where to place the blame. The return of a few females to be rebred may or may not be an indication of the breeding condition of the male. It all depends on the character of the females. However, the number of returns should be studied very carefully and if there be any suspicion the condition of the male should be certainly determined by examining his semen under a microscope.

A barren mare entails a loss of but one foal, but an infertile male may result in the loss of many possible foals. Our investigations show that in some cases as many as seventy mares have been bred to a single sterile stallion in one season, or a pen of twenty-five brood sows mated to a single impotent boar. Such mistakes are costly and the frequency with which they are made renders it wise for the breeder to exercise especial care in handling breeding males. The extent to which males contribute to the barrenness of females is not appreciated by practical breeders. The reason for this lack of knowledge is due to the inability of a breeder to determine the fertility or lack of it in any male. If the male is in good condition and serves readily with the usual discharge of semen he is considered fertile and any falling off in the production of young is blamed on the females.

There are a few classes into which, for the most part, non-breeding males fall.

1. Fibroid degeneration of the testes is a condition frequently encountered. It is thought that young males too highly conditioned on rich protein feeds during their show career are injured for breeding by the process. Whether the cause of fibrosis is due to the feed or not, the condition is not infrequent and the purchaser of a breeding male should always buy him on condition that he is to be found fertile on trial. There is no possible remedy for fibrosis as the condition of the glands renders the production of sperm cells impossible because the tubules are transformed into a tough fiber-like structure.

One of the most dangerous aspects of the condition is due to the fact that the secondary sex glands function in a normal way in secreting semen and the sex desire is not necessarily diminished; consequently animals not capable of maturing a single sex cell may serve as promptly and as often as tho they were in good breeding condition and the discharge of liquid semen may be copious.

Fibrosis is not the normal condition of old age. It may or it may not be found in very aged males used in the stud. It is the writer's belief that in certain families of almost all breeds of domestic animals there is a tendency to develop a friboid condition of the sex glands, some in early life and others later in life. Sterility that is due to age and age only is caused by the exhaustion of the glandular material so that few or no gland cells are left out of which sex cells can be matured. As extreme age comes on the discharge will be less and less and will contain fewer and still fewer sex cells until the time comes when there are too few to expect impregnation to follow. As long, however, as sex cells are formed and liberated, their size, shape and activity will be identical to those of a younger animal. That is to say, as old age comes on the condition is not in any way reflected in the morphology or activity of the sex cells themselves. Their number may be very greatly lessened and a point reached where there will be no more liberated; but as long as the glands function in their production the sex cells differ in no way from those matured in youth.

If a condition is found where the shape or activity of the sperm cells is abnormal the cause must be attributed to some

diseased condition rather than to age alone. The oldest stallion examined by the writer was 29 and the service at which the semen was obtained resulted in an impregnation and the next year in the birth of an excellent foal. The sex cells of this stallion were as active and vigorous as those of any young animal examined. However, a year later old age got in its work and the stallion was laid to rest to end his suffering. An investigation showed that he had ceased within the year to mature sperm cells.

2. Sterile males result from repeated attacks of orchitis. The inflammation of the glands, if severe enough or if repeated a sufficient number of times, ends in testes unable to mature sex cells. Little is known as to the cause of orchitis, and breeders as a rule do not understand the danger from the attacks. Any male that has had one or more severe attacks of the disease should be regarded with suspicion until it is proved that he is fully potent.

3. One of the most peculiar problems presented by the investigation is the class of males who regularly mature a large proportion of inactive sperm cells instead of all active ones. The proportion of the inactive sperm to the active cells varies from an insignificant number to more than one-half. Most of the males under our observation in this class have some offspring but none of them succeed in impregnating their full quota of females. Perhaps, the males commonly known as "shy" breeders fall into this class; and it is our opinion that a partial failure in the stud may often be traced to the presence of too great a number of dead sex cells among the active ones.

Since it has been determined that there are males of this character there has not been opportunity to adequately study them with a view of determining the cause of the condition or the remedy for it if there be one.

4. Another class of sterile or partially sterile males is the class that have pus in the discharge of semen. During the season of 1922 six stallions were discovered with a larger or smaller amount of pus in the seminal fluid. Some of these were sterile, others partially so and one, at least, did not seem to be in any way affected by the presence of the pus cells.

As far as the author is aware there is nothing in the literature on breeding which reports a case of sterility due to the presence of pus in the semen. It appears that our investigations are for the first time calling attention to this interesting cause of sterility.

One aspect of this matter is alarming. There is evidence, altho as yet not conclusive, that a stallion discharging certain kinds of pus cells may be communicating to the mare with whom he mates, the disease which is producing the pus in his own genito-urinary tract. The very presence of pus indicates that the stallion has some center of inflammation. If the organism which produces this center can be transferred by the male to the organs of the female there to start a center of growth the result will be, for the time, at least, a barren mare. Further study and investigation is contemplated on this matter.

CONCLUSION

From the facts stated it seems evident that the fertility of the male is not to be taken for granted; too many of them have been found to be infertile. It is also evident that a breeder has not the means to conclusively determine the breeding ability of his males if they are in condition and serve promptly. It requires examinations made under a microscope to be certain any male is potent if the knowledge is to be obtained during the breeding season.

II. Sterile Females

While an occasional male used in the stud is sterile the main loss from sterility is due to females. A large percentage of well-bred dairy cows are difficult to get with calf and many stop breeding at early ages. It often happens that the more milk a cow gives the more difficult it is to get her to breed. It is a well-known fact that one very popular type of Shorthorns almost became extinct because of the barren cows in the family.

The jennet and mare, of all domestic stock, are the most difficult to get to breed. Not one-half the mares in Kentucky that are bred any one year raise foals to maturity the next year.

Perhaps, two or three per cent of pregnant mares slip twin foals. Six to eight per cent will slip single foals. The breeders can depend on a loss of ten per cent from slipping foals, single and twins. This does not include any loss due to contagious abortion. When contagious abortion gets into a band of pregnant brood-mares it is liable to cause the majority of them to abort. Contagious abortion is caused by a specific germ, Bacillus abortivo-equinus,[1] which is communicated from one mare to another. There have been many outbreaks of contagious abortion in Kentucky but losses from it are not taken into consideration in this discussnon.

SOME CAUSES OF BARRENNESS IN MARES AND JENNETS

1. *Length of Heat Period.* The length of time a mare is in heat makes it difficult to know when to breed her. She may be in heat from three to nine days. No one knows when during the heat the egg is liberated. One egg only is liberated at each heat period. From work done with the semen of stallions[2] it seems unlikely that their sperm cells live longer than a few hours in the organs of the mare. If, then, the mating is made a day or two before the egg is shed or some days after, it is not probable that fertilization will follow.

The records we have been able to gather from the stud farms of Kentucky indicate that by the one mating a heat it requires an average of five matings to secure one impregnation. Each mare is mated on the average two and one-half times. One-half the mares bred are barren, so that but one foal can be expected from five services.

2. *Abnormal Discharges.* When this investigation was begun in 1914 the breeders of Kentucky paid but slight attention to the condition of the female at the time of breeding. Mares with obnoxious discharges were often mated with valuable stallions. The practical breeder gave little thought to any of the discharges caused by vaginitis, cervicitis or metritis. Gradually, however, the breeders came to recognize the futility of mat-

[1] 1912. Good, E. S., Bulletin No. 165, Ky. Exp. Station. 1916. Good, E. S., and Smith, W. V., Bulletin No. 204, Ky. Exp. Station.
[2] 1922. Anderson, W. S., Bulletin No. 239, Ky. Exp. Station.

ing mares suffering from any inflammation of their organs. When the discharge was found the mare either received treatment with douches of salt and sodium carbonate solutions or was turned over to a veterinarian.

An exhaustive study of the causes of such inflamed conditions of the female organs as cervicitis, metritis and salpingitis is now being made by Dr. W. W. Dimock, Head of the Veterinary Department of this Station.

3. *Irregular Heat Periods.* One of the first problems presented to us after the investigations began was the cause of irregular heat periods.

A jennet was donated for examination which appeared to be in heat constantly for two years after dropping her last foal; and had not been in heat at all for the next two years. She was destroyed that an examination of her reproductive organs could be made. The vagina, os and uterus were intensely inflamed (vaginitis, metritis and cervicitis).

Both ovaries were greatly enlarged by cysts. The cystic bodies were so numerous and so large that all ovarian tissues had degenerated to the extent that ovulation had been rendered impossible. Evidently as the cystic centers began to form in the ovaries the jennnet because of this congestion or enlargement of the glands manifested evidence of heat and constant instead of periodic heat periods. When at last all ovarian tissue had been transformed by the excessive enlargement of the cysts the animal ceased permanently to show signs of heat.

4. *Examples of Barrenness.* Just what relationship, if any, exists between cystic ovaries and an inflamed uterus has not been determined; nor has the cause of the cystic condition been discovered.

Three mares were donated by the Patchen Wilkes Stock Farm in 1921. The mares had been barren, one for eight and two for six years. Each mare had been bred five or six times each year and there was no apparent external reason why they should have been barren.

A post-mortem examination of No. 1 revealed a severe metritis and ovaries so enlarged by cysts that ovulation had ceased.

The uterus of No. 2 was less inflamed than No. 1, but the ovaries were completely degenerated by cystic bodies. The mucus membrane of the organs of No. 3 appeared to be in good condition, but the ovaries were as greatly enlarged and as far in the process of degeneration as those of No. 1 and No. 2.

A technique is being developed by skilled veterinarians of manipulating the ovaries of cows, mares and jennets per rectum. In this way embryo cysts can be broken and the ovaries saved from the degeneration consequent upon the completely developed cystic condition. To be of the greatest value the examination and treatment should be made as soon as there is any evidence of non-production.

5. *A Registered Jersey Cow.* This cow failed to breed after having produced several calves. She came in heat regularly and was bred until hope of securing another pregnancy was abandoned. She was sent to the slaughterhouse, but we were allowed the privilege of securing her reproductive organs immediately after her slaughter. The ovaries were normal save for a few very small cysts and the corpus luteum showed the recent liberation of an egg.

The vagina and womb were normal but the horns of the uterus showed an inflammation. We were unable to determine any cause for the inflammation. The cow had been mated regularly for twenty months. Evidently what appeared to be a slight inflammation of the horns of the uterus had prevented conception. We have no way of knowing whether the cow represents a class of sterile animals or whether she is an isolated case; but we believe she represents a class.

6. *Hostile Secretions.* In June, 1916, a barren mare was made available for examination. She had failed to produce for five years preceding that date altho she had been bred each year from six to eight times during the breeding season. Her physical appearance gave no evidence of any cause of barrenness. Examination by means of the speculum did not show a disordered cervix or vagina.

She was mated to a young and vigorous stallion and a sample of his semen procured. After an examination had been

made of a slide of the semen with the microscope a portion of it was inserted into the womb of the mare by means of a syringe used for artificial insemination. In two hours the sperm cells of the sample of semen retained as a control showed the usual vigor of semen held for that time. A sample obtained from the womb of the mare after it had been in the womb two hours gave no evidence of life.

The next day the experiment was repeated except that the semen was taken from the womb one hour after mating. In this short time the sperm cells had been deprived of the power of movement while the cells in the portion of semen kept for control had diminished little or none in their ability to move about.

Evidently there was in the womb of the mare some secretion unfriendly to the vigor of the sperm cells. This mare, no doubt, represents a type of barren mares, barren because of some abnormal secretion which destroys the vigor of the sperm cells before they can complete the journey thru the womb and horns into the fallopian tubes.

7. *Methods of Mating.* The fact remains, however, that a very great percentage of barrenness in mares is not due to disease or disorders but to the highly artificial method of mating horses. If a band of brood mares are turned into the pasture with a potent stallion, he will have foals by close to ninety per cent of them. Our best breeders rarely exceed fifty or sixty per cent. In the pastures the stallion will mate with each mare many times during one heat period, while under control a mare rarely gets more than one service. One would be sufficient were it made at the right time with reference to the liberation of the egg; but the time of liberation is one of nature's secrets not yet discovered by man.

There can be no doubt that the time of the shedding of the egg varies with the individual mares, the same mare, perhaps, behaving differently at different times. Assuming that such is the case, it is hopeless to expect a solution of the problem as long as the present method of breeding is employed.

The universal custom of horse breeding is to mate a broodmare if she does well at foaling time, on the seventh, eighth or

ninth day after dropping a foal. Most breeders prefer the eighth day if the services of a stallion can be secured on that day. Experience shows that this time after foaling is the right time in which to get the greatest number of pregnancies. If it were possible to give two services to a mare with foal at side, in order to double the chance of obtaining pregnancy, they should be given on the eighth and tenth days, or seventh and ninth.

8. *Indifferent Mares.* Often when a mare fails to catch at her first mating she passes two or three periods without showing any signs of heat. This may be due to the drain on her system in supplying nourishment for the foal or it may be due to such a quiet temperament that she manifests little sign when in heat, or again it may be due to an extreme nervous nature that causes the mare to exhibit such great anxiety about her foal that she gives no visible signs of heat. On every farm where there are any considerable numbers of brood mares some of them will be barren because it is not possible to catch them in heat after the first mating on the 8th day. Foals are weaned and the mares placed in winter quarters in the belief that they are safe in foal to the one service on the eighth day. The disappointment of the breeder comes in the early winter when he discovers that many of the mares are not in foal. The discovery may not be made until as late as March or April. Usually, however, February or early March ought to find all barren mares giving signs of heat.

Whether it is possible to keep a closer watch on bred mares with foal at side, than some of our best breeders keep is a question, because many of them do everything that seems possible and yet they fail to detect signs of barrenness until it is too late to rebreed the mares.

The overcautious breeder who makes a mistake in trying a mare and breeds her because she does not fight the teaser as vigorously as she might, runs the risk of making his mare abort. More than one example of this nature has come under our observation on the farms, while making this study. One incident may represent the type.

9. *Induced Abortion.* A kindly-disposed saddle mare had been bred on the eighth day after dropping her foal. She was returned to the stud for trial on the 21st day and it was decided from her behavior that she was not in heat. After the lapse of another 21 days she came back and her behavior left doubt as to her condition. There were no positive signs of heat nor was there any noticeable objection to the approaches of the trial stud. It was decided to breed her and to make the service the more effective, as they thought, a hand was inserted and the os dilated before the service. In thirty-six hours after the mating the mare aborted and they were fortunate enough to find the small fetus and its membranes. Of course, when the mare recovered from the shock of the abortion it was too late to breed her again that season.

When a mare, barren for one season, comes up for breeding, certain things may be done that will aid in getting her settled. She should be examined, first of all, for any disorders of the genitalia. If there is a discharge of any kind the mare should not be bred until that is corrected.

By means of the speculum the breeder can see directly the condition of the vagina and also the os. A little experience in its use will soon enable the breeder to detect the normal condition of the organs. The irregular conditions which the washes or douches will not rectify should go to the hand of an expert.

10. *Time of Breeding.* Many barren mares are in heat in February and some breeders begin to breed them in that month. Our records of February and up to March 15th breedings show a very small per cent of pregnancies. Some seasons early matings are more successful than in other years, due perhaps to the nature of weather conditions. The barren mare that runs out without shelter or protection from the storms, with little or no grain feed will not be in good condition for breeding as early as the mare that has had shelter and a balanced grain ration.

Unless an early foal is especially desired for some futurity, the 15th of March is early enough to begin breeding the barren mares. If the weather of March is very cold, it may be well to wait until the better weather of April comes before beginning.

It seems to be the safest plan to wait until the good weather of March or April comes before beginning on the barren mares. It is good practis to breed the mare that foals on the 7th and 9th or 8th and 10th days after foaling, regardless of the time or weather conditions, for after all is done no better results are obtained than from the first mating after parturition.

After watching the practis of breeders for nine years and getting the records on thousands of matings, the writer believes the best policy to be to wait until warm spring weather. If need be, feed the barren mare grain and some wholesome roughage so as to get her into good physical condition; then mate her on the second or third day of her heat, and every other day after that as long as she stays in.

III. Artificial Insemination

To aid in reducing barrenness, a method of introducing into the uterus of a mare by capsule or syringe the semen of a stallion is becoming widely practist. If proper care is taken in its use, the method of artificial insemination is of considerable value. In the hands of a careless operator it may become a serious detriment.

Obtaining the Semen. Three or four methods are used to obtain the semen of a stallion. One method is to insert a syringe into the womb and draw out the semen, immediately after the mare is served. To do this the hand of the operator must be thrust into the vagina to direct the nozzle thru the os into the womb. With some instruments made for this purpose it is necessary to force a finger thru the os also, to direct the end of the syringe down to the floor of the organ.

The objection to this method of obtaining the seminal fluid is the evil results following the mechanical disturbance of the organs of the mare. Often in serving a mare the stallion or jack does not eject into the womb any large quantity of semen, because the os may be so restricted that little or no fluid can enter during coitus. The mechanical pressure necessary on the part of the operator to force a syringe and finger thru such a small os is liable to cause irritation, to start hostile secretions or to set up some adverse bacterial growth.

Another objection to entering the womb for semen is the liability of carrying from a diseased organ contaminated liquid to a healthy animal. The purpose of taking the semen out of the womb is to divide it into portions to be used in artificially inseminating other mares so that one discharge of a male can be used to inseminate two or more mares. It is far better to leave the mares untouched than to inject semen that has been extracted from the womb of another mare the condition of which is not known.

A study of the flora of the genital tract of the cow has been made, in part at least, and some work of the same nature has been done on the mare. These studies, while not complete, indicate that the organs of the female are frequently harboring infections and that it is dangerous to transfer semen from one female to another. The speculum may be used to examine the vagina of the mare, but even if that organ is normal it does not follow that the uterus is in the same condition.

It is a practis of doubtful value to divide the discharge of a stallion into portions for two or more mares. The larger the quantity of semen that can be placed in the womb of a mare, either by natural or artificial means, the greater is the opportunity for impregnation. One spermatozoon is all that is needed by the ovum, but experience proves that the larger the number in the initial discharge of the male the greater will be the probability of impregnation.

Another method of obtaining the semen is to extract it from the vagina of the mare served. There is little or no objection to this method as far as injury to the mare served is concerned. A syringe can be inserted into the vagina and the semen recovered from the floor of the rear part of this organ without irritating or injuring the mare, provided, of course, that the syringe is completely sterilized before use and the operator exercises due caution.

If in making the service the stallion injects the semen into the womb, none will be found in the vagina, or if most of it goes into the womb not enough for use can be recovered from the vagina. Some stallions, however, leave most of the semen in the vagina of the mare served, and all stallions will leave semen

in the vagina of mares whose cervix fails to respond during coitus.

The same objection to using semen extracted from the vagina can be made as in using it from the womb, as far as carrying an infection from one animal to another is concernel. There is another and very serious objection to the practis of obtaining the semen from the vagina. It is the possibility of getting urine mixed with it. Some mares have naturally a considerable depression in the rear of the vagina which may be holding urine at the time of mating. Should the semen drop into it the urine will instantly kill the sperm cells and render the semen worthless.

A rubber bag can be utilized to catch the discharge with stallions that do not object to its presence. A large number refuse to work when it is adjusted. No more sanitary method is possible than the use of the breeder's bag, when the entire discharge is needed. It is better for the mares used in the service to receive a part of an uncontaminated discharge out of the rubber bag than to undergo the risk of contamination during the process of extracting a discharge.

The limitations, however, to the use of the rubber receptacle are found in the per cent of males who refuse to work when the bag is in place. No method has yet been discovered to overcome the aversion of a male to the use of the bag.

A method of collecting semen for artificial insemination practist by the expert veterinarians of Kentucky is as follows:

A small funnel about four inches wide at the top is used. The outlet of the funnel is plugged with a cork. Before use the funnel is sterilized in boiling water. The operator stands on the right of the stallion while he is serving the mare. In his right hand he holds the funnel and with his left he directs the organ of the stallion over the mouth of the funnel as he withdraws. By this means the semen which would have been lost is allowed to drop into the funnel, and it frequently amounts to from 5 to 10 cubic centimeters. At times the amount recovered is not enough for use, but a little experience in this method of collection soon results in the ability to obtain all that is necessary. However, in horse breeding where the

stud fee is a large one, as with the Thoroughbred and Trotting horses, the semen collected is not used on a second mare but it is put by means of a syringe or capsule into the uterus of the mare served. The whole purpose of the artificial insemination after a natural service on the same mare is to increase the opportunities for impregnation.

If the stallion were able to transfer all the semen directly to the uterus, there would be no necessity for following the service with an additional amount of semen. It cannot be known that all, or even any large part, of a discharge goes directly into the womb, so that as a precaution the natural service is supplemented by catching all that is available and using it in addition. This is the universal practis in breeding valuable mares of the Thoroughbred and Trotting breeds.

Some breeders in Kentucky a few years ago thoroly tried out the practis of catching the semen and using it on another mare. The number of foals secured that way was so few that the method has been practically abandoned. Those breeders of Kentucky who produce utility horses and mules have found artificial insemination of such little value to them that they have practically discarded the method. The decrease in the demand for the service of jacks and common stallions has been so great that there is no need for any method to supplement the natural service.

The reason that only a small number of foals are obtained by artificial insemination without a natural service seems to be the small volume of semen available. The capsules used hold from 4 to 5 cubic centimeters of semen and it is not customary to use more than one of them. The complete normal discharge should be from 15 to 20 cubic centimeters and even more. Experience has shown that the entire quantity is not too much and whenever the amount is reduced by dividing the discharge between two or more mares the chances for fertilization are decreased.

At the suggestion of the writer some breeders, when a valuable mare is hard to catch, have adopted the method of mating every other day while in heat, and to catch at the end of each service all available semen and inject this by means of a syringe

or capsule. This method has proved the most efficient yet devised to insure the impregnation of a valuable brood mare.

Methods of Insemination. There seems to be no especial objection to using either a syringe or capsule for placing the semen in the uterus. Both methods are used and both are successful. If a capsule is used very great care should be taken to keep it clean. If the os is small, as is the case with a great many young mares, it is a little more difficult to insert the capsule than it is to insert the syringe. One virtue in the use of the syringe is that it may be easily sterilized by placing it in boiling water; another slight advantage is that it does not dilate the cervix to the extent required for the capsule, nor does it leave a foreign substance in the womb as the capsule must do.

It is known that as large a body as the capsule may be so irritating to the uterus that it causes the mare to strain or exert muscular force to expel it, and in some cases it may be thrown to the ground before the capsule has had time to dissolve by the heat of the body.

Care of the Semen. In practis the funnel for catching the semen is sterilized by the use of boiling water and is raised to about animal heat by tepid water just before use. The life of the spermatozoa is not affected by the ordinary changes of temperature altho it may be just as well to keep the semen as near body temperature as possible. To do this the careful operator has water at hand of about 100°F. with which he keeps the funnel and syringe about the degree of animal heat.

To catch the semen with as little contamination from dirt and other debris as possible the mare is thoroly sponged and the stallion is kept very clean. With the utmost caution some foreign matter and hairs will fall into the semen. A very good practis is to strain the semen thru sterile gauze to take out the hairs and any large particles of dirt.

Length of Life of Spermatozoa. It has been shown by the author[1] that after semen has been obtained from a male at the end of copulation the life of the sperm cells has a very definite limit. Under the very best conditions the male sex cells begin to show loss of vigor in one or two hours and the extent of

[1] 1922, Anderson, W. S. Bulletin Ky. Ag. Ex. Sta. No. 239.

activity is from four to six hours. The semen is a perfect medium for bacterial growth and as the bacteria increase in the semen the vigor of the sperm cells diminishes.

In an attempt to obtain the get of a valuable sire semen has been taken considerable distances and used on females, but without result, because of the facts above stated. It is possible that semen may be carried from one farm to another close by and used successfully, provided the time elapsing does not exceed from 20 to 30 minutes, but the best practis is to have the mare present and to use it immediately after collecting.

It is not necessary in the technique of artificial insemination to protect the semen from light or even from the direct rays of the sun, as light has no appreciable ill effect on the vigor of the spermatozoa. Direct sunlight does not destroy the life of the sex cells instantly, as is the common belief, but it has rather an invigorating effect. Semen exposed to the direct rays of the sun for some minutes shows the sperm cells as very active. The increased vigor results in death somewhat sooner than if they had not been stimulated by sunlight.

Aid from Artificial Insemination. Too much should not be expected from the artificial method of breeding. It has a value and it has its limitations. Its most useful place is, perhaps, to follow the natural service of a stallion who cannot serve close and draws out most of the discharge as he comes down. To catch the semen and to use it on the mare is of much value. An occasional stallion cannot reach the average mare of his breed. He soon forms the habit of discharging just within the vulva and draws out the liquid as he comes off. It is in examples of this nature that a mechanical transfer of the semen to the organ of the mare is useful.

There are mares that require a number of services and when one of these is being bred it is well to follow the service with whatever semen can be collected, so as to add to the chances of fertilization. Some mares of this class may have a cervix unduly restricted, in which case a capsule or syringe can place the liquid within the womb when the natural service would not do so.

No Danger from the Artificial Method. Some owners of brood mares raise the question of ill results on the foal likely to follow the mechanical method of insemination. There is no danger of any deformity arising from its practis. Twins will not happen any oftener with it than without. Foals will be in every way the same as the result of the natural process alone. In short the breeder has all to gain and nothing to loose from the method. All, of course, dependent on the use of the right method with a due amount of caution as to cleanliness on the part of the operator.

Kentucky
Agricultural Experiment Station

University of Kentucky

BULLETIN NO. 245

Analyses of Commercial Fertilizers

LEXINGTON, KENTUCKY

DECEMBER 31, 1922

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BULLETIN NO. 245

ANALYSES OF COMMERCIAL FERTILIZERS

By H. E. Curtis, H. R. Allen and Lelah Gault

This bulletin gives the results of analyses of fertilizers under the operation of the Fertilizer Law during the year 1922.

Those interested in the fertilization of different crops should apply to the College of Agriculture, the Experiment Station, or to their County Agent, and such literature as bears on the subject in which they are interested will be furnished. Bulletin No. 228 of the Experiment Station, showing the results obtained on the soil experiment fields, is of special interest to all users of fertilizers.

Samples Analyzed

During the year 1922, 883 brands of fertilizer were registered for sale. Of these, 429 were complete fertilizers containing all three of the essential ingredients—phosphoric acid, nitrogen and potash (non-acidulated bones containing potash are not included in this item); 123 acid phosphates; 152 nitrogenous superphosphates; 99 acid phosphate and potash mixtures; 70 bones, tankage and non-acidulated bones with potash; 6 nitrate of soda, 3 potash salts, and 1 containing nitrogen and potash.

Samples sent by manufacturers representing these various registrations, samples collected by our inspectors from fertilizers on sale in the State, and samples sent in by farmers, have been analyzed and the results are to be found in the following pages. The analyses have been grouped into tables according to the above classification and, in addition to the analyses, we have shown the index of relative value of each fertilizer, for the purpose of comparison. The following factors have been used in computing the index of relative value.

Available phosphoric acid in mixed fertilizers	1.5
Available phosphoric acid in acid phosphates	1.2
Insoluble phosphoric acid in mixed fertilizers	0.4
Phosphoric acid in bones	0.8
Nitrogen in all fertilizers	7.0
Potash in all fertilizers	4.0

Explanation of the Tables

In the tables of analyses, following the name of each brand, will be found the analysis of such samples as have been collected by our inspectors, sent in by farmers, or furnished by manufacturers, the manufacturer's guaranty being printed in italics. The figures set in bold-face type in these tables are those results which in the judgment of the Director are too low to be acceptable.

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	A. D. Adair and McCarty Bros., Inc., Atlanta, Ga., and Chattanooga, Tenn.	
64087	Adairs Soluble Pacific Guano	C. A. Casteel, East Bernstadt .....
63753	Old Glory Mixture	Manufacturer .....
63832	McCarty's Soluble Fertilizer	Manufacturer .....
64090	Adairs Standard Tobacco Grower	C. A. Casteel, East Bernstadt .....
64091		W. C. Stewart, Horse Cave .....
	The American Agr'l Chem. Co., Inc., Cincinnati, O.	
64094	A. A. C. Kentucky Tobacco Grower	Ray and Corbett, New Haven .....
64095		E. M. Haynes, Franklin .....
64584		D. Sanders, McKinney .....
63299	A. A. C. Tobacco and Truck Fertilizer	Manufacturer .....
64102	Bowker's Harvest Bone Phosphate	Browning, McReynolds and Co., Lewisburg .....
64591		T. E. Richardson, Campbellsville ....
64561	Bowker's Harvest Queen	Harvey Stout & Sons, Fern Creek ..
64103	Bowker's Fish Guano	C. P. Clarke, Owensboro .....
64104	Bowker's Corn and Wheat Phosphate	Gooch & Payne, Eubank .....
64562		Harvey Stout & Sons, Fern Creek ..
64592		Gooch & Payne, Eubank .....
64593		D. Sanders, McKinney .....
64105	Bowker's Grain and Grass Grower	Mayhew & Gilbert, Franklin .....
64106		J. E. Buck, Stanford .....
64594		Mayhew & Gilbert, Franklin .....
64107	Bowker's Complete Fertilizer	W. R. Strange & Co., Middlesboro ...
64108	Bowker's Tobacco and Truck Grower	Bokhara Seed Co., Falmouth .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.10	0.40	10.50	0.77		1.08	1.85	2.25	2.05		32.6	64087
10.00						*1.65*	*2.00*	*2.00*		*30.9*	
10.60	0.40	11.00		1.14	0.76	1.90	2.31	2.93		36.3	63753
9.00						*1.65*	*2.00*	*3.00*		*32.4*	
10.65	0.40	11.05	0.98			0.98	1.19	1.51		26.6	63832
10.00						*0.82*	*1.00*	*1.00*		*22.9*	
8.55	0.60	9.15				1.68	2.04	2.43		30.4	64090
7.65	1.65	9.30	0.73		1.39	2.12	2.57	2.64		32.8	64091
8.00						*1.65*	*2.00*	*2.00*		*27.9*	
9.75	1.00	10.75		0.73	0.89	1.62	1.97	0.84	1.25	32.2	64094
8.85	0.85	9.70		0.65	1.30	1.95	2.37	2.34		32.3	64095
8.30	1.35	9.65		0.97	0.58	1.55	1.88	2.24		29.0	64584
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
8.90	1.40	10.30		0.34	1.46	1.80	2.19	4.96		39.6	63299
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
9.95	1.00	10.95		0.35	0.52	0.87	1.06	1.42		24.8	64102
8.45	1.25	9.70		0.25	0.52	0.77	0.93	1.09		21.1	64591
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
9.05	0.90	9.95				0.79	0.93	2.23		25.4	64561
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	
8.65	1.20	9.85				0.82	1.00	3.14		27.8	64103
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
11.50	0.50	12.00		0.37	0.59	0.96	1.17	1.07		26.4	64104
11.35	0.60	11.95				0.82	1.00	1.20		25.8	64562
10.85	2.10	12.95		0.25	0.53	0.78	0.95	1.06		25.0	64592
10.85	1.70	12.55		0.25	0.56	0.80	0.97	1.13		25.2	64593
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
9.95	1.50	11.45		0.62	1.20	1.82	2.21	2.17		33.0	64105
9.70	0.70	10.40		0.62	0.99	1.61	1.95	2.05		30.6	64106
8.45	1.75	10.20		0.76	0.89	1.65	2.00	2.25		30.0	64594
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
13.50	0.95	14.45		0.67	0.94	1.61	1.95	2.95		39.1	64107
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	
11.80	0.85	12.65		1.78	0.84	2.62	3.18	1.34		37.8	64108
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chem. Co., Inc.,	
64109	Bowker's High Grade Tobacco Grower	W. R. Strange & Co., Middlesboro ..
64110		John McCarley, Hopkinsville .....
64112	Bowker's Tobacco Grower	Mayhew & Gilbert, Franklin .....
63327	Bradley's Faultless Grain Grower	Manufacturer .....
63328	Bradley's Sure Crop	Manufacturer .....
63329	Bradley's Potato and Root Fertilizer	Manufacturer .....
63330	Bradley's Corn and Wheat Phosphate	Manufacturer .....
63331	Bradley's Grain and Grass Grower	Manufacturer .....
63332	Bradley's Complete Fertilizer	Manufacturer .....
63333	Bradley's Tobacco and Truck Grower	Manufacturer .....
63334	Bradley's High Grade Tobacco Grower	Manufacturer .....
63344	Cleveland Dryer Works Faultless Grain Grower	Manufacturer .....
63345	Cleveland Dryer Works Sure Crop	Manufacturer .....
63346	Cleveland Dryer Works Potato and Tobacco Fertilizer	Manufacturer .....
63347	Cleveland Dryer Works Phospho Bone	Manufacturer .....
64598	Cleveland Dryer Works Grain and Grass Grower	Grayson County Supply Co., Leitchfield
63349	Cleveland Dryer Works Complete Fertilizer	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.95	1.25	12.20		1.60	1.01	2.61	3.17	2.99		41.7	64109
10.40	0.85	11.25		1.36	1.07	2.43	2.95	3.22		40.2	64110
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	
8.90	0.80	9.70		0.67	1.08	1.75	2.12	5.89		41.8	64112
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
8.80	1.00	9.80		0.88		0.88	1.07	1.12		22.2	63327
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
9.10	0.75	9.85		0.88		0.88	1.07	2.13		25.6	63328
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	
9.35	0.85	10.20		0.89		0.89	1.08	3.44		30.0	63329
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
11.10	0.70	11.80		0.34	0.56	0.90	1.09	1.11		25.7	63330
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
9.05	1.25	10.30		0.34	1.44	1.78	2.16	1.96		30.6	63331
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
13.00	1.20	14.20		0.41	1.28	1.69	2.05	3.10		39.4	63332
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	
11.70	0.90	12.60		1.70	0.88	2.58	3.13	1.34		37.4	63333
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	
11.05	1.35	12.40		1.54	1.15	2.69	3.27	3.10		42.6	63334
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	
8.80	1.00	9.80		0.88		0.88	1.07	1.12		22.2	63344
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
9.10	0.75	9.85		0.88		0.88	1.07	2.13		25.6	63345
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	
9.35	0.85	10.20		0.89		0.89	1.08	3.44		30.0	63346
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
11.10	0.70	11.80		0.34	0.56	0.90	1.09	1.11		25.7	63347
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
8.00	1.70	9.70		0.74	0.66	1.40	1.70	2.15		27.5	64598
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
13.00	1.20	14.20		0.41	1.28	1.69	2.05	3.10		39.4	63349
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chem. Co., Inc.,	
63350	Cleveland Dryer Works Tobacco and Truck Grower	Manufacturer
63351	Cleveland Dryer Works H. Gr. Tobacco Grower	Manufacturer
64123	Red Line Complete Manure	L. B. Sievers & Son, Somerset
64124		Albert Long, Scottsville
64601		Woodson Lewis, Greensburg
64602		Scaggs & Nunn, Horse Cave
64125	Michigan Carbon Works Sure Crop	L. B. Sievers & Son, Somerset
64776		Denton Hardware Co., Madisonville
64126	Homestead A-1 Potash Fertilizer	Staggs Bros. & Co., Vanceburg
64603		Scaggs & Nunn, Horse Cave
64604	Michigan Carbon Works Corn and Wheat Phosphate	Coleman Sharp, Liberty
64127	Homestead A Bone Black Fertilizer	L. B. Sievers & Son, Somerset
64128		E. M. Haynes, Franklin
64605		Lebanon Carriage & Impl. Co., Lebanon
64606		Frank Baker, Clarkson
64777	Michigan Carbon Works Complete Fertilizer	J. B. Polk, Taylorsville
64129	Homestead Tobacco and Truck Grower	The Jansen Hardware Co., Covington.
64130		Lebanon Carriage & Impl. Co., Lebanon
64131	Homestead Tobacco Grower	Scaggs & Nunn, Horse Cave
64132		Moss & Gibson, Crestwood
64607		Woodson Lewis, Greensburg
64778		Greenup Milling Co., Grayson

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
11.70	0.90	**12.60**		1.70	0.88	2.58	3.13	1.34		37.4	63350
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	
11.05	1.35	12.40		1.54	1.15	2.69	3.27	3.10		42.6	63351
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	
9.90	0.60	10.50				0.86	1.04	1.17		23.8	64123
8.95	0.75	**9.70**		0.29	0.52	0.81	0.98	0.68	0.54	22.3	64124
9.20	1.65	10.85				0.84	1.02	1.09		22.9	64601
9.00	1.35	10.35		0.51	0.44	0.95	1.15	1.30		23.6	64602
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
8.65	0.65	**9.30**		0.28	0.54	0.82	1.00	2.10		24.5	64125
10.30	1.50	11.80		0.45	0.77	1.22	1.48	2.36		30.5	64776
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	
9.10	0.50	**9.60**		0.35	0.49	0.84	1.02	3.41		29.1	64126
9.20	1.25	10.45		0.35	0.44	0.79	0.96	2.94		28.0	64603
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
10.95	2.05	13.00		0.31	0.52	0.83	1.01	1.07		25.4	64604
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
10.00	0.75	10.75		1.32	1.00	2.32	2.82	1.76		34.5	64127
9.45	0.60	10.05		0.74	1.34	2.08	2.53	1.92		32.7	64128
8.25	1.25	**9.50**		1.33	0.56	1.89	2.29	2.32		31.2	64605
8.75	1.50	10.25		1.57	0.43	2.00	2.43	1.48		30.2	64606
8.00	*4.00*	*12.00*				*2.06*	*2.50*	*1.50*		*30.5*	
14.00	1.20	15.20		0.77	0.97	1.74	2.11	3.07		41.1	64777
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	
11.65	0.75	12.40		1.68	0.73	2.41	2.93	1.14		35.7	64129
11.80	0.90	12.70		1.95	0.81	2.76	3.35	1.22		38.3	64130
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	
11.50	1.05	12.55		1.66	0.96	2.62	3.18	2.75		41.6	64131
11.85	1.00	12.85		0.48	2.20	2.68	3.25	3.26		44.0	64132
10.45	1.30	**11.75**		1.68	0.61	2.29	2.78	2.63		37.8	64607
12.30	1.00	13.30		1.84	0.70	2.54	3.08	3.00		43.1	64773
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chem. Co., Inc.,	
64134	Homestead Potato and Tobacco Special	Staggs Bros. & Co., Vanceburg .....
64135		C. P. Clark, Owensboro .....
64608		Frank Baker, Clarkson .....
64779		Greenup Milling Co., Grayson .....
64140	N. W. Horseshoe Brand Dark Tobacco Grower	Woodson Lewis, Greensburg .....
63381	N. W. Horseshoe Brand Sure Crop	Manufacturer .....
63382	N. W. Horseshoe Br. Potash Manure	Manufacturer .....
64141	N. W. Horseshoe Brand Corn and Wheat Phosphate	Sam Terry, Big Clifty .....
64142		O. A. Bins, Eubank .....
64613		E. S. Ferrell & Sons, Buffalo .....
64143	N. W. Horseshoe Brand Challenge Corn Grower	Sam Terry, Big Clifty .....
64144		O. A. Bins, Eubank .....
64145	N. W. Horseshoe Brand Complete Fertilizer	Woodson Lewis, Greensburg .....
64146	N. W. Horseshoe Brand Tobacco and Truck Grower	Geo. W. Hill Co., Covington .....
64147	N. W. Horseshoe Brand H. Gr. Tobacco Grower	F. M. Mitchell, Scottsville .....
64148		Wainright Lae, Brooksville .....
63389	N. W. Horseshoe Br. Tobacco Grower	Manufacturer .....
63399	Packers Boar's Head Br. Faultless Grain Grower	Manufacturer .....
63400	Packers Boar's Head Br. Sure Crop	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.65	1.65	10.30		0.59	1.03	1.62	1.97	5.45		39.7	64134
8.05	1.80	**9.85**		0.24	1.37	1.61	1.95	5.60		39.3	64135
8.75	1.00	**9.75**		0.95	0.71	1.66	2.02	5.34		39.5	64608
9.10	1.50	10.60		0.74	0.93	1.67	2.03	5.62		41.1	64779
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
9.45	1.05	10.50		0.34	0.48	0.82	1.00	1.06		22.7	64140
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
9.10	0.75	**9.85**		0.88		0.88	1.07	2.13		25.6	63381
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	
9.35	0.85	10.20		0.89		0.89	1.08	3.44		30.0	63382
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
11.65	0.85	12.50		0.38	0.45	0.83	1.01	1.08		26.0	64141
11.30	0.90	12.20		0.31	0.51	0.82	1.00	1.14		25.7	64142
10.85	1.65	12.50		0.20	0.63	0.83	1.01	1.17		25.4	64613
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
8.75	1.90	10.65		0.60	1.01	1.61	1.95	2.59		31.2	64143
10.15	1.45	11.60		0.31	1.22	1.53	1.86	2.04		31.1	64144
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
13.00	0.85	**13.85**		1.12	0.62	1.74	2.11	3.79		41.7	64145
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	
11.20	1.25	12.45		1.35	1.04	2.39	2.90	1.49		36 1	64146
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	
9.70	1.25	**10.95**		0.95	0.77	**1.72**	2.09	5.29		41 2	64147
9.30	1.50	**10.80**		1.06	0.76	**1.82**	2.21	4.71		39.6	64148
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	
8.90	1.40	10.30		0.34	1.46	1.80	2.19	4.96		39.6	63389
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
8.80	1.00	**9.80**		0.88		0.88	1.07	1.12		22.2	63399
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
9.10	0.75	**9.85**		0.88		0.88	1 07	2.13		25.6	63400
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*2.00*		*24.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agr'l Chem. Co., Inc.,	
63401	Packers Boar's Head Br. Sure Growth Potash Manure	Manufacturer
63402	Packers Boar's Br. Corn and Wheat Phosphate	Manufacturer
63403	Packers Boar's Head Br. Corn and Wheat Grower	Manufacturer
63404	Packers Boar's Head Br. Complete Fertilizer	Manufacturer
63405	Packers Boar's Head Br. Tobacco and Truck Grower	Manufacturer
63406	Packers Boar's Head Br. High Grade Tobacco Grower	Manufacturer
63408	Packers Boar's Head Br. High Grade Vegetable Fertilizer	Manufacturer
	Armour Fertilizer Works, Louisville, Ky., Cincinnati, Ohio, and Nashville, Tennessee	
64150	Armour's Standard	R. L. Jones, Epworth
64151		Thurman & Enlow, Hodgenville
64614		Thurman & Enlow, Hodgenville
64615		G. W. Collins, Glens Fork
64563	Armour's Champion	R. M. Stark, Sulphur
64616		S. D. Harlin, Gamaliel
64152	Armour's Record Brand	W. O. Cropper, Burtonville
64617		S. D. Harlin, Gamaliel

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.35	0.85	10.20		0.89		0.89	1.08	3.44		30.0	63401
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
11.10	0.70	11.80		0.34	0.56	0.90	1.09	1.11		25.7	63402
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*1.00*		*24.5*	
9.05	1.25	10.30		0.34	1.44	1.78	2.16	1.96		30.6	63403
8.00	4.00	12.00				*1.65*	*2.00*	*2.00*		*29.5*	
13.00	1.20	14.20		0.41	1 28	1.69	2.95	3.10		39.4	63404
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*3.00*		*38.5*	
11.70	0.90	12.60		1.70	0.88	2.58	3.13	1.34		37.4	63405
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*1.00*		*34.4*	
11.05	1.35	12.40		1.54	1.15	2.69	3.27	3.10		42.6	63406
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*3.00*		*40.4*	
8.90	1.40	10.30		0.34	1.46	1.80	2.19	4.96		39.6	63408
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
8.55	2.60	11.15		0.37	0.43	0.80	0.97	1.12		22.0	64150
7.75	0.50	8.25				0.97	1.18	1.20		21.3	64151
9.55	0.65	10.20		0.46	0.32	0.78	0.95	1.20		22 9	64614
9.05	3.20	12.25		0.21	0.22	0.43	0.52	1.52		22.0	64615
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
8.20	1.30	9.50		0.44	0.47	0.91	1.10	3.96		30.2	64563
8.50	0.50	9.00		0.38	0.64	1.02	1.24	4.23		31.8	64616
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
10.75	0.50	11.25		0.37	0.54	0.91	1.10	1.36		25.9	64152
10.40	0.70	11.10		0.22	0.88	1.10	1.34	1.38		26.6	64617
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Armour Fertilizer Works.	
64153	Armour's Wheat, Corn, and Oats	W. O. Cropper, Burtonville
64154		R. Willis, Brownsville
64618		Frank Henry, Center
64619		Taylor County Supply Co., Campbellsville
63499	Armour's Kentucky Colonel	Manufacturer
64156	Armour's Grain Grower	Thurman & Enlow, Hodgenville
64780		D. M. Brakefield, Adairville
64157	Armour's Big Crop Beef, Blood, and Bone	Sam Hughes & R. H. Lile, Leitchfield
		Ed. Allen & Co., Smith's Grove
64158		Thurman & Enlow, Hodgenville
64621		Merrifield & Humphrey, Bloomfield
64781		
64159	Armour's Big Crop H. Gr. Potato Grower	Chas. D. Tyler, Jeffersontown
64564	Armour's Big Crop Truck Grower	C. S. Brent Seed Co., Lexington
64160	Armour's Big Crop Favorite	Cadiz Hardware Co., Cadiz
64163	Armour's Big Crop Tobacco Maker	Ed. Allen & Co., Smith's Grove
64164		W. O. Cropper, Burtonville
64622		Ransom Hatter, King's Mountain
64165	Armour's Big Crop Tobacco and Potato Grower	J. J. Stewart, Brownsville
64623		Ranson Hatter, King's Mountain

