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THE INFLUENCE OF VARIOUS FACTORS UPON THE GROWTH AND QUALITY OF FINE WOOL AS OBTAINED FROM MERINO SHEEP

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INTRODUCTION

For more than a century, fine wool as obtained from Merino sheep has been one of the principal commodities in the agriculture of southeastern and east central Ohio. The adjacent areas of southwestern Pennsylvania and the northwest section of West Virginia also carry a dense population of Merino sheep.

This so-called Tri-State fine wool territory has a rough topography which requires that the major portions of farm acreage be kept under grass. Only relatively small areas of the land in farms are suited to the production of seeded-harvested crops which may be used for winter feed. Merino sheep of the smooth-bodied type have proved to be unusually well adapted to the scheme of agriculture necessary in this area and, because of this adaptability, probably will continue to hold a dominant position among the various classes of livestock kept on farms. Hence, fine wool is likely to maintain its importance as one of the principal agricultural commodities in this region.

Fig. 1.—Merino sheep have proved to be unusually well adapted to the hilly pasture areas of the Tri-State region

The many qualities which fine wool from Merino sheep possesses and which contribute to make this animal fiber one of great importance in the textile industry are quite well known. On the other hand, present knowledge of the influence which such factors as age, breed, sex, pregnancy, seasonal condition of feed supply, climate, oil content of wool, and others exert upon the growth and quality of wool as produced by the sheep is largely empirical. That is to say, Merino breeding and production practices are based almost entirely upon the experiences of various sheep breeders. These experiences, for the most

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part, have guided Merino breeders well in the production of fine wool and the knowledge thus gained has been passed on from generation to generation by a "bringing up" in the traditions of Merino sheep husbandry. However, because experiences have varied, it is quite natural that more than a few opinions regarding the influence various factors have on the growth and quality of fine wool are the subject of frequent discussion, if not of controversy. Because of the conflicting opinions held and the lack of definite information on the subject, it is obvious that great benefit would accrue to the fine wool industry of Ohio and the Tri-State region if factual knowledge of the influence of various factors on the growth and quality of fine wool could be increased.

OBJECT OF EXPERIMENTS

In 1927, the Ohio Agricultural Experiment Station, in cooperation with the Bureau of Animal Industry, United States Department of Agriculture, started a series of experiments to study the influence of various factors upon the growth and quality of fine wool from Merino sheep. These tests were a part of a major project of the Federal Bureau of Animal Industry, "Studies in the Growth of Wool and Other Animal Fibers". More specifically, the tests at the Ohio Agricultural Experiment Station were planned with three objects in view:

1. To determine the periodic or seasonal rate of linear or length growth of fine wool produced by Merino sheep kept under a good system of feeding and management.
2. To determine the influence of sex, pregnancy, yeaning, breed, age, and seasonal condition of the feed supply upon the periodic or seasonal rate of growth of fine wool fibers produced by Merino sheep kept under a good system of feeding and management.
3. To determine what influence various factors exert on the growth and quality of wool through a comparison of the fleeces produced by American Merino and Tasmanian Merino sheep kept under similar conditions of feeding and management and under the climatic conditions prevailing in Ohio.

DEFINITION OF TERMS

In order to have a clear understanding of the experiments reported in this publication and the results secured, various terms should be defined and the factors studied should be explained. Similarly, the method of measuring the various factors to obtain the data should be outlined.

American Merino is the term used to designate smooth-bodied to slightly wrinkled Merino sheep classed as C-type or Delaine by the American and Delaine Merino Record Association. American Merino sheep possessing a pronounced degree of wrinkling or skin folding will herein be referred to as B-type American Merinos.

Tasmanian Merino is a breed name used to designate the fine wool strain of Australian Merino sheep and distinguishes this strain, in its native country, from Merinos which produce the medium and robust types of Australian Merino wool.

Growth of wool was measured in terms of length of fiber, so that when the expression "growth of wool" occurs it shall mean, unless otherwise specified, the growth of wool as measured by length.

Weight of fleece was taken at shearing time and represents all of the grease wool produced by each sheep, except that the heavy tags and dung locks were removed. Since all of the sheep were sheared not earlier than April 8 and not later than April 11 of any year included in these studies, the weight of fleece is considered as representing a full year's growth unless otherwise specified.

Length of staple was measured to the nearest ⅛ inch at the middle of the side of the sheep by inserting a thin rule into the fleece to the skin and then pressing but not stretching the wool against this measure. An average of readings by two and sometimes three investigators was taken for the records in order to eliminate, insofar as possible, the human factor.