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
12.50	1.10	13.60	0.37	0.53		0.90	1.09	1.49		29.1	64153
11.90	3.70	15.60		0.46	0.44	0.90	1.09	1.54		29.4	64154
13.80	2.00	15.80		0.20	0.33	0.53	0.64	0.61		26.5	64618
13.00	0.50	13.50				0.78	0.95	1.45		28.7	64619
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
10.25	3.05	13.30				0.90	1.09	2.23		28.7	63499
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*26.3*	
9.50	0.40	9.90	1.23		0.36	1.59	1.93	2.61		31.8	64156
8.90	2.40	11.30		0.67	0.80	1.47	1.78	2.04		29.3	64780
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
11.55	0.65	12.20	0.62	0.45	0.45	1.52	1.85	2.44		34.0	64157
12.20	1.10	13.30	1.06		0.29	1.35	1.64	2.08		33.0	64158
11.90	1.60	13.50		0.63	0.71	1.34	1.63	1.74		31.9	64621
11.90	2.00	13.90		0.53	0.80	1.33	1.61	2.23		33.3	64781
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
10.50	0.65	11.15		0.93	0.75	1.68	2.04	4.35		39.1	64159
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
9.70	0.25	9.95	0.56	0.90	1.15	2.61	3.17	1.64	0.89	37.9	64564
8.00	*1.00*	*9.00*				*3.29*	*4.00*	*3.00*		*41.1*	
9.75	2.90	12.65		0.88	0.78	1.66	2.02	5.28		41.6	64160
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*6.00*		*46.3*	
6.35	3.00	9.35	0.47		0.35	0.82	1.00	1.32	0.73	21.8	64163
8.45	0.75	9.20	1.30		0.38	1.68	2.04	1.94	2.05	35.0	64164
8.40	2.50	10.90		0.74	0.76	1.50	1.82	3.95		34.5	64622
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
9.80	5.50	15.30		0.87	0.97	1.84	2.23	2.29		34.8	64165
10.25	2.50	12.75		0.69	0 98	1.67	2.03	1.01		29.4	64623
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*31.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Armour Fertilizer Works.	
64166	Armour's Big Crop Burley Tobacco Grower	Barren C. Grocery & Hdw. Co., Glasgow
64167		Cantrell & Penick, Greensburg
64624		Ransom Hatter, King's Mountain
64168	Armour's Tobacco Guano	W. O. Cropper, Burtonville
64169	Armour's Special Tobacco Grower	J. W. Schoolcraft, Somerset
64170		Bradshaw, Hagan & Co., Tompkinsville
63516	Armour's Plant Bed Special	Manufacturer
64180	Armour's Big Crop Double Standard	Ed. Allen & Co., Smith's Grove
64565		R. M. Stark, Sulphur
64629		G. M. Hedrick, Monticello
64566	Armour's Big Crop 2-6-6 Fertilizer	R. M. Starke, Sulphur
63527	Ideal H. Gr. Blood and Bone	Manufacturer
63529	Ideal Tobacco Grower	
63530	Ideal Grain Grower	Manufacturer
63532	Ideal Special Tobacco Guano	Manufacturer
64182	Ideal H. Gr. Tobacco Grower	T. J. Turley Co., Owensboro
64183	Big Giant	Sam Hughes & R. H. Lile, Clarkson
64542	Armour's Big Crop Wheat Special	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.50	2.90	12.40				1.54	1.87	1.51	1.69	34.3	64166
8.65	1.90	10.55	1.20	0.53	0.45	2.18	2.65	3.28	1.96	42.5	64167
8.05	1.75	9.80		1.36	1.05	2.41	2.93	5.83		44.7	64624
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	
8.90	0.65	9.55	0.96		0.64	1.60	1.94	1.36		27.3	64168
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*1.00*	*25.3*	
9.05	3.00	12.05		0.38	0.58	0.96	1.17	0.99		23.5	64169
8.45	3.55	12.00		0.49	0.56	1.05	1.27	0.99		23.4	64170
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
12.25	1.35	13 60				2.77	3.36	1.62	0.53	42.0	63516
12.00	*1.00*	*13.00*				*2.47*	*3.00*		*2.00*	*39.2*	
16.70	0.90	17.60	0.93	0.61		1.54	1.87	2.87		43.3	64180
16.65	1.65	18.30		1.14	0.67	1.81	2.20	2.35		43.6	64565
16.45	1.20	17.65	0.26	1.00	0.28	1.54	1.87	1.94		40.2	64629
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
7.45	1.05	8.50		1.19	0.43	1.62	1.97	4.96		36.2	64566
6.00	*1.00*	*7.00*				*1.65*	*2.00*	*6.00*		*37.3*	
10.05	2.95	13.00		1.72	0.75	2.47	3.00	1.55		35.7	63527
10.00	*1.00*	*11.00*				*2.47*	*3.00*	*1.00*		*33.2*	
											63529
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*1.00*	*28.3*	
7.75	4.10	11.85		0.53	0.96	1.49	1.81	1.30		26.1	63530
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
10.10	2.60	12.70		1.26	0.62	1 88	2.28	1.58	0.71	34.4	63532
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*2.00*	*31.3*	
10.45	0.90	11.35		0.94	0.58	1.52	1.85	8.38	1.12	53.7	64182
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*10.00*	*55.3*	
11.25	1.00	12.25				1.91	2.32	3.40	8.87	65.6	64183
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*15.00*	*70.3*	
10.65	1.25	11.90		1.29	0.56	1.85	2.25	4.30		40.5	64542
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Armour Fertilizer Works	
64551	Ideal Wheat Grower	Manufacturer
	C. S. Brent Seed Co., Inc., Lexington, Ky.	
64567	Brent's Tobacco Special	Manufacturer's Warehouse
64568	Brent's Grain Grower	Manufacturer's Warehouse
	Buhner Fertilizer Co., Seymour, Ind.	
64516	Buhner's 1½-10-3	Manufacturer
64518	Buhner's 3-8-5	Manufacturer
	Calumet Fertilizer Co., New Albany, Ind.	
63756	Calumet Brand H. Gr. Tobacco and Truck Grower	
64631	Calumet Br. Otto Voyles' Two in One	Vine Grove Feed Co., Vine Grove
64632		I. K. Miller & Sons, Campbellsville
64184	Calumet Br. Corn and Wheat Special	Frank Baker, Clarkson
64185	Calumet Br. Potato and Tobacco Special	Pearson & Breedlove, Franklin
64570		Lexington Seed Co., Lexington
63760	Calumet Br. Two Eight Two	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.55	2.65	11.20		1.01	0.75	1.76	2.14	0.94		27.3	64551
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*1.00*		*25.3*	
9.15	0.65	9.80	0.43		0.57	1.00	1.21	1.24	1.73	28.9	64567
8.00						*1.65*	*2.00*		*3.00*	*30.9*	
9.45	0.50	9.95		0.25	0.58	0.83	1.01	1.22		23.0	64568
8.00						*0.82*	*1.00*	*1.00*		*19.9*	
11.15	3.40	14.55	0.63		1.26	1.89	2.29	2.83		37.9	64516
10.00						*1.23*	*1.50*	*3.00*		*31.4*	
11.35	1.85	13.20	0.84		1.52	2.36	2.87	5.51		48.5	64518
8.00						*2.47*	*3.00*	*5.00*		*41.8*	
											63756
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*4.00*		*43.4*	
17.30	3.40	20.70				1.68	2.04	1.86		43.0	64631
15.60	3.80	19.40				1.76	2.14	1.92		41.2	64632
16.00	*4.00*	*20.00*				*1.65*	*2.00*	*2.00*		*41.5*	
14.25	0.75	15.00		0.83	0.76	1.59	1.93	2.22		37.9	64184
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*2.00*		*35.5*	
9.95	1.10	11.05		0.93	0.85	1.78	2.16	2.80	2.09	40.7	64185
8.55	0.90	9.45	0.28	0.81	0.53	1.62	1.97	4.39		36.0	64570
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*5.00*		*38.5*	
											63760
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Calumet Fertilizer Co.	
64186	Calumet Br. Tobacco Manure	Sturgis Impl. & Hdw. Co., Sturgis ..
64187		Pearson & Breedlove, Franklin .....
64571	Calumet Br. Ky. Crop Grower	Lexington Seed Co., Lexington .....
64188	Calumet Br. Half Thirteen One	G. M. Hedrick, Monticello .....
64189	Calumet Br. Bone Phosphate and Potash Mixture	Frank Baker, Clarkson .....
64633		A. W. Tarter, Columbia .....
64634	Calumet Br. Half and Half	Vine Grove Feed Co., Vine Grove ...
	The Cincinnati Phosphate Co., (owned and operated by Armour Fertilizer Works,) Cincinnati O.	
63601	High Grade Manure	Manufacturer .....
63602	Grain and Grass Grower	Manufacturer .....
63603	Crop Booster	Manufacturer .....
63604	Tobacco and Potato Grower	Manufacturer .....
63605	Favorite Grain Grower	Manufacturer .....
63606	Conservation Brand	Manufacturer .....
63607	Sure Crop	Manufacturer .....
64195	Grain Grower	G. W. Collins, Glensfork .....
64637		L. R. Hart, Big Clifty .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.95	0.50	**9.45**		0.21	0.61	0.82	1.00	3.16		28.0	64186
9.55	0.95	10.50		0.42	0.49	0.91	1.10	1.40	1.92	30.1	64187
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*3.00*		*27.5*	
8.40	0.90	**9.30**	0.57		0.37	0.94	1.14	0.96	0.41	22.7	64571
8.00	*4.00*	*12.00*				*0.82*	*1.00*	*1.00*		*21.5*	
15.55	1.00	16.55				0.49	0.59	0.84	0.48	30.6	64188
13.00	*2.50*	*15.50*				*0.41*	*0.50*	*1.00*		*26.0*	
11.60	0.55	12.15		0.20	0.24	0.44	0.53	0.56	0.66	23.9	64189
10.50	1.30	**11.80**				0.41	0.50	0.74		**21.0**	64633
10.00	*4.00*	*14.00*				*0.41*	*0.50*	*1.00*		*22.1*	
10.50	2.00	12.50				2.16	2.62	1.60		34.3	64634
6.00	*6.00*	*12.00*				*2.06*	*2.50*	*1.00*		*26.8*	
13.10	1.30	14.40		0.21	0.79	1.00	1.21	1.13		29.6	63601
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
10.30	3.15	13.45		0.38	0.60	0.98	1.19	2.36		29.7	63602
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*26.3*	
9.95	3.15	13.10		0.25	0.63	0.88	1.07	1.36		25.5	63603
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
8.35	1.15	9.50		0.45	0.50	0.95	1.15	4.45		32.0	63604
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
7.60	1.80	9.40		0.37	0.61	0.98	1.19	1.78		23.3	63605
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
13.00	0.90	13.90		1.33	0.61	1.94	2.36	2.13		37.9	63606
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
10.70	1.40	12.10		1.24	0.62	1.86	2.26	4.41		41.0	63607
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
9.00	3.35	12.35		0.87	0.66	1.53	1.86	2.36		31.1	64195
8.70	0.80	9.50		1.04	0.57	1.61	1.95	1.97		28.9	64637
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Cincinnati Phosphate Co.	
64197	Big Tobacco Maker	G. E. Nell, Gradyville
64198	Burley Tobacco Grower	G. E. Nell, Gradyville
63619	Special Tobacco Grower	Manufacturer
64199	Double Standard	G. W. Collins, Glensfork
63621	Capitol 2-16-2 Fertilizer	Manufacturer
	Consolidated Chem. Co., Louisville, Ky.	
64200	Camel Brand Corn and Wheat Special	J. E. Marsh, Cooper
64201		Will Garner, Burnside
63970	Camel Brand Grain Grower	Manufacturer
63971	Camel Brand Grain and Grass Grower	Manufacturer
63972	Camel Brand Universal Crop Fertilizer	Manufacturer
63973	Camel Brand Vegetable, Potato, and Tobacco Special	Manufacturer
64787	Camel Brand Blue Grass Tobacco Grower	J. F. Collings, Shepherdsville
64202	Camel Brand High Grade Special	Will Garner, Stop
64572		D. A. Davis & Son, Jeffersontown
64788		J. D. Campbell, Monticello

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.90	1.05	9.95	1.18		0.54	1.72	2.09	2.30	2.26	37.8	64197
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
9.50	1.65	11.15	1.02	0.70	0.59	2.31	2.80	3.30	2.52	46.2	64198
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	
8.55	3.20	11.75		0.44	0.47	0.91	1.10	0.85		22.1	63619
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
13.55	1.50	15.05	0.39	0.86	0.55	1.80	2.19	2.24		38.5	64199
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
16.40	2.25	18.65		0.76	0.98	1.74	2.11	2.11		42.3	63621
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
11.90	1.50	13.40	0.53		0.30	0.83	1.01		1.57	28.1	64200
12.50	6.60	19.10	0.56			0.56	0.68	1.01		27.8	64201
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
11.80	1.90	13.70				0.56	0.68		0.86	24.4	63970
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*0.50*	*22.1*	
10.10	1.50	11.60				0.52	0.63		1.22	22.5	63971
8.00	*4.00*	*12.00*				*0.41*	*0.50*		*1.00*	*19.1*	
13.30	1.70	15.00	0.65		0.43	1.08	1.31		1.42	31.4	63972
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
12.20	1.80	14.00	0.61		0.47	1.08	1.31	0.82	3.11	37.3	63973
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
9.00	0.70	9.70	0.90		0.42	1.32	1.60	4.36		34.8	64787
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*4.00*	*33.0*	
11.30	4.40	15.70	0.78		0.65	1.43	1.74	0.90	1.10	33.3	64202
10.15	1.35	11.50	1.25		0.44	1.69	2.05	2.49		33.4	64572
10.80	0.80	11.60		0.87	0.92	1.79	2.17	2.26		34.0	64788
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Consolidated Chemical Co.	
64203	Camel Brand Extra High Grade Tobacco Fertilizer	Will Garner, Stop
64204		Zula Milling Co., Zula
64205	Camel Brand Tobacco Fertilizer	Will Garner, Stop
64206		Hudson & Farnau, Lancaster
64207	Camel Brand Standard Grain Fertilizer	Zula Milling Co., Zula
64639		E. S. Ferrell & Sons, Buffalo
63979	Camel Brand Truck and Tobacco Fertilizer	Manufacturer
63980	Camel Brand Bright Tobacco Special	Manufacturer
63981	Camel Brand General Crop Fertilizer	Manufacturer
64208	Camel Brand One Ten One Fertilizer	Zula Milling Co., Zula
	Darling & Co., Chicago, Ill.	
64069	Darling's Farmers Favorite	
	Duncan & Sherley, LaGrange, Ky.	
64211	Tiger Brand Special Tobacco Grower	Manufacturer's warehouse
	The Empire Guano Co., Nashville, Tenn.	
63267	Wheat, Oat, and Corn Grower	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN					POTASH			
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total	Equivalent to Ammonia	From Muriate	From Sulfate	Index of Relative Value	Station Number
11.40	2.95	14.35	0.84		0.80	1.64	1.99	2.68	1.43	40.5	64203
11.55	2.40	13.95	1.30		0.58	1.88	2.28	0.88	2.83	40.7	64204
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*38.5*	
9.10	7.70	16.80	0.66		1.01	1.67	2.03	2.00		32.8	64205
10.15	1.60	11.75	0.61	0.62	0.56	1.79	2.17	2.26		33.4	64206
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
9.60	1.75	11.35	1.29		0.45	1.74	2.11	0.62	1.44	31.7	64207
9.15	0.65	9.80	1.18		0.58	1.76	2.14	2.16		31.0	64639
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
10.30	2.40	12.70	2.14		0.78	2.92	3.54	1.02	2.94	45.8	63979
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*3.00*	*37.4*	
11.90	1.60	13.50	1.38		0.79	2.17	2.63	0.46	0.99	35.9	63980
9.00	*4.00*	*13.00*				*1.65*	*2.00*		*1.00*	*28.0*	
11.80	1.40	13.20	0.67		0.51	1.18	1.43	0.78	1.86	33.3	63981
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
11.80	1.95	13.75	0.60		0.58	1.18	1.43		1.31	29.5	64208
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*1.00*	*24.5*	
											64609
8.00	*2.00*	*10.00*				*2.47*	*3.00*	*4.00*		*39.6*	
12.35	2 65	15.00		0.37	1.03	1.40	1.70	3.88		39.6	64211
10.00	*2.00*	*12.00*				*1.65*	*2.00*		*4.00*	*37.7*	
9.65	6.30	15.95				1.45	1.76	1.55		30.4	63267
7.00	*10.00*	*17.00*				*0.82*	*1.00*	*1.00*		*22.4*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	COMPL... PHOSPH... Available
	The Empire Guano Co.		
63268	Climax Tobacco Grower	Manufacturer	10.00 *8.00*
64212	Blood, Bone, and Potash	Young Hardware Co., Hopkinsville	9.10 *8.00*
64792	Kentucky Premium Guano	Calloway County Farm Bureau, Murray	10.10 *8.00*
64213	High Grade Tobacco Grower	Young Hardware Co., Hopkinsville	9.15
64654		F. B. Lacy, Hopkinsville	10.50 *8.00*
63272	Red Banner Special	Manufacturer	11.75 *10.00*
64641	Wheat and Corn Grower	G. W. Collins, Glensfork	14.45 *11.00*
63275	Clover and Wheat Special	Manufacturer	14.35 *12.00*
	The Evansville Packing Co., Evansville, Ind.		
63448	Grain Booster	Manufacturer	14.80 *8.00*
63451	Harvest King	Manufacturer	13.25 *8.00*
63452	Golden Harvest	Manufacturer	12.75 *8.00*
64219	Farmers Pride	M. F. Hopson & Son, Cerulean	12.90 *12.00*
64220	Three "B"	Atherton-Kidd Co., Livermore	7.90 9.70
64221		C. B. Carden & Co., Hartford	8.90
64222	Half and Half Mixture	Atherton-Kidd Co., Livermore	8.90 *10.00*
63457	Corn and Wheat Special	Manufacturer	14.60 *12.00*

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN					POTASH			
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total	Equivalent to Ammonia	From Muriate	From Sulfate	Index of Relative Value	Station Number
10.00	7.60	17.60				1.58	1.92	0.60	0.34	30.3	63268
8.00	*5.00*	*13.00*				*0.82*	*1.00*		*1.00*	*21.9*	
9.10	2.10	11.20	0.60		0.94	1.54	1.87	2.95		32.5	64212
8.00	*5.00*	*13.00*				*1.65*	*2.00*	*2.00*		*29.9*	
10.10	6.10	16.20	0.20		0.34	0.54	0.66	2.84	1.04	32.5	64792
8.00	*5.00*	*13.00*				*0.41*	*0.50*	*4.00*		*28.5*	
9.15	2.50	11.65	0.32		1.41	1.73	2.10	2.18	2.37	38.8	64213
10.50	4.20	14.70				1.83	2.22	5.07		43.6	64654
8.00	*5.00*	*13.00*				*1.65*	*2.00*		*4.00*	*35.9*	
11.75	2.60	14.35				2.14	2.60	2.87		40.1	63272
10.00	*5.00*	*15.00*				*1.65*	*2.00*	*2.00*		*32.9*	
14.45	1.60	16.05	0.53			0.53	0.64	1.16	0.82	31.4	64641
11.00	*5.00*	*16.00*				*0.41*	*0.50*	*1.00*		*24.0*	
14.35	1.40	15.75				1.44	1.75	2.37		37.8	63275
12.00	*3.00*	*15.00*				*0.82*	*1.00*	*2.00*		*30.1*	
14.80	0.10	14.90		1.54	0.47	2.01	2.44	1.90		40.0	63448
8.00						*0.82*	*1.00*	*1.00*		*19.9*	
13.25	0.15	13.40		1.59	0.54	2.13	2.59	3.03		41.8	63451
8.00						*1.00*	*1.21*	*2.00*		*24.0*	
12.75	0.15	12.90		1.14	0.43	1.57	1.91	3.26	0.98	41.3	63452
8.00						*0.82*	*1.00*	*3.00*		*25.9*	
12.90	0.95	13.85		0.51	0.51	1.02	1.24	0.97		28.8	64219
12.00						*0.82*	*1.00*	*1.00*		*25.9*	
7.90	0.80	8.70		0.80	0.49	1.29	1.57	2.32		26.9	64220
9.70	1.30	11.00		0.87	0.79	1.66	2.02	2.05		31.2	64221
8.00						*1.65*	*2.00*	*2.00*		*27.9*	
8.90	1.10	10.00		1.54	0.76	2.30	2.79	1.47		32.0	64222
10.00						*2.47*	*3.00*	*1.00*		*32.8*	
14.60	0.30	14.90		0.95	0.32	1.27	1.54	2.24	0.57	38.1	63457
12.00						*0.82*	*1.00*	*3.00*		*31.9*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Evansville Packing Co.	
64223	Potato and Tobacco Grower	C. B. Carden & Co., Hartford
64644		Eldred Hardware Co., Princeton
63459	Farmers' Special	Manufacturer
64224	Tobacco Special	M. F. Hopson & Son, Cerulean
64033		Leander Wiggins, S. Carrollton
	Federal Chem. Co., Inc., Louisville, Ky.	
63665	Daybreak A-1 Champion	Manufacturer
64226	Daybreak Wheat and Corn Special	Burks & Anderson, Monticello
64227		J. N. Sanderson, Mayfield
64645		A. W. Tarter, Columbia
63667	Daybreak Cracker-Jack	Manufacturer
63668	Daybreak Special	Manufacturer
64228	Royal Wheat and Grain Special	Lake Brothers, Springfield
63670	Daybreak Special Manure	Manufacturer
64229	Daybreak Tobacco Manure	R. R. Lambert, Sulphur Well
64646	Daybreak Favorite	W. L. Anderson, Caneyville
64230	Standard Crop and Tobacco Grower	A. W. Tarter, Columbia
64231		Birk & Price, Owensboro

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.70	1.20	10.90		1.03	0.57	1.60	1.94	5.91		42.4	64223
8.35	0.50	8.85		0.95	0.76	1.71	2.08	4.79		37.4	64644
8.00						*1.65*	*2.00*	*5.00*		*36.9*	
13.70	0.30	14.00		1.90	0.45	2.35	2.85	2.14		41.2	63459
12.00						*1.65*	*2.00*	*2.00*		*33.9*	
											63460
10.30	1.20	11.50		2.13	1.22	3.35	4.07	4.07		48.2	64224
10.20	0.80	11.00				3.64	4.42	3.38	0.96	50.5	64033
10.00						*3.29*	*4.00*	*4.00*		*46.7*	
15.20	4.70	19.90		0.70		0.70	0.85	0.60	0.42	31.9	63665
11.50	*4.00*	*15.50*				*0.41*	*0.50*		*0.50*	*22.8*	
12.15	1.05	13.20				0.52	0.63	0.97		24.7	64226
11.35	1.65	13.00	0.39		0.22	0.61	0.74	2.33		28.3	64227
11.75	2.15	13.90				0.41	0.50	1.22		24.6	64645
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
15.80	3.10	18.90		0.78		0.78	0.95	0.50	0.92	33.9	63667
13.00	*4.00*	*17.00*				*0.41*	*0.50*		*1.00*	*26.6*	
13 35	4.10	17.45		0.75		0.75	0.91	0.68	5.11	43 5	63668
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*35.6*	
12.75	1.00	13.75	0.58		0.32	0.90	1.09	1.07		28.1	64228
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
12.45	6 50	18.95		1.31		1.31	1.59	0.82	1.81	37.0	63670
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
10.25	1.00	11.25	0.38	0.39	0.30	1.07	1.30	1.58	0.42	28.2	64229
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.25	1.90	14.15				0.66	0.80	2.97		32.0	64646
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
10.05	3.25	13.30	0.32	0.45	0.38	1.15	1.40	3.49		33.8	64230
8.70	3.00	11.70	0.56		0.25	0.81	0.98	3.12		28.5	64231
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*30.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co.	
64232	Daybreak Tobacco Grower	J. R. Sower Hdw. Co., Frankfort ...
64233		Luther Chinn, Beaver Dam .....
63675	Daybreak Vegetable Gower	Manufacturer .....
64234	Daybreak Special Tobacco Grower	J. N. Sanderson, Mayfield .....
64238	Standard Grain Grower	J. S. Whitfill, Leitchfield .....
64239		Goodman Bros. Co., Shelbyville .....
64649		Grayson County Supply Co., Leitchfield
64240	Ammoniated Potash Ten	W. C. Stewart, Horse Cave .....
64241	Tobacco, Truck, and Tomato Fertilizer	Farmers' Union Supply Co., Bowling Green .....
64242		Barnett Bros., London .....
63695	Potato Maker and Tobacco Fertilizer	Manufacturer .....
64243	Standard Corn and Wheat Grower	C. A. Lamkin, Hodgenville .....
64244	Premium H. Gr. Fertilizer	Sam Carpenter & Co., Maysville .....
64245		Chiles-Thompson Grocery Co., Mt. Sterling .....
64246	Special Tobacco Maker	L. R. Hart, Big Clifty .....
64247		Lake Bros., Springfield .....
64249	Beef, Blood, and Bone	Grayson County Supply Co., Leitchfield .....
64650		Grayson County Supply Co., Leitchfield .....
64575	Loam Land Fertilizer	Terrell Bros., Bedford .....
64576	Mid-West High Grade Mixture	Terrell Bros., Bedford .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.80	1.10	**9.90**				1.65	2.00	2.07		29.8	64232
8.30	1.20	**9.50**	0.42	0.79	0.48	1.69	2.05	1.86		28.7	64233
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
10.40	7.10	17.50		2.18	0.29	2.47	3.00	2.78	2.94	50.4	63675
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*38.5*	
											63676
10.35	2.65	13.00	0.22		0.27	0.49	0.59	4.17		32.0	64234
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*6.00*	*39.0*	
10.10	1.55	**11.65**	0.29		0.35	0.64	0.78	1.17		23.1	64238
11.05	0.95	12.00	0.56		0.33	0.89	1.08	1.22		26.0	64239
10.15	1.75	**11.90**				0.92	1.12	1.42		25.7	64649
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*1.00*	*24.5*	
7.90	3.00	10.90	1.00			1.00	1.21	9.78		48.4	64240
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*10.00*	*48.5*	
9.70	2.50	12.20		0.52	0.91	1.43	1.74	1.17		27.6	64241
10.20	1.20	11.40	0.42	0.63	0.47	1.52	1.85	1.20		28.5	64242
9.00	*4.00*	*13.00*				*1.65*	*2.00*		*1.00*	*28.0*	
12.50	7.00	19.50		2.39		2.39	2.90	0.68	1.02	33.8	63695
9.00	*4.00*	*13.00*				*1.65*	*2.00*		*1.00*	*28.0*	
9.05	0.60	**9.65**	0.38	0.73	0.39	1.50	1.82	2.12		29.2	64243
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
10.40	1.40	**11.80**				1.67	2.03	1.92		31.9	64244
11.10	0.45	**11.55**	1.29		0.22	1.51	1.83	1.95		31.7	64245
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
9.85	1.45	**11.30**	0.51		1.29	1.80	2.19	1.80		31.6	64246
9.80	1.40	**11.20**		1.20	0.43	1.63	1.98	2.05		31.2	64247
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
8.45	1.85	**10.30**	0.29	0.62	0.37	**1.28**	1.55	2.04		**27.2**	64249
10.15	1.90	12.05	1.63			1.63	1.98	2.31		32.7	64650
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
11.75	0.90	**12.65**	0.45	0.37	0.39	**1.21**	1.47	2.13		**31.6**	64575
12.00	*4.00*	*16.00*				*1.65*	*2.00*		*2.00*	*35.5*	
10.35	0.65	**11.00**	0.42	0.76	0.34	1.52	1.85	3.97		**36.8**	64576
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*38.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co.	
64254	Special Tobacco and Potato Grower	Bedford & Tuttle, Winchester .....
64255	High Grade Tobacco Grower	Sam Carpenter & Co., Maysville .....
64256		Grayson County Supply Co., Leitchfield .....
64796		Lancaster-Smith Seed Co., Owensboro
63994	2-8-3 Formula	Manufacturer .....
63995	A-1 High Grade Tobacco Grower	Manufacturer .....
64257	3-10-3 Formula	Chiles-Thompson Grocery Co., Mt. Sterling .....
64258	2-10-10 Formula	Guenther Hardware Co., Owensboro ..
63722	1st Prize Corn and Wheat Champion	Manufacturer .....
63723	1st Prize Corn, Wheat, and Oats Gr.	Manufacturer .....
63724	1st Prize Grain Maker	Manufacturer .....
63725	1st Prize Special	Manufacturer .....
63726	1st Prize Wheat and Grain Special	Manufacturer .....
63727	Blue Ribbon Corn and Wheat Grower	Manufacturer .....
63728	Blue Ribbon Tobacco Grower	Manufacturer .....
63729	1st Prize Formula	Manufacturer .....
64259	1st Prize Crop and Tobacco Grower	J. H. Dodson, Maysville .....
64260		Farmers' Union Supply Co., Russellville .....
63731	1st Prize Tobacco and Veg. Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
7.00	2.90	9.90	0.37	1.36	0.47	2.20	2.67	5.97		43.2	64254
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*6.00*	*46.4*	
7.00	1.20	8.20		0.83	2.19	3.02	3.67	4.36		42.2	64255
7.90	1.20	9.10	0.42	1.53	0.56	2.51	3.05	3.81		38.8	64256
5.60	2.20	8.10	1.57		1.70	3.27	3.97	3.99		40.9	64796
8.60	*4.00*	*12.00*				*3.29*	*4.00*		*4.00*	*45.3*	
11.10	7.70	18.80		2.65		2.65	3.22	1.60	2.08	46.8	63994
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*3.00*	*32.5*	
11.30	5.75	17.05		3.85		3.85	4.67	1.82	2.16	54.3	63995
8.00	*4.00*	*12.00*				*3.29*	*4.00*		*3.00*	*42.3*	
11.55	0.45	12.00	1.55		0.30	1.85	2.25	2.70		36.7	64257
10.00	*4.00*	*14.00*				*2.47*	*3.00*		*3.00*	*40.4*	
10.10	2.50	12.60	1.03	0.24	0.23	1.50	1.82	9.03		52.2	64258
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*10.00*	*56.5*	
15.20	4.70	19.90		0.70		0.70	0.85	0.60	0.42	31.9	63722
11.50	*4.00*	*15.50*				*0.41*	*0.50*		*0.50*	*22.8*	
15.05	6.00	21.05		0.57		0.57	0.69	0.44	0.97	32.6	63723
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
15.80	3.10	18.90		0.78		0.78	0.95	0.50	0.92	33.9	63724
13.00	*4.00*	*17.00*				*0.41*	*0.50*		*1.00*	*26.6*	
13.35	4.10	17.45		0.75		0.75	0.91	0.68	5.11	43.5	63725
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*35.6*	
15.10	4.10	19.20		1.25		1.25	1.52	0.46	1.23	36.9	63726
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
12.45	6.50	18.95		1.31		1.31	1.59	0.82	1.81	37.0	63727
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.45	6.50	18.95		1.31		1.31	1.59	0.82	1.81	37.0	63728
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
13.50	4.70	18.20		1.25		1.25	1.52	0.98	2.55	40.2	63729
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
8.05	1.50	9.55		0.84		0.84	1.02	3.98		29.7	64259
10.45	3.10	13.55	0.52		0.30	0.82	1.00	2.30		28.7	64260
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*30.5*	
10.55	7.25	17.80		1.64	0.47	2.11	2.56	1.98	5.21	53.0	63731
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*6.00*	*39.0*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co.	
63968	4-4-1 Goods (For Lawns and Gardens)	Manufacturer
	Fox Chemical Co., Br. Federal Chem. Co., Inc., Louisville, Ky.	
64262	Fox Ideal Fertilizer	J. S. Whitfill, Big Clifty
64263		A. R. Blakely, Esto
64659		Lancaster-Smith Seed Co., Owensboro
63774	Fox Blood Bone Phosphate and Potash	Manufacturer
63775	Red Fox Grain and Grass Grower	Manufacturer
64264	Fox Soil Builder	Lancaster-Smith Seed Co., Owensboro
63777	Fox High Grade Special	Manufacturer
64265	Fox Wheat and Grain Special	T. Z. Leachman, Greensburg
64266	Fox Early Harvest	B. R. Bacon Hdw. Co., Frankfort
63780	Early Harvest Tobacco Grower	Manufacturer
64660	Fox Formula	L. H. Phillips, Bengal
64267	Fox Crop and Tobacco Grower	Foley, Holt & Collins, Russell Springs
63783	Fox Wheat and Corn Manure	Manufacturer
64268	Fox Tobacco Grower	W. C. Bonta, Pleasureville
64269		J. S. Whitfill, Big Clifty
63785	Fox Wheat and Corn Grower	Manufacturer
63786	Fox Vegetable Grower	Manufacturer
64273	Fox Special Tobacco Grower	T. Z. Leachman, Greensburg

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN					POTASH			
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total	Equivalent to Ammonia	From Muriate	From Sulfate	Index of Relative Value	Station Number
6.55	2.15	8.70	1.81		1.40	3.21	3.90	2.25		36.7	63968
4.00	*0.10*	*4.10*				*3.29*	*4.00*	*1.00*		*28.8*	
11.45	1.05	12.50				0.31	0.38	0.45		20.8	64262
12.40	2.40	14.80				0.41	0.50	0.57		23.7	64263
11.40	2.50	13.90	0.64		0.31	0.95	1.15	1.26		27.6	64659
11.50	*4.00*	*15.50*				*0.41*	*0.50*		*0.50*	*22.8*	
15.05	6.00	21.05		0.57		0.57	0.69	0.44	0.97	32.6	63774
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
15.05	6.00	21.05		0.57		0.57	0.69	0.44	0.97	32.6	63775
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
14.65	1.60	16.25				0.30	0.36	0.85		27.0	64264
13.00	*4.00*	*17.00*				*0.41*	*0.50*		*1.00*	*26.6*	
13.35	4.10	17.45		0.75		0.75	0.91	0.68	5.11	43.5	63777
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*35.6*	
11.85	1.65	13.50	0.60		0.33	0.93	1.13	1.37		28.0	64265
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
9.90	1.30	11.20				0.81	0.98	2.06		26.4	64266
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.45	6.50	18.95		1.31		1.31	1.59	0.82	1.81	37.0	63780
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
11.50	2.00	13.50				0.74	0.90	3.06		31.7	64660
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
10.05	3.65	13.70	0.60	0.32	0.27	1.19	1.44	2.27		30.5	64267
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*30.5*	
10.45	8.75	19.20		2.30		2.30	2.79	1.46	1.12	40.7	63783
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
8.55	1.45	10.00				1.46	1.77	2.31		29.1	64268
8.40	0.70	9.10		0.63	0.76	1.39	1.69	1.84		26.7	64269
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
12.75	5.05	17.80		2.29		2.29	2.78	0.84	1.90	43.1	63785
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
10.40	7.10	17.50		2.18	0.29	2.47	3.00	2.78	2.94	50.4	63786
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*38.5*	
8.35	0.95	9.30	0.42	0.66	0.35	1.43	1.74	4.68		35.5	64273
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*38.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Globe Fert. Co., Br. Federal Chem. Co. Inc., Louisville, Ky.	
64274	Kentucky Standard Tobacco Grower	I. K. Miller & Sons, Campbellsville ..
64275		A. J. Higdon, Clarkson .....
64276	Globe Good Grower Fertilizer	John Harned, Big Clifty .....
64277	Globe Blood Bone Phosphate and Potash	Williamsburg Hdw. Co., Williamsburg
64278		J. B. Benjamin & Son, Providence ..
64662		Burton & Pyles, Ella .....
64663		Hutcheson Bros., Auburn .....
64279	Globe Grain and Grass Grower	A. T. Warder, Epworth .....
64280		Hafendorfer-Thornton Co., Owensboro
64664		Hafendorfer-Thornton Co., Owensboro
64281	Globe Money Maker	Pearson & Breedlove, Franklin .....
63807	Globe High Grade Special	Manufacturer .....
63808	Globe Wheat and Grain Special	Manufacturer .....
64282	Progress Corn and Wheat Grower	Pearson & Breedlove, Franklin .....
64283	Progress Tobacco Grower	T. M. Zachary, Dove .....
64284		H. C. Rogers, Sewellton .....
64285	Braden Formula	Cunningham & Robertson, Webbs Cross Roads .....
64665		W. C. Stewart, Horse Cave .....
64286	Universal Crop and Tobacco Grower	Ben Hook, Brandenburg .....
63813	Eagle Wheat and Corn Grower	Manufacturer .....
64287	Big 4 Tobacco Grower	I. K. Miller & Sons, Campbellsville ..
64288		Hafendorfer-Thornton Co., Owensboro
63815	Globe Wheat Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.50	0.95	**9.45**	0.43	0.80	0.39	1.62	1.97	4.92		37.6	64274
8.90	0.80	**9.70**	0.83	0.53	0.37	1.73	2.10	5.02		39.1	64275
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*38.5*	
12.45	0.80	**13.25**				0.33	0.40	0.57		22.7	64276
11.50	*4.00*	*15.50*				*0.41*	*0.50*		*0.50*	*22.8*	
11.90	1.60	13.50				0.31	0.38	0.97		23.3	64277
12.30	0.85	13.15				0.44	0.53	1.42		25.7	64278
12.00	2.25	14.25				0.43	0.52	0.74		23.7	64662
12.00	2.40	14.40				0.44	0.53	1.32		25.6	64663
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
11.80	2.10	13.90				0.51	0.62	1.02		24.7	64279
13.25	1.90	15.15				0.41	0.50	0.79		25.5	64280
12.95	2.00	14.95	0.41			0.41	0.50	1.29		26.6	64664
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
14.05	1.85	15.90				0.44	0.53	0.89		27.1	64281
13.00	*4.00*	*17.00*				*0.41*	*0.50*		*1.00*	*26.6*	
13.35	4.10	17.45		0.75		0.75	0.91	0.68	5.11	43.5	63807
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*35.6*	
15.10	4.10	19.20		1.25		1.25	1.52	0.46	1.23	36.9	63808
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
10.60	2.10	12.70				0.84	1.02	1.98		27.7	64282
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
11.30	0.95	12.25				0.88	1.07	2.06		28.8	64283
11.65	1.70	13.35				0.83	1.01	1.86		28.7	64284
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.15	1.65	13.80				0.83	1.01	2.38		31.0	64285
12.35	1.85	14.20				0.75	0.91	3.03		32.9	64665
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
8.65	1.00	**9.65**		0.31	0.43	0.74	0.89	3.88		29.5	64286
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*30.5*	
10.45	8.75	19.20		2.30		2.30	2.79	1.46	1.12	40.7	63813
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
9.25	0.50	**9.75**	0.47	0.91	0.40	1.78	2.16	2.26		31.5	64287
9.75	0.45	10.20	0.48	1.17	0.38	2.03	2.46	1.84		32.5	64288
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
12.75	5.05	17.80		2.29		2.29	2.78	0.84	1.90	43.1	63815
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Globe Fertilizer Co.	
64248	Kentucky Tobacco Maker	Collins Hardware Co., Frankfort ..
64289		John Harned, Big Clifty .....
63817	Globe Soluble Vegetable Manure	Manufacturer .....
63997	Globe Bone Phosphate Dust	Manufacturer .....
63998	Big Spread Tobacco Mixture	Manufacturer .....
	Groves' Fert. Works, Cincinnati, O.	
64294	Groves Standard	J. C. Everett & Co., Maysville .....
64578		J. C. Bowles, Jeffersontown .....
64670		Aaron Moore, Leitchfield .....
64295	Harvest King	J. F. Collings, Shepherdsville .....
64296		S. V. Kissee, Ingle .....
64297	Economy Brand	J. F. Collings, Shepherdsville .....
64298	Tobacco Special	S. V. Kissee, Somerset .....
64299		J. F. Collings, Shepherdsville .....
64797		J. F. Collings, Shepherdsville .....
64300	Special Truck Grower	J. F. Collings, Shepherdsville .....
64301		J. C. Bowles, Jeffersontown .....
64671		J. C. Everett & Co., Maysville .....
64305	Half and Half (Bone Mixture)	S. V. Kissee, Ingle .....
64306		Aaron Moore, Leitchfield .....
64672		Aaron Moore, Leitchfield .....
64673		J. C. Everett & Co., Maysville .....
64307	Bone and Potash Mixture (Bone Mixture)	J. O. McAninch, Joyce .....
	Hall Seed Co., Louisville, Ky.	
63565	Halco Tobacco Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.35	1.40	**11.75**				1.60	1.94	1.93		31.5	64248
10.30	0.60	**10.90**	0.44	0.52	0.44	1.40	1.70	2.06		30.3	64289
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
10.40	7.10	17.50		2.18	0.29	2.47	3.00	2.78	2.94	50.4	63817
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*5.00*	*38.5*	
13.55	6.35	19.90	1.36			1.36	1.65	1.46	0.37	36.5	63997
9.00	*4.00*	*13.00*				*0.82*	*1.00*		*1.00*	*23.0*	
11.85	8.25	20.10		2.15		2.15	2.61	1.94		39.8	63998
8.00	*8.00*	*16.00*				*1.23*	*1.50*		*0.50*	*24.1*	
10.70	0.95	11.65		0.81	0.60	1.41	1.71	1.69		30.0	64294
10.95	1.05	12.00		1.00	0.58	1.58	1.92	2.17		32.8	64578
9.70	2.55	12.25				1.20	1.46	2.70		30.9	64670
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*2.00*		*31.3*	
9.00	0.70	9.70		0.59	0.44	1.03	1.25	1.19		23.5	64295
9.00	1.00	10.00		0.39	0.54	0.93	1.13	1.04		22.6	64296
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
10.30	1.10	11.40		0.55	0.35	0.90	1.09	1.34		25.3	64297
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
8.40	0.70	9.10		0.25	0.46	0.71	0.86	4.34		30.2	64298
8.80	0.95	9.75		0.24	0.36	0.60	0.73	5.42		33.4	64299
8.80	1.40	10.20				0.87	1.06	4.65		32.9	64797
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
8.75	1.20	9.95		0.70	0.91	1.61	1.95	8.09		47.5	64300
9.55	1.15	10.70		1.01	1.18	2.19	2.66	**4.98**		42.9	64301
8.00	1.70	9.70		0.48	1.06	1.54	1.87	**7.06**		43.1	64671
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*8.00*		*46.3*	
9.90	6.60	16.50		0.56	1.13	1.69	2.05	2.07		33.8	64305
10.30	6.65	16.95		0.60	0.80	1.40	1.70	2.02		32.6	64306
7.95	8.45	16.40		0.42	0.97	1.39	1.69	2.17		30.2	64672
10.10	8.60	18.70		0.86	0.93	1.79	2.17	1.84		34.9	64673
8.00	*8.00*	*16.00*				*1.65*	*2.00*	*2.00*		*31.1*	
11.55	6.55	18.10				0.74	0.90	5.52		41.0	64307
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*5.00*		*38.9*	
10.25	3.05	13.30				0.90	1.09	2.23		28.7	63565
10.00	*1.00*	*11.00*				*0.82*	*1.00*		*2.00*	*26.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Hall Seed Co.	
63570	Halco Special Tobacco Grower	Manufacturer
63571	Halco Potato and Tobacco Grower	Manufacturer
	Hopkins Fertilizer Co., New Albany, Ind.	
63862	Kentucky Tobacco Grower	Manufacturer
63866	Potato and Tobacco Grower No. 1	Manufacturer
64315	Wheat and Corn Grower No. 2	Conner, Hayden & Co., Bardstown
64316		L. C. Goering & Son, Hawesville
64681		A. G. Miller, Magnolia
64317	Tobacco Bed and Field Mixture	J. Von Grunigen, Nicholasville
64318		A. G. Miller, Magnolia
64319	H. Gr. Tobacco Grower	Floyd Nealy, Glasgow
63870	Potato and Tobacco Grower	Manufacturer
64320	Superior	J. J. Eskridge, Clarkson
64321		Conner, Hayden & Co., Bardstown
64682		Jim Hill, St. John
64322	Half and Half No. 1	J. J. Eskridge, Clarkson
64683		J. J. Eskridge, Clarkson
64684		Sam Walker, Big Clifty
64323	Tobacco Special	D. A. Davis & Son, Jeffersontown
64324		L. C. Goering & Son, Hawesville
64038	Potato Grower	
64532	General Crop Grower	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.55	1.95	10.50				0.52	0.63	0.70	0.33	19.8	63570
8.00	*1.00*	*9.00*				*0.41*	*0.50*		*1.00*	*17.9*	
9.10	1.50	10.60		1.22	0.60	1.82	2.21	3.53		35.8	63571
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*3.00*		*31.3*	
5.90	0.45	6.35		2.19		2.19	2.66	3.23		31.9	63862
6.00	*2.00*	*8.00*				*1.65*	*2.00*	*2.00*		*25.7*	
11.45	0.70	12.15		1.45		1.45	1.76	2.39		33.3	63866
11.00	*2.00*	*13.00*				*0.82*	*1.00*	*2.00*		*28.2*	
10.25	1.90	12.15	0.39		0.22	0.61	0.74	0.66	0.61	23.6	64315
12.95	1.95	14.90	0.25		0.24	0.49	0.59	1.22		26.8	64316
10.15	0.80	10.95	0.58			0.58	0.70	0.48	0.64	22.4	64681
10.00	*2.00*	*12.00*				*0.41*	*0.50*	*1.00*		*21.3*	
11.50	2.85	14.35	0.47	0.45	1.26	2.18	2.65	3.03		40.6	64317
12.50	3.10	15.60		1.05	1.45	2.50	3.04	2.81		43.4	64318
10.00	*2.00*	*12.00*				*2.47*	*3.00*	*3.00*		*39.6*	
9.15	4.85	14.00	0.21		0.68	0.89	1.08	1.14		24.4	64319
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*1.00*		*20.7*	
12.15	0.55	12.70		0.99		0.99	1.20	1.30		28.3	63870
11.00	*2.00*	*13.00*				*0.82*	*1.00*	*1.00*		*25.2*	
11.50	1.80	13.30	0.68		0.87	1.55	1.88	3.89		38.9	64320
11.20	2.25	13.45		0.53	1.18	1.71	2.08	4.18		40.5	64321
10.00	3.50	13.50				1.60	1.94	3.78		37.3	64682
10.00	*2.00*	*12.00*				*1.65*	*2.00*	*4.00*		*37.7*	
11.00	3.45	14.45		0.55	1.35	1.90	2.31	1.42		33.5	64322
7.95	4.80	12.75				1.78	2.16	1.47		28.9	64683
7.45	5.80	13.25				1.74	2.11	1.42		28.4	64684
6.00	*7.00*	*13.00*				*1.65*	*2.00*	*1.00*		*24.7*	
9.95	1.15	11.10	0.25	0.44	0.22	0.91	1.10	3.42		31.1	64323
9.05	0.75	9.80	0.91			0.91	1.10	3.01		28.4	64324
8.00	*2.00*	*10.00*				*0.82*	*1.00*	*3.00*		*26.7*	
8.00	*2.00*	*10.00*				*1.65*	*2.00*	*3.00*		*31.7*	64038
12.00	*2.00*	*14.00*				*1.65*	*2.00*	*2.00*		*34.7*	64532

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	International Agr'l Corp., Inc., Cincinnati, O.	
63410	I. A. C. Special Tobacco Grower	Manufacturer
64327	I. A. C. A-1 Tobacco Fertilizer	C. M. Langdon, Science Hill
64328		J. W. Bratcher, Berea
63412	I. A. C. High Grade Fertilizer	Manufacturer
64329	I. A. C. Standard Fertilizer	J. B. Stone, Leitchfield
63414	I. A. C. Farmers' Favorite Manure	Manufacturer
64330	I. A. C. Old Kentucky Special	R. H. Lisle, Clarkson
64331		C. M. Langdon, Science Hill
64689		C. M. Langdon, Science Hill
63416	I. A. C. Complete Manure	Manufacturer
64332	I. A. C. Wheat and Corn Grower	J. B. Stone, Leitchfield
64690		C. M. Langdon, Science Hill
63429	Buffalo Tobacco and Potato Grower	Manufacturer
64337	Buffalo H. Gr. Tobacco Special	W. E. Ellis & Bro., Hartford
64338		R. F. Collier, Paris
63431	Buffalo High Grade Special	Manufacturer
64695	Buffalo Tobacco and Corn Grower	J. W. Hardyman, Mt. Carmel
64339	Buffalo Kentucky Standard	Tarter, Ham & Co., Somerset
64340		London Hardware Co., London
64696		G. W. Richardson, Somerset
64341	Buffalo Corn and Grain Grower	R. Y. Ballard, Waynesburg
64342		Tarter, Ham & Co., Somerset
64697		Coffey & Van Hook, Moreland
63435	Buffalo Complete Fertilizer	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.00	2.05	12.05	1.01	0.42	1.76	3.19	3.87	1.00	3.09	47.2	63410
8.00	*4.00*	*12.00*				*3.29*	*4.00*		*4.00*	*45.3*	
8.60	3.80	12.40	0.43	0.21	1.13	1.77	2.15	1.78	3.13	39.8	64327
8.40	1.50	9.90	0.64		0.82	1.46	1.77	5.17		37.5	64328
7.00	*4.00*	*11.00*				*1.65*	*2.00*		*5.00*	*37.0*	
12.90	2.40	15.30	0.55	0.38	0.84	1.77	2.15	2.19		37.5	63412
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*2.00*		*35.5*	
8.70	4.35	13.05				1.49	1.81	2.48		31.2	64329
8.00	*4.00*	*12.00*				*1.65*	*2.00*	*2.00*		*29.5*	
11.10	4.40	15.50				0.94	1.14	0.96	2.43	34.2	63414
10.00	*5.00*	*15.00*				*0.82*	*1.00*	*3.00*		*30.9*	
8.35	4.35	12.70				0.86	1.04	2.33		26.4	64330
9.05	4.05	13.10				0.90	1.09	2.19		27.2	64331
8.85	3.15	12.00	0.93		0.30	1.23	1.49	2.16		28.4	64689
8.00	*5.00*	*13.00*				*0.82*	*1.00*	*2.00*		*24.9*	
9.10	4.25	13.35	0.43	0.20	0.47	1.10	1.34	1.58		26 7	63416
8.00	*5.00*	*13.00*				*0.82*	*1.00*	*1.00*		*21.9*	
11.40	4.80	16.20				0.48	0.58	1.09		25.2	64332
11.35	4.20	15.55				0.50	0.61	1.28		25.6	64690
11.00	*5.00*	*16.00*				*0.41*	*0.50*	*1.00*		*23.9*	
10.30	2.50	12.80		0.31	2.00	2.31	2.80	1.06	5.53	50.1	63429
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*6.00*	*46.4*	
11.00	2.10	13.10	0.56	0.29	1.03	1.88	2.28		4.34	41.6	64337
11.45	2.40	13.85				1.59	1.93	4.33		40.7	64338
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*38.5*	
12.90	2.40	15.30	0.55	0.38	0.84	1.77	2.15	2.19		37.5	63431
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*2.00*		*35.5*	
9.05	0.85	9.90	0.96		0.60	1.56	1.89	2.17		29.8	64695
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
11.45	2.70	14.15				0.68	0.83	3.23		32.0	64339
11.70	2.75	14.45				0.81	0.98	2.87		32.1	64340
9.90	1.10	11.00	0.61		0.33	0.94	1.14	3.05		30.1	64696
10.00	*5.00*	*15.00*				*0.82*	*1.00*	*3.00*		*30.9*	
9.60	6.40	16.00				0.83	1.01	2.34		29.0	64341
9.50	6.75	16.25				0.84	1.02	2.21		28.6	64342
8.15	3.65	11.80	0.21	0.34	0.35	0.90	1.09	2.33		26.1	64697
8.00	*5.00*	*13.00*				*0.82*	*1.00*	*2.00*		*24.9*	
9.10	4.25	13.35	0.43	0.20	0.47	1.10	1.34	1.58		26.7	63435
8.00	*5.00*	*13.00*				*0.82*	*1.00*	*1.00*		*21.9*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	International Agr'l Corp.	
63436	Buffalo Corn and Oats Special	Manufacturer
	The Jarecki Chemical Co., (Armour owned) Cincinnati, O.	
63575	Lake Erie Guano with Phosphate and Potash	Manufacturer
63576	Number One Formula	Manufacturer
64347	Little Giant	C. L. & F. F. Dudley, Flemingsburg
64348		J. E. Cain, Hogue
64349	Tobacco and Potato Food	G. C. Anderson, Glasgow
63579	Favorite Grain Grower	Manufacturer
63580	Middle West Formula	Manufacturer
64350	Double Standard	W. G. Nunelley, Somerset
64351	Sure Crop	J. C. Everett & Co., Maysville
63583	Grain Grower	Manufacturer
63592	Big Tobacco Maker	Manufacturer
63593	Burley Tobacco Grower	Manufacturer
64354	Special Tobacco Grower	J. E. Cain, Hogue
63595	Tobacco and Truck Grower	Manufacturer
64355	Jarecki's 2-16-2 Fertilizer	J. C. Everett & Co., Maysville
63599	Indian Br. Tobacco and Potato Food	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN					POTASH			
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total	Equivalent to Ammonia	From Muriate	From Sulfate	Index of Relative Value	Station Number
11.80	4.15	15.95	0.27		0.31	0.58	0.70	1.24		26.6	63436
11.00	*5.00*	*16.00*				*0.41*	*0.50*	*1.00*		*24.0*	
13.10	1.30	14.40		0.21	0.79	1.00	1.21	1.13		29.6	63575
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
10.30	3.15	13.45		0.38	0.60	0.98	1.19	2.36		29.7	63576
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*26.3*	
9.40	3.20	12.60		0.43	0.41	0.84	1.02	1.16		23.9	64347
10.65	3.40	14.05		0.70	0.39	1.09	1.32	1.50		28.4	64348
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
14.90	2.10	17.00				0.20	0.24		0.76	26.7	64349
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
7.60	1.80	9.40		0.37	0.61	0.98	1.19	1.78		23.3	63579
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
13.00	0.90	13.90		1.33	0.61	1.94	2.36	2.13		37.9	63580
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
16.35	0.50	16.85		0.88	0.73	1.61	1.95	2.12		40.8	64350
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
10.30	2.20	12.50	0.27	1.33		1.60	1.94	4.33		38.9	64351
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
7.90	1.80	9.70		0.72	0.86	1.58	1.92	2.17		28.6	63583
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
8.75	2.20	10.95	0.58	0.46	0.67	1.71	2.08	1.16	2.91	36.5	63592
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
8.80	1.55	10.35	0.51	1.18	0.86	2.55	3.10	2.32	3.90	47.8	63593
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	
8.40	3.70	12.10		0.48	0.43	0.91	1.10	1.32		23.5	64354
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
6.10	1.00	7.10		1.14	0.57	1.71	2.08	6.42		39.1	63595
6.00	*1.00*	*7.00*				*1.65*	*2.00*	*6.00*		*37.3*	
16.85	2.45	19.35		1.07	0.78	1.85	2.25	2.23		44.1	64355
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
9.00	*1.00*	*10.00*				*2.47*	*3.00*		*3.00*	*37.7*	63599

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Jarecki Chem. Co.	
64356	Indian Br. Tobacco and Potato Fertilizer	Eminence Milling Co., Eminence ....
	The Kaufman Fertilizer Co. (owned and operated by Armour Fertilizer Works) Cincinnati, O.	
64357	Corn, Wheat, and Oats Grower	James Roe, Mouth of Laurel .....
63625	Harvest King	Manufacturer .....
64358	Banner Crop Grower	James Roe, Mouth of Laurel .....
64359	Tobacco and Potato Grower	James Roe, Mouth of Laurel .....
63628	Favorite Grain Grower	Manufacturer .....
63629	Complete Ration	Manufacturer .....
64360	Sure Crop	Pleasureville Supply Co., N. Pleasureville .....
63631	Grain Grower	Manufacturer .....
63640	Big Tobacco Maker	Manufacturer .....
64362	Burley Tobacco Grower	James Roe, Mouth of Laurel .....
64363	Special Tobacco Grower	James Roe, Mouth of Laurel .....
63643	Double Standard	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.30	1.55	11.85		1.85	0.45	2.30	2.79	3.22	2.09	45.8	64356
9.00	*1.00*	*10.00*				*2.47*	*3.00*		*5.00*	*43.7*	
11.35	0.70	12.20				0.91	1.10	1.26		26.6	64357
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
10.30	3.15	13.45		0.38	0.60	0.98	1.19	2.36		29.7	63625
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*2.00*		*26.3*	
11.10	0.70	11.80		0.53	0.35	0.88	1.07	1.36		26.3	64358
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
8.90	0.70	9.60		0.29	1.03	1.32	1.60	3.10	1.61	35.7	64359
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
7.60	1.80	9.40		0.37	0.61	0.98	1.19	1.78		23.3	63628
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
13.00	0.90	13.90		1.33	0.61	1.94	2.36	2.13		37.9	63629
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
10.45	3.00	13.45		0.27	1.39	1.66	2.02	4.42		40.1	64360
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
7.90	1.80	9.70		0.72	0.86	1.58	1.92	2.17		28.6	63631
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
8.75	2.20	10.95	0.58	0.46	0.67	1.71	2.08	1.16	2.91	36.5	63640
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
8.70	2.20	10.90	0.87	0.65	0.88	2.40	2.91	3.74	1.10	42.9	64362
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	
8.15	0.70	8.85	0.42	0.20	0.35	0.97	1.18		1.41	22.6	64363
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
16.40	2.25	18.65		0.76	0.98	1.74	2.11	2.11		42.3	63643
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Kaufman Fertilizer Co.	
63644	Kaufman's 2-16-2 Fertilizer	Manufacturer
	Ky. Fert. Co., Br. Federal Chem. Co., Inc., Louisville, Ky.	
63836	O. K. Special Mixture	Manufacturer
64364		J. L. Siler, Corbin
64701	O. K. Grain Grower	Smith & Smith, Shepherdsville
64702		C. M. Hill, Cecilia
64365	O. K. Corn, Wheat, and Oats Grower	Albert Hayes, Brodhead
63839	O. K. Old Reliable	Manufacturer
63840	O. K. Special	Manufacturer
63841	O. K. Wheat and Grain Special	Manufacturer
64367	O. K. Corn and Wheat Grower	Sam Carpenter & Co., Maysville
64368		Guenther Hardware Co., Owensboro
63843	O. K. Tobacco Fertilizer	Manufacturer
64703	O. K. High Grade Mixture	C. M. Hill, Cecilia
63845	O. K. Crop and Tobacco Grower	Manufacturer
64369	Golden Leaf Tobacco Grower	L. H. Hart, Big Clifty
63847	O. K. Tobacco and Vegetable Grower	Manufacturer
	Louisville Fertilizer Co. (Armour owned), Louisville, Ky., Cincinnati, O., and Nashville, Tenn.	
64373	Louisville Standard	M. B. Wallingford, Mt. Carmel
64707		S. A. Browning, Vanceburg
64708		M. B. Wallingford, Mt. Carmel

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
16.40	2.25	18.65		0.76	0.98	1.74	2.11	2.11		42.3	63644
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
15.20	4.70	19.90		0.70		0.70	0.85	0.60	0.42	31.9	63836
12.60	2.45	15.05				0.43	0.52	0.52		24.0	64364
11.50	*4.00*	*15.50*				*0.41*	*0.50*		*0.50*	*22.8*	
11.65	0.45	**12.10**				0.42	0.51	1.37		24.3	64701
12.25	2.00	14.25				0.39	0.47	1.12		24.9	64702
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
11.25	1.15	**12.40**				0.42	0.51	1.47		24.3	64365
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
15.80	3.10	18.90		0.78		0.78	0.95	0.50	0.92	33.9	63839
13.00	*4.00*	*17.00*				*0.41*	*0.50*		*1.00*	*26.6*	
13.35	4.10	17.45		0.75		0.75	0.91	0.68	5.11	43.5	63840
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*5.00*	*35.6*	
15.10	4.10	19.20		1.25		1.25	1.52	0.46	1.23	36.9	63841
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
10.45	0.90	**11.35**				0.92	1.12	1.89		27.2	64367
10.80	0.90	**11.70**				0.83	1.01	1.96		27.4	64368
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.45	6.50	18.95		1.31		1.31	1.59	0.82	1.81	37.0	63843
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	
12.50	1.80	14.30				0.58	0.70	**2.06**		**29.1**	64703
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
11.00	8.80	19.80		1.29		1.29	1.57	1.30	3.26	41.4	63845
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*4.00*	*30.5*	
9.70	1.00	10.70				1.68	2.04	1.69		30.1	64369
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
10.55	7.25	17.80		1.64	0.47	2.11	2.56	1.98	5.21	53.0	63847
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*6.00*	*39.0*	
9.35	0.95	10.30				0.95	1.15	1.56		24.8	64373
8.20	3.20	11.40		0.42	0.45	0.87	1.06	1.14		22.2	64707
8.70	0.30	9.00		0.24	0.52	0.76	0.92	1.42		22.0	64708
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Louisville Fertilizer Co.	
63464	Stock Yard Guano	Manufacturer
64374	Wheat, Corn, and Oats	D. E. Patterson, Hodgenville
64709		Lewis & Drye, Lebanon
64375	Grain Grower	Henry & Harvey, Carlisle
64376		M. B. Wallingford, Mt. Carmel
64710	Blood, Phosphate, and Bone	Copple Bros., Guthrie
64800		Harrodsburg Impl. Co., Harrodsburg.
64579	Golden Crop Grower	E. F. Humphrey, Dry Ridge
64711		Copple Bros., Guthrie
64377	Purdue's Choice	Durham Produce Co., Columbia
64378		Lewis & Drye, Lebanon
64379	H. Gr. Potato Grower	Henry & Harvey, Carlisle
64380	Truck Gardeners Pride	J. A. Bennett, Taylorsville
64381	Louisville Tobacco Grower	D. L. D. Sandefur, Beaver Dam
64383	Blue Grass Tobacco Grower	J. A. Bennett, Taylorsville
64384		M. B. Wallingford, Mt. Carmel
64385	Special Tobacco Grower	M. B. Wallingford, Mt. Carmel
64386		Elkin & Kimmel, Greenville
64387	Special Corn and Tobacco Maker	Walter Young Coal Co., Owingsville

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.80	3.30	13.10		0.48	0.56	1.04	1.26	1.12		25.6	63464
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
12.40	0.90	13.30				0.77	0.93	1.26		27.3	64374
13.10	0.30	13.40		0.46	0.34	0.80	0.97	0.95		27.4	64709
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
9.65	1.00	10.65	1.49		0.47	1.96	2.38	2.64		34.6	64375
9.30	0.80	10.10	1.18		0.40	1.58	1.92	2.52		31.3	64376
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
11.10	1.00	12.10		0.67	0.79	1.46	1.76	1.64	0.80	33.1	64710
14.10	0.60	14.70		0.72	0.79	1.51	1.83	2.23		37.1	64800
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
9.60	3.30	12.90		0.37	1.16	1.53	1.86	3.69		36.0	64579
10.70	1.30	12.00		0.53	0.67	1.20	1.46	3.66		34.8	64711
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
11.25	1.00	12.25	0.91	0.35	0.42	1.68	2.04	4.83		41.9	64377
12.50	0.80	13.30	0.57	0.53	0.60	1.70	2.06	6.09		47.5	64378
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*6.00*		*46.3*	
8.75	0.90	9.65	1.16	0.20	0.40	1.76	2.14	2.28	1.87	36.5	64379
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*4.00*		*34.3*	
9.20	1.05	10.25	1.11	0.98	1.09	3.18	3.86	2.82	0.61	43.6	64380
8.00	*1.00*	*9.00*				*3.29*	*4.00*	*3.00*		*41.1*	
9.45	7.35	16.80		0.70	0.75	1.45	1.76	2.23		32.5	64381
10.00	*1.00*	*11.00*				*0.82*	*1.00*		*2.00*	*26.3*	
9.30	0.70	10.00	0.52		0.28	0.80	0.97	0.84	1.45	25.8	64383
9.90	1.00	10.90	0.57		0.36	0.93	1.13	1.48	1.78	30.6	64384
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*3.00*	*26.3*	
8.80	1.00	9.80	0.47	0.20	0.34	1.01	1.23	1.35		23.7	64385
9.95	7.15	17.10		0.32	0.31	0.63	0.76	1.28		25.4	64386
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
12.55	1.30	13.85		0.27	0.71	0.98	1.19	1.16		28.7	64387
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Louisville Fertilizer Works	
64388	Tobacco and Potato Grower	Yopp Seed Co., Paducah
64713		Yopp Seed Co., Paducah
64389	Big Tobacco Maker	M. B. Wallingford, Mt. Carmel
64390		Henry & Harvey, Carlisle
64391	Burley Tobacco Grower	D. E. Patterson, Hodgenville
64392		M. B. Wallingford, Mt. Carmel
64714		M. B. Wallingford, Mt. Carmel
63486	Plant Bed Special	Manufacturer
64398	Double Standard	S. A. Browning, Vanceburg
64718		Lewis & Drye, Lebanon
63745	Potato and Tobacco Maker	
63860	Big Giant	Manufacturer
	Morris & Co., Chicago Ill.	
64830	Morris Big Three	Manufacturer
64834	Morris Big Eight	Manufacturer
64835	Morris Big Nine	Manufacturer
64836	Morris Big Ten	Manufacturer
64839	Morris Big Fourteen	Manufacturer
	Mt. Pleasant Fert. Co., Mt. Pleasant, Tenn.	
63647	V. C. Plant Food	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.80	3.00	11.80		0.72	0.79	1.51	1.83	1.14		26.9	64388
8.85	2.80	11.65		0.73	0.71	1.44	1.75	0.98		26.0	64713
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*1.00*		*25.3*	
9.20	0.70	9.90	1.21		0.49	1.70	2.06	1.98	2.13	36.6	64389
9.80	0.60	10.40	1.28		0.42	1.70	2.06	2.60	1.03	36.0	64390
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
9.20	1.05	10.25	1.11	0.72	0.62	2.45	2.97	3.64	3.08	49.1	64391
10.15	1.20	11.35	0.93	0.81	0.70	2.44	2.96	2.96	2.62	47.2	64392
9.00	0.60	9.60		0.49	1.90	2.39	2.90	4.69		42.2	64714
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	
12.25	1.35	13.60				2.77	3.36	1.62	0.53	42.0	63486
12.00	*1.00*	*13.00*				*2.47*	*3.00*		*2.00*	*39.2*	
15.45	1.85	17.30		0.98	0.70	1.68	2.04	2.41		41.2	64398
16.50	1.05	17.55		1.08	0.53	1.61	1.95	2.27		41.6	64718
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
											63745
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
10.75	0.85	11.60		0.48	1.32	1.80	2.19		16.21	75.9	63860
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*15.00*	*70.3*	
9.25	0.90	10.15				1.16	1.41	1.46	2.11	31.9	64830
9.00	*1.00*	*10.00*				*0.82*	*1.00*		*3.00*	*27.8*	
8.05	0.60	8.65				1.19	1.44	0.76	0.44	23.1	64834
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
13.65	2.40	16.05				1.15	1.40	0.68	0.48	31.8	64835
12.00	*1.50*	*13.50*				*0.82*	*1.00*		*1.00*	*26.5*	
8.70	2.05	10.75				1.85	2.25	1.32	1.24	32.7	64836
8.00	*1.50*	*9.50*				*1.65*	*2.00*		*2.00*	*28.5*	
12.10	1.90	14.00	0.99		1.31	2.30	2.79	1.58	0.80	39.9	64839
12.00	*1.50*	*13.50*				*1.65*	*2.00*		*2.00*	*34.5*	
											63647
8.00	*2.00*	*10.00*				*4.94*	*6.00*		*3.00*	*51.4*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Mt. Pleasant Fert. Co.	
64402	Mt. Pleasant Special Tobacco Gr.	Jackson Hdw. & Grocery Co., Dixon .
64403	Mt. Pleasant Black Patch Tobacco Grower	W. B. Davis, Princeton .....
64404	Mt. Pleasant H. Gr. Tobacco Grower	Farmers' Union Supply Co., Franklin
64406	Mt. Pleasant Superior Burley Grower	Hudson & Farnau, Lancaster .....
63660	Mt. Pleasant Burley Special	Manufacturer .....
63662	Mt. Pleasant Corn Grower	Manufacturer .....
63664	Grigsby Special	Manufacturer .....
64407	Mt. Pleasant 10-4-4	Cadiz Hardware Co., Cadiz .....
64528	Mt. Pleasant Wheat Grower	Manufacturer .....
64530	Black Patch Grain Grower	Manufacturer .....
	The Peerless Chemical Co., Columbia, Tenn.	
64027	Peerless 2-8-2	Manufacturer .....
	Poultry Feed Co., Chicago, Ill.	
63244	Premier Brand Pulverized Poultry Manure	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.10	6.50	16.60		0.55	0.63	1.18	1.43	1.64		29.8	64402
8.00	*2.00*	*10.00*				*1.23*	*1.50*		*1.50*	*24.7*	
8.65	11.20	19.85				0.51	0.62	1.24		24.2	64403
7.00	*2.00*	*9.00*				*0.41*	*0.50*		*1.00*	*16.8*	
11.55	1.55	13.10		0.86	0.61	1.47	1.78	2.85		35.4	64404
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*3.00*	*31.7*	
10.40	3.70	14.10		1.04	1.02	2.06	2.50	2.13		35.8	64406
8.00	*2.00*	*10.00*				*1.65*	*2.00*		*2.00*	*28.7*	
8.70	5.35	14.05	0.57		0.22	0.79	0.96	4.68		34.0	63660
8.00	*2.00*	*10.00*				*0.82*	*1.00*		*4.00*	*29.7*	
9.15	9.55	18.70				0.60	0.73	1.40		25.4	63662
7.00	*2.00*	*9.00*				*0.41*	*0.50*		*1.00*	*16.8*	
9.20	5.20	14.40	1.07			1.07	1.30	1.36		26.4	63664
10.00	*2.00*	*12.00*				*0.82*	*1.00*		*1.00*	*23.7*	
12.85	2.50	15.35		2.93	0.33	3.26	3.96	4.11		52.2	64407
10.00	*8.00*	*18.00*				*3.29*	*4.00*		*4.00*	*49.9*	
8.75	13.00	21.75		1.07	0.25	1.32	1.60	1.70		31.4	64528
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*1.50*	*25.5*	
7.35	16.70	24.05				0.40	0.49	1.03		23.2	64530
7.00	*9.00*	*16.00*				*0.41*	*0.50*		*1.00*	*19.6*	
12.20	1.05	13.25		3.23	0.41	3.64	4.42	2.64		48.5	64027
8.00						*1.65*	*2.00*	*2.00*		*27.9*	
2.35	0.20	2.55		0.60	4.32	4.92	5.97	0.98	0.56	37.8	63244
1.70	*1.00*	*2.70*				*4.10*	*4.98*		*1.30*	*31.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Price Chem. Co., Inc., Louisville, Ky.	
64410	Special Corn and Wheat Fertilizer	Johnson & Viers, Elizabethtown ....
64411		H. F. Upchurch, Monticello .....
64729		J. C. Everett & Co., Maysville ....
64730		Johnson & Viers, Elizabethtown ....
63944	Good Grain Grower	Manufacturer .....
64412	Grain and Grass Grower	W. A. Johnson, Brodhead .....
63946	Universal Crop Fertilizer	Manufacturer .....
63947	Walter Crady's Vegetable, Potato, and Tobacco Special	Manufacturer .....
64413	Ky. Blue Grass Tobacco Special	Pleasureville Impl. Co., N. Pleasureville
64821	High Grade Special	G. M. Hedrick, Burnside .....
64414	Extra H. Gr. Tobacco Fertilizer	W. A. Johnson, Brodhead .....
64803		W. W. Higginbotham, Monticello ....
64415	Old Time Grain Fertilizer	W. A. Johnson, Brodhead .....
64416		Oakley D. Bertram, Cooper .....
64804		W. W. Higginbotham, Monticello ...
64417	Old Time Tobacco Fertilizer	J. C. Everett & Co., Maysville .....
64418		E. L. Cox, Cub Run .....
63953	Truck and Tobacco Fertilizer	Manufacturer .....
63954	Bright Tobacco Special	Manufacturer .....
63955	General Crop Fertilizer	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
11.50	1.70	13.20	0.58			0.58	0.70	1.12		24.8	64410
12.40	5.50	17.90				0.53	0.64	1.05		27.1	64411
12.40	1.00	13.40	0.43		0.25	0.68	0.83	1.11		26.4	64729
12.30	0.50	12.80	0.27		0.21	0.48	0.58	1.16		25.0	64730
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*1.00*	*23.6*	
11.80	1.90	13.70				0.56	0.68		0.86	24.4	63944
11.00	*4.00*	*15.00*				*0.41*	*0.50*		*0.50*	*22.1*	
9.55	1.00	10.55				0.60	0.73	0.99		21.3	64412
8.00	*4.00*	*12.00*				*0.41*	*0.50*		*1.00*	*19.1*	
13.30	1.70	15.00	0.65		0.43	1.08	1.31		1.42	31.4	63946
12.00	*4.00*	*16.00*				*0.82*	*1.00*		*1.00*	*27.5*	
12.20	1.80	14.00	0.61		0.47	1.08	1.31	0.82	3.11	37.3	63947
11.00	*4.00*	*15.00*				*0.82*	*1.00*		*3.00*	*32.0*	
11.35	0.90	12.25		0.55	0.66	1.21	1.47	4.04		36.8	64413
8.00	*4.00*	*12.00*				*1.23*	*1.50*		*4.00*	*33.0*	
11.20	1.20	12.40		0.72	0.99	1.71	2.08	2.27		34.4	64821
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*2.00*	*32.5*	
10.45	0.90	11.35		0.88	0.74	1.62	1.97	4.15		38.2	64414
11.00	0.70	11.70		0.95	0.91	1.86	2.26	4.15		40.4	64803
10.00	*4.00*	*14.00*				*1.65*	*2.00*		*4.00*	*38.5*	
9.15	0.70	9.85		0.84	0.81	1.65	2.00	2.11		30.2	64415
9.65	7.80	17.45		0.20	1.43	1.63	1.98	2.17		33.9	64416
8.70	0.60	9.30	1.14		0.45	1.59	1.93	2.63		30.7	64804
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
9.85	1.45	11.30	1.22		0.55	1.77	2.15	2.14		32.4	64417
8.70	0.90	9.60		0.67	0.97	1.64	1.99	2.15		29.7	64418
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*2.00*	*29.5*	
10.30	2.40	12.70	2.14		0.78	2.92	3.54	1.02	2.94	45.8	63953
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*3.00*	*37.4*	
11.90	1.60	13.50	1.38		0.79	2.17	2.63	0.46	0.99	35.9	63954
9.00	*4.00*	*13.00*				*1.65*	*2.00*		*1.00*	*28.0*	
11.80	1.40	13.20	0.67		0.51	1.18	1.43	0.78	1.86	33.3	63955
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*2.00*	*27.5*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Price Chemical Co.	
64419	One-Ten-One Fertilizer	J. C. Bertram, Hidalgo
	Rasin-Monumental Co., (Sub. of Va-Car. Chem. Co., Inc.,) Cincinnati, O.	
63914	Rasin's Farmers Success	Manufacturer
63915	Rasin's Reliable Wheat and Corn Fertilizer	Manufacturer
63916	Rasin's Big Giant Phosphate	Manufacturer
64737	Rasin's General Favorite	J. H. Wyan, London
63918	Rasin's Sweepstakes Fertilizer	Manufacturer
63919	Rasin's Potato and Truck	Manufacturer
64429	Rasin's Big Burley Grower (Potash from Sulphate)	Lessenbery & Jones, Glasgow
	Read Phosphate Co., Nashville, Tenn.	
64436	Corn, Wheat, and Oat Grower	C. T. Calhoun, Montpelier
64742		J. H. Jasper, Somerset
64743		U. G. Antle, Columbia
64437	Kentucky Tobacco Grower	J. W. Bratcher, Berea
64438		Hollingsworth-Young Hdw. Co., Bowling Green

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
12.65	1.50	14.15	0.61	-	0.37	0.98	1.19		1.07	28.7	64419
10.00	*4.00*	*14.00*				*0.82*	*1.00*		*1.00*	*24.5*	
10.10	2.40	12.50				1.04	1.26	1.25		26.1	63914
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*1.00*		*20.5*	
10.00	1.70	11.70				1.04	1.26	1.16	1.39	29.6	63915
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*2.00*		*23.5*	
10.30	0.70	11.00		0.89	0.27	1.16	1.41	1.66	1.73	32.9	63916
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*3.00*		*26.5*	
9.20	1.20	10.40	0.47	0.81	0.38	1.66	2.02	2.37		31.4	64737
8.00	*1.50*	*9.50*				*1.65*	*2.00*	*2.00*		*28.5*	
13.90	0.90	14.80		1.52	0.28	1.80	2.19	0.82	1.37	38.6	63918
12.00	*1.50*	*13.50*				*1.65*	*2.00*	*2.00*		*34.5*	
11.50	0.60	12.10	2.00			2.00	2.43	4.21		42.1	63919
10.00	*1.50*	*11.50*				*2.47*	*3.00*	*4.00*		*42.4*	
9.70	1.30	11.00				0.78	0.95	0.92	1.45	26.9	64429
8.00	*1.50*	*9.50*				*0.82*	*1.00*		*2.00*	*23.5*	
7.50	9.00	16.50	0.25		0.74	0.99	1.20	1.10		24.1	64436
8.20	6.90	15.10	0.25		0.61	0.86	1.04	0.84	0.42	24.0	64742
8.60	6.90	15.50	0.20		0.69	0.89	1.08	1.01		24.0	64743
7.00	*10.00*	*17.00*				*0.82*	*1.00*	*1.00*		*22.4*	
8.20	6.00	14.20				0.82	1.00	1.20		23.2	64437
10.20	4.10	14.30	0.54		0.32	0.86	1.04	1.70	1.38	29.5	64438
8.00	*5.00*	*13.00*				*0.82*	*1.00*		*1.00*	*21.9*	

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Read Phosphate Co.	
64439	Standard Tobacco Grower	Hollingsworth-Young Hdw. Co., Bowling Green
63257	Blood and Bone No. 1	Manufacturer
64440	Kentucky Special	Hatcher & Rawls, Cerulean
64441		Cowherd & Durham, Greensburg
64744		U. G. Antle, Columbia
64442	High Grade Tobacco Grower	Hollingsworth-Young Hdw. Co., Bowling Green
64443		John L. Hart, Cynthiana
63260	Blood and Bone Special	Manufacturer
63261	H. Gr. Ammoniated Dissolved Bone	Manufacturer
63262	Corn and Wheat Grower	Manufacturer
64444	Wheat and Clover Grower	Hatcher & Rawls, Cerulean
	The Smith Agricultural Chemical Co., Columbus, O.	
64028	Smith's Tobacco Grower 1-8-2	Manufacturer
64029	Smith's Tobacco Grower 1-8-4	Manufacturer
64030	Smith's Potato and Tobacco Special	Manufacturer
	Southern Fertilizer Co., Inc., Louisville, Ky.	
63749	Elk Corn and Wheat Grower	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.90	1.70	11.60		0.20	1.20	1.40	1.70	1.93		29.7	64439
8.00	*5.00*	*13.00*				*1.65*	*2.00*		*2.00*	*29.9*	
10.60	6.10	16.70				2.23	2.71	2.23		37.4	63257
8.00	*5.00*	*13.00*				*1.65*	*2.00*	*2.00*		*29.9*	
7.50	2.80	10.30				0.81	0.98	2.97		26.1	64440
9.85	3.90	13.75				0.38	0.46	4.67		32.6	64441
9.40	6.60	16.00				0.49	0.59	3.38	0.91	32.6	64744
8.00	*5.00*	*13.00*				*0.41*	*0.50*	*4.00*		*28.5*	
8.00	3.80	11.80		0.55	1.12	1.67	2.03	3.86		35.1	64442
8.45	1.35	9.80		0.27	1.55	2.02	2.45	1.54	2.72	38.1	64443
8.00	*5.00*	*13.00*				*1.65*	*2.00*		*4.00*	*35.9*	
13.10	4.30	17.40				1.45	1.76	1.44		34.4	63260
10.00	*5.00*	*15.00*				*0.82*	*1.00*	*1.00*		*24.9*	
11.75	2.60	14.35				2.14	2.60	2.87		40.1	63261
10.00	*5.00*	*15.00*				*1.65*	*2.00*	*2.00*		*32.9*	
13.90	3.50	17.40				0.82	1.00	1.50		33.2	63262
11.00	*5.00*	*16.00*				*0.41*	*0.50*	*1.00*		*24.0*	
11.20	2.70	13.90		0.32	0.94	1.26	1.53	1.94		31.4	64444
12.00	*3.00*	*15.00*				*0.82*	*1.00*	*2.00*		*30.1*	
9.60	0.70	10.30		0.58	0.24	0.82	1.00	2.31		26.5	64028
8.00						*0.82*	*1.00*	*2.00*		*22.9*	
8.90	0.90	9.80		0.35	0.51	0.86	1.04	3.96		30.8	64029
8.00						*0.82*	*1.00*	*4.00*		*28.9*	
13.30	1.00	14.30		1.04	0.58	1.62	1.97	2.09		36.3	64030
12.00						*1.65*	*2.00*	*2.00*		*33.9*	
7.00	*1.00*	*8.00*				*0.82*	*1.00*		*1.00*	*18.8*	63749

TABLE I.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Southern Fertilizer Co.	
64447	Elk General Crop Grower	Corbin Supply Co., Corbin .....
63751	Elk Standard Guano	
64448	Elk Potash Special	Ratliff Hardware Co., Princeton ....
64449	Elk Tobacco Grower	Bush Coal Co., Winchester .....
64580		Chas. Griffith and Co., Carrollton ....
64451	Elk Wheat, Corn and Tobacco Special	Conrad-Payne and Co., Cloverport ...
	Southern Fertilizer & Chemical Co., Savannah, Ga.	
63747	Southern Fertilizer 2-12-2	Manufacturer .....
	Swift & Co., National Stock Yards, Ill.	
64452	Swift's Diamond "B" Fertilizer	W. E. Burress, Greensburg .....
64453		Jno. B. Marriott, Cecilia .....
64454	Swift's Diamond "A" Fertilizer	J. F. Collings, Shepherdsville .....
64455		John B. Marriott, Cecilia .....
64456	Swift's Grain and Tobacco Grower	Green & Duff, Mt. Sterling .....
64457		Vine Grove Feed Co., Vine Grove ....
64458	Swift's Champion Wheat and Corn Grower	Green & Duff, Mt. Sterling .....
64745		John B. Marriott, Cecilia .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
10.15	0.70	10.85	0.23		0.29	0.52	0.63	1.24		22.4	64447
10.00	*1.00*	*11.00*				*0.41*	*0.50*		*1.00*	*20.9*	
											63751
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*1.00*	*25.3*	
9.20	0.50	9.70		0.38	0.49	0.87	1.06	4.80		33.6	64448
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*4.00*		*29.3*	
10.50	0.80	11.30	0.85	0.42	0.63	1.90	2.31	2.10		33.8	64449
8.45	0.90	9.35	0.86	0.56	0.29	1.71	2.08	1.33		27.3	64580
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*1.00*	*25.3*	
8.30	0.40	8.70	0.88		0.62	1.50	1.82	2.20		28.2	64451
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
12.00	0.90	12.90		1.01	0.72	1.73	2.10	2.42		36.0	63747
12.00	*0.50*	*12.50*				*1.65*	*2.00*	*2.00*		*34.1*	
7.95	4.20	12.15	1.19	0.86	0.40	2.45	2.97	5.28		44.2	64452
11.15	2.75	13.90	1.14	0.74	0.40	2.28	2.77	3.20		40.9	64453
8.00	*3.00*	*11.00*				*2.47*	*3.00*	*5.00*		*43.0*	
8.30	3.80	12.10	0.92	0.90	0.31	2.13	2.59	2.56		34.4	64454
9.50	4.10	13.60	0.61	0.81	1.08	2.50	3.04	3.73		42.1	64455
8.00	*3.00*	*11.00*				*2.47*	*3.00*	*3.00*		*37.0*	
10.60	3.30	13.90	0.21	0.90	0.58	1.69	2.05	3.15		36.8	64456
10.95	1.45	12.40		0.81	0.86	1.67	2.03	3.32		37.0	64457
10.00	*3.00*	*13.00*				*1.65*	*2.00*	*4.00*		*38.1*	
12.40	3.10	15.50		0.94	0.92	1.86	2.26	1.98		36.9	64458
13.60	2.50	16.10		0.88	1.06	1.94	2.36	1.97		39.0	64745
12.00	*3.00*	*15.00*				*1.65*	*2.00*	*2.00*		*35.1*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Swift & Co.	
64746	Swift's Special Grain Grower	Finley Hardware Co., Madisonville ..
64459	Swift's Diamond "K" Grain Grower	John B. Marriott, Cecilia .....
64460		Farmer's Union Supply Co., Somerset
64747		John B. Marriott, Cecilia .....
64748		D. C. Hopper, Font Hill .....
64461	Swift's Diamond "W" Vegetable and Tobacco Grower	Staggs Brothers & Co., Vanceburg ....
64462		Vine Grove Feed Co., Vine Grove ..
64463	Swift's Superphosphate	Sam Terry, Big Clifty .....
64464		G. H. Harris, Cloverport .....
64465	Swift's Complete Fertilizer	F. M. Mitchell, Scottsville .....
64466		Farmer's Union Supply Co., Somerset.
64749		H. C. McClure, Somerset .....
64467	Swift's Diamond "W" Tobacco Gr	Mayhew & Gilbert, Franklin .....
64468		J. F. Collings, Shepherdsville .....
64750		E. M. Ford & Sons, Cave City .....
64535	Swift's Red Steer 3-12-3 Fertilizer	Manufacturer .....
64755	Swift's Red Steer 2-16-2 Fertilizer	D. C. Hopper, Font Hill .....
64538	Swift's Bone Meal and Potash	Manufacturer .....
	Taylor and Powell Fertilizer Co., Inc., Springfield, Tenn.	
64056	No. 6 Tobacco Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
8.90	1.80	11.00		0.35	0.77	1.12	1.36	1.76		26.1	64746
10.00	*3.00*	*13.00*				*1.65*	*2.00*	*2.00*		*32.1*	
11.75	2.45	14.20		1.42		1.42	1.72	1.21		30.8	64459
12.40	1.80	14.20		0.37	0.61	0.98	1.19	1.89		30.9	64460
12.90	3.20	16.10		0.28	0.64	0.92	1.12	1.01		29.2	64747
13.30	2.60	15.90		0.42	0.68	1.10	1.34	1.15		31.0	64748
12.00	*3.00*	*15.00*				*0.82*	*1.00*	*1.00*		*27.1*	
9.05	3.10	12.15		0.39	0.92	1.31	1.59	2.74		30.9	64461
8.90	1.90	10.80	0.64	0.48	0.38	1.50	1.82	2.71		31.2	64462
8.00	*3.00*	*11.00*				*1.65*	*2.00*	*3.00*		*32.1*	
8.50	2.30	10.80	0.81	0.45	0.33	1.59	1.93	1.52		27.8	64463
10.10	3.60	13.70		0.55	1.18	1.73	2.10	1.47		31.4	64464
8.00	*3.00*	*11.00*				*1.65*	*2.00*	*2.00*		*29.1*	
12.10	2.75	14.85	0.28	0.60	0.37	1.25	1.52	1.13		30.1	64465
9.20	2.40	11.60		0.25	0.44	0.69	0.84	1.64		23.8	64466
7.70	3.00	10.70		0.31	0.55	0.86	1.04	0.65		19.9	64749
8.00	*3.00*	*11.00*				*0.82*	*1.00*	*1.00*		*21.1*	
8.10	2.90	11.00	0.43	0.84	0.33	1.60	1.94	1.01		25.9	64467
8.55	3.15	11.70		0.95	0.68	1.63	1.98	0.99		26.8	64468
8.90	1.70	10.60		0.51	1.14	1.65	2.00	1.19		27.5	64750
8.00	*3.00*	*11.00*				*1.65*	*2.00*	*1.00*		*26.1*	
12.80	1.15	13.95	1.83	0.65		2.48	3.01	3.08	0.42	45.0	64535
12.00	*1.00*	*13.00*				*2.47*	*3.00*	*3.00*		*42.2*	
17.10	0.90	18.00		1.34		1.34	1.63	2.23		40.7	64755
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
15.20	3.70	18.90				0.90	1.09	4.89		44.4	64538
13.00	*5.00*	*18.00*				*0.82*	*1.00*		*4.00*	*38.4*	
9.85	1.55	11.40	2.40	0.41	0.59	3.40	4.13	3.95		47.7	64056
10.00						*1.65*	*2.00*		*4.00*	*36.9*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Tennessee Chemical Co., (Armour Owned) Louisville, Ky., Cincinnati, O., Nashville, Tenn.	
64478	Ox Louisville Standard	Pineville Produce Co., Pineville ....
63535	Ox Crop Grower	Manufacturer .....
64757	Ox Wheat, Corn and Oats	N. B. Kelsay, Columbia .....
64479	Ox Slaughter House Bone	W. F. Grainger, Franklin .....
63540	Ox Beef, Blood and Bone	Manufacturer .....
64480	Ox High Grade Potato Grower	W. F. Grainger, Franklin .....
64481	Ox Truck Grower	McClure & Simms, Springfield .....
63544	Ox Kentucky's Choice	Manufacturer .....
64483	Ox Louisville Tobacco Grower	Shaw & Reynolds, Cave City .....
64484		J. D. Wilson & Bro., Paris .....
63550	Ox Tobacco and Potato Grower	Manufacturer .....
64485	Ox Special Tobacco Grower	J. S. Duke, Crab Orchard .....
63552	Ox Special Corn and Tobacco Maker	Manufacturer .....
64486	Ox Big Tobacco Maker	Sexton Bros., Murray .....
64487		P. A. Blackwell & Co., Henderson ....
63554	Ox Burley Tobacco Grower	Manufacturer .....

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.15	0.50	9.65	0.21	0.34	0.41	0.96	1.17	1.32		23.7	64478
8.00	*1.00*	*9.00*				*0.82*	*1.00*	*1.00*		*20.3*	
9.80	3.30	13.10		0.48	0.56	1.04	1.26	1.12		25.6	63535
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*1.00*		*23.3*	
12.60	0.80	13.40	0.61		0.24	0.85	1.03	1.28		28.2	64757
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
8.35	2.85	11.20	0.45	0.46	0.43	1.34	1.63	2.15		28.2	64479
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*2.00*		*28.3*	
11.50	1.30	12.80	0.96	0.25	0.37	1.58	1.92	2.06		33.4	63540
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*2.00*		*34.3*	
10.05	3.25	13.30		1.04	0.75	1.79	2.17	3.52		37.7	64480
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
7.60	2.00	9.60	0.73	0.94	1.60	3.27	3.98	4.15		44.3	64481
8.00	*1.00*	*9.00*				*3.29*	*4.00*	*3.00*		*41.1*	
12.10	1.30	13.40	0.24	0.56	0.91	1.71	2.08	6.48		48.4	63544
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*6.00*		*46.3*	
10.45	3.15	13.60		0.52	0.31	0.83	1.01	1.64		26.8	64483
10.95	0.75	11.70		0.21	0.59	0.80	0.97	1.14	0.39	26.2	64484
10.00	*1.00*	*11.00*				*0.82*	*1.00*		*2.00*	*26.3*	
8.80	2.50	11.30	0.79	0.34	0.44	1.57	1.91	1.13		27.0	63550
8.00	*1.00*	*9.00*				*1.65*	*2.00*	*1.00*		*25.3*	
8.45	0.55	9.00	0.63		0.41	1.04	1.26	1.11		22.5	64485
8.00	*1.00*	*9.00*				*0.82*	*1.00*		*1.00*	*20.3*	
11.80	2.70	14.50		0.48	0.51	0.99	1.20	1.15		28.2	63552
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*1.00*		*26.3*	
8.95	5.60	14.55		0.98	0.72	1.70	2.06	1.60	1.99	36.6	64486
8.10	2.75	10.85		0.84	0.70	1.54	1.87	2.02	1.94	34.4	64487
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*4.00*	*34.3*	
8.50	2.70	11.20	0.57	1.25	0.68	2.50	3.04	2.10	3.74	46.4	63554
8.00	*1.00*	*9.00*				*2.47*	*3.00*		*6.00*	*45.2*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Tennessee Chemical Co.	
64488	Ox Plant Bed Special	McClure & Simms, Springfield
63564	Ox Double Standard	Manufacturer
64493	Ox Special Tobacco Guano	W. F. Grainger, Franklin
64494		T. J. Turley Co., Owensboro
64061	Ox Tobacco Grower	
64544	Ox Wheat Special	
	Victor Guano Co., Nashville, Tenn.	
64497	Standard Tobacco Grower	Lambert, Gresham Hdw. Co., Henderson
63283	Kentucky Home Guano	Manufacturer
63284	Kentucky Soil Food	Manufacturer
63285	Corn and Wheat Grower	Manufacturer
63286	High Grade Grain Guano	Manufacturer
63287	Wheat, Oats, and Corn Guano	Manufacturer
63288	Complete Grain Guano	Manufacturer
63289	High Grade Tobacco Guano	Manufacturer
	Virginia-Carolina Chem. Co., Inc., Cincinnati, Ohio.	
63889	V.-C. Complete Manure	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
12.90	1.00	13.90	0.91	0.77	0.73	2.41	2.93	1.06	1.09	40.7	64488
12.00	*1.00*	*13.00*				*2.47*	*3.00*		*2.00*	*39.2*	
16.10	0.90	17.00		1.00	0.67	1.67	2.03	2.53		42.1	63564
16.00	*1.00*	*17.00*				*1.65*	*2.00*	*2.00*		*40.3*	
10.10	2.60	12.70	0.87	0.44	0.63	1.94	2.36	1.97		33.7	64493
10.05	2.60	12.65	0.43	0.46	0.52	1.41	1.71	2.74		32.8	64494
10.00	*1.00*	*11.00*				*1.65*	*2.00*		*2.00*	*31.3*	
											64061
8.00	*1.00*	*9.00*				*1.65*	*2.00*		*10.00*	*52.3*	
											64544
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*4.00*		*37.3*	
11.85	2.60	14.45	0.42		0.81	1.23	1.49	1.78		31.6	64497
8.00	*5.00*	*13.00*				*1.65*	*2.00*		*2.00*	*29.9*	
10.00	7.60	17.60				1.58	1.92	0.60	0.34	30.3	63283
8.00	*5.00*	*13.00*				*0.82*	*1.00*	*1.00*		*21.9*	
11.00	3.00	14.00				0.87	1.06	4.13		35.3	63284
8.00	*5.00*	*13.00*				*0.41*	0.50	*4.00*		*28.5*	
13.10	4.30	17.40				1.45	1.76	1.44		34.4	63285
10.00	*5.00*	*15.00*				*0.82*	*1.00*	*1.00*		*24.9*	
11.75	2.60	14.35				2.14	2.60	2.87		40.1	63286
10.00	*5.00*	*15.00*				*1.65*	*2.00*	*2.00*		*32.9*	
13.90	3.50	17.40				0.82	1.00	1.50		33.2	63287
11.00	*5.00*	*16.00*				*0.41*	*0.50*	*1.00*		*24.0*	
14.35	1.40	15.75				1.44	1.75	2.37		37.8	63288
12.00	*3.00*	*15.00*				*0.82*	*1.00*	*2.00*		*30.1*	
8.70	7.30	16.00				2.31	2.80	0.72	3.44	42.3	63289
8.00	*5.00*	*13.00*				*1.65*	*2.00*		*4.00*	*35.9*	
10.10	2.40	12.50				1.04	1.26	1.25		26.1	63889
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*1.00*		*20.5*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Virginia-Carolina Chemical Co.	
64581	V.-C. Champion Corn and Wheat Gr.	Franks & Fry, Walton
64505	V.-C. Farmer's Friend	Taylor County Supply Co., Campbellsville
64770		Taylor County Supply Co., Campbellsville
64506	V.-C. Beef, Blood, and Bone B B B	Jack Hysinger, Mt. Vernon
64507		Patrick Dillon, Hardinsburg
64771		Patrick Dillon, Hardinsburg
64772		Taylor County Supply Co., Campbellsville
64508	V.-C. Springfall Fertilizer	Aaron Moore, Leitchfield
64509		Wayne County Farm Bureau, Monticello
63894	V.-C. Big Potato and Truck	Manufacturer
64510	V.-C. Bright Tobacco Fertilizer (Potash from Sulphate)	Stewart & Co., Munfordville
64511	V.-C. Gem Fertilizer for Tobacco	Stewart & Co., Munfordville
64512		Jack Hysinger, Mt. Vernon
63899	V.-C. Plant Food for Vegetables, Lawns, and Flowers	Manufacturer
64558	V.-C. Progressive Farmer	

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.45	1.60	11.05	0.21	1.61	0.28	2.10	2.55	2.21		34.1	64581
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*2.00*		*23.5*	
9.20	1.75	10.95				0.90	1.09	2.88		28.5	64505
9.20	8.70	17.90	0.63		0.28	0.91	1.10	2.89		31.4	64770
8.00	*1.50*	*9.50*				*0.82*	*1.00*	*3.00*		*26.5*	
9.05	1.60	10.65		1.28	0.50	1.78	2.16	2.11		30.7	64506
8.10	1.20	9.30		1.04	0.44	1.48	1.80	2.21		28.1	64507
9.50	9.10	18.60		1.32	0.39	1.71	2.08	2.19		34.7	64771
10.00	7.90	17.90	0.30	0.95	0.29	1.54	1.87	1.83		32.9	64772
8.00	*1.50*	*9.50*				*1.65*	*2.00*	*2.00*		*28.5*	
12.55	1.40	13.95		0.56	1.08	1.64	1.99	2.00		35.2	64508
13.25	1.85	15.10		1.35	0.43	1.78	2.16	2.19		37.9	64509
12.00	*1.50*	*13.50*				*1.65*	*2.00*	*2.00*		*34.5*	
10.50	1.00	11.50	2.28			2.28	2.77	4.40		43.0	63894
10.00	*1.50*	*11.50*				*2.47*	*3.00*	*4.00*		*42.4*	
9.55	0.90	10.45	0.69		0.35	1.04	1.26	0.78	1.26	27.1	64510
8.00	*1.50*	*9.50*				*0.82*	*1.00*		*2.00*	*23.5*	
10.00	1.30	11.30				1.72	2.09	0.66	0.45	29.2	64511
9.95	1.15	11.10	0.61		1.23	1.84	2.23	0.90	0.49	30.6	64512
9.00	*1.50*	*10.50*				*1.65*	*2.00*		*1.00*	*27.0*	
9.80	2.70	12.50	0.68	4.48	0.53	5.69	6.91	3.33		59.9	63899
8.00	*1.50*	*9.50*				*4.92*	*6.00*	*3.00*		*51.1*	
											64558
16.00	*2.00*	*18.00*				*1.65*	*2.00*	*2.00*		*40.7*	

TABLE I.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Wood, Stubbs & Co., Inc., Louisville, Ky.	
63999	Acme Potato and Tobacco Grower	Manufacturer
64000	Acme Special Potato Grower	Manufacturer
64001	Acme Wheat and Corn Grower	Manufacturer
64004	Acme Three-Eight-Five	Manufacturer

COMPLETE FERTILIZERS.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total		From Muriate	From Sulfate		
9.60	2.10	11.70				1.07	1.30	0.76	1.11	27.3	63999
8.00	*4.00*	*12.00*				*0.82*	*1.00*		*2.00*	*24.5*	
9.30	3.00	12.30	1.21		0.81	2.02	2.45	1.44	2.22	38.3	64000
8.00	*4.00*	*12.00*				*1.65*	*2.00*		*3.00*	*32.5*	
12.40	2.30	14.70				0.62	0.75	0.72	0.86	28.0	64001
10.00	*4.00*	*14.00*				*0.41*	*0.50*		*1.00*	*22.1*	
8.85	2.60	11.45	2.09		1.00	3.09	3.75	1.06	5.20	51.6	64004
8.00	*4.00*	*12.00*				*2.47*	*3.00*		*5.00*	*43.4*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	Bones, Fine Bone
	The American Agr'l Chem. Co., Inc., Cincinnati, O.		
64096	A. A. C. Ground Bone	L. B. Sievers & Son, Somerset	83
64097		Hill Hardware Co., Bowling Green	87
64585		Hill Hardware Co., Bowling Green	75
64586		Woodson Lewis, Greensburg	70
	Armour Fertilizer Works, Louisville, Ky., Cincinnati, O., Nashville, Tenn.		
64172	Armour's Big Crop Bone Meal	Lebanon Carriage & Impl. Co., Lebanon	83
64173		Barren Co. Grocery & Hdw. Co., Glasgow	77
64626		Lebanon Carriage & Impl. Co., Lebanon	79
64783		Wilson, Winn & Co., Russellville	66
64174	Armour's Big Crop Raw Bone	Ed. Allen & Co., Smith's Grove	100
64175		Moss & Gibson, Crestwood	64
64784		The T. J. Turley Co., Owensboro	100
63522	Armour's Big Crop Kentucky Bone Meal	Manufacturer	76
64521	Bone Meal		
64786	Bone Meal	Jenkins-Essex Co., Elizabethtown	78
	Buhner Fertilizer Co., Seymour, Ind.		
64517	Buhner's Raw Bone	Manufacturer	56
	Calumet Fertilizer Co., New Albany, Ind.		
64194	Calumet Br. Spl. Pure Bone Meal	Pearson & Breedlove, Franklin	76
64635		I. K. Miller & Sons, Campbellsville	69
64636		A. W. Tarter, Columbia	69

BONES, TANKAGE, &c.

PERCENTAGE OF FINENESS		Total Phosphoric Acid.	Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Fine Bone	Medium Bone					From Muriate	From Sulfate		
83	17	31.10	67.92	1.71	2.08			35.1	64096
87	13	28.50	62.25	1.67	2.03			32.8	64097
75	25	29.40	64.21	1.97	2.39			35.3	64585
70	30	30.95	67.62	1.60	1.94			34.4	64586
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
83	17	26.00	56.77	3.02	3.67			38.9	64172
77	23	27.00	58.96	2.55	3.10			36.9	64173
79	21	28.15	61.48	2.50	3.04			37.5	64626
66	34	27.30	59.62	3.00	3.64			39.8	64783
		24.00	*52.42*	*2.47*	*3.00*			*34.0*	
100		23.80	51.96	3.59	4.36			40.6	64174
64	36	24.00	52.42	3.60	4.37			40.8	64175
100		25.00	54.59	2.85	3.46			37.1	64784
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
76	24	26.25	57.33	2.26	2.74			34.6	63522
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
									64521
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
78	22	26.70	58.31	2.99	3.63			39.3	64786
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
56	44	21.50	46.95	4.20	5.10			42.4	64517
		20.00	*43.67*	*3.71*	*4.50*			*38.3*	
76	24	34.70	75.77	0.72	0.87			32.1	64194
69	31	34.80	76.00	0.62	0.75			31.6	64635
69	31	34.80	76.00	0.66	0.80			31.8	64636
		30.00	*65.52*	*0.82*	*1.00*			*28.9*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Calumet Fertilizer Co.	
63771	Calumet Br. Raw Bone Meal	
	The Cincinnati Phosphate Co., (owned and operated by Armour Fertilizer Works) Cincinnati, O.	
63615	Bone Meal	
63616	Raw Bone	Manufacturer
64547	Bone Meal	
64548	Bone Meal	
	Consolidated Chem. Co., Louisville, Ky.	
63992	Camel Brand Raw Bone	Manufacturer
63993	Camel Brand Steamed Bone	Manufacturer
	Duncan & Sherley, LaGrange, Ky.	
64574	Tiger Brand Raw Bone Meal	Manufacturer's warehouse
	The Empire Guano Co., Nashville, Tenn.	
63280	Bone Mixture	Manufacturer
63281	Raw Bone Meal	Manufacturer
	The Evansville Packing Co., Evansville, Ind.	
63461	Bone Meal	Manufacturer

BONES,

PERCENTAGE	
Fine Bone	
100	
59	
78	
45	
56	
40	
72	

BONES, TANKAGE, &c.

PERCENTAGE OF FINENESS		Total Phosphoric Acid.	Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Fine Bone	Medium Bone					From Muriate	From Sulfate		
									63771
		20.00	*43.67*	*3.71*	*4.50*			*38.3*	
									63615
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
100		23.60	51.55	4.05	4.92			43.2	63616
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
									64547
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
									64548
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
59	41	20.80	45.43	4.70	5.71			44.8	63992
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
78	22	30.40	66.39	0.74	0.90			28.8	63993
		30.00	*65.52*	*1.03*	*1.25*			*30.2*	
45	55	22.55	49.26	4.05	4.92			42.3	64574
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
56	44	19.30	42.16	1.86	2.26			26.6	63280
		20.00	*43.67*	*1.23*	*1.50*			*23.4*	
40	60	20.85	45.54	5.06	6.14			47.0	63281
		20.00	*43.67*	*3.71*	*4.50*			*38.3*	
72	28	36.20	79.07	0.58	0.70			32.4	63461
		29.00	*63.34*	*0.82*	*1.00*			*28.1*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Evansville Packing Co.	
64225	Pure Raw Bone Meal	C. B. Carden and Co., Hartford.....
	Federal Chemical Co., Inc., Louisville, Ky.	
64794	Daybreak Raw Bone	St. Matthews Produce Exchange, St. Matthews .....
64253	Pure Bone	J. S. Whitfill, Leitchfield.....
64652		Planters Hdw. Co., Hopkinsville.....
63743	1st Prize Raw Bone	Manufacturer .....
	Fox Chemical Co., Br. Federal Chemical Co., Inc. Louisville, Ky.	
63800	Fox Raw Bone	Manufacturer .....
	Globe Fert. Co., Br. Federal Chem. Co., Inc., Louisville, Ky.	
63831	Globe Raw Bone	Manufacturer .....
	Groves Fertilizer Works, Cincinnati, Ohio.	
64023	Bone Meal	Manufacturer .....
64313	Raw Bone	S. V. Kissee, Ingle .....
	Hall Seed Co., Louisville, Ky.	
63573	Halco Bone Meal	Manufacturer .....
63574	Halco Raw Bone	Manufacturer .....

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 Sulfate	Index of Relative Value	Station Number.
52	48	25.20	55.04	3.45	4.19			40.9	64225
		23.00	*50.24*	*3.71*	*4.50*			*40.7*	
74	26	22.40	48.92	3.90	4.73			41.3	64794
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
74	26	34.50	75.36	0.78	0.95			32.3	64253
72	28	34.50	75.35	0.86	1.04			32.8	64652
		30.00	*65.52*	*1.03*	*1.25*			*30.2*	
50	50	23.65	51.66	4.38	5.32			45.2	63743
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
50	50	23.65	51.66	4.38	5.32			45.2	63800
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
50	50	23.65	51.66	4.38	5.32			45.2	63831
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
84	16	29.30	63.98	1.58	1.92			32.9	64023
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
59	41	24.35	53.17	4.11	4.99			44.1	64313
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
76	24	26.25	57.33	2.26	2.74			34.6	63573
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
79	21	23.70	51.73	3.99	4.84			42.9	63574
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Hopkins Fertilizer Co., New Albany, Ind.	
64685	Pure Raw Bone	J. J. Eskridge, Leitchfield.....
64798		Duncan and Sherley, LaGrange.....
63875	Pure Steamed Bone	Manufacturer .....
64687	Bone Meal and Phosphate	J. J. Eskridge, Leitchfield.....
64688	Pig Knuckle Bone Meal	J. J. Eskridge, Leitchfield.....
	International Agri. Corp., Inc., Cincinnati, O.	
63427	I. A. C. Bone Mixture	Manufacturer .....
64336	I. A. C. Bone Meal	W. E. Ellis and Bro., Hartford.....
64346	Buffalo Special Bone and Phosphate	W. B. Davis, Princeton.....
	The Jarecki Chem. Co. (Armour owned), Cincinnati, O.	
63590	Bone Meal	
63591	Raw Bone	Manufacturer .....
64539	Bone Meal	
64546	Bone Meal	
	The Kaufman Fert. Co. (Owned and operated by Armour Fert. Works), Cincinnati, O.	
63638	Bone Meal	
63639	Raw Bone	Manufacturer .....

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 Sulfate	Index of Relative Value	Station Number.
53	47	20.90	45.65	3.82	4.64			39.6	64685
64	36	22.00	48.06	4.17	5.06			42.6	64798
		21.50	*46.95*	*3.51*	*4.25*			*38.3*	
73	27	31.50	68.79	0.74	0.90			29.6	63875
		29.00	*63.34*	*0.82*	*1.00*			*28.1*	
80	20	20.50	44.77	1.13	1.37			23.2	64687
		21.00	*45.87*	*1.03*	*1.25*			*23.0*	
75	25	23.40	51.10	1.90	2.31			30.1	64688
		22.00	*48.06*	*2.00*	*2.43*			*29.6*	
83	17	23.50	51.33	0.95	1.15			24.5	63427
		22.00	*48.06*	*0.82*	*1.00*			*22.5*	
74	26	29.60	64.65	1.56	1.89			33.0	64336
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
78	22	22.50	49.15	0.95	1.15			23.7	64346
		22.00	*48.06*	*0.82*	*1.00*			*22.5*	
									63590
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
100		23.60	51.55	4.05	4.92			43.2	63591
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
									64539
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
									64546
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
									63638
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
100		23.60	51.55	4.05	4.92			43.2	63639
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The Kaufman Fertilizer Co.	
64549	Bone Meal	
64550	Bone Meal	
	Ky. Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.	
63859	O. K. Raw Bone	Manufacturer
	Louisville Fertilizer Co. (Armour owned), Lou. Ky., Cin. O., Nash., Tenn.	
63488	Bone Meal	Manufacturer
64393	Raw Bone	D. E. Patterson, Hodgenville
64397	Kentucky Bone Meal	Yopp Seed Co., Paducah
64519	Bone Meal	
64720	Bone Meal	Hurst-Brown Hardware Co., Bardstown
64721		Yopp Seed Co., Paducah
	Morris and Co., Chicago, Ill.	
64819	Morris Big Seven	Farmers' Union Supply Co., Franklin
	Mt. Pleasant Fertilizer Co., Inc., Mt. Pleasant, Tenn.	
64725	Mt. Pleasant Half and Half	Farmers' Union Supply Co., Franklin

Bones, Tankage, &c.

PERCENTAGE OF FINENESS		Total Phosphoric Acid.	Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Fine Bone	Medium Bone					From Muriate	From Sulfate		
									64549
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
									C4550
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
50	50	23.65	51.66	4.38	5.32			45.2	63859
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
72	28	27.40	59.85	2.49	3.02			36.9	63488
		24.00	*52.42*	*2.47*	*3.00*			*34.0*	
									63489
29	71	24.85	54.27	4.00	4.86			43.9	64393
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
70	30	29.85	65.18	1.89	2.29			35.2	64397
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
									64519
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
32	68	25.20	55.04	4.01	4.87			44.2	64720
71	29	28.70	62.68	2.11	2.56			35.6	64721
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
71	29	20.40	44.56	1.00	1.21			22.3	64819
		22.00	*48.06*	*0.82*	*1.00*			*22.5*	
69	31	26.70	58.31	1.62	1.97			31.1	64725
		20.00	*43.67*	*1.65*	*2.00*			*25.9*	

TABLE II.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	New Louisville Rendering Co., Inc., Louisville, Ky.	
64041	Pure Animal Matter, Meat, Bones and Blood	
64042	Pure Bone Meal	—
	Price Chemical Co., Inc., Louisville, Ky.	
63966	Raw Bone	Manufacturer
64424	Steamed Bone	John Keeton, Monticello
	Read Phosphate Co., Nashville, Tenn.	
63265	Bone Mixture	Manufacturer
64445	Pure Raw Bone Meal	O. D. Smith, Jamestown
64446		Hollingsworth-Young Hdw. Co., Bowling Green
	Smith Brothers, New Albany, Ind.	
64552	Pure Raw Bone	
	Swift and Co., National Stock Yards, Ill.	
64475	Swifts' 2¼-29 Bone Meal Fertilizer	J. L. Townsend and Co., Clay
64476		Clay Sutherland, Monticello
64754		Mayhew and Gilbert, Franklin
64477	Swifts' Raw Bone Meal Fertilizer	Mayhew and Gilbert, Franklin

Bones, Tankage, &c.

Percentage of Fineness		Total Phosphoric Acid.	Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	Potash		Index of Relative Value	Station Number.
Fine Bone	Medium Bone					From Muriate	From Sulfate		
									64041
		10.00	*21.85*	*4.00*	*4.86*			*32.0*	
									64042
		22.00	*48.06*	*3.50*	*4.25*			*38.6*	
59	41	20.80	45.43	4.70	5.71			44.8	63966
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
71	29	30.45	66.50	0.78	0.95			29.0	64424
		30.00	*65.52*	*1.03*	*1.25*			*30.2*	
56	44	19.30	42.16	1.86	2.26			26.6	63265
		20.00	*43.67*	*1.23*	*1.50*			*23.4*	
31	69	23.00	50.24	3.77	4.58			41.0	64445
45	55	22.25	48.59	3.86	4.69			41.0	64446
		20.00	*43.67*	*3.71*	*4.50*			*38.3*	
									64552
		21.50	*46.95*	*3.50*	*4.25*			*38.2*	
80	20	29.95	65.41	1.73	2.10			34.3	64475
84	16	29.30	63.98	2.21	2.68			36.7	64476
82	18	30.80	67.28	1.79	2.17			35.4	64754
		29.00	*63.34*	*1.85*	*2.25*			*34.3*	
73	27	25.50	51.33	4.17	5.06			45.4	64477
		23.00	*50.24*	*3.71*	*4.50*			*40.7*	

TABLE II.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Taylor and Powell Fertilizer Co. Inc., Springfield, Tenn.	
64053	Half and Half	Manufacturer .....
64054	Pure Raw Bone Meal	Manufacturer .....
	Tennessee Chemical Co. (Armour owned), Lou., Ky., Cin., O., Nash., Tenn.	
64489	Ox Bone Meal	W. F. Grainger, Franklin.....
63558	Ox Raw Bone	
64492	Ox Kentucky Bone Meal	J. J. Shaver, Mayfield.....
64523	Bone Meal	
64524	Bone Meal	
	Virginia-Carolina Chemical Co., Inc., Cincinnati, O.	
64513	V-C Raw Bone Meal	R. H. Chrisman, Berea.....
64514		C. E. Preston, Smith's Grove.....
64773	V-C Pure Bone Meal	Patrick Dillon, Hardinsburg.....

BONES, TANKAGE, &c.

PERCENTAGE OF FINENESS		Total Phosphoric Acid.	Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	POTASH		Index of Relative Value	Station Number.
Fine Bone	Medium Bone					From Muriate	From Sulfate		
86	14	21.80	47.61	1.77	2.15			28.1	64053
		20.00	*43.67*	*1.65*	*2.00*			*25.9*	
100		25.30	55.27	3.54	4.30			41.5	64054
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
78	22	27.40	59.85	2.57	3.12			37.3	64489
		24.00	*52.42*	*2.47*	*3.00*			*34.0*	
									63558
		22.00	*48.06*	*3.71*	*4.50*			*39.9*	
79	21	26.90	58.76	2.69	3.27			37.7	64492
		27.00	*58.96*	*1.65*	*2.00*			*31.5*	
									64523
		30.00	*65.52*	*1.85*	*2.25*			*35.1*	
									64524
		27.00	*58.96*	*2.47*	*3.00*			*36.4*	
65	35	20.95	45.77	3.65	4.43			38.7	64513
67	33	23.65	51.66	3.68	4.47			41.0	64514
		20.00	*43.67*	*3.71*	*4.50*			*38.3*	
100		25.50	55.68	3.30	4.01			40.2	64773
		22.00	*48.06*	*2.47*	*3.00*			*32.4*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	A. D. Adair and McCarty Bros., Inc., Atlanta, Ga. and Chattanooga, Tenn.						
64088	Adair's High Grade Acid Phosphate No. 16	C. A. Castel, East Bernstadt.....	18.10	1.10	19.20	21.7	64088
64089		W. C. Stewart, Horse Cave.....	18.55	0.45	19.00	22.3	64089
			16.00			*19.2*	
	The American Agri. Chem. Co., Inc., Cincinnati, O.						
63300	Bowker's 10% Acid Phosphate	Manufacturer	11.50	1.30	12.80	13.8	63300
			10.00	*2.00*	*12.00*	*12.0*	
63301	Bowker's Soluble Bone	Manufacturer	15.55	1.50	17.05	18.7	63301
			14.00	*2.00*	*16.00*	*16.8*	
64099	Bowker's 16% Acid Phosphate	Mayhew and Gilbert, Franklin....	18.55	1.40	19.95	22.3	64099
64100		L. B. Sievers and Son, Somerset...	16.95	1.60	18.55	20.3	64100
64587		Gooch and Payne, Eubank.....	17.40	1.50	18.90	20.9	64587
64588		Mayhew and Gilbert, Franklin....	18.10	1.20	19.30	21.7	64588
			16.00	*2.00*	*18.00*	*19.2*	
63318	Bowker's 20% Acid Phosphate	Manufacturer	21.20	2.00	23.20	25.4	63318
			20.00	*2.00*	*22.00*	*24.0*	
63319	Bradley's 10% Acid Phosphate	Manufacturer	11.50	1.30	12.80	13.8	63319
			10.00	*2.00*	*12.00*	*12.0*	
63320	Bradley's Soluble Dissolved Bone	Manufacturer	15.55	1.50	17.05	18.7	63320
			14.00	*2.00*	*16.00*	*16.8*	
64113	Bradley's 16% Acid Phosphate	G. V. Green, Caneyville.....	18.60	1.05	19.65	22.3	64113
			16.00	*2.00*	*18.00*	*19.2*	
63335	Bradley's 20% Acid Phosphate	Manufacturer	21.20	2.00	23.20	25.4	63335
			20.00	*2.00*	*22.00*	*24.0*	
63336	Cleveland Dryer Works, Horsehead						

63320	Bradley's Soluble Dissolved Bone	Manufacturer	14.00	2.00	16.00	16.8	
64113	Bradley's 16% Acid Phosphate	G. V. Green, Caneyville	18.60 16.00	1.05 2.00	19.65 18.00	22.3 19.2	64113
63335	Bradley's 20% Acid Phosphate	Manufacturer	21.20 20.00	2.00 2.00	23.20 22.00	25.4 24.0	63335
63336	Cleveland Dryer Works Horsehead Phosphate	Manufacturer	11.50 10.00	1.30 2.00	12.80 12.00	13.8 12.0	63336
64114	Cleveland Dryer Works XXX Super-Phosphate	Wesley and Jasper, Mangum	16.45 14.00	1.05 2.00	17.50 16.00	19.7 16.8	64114
64115	Cleveland Dryer Works 16% Acid Phosphate	Wesley and Jasper, Mangum	18.05	1.35	19.40	21.7	64115
64116		H. M. Tomes, Caneyville	18.20	1.00	19.20	21.8	64116
64597		H. M. Tomes, Caneyville	18.00 16.00	1.30 2.00	19.30 18.00	21.6 19.2	64597
63352	Cleveland Dryer Works 20% Acid Phosphate		21.20 20.00	2.00 2.00	23.20 22.00	25.4 24.0	63352
64117	Michigan Carbon Works 10% Acid Phosphate	Albert Long, Scottsville	12.90 10.00	0.85 2.00	13.75 12.00	15.5 12.0	64117
64118	Red Lime Phosphate	Albert Long, Scottsville	16.15	1.00	17.15	19.4	64118
64599		Albert Long, Scottsville	16.40 14.00	1.90 2.00	18.30 16.00	19.7 16.8	64599
64119	Michigan Carbon Works 16% Acid Phosphate	The Jansen Hardware Co., Covington	18.10	0.90	19.00	21.7	64119
64120		Denton Hardware Co., Madisonville	17.85	0.70	18.55	21.4	64120
64600		Scaggs and Nunn, Horse Cave	17.20	1.40	18.60	20.6	64600
64775		Greenup Milling Co., Grayson	18.40 16.00	1.40 2.00	19.80 18.00	22.1 19.2	64775
63371	Michigan Carbon Works 20% Acid Phosphate	Manufacturer	21.20 20.00	2.00 2.00	23.20 22.00	25.4 24.0	63371
64136	N. W. Horseshoe Br. Quick Acting Phosphate	Sam Terry, Big Clifty	11.95	1.00	12.95	14.3	64136
64609		Frank Baker, Clarkson	10.15 10.00	2.35 2.00	12.50 12.00	12.2 12.0	64609
64137	N. W. Horseshoe Br. Square Deal Phosphate	Sam Terry, Big Clifty	15.85	1.45	17.30	19.0	64137
64610		Woodson Lewis, Greensburg	15.10 14.00	1.50 2.00	16.60 16.00	18.1 16.8	64610

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	The American Agri. Chem. Co.						
64138	N. W. Horseshoe Br. 16% Acid Phosphate	J. C. Phelps, Morgantown	18.60	1.40	20.00	22.3	64138
64139		Woodson Lewis, Greensburg	17.85	1.40	19.25	21.4	64139
64611		Woodson Lewis, Greensburg	17.10	2.00	19.10	20.5	64611
		Dickey and Co., Glasgow	18.20	1.40	19.60	21.8	64612
64612			*16.00*	*2.00*	*18.00*	*19.2*	
63390	N. W. Horseshoe Br. 20% Acid Phosphate	Manufacturer	21.20	2.00	23.20	25.4	63390
			20.00	*2.00*	*22.00*	*24.0*	
63391	Packers Boars Hd. Br. Soluble Phosphate	Manufacturer	11.50	1.30	12.80	13.8	63391
			10.00	*2.00*	*12.00*	*12.0*	
63392	Packers Boars Hd. Br. Gilt Edge Phosphate	Manufacturer	15.55	1.50	17.05	18.7	63392
			14.00	*2.00*	*16.00*	*16.8*	
64149	Packers Boars Head Br. 16% Acid Phosphate	R. Z. Hook, Hardinsburg	18.55	1.15	19.70	22.3	64149
			16.00	*2.00*	*18.00*	*19.2*	
63409	Packers Boars Head Br. 20% Acid Phosphate	Manufacturer	21.20	2.00	23.20	25.4	63409
			20.00	*2.00*	*22.00*	*24.0*	
	Armour Fertilizer Works, Louisville, Ky., Cincinnati, Ohio and Nashville, Tennessee						
64176	Armour's Big Crop Sixteen Per Cent	Pearson and Breelove, Franklin	16.30	2.20	18.50	19.6	64176
64177		M. T. Jasper and Son, Mintonville	16.05	1.65	17.70	19.3	64177
64627		Frank Henry, Center	16.15	2.30	18.45	19.4	64627
64628		G. W. Collins, Glens Fork	16.15	1.40	17.55	19.4	64628
			16.00	*1.00*	*17.00*	*19.2*	

64176	Armour's Big Crop Sixteen Per Cent	Pearson and Breelove, Franklin...	16.30	2.20	18.50	19.6	64176
64177		M. T. Jasper and Son, Mintonville.	16.05	1.65	17.70	19.3	64177
64627		Frank Henry, Center.....	16.15	2.30	18.45	19.4	64627
64628		G. W. Collins, Glens Fork.....	16.15	1.40	17.55	19.4	64628
			16.00	*1.00*	*17.00*	*19.2*	
64178	Armour's Big Crop Twenty Per Cent	W. O. Cropper, Burtonville.....	20.85	0.95	21.80	25.0	64178
			20.00	*1.00*	*21.00*	*24.0*	
64181	Ideal Super Phosphate	T. J. Turley Co., Owensboro.....	13.70	2.20	15.90	16.4	64181
64785		T. J. Turley Co., Owensboro.....	18.30	2.10	20.40	22.0	64785
			16.00	*1.00*	*17.00*	*19.2*	
64059	Armour's Fourteen Per Cent						64059
			14.00	*1.00*	*15.00*	*16.8*	
	C. S. Brent Seed Co., Inc., Lexington, Ky.						
64569	Brent's Acid Phosphate	Manufacturer's warehouse	16.80	0.45	17.25	20.2	64569
			16.00			*19.2*	
	Calumet Fertilizer Co., New Albany, Ind.						
64192	Calumet Br. 16% Acid Phosphate	Frank Baker, Clarkson.....	18.25	0.30	18.55	21.9	64192
64193		Sturgis Impl. and Hdw. Co., Sturgis	17.40	0.45	17.85	20.9	64193
			16.00	*2.00*	*18.00*	*19.2*	
	The Cincinnati Phos. Co. (owned and operated by Armour Fertilizer Works), Cincinnati, O.						
64196	Acid Phosphate	G. W. Collins, Glensfork.....	17.69	1.15	18.84	21.2	64196
64638		L. R. Hart, Big Clifty.....	16.90	0.30	17.20	20.3	64638
			16.00	*1.00*	*17.00*	*19.2*	
63622	Acid Phosphate		20.75	1.75	22.50	24.9	63622
			20.00	*1.00*	*21.00*	*24.0*	
	Consolidated Chemical Co., Louisville, Ky.						
64209	Camel Brand H. Gr. Phosphate	J. R. Duncan, Monticello.....	18.25	2.40	20.65	21.9	64209
64640		E. S. Ferrell and Sons, Buffalo.....	17.00	0.90	17.90	20.4	64640
			16.00	*2.00*	*18.00*	*19.2*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	Consolidated Chemical Co.						
63991	Camel Brand Acid Phosphate	Manufacturer	22.40	0.70	23.10	26.9	63991
			14.00	*2.00*	*16.00*	*16.8*	
	Darling and Co., Chicago, Ill.						
64071	Darling's 16% Acid Phosphate						64071
			16.00			*19.2*	
	Duncan and Sherley, LaGrange, Ky.						
64790	Tiger Brand Phosphate	Manufacturer's warehouse	17.80	3.80	21.60	21.4	64790
			16.00	*2.00*	*18.00*	*19.2*	
	The Empire Guano Co., Nashville, Tenn.						
63278	High Grade Acid Phosphate	Manufacturer	17.20	1.90	19.10	20.6	63278
			14.00	*4.00*	*18.00*	*16.8*	
64215	Climax Acid Phosphate	Young Hardware Co., Hopkinsville	20.30	0.65	20.95	24.4	64215
64216		C. I. Medaris, Esto	17.95	2.25	20.20	21.5	64216
64643		G. W. Collins, Glens Fork	16.50	3.50	20.00	19.8	64643
64793		Calloway County Farm Bureau, Murray	17.90	3.90	21.80	21.5	64793
			16.00	*2.00*	*18.00*	*19.2*	
	The Evansville Packing Co., Evansville, Ind.						

	The Evansville Packing Co., Evansville, Ind.						
64217	H. Gr. Acid Phosphate	Atherton-Kidd Co., Livermore.....	17.00	0.60	17.60	20.4	64217
64218		C. B. Carden and Co., Hartford...	16.70	0.50	17.20	20.0	64218
			16.00			*19.2*	
	Federal Chemical Co., Inc., Louisville, Ky.						
64236	Daybreak H. Gr. Phosphate	Birk and Price Co., Owensboro....	17.20	2.00	19.20	20.6	64236
64237		Burks and Anderson, Monticello...	16.85	0.90	17.75	20.2	64237
64647		A. W. Tarter, Columbia.....	18.50	1.20	19.70	22.2	64647
64648		Grayson County Supply Co., Leitchfield	17.45	0.35	17.80	20.9	64648
			16.00	*2.00*	*18.00*	*19.2*	
63688	Daybreak Royal Phosphate	Manufacturer	16.60	3.70	20.30	19.9	63688
			14.00	*2.00*	*16.00*	*16.8*	
63689	Daybreak Standard Phosphate	Manufacturer	14.55	7.40	21.95	17.5	63689
			12.00	*2.00*	*14.00*	*14.4*	
63690	Daybreak Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63690
			10.00	*10.00*	*20.00*	*12.0*	
63717	Extra H. Gr. Phosphate	Manufacturer	18.30	0.25	18.55	22.0	63717
			18.00	*2.00*	*20.00*	*21.6*	
63719	Blue Bull Phosphate	Manufacturer	18.40	0.25	18.65	22.1	63719
			16.00			*19.2*	
63996	A A Phosphate	Manufacturer	12.20	3.50	15.70	14.6	63996
			10.00	*2.00*	*12.00*	*12.0*	
64261	1st Prize H. Gr. Phosphate	Bob Humphrey, Central City.....	19.05	0.90	19.95	22.9	64261
64657		Stewart and Co., Munfordville....	18.00	0.90	18.90	21.6	64657
64658		Farmers' Union Supply Co., Russelville	16.95	1.15	18.10	20.3	64658
			16.00	*2.00*	*18.00*	*19.2*	
63740	1st Prize Phosphate	Manufacturer	16.60	3.70	20.30	19.9	63740
			14.00	*2.00*	*16.00*	*16.8*	
63741	1st Prize Standard Phosphate	Manufacturer	14.55	7.40	21.95	17.5	63741
			12.00	*2.00*	*14.00*	*14.4*	
63742	1st Prize Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63742
			10.00	*10.00*	*20.00*	*12.0*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	Fox Chemical Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.						
64270	Fox H. Gr. Phosphate	J. S. Whitfill, Big Clifty	16.00	1.20	17.20	19.2	64270
64271		K. J. McKenney, Brodhead	16.90	0.70	17.60	20.3	64271
64661		Ed Foster, Liberty	18.45	0.55	19.00	22.1	64661
			16.00	*2.00*	*18.00*	*19.2*	
64272	Fox Phosphate	J. S. Whitfill, Big Clifty	14.90	0.70	15.60	17.9	64272
			14.00	*2.00*	*16.00*	*16.8*	
63798	Fox Standard Phosphate	Manufacturer	14.55	7.40	21.95	17.5	63798
			12.00	*2.00*	*14.00*	*14.4*	
63799	Fox Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63799
			10.00	*10.00*	*20.00*	*12.0*	
	Globe Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.						
64067	Globe H. Gr. Phosphate	J. B. Gardner, Murray	17.75	2.30	20.05	21.3	64067
64068		J. B. Gardner, Murray	17.85	1.75	19.60	21.4	64068
64291		J. H. Carter, Strode	17.35	0.55	17.90	20.8	64291
64668		Farmers' Union Supply Co., Bowling Green	17.50	1.05	18.55	21.0	64668
64669		Burton and Pyles, Ella	16.95	1.60	18.55	20.3	64669
			16.00	*2.00*	*18.00*	*19.2*	
64292	Globe Phosphate	I. K. Miller and Sons, Campbellsville	16.20	1.65	17.85	19.4	64292
			14.00	*2.00*	*16.00*	*16.8*	
64293	Globe Standard Phosphate	I. K. Miller and Sons, Campbellsville	13.15	0.75	13.90	15.8	64293
			12.00	*2.00*	*14.00*	*14.4*	
63830	Globe Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63830
			10.00	*10.00*	*20.00*	*12.0*	
	Groves Fertilizer Works, Cincinnati, Ohio						
64311	16% Acid Phosphate	S. V. Kissee, Ingle	17.35	1.50	18.85	20.8	64311

63830	Globe Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63830
			10.00	*10.00*	*20.00*	*12.0*	
	Groves Fertilizer Works, Cincinnati, Ohio						
64311	16% Acid Phosphate	S. V. Kissee, Ingle	17.35	1.50	18.85	20.8	64311
64676		T. Z. Leachman, Greensburg	16.45	2.05	18.50	19.7	64676
64677		J. C. Everett and Co., Maysville	17.05	2.15	19.20	20.5	64677
			16.00	*1.00*	*17.00*	*19.2*	
64312	Monarch Brand	J. F. Collings, Shepherdsville	13.35	1 25	14.60	16.0	64312
64678		I. K. Miller and Sons, Campbellsville	14.35	1.95	16.30	17.2	64678
			14.00	*1.00*	*15.00*	*16.8*	
	Hall Seed Co., Louisville, Ky.						
64679	Halco Acid Phosphate	Dulworth and Durham, Greensburg	15.70	1.70	17.40	18.8	64679
			16.00	*1.00*	*17.00*	*19.2*	
64680	Halco 14% Phosphate	Dulworth and Durham, Greensburg	13.95	2.25	16.20	16.7	64680
			14.00	*2.00*	*16.00*	*16.8*	
	Hopkins Fertilizer Co., New Albany, Ind.						
64325	Climax Acid Phosphate	Conner, Hayden and Co., Bardstown	18.80	2.70	21.50	22.6	64325
64326		Floyd Nealy, Glasgow	18.10	2.90	21.00	21.7	64326
64686		J. J. Eskridge, Leitchfield	17.00	3.20	20.20	20 4	64686
			16.00	*2.00*	*18.00*	*19.2*	
	International Agri. Corp., Inc., Cincinnati, O.						
63424	I. A. C. Extra H. Gr. Acid Phosphate	Manufacturer	18.70	3.55	22.25	22.4	63424
			18.00	*1.00*	*19.00*	*21.6*	
64333	I. A. C. Standard Acid Phosphate	C. M. Langdon, Science Hill	18.10	2.30	20.40	21.7	64333
64334		V. B. Nichols, Elkton	18.50	2.20	20.70	22.2	64334
64693		C. M. Langdon, Science Hill	18.15	2.10	20.25	21.8	64693
64694		Eldred Hardware Co., Princeton	16.20	2.00	18.20	19.4	64694
			16.00	*2.00*	*18.00*	*19.2*	
64335	I. A. C. Dissolved Phosphate	C. M. Langdon, Science Hill	15.10	3.40	18.50	18.1	64335
			14.00	*2.00*	*16.00*	*16.8*	
63442	Buffalo 18% Acid Phosphate	Manufacturer	18.70	3.55	22.25	22.4	63442
			18.00	*1.00*	*19.00*	*21.6*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	International Agricultural Corp.						
64343	Buffalo 16% Acid Phosphate	Tartar-Ham and Co., Somerset....	17.55	2.90	20.45	21.1	64343
64698		M. R. Wheldon, Waynesburg.....	17.85	2.00	19.85	21.4	64698
64699		London Hardware Co., London....	17.60	2.85	20.45	21.1	64699
			16.00	*2.00*	*18.00*	*19.2*	
64344	Buffalo Dissolved Phosphate	Tarter-Ham and Co., Somerset....	15.55	4.40	19.95	18.7	64344
64345		R. Y. Ballard, Waynesburg.....	14.80	4.70	19.50	17.8	64345
			14.00	*2.00*	*16.00*	*16.8*	
	The Jarecki Chemical Co., (Armour owned). Cincinnati, O						
64352	Acid Phosphate	C. L. and F. F. Dudley, Flemingsburg	16.55	0.95	17.50	19.9	64352
64353		J. E. Cain, Hogue.....	15.25	2.30	17.55	18.3	64353
64700		Fred Evans, Tompkinsville.....	15.45	1.80	17.25	18.5	64700
			16.00	*1.00*	*17.00*	*19.2*	
63598	Acid Phosphate	Manufacturer	20.75	1.75	22.50	24.9	63598
			20.00	*1.00*	*21.00*	*24.0*	
	The Kaufman Fert. Co., (Owned and operated by Armour Fert. Works), Cincinnati, O.						
64361	Acid Phosphate	James Roe, Mouth of Laurel.....	16.85	0.60	17.45	20.2	64361
			16.00	*1.00*	*17.00*	*19.2*	
63645	Acid Phosphate	Manufacturer	20.75	1.75	22.50	24.9	63645
			20.00	*1.00*	*21.00*	*24.0*	
	Ky. Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.						
64370	O. K. High Grade Phosphate	J. L. Siler, Corbin.....	17.55	0.55	18.10	21.1	64370
64371		T. G. Moren, London.....					

63645	Acid Phosphate	Manufacturer	16.00	1.00	17.00	19.2	
			20.75	1.75	22.50	24.9	63645
			20.00	1.00	21.00	24.0	
	Ky. Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.						
64370	O. K. High Grade Phosphate	J. L. Siler, Corbin	17.55	0.55	18.10	21.1	64370
64371		T. G. Moren, London	16.10	0.90	17.00	19.3	64371
64704		Smith and Smith, Shepherdsville	17.75	0.40	18.15	21.3	64704
64705		C. M. Hill, Cecelia	17.25	1.00	18.25	20.7	64705
			16.00	2.00	18.00	19.2	
64372	O. K. Phosphate	L. R. Hart, Big Clifty	15.95	0.80	16.75	19.1	64372
			14.00	2.00	16.00	16.8	
64706	O. K. Standard Phosphate	Smith and Smith, Shepherdsville	12.70	0.50	13.20	15.2	64706
			12.00	2.00	14.00	14.4	
63858	O. K. Special Phosphate Mixture	Manufacturer	12.70	9.40	22.10	15.2	63858
			10.00	10.00	20.00	12.0	
	Louisville Fert. Co., (Armour owned). Lou., Ky., Cin., O., Nash., Tenn.						
64290	Sixteen Per Cent	Elkin and Kimmel, Greenville	15.55	2.10	17.65	18.7	64290
64394		Hurst Brown Hardware Co., Bardstown	16.70	1.70	18.40	20.0	64394
64395		G. D. James, Rocky Hill	17.90	2.05	19.95	21.5	64395
64716		S. E. Redford, Glasgow	16.30	1.75	18.05	19.6	64716
64717		S. A. Browning, Vanceburg	16.35	1.15	17.50	19.6	64717
			16.00	1.00	17.00	19.2	
64396	Twenty Per Cent	Durham Produce Co., Columbia	19.95	1.60	21.55	23.9	64396
			20.00	1.00	21.00	24.0	
64719	Louisville Fourteen Per Cent	Ratliff Hdw. Co., Princeton	13.50	2.35	15.85	16.2	64719
			14.00	1.00	15.00	16.8	
	Morris and Co., Chicago, Ill.						
64829	Morris H. Gr. Acid Phosphate	Manufacturer	15.95	1.15	17.10	19.1	64829
			16.00			19.2	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	Mt. Pleasant Fert. Co., Inc., Mt. Pleasant, Tenn.						
64400	Mt. Pleasant Big Winner Acid Phosphate	Farmers Union Supply Co., Franklin	17.90	1.80	19.70	21.5	64400
64401		Grigsby and Co., Bardstown	18.55	0.85	19.40	22.3	64401
64723		Cayce-Yost Co., Hopkinsville	18.80	4.20	23.00	22.6	64723
64724		Egner and Vaughn, Benton	17.40	1.40	18.80	20.9	64724
			16.00	*2.00*	*18.00*	*19.2*	
63649	Black Patch Mt. Pleasant Spl. Acid Phosphate	Manufacturer	16.00	3.30	19.30	19.2	63649
			14.00	*2.00*	*16.00*	*16.8*	
63650	Black Patch Mt. Pleasant Soluble Bone	Manufacturer	12.45	9.30	21.75	14.9	63650
			12.00	*2.00*	*14.00*	*14.4*	
63651	Mt. Pleasant Acid Phosphate	Manufacturer	10.85	13.25	24.10	13.0	63651
			10.00	*2.00*	*12.00*	*12.0*	
64555	Mt. Pleasant H. Gr. Acid Phosphate	Manufacturer	21.20	0.65	21.85	25.4	64555
			20.00	*2.00*	*22.00*	*24.0*	
	The Peerless Chemical Co., Columbia, Tenn.						
64065	16% Peerless Acid Phosphate	J. B. Gardner, Murray	17.20	2.80	20.00	20.6	64065
64066		J. B. Gardner, Murray	16.15	3.35	19.50	19.4	64066
64076		Harry Gatton, Elizabethtown	18.35	2.15	20.50	22.0	64076
64408		Warren Co. Farm Bureau, Bowling Green	17.85	2.80	20.65	21.4	64408
64409		Barren Co. Farm Bureau, Glasgow	17.80	2.50	20.30	21.4	64409
64653		W. H. Adams, Olmstead	15.90	4.05	19.95	19.1	64653
64727		Allen Co. Farm Bureau, Scottsville	18.20	2.30	20.50	21.8	64727
64728		Fred Kelly, Bowling Green	18.70	1.80	20.50	22.4	64728

64076		Harry Gatton, Elizabethtown	18.35	2.15	20.50	22.0	64076
64408		Warren Co. Farm Bureau, Bowling Green	17.85	2.80	20.65	21.4	64408
64409		Barren Co. Farm Bureau, Glasgow	17.80	2.50	20.30	21.4	64409
64653		W. H. Adams, Olmstead	15.90	4.05	19.95	19.1	64653
64727		Allen Co. Farm Bureau, Scottsville	18.20	2.30	20.50	21.8	64727
64728		Fred Kelly, Bowling Green	18.70	1.80	20.50	22.4	64728
64801		St. Matthews Produce Exchange, St. Matthews	19.60	1.80	21.40	23.5	64801
			16.00			*19.2*	
	Price Chemical Co., Inc., Louisville, Ky.						
64422	H. Gr. Phosphate	W. A. Johnson, Brodhead	15.40	1.50	16.90	18.5	64422
64423		G. W. Richardson, Somerset	16.75	1.65	18.40	20.1	64423
64731		Peoples Store, Loretto	17.70	0.30	18.00	21.2	64731
64732		Farmers Union Supply Co., Glasgow	18.60	1.40	20.00	22.3	64732
			16.00	*2.00*	*18.00*	*19.2*	
63965	Acid Phosphate	Manufacturer	22.40	0.70	23.10	26.9	63965
			14.00	*2.00*	*16.00*	*16.8*	
	Rainbow Guano Co., (Sub. of Int. Agri. Corp.) Florence, Ala.						
63744	Rainbow Pure H. Gr. Acid Phosphate	Manufacturer	17.40	0.80	18.20	20.9	63744
			16.00	*1.00*	*17.00*	*19.2*	
	Rasin-Monumental Co., (Sub. of Va.-Car. Chem. Co., Inc.,) Cin., Ohio						
64425	Rasin's 16% Acid Phosphate	R. D. Robinson, Mayfield	19.20	0.85	20.05	23 0	64425
64426		J. H. Wyan, London	17.95	2.35	20.30	21.5	64426
64733		J. H. Wyan, London	18.20	1.90	20.10	21.8	64733
64734		Lessenbery and Jones, Glasgow	17.70	4.00	21.70	21.2	64734
			16.00	*1.50*	*17.50*	*19.2*	
64735	Rasin's 20% Acid Phosphate	J. H. Wyan, London	21.30	1.80	23.10	25 6	64735
			20.00	*1.50*	*21.50*	*24.0*	
63908	Rasin's 24% Acid Phosphate						63908
			24.00	*1.50*	*25.50*	*28.8*	
63923	Rasin's Phospho Tobacco	Manufacturer	19.90	1.30	21.20	28.9	63923
			16.00	*1.50*	*17.50*	*19.2*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	Read Phosphate Co., Nashville, Tenn.						
64430	XXX Dissolved Bone	Hatcher and Rawls, Cerulean.....	18.60	2.00	20.60	22.3	64430
64738		U. G. Antle, Columbia.....	16.30	4.00	20.30	19.6	64738
			12.00	*6.00*	*18.00*	*14.4*	
64431	High Grade Acid Phosphate	Hatcher and Rawls, Cerulean.....	18.05	2.45	20.50	21.7	64431
			14.00	*4.00*	*18.00*	*16.8*	
64432	Special High Grade Acid Phosphate	Lester-Crawford and Baugh, Science Hill	18.50	1.50	20.00	22.2	64432
64433		Hollingsworth-Young Hdw. Co., Bowling Green	18.75	1.90	20.65	22.5	64433
64739		J. H. Jasper, Somerset.....	19.00	2.80	21.80	22.8	64739
64740		B. F. Beard and Co., Hardinsburg..	17.60	4.00	21.60	21.1	64740
			16.00	*2.00*	*18.00*	*19.2*	
	The Smith Agricultural Chem. Co., Columbus, O.						
64031	Smith's 16% Acid Phosphate	Manufacturer	17.05	0.35	17.40	20.5	64031
			16.00			*19.2*	
64040	Smith's 20% Acid Phosphate	Manufacturer	21.70	0.30	22.00	26.0	64040
			20.00			*24.0*	
	Southern Agricultural Chem. Corp., Atlanta, Ga.						
63772	High Grade Acid Phosphate	Manufacturer	18.30	0.90	19.20	22.0	63772
			16.00			*19.2*	
	Southern Fertilizer Co., Inc., Louisville, Ky.						
64450	Atlas Phosphate	Conrad-Payne and Co., Cloverport.	16.25	0.55	16.80	19.5	64450

			16.00			*19.2*	
	Southern Fertilizer Co., Inc., Louisville, Ky.						
64450	Atlas Phosphate	Conrad-Payne and Co., Cloverport.	16.25	0.55	16.80	19.5	64450
			16.00			*19.2*	
	Southern Fertilizer and Chemical Co., Savannah, Ga.						
63748	Southern Acid Phosphate 16%	Manufacturer	17.00	0.50	17.50	20.4	63748
			16.00	*0.50*	*16.50*	*19.2*	
	Swift and Co., National Stock Yards, Ill.						
64471	Swift's H. Gr. Acid Phosphate Fertilizer	Rufus Tarter, Oil Center.....	18.05	0.65	18.70	21.7	64471
64472		E. M. Ford and Sons, Cave City..	17.80	0.50	18.30	21.4	64472
64752		E. M. Ford and Sons, Cave City..	18.50	0.50	19.00	22.2	64752
64808		W. S. Overstreet, LaGrange.....	16.40	2.80	19.20	19.7	64808
			16.00			*19.2*	
64534	Swift's Red Steer 20% Acid Phosphate	Manufacturer	23.15	0.35	23.50	27.8	64534
			20.00	*1.00*	*21.00*	*24.0*	
	Taylor and Powell Fertilizer Co., Inc., Springfield, Tenn.						
64051	16% Acid Phosphate	Manufacturer	15.95	1.75	17.70	19.1	64051
			16.00			*19.2*	
	Tennessee Chemical Co., (Armour owned). Lou., Ky., Cin., O., Nash., Tenn.						
64490	Ox Sixteen Per Cent	The Young Co., Columbia.....	17.35	1.55	18.90	20.8	64490
64491		P. A. Blackwell and Co., Henderson	16.30	1.80	18.10	19.6	64491
64758		Dickinson Bros., Glasgow.....	17.00	2.20	19.20	20.4	64758
64759		Marion Milling Co., Marion.....	17.60	1.00	18.60	21.1	64759
			16.00	*1.00*	*17.00*	*19.2*	

Table III.—Acid Phosphates.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	PHOSPHORIC ACID			Index of Relative Value	Station Number.
			Available	Insoluble	Total		
	Tennessee Chemical Co.						
63560	Ox Twenty Per Cent	Manufacturer	22.50	0.50	23.00	27.0	63560
			20.00	*1.00*	*21.00*	*24.0*	
64760	Ox Fourteen Per Cent	F. M. Mitchell, Scottsville	15.10	2.40	17.50	18.1	64760
			14.00	*1.00*	*15.00*	*16.8*	
64761	Ox Twelve Per Cent Phosphate	J. M. Johnson, Benton	13.90	2.40	16.30	16.7	64761
			12.00	*1.00*	*13.00*	*14.4*	
	Tennessee Coal, Iron and Railroad Co., Birmingham, Ala.						
64495	Duplex Basic Phosphate	Farmers Union Supply Co., Franklin			18.45	22.1	64495
64496		Farmers Union Supply Co., Somerset			18.85	22.6	64496
64764		Farmers Union Supply Co., Glasgow			18.50	22.2	64764
64765		Taylor County Supply Co., Campbellsville			18.30	22.0	64765
					18.00	*21.60*	
63246	14% Duplex Basic Phosphate	Manufacturer			13.45	16.1	63246
					14.00	*16.8*	
63247	12% Duplex Basic Phosphate				*12.00*	*14.4*	63247
	Tupelo Fertilizer Factory, Tupelo, Miss.						
64046	Cotton Belt H. Gr. Acid Phosphate	Manufacturer	19.65	1.45	21.10	23.6	64046
			16.00	*1.00*	*17.00*	*19.2*	
64047	Tupelo Special H. Gr. Acid Phosphate	Manufacturer	20.10	0.10	20.20	24.1	64047
			18.00	*1.00*	*19.00*	*21.6*	
	Victor Guano Co., Nashville, Tenn.						

64046	Cotton Belt H. Gr. Acid Phosphate	Manufacturer	16.00	1.00	17.00	19.2	
64047	Tupelo Special H. Gr. Acid Phosphate	Manufacturer	20.10	0.10	20.20	24.1	64047
			18.00	*1.00*	*19.00*	*21.6*	
	Victor Guano Co., Nashville, Tenn.						
63292	High Grade Acid Phosphate	Manufacturer	17.20	1.90	19.10	20.6	63292
			14.00	*4.00*	*18.00*	*16.8*	
64498	Special High Grade Acid Phosphate	Lambert-Gresham Hdw. Co., Henderson	19.65	0.85	20.50	23.6	64498
64499		L. F. Hubble, Somerset	18.10	2.10	20.20	21.7	64499
64766		L. F. Hubble, Somerset	17.50	3.70	21.20	21.0	64766
			16.00	*2.00*	*18.00*	*19.2*	
	Virginia-Carolina Chem. Co., Inc., Cincinnati, O.						
64500	V-C 16% Acid Phosphate	Wayne County Farm Bureau, Monticello	17.55	1.00	18.55	21.1	64500
64501		Taylor County Supply Co., Campbellsville	18.60	1.90	20.50	22.3	64501
64767		Thurman and Enlow, Hodgenville	19.40	3.00	22.40	23.3	64767
64768		Taylor County Supply Co., Campbellsville	19.70	3.30	23.00	23.6	64768
			16.00	*1.50*	*17.50*	*19.2*	
64502	V-C 20% Acid Phosphate	Vine Grove Feed Co., Vine Grove	22.40	1.70	24.10	26.9	64502
64503		R. H. Chrisman, Berea	21.30	1.90	23.20	25.6	64503
			20.00	*1.50*	*21.50*	*24.0*	
63882	V-C 24% Acid Phosphate						63882
			24.00	*1.50*	*25.50*	*28.8*	
63883	V-C Phospho Tobacco	Manufacturer	19.90	1.30	21.20	23.9	63883
			16.00	*1.50*	*17.50*	*19.2*	
64774	V-C 14% Acid Phosphate	C. B. Cardon and Co., Hartford	15.60	8.00	23.60	18.7	64774
			14.00	*2.00*	*16.00*	*16.8*	
	Wood, Stubbs and Co., Inc., Louisville, Ky.						
64005	Acme High Grade Phosphate						64005
			16.00	*2.00*	*18.00*	*19.2*	

Table IV.—Acid Phosphates with Potash.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	Phosphoric Acid: Available	Phosphoric Acid: Insoluble	Phosphoric Acid: Total	Potash: From Muriate	Potash: From Sulphate	Index of Relative Value	Station Number.
	A. D. Adair and McCarty Bros., Inc., Atlanta, Ga., Chattanooga, Tenn.								
63754	Adair's Formula	Manufacturer	10.30 *10.00*	0.30	10.60	1.76 *2.00*		20.9 *21.0*	63754
63834	Adair's High Grade Potash Compound	Manufacturer	10.50 *10.00*	0.40	10.90	4.03 *4.00*		28.0 *27.0*	63834
	The American Agri. Chem. Co., Inc., Cincinnati, O.								
63298	A. A. C. High Grade Bone and Potash	Manufacturer	11.00 *10.00*	1.00 *2.00*	12.00 *12.00*	5.42 *5.00*		33.2 *30.8*	63298
64101	Bowker's Dissolved Bone With Potash	Jones and Harrison, Allegree	12.60	1.15	13.75	2.19		25.9	64101
64589		S. D. Harlin, Gamaliel	11.05	1.00	12.05	2.29		23.9	64589
64590		Jones and Harrison, Allegree	10.95 *10.00*	1.05 *2.00*	12.00 *12.00*	2.29 *2.00*		23.7 *21.8*	64590
63306	Bowker's Acid Phosphate and Potash	Manufacturer	12.70 *12.00*	0.80 *2.00*	13.50 *14.00*	2.20 *2.00*		26.0 *24.8*	63306
64111	Bowker's Potash Fertilizer	R. L. McFerron, Mt. Vernon	11.70	0.70	12.40	5.14	0.72	35.4	64111
64595		T. E. Richardson, Campbellsville	10.85	1.00	11.85	5.22		32.3	64595
64596		Mayhew and Gilbert, Franklin	11.60 *10.00*	1.00 *2.00*	12.60 *12.00*	4.92 *5.00*		32.6 *30.8*	64596
63322	Bradley's Alkaline Bone with Potash	Manufacturer	10.95 *10.00*	0.95 *2.00*	11.90 *12.00*	2.06 *2.00*		23.0 *21.8*	63322
63323	Bradley's Twelve-Two	Manufacturer	12.70 *12.00*	0.80 *2.00*	13.50 *14.00*	2.20 *2.00*		26.0 *24.8*	63323

64596			*10.00*	*2.00*	*12.00*	*5.00*		*30.8*	
63322	*Bradley's Alkaline Bone with Potash*								
		Manufacturer	10.95	0.95	11.90	2.06		23.0	63322
			10.00	*2.00*	*12.00*	*2.00*		*21.8*	
63323	Bradley's Twelve-Two	Manufacturer	12.70	0.80	13.50	2.20		26.0	63323
			12.00	*2.00*	*14.00*	*2.00*		*24.8*	
63339	Cleveland Dryer Works, Soluble Bone with Potash	Manufacturer	10.95	0.95	11.90	2.06		23.0	63339
			10.00	*2.00*	*12.00*	*2.00*		*21.8*	
63340	Cleveland Dryer Works Twelve-Two	Manufacturer	12.70	0.80	13.50	2.20		26.0	63340
			12.00	*2.00*	*14.00*	*2.00*		*24.8*	
64121	Red Line Phosphate with Potash	E. Farris and Co., Cave City	11.65	0.60	12.25	1.22	1.15	24.8	64121
			10.00	*2.00*	*12.00*	*2.00*		*21.8*	
63357	Michigan Carbon Works Twelve-Two	Manufacturer	12.70	0.80	13.50	2.20		26.0	63357
			12.00	*2.00*	*14.00*	*2.00*		*24.8*	
64133	Michigan Carbon Works High Potash Phos.	Albert Long, Scottsville	11.65	0.65	12.30	4.42	1.07	34.2	64133
			10.00	*2.00*	*12.00*	*5.00*		*30.8*	
63375	N-W Horseshoe Br. Bone with Potash	Manufacturer	10.95	0.95	11.90	2.06		23.0	63375
			10.00	*2.00*	*12.00*	*2.00*		*21.8*	
63376	N-W Horseshoe Brand Twelve-Two	Manufacturer	12.70	0.80	13.50	2.20		26.0	63376
			12.00	*2.00*	*14.00*	*2.00*		*24.8*	
63388	N-W Horseshoe Brand 10-5 Potash Manure	Manufacturer	11.00	1.00	12.00	5.42		33.2	63388
			10.00	*2.00*	*12.00*	*5.00*		*30.8*	
63394	Packer's Boars Head Br. Ky. Potash Mixture	Manufacturer	10.95	0.95	11.90	2.06		23.0	63394
			10.00	*2.00*	*12.00*	*2.00*		*21.8*	
63395	Packer's Boars Head Br. Twelve-Two	Manufacturer	12.70	0.80	13.50	2.20		26.0	63395
			12.00	*2.00*	*14.00*	*2.00*		*24.8*	
63407	Packer's Boars Head Br. Potash Phosphate Fertilizer	Manufacturer	11.00	1.00	12.00	5.42		33.2	63407
			10.00	*2.00*	*12.00*	*5.00*		*30.8*	

Table IV.—Acid Phosphates with Potash.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	Phosphoric Acid: Available	Phosphoric Acid: Insoluble	Phosphoric Acid: Total	Potash: From Muriate	Potash: From Sulphate	Index of Relative Value	Station Number.
	Armour Fertilizer Works, Lou., Ky., Cin., O., Nash., Tenn.								
64161	Armour's Big Crop Ten-Ten	Joe Waddle, Munfordville..	10.00 *10.00*	1.50 *1.00*	11.50 *11.00*	10.86 *10.00*		48.2 *45.4*	64161
64162	Armour's Big Crop Phosphate and Potash	Thurman and Enlow, Hodgenville	12.20 *12.00*	0.20 *1.00*	12.40 *13.00*	2.03 *2.00*		24.5 *24.4*	64162
63510	Armour's Big Crop Potash Formula	Manufacturer	12.70 *12.00*	1.50 *1.00*	14 20 *13.00*	4.89 *4.00*		34.3 *30.4*	63510
64179	Armour's Potash Mixture	Cadiz Hardware Co., Cadiz.	9.65 *10.00*	7.10 *1.00*	16.75 *11.00*	2.38 *2.00*		24.5 *21.4*	64179
64630	Armour's Big Crop Wheat Grower	Cayce-Yost Co., Hopkinsvill	9.80 *10.00*	1.80 *1.00*	11.60 *11.00*	5.10 *5.00*		30.7 *30.4*	64630
	Calumet Fertilizer Co., New Albany, Ind.								
64190	Calumet Brand Phosphate and Potash	Sturgis Impl. and Hdw. Co., Sturgis	11.35 *10.00*	0.45 *4.00*	11.80 *14.00*	0.54 *2.00*	1.06	22.0 *22.6*	64190
64191	Calumet Brand Ten Five	Frank Baker, Clarkson.....	11.80 *10.00*	0.80 *4.00*	12.60 *14.00*	1.28 *5.00*	3.35	31.9 *31.6*	64191
	The Cincinnati Phosphate Co., (Owned and operated by Ar-								

64191	Calumet Brand Ten Five	Frank Baker, Clarkson.....	11.80 *10.00*	0.80 *4.00*	12.60 *14.00*	1.28 *5.00*	3.35	31.9 *31.6*	64191
	The Cincinnati Phosphate Co., (Owned and operated by Armour Fert. Works), Cin., O.								
63611	Dissolved Phosphate and Potash	Manufacturer	12.30 *12.00*	1.40 *1.00*	13.70 *13.00*	4.29 *4.00*		31.9 *30.4*	63611
63612	Alkaline Phosphate	Manufacturer	12.10 *12.00*	1.40 *1.00*	13.50 *13.00*	2.00 *2.00*		24.7 *24.4*	63612
63623	Ten Ten Fertilizer	Manufacturer	10.10 *10.00*	1.00 *1.00*	11.10 *11.00*	10.46 *10.00*		46.9 *45.4*	63623
	Consolidated Chemical Co., Louisville, Ky.								
63988	Camel Brand Potash Tobacco Fertilizer	Manufacturer	11.70 *10.00*	0.70 *2.00*	12.40 *12.00*	0.94	5.05 *5.00*	35.8 *30.8*	63988
63989	Camel Brand Phosphate and Potash	Manufacturer	11.40 *10.00*	0.50 *2.00*	11.90 *12.00*	0.54	2.09 *2.00*	25.2 *21.8*	63989
	Darling and Co., Chicago, Ill.								
64070	Darling's Ten Five		 *10.00*	 *1.00*	 *11.00*	 *5.00*		 *30.4*	64070
	The Empire Guano Co., Nashville, Tenn.								
64642	Bone and Potash	G. W. Collins, Glen's Fork..	12.05 *10.00*	6.80 *8.00*	18.85 *18.00*	1.52 *2.00*	0.51	26.9 *24.2*	64642
63277	H. Gr. Potash Phosphate	Manufacturer	12.45 *10.00*	3.05 *7.00*	15.50 *17.00*	3.57 *4.00*		30.6 *29.8*	63277

Table IV.—Acid Phosphates with Potash.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	Phosphoric Acid: Available	Phosphoric Acid: Insoluble	Phosphoric Acid: To	Potash: From Muriate	Potash: From Sulphate	Index of Relative Value	Station Number.
	The Evansville Packing Co., Evansville, Ind.								
63450	Phosphate and Potash	Manufacturer	15.00 *10.00*	0.15	15.15	2.83 *2.00*		31.1 *21.0*	63450
	Federal Chemical Co., Inc., Louisville, Ky.								
63683	Daybreak Champion Potash Fertilizer	Manufacturer	11.20 *8.00*	11.80 *8.00*	23.00 *16.00*		2.85 *2.00*	30.1 *21.2*	63683
64235	Daybreak Potash Special	Burks and Anderson, Monticello	10.60 *10.00*	0.80 *2.00*	11.40 *12.00*	1.76	 *2.00*	21.5 *21.8*	64235
63685	Daybreak Potash Mixture	Manufacturer	11.85 *10.00*	7.75 *2.00*	19.60 *12.00*		4.93 *4.00*	35.7 *27.8*	63685
63686	Daybreak Phosphate and Potash	Manufacturer	15.30 *12.00*	3.80 *2.00*	19.10 *14.00*		2.97 *2.00*	33.4 *24.8*	63686
63712	Double Phosphate and Potash Formula	Manufacturer	11.60 *8.00*	8.80 *8.00*	20.40 *16.00*		4.25 *4.00*	33.7 *27.2*	63712
63713	Potash Special	Manufacturer	13.75 *10.00*	6.90 *2.00*	20.65 *12.00*		2.68 *2.00*	31.4 *21.8*	63713
63714	Potash Mixture	Manufacturer	12.45 *10.00*	7.60 *2.00*	20.05 *12.00*		4.85 *4.00*	36.3 *27.8*	63714
63715	Potash Compound	Manufacturer	15.30 *12.00*	3.80 *2.00*	19.10 *14.00*		2.97 *2.00*	33.4 *24.8*	63715
64795	Black Land Special	St. Matthews Produce Exchange, St. Matthews	14.60 *12.00*	0.80 *2.00*	15.40 *14.00*		4.18 *4.00*	34.8 *30.8*	64795
63738	Mogul Potash Fertilizer	Manufacturer	11.20	11.80	23.00		2.85	30.1	63738

64795	Black Land Special	St. Matthews Produce Exchange, St. Matthews....	14.60	0.80	15.40		4.18	34.2	64795
			12.00	*2.00*	*14.00*		*4.00*	*30.8*	
63738	Mogul Potash Fertilizer	Manufacturer	11.20	11.80	23.00		2.85	30.1	63738
			8.00	*8.00*	*16.00*		*2.00*	*21.2*	
	Fox Chem. Co., Br. Federal Chem. Co., Inc., Louisville, Ky.								
63792	Fox Ideal Potash Fertilizer	Manufacturer	11.20	11.80	23.00		2.85	30.1	63792
			8.00	*8.00*	*16.00*		*2.00*	*21.2*	
63793	Fox Potash Special	Manufacturer	13.80	7.20	21.00		2.64	31.5	63793
			10.00	*2.00*	*12.00*		*2.00*	*21.8*	
63794	Fox Bone Phosphate and Potash	Manufacturer	11.85	7.75	19.60		4.93	35.7	63794
			10.00	*2.00*	*12.00*		*4.00*	*27.8*	
63795	Fox Bone Phosphate	Manufacturer	15.30	3.80	19.10		2.97	33.4	63795
			12.00	*2.00*	*14.00*		*2.00*	*24.8*	
	Globe Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.								
63823	Globe Tip Top Potash Fertilizer	Manufacturer	11.20	11.80	23.00		2.85	30.1	63823
			8.00	*8.00*	*16.00*		*2.00*	*21.2*	
63824	Globe Potash Special	Manufacturer	13.80	7.20	21.00		2.64	31.5	63824
			10.00	*2.00*	*12.00*		*2.00*	*21.8*	
64667	Globe Bone Phosphate and Potash	Hutchenson Bros., Auburn ..	11.20	2.45	13.65	3.65		28.7	64667
			10.00	*2.00*	*12.00*		*4.00*	*27.8*	
63826	Globe Potash Compound	Manufacturer	15.30	3.80	19.10		2.97	33.4	63826
			12.00	*2.00*	*14.00*		*2.00*	*24.8*	
	Groves Fertilizer Works, Cincinnati, O.								
64013	Corn and Tobacco	Manufacturer	10.90	0.50	11.40	2 04		22.7	64013
			10.00	*1.00*	*11.00*	*2.00*		*21.4*	

Table IV.—Acid Phosphates with Potash.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	PHOSPHORIC ACID			POTASH		Index of Relative Value	Station Number.
			Available	Insoluble	Total	From Muriate	From Sulphate		
	Groves Fertilizer Works, Cincinnati, O.								
64303	Phosphate and Potash	Minges Hardware Co., Newport	10.05	1.70	11.75	2.89		24.4	64303
			10.00	*1.00*	*11.00*	*4.00*		*27.4*	
64304	Ten and Ten	J. O. McAninch, Joyce	11.35	1.50	12.85	4.52	5.64	48.1	64304
			10.00	*1.00*	*11.00*	*10.00*		*45.4*	
	Hopkins Fertilizer Co., New Albany, Ind.								
									64533
64533	Double Action		*11.00*	*2.00*	*13.00*	*3.00*		*26.3*	
	International Agricultural Corp., Inc., Cincinnati, O.								
64691	I. A. C. Standard Potash Mixture	V. B. Nuckols, Elkton	10.95	1.55	12.50	4.44		30.4	64691
			10.00	*5.00*	*15.00*	*5.00*		*32.0*	
64692	I. A. C. Potash Fertilizer	Sturgis Impl. and Hdw. Co. Sturgis	13.05	1.25	14.30	2.37		27.3	64692
			12.00	*5.00*	*17.00*	*2.00*		*26.0*	
63440	Buffalo Potash Mixture	Manufacturer	10.70	2.20	12.90	5.11		32.3	63440
			10.00	*5.00*	*15.00*	*5.00*		*32.0*	
63441	Buffalo Phosphate and Potash	Manufacturer	13.40	3.55	16.95	0.74	1.36	27.7	63441
			12.00	*5.00*	*17.00*	*2.00*		*26.0*	
	The Jarecki Chem. Co., (Armour owned). Cincinnati, O.								
63586	Cross Phosphate and Potash	Manufacturer	12.30	1.40	13.70		4.29	31.9	63586
			12.00	*5.00*	*17.00*		*2.00*	*26.0*	

	The Jarecki Chem. Co., (Armour owned). Cincinnati, O.								
63586	Super Phosphate and Potash	Manufacturer	12.30	1.40	13.70		4.29	31.9	63586
			12.00	*1.00*	*13.00*	*4.00*		*30.4*	
63587	Phosphate and Potash	Manufacturer	12.10	1.40	13.50	2.00		24.7	63587
			12.00	*1.00*	*13.00*	*2.00*		*24.4*	
63597	Big Ben Ten Ten	Manufacturer	10.10	1.00	11.10	10.46		46.9	63597
			10.00	*1.00*	*11.00*	*10.00*		*45.4*	
	The Kaufman Fert. Co. (Owned and operated by Armour Fert. Works). Cincinnati, O.								
63634	Dissolved Phosphate and Potash	Manufacturer	12.30	1.40	13.70	4.29		31.9	63634
			12.00	*1.00*	*13.00*	*4.00*		*30.4*	
63635	Alkaline Phosphate	Manufacturer	12.10	1.40	13.50	2.00		24.7	63635
			12.00	*1.00*	*13.00*	*2.00*		*24.4*	
63646	Ten Ten Fertilizer	Manufacturer	10.10	1.00	11.10	10.46		46.9	63646
			10.00	*1.00*	*11.00*	*10.00*		*45.4*	
	Ky. Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.								
63853	Gold Metal Potash Fertilizer	Manufacturer	11.20	11.80	23.00		2.85	30.1	63853
			8.00	*8.00*	*16.00*		*2.00*	*21.2*	
63854	O. K. Potash Special	Manufacturer	13.80	7.20	21.00		2 64	31.5	63854
			10.00	*2.00*	*12.00*		*2.00*	*21.8*	
	Louisville Fert. Co., Armour owned). Lou., Ky., Cin., O., Nash., Tenn.								
63475	Phosphate and Potash	Manufacturer	12.50	2.05	14.55	2.18		26.1	63475
			12.00	*1.00*	*13.00*	*2.00*		*24.4*	
64712	Black Soil Special	Irvington Hdw. and Impl. Co., Irvington	12.60	0.85	13.45	3.56		29.9	64712
			12.00	*1.00*	*13.00*	*4.00*		*30.4*	
63477	Big Ben								63477
			10.00	*1.00*	*11.00*	*10.00*		*45.4*	

Table IV.—Acid Phosphates with Potash.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	Phosphoric Acid: Available	Phosphoric Acid: Insoluble	Phosphoric Acid: Total	Potash: From Muriate	Potash: From Sulphate	Index of Relative Value	Station Number.
	Louisville Fertilizer Co.								
64382	Superior Tobacco Grower	D. E. Patterson, Hodgenville	12.00	0.70	12.70	1.72	2.85	32.0	64382
			10.00	*1.00*	*11.00*		*5.00*	*30.4*	
63492	Potash Mixture	Manufacturer	10.80	2.35	13.15	2.23		32.3	63492
			10.00	*1.00*	*11.00*	*2.00*		*21.4*	
64722	Wheat Grower	Copple Bros., Guthrie	10.00	2.10	12.10	4.80		30.2	64722
			10.00	*1.00*	*11.00*	*5.00*		*30.4*	
	Morris & Co., Chicago, Ill.								
64832	Morris Big Five	Manufacturer	10.40	0.75	11.15	1.12	4.91	34.0	64832
			10.00	*1.00*	*11.00*		*4.00*	*27.4*	
	Mt. Pleasant Fert. Co., Inc., Mt. Pleasant, Tenn.								
64405	Mt. Pleasant Superior Tobacco Grower	Mrs. Myrtle Scruggs, Adairville	10.15	4.60	14.75	3.87		28.7	64405
			8.00	*2.00*	*10.00*		*4.00*	*24.8*	
64529	Mt. Pleasant Bone and Potash	Manufacturer	11.10	12.30	23.40	3.44		31.9	64529
			10.00	*4.00*	*14.00*		*3.00*	*25.6*	
64726	Black Patch Wheat and Clover	Farmers' Union Supply Co, Franklin	11.50	12.30	23.80	1.94		28.1	64726
			10.00	*4.00*	*14.00*		*2.00*	*22.6*	
64553	Mt. Pleasant 10-0-5	Manufacturer	10.55	9.75	20.30	5.65		36.7	64553
			10.00	*2.00*	*12.00*		*5.00*	*30.8*	
	Price Chemical Co., Inc., Louis-								

64553	Mt. Pleasant 10-0-5	Manufacturer	10.55 *10.00*	9.75 *2.00*	20.30 *12.00*	5.65	*5.00*	36.7 *30.8*	64553
	Price Chemical Co., Inc., Louisville, Ky.								
64421	Potash Tobacco Fertilizer	E. L. Cox, Cub Run	10.80 *10.00*	0.70 *2.00*	11.50 *12.00*	5.16	*5.00*	31.9 *30.8*	64421
63963	Phosphate and Potash	Manufacturer	11.40 *10.00*	0.50 *2.00*	11.90 *12.00*	0.54	2.09 *2.00*	25.2 *21.8*	63963
	Rasin-Monumental Co., (Sub. of Va.-Car. Chem. Co., Inc., Cincinnati, O.								
63909	Rasin's 10-4 Acid and Potash	Manufacturer	12.40 *10.00*	0.70 *1.50*	13.10 *11.50*	0.72 *4.00*	4.05	33.2 *27.6*	63909
63910	Rasins' Royal Grain Grower		*12.00*	*1.50*	*13.50*	*2.00*		*24.6*	63910
	Read Phosphate Co., Nashville, Tenn.								
64741	Alkaline Bone	J. H. Jasper, Somerset	12.60 *10.00*	7.70 *8.00*	20.30 *18.00*	1.66 *2.00*	0.42	28.3 *24.2*	64741
63253	High Grade Potash Mixture	Manufacturer	12.45 *10.00*	3.05 *7.00*	15.50 *17.00*	3.57 *4.00*		30.6 *29.8*	63253
	Swift and Co., National Stock Yards, Ill.								
63931	Swift's 12-4 Phosphate and Potash	Manufacturer	13.70 *12.00*	2.90	16.60	4.05 *4.00*		33.9 *30.0*	63931
63932	Swift's 14-2 Phosphate and Potash	Manufacturer	15.40 *14.00*	3.10	18.50	1.81 *2.00*		29.8 *27.0*	63932

TABLE IV.—ACID PHOSPHATES WITH POTASH.

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained	PHOSPHORIC ACID			POTASH		Index of Relative Value	Station Number.
			Available	Insoluble	Total	From Muriate	From Sulphate		
	Tennessee Chemical Co., (Armour owned). Lou., Ky., Cin., O., Nash., Tenn.								
64482	Ox Big Ben	J. M. Johnson, Benton.....	9.25	2.15	11.70	6.47		34.2	64482
			10.00	*1.00*	*11.00*	*10.00*		*45.4*	
63546	Ox Phosphate and Potash	Manufacturer	12.50	2.05	14.55	2.18		26.1	63546
			12.00	*1.00*	*13.00*	*2.00*		*24.4*	
63547	Ox Potash Formula	Manufacturer	12.70	1.50	14.20	4.89		34.3	63547
			12.00	*1.00*	*13.00*	*4.00*		*30.4*	
63549	Ox Superior Tobacco Grower	Manufacturer	10.45	1.90	12.35		4.87	31.1	63549
			10.00	*1.00*	*11.00*		*5.00*	*30.4*	
63561	Ox Potash Mixture	Manufacturer	10.80	2.35	13.15	2.23		32.3	63561
			10.00	*1.00*	*11.00*	*2.00*		*21.4*	
64762	Ox Wheat Grower	G. W. Collins, Glen's Fork..	10.70	1.80	12.50	4.24		29.5	64762
64763		R. E. Moore, Madisonville...	12.20	1.20	13.40	4.25		31.5	64763
			10.00	*1.00*	*11.00*	*5.00*		*30.4*	
	Victor Guano Co., Nashville, Tenn.								
63290	Bone and Potash	Manufacturer	11.90	4.60	16.50	2.39		26.9	63290
			10.00	*8.00*	*18.00*	*2.00*		*24.2*	
63291	High Grade Bone and Potash	Manufacturer	12.45	3.05	15.50	3.57		30.6	63291
			10.00	*7.00*	*17.00*	*4.00*		*29.8*	
	Virginia-Carolina Chem. Co., Inc., Cincinnati, O.								
64769	V-C Acid and Potash King	A. W. Tarter, Columbia.....	10.00	8.10	18.10	3.22		27.9	64769

	Virginia-Carolina Chem. Co., Inc., Cincinnati, O.								
64769	V-C Acid and Potash King	A. W. Tarter, Columbia.....	10.00	8.10	18.10	3.22		27.9	64769
			10.00	*1.50*	*11.50*	*4.00*		*27.6*	
63885	V-C Prolific Grain Grower								63885
			12.00	*1.50*	*13.50*	*2.00*		*24.6*	
	Wood, Stubbs and Co., Inc., Louisville, Ky.								
64003	Acme Crop Booster	Manufacturer	10.55	0.65	11.20	1.20	5.45	36.0	64003
			10.00	*2.00*	*12.00*		*5.00*	*30.8*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	A. D. Adair and McCarty Bros., Inc., Atlanta, Ga., Chattanooga, Tenn.	
63835	Adair's Ammoniated Phosphate No. 1220	Manufacturer
	The American Agr. Cmemical Co., Inc., Cincinnati, O.	
64092	A. A. C. Special Tobacco Grower	Bokhara Seed Co., Falmouth
64093		H. T. Simpson, Caneyville
64098	A. A. C. Little Wonder Fertilizer	Sam Terry, Big Clifty
63304	Bowker's 1-10 Am. Acid Phosphate	Manufacturer
63305	Bowker's 2-10 Am. Acid Phosphate	Manufacturer
63307	Bowker's 2-12 Am. Acid Phosphate	Manufacturer
63324	Bradley's 1-10 Am. Acid Phosphate	Manufacturer
63325	Bradley's 2-10 Am. Acid Phosphate	Manufacturer
63326	Bradley's 2-12 Am. Acid Phosphate	Manufacturer
63341	Cleveland Dryer Works 1-10 Am. Acid Phos.	Manufacturer
63342	Cleveland Dryer Works 2-10 Am. Acid Phos.	Manufacturer
63343	Cleveland Dryer Works, 2-12 Am. Acid Phos.	Manufacturer
64122	Michigan Carbon Works 1-10 Am. Acid Phos.	Stevens and Applegate, Epworth
63359	Michigan Carbon Works 2-10 Am. Acid Phos.	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
11.70	1.25	12.95	0.98		1.46	2.44	2.96	32.7	63835
12.00						*1.65*	*2.00*	*27.9*	
11.00	1.50	12.50		0.67	1.19	1.86	2.26	28.3	64092
11.90	1.20	13.10		0.94	0.88	1.82	2.21	29.3	64093
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
10.75	1.50	12.25		0.28	0.65	0.93	1.13	22.3	64098
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.95	1.55	12.50		0.22	0.74	0.96	1.17	22.8	63304
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63305
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63307
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
10.95	1.55	12.50		0.22	0.74	0.96	1.17	22.8	63324
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63325
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63326
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
10.95	1.55	12.50		0.22	0.74	0.96	1.17	22.8	63341
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63342
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63343
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
11.80	0.75	12.55				0.91	1.10	23.5	64122
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63359
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	The American Agricultural Chem. Co., Inc., Cincinnati, O.	
63360	Michigan Carbon Works 2-12—Am. Acid Phos.	Manufacturer
63377	N. W. Horseshoe Br. 1-10 Am. Acid Phos.	Manufacturer
63378	N. W. Horseshoe Br. 2-10 Am. Acid Phos.	Manufacturer
63379	N. W. Horseshoe Br. 2-12 Am. Acid Phos.	Manufacturer
63396	Packers Boars Head Br. 1-10 Am. Acid Phos.	Manufacturer
63397	Packers Boars Head Br. 2-10 Am. Acid Phos.	Manufacturer
63398	Packers' Boars Head Br. 2-12 Am. Acid Phos.	Manufacturer
	Armour Fertilizer Works, Lou., Ky., Cin., O., Nash., Tenn.	
64155	Armour's Tankage and Phosphate	W. S. Overstreet, LaGrange
64620		Lebanon Carriage and Impl. Co., Lebanon
63501	Armour's Grain and Grass Grower	Manufacturer
63506	Armour's Big Crop Vegetable Grower	Manufacturer
64171	Armour's Big Crop Bone Meal and Acid Phosphate	Lebanon Carriage and Impl. Co., Lebanon
64625		Thurman and Enlow, Hodgenville
64782		Merrifield and Humphrey, Bloomfield.

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63360
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
10.95	1.55	12.50		0.22	0.74	0.96	1.17	22.8	63377
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63378
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63379
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
10.95	1.55	12.50		0.22	0.74	0.96	1.17	22.8	63396
10.00	*4.00*	*14.00*				*0.82*	*1.00*	*21.5*	
10.80	1.85	12.65		0.95	0.98	1.93	2.34	27.3	63397
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
13.80	1.20	15.00		0.87	0.89	1.76	2.14	31.7	63398
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
12.25	0.45	12.70				0.81	0.98	23.4	64155
12.45	2.90	15.35		0.24	0.45	0.69	0.84	24.0	64620
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
12.50	2.60	15.10				1.80	2.19	30.6	63501
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
9.85	1.55	11.40	1.75		0.48	2.23	2.71	28.8	63506
10.00	*1.00*	*11.00*				*3.29*	*4.00*	*35.1*	
14.05	7.35	21.40				1.05	1.27	30.3	64171
14.05	8.65	22.70				0.94	1.14	30.2	64625
14.80	5.90	20.70				1.21	1.47	31.8	64782
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Armour Fertilizer Works	
63531	Ideal Corn Grower	Manufacturer .....
	Buhner Fertilizer Co., Seymour, Ind.	
64515	Buhner's 4-10	Manufacturer .....
	Calumet Fertilizer Co., New Albany, Ind.	
63767	Calumet Br. Extra Am. Bone Phosphate	
64025	Calumet Br. Potato and Tobacco Grower	
	The Cincinnati Phosphate Co. (owned and operated by Armour Fert. Works), Cin., O.	
63609	Clay Soil Special	Manufacturer .....
63610	"Bonus" A Humus Phosphate	Manufacturer .....
63614	Bone Meal and Acid Phosphate	Manufacturer .....
	Consolidated Chemical Co., Louisville, Ky.	
63983	Camel Brand High Gr. Tobacco Bed Special	Manufacturer .....
63984	Camel Brand Potato and Tobacco Fertilizer	Manufacturer .....
63985	Camel Brand High Grade Fertilizer	Manufacturer .....

ACID PHOSPHATES WITH NITROGEN.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
10.20	2.25	12.45		1.32	0.59	1.91	2.32	27.7	63531
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*25.3*	
10.65	1.60	12.25		1.67	1.57	3.24	3.93	36.1	64515
10.00						*3.29*	*4.00*	*34.7*	
									63767
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
									64025
10.00	*4.00*	*14.00*				*2.47*	*3.00*	*31.4*	
14.00	1.45	15.45		1.31	0.48	1.79	2.17	32.3	63609
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
13.30	2.10	15.40		0.34	0.47	0.81	0.98	25.7	63610
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
10.35	10.40	20.75				0.90	1.09	25.1	63614
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.70	1.70	13.40	3.22		0.90	4.12	5.00	43.0	63983
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
12.40	1.50	13.90	3.02		0.78	3.80	4.61	42.0	63984
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
12.30	2.00	14.30	1.18		0.81	1.99	2.42	31.2	63985
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Consolidated Chemical Co., Louisville, Ky.	
63986	Camel Brand Corn, Wheat and Oats Grower	Manufacturer
63987	Camel Brand No. 1 Fertilizer	Manufacturer
	Duncan and Sherley, LaGrange, Ky.	
64210	Tiger Brand Phosphate and Tankage	Manufacturer's warehouse
64789		Manufacturer's warehouse
64078	Tiger Brand Potato Grower	Manufacturer
64573	Tiger Brand Corn and Wheat Grower	Manufacturer's warehouse
64791		Manufacturer's warehouse
	The Empire Guano Co., Nashville, Tenn.	
64214	Climax Formula	Darnell Hardware Co., Russell Springs
64525	Half and Half Raw Bone Meal and Acid Phosphate	Manufacturer
	The Evansville Packing Co., Evansville, Ind.	
63447	Ammoniated Phosphate	Manufacturer
63449	Corn and Wheat Grower	Manufacturer
63453	Wonder Growth	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
16.70	1.20	17.90				0.59	0.72	29.1	63986
14.00	*4.00*	*18.00*				*0.41*	*0.50*	*25.1*	
14.00	1.50	15.50				0.55	0.67	24.9	63987
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
13.20	1.30	14.50		0.27	0.49	0.76	0.92	24.9	64210
11.70	2.80	14.50				0.94	1.14	24.3	64789
12.00	*2.00*	*14.00*				*0.82*	*1.00*	*23.7*	
11.95	3.50	15.45				3.46	4.20	40.1	64078
10.00	*2.00*	*12.00*				*3.29*	*4.00*	*35.5*	
10.95	1.25	12.20				0.46	0.56	19.7	64573
12.60	1.80	14.40				0.47	0.57	22.4	64791
10.00	*4.00*	*14.00*				*0.41*	*0.50*	*19.1*	
13.45	3.80	17.25				0.52	0.63	24.8	64214
12.00	*7.00*	*19.00*				*0.41*	*0.50*	*23.3*	
13.60	8.30	21.90				1.96	2.38	35.5	64525
10.00	*10.00*	*20.00*				*1.85*	*2.25*	*30.1*	
17.60	0.25	17.85		0.55	0.40	0.95	1.15	32.2	63447
12.00						*0.41*	*0.50*	*20.5*	
16.35	0.15	16.50		1.66	0.52	2.18	2.65	37.7	63449
10.00						*0.82*	*1.00*	*19.9*	
15.30	0.10	15.40		2.46	0.49	2.95	3.58	40.7	63453
10.00						*1.65*	*2.00*	*24.9*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co., Inc., Louisville, Ky.	
63677	Red Rooster Mixture	Manufacturer
63678	Daybreak Nitro Phosphate	Manufacturer
63679	Daybreak Harvest Home	Manufacturer
63680	Royal Meal Mixture	Manufacturer
63681	Daybreak Double-Duty Corn and Wheat Grower	Manufacturer
63682	Daybreak Half and Half Meal Mixture	Manufacturer
63702	A-1 Fertilizer	Manufacturer
64250	A-1 Corn and Wheat Fertilizer	T. G. Moren, London
64651		L. R. Hart, Big Clifty
63704	A-1 Formula	Manufacturer
63705	High Grade Fertilizer	Manufacturer
63706	A-1 Soluble Vegetable Manure	Manufacturer
63707	A-1 Potato Grower	Manufacturer
64251	A-1 Extra Tobacco Special	J. A. Shaver, Greenville
64577		St. Matthews Produce Exchange, St. Matthews
63709	Liberty Grain Grower	Manufacturer
63710	Standard Meal Mixture	Manufacturer
64252	Liberty Potato Grower	Bob Humphrey, Central City
63732	1st Prize Phosphate Mixture	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
15.00	5.70	20.70		0.83		0.83	1.01	29.8	63677
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
17.90	1.10	19.00		0.75		0.75	0.91	31.8	63678
15.00	*4.00*	*19.00*				*0.41*	*0.50*	*26.6*	
13.30	5.90	19.20		2.61	0.26	2.87	3.48	39.5	63679
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63680
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63681
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.15	9.95	21.10		1.74	0.26	2.00	2.43	32.7	63682
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	
14.50	5.20	19.70		1.12	0.22	1.34	1.63	31.9	63702
12.00	*4.00*	*16.00*				*0.82*	*1.00*	*24.5*	
15.00	0.70	15.70		0.45	0.36	0.81	0.98	27.6	64250
15.50	0.85	16.35		0.55	0.45	1.00	1.21	29.6	64651
14.00	*4.00*	*18.00*				*0.82*	*1.00*	*27.5*	
11.65	9.75	21.40		1.74	0.29	2.03	2.46	33.6	63704
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
14.40	3.70	18.10		2.13	0.23	2.36	2.87	37.2	63705
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
14.40	3.70	18.10		2.13	0.23	2.36	2.87	37.2	63706
12.00	*4.00*	*16.00*				*1.65*	*2.00*	*29.5*	
13.20	3.60	16.80		4.13		4.13	5.01	46.0	63707
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
11.00	9.40	20.40		0.66	2.46	3.12	3.79	39.0	64251
10.35	0.95	11.30		0.86	2.43	3.29	4.00	35.7	64577
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
12.85	9.20	22.05		0.81		0.81	0.98	27.8	63709
10.00	*10.00*	*20.00*				*0.41*	*0.50*	*21.5*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63710
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.55	0.25	11.80		0.63	1.02	1.65	2.00	29.4	64252
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	
15.00	5.70	20.70		0.83		0.83	1.01	29.8	63732
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Federal Chemical Co., Inc., Louisville, Ky.	
63733	1st Prize Ammoniated Bone Phosphate	Manufacturer
63734	Mogul Corn and Wheat Fertilzer	Manufacturer
63735	1st Prize Ammoniated Meal Mixture	Manufacturer
63736	Sweepstakes Corn and Wheat Grower	Manufacturer
63737	Blue Ribbon Meal Mixture	Manufacturer
	Fox Chem. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.	
63787	Red Fox Mixture	Manufacturer
63788	Fox Ammoniated Phosphate	Manufacturer
63789	Fox Ammoniated Fertilizer	Manufacturer
63790	Fox Double-Quick Corn and Wheat Grower	Manufacturer
63791	Fox Half and Half Meal Mixture	Manufacturer
	Globe Fert. Co., Br. Fed. Chem. Co., Inc., Louisville, Ky.	
64666	Globe Gold Medal Mixture	I. K. Miller & Sons, Campbellsville
63819	Globe Grain-O-Phosphate	Manufacturer
63820	Globe Golden Harvest	Manufacturer
63821	Globe Double Value Corn and Wheat Grower	Manufacturer
63822	Globe Half and Half Meal Mixture	Manufacturer

ACID PHOSPHATES WITH NITROGEN.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
17.90	1.10	19.00		0.75		0.75	0.91	31.8	63733
15.00	*4.00*	*19.00*				*0.41*	*0.50*	*26.6*	
14.50	5.20	19.70		1.12	0.22	1.34	1.63	31.9	63734
12.00	*4.00*	*16.00*				*0.82*	*1.00*	*24.5*	
13.30	5.90	19.20		2.61	0.26	2.87	3.48	39.5	63735
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63736
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.15	9.95	21.10		1.74	0.26	2.00	2.43	32.7	63737
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	
15.00	5.70	20.70		0.83		0.83	1.01	29.8	63787
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
17.90	1.10	19.00		0.75		0.75	0.91	31.8	63788
15.00	*4.00*	*19.00*				*0.41*	*0.50*	*26.6*	
13.30	5.90	19.20		2.61	0.26	2.87	3.48	39.5	63789
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
12.60	8.60	21.20		0 97	0.24	1.21	1.47	29.6	63790
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.15	9.95	21.10		1.74	0.26	2.00	2.43	32.7	63791
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	
13.35	1.65	15.00				0.59	0.72	24.2	64666
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
17.90	1.10	19.00		0.75		0.75	0.91	31.8	63819
15.00	*4.00*	*19.00*				*0.41*	*0.50*	*26.6*	
13.30	5.90	19.20		2.61	0.26	2.87	3.48	39.5	63820
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63821
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.15	9.95	21.10		1.74	0.26	2.00	2.43	32.7	63822
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Groves Fertilizer Works, Cincinnati, Ohio	
64011	Grain Grower	Manufacturer
64302	Ammoniated Phosphate	J. C. Bowles, Jeffersontown
64308	Perfect Driller	Aaron Moore, Leitchfield
64309		S. V. Kissee, Somerset
64674		T. Z. Leachman, Greensburg
64675		Aaron Moore, Leitchfield
64310	Bone and Phosphate (Bone Mixture)	I. K. Miller & Sons, Campbellsville
64020	Special Bone Mixture (Bone Mixture)	Manufacturer
	Hall Seed Co., Louisville, Ky.	
63567	Halco Corn and Wheat Grower	Manufacturer
63568	Halco Potato Grower	Manufacturer
63569	Halco Vegetable Grower	Manufacturer
63572	Halco Half Bone and Phosphate	Manufacturer
	Hopkins Fertilizer Co., New Albany, Ind.	
63863	Tankage and Phosphate Special	Manufacturer
63864	Favorite	Manufacturer
64314	Ammoniated Special	Duncan & Sherley, LaGrange
	International Agricultural Corporation, Inc., Cincinnati, O.	
63418	I. A. C. Potato and Truck Grower	Manufacturer

ACID PHOSPHATES WITH NITROGEN.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
12.50	0.80	13.30		0.49	0.39	0.88	1.07	24.4	64011
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
13.70	1.50	15.20		0.80	0.74	1.54	1.87	30.4	64302
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
12.25	5.90	18.15				0.44	0.53	23.4	64308
11.30	6.50	17.80				0.33	0.40	21.5	64309
9.45	7.15	16.60				0.40	0.49	19.4	64674
7.20	6.75	13.95				0.43	0.52	16.1	64675
8.00	*8.00*	*16.00*				*0.41*	*0.50*	*17.7*	
13.70	7.70	21.40				0.90	1.09	26.3	64310
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
12.90	2.95	15.85		0.87	0.83	1.70	2.06	30.7	64020
8.00	*8.00*	*16.00*				*1.65*	*2.00*	*25.1*	
10.40	1.75	12.15		0.66	0.32	0.98	1.19	22.2	63567
10.00	*1.00*	*11.00*				*0.82*	*1.00*	*20.3*	
10.20	2.25	12.45		1.32	0.59	1.91	2.32	27.7	63568
10.00	*1.00*	*11.00*				*1.65*	*2.00*	*25.3*	
9.85	1.55	11.40	1.75		0.48	2.23	2.71	28.8	63569
10.00	*1.00*	*11.00*				*3.29*	*4.00*	*35.1*	
14.00	7.35	21.35				0.81	0.98	28.8	63572
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
13.55	0.95	14.50		0.59	0.21	0.80	0.97	25.5	63863
12.00	*2.00*	*14.00*				*0.82*	*1.00*	*23.7*	
13.05	0.55	13.60		1.64	0.92	2.56	3.11	35.2	63864
12.00	*2.00*	*14.00*				*1.65*	*2.00*	*28.7*	
14.30	1.70	16.00		1.31	2.02	3.33	4.04	42.1	64314
10.00	*2.00*	*12.00*				*3.29*	*4.00*	*35.5*	
10.65	2.15	12.80	1.17	0.49	1.72	3.38	4.10	37.1	63418
10.00	*5.00*	*15.00*				*3.29*	*4.00*	*36.7*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	International Agri. Corporation	
63419	I. A. C. High Grade Special	Manufacturer
63420	I. A. C. Corn and Grain Grower	Manufacturer
63421	I. A. C. Farmers' Best Friend	Manufacturer
63437	Buffalo H. Gr. Plant Food	Manufacturer
63438	Buffalo Ammoniated Phosphate	Manufacturer
63439	Buffalo Grain Grower	Manufacturer
	The Jarecki Chem. Co. (Armour owned), Cincinnati, O.	
63584	Clay Soil Special	Manufacturer
63585	Ammoniated Phosphate	Manufacturer
63589	Bone Meal and Acid Phosphate	Manufacturer
	The Kaufman Fert. Co. (owned and operated by Armour Fert. Wks.), Cincinnati, O.	
63632	Clay Soil Special	Manufacturer
63633	Ammoniated Phosphate	Manufacturer
63637	Bone Meal and Acid Phosphate	Manufacturer
	Ky. Fert. Co., Br. Federal Chem. Co., Inc., Louisville, Ky.	
63848	O. K. Mixture	Manufacturer
63849	O. K. Ammoniated Phosphate	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
10.15	5.10	15.25	0.83	0.59	1.37	2.79	3.39	34.0	63419
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
13.15	3.90	17.05	0.67	0.32	0.86	1.85	2.25	32.4	63420
12.00	*5.00*	*17.00*				*1.65*	*2.00*	*29.9*	
13.15	4.80	17.95				0.91	1.10	27.1	63421
13.00	*5.00*	*18.00*				*0.82*	*1.00*	*26.4*	
10.15	5.10	15.25	0.83	0.59	1.37	2.79	3.39	34.0	63437
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
13.15	3.90	17.05	0.67	0.32	0.86	1.85	2.25	32.4	63438
12.00	*5.00*	*17.00*				*1.65*	*2.00*	*29.9*	
13.15	4.80	17.95				0.91	1.10	27.1	63439
13.00	*5.00*	*18.00*				*0.82*	*1.00*	*26.4*	
14.00	1.45	15.45		1.31	0.48	1.79	2.17	32.3	63584
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
13.30	2.10	15.40		0.34	0.47	0.81	0.98	25.7	63585
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
10.35	10.40	20.75				0.90	1.09	25.1	63589
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
14.00	1.45	15.45		1.31	0.48	1.79	2.17	32.3	63632
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
13.30	2.10	15.40		0.34	0.47	0.81	0.98	25.7	63633
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
10.35	10.40	20.75				0.90	1.09	25.1	63637
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
15.00	5.70	20.70		0.83		0.83	1.01	29.8	63848
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
17.90	1.10	19.00		0.75		0.75	0.91	31.8	63849
15.00	*4.00*	*19.00*				*0.41*	*0.50*	*26.6*	

TABLE V.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Kentucky Fertilizer Co.	
63850	O. K. Special Meal Mixture	Manufacturer
63851	O. K. Double-Header Corn and Wheat Grower	Manufacturer
63852	O. K. Half and Half Meal Mixture	Manufacturer
	Louisville Fert. Co. (Armour owned), Louisville, Ky.; Cincinnati, O.; Nashville, Tenn.	
63466	Tankage and Phosphate	Manufacturer
63467	Clay Soil Special	Manufacturer
63474	Big Vegetable Grower	Manufacturer
64715	Bone Meal and Acid Phosphate	Hurst Brown Hardware Co., Bardstown
64399	4-12 Fertilizer	Humlong & Wheat, Germantown
	Morris & Co., Chicago, Ill.	
64831	Morris Big Four	Manufacturer
64837	Morris Big Eleven	Manufacturer
64838	Morris Big Twelve	Manufacturer
	Mt. Pleasant Fertilizer Co., Inc., Mt. Pleasant, Tenn.	
63655	Mt. Pleasant Grain Grower	Manufacturer
63656	Mt. Pleasant Corn Special	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
13.30	5.90	19.20		2.61	0.26	2.87	3.48	39.5	63850
10.00	*5.00*	*15.00*				*2.47*	*3.00*	*31.8*	
12.60	8.60	21.20		0.97	0.24	1.21	1.47	29.6	63851
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
11.15	*9.95*	*21.10*		1.74	0.26	2.00	2.43	32.7	63852
10.00	*10.00*	*20.00*				*1.65*	*2.00*	*28.9*	
11.80	3.00	14.80	0.57		0.48	1.05	1.27	25.2	63466
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
12.50	2.60	15.10				1.80	2.19	30.6	63467
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
9.85	1.55	11.40	1.75		0.48	2.23	2.71	28.8	63474
10.00	*1.00*	*11.00*				*3.29*	*4.00*	*35.1*	
13.80	7.55	21.35				1.30	1.58	31.5	64715
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
14.15	0.80	14.95		2.33	0.75	3.08	3.74	40.0	64399
12.00	*1.00*	*13.00*				*3.29*	*4.00*	*38.1*	
12.55	6.55	19.10				1.15	1.40	28.4	64831
13.00	*5.00*	*18.00*				*0.82*	*1.00*	*26.4*	
11.30	2.30	13.60				1.99	2.42	29.8	64837
10.00	*1.50*	*11.50*				*0.82*	*1.00*	*20.5*	
12.60	2.90	15.50				2.19	2.66	33.2	64838
12.00	*1.50*	*13.50*				*1.65*	*2.00*	*28.5*	
11.25	9.55	20.80		0.67	0.62	1.29	1.57	28.4	63655
8.00	*2.00*	*10.00*				*1.23*	*1.50*	*20.2*	
13.30	5.00	18.30				0.81	0.98	26.8	63656
12.00	*2.00*	*14.00*				*0.82*	*1.00*	*23.7*	

TABLE V.

Number. Station	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Mt. Pleasant Fertilizer Co.	
63657	Black Patch Universal	Manufacturer
63661	Mt. Pleasant Burley Tobacco Grower	Manufacturer
64048	Mt. Pleasant 10-4-0	
	Price Chem. Co., Inc., Louisville, Ky.	
63957	H. Gr. Tobacco Bed Special	Manufacturer
63958	Potato and Tobacco Fertilizer	Manufacturer
64420	H. Gr. Fertilizer	Peoples Store, Loretto
63960	Victory Grain Special	Manufacturer
63961	No. 1 Fertilizer	Manufacturer
	Rasin Monumental Co. (Sub. of Va.-Car. Chem. Co., Inc.), Cincinnati, O.	
63911	Rasin's Fenhumus Fertilizer	Manufacturer
63912	Rasin's Grain Fertilizer	Manufacturer
64427	Rasin's Special Plant Food	J. H. Wyan, London
64736		J. H. Wyan, London
64428	Rasin's Truck and Tobacco Fertilizer	Martin-Hodgkin Supply Co., Winchester
63922	Rasin's Phosphate and Bone Meal	Manufacturer

ACID PHOSPHATES WITH NITROGEN.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
11.75	7.65	19.40		1.08	0.62	1.70	2.06	30.9	63957
10.00	*2.00*	*12.00*				*1.65*	*2.00*	*25.7*	
12.95	4.80	17.75		1.10	0.50	1.60	1.94	31.0	63661
12.00	*2.00*	*14.00*				*1.65*	*2.00*	*28.7*	
									64048
10.00	*8.00*	*18.00*				*3.29*	*4.00*	*37.9*	
11.70	1.70	13.40	3.22		0.90	4.12	5.00	43.0	63957
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
12.40	1.50	13.90	3.02		0 78	3.80	4.61	42.0	63958
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	
13.35	1.95	15.30	1.08		0.72	1.80	2.19	31.6	64420
10.00	*4.00*	*14.00*				*1.65*	*2.00*	*26.5*	
16.70	1.20	17.90				0.59	0.72	29.1	63960
14.00	*4.00*	*18.00*				*0.41*	*0.50*	*25.1*	
14.00	1.50	15.50				0.55	0.67	24.9	63961
12.00	*4.00*	*16.00*				*0.41*	*0.50*	*22.1*	
14.80	1.80	16.60				0.71	0.86	27.2	63911
12.00	*1.50*	*13.50*				*0.41*	*0.50*	*21.1*	
17.10	1.50	18.60				1.15	1.40	33.2	63912
13.00	*1.50*	*14.50*				*0.82*	*1.00*	*25.0*	
12.50	1.20	13.70		0.93	0.74	1.67	2.03	29.3	64427
12.70	1 70	14.40				1.61	1.95	29.4	64736
11.00	*1.50*	*12.50*				*1.65*	*2.00*	*27.0*	
10.95	0.45	11.40	1.24	1.21	0.54	2.99	3.63	34.6	64428
9.00	*1.50*	*10.50*				*2.47*	*3.00*	*28.9*	
11.20	12.60	23 80				1.03	1.25	28.0	63922
10.00	*12.00*	*22.00*				*0.82*	*1.00*	*24.7*	

TABLE V.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Read Phosphate Co., Nashville, Tenn.	
64434	Standard Grain Grower	W. L. Calhoun, Montpelier
64435		I. K. Miller & Sons, Campbellsville
63264	Red Diamond Favorite	Manufacturer
64526	Half and Half Raw Bone Meal and Acid Phosphate	Manufacturer
	St. Matthews Produce Exchange, Inc., St. Matthews, Ky.	
64805	Exchange Special	Manufacturer's Warehouse
64806		Manufacturer's Warehouse
	The Smith Agricultural Chem. Co., Columbus, O.	
64032	Smith's Wheat Maker and Seeding Down	Manufacturer
	Swift & Co., National Stock Yards, Ill.	
63930	Swift's Blood and Phosphate	Manufacturer
63937	Swift's Corn and Oats Special	Manufacturer
64469	Swift's Tankage and Bone Phosphate	E. M. Ford & Sons, Cave City
64470		W. S. Overstreet, LaGrange
64751		H. C. McClure, Somerset
64807		W. S. Overstreet, LaGrange
64473	Swift's Bone Meal and Phosphate Fertilizer	Mayhew & Gilbert, Franklin
64474		J. W. Collier, Crab Orchard
64753		Mayhew & Gilbert, Franklin
64809		W. S. Overstreet, LaGrange

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
14.60	2.90	17.50				0.52	0.63	26.2	64434
12.65	3.75	16.40				0.63	0.76	24.3	64435
12.00	*7.00*	*19.00*				*0.41*	*0.50*	*23.3*	
14.20	3.30	17.50	0.48		1.82	2.30	2.79	36.4	63264
12.00	*3.00*	*15.00*				*1.65*	*2.00*	*29.1*	
13.60	8.30	21.90				1.96	2.38	35.5	64526
10.00	*10.00*	*20.00*				*1.85*	*2.25*	*30.1*	
13.40	4.00	17.40	1.36	0.21	1.64	3.21	3.90	41.0	64805
14.80	3.50	18.30	0.56		1.20	1.76	2.14	34.2	64806
8.00						*0.82*	*1.00*	*16.9*	
12.70	1.10	13.80				0.41	0.50	22.0	64032
12.00						*0.41*	*0.50*	*20.5*	
13.40	3.10	16.50		1.05	0.79	1.84	2.23	32.4	63930
12.00	*3.00*	*15.00*				*1.65*	*2.00*	*29.1*	
11.10	3.40	14.50		1.17	0.76	1.93	2.34	29.6	63937
10.00	*3.00*	*13.00*				*1.65*	*2.00*	*26.1*	
13.70	2.70	16.40		0.49	0.39	0.88	1.07	26.9	64469
10.55	2.40	12.95	0.32	0.66	0.31	1.29	1.57	24.5	64470
13.40	3.00	16.40		0.37	0.62	0.99	1.20	27.2	64751
13.70	2.00	15.70		0.20	0.53	0.73	0.89	25.7	64807
12.00	*3.00*	*15.00*				*0.82*	*1.00*	*24.1*	
15.75	5.50	21.25				0.84	1.02	30.9	64473
15.75	5.50	21.25				0.72	0.87	30.2	64474
15.80	5.70	21.50				0.87	1.06	31.2	64753
16.50	5.80	22.30				1.00	1.21	33.1	64809
13.00	*7.00*	*20.00*				*0.82*	*1.00*	*27.2*	

TABLE V.

Station Number	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.
	Taylor & Powell Fertilizer Co., Inc., Springfield, Tenn.	
64044	No. 4 Tobacco Grower Without Potash	Manufacturer
64052	No. 3 Tobacco Grower	Manufacturer
64055	No. 1 Corn Grower	Manufacturer
	Tennessee Chemical Co. (Armour owned), Louisville, Ky.; Cincinnati, O.; Nashville, Tenn.	
63537	Ox Harvester	Manufacturer
63538	Ox Ammoniated Phosphate	Manufacturer
63543	Ox Big Vegetable Grower	Manufacturer
63556	Ox Bone Meal and Acid Phosphate	
	Virginia-Carolina Chem. Co., Inc., Cincinnati, O	
64504	V.-C. Richmus Fertilizer	Patrick Dillon, Hardinsburg
63887	V.-C. Sure Grain Producer	Manufacturer
63888	V.-C. Rescue Fertilizer	Manufacturer
63895	V.-C. Tobacco Plant Food	Manufacturer
63898	V.-C. Bone Meal and Phosphate	Manufacturer
	Wood, Stubbs & Co., Inc., Louisville, Ky.	
64002	Acme High Grade Vegetable Grower	Manufacturer

Acid Phosphates with Nitrogen.

PHOSPHORIC ACID			NITROGEN				Equivalent to Ammonia	Index of Relative Value	Station Number.
Available	Insoluble	Total	In Nitrates	In Ammonia Salts	Organic	Total			
8.85	4.85	13.70	3.40	0.60	0.65	4.65	5.65	43.1	64044
10.00						*2.47*	*3.00*	*29.8*	
12.60	8.20	20.80		0.88	1.36	2.24	2.72	35.6	64052
11.00						*1.23*	*1.50*	*23.9*	
11.00	6.90	17.90		1.43	0.45	1.88	2.28	30.5	64055
11.00						*1.23*	*1.50*	*23.9*	
11.80	3.00	14.80	0.57		0.48	1.05	1.27	25.2	63537
12.00	*1.00*	*13.00*				*0.82*	*1.00*	*23.3*	
12.50	2.60	15.10				1.80	2.19	30.6	63538
12.00	*1.00*	*13.00*				*1.65*	*2.00*	*28.3*	
9.85	1.65	11.40	1.75		0.48	2.23	2.71	28.8	63543
10.00	*1.00*	*11.00*				*3.29*	*4.00*	*35.1*	
									63556
10.00	*10.00*	*20.00*				*0.82*	*1.00*	*23.9*	
12.95	1.60	14.55				0.48	0.58	23.0	64504
12.00	*1.50*	*13.50*				*0.41*	*0.50*	*21.1*	
17.10	1.50	18.60				1.15	1.40	33.2	63887
13.00	*1.50*	*14.50*				*0.82*	*1.00*	*25.0*	
12.70	2.70	15.40				2.03	2.46	32.3	63888
11.00	*1.50*	*12.50*				*1.65*	*2.00*	*27.0*	
11.20	1.70	12.90		1.63	1.21	2.84	3.45	34.5	63895
9.00	*1.50*	*10.50*				*2.47*	*3.00*	*28.9*	
10.50	13.10	23.60				0.99	1.20	26.9	63898
10.00	*12.00*	*22.00*				*0.82*	*1.00*	*24.7*	
10.90	1.90	12.80	3.30		0.82	4.12	5.00	41.8	64002
10.00	*4.00*	*14.00*				*3.29*	*4.00*	*36.3*	

Table VI.—Materials Containing Nitrogen

Station Number.	Name and Address of Manufacturer and Name of Brand	From Whom Obtained.	NITROGEN	Equivalent to Ammonia	Index of Relative Value	Station Number.
	Armour Fertilizer Works, Louisville, Ky.; Cincinnati, O.; Nashville, Tenn.					
63523	Armour's Big Crop Nitrate of Soda	Manufacturer	17.56 *14.81*	21.32 *17.98*	105.4 88.9	63523
	Hopkins Fertilizer Co., New Albany, Ind.					
63878	Nitrate of Soda		*15.00*	*18.21*	*90.0*	63878
	Norwegian Nitrogen Products Co., Inc., New York, N. Y.					
64026	Norwegian Nitrate of Lime	Manufacturer	12.28 *13.00*	14.91 *15.78*	73.7 78.0	64026
	Tennessee Chem. Co. (Armour owned), Louisville, Ky.; Cincinnati, O.; Nashville, Tenn.					
63563	Ox Nitrate of Soda	Manufacturer	17.56 *14.81*	21.32 *17.98*	105.4 88.9	63563
	Virginia-Carolina Chem. Co., Inc., Cincinnati, O.					
63902	V.-C. Nitrate of Soda	Manufacturer	15.92 *14.82*	19.33 *18.00*	95.5 88.9	63902
63905	V.-C. Sulphate of Ammonia	Manufacturer	20.62 *20.59*	25.04 *25.00*	123.7 *123.5*	63905

Table VII.—Potash Salts.

TABLE VII.—POTASH SALTS.

Station Number	Name and Address of Manufacturer and Name of Brand	From Whom Obtained.	Potash From Muriate	Potash From Sulphate	Index of Relative Value	Station Number.
	Hopkins Fertilizer Co., New Albany, Ind.					
63877	Muriate of Potash					63877
			50.00		*150.0*	
	Virginia-Carolina Chem. Co., Inc., Cincinnati, O.					
63903	V.-C. Muriate of Potash	Manufacturer	51.00		153.0	63903
			50.00		*150.0*	
63904	V.-C. Sulphate of Potash	Manufacturer		51.36	154.1	63904
				48.00	*144.0*	
63905	V.-C. Sulphate of Ammonia	Manufacturer	20.62	25.04	123.7	63905
			20.59	*25.00*	*123.5*	

TABLE VIII.—NITROGEN AND POTASH MATERIALS.

Station Number.	Name and Address of Manufacturer and Name of Brand.	From Whom Obtained.	NITROGEN			Equivalent to Ammonia	Potash from Muriate	Index of Relative Value	Station Number.
			In Nitrates	Organic	Total				
	Dosch Chemical Co., Inc., Louisville, Ky.								
64085	Dosch Tobacco Fertilizer	Manufacturer	0.74	1.78	2.52 *2.06*	3.06 *2.50*	3.56 *1.50*	25.8 *16.9*	64085

Kentucky
Agricultural Experiment Station
University of Kentucky, Lexington, Ky.
THOMAS P. COOPER, Director

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The importance of the disease factor in tobacco production has been forced upon the attention of tobacco growers in the past two years by the widespread occurence of the leaf spot diseases and the serious losses resulting from them. These diseases have caused considerable alarm to all tobacco growers because of the losses which they entail and also because of the fact that they can readily be recognized as diseases. Root-rot of tobacco is a much more serious disease, however, because it causes immense losses each year to a majority of Burley tobacco growers, and yet is recognized by comparatively few of them as a distinct disease. This disease rots the roots as they develop and, altho it does not kill the plant, stunts it seriously. In some cases it causes only minor losses due to late maturity and a slight decrease in the size of the leaf; in other cases the losses may be practically complete. It is common in the Burley section of Kentucky to see fields of tobacco in which the plants have made practically no growth thru the greater part of the summer but which, when a rainy season comes on, suddenly start into growth. Some of the plants may grow rapidly while others remain small and stunted. This condition is particularly common where tobacco is grown two or more years in succession and is especially marked when an abundance of barnyard manure has been added to the soil. These symptoms are commonly attributed to lack of rain, low soil fertility, or to tobacco being "hard" on the land. It has been determined definitely, however, that root-rot is the primary cause in most instances.

Fortunately, a method of controlling this serious disease has been found, which adds no burdens whatever to the already tedious task of growing the crop. It may actually cut down, to some extent, the labor involved in handling the crop in the field because of greater uniformity in growth of the plants (Figure 6.) This method is by the use of strains of tobacco resistant or immune to the disease. In the following pages will be given a discussion of the nature of tobacco root-rot and the progress which is being made in the development of resistant strains of Standup White Burley.

LOSSES CAUSED BY TOBACCO ROOT-ROT.

To any grower who has experienced the rapid decrease in yield on highly fertile soil where tobacco has been grown for two or more years in succession, or where tobacco has come fairly often in the rotation and has consistently produced low yields while other crops on the same land yielded well, it will not be necessary to point out the importance of controlling this disease. Some fields are not at all affected, while others may be a complete loss. Still others may appear on casual inspection to be doing well but on examination be found to have a considerable portion of the plants badly stunted and wilting during hot, dry periods. The fungus which causes root-rot is widespread in the tobacco growing sections of Kentucky. It has been found to be present in the majority of fields of White Burley examined during the past two years by the senior author. Undoubtedly some loss resulted in all of the infected fields even tho it may have been slight in some of them.

EFFECT OF ROOT-ROT ON CULTURAL PRACTISES.

The cultural practis common in the Bluegrass section of Kentucky of growing tobacco on bluegrass soil for one or two years and then seeding to bluegrass again for a long period of time is, in a large measure, due to the fact that the land becomes infected with the root-rot organism, thus making the growing of tobacco on the same land unprofitable until several years have past. Keeping the land in bluegrass decreases soil infection

after a few years to the point where it again becomes possible to raise a profitable crop of tobacco. The introduction of strains of Burley immune to the attacks of root-rot should make it possible to produce good yields in any system of cropping desired.

NATURE OF TOBACCO ROOT-ROT.

Cause. Root-rot is caused by a fungus* which lives in the soil for a long time after it has been introduced. It attacks the roots of tobacco, soon after the plants are set in the field, (Figure 2) causing them to rot and turn black (Figure 1). Because of this fact, the disease is known to many growers as black-root.

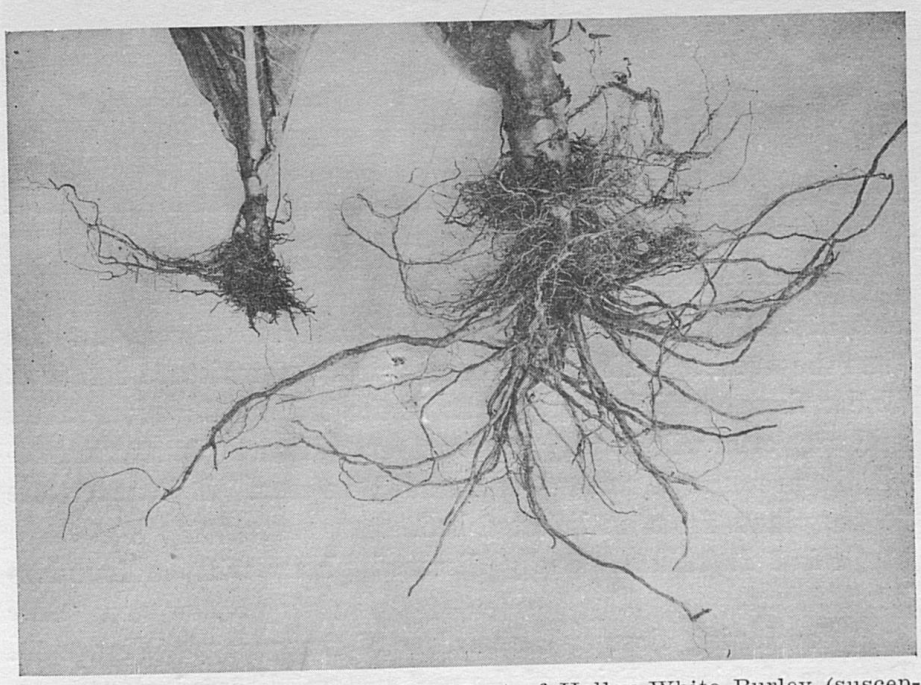

Figure 1. The root system of a plant of Halley White Burley (susceptible) and of one of the Judy's Pride White Burley resistant selections. Grown on diseased soil, 1920.

Plant-bed infection. Plant-bed infection may be expected where a plot of ground is used more than one season for the plant bed, unless the bed is steamed. Even plant beds on new ground may become infected by drainage from an old tobacco field. The plants in infected beds may appear entirely

*Thielavia basicola.



Figure 2. The resistant selection P (left), Halley (center) and Q (right) showing the difference in early growth of resistant and susceptible strains when grown on diseased soil. 1920.

normal until about the time they are ready to be set. At this time the weather is likely to become warm and moisture deficient. Under these conditions the plants in the bed rapidly turn yellow and may even wilt in very hot weather. If such plants are pulled, the presence of root-rot can readily be seen. It is never safe to use plants from an infected bed.

Field Infection. Badly diseased plants will be found to have a mass of stubby black roots with only a few new white ones developing close to the surface of the ground (Figure 1). Because of this condition of the root system, diseased plants may wilt badly on hot days, reviving during rains or at night (Figures 3 and 6). It is not uncommon to see plants wilting again immediately after a considerable rain if the sun comes out hot. Plants only slightly infected may show no visible signs of the disease until the roots are closely examined. The loss may be quite considerable in such cases but not be apparent for lack of healthy plants for comparison. The extent of loss in such a field can be determined only by growing a row of resistant plants



Figure 3. Resistant selection Q (left), the susceptible variety, Halley (center) and resistant selection P (right). Selections Q and P were grown from seed of two of the original mother plants selected for resistance from the variety Judy's Pride. They illustrate two of the distinct types which are found in this variety and which breed fairly true to type. Selection P is typical of the 8 desirable selections obtained from the 16 original selections of Judy's Pride. Selection Q is the best of the twist-bud types obtained. The diseased Halley plants are wilting. Grown on diseased soil, 1920.

thru the field and observing closely the relative rates of growth thruout the season and obtaining relative yields. Many farmers in the Burley section who at present believe their fields to be disease-free would be greatly surprised at the results of such a test.

Relation of Degree of Infection to Root-rot. The extent of injury either in the plant bed or in the field depends directly on the amount of the fungus present in the soil. A few diseased plants one year may produce enough infective material in the soil to cause a complete failure the following year. It is because of this fact that an apparently disease-free crop of tobacco may be followed the next year by a complete loss due to root-rot.

Some growers have had success in setting plants from badly diseased beds in land free from the disease. In such cases the small amount of infective material is not sufficient to attack all the roots produced and as a consequence they are able to penetrate into disease-free soil and survive. The practis of setting diseased plants is very objectionable, however, as it may pollute a disease-free piece of land.

Altho it is true that root-rot usually appears only where tobacco has been grown, yet several instances have been observed in which land which had not been plowed for many years showed a high degree of infection. In these cases it was possible to trace the source of infection to drainage from an old tobacco field.

METHODS OF CONTROL.

The losses from root-rot may be reduced greatly, even where very susceptible strains of tobacco are grown, if certain cultural directions are followed. These consist in: (1) Proper selection of seed-bed site, choosing only land which can receive no drainage whatever from old tobacco fields. Such a site should be used only once, unless the bed is steamed each year instead of burned. If steaming can be practist, it is desirable to select a permanent seed-bed site fence it and use it continuously for this purpose and no other. (2) Tobacco should not be grown on land more than one year if the land is to be kept comparatively free from the disease; and a fairly long rotation should be practist. If the seed-bed and the rotation are given close attention, there should be comparatively slight loss from root rot. It is obvious that with the present system of cropping these recommendations can not always be followed as it is not always economical to break up bluegrass sod for a single crop when it is capable as far as fertility is concerned of growing two and often four crops of tobacco. The necessity for the use of immune strains of tobacco is thus apparent.

RESISTANT STRAINS OF WHITE BURLEY TOBACCO.

The value of resistant strains of tobacco in controlling root-rot has been demonstrated in the Burley section of Kentucky thru the efforts of the agents of the United States Department of Agriculture.* That the use of resistant strains has not become widespread is due to the fact that the strains of resistant tobacco used did not meet with favor among Burley tobacco growers. The impression has grown, as a consequence, that resistance and undesirable qualities in tobacco are associated. That this idea is incorrect and that strains of White Burley can be developed which are resistant to root-rot and of as high quality as the varieties generally grown has been shown by experiments during the past two years at the Kentucky Experiment Station.

METHODS OF DEVELOPING RESISTANT STRAINS.

The method used in developing strains resistant to root-rot is simple. It consists merely in finding a severely diseased field in which a few plants are developing normally altho surrounded by severely diseased plants. The seed heads of such plants are bagged in order to prevent crossing. The seed of each original mother plant is sown separately the following year, and the plants set in individual rows on land known to be diseased. Susceptible varieties are set along side so that comparisons can be made between the selections and the check rows, to determine relative resistance, and between the various selections, to determine those of highest quality. Only the most resistant selections of the highest quality are retained for further testing and continued selection. During the first season's trial in the diseased plot the most desirable plants are selected from the best strains and these bagged for seed.

In all, 25 resistant strains of White Burley tobacco have been tested. These are the result of 16 selections made by Mr. Roy Milton in a field of Judy's Pride White Burley, and 10 selections made by one of the writers in a small plot of Vimont Kelley White Burley which was badly diseased. The former have been tested at the Experiment Station over a period of two

* U. S. Dept. of Agr. Bul. No. 765.

years, in soil heavily infected with the root-rot organism, and have been tested in several parts of the Burley section the past season. Fifteen of the selections proved resistant. The latter 10 selections have been tested one year, in diseased soil, and all proved highly resistant. Besides these, about 50 other selections have been made from a standup tobacco grown on the Experiment Station farm for the past 8 or 9 years, called Station Kelley.



Figure 4. A typical plant of Judy's Pride White Burley, selection P. It is typical of the most desirable strains obtained from Judy's Pride White Burley. Grown on diseased soil, 1920.

JUDY'S PRIDE WHITE BURLEY SELECTIONS.

The results obtained from the 16 selections of Judy's Pride White Burley are interesting not only from the standpoint of the resistant strains obtained, but also because they show quite clearly that our so-called varieties of White Burley tobacco are not varieties in the true sense of the word but are rather a mixture of strains (Figures 3 and 6).

From these 16 mother plants, 15 strains were obtained practically immune to root-rot, while one strain produced only a single moderately resistant plant. Ten of the resistant strains were of the desired standup type and were nearly uniform (Figure 4). Two were evidently hybrids as both broadleaf plants and twist-bud plants were obtained. Three strains were of the twist-bud type and nearly uniform (Figure 3). The breadth of the leaf varied slightly within a strain, but there were considerable differences in the breadth of leaf among the various strains. The uniformity of plant type within any one strain (with the two exceptions mentioned) was very marked (Figures 2 and 3). At stripping time considerable differences in color and quality were apparent between the strains. The twist-bud types produced the roughest, poorest colored leaf. Because of undesirable field characters and quality as shown at stripping time, 8 of the original 16 strains have been discarded.

Field Trials. Because of the marked uniformity in type and resistance shown by the most desirable strains in 1920, it was considered advisable to obtain information as to the value of these strains in comparison with the commonly grown varities under field conditions. Therefore small lots of seed of the strains which were considered best in 1920 were sent out thru county agents or direct to a few growers to test in comparison with the commonly grown varieties. The results of these tests are very promising. Of 18 answers to requests for information, 14 men stated that the strains were better, and 4 said it was as good as their own variety. Of those who thought the resistant strains as good as their own, all four raised the crop on land not infected with root-rot. The growth was about the same in each of these cases as compared with the local variety and the

quality about the same. One of these men reported that the resistant strain was much more uniform than his own variety. The reasons given by the 14 men who considered the resistant



Figure 5. A single plant of Selection As. 9, a resistant selection of Vimont Kelley. It is typical of the ten selections made from this variety at Dry Ridge, Ky., in 1920. Grown on diseased soil, 1921. The method of bagging to prevent cross-pollination is shown.

strains better than their own, included earlier and more constant growth thruout the season, greater uniformity in growth and, without exception, earlier maturity. Earlier maturity results probably because the resistant plants can continue growth thru dry periods, as the root systems are not decreased by rot. Of those who expressed an opinion as to quality, 13 considered the quality of the resistant strains distinctly better than that of their own, and two stated they could see little difference. These results seem to show clearly that it is possible to develop strains of White Burley of high quality which are resistant to root-rot.

It certainly is possible to develop strains of White Burley which, because of uniformity, will give a crop of a higher average quality than that of the varieties commonly grown. This is true because the commonly grown Burley varieties are a mixture of strains. We have demonstrated that some of these strains are decidedly poorer in quality than others and when mixed with them, necessarily lower the average quality of the crop. The selection of a high-quality pure strain automatically eliminates the poorer strains and, as a consequence, raises the average quality of the crop. From the results obtained thus far, it would seem that our best resistant selections represent the better strains, as to quality, contained in the commonly grown varieties. As a consequence, it may be expected that a more general use of such strains will increase the average quality of the crop raised in the Burley section, both because of uniformity and earlier maturity.

VIMONT KELLEY SELECTIONS.

In 1920, one of the writers found a small garden plot set to Vimont Kelley White Burley tobacco at Dry Ridge, Kentucky. This plot of ground had been heavily manured the previous seasons, with the object of raising a large crop of tobacco on a small piece of land. The crop, with the exception of about 10 plants, scattered over the plot, and a few plants near the fence, was practically a failure. The small plants many of which were not over 3 or 4 inches high, were found to be badly diseased. An occasional plant within two feet of such stunted plants was normal

in development and just coming into flower. With the permission of the owner*, these plants were bagged to protect the flowers from being cross-pollinated. The seed of ten of these plants was sent to the Experiment Station in the fall. These strains have been tried the past season and without exception proved to be very resistant to root-rot. The ten strains were all very much alike as to quality, type and resistance. Within all the strains there was some variation indicating that improvement may still be made by selection. These strains produce a heavier, broader, longer leaf than the selections previously discust and have the leaves placed closer on the stalk. Further tests of them will be necessary before their true value can be ascertained.

STATION KELLEY WHITE BURLEY SELECTIONS.

In testing the various strains in diseased soil every 5th row was planted to a variety not considered to be resistant. In 1920 the White Burley variety Halley was used. This proved to be very susceptible and was therefore a good variety for this purpose, as marked contrasts were evident in the growth of it and in the growth made by the resistant selections (Figures 1, 2 and 3). In 1921, Station Kelley White Burley was used as the check. This is called Station Kelley because the seed has been saved annually from plants of Kelly's Improved Standing Up Burley variety grown on the Station farm for the past 8 or 9 years. It was not supposed that plants of this variety would prove resistant, as the Kelley variety does not do well when grown on diseased soil. As a matter of fact, a considerable number of plants of Station Kelley were just as resistant as the most resistant selections. Of 528 plants grown, 76, or 14 per cent, apparently were immune, 141 showed considerable resistance, while 311 showed no resistance (Figure 6). Evidently resistant strains have been isolated by the ordinary practis of selecting the best plants for seed during the 8 or 9 years this variety has been grown on the Station farm. Several of the fields on the Station farm are known

*The seed used in this planting was received from Mr. Charles Marvin, Midway, Kentucky, and planted by Mr. Leo Aswerus. Thru the co-operation of Mr. and Mrs. Aswerus, the seed of the selections was received by the Experiment Station.



Figure 6. Selection As. 10 (left) grown from seed of one of the 10 Vimont Kelley plants selected at Dry Ridge, Ky., in 1920. These plants were uniformly resistant. Center, a row planted from seed of Station Kelley obtained from several plants grown on disease-free soil the previous year. Several degrees of resistance are illustrated in the few plants shown. The value of obtaining seed from a single resistant mother plant is evident both because of resistance to root-rot and uniformity of type. Grown on diseased soil, 1921.

to be slightly infected with the root-rot organism and only the most vigorous plants have been saved for seed. A considerable number of selections were made from the 76 most resistant plants. These will be given further trial in 1922. In this field 5 strains known to be susceptible were grown and proved uniformly susceptible, indicating that the Station Kelley White Burley actually is a mixture of resistant, semi-resistant and susceptible strains and that the results obtained were not the result of chance.

CONCLUSION.

In conclusion it seems safe to state that we may expect to obtain strains of Standup White Burley tobacco immune to root-rot and of as high quality as the best strains contained in the commonly grown varieties. Already, resistant strains have been obtained having quality at least equal to that of the commonly grown varities. In view of the prevalence of root-rot thruout the Burley section of Kentucky, we do not hesitate to recommend the use of these strains either on new land or on old land known to be diseased. On new land, as good results should be expected as can be obtained from the present varieties, with the added advantage of uniformity, making topping and grading easier. On diseased land or on land which has grown a single crop of tobacco, the value of the resistant strains is unquestioned.

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SELF-FERTILITY IN RED CLOVER

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SELF-FERTILITY IN RED CLOVER

A REPORT OF PROGRESS ON AN ATTEMPT TO SECURE SELF-FERTILE LINES IN THIS CROP

by
ERNEST N. FERGUS

A survey of the agricultural press will convince one that, in the eyes of the American farmer, red clover (Trifolium pratense) is the most desirable legume available for general farm purposes. It not only supplies the legume requirement of the rotation into which it fits nicely, but also gives a good yield of excellent hay. In addition it furnishes good temporary pasturage.

Since this crop is of so great importance, it deserves the earnest efforts of plant breeders in its improvement. While little has been done by plant breeders on the crop, the few isolated attempts made in that direction have indicated the possibilities. An illustration is the well known work of Bain and Essary (1) in securing an anthracnose-resistant variety.

The increasing difficulties in growing this crop (7) have made it desirable to attempt to overcome them as far as possible by securing strains better adapted to the environments under which the crop is to be grown, as well as to secure those better adapted to the purposes for which it is cultivated.

There are of course several reasons why the improvement of this crop has not been undertaken more extensively, one being the fact that it has generally been regarded as self-sterile. For example, Westgate and Coe and coworkers (9) in a resume of previous investigations along this line believe that the evidence

The author wishes to express his appreciation to Professor E. J. Kinney and Dr. W. D. Valleau for suggestions made and assistance rendered during the progress of this work and the preparation of this manuscript.

strongly supports this view. They also state, based on their own work, "The amount of seed obtained is so small that it was probably the result of bees working thru the tarletan (covers)." Malte (5) in a more recent review arrives at the same conclusion from the evidence which he considered.

Schlecht (8) has reported a recent attempt to artificially self-pollinate a few red clover plants and while securing a few seeds states that tho these may represent exceptions to the general rule of self-sterility in red clover, he believes them to be due to the introduction of foreign pollen.

Self-sterility of the crop being granted, the only method for improvement left has been mass selection. This at best offered but slow and rather uncertain results except in such cases as those in which the undesirable factor was one which would automatically eliminate itself, as for instance in the selection of the anthracnose resistant strains previously mentioned.

Several of the investigators mentioned in the two reviews previously noted have asserted that red clover is not entirely self-sterile, a few even believing the crop to be self-fertile to a considerable degree. In fact, Westgate, Coe and coworkers state that their cytological work showed that it was possible to have an occasional seed produced from self-pollination. They, however, attributed the few seeds secured in the heads which they artifically self-pollinated to the accidental entrance of insects.

In view of the conflicting opinions with regard to self-sterility, it seemed possible to the writer that the few seeds secured under artificial self-pollination might represent actual self-fertilization. If such were the case, it perhaps indicated that red clover consists genetically of both self-sterile and self-fertile lines, the former considerably outnumbering the latter and that a search among a large number of red clover plants should discover a few plants carrying a high degree of self-fertility. Such plants might be expected to prove the foundation of self-fertile lines. In the hope of finding these highly self-fertile plants, the writer outlined a project calling for the artifical self-pollination of a large number of plants in the field.

PRELIMINARY TESTS

One of the methods of artificial self-pollination used by Westgate, Coe and coworkers consisted in rolling the head between the thumb and fingers. As this offered the most rapid method it was tested as to its efficiency before being used. Twenty heads on as many different red clover plants were bagged when the first flowers were just beginning to show. One-fourth pound paper bags were used for this purpose. When the flowers on one-half of the heads blossomed, the heads were rolled gently between the thumb and fingers, the bag of course being removed for this purpose. The remaining heads remained bagged, but were not rolled. After a few days five or more stigmas from different parts of the best heads of each group were examined under the microscope with the results shown in Table I.

TABLE I.

Efficiency of Rolling Heads Between Thumb and Fingers as a Method of Artificial Self-Pollination

Heads Rolled		Heads Not Rolled	
Head	Result	Head	Result
1	+++++	1	?+++–––
2	++++?	2	+??–––––
3	?++?+	3	––+–––
4	++??+++	4	+–––––––
5	?+++?+	5	+?–––––
6	++?+++–	6	+'–?––
7	+++++–	7	–––––––
8	++++?–	8	–––––––
		9	–––––––

Note: + = individual floret pollinated.
– = individual floret not pollinated.
? = pollination of individual floret doubtful.

Pollen was found upon the stigmatic surface of all pistils examined, irrespective of treatment. In most instances, however, it was possible to distinguish between the pollination which had occurred at the time of treatment and that which

had occurred during the removal of the pistil. In the former case the pollen tubes were numerous and had grown well into the style. The pollen grains were also much shrunken showing that their contents had been transferred to the pollen tubes. In the latter case the pollen grains were full sized, no pollen tubes were present and the pollen grains were easily jarred loose from the stigmatic surface by lightly tapping the cover glass on the slide. In a few of the florets in both rolled and unrolled heads it was impossible to tell whether the earlier pollination had actually occurred or not, as the pollen grains were somewhat shrunken and stuck to the stigmatic surface rather tenaciously altho no pollen tubes were visible. These are designated as doubtful in the table.

This method, therefore, appeared efficient enough for field use, considering the large number of heads which could be so pollinated per unit of time, and it was adopted.

FIELD WORK DURING 1921

Accordingly approximately 650 heads, each representing a separate plant, were artificially self-pollinated during the latter part of July, 1921. The heads were bagged just as the flowers were beginning to show and then rolled gently between the thumb and fingers after the flowers had opened. As a precaution against the transfer of pollen from one plant to another, the fingers were cleaned on a piece of cheesecloth. After pollination, the bags were replaced and left until the heads browned when they were carefully examined for seed.

The bags used for this work were the ¼ pound "Kraft" paper bags. These have proved very satisfactory as they are light in weight, may be folded tightly to the stem, and will withstand almost unlimited rain. They also have been free from grasshopper injury during the two seasons in which they have been used. They therefore have possessed advantages over the tarlatan covers used by Westgate and Coe and coworkers, which were adversely affected by rain and damaged by grasshoppers.

Experience with these bags has, however, shown that care must be taken when tieing the bag below the head, as the string

may be drawn too tightly and crush the stem. If the stem on which the bagged head is carried is long or very slender, it should be supported in some way to prevent breaking from the weight of the bag, or swaying by the wind.

Upon harvesting the bagged heads, 153 seeds were secured from 32 plants, distributed as shown in Table II.

TABLE II.

Seed Secured From Approximately 650 Artificially Self-Pollinated Red Clover Plants

Plant	Number of Seed	Plant	Number of Seed
1	2	17	2
2	1	18	11
3	1	19	1
4	5	20	9
5	1	21	14
6	11	22	3
7	1	23	3
8	3	24	1
9	4	25	3
10	7	26	5
11	4	27	3
12	2	28	1
13	4	29	7
14	1	30	6
15	11	31	24
16	1	32	1
		Total	153

This gives an average production for the 650 plants of nearly .24 seeds per plant. With the similar method which Westgate and Coe and coworkers used they secured an average of 18. seeds per plant from a total of 145 plants in two years tests. Schlecht secured an average of .59 seed per plant from a total of 17 plants on which he attempted artificial self-pollination or geitonogamy. He, however, worked with from 5 to 20 heads per plant.

FIELD WORK DURING 1922

The 153 seeds secured in 1921 were pricked with a needle and planted, one seed per pot, in steam sterilized soil in the greenhouse in the winter of 1921-22.

Some of the seeds did not germinate. Of those which did germinate, a number of the seedlings seemed unable to put out root systems, the radicle growing out approximately an inch and remaining so until the death of the plantlet. Other seedlings "damped off." Unfortunately no records were kept as to the percentage of the seed which failed to germinate or which seedlings disappeared due to either of the above causes.

Of the plants which became established some developt normally while others either made no further growth or developt abnormally. Those plants which developt normally were removed from the pots and set out in the field during the first part of May while the remainder were left in the pots until they died. The members of this latter group were, with three exceptions, etiolated or a very light yellowish green color. One exception was a plant apparently normal in all respects except for the petioles which were only 3/8 to 1/2 inch long. This caused the leaflets to be bunched tightly at the crown of the plant. No stems were produced. Another grew normally but slowly until it had produced 10 leaves, then it rapidly put out 13 virescent very small leaves with petioles 1/2 to 1 inch long. The third exception was a plant which seemed to grow normally but the leaves soon withered and turned brown. Altho it produced new leaves rapidly, the plant seldom had more than one functioning leaflet at any one time.

The plants set out in the field were self-pollinated as they came into bloom, using the method previously described, except that the cheesecloth used to clean the fingers was dampened with kerosene as another precaution against possible transfer of pollen. The results of these selfings as well as other essential facts are shown in Table III.

TABLE III

Description of F_1 Red Clover Plants Resulting From Artificially Self-Pollinated Parents and the Yield of Seed Secured From Them Following Artificial Self-Pollination.

1 Plant No. Parent - F_1	2 Description of Plants	3 No. of heads per plant artificially self-pollinated	4 No. of Self-pollinated heads yielding seed	5 No. of seed secured per plant	6 Total No. of seed secured from sibs.
1—a	Normal	10	1	1	
—b	Note[1]				1
2—a	Normal	8	0		
3—a	Note[1]				
4—a	Normal	3	0		
—b	Note[1]				
—c	Note[1]				
—d	Normal	5	2	7	
—e	No bloom, note[5]				7
5—a	Note[1]				
6—a	Normal	6	0		
—b	Note[1]				
—c	Note[1]				
—d	Note[1]				
—e	No bloom, note[5]				
—f	Note[1]				
—g	No bloom, note[5]				
—h	Note[1]				
—i	Normal	4	3	14	
—j	Note[2]				14
—k	Note[2]				
7—a	Note[1]				
8—a	Normal	14	0		
—b	Normal	7	0		
—c	Normal	6	0		
9—a	Note[1]				
—b	Normal	7	0		
—c	Note[6]				
—d	Normal	1	0		
10—a	Note[1]				
—b	Note[1]				

See notes on page 29.

1 Plant No. Parent F_1	2 Description of Plants	3 No. of heads per plant artificially self-pollinated	4 No. of Self-pollinated heads yielding seed	5 No. of seed secured per plant	6 Total No. of seed secured from sibs.
—c	Note[1]				
—d	Note[1]				
—e	Normal	2	0		
—f	Normal	4	2	22	
—g	Normal	4	0		22
11—a	Normal	4	0		
—b	Normal	3	0		
—c	Note[1]				
—d	Note[1]				
12—a	Note[1]				
—b	Note[1]				
13—a	Note[1]				
—b	Normal	14	0		
—c	Normal	6	0		
—d	Normal	6	0		
14—a	Note[1]				
15—a	Normal	4	0		
—b	Normal	14	1	8	
—c	Note[1]				
—d	Note[1]				
—e	Note[1]				
—f	Normal	5	1	6	
—g	Note[1]				
—h	Normal	5	4	38	
—i	Normal	9	6	36	
—j	Normal	7	5	27	
—k	Normal	6	1	2	117
16—a	Note[1]				
17—a	Note[1]				
—b	Note[1]				
18—a	Note[1]				
—b	Note[1]				
—c	Note[2]				
—d	Note[1]				
—e	Note[1]				
—f	Normal	11	5	31	

1 Plant No. Parent F,	2 Description of Plants	3 No. of heads per plant artificially self-pollinated	4 No. of Self-pollinated heads yielding seed	5 No. of seed secured per plant	6 Total No. of seed secured from sibs.
—g	Normal	7	3	6	
—h	Note[1]				
—i	Normal	7	3	55	
—j	Normal	2	0		
—k	Normal	5	0		92
19—a	Note[1]				
20—a	Normal	9	9	111	
—b	Normal	3	2	22	
—c	Normal	11	11	100	
—d	Normal	6	3	18	
—e	Normal	5	5	134	
—f	Normal	5	5	91	
—g	Normal	2	1	6	
—h	Normal	5	0		
—i	Normal	3	2	22	504
21—a	Note[1]				
—b	Note[1]				
—c	Normal	14	0		
—d	Note[1]				
—e	Normal	11	0		
—f	Note[1]				
—g	Normal	9	3	18	
—h	Normal	3	0		
—i	Note[1]				
—j	Note[1]				
—k	Note[4]				
—l	Note[1]				
—m	Normal	2	0		
—n	Note[5]				18
22—a	Normal	6	1	4	
—b	Normal	11	0		
—c	Normal	8	0		4
23—a	Normal	7	0		
—b	Normal	4	0		
—c	Normal	3	0		
24—a	Normal	6	0		

1 No. Plant Parent F_4	2 Description of Plants	3 No. of heads per plant artificially self-pollinated	4 No. of Self-pollinated heads yielding seed	5 No. of seed secured per plant	6 Total No. of seed secured from sibs.
25—a	Note[6]				
—b	Note[1]				
—c	Normal	1	0		
26—a	Normal	14	0		
—b	Normal	8	1	41	
—c	Normal	7	2	9	
—d	Normal	5	3	8	
—e	Normal	4	0		58
27—a	Normal	9	1	1	
—b	Normal	5	0		1
—c	Note[1]				
28—a	Note[7]				
29—a	Note[1]				
—b	Note[1]				
—c	Normal	3	0		
—d	Normal	4	0		
—e	Note[2]				
—f	Normal	7	0		
—g	Note[1]				
30—a	Note[1]				
—b	Note[1]				
—c	Normal	4	0		
—d	Note[1]				
—e	Normal	7	0		
—f	Note[1]				
31—a	Note[1]				
—b	Note[2]				
—c	Note[3]				
—d	Normal	6	5	60	
—e	Note[1]				
—f	Normal	2	0		
—g	Normal	6	1	3	
—h	Note[2]				
—i	Normal	2	0		
—j	Normal	5	1	3	
—k	Normal	4	2	22	

1 Plant No. Parent F_1	2 Description of Plants	3 No. of heads per plant artificially self-pollinated	4 No. of Self-pollinated heads yielding seed	5 No. of seed secured per plant	6 Total No. of seed secured from sibs.
—l	Note[2]				
—m	Normal	4	0		
—n	Note[2]				
—o	Normal	4	4	32	
—p	Note[2]				
—q	Normal	2	0		
—r	Normal	3	3	25	
—s	Note[3]				
—t	Note[1]				
—u	Normal	5	5	27	
—v	Normal	3	3	4	
—w	Normal	6	2	5	
—x	Note[1]				181
32—a	Normal	4	3	15	15
Total 79	Normal	463	115		1034

SUMMARY

Average number of seed per normal plant 13.1
Average number of seed per self-pollinated head 2.2
Average number of seed per seed-yielding head 9.0

NOTES

1. These are the seedlings which disappeared because of "damping off" or failure to produce roots. The seeds which failed to germinate are also included in this list.
2. These were seedlings with etiolated leaves. They existed from 4 to 8 weeks without making growth, and then died.
3. These were seedlings with very pale yellowish-green leaves. They existed 8 to 10 weeks without making any growth, and then died.
4. Seedling 21-k produced the first 10 leaves normally, then instead of a second normal leaf it put out thirteen small pale yellowish-green leaves borne on petioles ½ to 1 inch long. It existed in this condition for one month and then died.
5. Seedling 21-n seemed to grow normally but the leaves would quickly wither and turn brown. Very seldom did it carry more than one functioning leaf at a time. It lived approximately 3 months.
6. These plants appeared normal but died before blooming.
7. Plant 28-a produced leaves with petioles ⅜ to ½ inch long. It died on June 18 without having put out any stems.
8. Plants described as "no bloom" grew thruout the summer without blossoming.

The "parent" plant numbers in Table III, correspond to the plant numbers in Table II. In column "F_1" all seed from the "parent" plants are accounted for. The third column shows the number of heads on each plant which were bagged and artificially self-pollinated. The fourth column gives the number of those heads producing seed, while the fifth column shows the number of seed secured from all of the heads on the individual plants which yielded seed. The last column is of interest in that it shows the variations in the total number of seed secured from each group of sibs.

A study of Table III will disclose certain features which the writer considers strong evidence that at least some of the parent plants were self-fertile and that this ability was transmitted to their progeny.

In the first place it will be observed that, generally speaking, the progeny from those parent plants yielding the larger number of seeds under self-pollination, produced large numbers of seeds themselves when self-pollinated. On the contrary, the progeny from those parents yielding few seeds, when self-pollinated, with three exceptions yielded very few or no seed. It will be noted that there were 23 groups of sibs which contained at least one normal plant; of those six which came from parents producing 9 or more seeds, five produced seed rather abundantly. One group (from parent No. 20) produced very freely, one of the members (No. 20-e) producing nearly 27 seeds per head, or approximately the same average as that secured under normal field conditions (7). On the other hand, the seventeen groups from parents producing less than 9 seeds, with three exceptions, produced but few or no seeds. The explanation of those cases in which but few seeds were secured is, of course, problematical. It is possible that an occasional seed may have been due to the accidental introduction of foreign pollen. Again they may be caused by actual self-fertilization, the pollen tube being permitted to reach the ovule thru a style accidentally mutilated in treatment (2); or it may be that the variations in the rate of pollen-tube growth permitted self-fertilization in some cases. Martin (6) found a variation of pollen-tube growth

within the style of self-pollinated red clover flowers ranging from a fraction of a millimeter to 7.25 mm. after 90 hours' growth. While no tubes had reached the ovules, a distance of 11.5 mm., the variation seems significant, considering that he worked with but 20 flowers.

Again it will be observed that of a total of seventy-nine normal F_1 plants, eight yielded seed from every head treated and that forty-two yielded no seed from any head treated even tho the number of heads was frequently quite large. These consistencies would seem good evidence that the amount of pollen that may have been accidentally introduced was very small. The remaining 29 plants yielded seed on some of the treated heads but not on others. The cause of these variations remains a problem for future investigation.

Another evidence supporting self-fertilization is the production of abnormal seedlings, particularly those which were chlorophyll deficient in the F_1 generation. It will be observed that four groups of sibs contained chlorophyll deficient seedlings, one group (parent plant 31) containing 7 in a total of 20 which became established. The production of such seedlings is suggestive if not positive proof of self-fertilization, as in certain other normally cross-pollinated plants chlorophyll deficient seedlings show up in considerable numbers when those plants are self-fertilized. Jones (4) points out that these are found in corn, particularly in the earlier generations of self-fertilization. Hayes and Barker (3) have recently reported the same segregation for self-fertilized timothy as well as for corn.

Another indication that self-fertilization occurred is furnished by the marked similarity which existed among the members of certain of the F_1 groups of sibs. While these similarities existed in most instances, only with regard to general appearances, they were so pronounced that most of the groups of sibs were easily separated with the eye while walking along the rows in which they were growing. These similarities existed with regard to height, leafiness and shade of leaf color. In some groups it extended to the number and color of stems while in one group the plants were apparently exactly alike except

for a slight difference in the number of stems. In two other groups the plants within each group varied only in a few minor details.

The following brief description of each group of sibs will indicate in a general way the similarity as well as the differences among the individual plants of each group. Incidentally the differences among the groups will also become evident to some extent altho the descriptions express these differences very inadequately.

4.* Plants erect; (a) and (d) approximately 10 inches and (e) 4 inches in height. Number of stems were 20, 12 and 0 respectively. Stems greenish red color. Number of leaves average. Leaflets uniformly gray-green color, varying in shape with the individual plant. Leaflet markings small but prominent. Pubescence very scant. Late blooming plants.

6. Plants erect, 7" in height. Number of stems 8, 10, 2 and 9 respectively. Stems uniformly reddish brown color. Number of leaves average. Leaflets light green color but varied as to shape, size and pattern of marking. Pubescence scant; time of blooming late.

8. Plants erect, approximately 10" in height. Number of stems, 15, 21 and 19 respectively; stems uniformly of green color. Leaves numerous. Leaflets of average size, long oval in shape, light green color and prominently marked, the pattern varying with the plant. Veins in leaflets uniformly very large. Pubescence very scant. Time of blooming average to late.

Plants (a) and (b) were very similar even as to size, shape and marking of leaflets, while (c) differed in these respects.

9. Plants erect, approximately 8" in height. Number of stems 9 and 20 respectively; stems uniformly reddish green in color; number of leaves average. Leaflets broadly oval, of gray-green color, but varied with the plant as to size, and pattern of marking. Pubescence average. Time of blooming late.

The above description holds also with regard to leaf characters, and pubescence of plant (c). As this plant died prematurely it was impossible to determine the height or number of stems.

10. Plants erect, approximately 8" in height. Number of stems 5, 9 and 11. Stems were uniformly of brownish green color. Leaves average in number. Leaflets light green in color but varied as to

*Numbers at head of each paragraph refer to "parent plant" in Table III. Respectively refers to the order used for the F_1 "normal plants" in same table. In case of No. 6, they include plants described as "no bloom" also.

shape and size. Pattern of leaflet marking similar in all plants. Pubescence very scant. Time of blooming, average.

11. Plants erect, approximately 8″ in height. Number of stems, 10 and 12 respectively. Stems uniformly dark red in color; number of leaves, shape of leaflets, their color and marking varied. Pubescence uniformly average. Time of blooming late.

13. Plants erect, approximately 14″ in height. Number of stems 15, 10 and 12 respectively. Stems uniformly brownish green in color. Leaves numerous, leaflets broadly oval but varied as to exact shape, size and markings. Pubescence scant. Time of blooming medium late to late.

15. Plants erect, approximately 20″ in height. Number of stems 6, 8, 9, 9, 9, 6 and 9 respectively. Stems varied as to color. Leaves uniformly very few in number; leaflets varied as to size, shape, color and markings. Amount of pubescence varied with the plant. Time of blooming varied from average to late.

18. Plants erect, approximately 12″ in height. Number of stems 8, 10, 7, 5 and 7 respectively. Stems uniformly green in color. Leaves average in number, of a very light green color, with very large almost transparent veins. Leaflets varied as to size and markings but on no plant were markings prominent. Pubescence average. Time of blooming uniformly medium late.

20. Plants erect, approximately 10″ in height. Number of stems 8, 5, 8, 6, 6, 9, 7, 10 and 6 respectively. Stems varied as to color. Leaves uniformly average in number. Leaflets vary as to shape and color. Marking in 8 of the plants was a small triangle and located in tip half of leaflet. Pubescence varied with the plant. Time of blooming varied with the plant from early to late.

21. Plants erect, approximately 15″ in height. Number of stems 11, 10, 8, 7 and 6 respectively. Stems uniformly brownish green in color. Leaves uniformly few in number and from average to very large size. Leaflets varied as to size, shape, markings, and shade of color, tho all were rather dark green. Pubescence uniformly average in amount; time of blooming early. All plants were highly resistant if not actually immune to the powdery mildew which has been so widespread on red clover during 1921 and 1922.

22. Plants semi-erect, approximately 18″ in height. Number of stems, 9, 10, and 8 respectively. Stems uniformly reddish green in color. Leaves of average number. Leaflets uniformly long and narrow, of normal green. Markings similar as to pattern and prominence. Time of blooming early average.

23. Plants erect, approximately 6″ in height. Number of stems 8, 9 and 5 respectively. Stems uniformly quite slender, and of greenish

red color. Leaves average in number. Leaflets uniformly very broad oval in shape, of light green color. Markings similar as to pattern and prominence. Flower heads uniformly small.

25. Plant (a). Plant erect, approximately 4″ high. No stems. Many leaves. Slow growing.

Plant (c). Plant erect, approximately 10″ high. Stems 3, leaves few. Fairly rapid growing plant.

26. Plants erect, approximately 12″ high. Number of stems 10, 4, 10, 5 and 6 respectively Much variation as to color of stems, size, color and marking of leaflets, pubescence, and time of blooming.

29. Plants approximately 12″ high. Number of stems 10, 11 and 7 respectively. Much variation in all characters except for size of flower heads which were uniformly small.

30. Plants erect, approximately 12″ in height Number of stems 12 and 10 respectively. Stems of both plants green. Number of leaves average. Leaflets average sized, oval in shape and of a striking very light gray-green color. Markings large, pronounced and exactly alike in both plants. Pubescence average. Time of blooming medium. These two plants appeared exactly alike and were particularly striking because of their peculiar color.

31. Plants erect, approximately 6-8″ high. Number of stems 18, 15, 13, 14, 11, 5, 6, 3, 6, 8, 9 and 10 respectively. Stems varied with the individual plant as to color; leaves uniformly numerous. Leaflets were uniformly of a broad, oval type, light green in color and marked. The marking, however, varied with the plant as to shape, size, prominence and location in leaflet. Pubescence varied from rather heavy to very scant. Time of blooming late.

In comparison with the above descriptions, it might be interesting to note the number of stems in the plants of the F_1 generation from individual mother red clover plants which were open to miscellaneous cross-pollination.

During the summer of 1921 seed was harvested from such a lot of plants, seed from each plant being kept separate. Seedlings were grown from these seeds and while still small set out in the field, spacing them 24″ x 20″. The counts of the number of stems in four representative groups showed the following variations:

Mother Plant No.	Stems in F_1 generation plants. (Each separate number represents a plant.)
2	3, 2, 12, 10, 4, 12, 9, 8, 9, 7, 8, 10, 13, 14, 4, 11, 20.
11	6, 12, 12, 16, 6, 6, 10, 5, 5, 16, 10, 9, 12.
18	3, 4, 9, 13, 5, 4, 10, 23, 17, 12, 2.
22	27, 10, 10, 28, 6, 3, 4, 6, 5, 20, 10, 4, 6.

The general appearance of these first generation plants exhibited no marked similarities. The only character, in fact, which seemed to indicate any inheritance from the parent or show any uniformity within the individual group was that of weight and then only when one group as a whole was compared with another. For example, the progeny from parent plants Nos. 18 and 22 weighing 7.8 grams and 70.5 grs. dry weight respectively, averaged 19.9 grs. and 40.2 grs. respectively. The variations as to size within the two groups of progeny were almost the same in each, however, as is indicated by the variation in the number of stems per plant shown above. Other characteristics, as color of stems, color of leaves and pubescence in ten separate groups showed no more similarity within the group than among the plants of the different groups. In other words, the similarity between the F_1 plants from self-pollinated mother plants in nearly all cases exhibited much more uniformity than did the F_1 plants from open pollinated mother plants. This would seem to indicate that self-fertilization actually occurred in the plants self-pollinated in 1921.

CONCLUSION

The author wishes to present the foregoing data without attempting to draw any positive conclusion. It is believed, however, that they do justify their presentation as they indicate that self-fertile lines do exist in red clover. The production of

chlorophyl-deficient seedlings probably is the strongest evidence supporting this position. Another is the striking consistency in the seed yielding ability of some groups of sibs when self-pollinated as well as in the inability of other groups to fertilize themselves. The high yield of seed from some of the F_1 plants also strengthens this view. Again, the F_1 generation, in general, showed a marked tendency towards uniformity within the individual group of sibs. These results are therefore presented because it is believed they at least justify reopening the question of self-sterility in this crop.

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Kentucky
Agricultural Experiment Station

University of Kentucky, Lexington, Ky.

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CIRCULAR NO. 30

Discussions and Demonstrations on Breeding Problems.

December, 1922

DISCUSSIONS AND DEMONSTRATIONS ON BREEDING PROBLEMS

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Discussions and Demonstrations on Breeding Problems.

INTRODUCTION.

Many land owners of Kentucky, especially those of Central Kentucky, are engaged in the breeding of Thoroughbred and Standardbred horses as well as the breeding of other purebred live stock. The light horse industry on certain farms has become highly specialized and the total investment involved and the income returned are comparatively large. Frequently, the individual animals owned represent an investment of thousands of dollars and this investment may be jeopardized by failure to breed or by abortion. The Kentucky Agricultural Experiment Station has for several years past been engaged in researches bearing upon the problems of the light horse breeder as well as of the breeders of other purebred live stock. In 1916, after several years of investigation, a bacterial vaccine was developed that has proved effective in the control of infectious abortion in mares. Other researches as to the sterility of the stallion and the possibility of insuring a greater potency in sires have developed methods of determination and possibilities of remedial treatment that are of importance to the breeder. Still other investigations have been developed as relating to the control of barrenness in mares.

Considerable progress has been made in the lines of work named. The funds that the Experiment Station could assign to these particular problems were small and during the past two years additional funds have been furnished by the Kentucky Jockey Club to supplement those of the Experiment Station, resulting in a materially increased progress of the work.

A conference of live stock breeders was called in March, 1922, at the Experiment Station in order that they might present their problems and viewpoints to the Station staff and that such progress as had taken place thru the researches of the Experiment Station might be presented to the breeders. So much interest was manifested in the papers and demonstrations presented at this conference that the papers are herein published for general distribution in the hope that they may be of permanent aid to many who are engaged in the breeding industry.

THOMAS COOPER, *Director.*

ABORTION, STERILITY AND BREEDING HYGIENE.

By Cassius Way, D. V. M.

New York City

To the owner who maintains live stock for breeding, efficient performance in reproduction is essential to success. To the veterinarian who assumes to control breeding diseases and establish breeding efficiency, the problems presented often reach far beyond our present knowledge on this subject. To the scientific investigators and research workers the great problems that unfold before them are so fruitful with possibilities of rendering service to the live stock industry that some of our ablest investigators have chosen this field as one offering greatest opportunities.

Breeding diseases of cattle have received more attention than those of any other species of live stock. The same problems, the same principles, the same features of these diseases prevail in horses. Certain anatomical differences in the genital organs of cattle and horses present different problems that necessitate certain differences in methods of treatment. Sheep and swine present still different problems. The principle of disease control in the different species, however, is quite similar.

Some of us who may be interested primarily in cattle practice naturally look to the great State of Kentucky, the home of the thoroughbred, the trotter and the saddle horse, to undertake investigations that will definitely establish facts pertaining to the breeding diseases of horses that may be on a par with the work of some of our leading investigators in the great dairy and cattle raising states. Problems pertaining to any disease can best be studied where the disease exists in nature. Thoroughbreds, trotters and saddlers are not bred in the North on a large scale. Therefore, we look and hope for someone in this famous bluegrass country to unravel the problems of equine breeding diseases along the lines that Bang, Albrechtsen, Williams, Schroeder and others have begun to give us light in the breeding diseases of bovines. While much of great value is al-

ready known there still remain many problems for research and scientific investigation.

Contagious abortion, sterility and breeding diseases have been discussed from many angles during the past few years. More recently Dr. Schroeder of the United States Bureau of Animal Industry has published the results of an interesting and valuable investigation. The exact text of this article as published in the Journal of the American Veterinary Medical Association is much to be commended. Agricultural publications, however, in an attempt to present this subject to the breeder and live stock owner have, in some instances, presented it in a way that is somewhat confusing. Many points of interest have been omitted, distorted conclusions have been drawn and many factors involving a healthy herd, herd efficiency and breeding hygiene have been ignored.

An aborted fetus is simply a symptom of disease. True Abortion Disease is infection and inflammation of the uterus of the mother and the fetal placenta (afterbirth) of the fetus. The actual disease in cattle is cotyledonitis and placentitis, more commonly known as *Abortion Disease.* This condition is caused by bacteria, usually *Bacterium abortus,* in cows and probably in swine and sheep, and *"B. abortivo-equinus"* in mares. *Bacterium abortus* was discovered by Prof. Bernard Bang of the Veterinary College of Copenhagen, and is commonly called the *"Bang Bacillus."* The presence of these bacteria in the uterus of pregnant cows causes a separation of the fetal and maternal cotyledons, cutting off the food supply to the fetus, contaminating the uterine fluids and resulting in the premature expulsion of the contents of the uterus.

In mares the etiology of Abortion has been studied by several investigators. Prof. Good of this institution has named the specific organsim *"B. abortivo-equinus."* The general infections of the genitalia of horses conform, so far as can now be seen, to those of cattle and what is also important, they conform to the fundamental laws of general genital infections in all mammals. Many infections may not cause visible harm but when intensified by bad physical or sexual hygiene may attain

high virulence and produce a great variety of lesions and extensive losses. Unlike the specific venereal diseases such as syphilis, dourine, venereal tumors of dogs, etc., these general infections are commonly present in the genital organs and elsewhere, their numbers are unknown and their lesions are alike. The lesions in the uterus and fetus attributed to the *B. abortus* (Bang) cannot be distinguished from those of the *spirillum* of Smith, the *bacillus* of Moussu, or the *B. abortivo-equinus* of Good. Each of these is believed to be capable of living and multiplying in the genital organs of an extended list of mammals. Genital disorders in horses present analogous problems to those of cattle modified by certain differences in the anatomical structure of the organs involved.

Unfortunately many breeders consider that an abortion or the premature expulsion of a fetus constitutes the entire disease. They fail to recognize that the numerous other breeding troubles such as cystic ovaries, inflammation and occlusion of the Fallopian tubes (salpingitis), pus in the uterus, inflammation of the neck of the uterus (cervicitis infection and inflammation of the vagina (vaginitis) and many secondary infections often go hand in hand with contagious abortion and follow this troublesome disease.

In considering these various phases of breeding troubles together with the complications and loss attendant thereto, we must realize that an abortion is only one of our problems. Therefore, when the prominent agricultural papers feature *isolation, sanitation and good care* as the great panacea that will lead the breeder out of the wilderness into the promised land of peace, prosperity and freedom from breeding diseases they give the impression to the average breeder that it is only a short jump from the present undesirable condition to the ideal. The majority of breeders of experience know otherwise.

Literally, and under ideal conditions, these three cardinal essentials of disease control will solve the problem of abortion or any other disease. In the control of tuberculosis this is literally true. If we could by isolation confine the disease to the present animals infected, preventing its spread to new hosts,

the disease would die out with the death of the individuals now harboring the infection. This is true of tuberculosis in man, glanders in horses, rabies in dogs, hog cholera in hogs, etc. Practically, however, a different picture is presented. Under practical farm conditions it is often almost impossible to completely isolate several individuals. Caretakers as well as owners are constantly prone to break quarantine rules and often they treat lightly suggestions of this kind. The problem, therefore, of carrying out these three cardinal essentials of disease control is difficult.

Losses from recognized abortion in many herds are very great. If we had to deal only with the loss of a particular fetus and could after two months get the female to conceive we could perhaps then almost recover from the loss of this particular individual. But, as most breeders know, this is not usually the case. Bacteria other than the specific type also gain a foothold and cause certain changes in the genital tract of these females which if not properly treated cause lesions which result in impaired breeding or sterility. Investigators tell us that in cattle *Bacterium abortus* cannot be found in the uterus two months after an abortion. But in many cases the cow will not conceive due to the fact that other bacteria have gained entrance and are making themselves manifest by causing sterility.

One agricultural paper features the following: "*Treatment with drugs or chemical agents externally or internally gives false encouragement.*" Literally and generally speaking we grant this to be the case. Many individuals, however, respond more promptly and recover more completely through the judicious administration of medicinal and surgical treatment than if left to weather the storm under their own powers of resistence. What Dr. Schroeder says is this: "Unquestionably it is economical to give proper treatment to cows that have aborted, or that do not clean properly, or that are afflicted with other troubles of the reproductive organs and functions; but such treatment should not include attempts to disinfect the uterine and vaginal cavities by irrigating them with strong germicidal solutions, because such attempts will prove futile

and cannot be made without serious danger of doing harm. The modern and rational idea of wound treatment should be applied to the treatment of the injured or diseased uterus.'' This means the removal of dead and foreign material on which many forms of micro-organisms feed and multiply, without further devitalization of the injured and diseased tissues.

One familiar with the treatment of abnormal genital conditions common to breeding diseases would hardly presume to endeavor to thoroughly disinfect the uterine and vaginal cavities with strong germicidal solutions. The futility of such procedure is self-evident. In order to kill infecting organisms it would be necessary to use solutions of sufficient strength to kill the tissues of the uterus and thus defeat the purpose desired. By proper methods of treatment what can be done is to mechanically remove all debris and billions and billions of bacteria and in this way materially assist nature in combating the infection which remains in the system. Therefore, the point that we wish to bring out is that the breeding life of many animals can be prolonged by proper treatment and sanitary measures in overcoming bacterial invasion which if not properly removed may gain a permanent lodging place and cause shy breeding, diseases of the newborn and sterility.

Another important fact is the proper treatment of abnormal females thought by owners to be normal. Many highly infected females do not abort; however, they harbor certain types of infection which are harmful. In cows doing advanced registry work demanding maximum milk and butter fat production, brought about by high and sometimes forced feeding, various genital disorders are common. These disorders are usually cystic ovaries resulting in cervicitis, vaginitis, deformed tail heads and oftentimes a nymphomaniac condition. High protein feeding, delayed breeding beyond the normal and customary time and conditions attendant to advanced registry work are closely related to this particular variety of genital disorders. Many breeders do not have these conditions cared for until they become discouraged trying to get the female to conceive. All this valuable time and the services of a great sire may be

wasted. The productive life of more valuable sires has been brought to a close because they have been used repeatedly on a great number of diseased females than in any other way. They are put to such sexual strain that their resistance is lowered, bacteria gain entrance causing chronic lesions in their organs and in turn varying degrees of impotency and finally total sterility result.

There are many virgin heifers which do not conceive to a normal sire. There are others which are bred a few, and in many cases a dozen or more, times before they finally conceive. The abortion rate in this type of heifers is relatively high. The work of Carpenter and Gilman of Cornell University on this type of sterility has been a great aid in bringing to light many interesting facts. It is a well established fact that the genitals of most of these heifers are infected. If this infection persists it naturally lowers the resistance after conception and perhaps may interrupt the pregnancy or be a predisposing accessory cause. Streptococci seem to be the most common organisms found in these cases. Streptococci are a type of bacteria that resemble a chain of beads. They belong to the pus-producing group and often cause inflammations such as septic sore throat, mastitis (garget), pus tubes, etc. Streptococci infection in humans is considered by gynecologists to be very serious. We are beginning to know that this type of infection in bovines is the cause of many breeding troubles and is likewise a very serious condition.

We have observed many mares with apparently normal genitals so far as could be determined on physical examination. However, they do not conceive or are very hard to get in foal and frequently remain barren for an indefinite period. It is possible that Salpingitis, or inflammation of the Fallopian Tubes may be a common condition in these cases. Careful and thorough investigation only will tell. It is necessary to sacrifice many mares of this type in order to collect data that will be reliable and conclusive. Investigation of the relation of a slight retention of the fetal membranes to sterility is important. Treatment with vaccine or bacterins made from cultures

of individual cases seems to be a possible solution of this troublesome phase of the disease. The work by Dr. Dimock that is being carried on at this institution at the present time is most interesting. It is pioneer work and superficial evidence seems to indicate that he is working on a line that may be fruitful of interesting and valuable results. Time, cases for study and persistent work will ultimately tell.

There are other inflammations and abnormalities in the breeding tracts of females that, from clinical evidence, may act as predisposing causes to abortion and be the direct cause of sterility. It is, therefore, important from the standpoint of best breeding and economy to have these conditions properly cared for, thus preventing abnormalities in these breeding females rather than to try to correct them after they have become almost permanently diseased. Many thousands of dollars have been lost on valuable breeding females. If these animals had been properly treated at the proper time they might still be alive and be producers today of the best type individuals of their respective breeds. One calf or foal saved from a good female and by an exceptional sire often pays for the service rendered at many of our large breeding establishments for a long time. The question resolves itself into a commercial and economic problem.

Males are a most important element in every herd and stud both from the standpoint, in many cases, of a large monetary value as well as exceptional and valued blood lines. They are fifty per cent of the herd as far as breeding operations are concerned. Yet, with this fact in mind, they are often the most neglected of any of our animals. At many farms they receive very little care, little or no exercise, are improperly fed, and at times are bred without using any reason at all. This is particularly true in reference to bulls. As a rule stallions, however, during the breeding season receive better care and attention.

One agricultural paper features the following as a fact: *"The bull does not disseminate abortion even though he may be infected with the disease."*

Dr. Schroeder infers that the bull does not transmit abortion disease directly via the genital tract route even though he be infected. He says, however, that there is danger in many cases where the female may take the infection from the bull into her system on feed or in water through the digestive tract. Let us take this for granted. Dr. Schroeder states further in the same article, after discussing blood tests of some three hundred and twenty-five bulls of which approximately ten per cent reacted and approximately ten per cent showed lesions in the reproductive organs from which abortion bacilli were isolated, that: "Their value lies in the fact that they show that abortion bacillus disease of the bull's reproductive organs is not a wholly unique affection which practically may be ignored, *but it is an important condition that must be taken seriously into account in our efforts to combat infectious abortion,* since it has been proved to be associated with the contamination of the seminal fluid."

This condition undoubtedly exists in many stallions and is one of the many problems in connection with equine breeding diseases to be solved. Secondary infections, abscesses in the genitals and abnormal conditions are just as important and probably occur in a similar percentage of cases to those in bovines.

Recently a very interesting and valuable work has been done by Drs. Carpenter, Gilman and Williams. These writers state:

"Clinical evidence clearly incriminates the bull in a large number of cases, and the clinical findings, substantiated by laboratory diagnoses, demonstrate that the bull often becomes a dangerous source of genital infections in the herd."

"Clinical studies now indicate with great clearness that the bull is an active spreader of that group of genital infections which cause sterility, abortion and related phenomena."

"It has been demonstrated that very frequently the bull harbors streptococci, micrococci, and other organisms associated with genital infections in the female. These organisms become localized in the seminal vesicles and testes and during ejacula-

tion of the semen are discharged and deposited in the vagina of the female."

While the work so far is but in its infancy, the results are such as to demonstrate that the bull often becomes infected and may be a dangerous source of infection in the herd. The semen is very frequently abnormal and contains bacteria which are similar to or identical with those isolated on post-mortem examination from diseased genitalia, especially the seminal vesicles. Likewise these organisms found in the semen are very frequently associated with a wide variety of genital infections in the female."

"The cows served by one bull conceive in larger percentage than those served by another. Cows pregnant by a bull of low fertility abort in larger ratio than cows bred to bulls of high fertility. Those cows which are sterile after having been bred to bulls of low fertility often prove persistently sterile when bred to highly fertile bulls. In these cases not only has the bull ejaculated an infection fatal to the spermatozoa and ovum of the coitus concerned, but he has implanted in the genital tract of the cow an infection which prevents fertilization in the future by a fertile bull."

Hadley states that unquestionably the male often becomes infected with germs that produce the various secondary diseases in the female, which are more properly classed under the more inclusive term of "abortion disease." Further on he states that douching the bull before and after service certainly will keep the bull from transmitting the organisms that cause the secondary infections.

In our practice we are convinced that the male is fully as important as the female so far as the breeding health of the herd is concerned. The male's genital tract harbors various kinds of bacteria. He is bred to a female and shortly (within a few days) a marked discharge is noted. We have had cases where every female bred to certain males presested the same characteristic symptoms of disease. In one case upon careful miscroscopic and bacteriological examination a bull was found

to be eliminating harmful organisms causing sterility even though the service was vigorous and seemed normal.

In another case of a valuable herd sire every cow bred to this bull aborts. Material is now in the process of study and examination to reveal if possible the presence of abortion bacilli in the semen of this animal. This is a valuable purebred herd. Cows are calving normally almost every day to services by other bulls in the herd and breeding conditions are quite normal. All members of the herd are cared for in a similar way.

Again, in another herd severe vaginitis with copious discharges developed in a group of clean normal heifers that were bred to a bull that later on bacteriological and microscopic examination proved to be infected. After a course of proper treatment of both the bull and the infected females he was returned to service and the disease has not recurred. The bull is douched before and after each service and all females are clean and normal before being bred.

In still another case a bull of low potency and infected with many non-specific organisms was bred to a group of imported heifers that were apparently clean and normal. Vaginitis, pus discharge, and much difficulty in conception resulted. The bull and all females were placed under treatment. The bull received proper exercise, proper feed and proper sanitary treatment. The heifers improved in a few weeks, potency in the bull was increased until more recently results obtained from this apparently abnormal sire have been very gratifying and satisfactory.

On the other hand, if we breed a clean bull to a cow that has an infected cervix or uterus, the vagina containing many bacteria, and a few hours later we breed him to a virgin heifer or a clean cow it naturally follows that some of the organisms remain on the genitals and in the sheath and are transmitted to the clean female. Is this not the best way to spread many types of infection?

It is in accordance with the best sanitary measures of the day that we should do all in our power to prevent infection. Therefore, our policy is that we breed only clean females and

that all bulls be douched before and after service. The same principle is equally applicable to the stallion. Wash with therapogen or some equally efficient, non-irritating, non-toxic disinfectant, especially after service. We firmly believe that in many cases this practice will reduce to a minimum the chances of transmitting certain types of secondary and dangerous infection. Safe conclusions that may be drawn indicate that from clinical findings and microscopic examinations it is an important fact that all males of lowered potency should be carefully watched during their breeding terms. In our experience the evidence is very clear that the early abortion rate and the death of the fetus with or without expulsion during the first thirty to ninety days of pregnancy is very high where males of lowered potency are continued in service unless some radical change is made in their mode of living. *All males whose potency is lowered because of infection are dangerous and should not be used for service.*

Good sanitation plays an important part in the control of any disease. In herds of mares or cows where there is constant or even occasional shifting of animals, buying and selling, or introduction of new individuals special precautions are indicated. New infections may be introduced which may be serious, new individuals may be subject to the present infection in the herd to which the present herd has become immune. Oftentimes re-infection is more serious than the primary infection.

In the spread of diseases the digestive tract is by far the most important factor. In the construction of stables labor saving devices and convenient arrangement have received primary consideration. Continuous mangers used for feeding and watering make ideal avenues for the spread of disease. They are in reality no better than common sewers and spread filth and disease from one animal to another. In the control of tuberculosis it is an established fact that a certain percentage of tubercular cows do not react to any test. Often they are badly diseased and are active spreaders. To guard against this hidden source of danger is important in stable sanitation and disease control. We could relate many sad and disasterous

experiences along this line among conscientious breeders in the endeavor to eradicate tuberculosis from a herd. The principle is just as applicable to the control and eradication of abortion disease. Barriers in the path of the disease will materially reduce its spread from animal to animal. Make the living conditions of the individual members of the herd as *individual* as possible. *Individual mangers and individual drinking cups are absolutely essential.* Build permanent mangers with manger partitions high enough to insure individuality and of material that can be cleaned and disinfected. This is probably the most important factor of disease control in the herd.

Sanitary stables should be well lighted, properly ventilated and equipped with a proper drainage system. Sunlight is Nature's disinfectant and an abundance of this great natural agent is accessible to all. Efficient and adequate systems of ventilation may be installed at moderate cost. They do not need to be elaborate and expensive. Dry, clean, well lighted, airy stables help to build up resistance against disease.

Health often depends on cleanliness. Sanitation and breeding hygiene in references to disease control among live stock are most important factors. All females should be examined a few weeks before breeding to ascertain if they are normal. Many services of a valuable sire and much time may be saved by a little sanitary treatment. Douche the bull before and after each service, this is good breeding hygiene. Often a minute's prevention saves months of treatment.

Vaccination against abortion disease has been heralded by some as the great panacea on which to rely. By others it has been most severely criticized and condemned. It would seem that neither faction is entirely correct in the conclusions drawn. It is easy to pick flaws, to tear down and destroy. It is hard to build and develop conclusive scientific facts. The work of many English investigators seems to demonstrate much of value in the control of abortion disease by the use of proper vaccine (living organisms). In the article by Dr. Schroeder previously referred to several interesting points are recorded. In several large herds under his supervision the abortion rate has been

materially reduced by the use of vaccine. One experiment that was omitted by the agricultural publications is recorded in the original articles as follows:

"Twenty-three cattle, part of a drove of 66, not one of which, according to the tests that could be made, was infected with bovine infectious abortion, were divided into three groups. Eleven received subcutaneous injections of pure living cultures of abortion bacilli about two months before they were served by bulls; 4 received repeated injections of killed cultures of abortion bacilli after they had become pregnant; and 8 were retained untreated, as checks or controls. The 23 cattle were equally and similarly exposed to abortion infection; the exposure was via the digestive tract, or the kind of exposure that would occur in nature, and the material used for the exposure was obtained from actual cases of infectious abortion.

"Of the eleven cows treated with live organisms before conception, 10 calved normally in all respects and 1 aborted.

"Of the 4 given dead-organism treatment after becoming pregnant, 2 calved normally and 2 aborted.

"Of the 8 controls, 7 aborted.

"The cattle of the first group, those which received treatment before they were served by a bull, were kept under further observation until they had produced an additional 15 calves. They suffered no breeding troubles, such as retained placentas, sterility, etc.

"The number of animals in the second group, only 4, is too small to permit drawing the conclusion that treatment with dead organisms in some measure protects gravid cows; but the difference of 1 abortion among 11 cattle and 1 normal parturition among 8 controls can leave little doubt that a serviceable degree of immunity against abortion can be engendered by subcutaneous injections, prior to conception, of living abortion bacilli."

Our experience with vaccination leads us to believe that treatment with living organisms (vaccine) has possibilities that merit careful consideration. While the whole subject is still in the experimental stage and hasty conclusions should be avoided

the results thus far obtained in herds varying in size from a few very high-class purebreds to large and influential breeding establishments together with a few large commercial dairies, operated entirely from a practical and revenue producing standpoint, indicate that this method of controlling abortion disease in conjunction with breeding hygiene and sanitation is profitable and in many cases highly satisfactory. As the subject of immunity in connection with this disease becomes better understood and more research in the practical application of this method is completed we will of course be in a position to draw more definite conclusions.

In all herds under our supervision good breeding hygiene is practiced. Two years ago, in a herd acquired by the writer, producing a high-grade certified milk, the abortion rate was high. Good breeding hygiene was practiced, we have individual mangers and as an index to methods employed we might say that for two years, 1920 and 1921, we have produced the lowest average bacteria count of about sixteen farms coming under the supervision of our Medical Milk Commission. Nearly two years ago we decided to give vaccination a thoro trial. Every open cow was vaccinated (living organisms) and every cow pregnant up to six months was treated with bacterins (dead organisms). The abortion rate was reduced immediately to less than five per cent. Since then every cow is vaccinated as she freshens, is bred in 60 to 90 days and to date the abortion rate is nil.

In another large establishment of 900 to 1,000 cows the abortion rate has been reduced to less than one per cent.

In some instances where the disease seems to include many types of secondary infection, where bulls are apparently badly infected and of low potency and where breeding diseases are prevalent, the results are not as satisfactory. These cases tend toward the conclusion that abortions from other causes than the specific *Bang bacillus* are more numerous than is generally recognized. In our opinion the breeding problems discussed earlier in this paper play an important part in these obstinate cases. The possibility of treating certain types of sterility by

this method is interesting. Many instances in our practice might be cited where satisfactory results prevail. Many reports have come to us from able practitioners recording practically the same results as ours. However, as previously stated, the whole subject is more or less in the experimental stage and we prefer to withhold final judgment until more data are available and work under way at present is complete. It would seem that vaccination holds most interesting possibilities for the the future.

The principal studies in this country in the treatment of abortion in mares have been carried out at this institution. Professor Good has reported the results of experiments that seem to be even more fruitful of good results than vaccination in cattle. The results of his experiments seem to show that the practice of using vaccine or bacterins (dead organisms) as a prophylaxis against equine infectious abortion is highly profitable. It is hoped that future studies along this line will determine definitely the avenues of infection. Undoubtedly they are similar and in practically all respects analagous to those of bovine abortion. The fundamentals of treatment and prevention are the same. In swine and sheep these fundamental principles prevail also.

Investigations relative to the possibilities of making a diagnosis of the infection by means of blood tests will be of material assistance in locating possible spreaders of the disease. Investigation of these many problems is sorely needed and only thru work of this nature will we be able to arrive at satisfactory and definite conclusions with prevention and treatment of this disease.

Isolation of all aborting animals until all discharges cease, the destruction of aborted fetuses and membranes together with isolation and segregation of all known spreaders of the disease is imperative. Isolation is a most important factor in disease control, applicable to abortion as well as to all other diseases.

The most important phase of disease control in calves, foals and the newborn of any species, especially where infection exists, is proper maternity pens or stalls. These should be con-

structed in such a way that they are entirely separate from each other and from other parts of the stable and can be thoroly and completely disinfected and then fumigated with formaldehyde gas after occupancy and before another animal is permitted to enter. They should be bedded with clean straw. All cows and mares should be placed in these pens just before parturition and remain in them until all discharges cease. Enough of these stalls should be provided to care for all individuals that may need them at any one time. Our experience in large herds of purebred cattle has been to bring the calves into the world in a clean place and in clean surroundings, vaccinate and treat them for pneumonia (hemorrhagic septicemia) and the majority of the calf trouble will subside. In mares this same principle applies to the foal. It is believed by the writer that such diseases as navel ill, scours, pneumonias, etc. are equally controllable by similar methods.

The control of breeding diseases is not a temporary or a transient proposition. It is an all-year problem and also year after year. Prevention is the secret of success. Much research is needed. The great institutions in human medicine have solved many problems that a few years ago were thought to be almost unsurmountable. From those who benefit most must come the majority of the work and the support. In this great section where purebred live stock abounds on almost every farm the possibilities for service and research are unlimited.

In the control of disease the resistance of the host bears a direct relationship to the progress of disease. The formula for disease is $D=\frac{V}{R}$, which means that *Disease* equals *Virulence* of the invading organisms over *Resistance* of the host. A vigorous constitution, strong resistance, good food and hygiene materially help in the battle against disease. We have come to know more recently that the diet should contain a maximum of essential salts, or calcium, phosphorous, magnesium, potash, etc., which are so necessary in building up this increased resistance. These elements together with what scientists have chosen to call vitamines make the necessary combination for the growth of strong

healthy tissues and the development of maximum resistance against disease. The entire subject of nutrition and nutritional diseases is a great study in itself and can only be touched on briefly at this time.

These factors of disease prevention and control demand the earnest attention of live stock owners and it is thru careful, hard-headed and thoro practice in the field that the real value of scientific research is measured.

Owners of live stock can do much to control breeding diseases and abortion.

1. Breed normal females only. Mate them with healthy vigorous, potent sires.
2. Treat all diseased animals as dangerous spreaders. Practice isolation, sanitation and breeding hygiene. .
3. *Prophylactic measures that prevent the development of disease should be employed.* Be sure the females are normal before breeding. Heifers that show any evidence of discharge, vaginitis or other genital infections should have treatment. Mild antiseptic and saline douches often work wonders.
4. Douche or wash the male before and after service. This is good breeding hygiene.
5. Sterility in the male is fully as important as in the female. Watch this condition carefully. Exercise and proper feed and care are essential.
6. Individual mangers of the permanent type and individual drinking buckets are strong barriers in the path of disease.
7. Individual maternity pens are essential in the control of many diseases of the newborn.
8. *Build up resistance.* Feed calcium (air-slaked lime), steamed bone meal (sterilized), screened hard-wood ashes and common salt in conjunction with properly cured hay, alfalfa, corn silage and roots. Ground oats, barley and yellow corn are

rich in essential mineral elements and are valuable factors in the grain ration.

9. Natural resistance and immunity to disease are the ideal. To develop a race of live stock with sufficient resistance to withstand natural infection should be the goal of all constructive breeders. Prophylaxis, sanitation, breeding hygiene, proper nutrition and vigorous constitutions in our live stock will tend toward the attainment of this ideal.

REPORT OF PROGRESS OF WORK ON STERILITY.

By W. W. Dimock

Kentucky Agricultural Experiment Station.

Extensive studies and investigations on abortion and sterility in cattle have been carried on for a number of years in this and many other counties, and while substantial progress has been made, there are still many phases of both problems that need to be investigated further in order that apparent inconsistencies can be explained, and certain opinions verified. Kentucky, through investigations carried on at the Agricultural Experiment Station, has made notable and significant contributions to the solution of certain phases of these problems, among them being the cause and prevention of abortion in mares and sows, worked out at this station under the direction of Professor E. S. Good, and the work of Professor W. S. Anderson in his studies in genetics. For a number of years Professor Anderson has been working upon some features of sterility in the male, and has demonstrated many significant conditions. With all the work that has been done on abortion and sterility in the different species of domestic animals, a search of the literature shows that almost no systematic work has been done on sterility or barrenness in mares, nor on certain important conditions in the stallion which may render the animal temporarily unfit for service or permanently sterile. There certainly is no place in the United States, and possibly in the world, offering material and facilities for a study of these problems in the equine species equal to those found here in Central Kentucky where within a given area are to be found so many large breeding establishments. Veterinarians and the breeders of thoroughbred and standard bred horses and of beef and dairy cattle, are quite as well aware of the practical economic importance of this problem as I. Therefore, I only need to say that information coming to us almost daily is to the effect that abortion and sterility form a major and very serious problem to the breeder. If an understanding of the cause and nature of the disturbances which prevent conception in the female, and I refer particularly

to the horse industry of this section, can be found and methods for making a correct diagnosis and handling such cases worked out, whatever the cost of the investigation, I believe it will have been well worth while. Owing to the value of a very large percentage of the mares and stallions to be dealt with, a direct attack such as would come from holding post-mortem examinations cannot be thought of, except as a last resort. The problem stated briefly is, to find out during the life of the particular individual the cause of barrenness, and then to undertake its correction. We have in the reproductive organs, as has already been pointed out to you, many different parts and sections to consider when searching for the cause. For the many abnormal conditions not well understood our only hope of gaining knowledge upon which fundamental and specific treatment may be applied is by painstaking research. The clinician who undertakes to correct pathological conditions must be well trained in the application of knowledge already acquired. Efficiency depends upon energy and a capacity to acquire and apply new facts; and in being able to interpret clinical history, and at the same time depends on his dexterity and self reliance in the use of special senses, for nothing that one can learn to see, feel, hear or do can be overlooked if one hopes to attain full success in this work.

Investigations on the pathology and bacteriology of the reproductive organs of mares, and their relation to sterility or barrenness was not begun officially at the Kentucky Agricultural Experiment Station, until July first, 1921. Previous to this time a number of mares had been examined and a few post-mortem examinations held, the results of which are included in this report. From a total of ninety-seven mares examined, the following data were obtained:

Twenty-six were apparently normal and cultures from the cervix or os showed no bacterial growth.

Twenty-eight showed no lesions other than a slight congestion and discoloration of the membranes, vagina and cervix. Cultures from the cervix of each revealed one and not more than two different micro-organisms.

Thirteen were found to be suffering with vaginitis and cervicitis and cultures showed three or more different micro-organisms from each case.

Twenty-seven were found to be suffering with a purulent inflammation of the uterus or pyo-metra. In all twenty-seven cases a streptococcus was isolated, and in many of these cases other organisms as well.

One, which had aborted ten days previous to examination showed reproductive organs apparently normal, no cultures made. A streptococcus has been isolated from the foetus.

Eight not examined (bacteriologically) during life were killed for the purpose of study.

Listed in the order of their frequency of occurrence, the following micro-organisms have been isolated from the sixty-eight mares from which bacterial growth occurred in cultures.

A streptococcus, M. pyogenes varians albus and B. coli, have been isolated from about the same number of cases, that is, between twenty-seven and thirty per cent of the entire number cultured.

A short rod belonging to the colon-typhoid group, and somewhat resembling B. abortivo equinus in the appearance of the colony on agar plates, has been encountered in about fifteen cases.

Fifteen other varieties of micrococci have been found, some of them in only one instance, others in several. Of these, the following have been positively identified to date.

M. candicans. (Normal habitat, air, water, milk, urine, etc.)
M. viridis (water)
M. descidens (air and water)
M. expositionis (milk)
M. luteus (air and water)
M. citreus
M. aureus
M. beta
M. simplex
Sarcina subflava

The rods isolated have been confined mostly to spore producers and those closely related to the colon-typhoid group. In one case B. viscosus has been found, in another Ps. pyocyanea.

In all, a streptococcus has been found and cultured from twenty-seven different cases.

Many more organisms are well under way for identification. Of this number the most will prove to be organisms which have already been isolated and studied in other lines of research, while a lesser number are disclosing characteristics for which we can find no description in bacteriological literature and so are more than likely new, and have yet to be classified and named.

It is quite generally recognized that the presence of a streptococcus is indicative of some abnormal condition, especially as they are not widely distributed in nature and only live and multiply under certain favorable conditions. While some of the micrococci which have been isolated are pus producers, others have as yet not been assigned any specific place in relation to sterility or barrenness and it will mean a long and careful study of each before the importance of their presence can be definitely determined.

Aborted Feti:

1031—All organs cultured—growth from:

(1) Area of degeneration on liver (micrococcus)

(2) Peritoneal fluid (micrococcis.)

1100—All organs cultured—no growth.

1101—Fetal placenta from mare giving premature birth to a colt that lived; a micrococcus from cord.

1102—Shetland pony (fetus). All organs cultured—a pure culture of a streptococcus from:

(1) Stomach.

(2) Cord.

1187—Fetal plactena—a micrococcus from cord.

1087—Colt 13 days old. All organs cultured—growth from:

(1) Cord—B. coli and a rod staining similarly to a bipolar —Injected in rabbit but did not kill.

(2) Intestine—An organism belonging to colon—typhoid group.

1236—Colt—24 hours old. All organs cultured; a pure culture of Bact. viscosum equi isolated from each.

1243—Colt twenty-four hours old. All organs cultured; no growth from kidney; B. coli and the rod with the wrinkled colony from all other organs and cord.

1272—Colt—born dead. All organs cultured—growth from:

(1) Cord—B. coli.

1307—Colt—cultures from all organs and joints—growth from:

(1) All organs and joints—B. coli.

(2) Rod belonging to colon-typhoid group.

1312—Culture from abscess on leg of colt. Resulting growth.

(1) Streptococcus.

(2) B. coli.

(3) M pyogenes var albus.

Of the fourteen stallions examined the same bacterial growth resulted from twelve. This growth consisted of a streptococcus, M. pyogenes var albus, M. roseus, M. citreus, B. coli, a rod with a wrinkled colony and sometimes M. aureus. Cultures from one of the two remaining stallions were the same as the above except that no streptococcus was detected, while the inoculations from the other one showed M. pyogenes var albus alone.

It is not possible for us to tell, at the present time, the significance of the presence of micro-organisms in the semen of stallions, nor the connection, if any, between them and micro-organisms found in mares that are suffering from inflammatory changes in the reproductive organs, or that are non-breeders. The observations so far made are to be taken as strictly preliminary in nature: The studies will be continued just as rapidly as possible and it is hoped that as the work progresses something definite may be determined.

Mare No. 1006—*Killed Jan.* 1, 1922.

Post-mortem examination of reproductive organs.

Gross pathology:

Vagina: Normal.

Cervix: Normal.

Uterus: Enlarged, somewhat edematous, mucous membrane showing an abnormal number of folds.

Fallopian tubes: Right fallopian tube had very small lumen especially near the ovarian end. Left tube was normal. No salpingitis was observed.

Ovaries: Left ovary somewhat enlarged and cystic, weighed 100 grams. Right ovary about normal in size, contained one large cyst, weighed 55 grams.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

Growth from right ovary.

Note—This mare was twelve years old, had been bred repeatedly, but so far as known never had a colt.

Mare No. 1041—*Killed Jan.* 16, 1922.

Post-mortem examination of reproductive organs.

Vagina: Chronic vaginitis. Mucous membrane of a dirty gray color.

Cervix: Cervicitis. The os had lost its normal tone and power of contraction and was open enough to readily admit the hand.

Uterus: Chronic metritis. Organ was about normal in size but the wall was thick and somewhat edematous. Mucous membrane of a dirty gray color and contained numerous submucous cysts.

Fallopian tubes: Normal in size, no inflammation present except for a short distance near the uterine end.

Ovaries: Normal in size. One large cyst on each ovary. Some fibrosis. Left ovary weighed 75 grams, right 62 grams.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

Growth from left horn of uterus.

Mare No. 767—*Killed Sept.* 13, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Normal.

Cervix: Closed; the opening from the vagina into the uterus was completely closed by a membrane that had grown over the external os and which was continuous with the vaginal mucosa. The cervical canal was closed by a fibrous tissue growth which was probably the result of injury.

Uterus: Normal.

Fallopian tubes: Normal.

Ovaries: Small and firm, several small cysts in each ovary. Left weighed 60 grams, right weighed 48 grams.

Culture tubes were inoculated from uterus—horns—fallopian tubes and ovaries.

Growth obtained from left fallopian tube.

Mare No. 768—*Killed May* 26, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Apparently normal.

Cervix: Apparently normal.

Uterus: Apparently normal.

Fallopian tubes: Normal in size, both contained a cheesy white material (exudate) near their ovarian ends.

Ovaries: Enlarged. Left ovary was about twice normal size, right $1\frac{1}{2}$ times as large as normal, each contained one large cyst and a number of smaller cysts.

Culture tubes were inoculated from uterus—horns—fallopian tubes and ovaries.

Growth obtained from right ovary and right fallopian tube.

Mare No. 893—*Killed Nov.* 29, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Normal.

Cervix: Normal.

Uterus: Enlarged, thickened and edematous. Chronic

metritis. Mucous membrane of a dirty gray color and contained numerous small sub-mucous cysts.

Fallopian tubes: Chronic inflammation in both tubes. Salpingitis.

Ovaries: Slightly enlarged. Both weighed 90 grams. A number of small cysts found in each ovary.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

No growth.

Mare No. 841—*Killed June.* 20, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Slight vaginitis.

Cervix: Normal.

Uterus: Normal.

Fallopian tubes: Normal.

Ovaries: Enlarged and cystic.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

All cultures were negative.

Mare No. 806—*Killed May* 14, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Normal.

Cervix: Normal.

Uterus: Normal.

Fallopian tubes: Normal.

Ovaries: Fibrous, smaller than normal.

Note—Animal was found to be suffering with organic diseases. Animal had been sick for two years (was four years old) but had never been in condition to breed.

Autopsy revealed an extensive scirrhosis of both the liver and pancreas, accompanied with great enlargement of the lymph nodes draining them.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

Cultures all negative.

Mare No. 799--*Killed June* 2, 1921.

Post-mortem examination of reproductive organs.

Gross pathology.

Vagina: Chronic vaginitis. Mucous membrane of a dirty yellow color and somewhat edematous.

Cervix: Chronic cervicitis of the same character as the inflammation in the vagina.

Uterus: Enlarged, soft and spongy. Chronic metritis. Mucous membrane edematous and of a mottled dirty yellow color.

Fallopian tubes: Showed chronic inflammation (salpingitis).

Ovaries: Cystic, greatly enlarged. Left weighed 220 grams, right weighed 140 grams. There was also considerable fibrosis of both ovaries.

Culture tubes inoculated from uterus—horns—fallopian tubes and ovaries.

Growth was obtained from left ovary and left tube.

TABLE SHOWING GROWTH FROM ORGANS OF MARES THAT WERE KILLED AND CULTURED.

Mare No.	Uterus	Horns	Tubes	Ovaries
717	+	—	—	+ R and L
767	—	—	+ R	—
768	—	—	+ R	+ R
799	—	—	+ L	+ L
806	—	—	—	—
841	—	—	—	—
893	—	—	—	—
1006	—	—	—	+ R
1041	—	+ L	—	—

717—Micrococcus.
767—Short rod.
768—R. tube, A micrococcus (M. pyogenes albus).
768—R. ovary, A micrococcus (M. pyogenes albus).
799—L. ovary, short rod.
799—L. horn, micrococcus.
1006—A micrococcus.
1041—A micrococcus.

The treatment of mares for barrenness is being carried on in co-operation with practicing veterinarians, and while considerable success has apparently been obtained, we are not prepared to say that any one method of treatment is superior to another. On the other hand, indications are that no two cases can be handled exactly the same. On the basis of the result of our laboratory studies and field observations we tentatively place non-breeders in groups, the grouping being based on the presence of infection and the type of abnormality found.

A certain group of mares require ovarian massage only; another group, for example, showing pus in the uterus, will require irrigation and massage of the uterus; another group showing vaginitis and cervicitis may require irrigation and local applications to the vagina and cervix only; another group in which there seems to be no serious bacteriological infection but in which the uterus is found to be enlarged and showing a partial or complete loss of tone, may require stimulation which is brought about by irrigation, massage and internal medication.

In all cases where the trouble is apparently due to micro-organisms an autogenous vaccine has been used in an experimental way. We feel that the use of the vaccine has been of material value, when used in conjunction with other forms of treatment.

We do not expect that the time will ever come when it will be possible to write out directions for treating sterility in mares that can be applied to any considerable number of cases successfully. This work requires the greatest skill on the part of the diagnostician, and the treatment employed will have to be modified to fit the particular requirements of each individual case.

INFECTIOUS ABORTION OF MARES

By E. S. Good.

Kentucky Agricultural Experiment Station.

One of the great losses in the horse breeding industry is due to the disease of infectious abortion. This disease in 1880 first made its appearance in the United States among draft horses of the Mississippi Valley. From this section of the country, the disease made its way to other sections, including Kentucky, the largest breeding ground of Thoroughbred and Standardbred horses in the country. In some seasons as high as seventy-five per cent of the mares of certain studs in this State have aborted and, in a few instances all the foals have been lost. The loss of a crop of foals from a stud of high-priced horses is a heavy blow to the owner. For illustration, one aborted colt sent to our laboratory was from a mare valued at $40,000 and the stallion $100,000. This was a male colt and had he lived would have been a full brother to a Derby winner in France. This colt was aborted late in gestation so he was well developed. He was of unusually good form and of a beautiful chestnut color. A number of other fetuses sent to the laboratory for examination while we were endeavoring to determine the cause of the disease had very notable parentage. The service fee for our best stallions runs from $500 to $2,500 per live foal. If there is an abortion the owner of the stallion loses his fee.

Infectious abortion has been known to exist among stock for centuries. Much speculation over its cause has been made by the breeders. In 1896 Drs. Bang and Stribolt of Denmark succeeded in isolating an organism which is now conceded to be the cause of this disease in the cow. This germ is known as the Bacillus abortus (Bang). Altho Dr. Bang had never isolated this particular bacillus from an aborting mare, he had produced cases of abortion in mares experimentally by the use of the bacillus mentioned and inferred from these experiments that this germ was responsible for the disease in the mare as well as in the cow. We found this not to be the case.

In 1907, a laboratory was equipped at the Kentucky Agricultural Experiment Station for a study of the cause of this

disease among mares, and, if it could be discovered, to endeavor to immunize mares against the malady. This work has been in progress since the beginning in 1907. In making a preliminary investigation as to what was thought to be the cause of mares aborting, we found quite a number of theories among the breeders some of which were as follows: That the trouble was caused by the mare eating frostbitten grass late in the fall or early in the spring; the flushing of the system by eating too much succulent feed; the presence of bad odors; that is, if a mare aborts in a field and the fetus 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; others were quite positive that the smelling of hog's blood could cause mares to abort. From the nature of the malady, we came to the conclusion that the disease was caused by a germ. The first few years of the investigation as to the cause of the trouble were not followed by pronounced results. It was found difficult to secure specimens, for when we heard of a case usually the afterbirth and fetus of the aborting mare had been buried or burned before we arrived on the ground. Then definite cooperative arrangements were made with the veterinary practitioners of Lexington for the securing of specimens. The specimen could consist of the afterbirth or fetus of an aborting mare or any discharge from such a mare, also, the soiled bedding or grass on which the mare aborted. After this arrangement had been made, many specimens found their way to our laboratory. Under the most careful conditions, such material usually becomes contaminated with different species of bacteria before it reaches the investigator and it was not until the spring of 1911 that we succeeded in isolating the particular germ that we have since proved to be the cause of the disease. Of course, all germs are small in size but the microbe which causes this malady is much smaller than the average, being so small that from 25000 to 50000 could be placed lengthwise, end to end, in the space of one inch. The germ varies somewhat in length. To have some realization as to how small this is, measure off one inch and with the finest pointed pen you can

get see how many dots you can make, end to end, in this space. The best the speaker can do is 60 dots. Of course, it is needless to say that it requires a microscope of high power to see this germ. Keeping the minuteness of size of this organism in mind, one can readily understand how easily it can be distributed around the barn and premises. When given proper food which the bacteriologist calls "media" this germ will multiply abundantly. It will grow in the free air or in air from which the oxygen has been removed. It is not so particular as to temperature as some disease producing germs are as it will grow to some extent at ordinary room temperature but, of course, will grow much faster when put in an incubator. This bacillus belongs to a group of organisms which produce different diseases in man and animals but is not identical with any of them. Its only role as far as we have so far determined is to produce abortion in mares. We have proposed the name of Bacillus abortivo-equinus for this germ. The disease can be produced in a mare both by feeding the bacillus to her and by intravenous inoculations, the incubation stage being ten to twenty days. Up to date, we have isolated this organism from some twenty studs of aborting mares.

In our experience, we were never able to isolate the bacillus of infectious abortion from mares which had aborted very early in pregnancy, that is the mare aborting within a few weeks after conception. We did once or twice find the colon bacillus associated with these early abortions. Whether it was a secondary infection we are unable to state. In our experience, the larger number of foals were lost during the eighth month of pregnancy. There is much to be learned as to the cause of mares aborting during the early stages of pregnancy; I mean by this when the fetus is but a few weeks along. Dr. Dimock is investigating this phase of the question at the present time.

Symptoms: Uusually a mare will abort a fetus well along in gestation with little effort, and in most cases with no injurious after effects. However, in a large stud of mares afflicted with this disease, an individual or two may succumb after aborting. The symptoms presented in such cases are a con-

tinued discharge from the vagina, elevated temperature, and marked depression. Our investigations also show that the internal organs of the fetuses of aborting mares usually present marked pathological conditions. The afterbirth of an aborting mare is of a chocolate color and has a peculiar odor sometimes called "a sour odor."

Our investigations show that the disease is acute and not chronic like the disease in the cow. From the results of the intravenous inoculation of the germ or by feeding the germ, the mare can be aborted in from 10 to 20 days. We would conclude from this that the stallion plays small role in the transmission of the disease. It would seem that after the disease starts in a herd of mares and a mare aborts, feed or grass becomes contaminated with the germ and other mares become infected by eating this material the organism being absorbed by the digestive tract into the blood stream and conveyed to the pregnant uterus where it finds suitable conditions for its multiplication and destruction of the fetus.

Dr. W. A. Schofield, an investigator of this disease in Ontario, Canada, says that it is his opinion that the stallion does transmit the disease because the trouble appeared on mares bred to certain stallions. If this were true the germ would be conveyed from the stallion either in his semen or by it being on the outside of the penis. This may be possible altho from the incubation stage from experimental work we think it scarcely probable. We did, however, in one case isolate this particular germ together with the germ which causes green pus from the testicle of a stallion afflicted with orchitis.

As soon as we had succeeded in isolating the germ causing the disease of abortion in mares, our next step was to carry on investigations to determine whether mares could be immunized against the disease. We first carried on our investigations with rabbits. Small doses of the germ freshly isolated from the mare will kill a rabbit in from two to twenty-four hours. Our first work was to determine whether we could immunize rabbits against the disease. This we found we were able to do by repeated and increased doses of a vaccine made from the germ.

Our next step was to determine if mares could be immunized against the disease which this germ produced in a mare, namely infectious abortion. Inasmuch as mares immunized in the Blue-grass Region of Kentucky are worth large sums of money, it was necessary to determine whether or not this system of immunizing the mare would be harmful to the animal. We found that small and increasing doses of bacterin injected under the skin seven or eight days apart produced no injurious effects other than perhaps a slight swelling at the seat of inoculation and some stiffness of neck and leg muscles for one or two days after the vaccination. All these symptoms soon passed away. After this procedure, our next step was to endeavor to produce a hyperimmune serum by injecting into a mare increasing doses of the live germ. These doses at times were injected into the jugular vein and under the skin. We found that the blood serum of these mares would protect rabbits from death when the germ was injected into that animal. We also found that it was quite effective in immunizing mares against the disease. Serums, however, are expensive and easily contaminated and the immunization of short duration. Bacterins and vaccines produce a much more lasting immunity and are much cheaper in their preparation. After we had determined by experimentation with pregnant mares purchased by the Experiment Station, that no trouble was experienced by the process of vaccinating mares and that immunity could be built up against the disease, we began to use this method of immunization in the field. In the main, our method of immunization has been to inject into the mare subcutaneously four doses of the bacterin seven days apart. Our first inoculation consists of injecting 8,500,000,000 dead organisms, 17,000,000,000 for the second, 25,000,000,000 for the third, and 68,000,000,000 for the fourth. We have found that this method of immunization will protect the mare from one foaling time until the next. We are now investigating to see whether the number of inoculations cannot be reduced and still produce the desired effect. We believe, if no infection exists among the mares and one existed the previous year, that it is best to vaccinate them in August. If one puts off vaccinat-

ing until the disease appears in the herd, it is best to remove all mares which have not aborted to a pasture on which no aborting mares have run and vaccinate them. Seven days after the last injection of the vaccine, the mares can again be returned with those which have aborted if it is desirable to do so.

The results of vaccinating mares in the field have been excellent. During the past five years the vaccine has been used on from 150 to 400 mares yearly. During the past year 401 mares were vaccinated.

While we believe we can control infectious abortion in mares there are many problems connected with the breeding of mares which have not been solved. Some of these problems are the aborting of a very young fetus and the problems relating to sterility and we are very fortunate that these problems are being investigated and will be discussed today by Drs. Way, Dimock and Anderson.

GENETICS IN RELATION TO HORSE BREEDING.

By W. S. Anderson.

Kentucky Agricultural Experiment Station.

I have been requested to say something in this address about the laws of breeding and something about the work which I have done with sterile stallions.

The first fact of breeding which needs mention is that all the contribution which a stallion can make to his son or daughter is bound up in one tiny sex cell which he contributes to the new life. At any one mating he furnishes myriads of sex or sperm cells. Under ideal conditions and with a maximum discharge of semen at a mating, the actual number of a stallion's sperm cells may exceed two hundred millions. Only one of all this great number is utilized by the egg; all the others perish. What the stallion hands on must be centered in the one living, active cell which finds the egg and unites with it. There is no physical mechanism whereby the sire can give his offspring any of his physical, emotional or mental qualities, save as they are stored in the one minute spermatozoon.

The male sex cell is so small that it must be magnified almost one hundred times its actual size in order to make it visible. Its head is somewhat pear-shaped and its movement is effected by the lashings of its tail which is many times longer than the head. The cell itself is composed of a cell wall and of nuclear matter or bodies which carry the determiners for the qualities which the sire is passing on to his progeny. By means of the tail the sperm travels over the mucus membrane of the female until it looses its energy or finds the egg and unites with it. When the head penetrates the cell wall of the egg the tail is severed and remains on the outside.

The egg of the female is such a sensitive body that as soon as it receives one sperm its entire cell wall undergoes a chemical change which makes it impossible for any other male sex cells to perforate it. This is nature's way of starting a new life with the union of two sex cells and only two—one from the male and the other from the female.

Once in a while a mare will shed two eggs instead of one in which case both may be fertilized and twins result. In the multiviporous animals like swine the female regularly sheds a number of eggs and the size of the litter depends on the number which she liberates.

The egg of the mare is much larger than the sex cell of the stallion. It is visible, or almost visible, to the naked eye. It is a spherical body a little less than one hundreth of an inch in diameter. It has a cell wall and nuclear matter or hereditary material and, in addition, it has a supply of food material to nourish the embryo when growth begins until the new organism can make connection with the uterine wall thru which it can obtain its nourishment. It is to be noted that while the sex cell, or egg, of the female is many times larger than the sex cell, or sperm, of the male the difference in size is due solely to the presence in the egg of protoplasm or food material. The essential part which conveys her hereditary contribution is no greater than the corresponding part contributed by the male.

There are some breeders who believe that the stallion furnishes the qualities of the foal while the mare furnishes the means for its growth only and should be given no credit aside from furnishing food before and after birth. Other breeders take the opposite view and claim that the mare makes the more important contribution to the foal because for eleven months she carries it *in utero*. Both views are incorrect. Both sire and dam make equal contributions of hereditary material to the offspring. The quality of the contribution made by the sire may be more desirable than that furnished by the dam but the quantity is the same. Whether the sire can give better material than the dam to a foal depends altogether on whether he is better bred than she is, because both of them pass on just what they have received from their ancestors.

In animal breeding the male is more frequently used to make improvements because it is so much easier to obtain well-bred males than it is to replace a herd of common females by fashion-

ably bred ones. One good male can materially lift the quality of the offspring of a considerable band of females. However, the male is expected to make such marked improvement only when he is used on indifferent females. When they are as well bred as he is then he exerts no greater influence in any one mating than the influence of the dam.

Perhaps one of the features of animal breeding which has been difficult to understand is that some character may be passed from sire to offspring or from dam to offspring intact; that is without any influence seeming to have been exerted by the other parent. For example, a Hereford bull or cow will always pass to the calves a white face regardless of how black the face of the other parent may be. So will Aberdeen Angus animals pass to the calves polled heads without any reference to the length of horns which the cattle may have to whom they are mated. A gray mare can pass the gray coat color to her foals regardless of how well bred the stallion may be to which she is bred. One of the very best bred black stallions of a noted breed was bred to a bay and white-splashed pony mare. The foal was bay and white-splashed just like its dam.

Characters which can be passed over by one parent to an offspring are called dominant traits; and while they appear to eliminate opposing features the appearance is deceptive. The trait which a dominant covers up is not lost or bred out. It is still carried by the offspring and can be passed on by it. The reproductive glands of a crossbred animal carry the hereditary features of both its sire and its dam. When its own sex cells are matured the invisible qualities will have as great an opportunity to be sent on as those dominant and visible traits which can be seen in the animal itself. The splashed pony foal can hand on the black of the sire as often as he can transmit the white and bay of his own color.

The investigations made by geneticists have resulted in the discovery of many of the laws of heredity but not many of the results of genetic research will aid the racehorse breeder in

his effort to make breed improvement. The breeders of racehorses are so far out in front in the breeding world and so successful in the methods which they are using that they can receive little benefit from any suggestions which the geneticist can make. It is rather an opportunity for the geneticist to follow in their wake, studying the methods which they are using and interpreting the results which they are obtaining.

STERILE MALES.

By W. S. ANDERSON

Kentucky Agricultural Experiment Station.

There is no life unless there is in the natural order of things a union of two germ cells. Pregnancy does not result from a mating if the male fails to transfer vigorous sperm cells, nor if the female fails to shed at the proper time an egg that can be fertilized. Since the sex cells carry all the hereditary materials that go over from one generation to the next and since the egg will not develop unless it is fertilized by the sperm the sole purpose of breeding horses is to bring about the meeting of the two sex cells. The sperm cells after being placed in the uterus travel by the lashing of their tails on the mucus membrane of the organ in the direction of the horns, and thru them into the small tubes leading from the horns upward to the ovaries. As a rule the egg is fertilized in one or the other of these tubes into which it has fallen when shed by the ovary. The lumen or passage of the tubes is very small, not larger than necessary to admit a slender needle. After the egg is fertilized in the tube it continues its passage on to the horn or even to the uterus where it sets up a connection which is to last during foetal growth.

My study for the last nine years has been mainly with males and I shall give in a somewhat general statement the facts which I have ascertained by the investigations in this series of years. The breeders of Kentucky have kindly cooperated by giving me free access to their farms and free use of their valuable breeding stock.

1. A certain number of males of all domestic animals are sterile. The more highly bred the animals are the greater percentage of sterility will be found among them. I have found sterile stallions, sterile bulls in three different breeds of cattle and sterile boars.

2. Sterile stallions and jacks can not be discovered by watching their service or by examining their semen with the naked eye. A stallion may be sterile and yet serve promptly and contribute semen normal in appearance. The semen of

stallions especially may vary from a very thick viscid liquid of a milky color to a very pale thin fluid. One of the greatest sires even known discharged semen almost waterlike in its appearance. The only method of learning the breeding condition of a male is by examining the discharge under the miscroscope.

3. Sterility may be due to any one of the following conditions:

A. The semen may contain no germ cells. This can be caused by an inflammation somewhere in the genito-urinary canal which has closed the passage or it may be due to fibroid degeneration of the glands, or again it may be due to the destructive effect of orchitis on the glands. It matters not to what it is due the absence of spermatozoa is positive proof of sterility. The semen which is obtained from a sterile male of this nature is secreted by the accessory sex glands and may have little or no material from the sex glands.

B. The semen may contain very large numbers of spermatozoa all of which are inactive. There may be other reasons for the germ cells being dead, but perhaps, fibroid degenration in its various degrees of development is the principal cause of this condition which renders the animal completely sterile.

C. The semen may contain a small number of active germ cells. In a given field there will be found three or four cells where there should be hundreds. When this condition is observed there is but feeble movement, which does not continue long. All animals examined where semen is of the nature just described were totally sterile.

D. The semen may have both active and inactive germ cells. If large numbers of inactive spermatozoa are present in the semen it indicates partial sterility. No more perplexing problem has been encountered in our investigations than the one of the stallion furnishing sex cells about half of which are inactive. It appears that a male with this fault may not at the beginning of his stud season have more than one-fourth of his sex cells inactive, but as the season goes on the number of inactive sperm increases until over one-half do not give evidence of life. If at any time a stallion shows more than one-half his

sperm inactive it is an indication of sterility. Actual breeding records show a less than fifty per cent production for those males with a half or less of inactive cells and no production when the proportion of dead ones increased over a half. Our laboratory work with the semen shows that the presence of any large number of inactive spermatozoa is an indication that the active ones will not retain their vigor as long as activity can be observed in sample of normal semen.

E. There are certain cases of sterility due to the discharge of small or large quantities of pus with the semen. These, of course, come from some center of inflammation in the canal. In some cases there are no sperm cells at all, in other cases sperm cells are present in abundance and with apparent normal vigor but in these cases partial and in most instances absolute sterility result. The pus can come from the testicles as a result of orchitis or it may have its origin in some of the accessory glands or seminal vesicles or elsewhere in the canal. Its presence is a danger signal and if it is discharged in large amounts it is an indication of grave danger. The writer is not aware that any other investigator has found pus in the semen of stallions, or has pointed out its dangers. During the season of 1922 six stallions were under observation in whose seminal discharge pus was regularly found. We especially want to call attention to the danger that may result from using the stallion who may have developed some center of inflammation and may pass it on to the mares to which he is mated. It is too early in our investigations to say positively that it is possible for a male suffering from some genito-urinary disease that causes a pus discharge to communicate the disorder to his females, but we think it wise to advise caution in the use of such a male.

F. A few cases have been found where males were unable to make the service because the intromittent organ itself had a center of inflammation in the urethra. The cause of such inflammation we have not ascertained.

Since there is no way of determining a stallion's potency by physical appearance or behavior in stud duty, it follows that microscopic examinations should be made at regular intervals.

If this examination is made at the beginning of the season and the sire is found in good condition, only one other examination might be necessary during the year. But in the case of very valuable animals it is advisable that these examinations be made at regular intervals not too far apart.

When a stallion has been mated to a number of brood mares and all of them have returned it is a suspicious circumstance and immediate steps should be taken to ascertain his condition.

The examination to be of value must be made by one trained in the work. The microscope is a very delicate instrument and requires the services of an operator who understands its manipulation in order that its results may be trustworthy. The breeder should not expect to use the instrument without considerable instruction from one skilled in its use. The instruments themselves are not so expensive as the extremely high power lenses are not necessary. For a field that will show the comparative number of germ cells and their vigor of movement, a No. 5 or No. 10 eyepiece and a 16 m.m. objective are ideal. If a much greater magnification is desired it will be necessary to use a No. 10 eyepiece and a 4 m.m. objective. This combination will give over four hundred diameter magnification. Perhaps, after all, it is just as well for the breeder to call in for this special work some one who is trained in the use of the lenses.

DEMONSTRATIONS.

Following the presentation of the papers in the afternoon session, Dr. Cassius Way gave a demonstration of the technique involved in examining the reproductive organs of cows and mares for the causes of sterility. Since many of those present had never witnessed such an examination and were undoubtedly skeptical as to the possibility of one's being able to determine the reasons for an animal's failure to breed, there was keen interest of the audience in the work, as was well demonstrated by their undivided attention and by the numerous questions asked. Dr. Way not only spoke of the abnormalties as he encountered them, but when possible he exposed the affected parts to view. This could only be done when the abnormal condition occurred in either the vagina or cervix.

Five cows and one mare from the Station farm were selected to represent as many different conditions as possible.

Case No. 1: A Hereford cow which has been with calf for seven months developed a partial prolapse of the vagina and rectum. Examination revealed a very bad case of vaginitis and a small tumor-like formation which had developed in the wall of the vagina not far from the os. The vagina had possibly been lacerated during parturition. The irritation had caused the animal to strain and force out the vagina and rectum. Uterine forceps were placed on the os and the part pulled out so that it could be plainly seen. Other organs of this cow he pronounced normal. Recommendation in this case was the removal of the tumor surgically, but not until after parturition.

Case No. 2. Holstein cow that had failed to come in heat for the last four or five months. Upon examination a retained corpus luteum was found in one of the ovaries. This was broken down, or squeezed out of the ovary and the heardsman was informed that the cow would come in heat in the next three to five days. The cow took the bull on the third day.

Case No. 3: Examination for pregnancy. Guernsey cow which had been bred two months previous. After the examination Dr. Way stated that the os was closed, the uterus was enlarged, one of the ovaries contained a corpus luteum, and that

the vessels supplying the uterus were large and pulsating, all of which were signs of pregnancy.

Case No. 4: Holstein cow which had been bred repeatedly but did not conceive. Upon rectal examination the ovaries were found to be normal, but the uterus was enlarged. A uterine catheter was passed and a considerable amount of muco-purulent exudate removed. The vagina was apparently normal. Recommendation in this case was the irrigation of the uterus every day with a sterile, normal salt solution.

Case No. 5: A Hereford cow that had failed to conceive after repeated services. Examination revealed a large torn cervix. The cervix had probably been ruptured at the time of parturition, and had never completely healed. It was recommended that this animal be given a vaginal douche every day, alternated with a sterile, normal salt solution and a solution of theropogen.

Case No. 6: An aged mare that had been barren for several years. The organs of this mare were apparently normal except that there seemed to be a loss of tone. Small cysts were found on the ovaries but are not considered abnormal in mares. Dr. Way attributed the sterility of this mare to senile atrophy. The mare has not been in heat this spring (February to July, 1922).

Case No. 7: The complete genital organs that had been removed from a mare which had been sterile for a number of years were used to demonstrate the anatomical structure and relationship of these parts. This specimen was used to show the relative positions of the various organs to each other and also to demonstrate where pathological lesions were most often found. The ovaries were enlarged and cystic, each containing a number of rather large cysts. The vagina, uterus and fallopian tubes were all dissected so as to expose their interior to view to the best advantage. These latter organs were all apparently normal so far as could be determined from their gross appearance.

THE HYDROGEN ION CONCENTRATION OF HORSE SEMEN.*

W. S. Anderson, A. M. Peter and D. J. Healy.

Kentucky Agricultural Experiment Station

Many noted Thoroughbred and Standardbred stallions are located in the Bluegrass Region of Kentucky and the breeding of such animals is an important industry. The uncertainty of impregnation of the mare is one of the difficulties encountered and, at times, causes serious financial loss.

A microscopial study of the semen of those stallions which failed to impregnate the mares demonstrated that many, in some cases all, of the spermatozoa were motionless immediately after copulation. It occurred to us that a study of the hydrogen ion concentration of the semen in relation to the motility of the spermatozoa would be interesting and valuable. Upon examining the literature we failed to find a record of the hydrogen ion concentration of semen.

All protoplasm carries electric charges and every living cell is essentially an electric battery. Protoplasmic activity develops an electric disturbance, the current flowing from the more active to the less active portion of the protoplasm, and many of the activities of protoplasm bear a direct relation to the ratio of electrolytes which it contains. Of the many electrolytes present in protoplasm, the hydrogen ion has been most successfully studied, and its concentration has been correlated with many of the physiological activities of biologic tissues and fluids.

The chemical reaction of protoplasm may be expressed in terms of hydrogen ion concentration, and very slight variations in this concentration profoundly affect the colloidal condition, enzymic activity, and respiratory processes of protoplasm.

Living cells require the maintenance of a strictly limited hydrogen ion concentration in their environment, a limitation frequently between .00001 and .00000001 gram ionized hydrogen per liter. Enzymes are extraordinarily sensitive to minute

*Journal of the American Veterinary Medical Association, Vol. LX. (New Series, No. 13) No. 3, December, 1921, pp. 291-298.

changes in the hydrogen ion concentration of the medium in which they are working. Reed[1] demonstrated that the oxidases present in the potato and apple are quite active at pH 4.2 and inactive at pH 3.3. Fortunately protoplasm contains salts of carbonic and phosphoric acids which act as "buffers" checking pronounced changes in hydrogen ion concentration, the bicarbonate acting by releasing or absorbing CO_2, while the phosphates readily change from mono- to diphosphate and vice-versa.

Some of the more important biologic fluids of which the hydrogen ion concentration has been determined by others are gastric juice pH 0.9-1.6; perspiration pH 4.5; urine pH 6; milk (cow) pH 6.16-6.8; muscle juice pH 6.8; blood pH 7.4; normal plant cell sap pH 5.3-5.8. It is interesting to note that gastric juice contains a free mineral acid in considerable strength and that it may be kept for months without becoming putrid and with very little change in its digestive action or in its total acidity.[2]

Modern methods of determining hydrogen ion concentration are much more reliable than methods of determining the chemical reaction of protoplasm based upon its color reactions to various staining reagents.

Two methods are available for the measurement of hydrogen ion concentrations in solutions—the colorimetric and the electrometric. The color indicators of chemical reaction are substances which ionize in solutions containing definite hydrogen ion concentrations. Above a certain concentration of hydrogen ions phenolphthalein, in solution, remains undissociated and colorless, below this concentration of hydrogen ions phenolphthalein dissociates with the production of color. Methyl red, in solution, dissociates with a change of color at a hydrogen ion concentration greater than that at which phenophthalein dissociates. Thus a series of indicators which dissociate with change of color at successively diminishing hydrogen ion concentrations have been obtained and may be used to determine the

[1] Reed, Guilford B., Jour. Biol. Chem., Vol. 27, 1916, p. 299.
[2] Howell, W. H., Physiology, 1915, p. 772.

hydrogen ion concentrations of solutions at various points between N/10 HCl and N/10 NH_4OH.[1]

The hydrogen ion carries a positive electric charge thus maintaining an electric potential in the solution; the electrometric method measures this potential by means of a potentiometer and galvanometer. When the biological process under observation is constant over a wide range of hydrogen ion concentration, an approximate determination is sufficient, and the colorimetric method may be used. When the process is seriously affected by the hydrogen ion concentration of the solution, the electrometric method should be used because it is the most accurate method available. Minute variations in hydrogen ion concentrations indicate the position of equilibrium among the important electrolytes present. Thus the determination of hydrogen ion concentration takes its place beside the use of the delicate analytical balance, or the use of the thermometer.

The apparatus used in this investigation consisted of the Clark hydrogen ion apparatus supplied by the Leeds and Northrup Company, a portable lamp and scale galvanometer, a Leeds and Northrup type K potentiometer, and a standard Weston cell, model 4. Two Columbia dry cells furnished the working current. Hydrogen, obtained from a Kipp generator, was past thru two washbottles (the first containing N/2 NaOH and a small quantity of lead acetate; the second containing distilled water), and then conducted into the hydrogen electrode vessel. A normal KCl calomel electrode was used and normal KCl solution, saturated with calomel, was used in the connecting vessel. Measurements were made at room temperature without the aid of a constant temperature bath, but the temperature of the calomel electrode was carefully noted immediately following each measurement, the reading being made to the nearest degree or half degree C. Following Clark's suggestions hydrogen was not bubbled thru the semen. Clark[2] states that "in biological fluids containing carbonate the double effect of the CO_2 upon the partial pressure of hydrogen and upon the hydrogen ion

[1] Clark, W. M., and Lubs H. A., Jour. Bact., Vol. 2, 1917, pp. 1, 109, 191.
[2] Clark, W. Mansfield, The Determination of Hydrogen Ions, 1920, p. 187.

equilibrium renders accurate measurements difficult. It is of more importance to maintain the original CO_2 content of the solution than it is to be concerned about the effect of CO_2 upon the partial pressure of hydrogen.''

The accuracy of electrometric measurements made by such an apparatus under the above conditions depends upon the stability of the electromotive force balance for a definite period. In this investigation the E. M. F. balance was maintained for a period of two minutes. To test the accuracy of the measurements a N/10 HCl solution was measured as follows:

TABLE 1

Solution for Measurement	Time	Reading Volt	Temp.	pH Value	Theory
N/10 HCl, factor 1.0006	10.20	.3490	31° C.	1.08	
	10.22	.3490			pH 1.07[1]
Duplicate measurement	10.37	.3475	31° C.	1.06	
	10.39	.3475			

As a further test two standard ''buffer'' solutions were measured electrometrically and colorimetrically as follows:

TABLE 2

Solution for Measurement	Time	Reading Volt	Temp.	pH Value	Colorimetric pH Value
Buffer solution 1	2.17	.6995	32° C.	6.88	7.0
	2.19	.6995			
Duplicate measurement	2.43	.6995	32° C.	6.88	7.0
	2.45	.6995			
Buffer solution 2	3.06	.7670	32° C.	7.99	8.2
	3.08	.7670			
Duplicate measurement	3.26	.7675	32° C.	8.00	8.2
	3.28	.7675			

[1] Michaelis, L., Die Wasserstoffionenkonzentration, 1914, p. 23.

The colorimetric method measures to two tenths of a pH value. Tables 1 and 2 demonstrate that without extensive equipment electrometric measurements of hydrogen ion concentrations afford a fair degree of accuracy. Great refinement in correcting for barometric and temperature fluctuations is necessary only in physico-chemical research.

The semen used in this investigation was obtained as the mare was served and delivered to the laboratory in a clean sterile container with as little delay as possible. The measurements were made within an hour or two of the service. The quantity of semen obtained varied from 7 cc to 20 cc. With the larger quantities of semen the hydrogen electrode vessel was completely filled, the platinum electrode placed in position, the semen flushed out with hydrogen which was used freely, and the vessel half filled with semen and, of course, remaining half filled with hydrogen. The hydrogen electrode vessel was now closed and shaken for five minutes, after which it was so adjusted that the platinum electrode was half immersed in the semen and the connections were made with the potentiometer, the apparatus remaining undisturbed for six minutes, after which the readings were made. With the smaller quantities of semen, the hydrogen vessel was first filled with CO_2-free water, flushed out with hydrogen, half filled with semen and then treated as above. The following measurements were made to determine the effect of thus filling the hydrogen vessel with CO_2-free water before introducing the semen.

TABLE 3

Semen From	Time	Reading Volt	Temp.	pH Value
6th stallion	9.50	.7280	22.5° C.	7.55
	9.52	.7280		
After using CO_2—free water	10.16	.7379	22.5° C.	7.70
	10.18	.7379		
7th stallion	10.42	.7300	22.5° C.	7.58
	10.44	.7300		
After using CO_2—free water	11.03	.7356	22.5° C.	7.68
	11.05	.7356		

Table 3 demonstrates that the effect of the preliminary use of CO_2-free water is to reduce the hydrogen ion concentration of the semen .125 of a pH value.

With the electrometric measurements of normal horse semen we obtained the following results:

TABLE 4. NORMAL SEMEN

Stallion	Time	Reading Volt	Temp.	pH Value
1—Etowa	10.11	.7335	26.5° C.	7.43*
2—Huon	9.47	.7230	23.5° C.	7.44
3—Uncle	10.03	.7255	23.5° C.	7.47
4—Rapid Water	11.13	.7080	19.5° C.	7.14*
9—Prince Palatine	9.20	.7010	23.5° C.	6.94*
12—Fritter Gold	9.38	.7325	22.0° C.	7.51*
14—Fairplay**	11.40	.7180	29.0° C.	7.24
			Average....	7.31

* Correction for CO_2-free water, (.125 pH) has been deducted.
**Sire of Man-O'-War.

The average of seven electrometric measurements of normal horse semen was pH 7.31, ranging from pH 6.94 to pH 7.51.

With horse semen containing non-motile spermatozoa we obtained the following results:

TABLE 5. SEMEN CONTAINING NON-MOTILE SPERMATOZOA

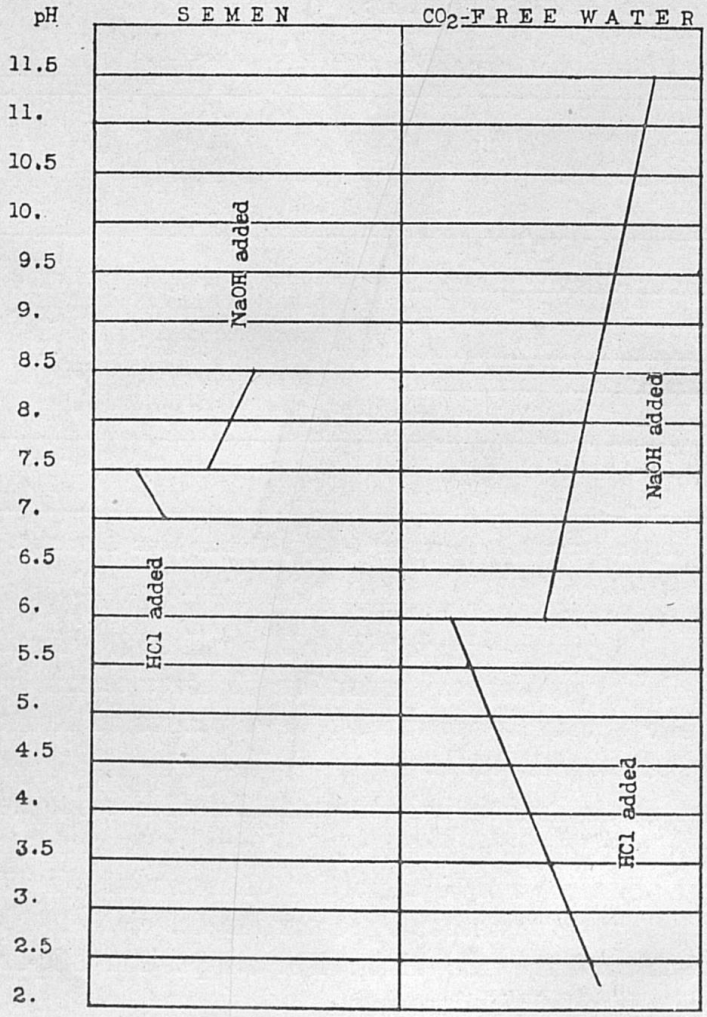
Stallion	Time	Reading Volt	Temp.	pH Value
5th	8.50	.7280	19.5° C.	7.49*
6th	9.17	.7320	19.5° C.	7.55*
7th	9.07	.7280	22.5° C.	7.55
8th	9.23	.7300	22.5° C.	7.58
13th	9.47	.7480	22.5° C.	7.76*
			Average....	7.58

* Correction for CO_2-free water (-.125 pH) has been deducted.

The average of five measurements of abnormal horse semen was pH 7.58, ranging from pH 7.49 to pH 7.76. Therefore the average hydrogen ion concentration of horse semen containing non-motile spermatozoa was .27 of a pH value less than the average of normal semen.

That the hydrogen ion concentration of horse semen is not readily altered is demonstrated in diagram 1. In this experiment we added to one 10 cc portion of semen, of pH 7.56, 0.5 cc N/10 HCl; and to another 10 cc portion, 0.5 cc N/10 NaOH and again measured the pH values. For comparison CO_2-free water was treated in a similar manner.

BUFFER EFFECT OF SEMEN



It appears from our measurements of the semen that a hydrogen ion concentration of pH 7.5 indicates a critical condition of the equilibrium of the electrolytes present in horse semen. Above this concentration the spermatozoa are active, below they are inactive. A preliminary chemical analysis of portions of the above normal and abnormal semen gave the following results:

TABLE 6. CHEMICAL ANALYSES OF SEMEN.

Items	Per cent by weight	
	Normal	Abnormal
Total solids, dried at 105° C.	2.38	3.49
Ash	0.78	0.60
Total nitrogen, (N)	0.241	0.366
Total phosphorus (P)	0.017	0.028
Per cent ash in total solids	32.8	17.2
Per cent phosphorus in total solids	0.7	0.8
Per cent nitrogen in total solids	9.9	9.5

The proportion of total solids is distinctly larger in the abnormal semen than in the normal; the proportion of ash in the total solids of the abnormal semen, however, is markedly less than in the normal. The proportions of nitrogen and phosphorus in the total solids are sensibly the same in both.

Summary.

The average hydrogen ion concentration of normal horse semen was pH 7.31.

The average hydrogen ion concentration of horse semen in which the spermatozoa were inactive was pH 7.58.

The hydrogen ion concentration of horse semen is not readily altered.

It has been shown that without extensive equipment electrometric measurements of hydrogen ion concentrations afford a fair degree of accuracy.

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