Fineness of fleece was judged at the shoulder, side, and thigh by two and usually three investigators thoroughly trained and experienced in judging the fineness of wool according to the numerical expression of the official grade standards of the United States Department of Agriculture. The average of these several judgments was recorded each year without any reference to the preceding records.

Character of fleece was judged at the side of the fleece while still on the sheep and just prior to shearing and recorded in terms of per cent of perfect defined on Page 6. The term "character" represents regularity, desirability, and closeness of crimp, brightness of the fleece, and evenness of distribution and freedom of flow of the wool oil or grease (that is, the ability of the oil to bathe and protect the growing fiber from base to tip). Unprotected fibers are subject to weathering, and for this reason the grade for character partially measures the influence of climatic factors on wool during its growth.

Density of fleece was judged by the touch of the hands and verified by parting the fleece and examining the apparent density of the fibers on the skin of the sheep. This observation was recorded in terms of per cent of perfect.

Density of fiber, in contrast to *Density of fleece*, was determined according to a method which consists of clipping all wool fibers from a measured area of the skin with a special clipper developed by J. I. Hardy. The total clean weight of this volume of wool was then obtained. One hundred fibers were drawn from this sample and weighed on balance scales, to one ten-thousandth of a gram. The result of this technique is expressed as the number of fibers per square inch of body surface.

Closure of the fleece was judged at the shoulder, loin, and rump. Perfect closure of the fleece is a measure of the tendency of wool fibers to stand erect and remain sealed over the back so as to prevent weathering from climatic factors and the entrance of seeds, chaff, or other foreign material into the fleece. A completely imperfect closure would represent a fleece that was cracked open along the back, fibers which were weathered to their base, and a fleece full of seeds, chaff, dirt, or other foreign material along the spine. Since the score for closure also measures weathering, character and closure become the measure of the influence of climatic factors on wool during its growth.

Belly covering represents the completeness with which the under skin surface is utilized for growing wool, as well as the density of the wool.

Face covering is the judgment of the extent to which the face is covered with or free from wool, the perfect or highest score being given to those sheep free from face wool and the lowest score being given to those which were completely wooled and exhibited wool blindness.

Body scores which were recorded in terms of per cent of perfect by the five-count score system and which related to type, skin folding or wrinkles, and carcass conformation are assumed to be so well fixed in the minds of breeders that definitions of them are omitted.

Per cent of perfect is the numerical measure used to show variations which occur under such factors of fleece quality as character, density, closure, face covering, belly covering, and the various body scores. It was developed by the Bureau of Animal Industry of the United States Department of Agriculture and is based on their five-count score system (13). In judging character of fleece, for example, the figure 1 represents those fleeces having a character of from 90.1 to 100 per cent perfect, with the fleeces in this group assigned a character value of 95 per cent. The figure 1 plus would give a score of 97.5 per cent perfect while 1 minus would give a score of 92.5 per cent perfect. The group or grade 2 equaled an interval of 80.1 to 90 per cent with an assigned value for the straight grade of 85 per cent. The plus and minus signs represent those variations, respectively, above and below the grade of 2. The grades 3, 4, and 5 are rated in a similar manner, with the grade 5 representing character values lower than 60 per cent. Since grade 5 seldom contained fleeces with a character value less than 50 per cent, the interval for this grade was regarded as 50.1 to 60 per cent, with an average of 55 per cent of perfect. Under this system, 100 per cent of perfect is just beyond the range of attainment.

Body measurements were taken just after shearing with the aid of calipers, steel tape, and height measuring instruments when the sheep were standing in normal position. These measurements afford a numerical comparison of the individual sheep of the two breeds with respect to depth and width of chest, length of body from shoulder point to hip bone, height from floor to top of withers, circumference of barrel, and the over-all length from tip of nose to end of dock.

Percentage of moisture, grease, dirt, and clean wool in fleeces was determined in the wool laboratories of the Federal Bureau of Animal Industry, at Beltsville, Md., on side samples taken from the fleece at shearing time and preserved in air-tight containers. The carbon tetrachloride method of degreasing the wool was used; otherwise, the procedure was the same as described in Technical Bulletin 85, of the United States Department of Agriculture.

Per cent of stretch of wool fiber represents the per cent of elongation due to elasticity of the fiber between the tautness to remove crimp and the point of rupture of the fiber.

Breaking strength of wool fiber signifies the amount of pull, measured in grams, necessary to rupture a single wool fiber. The figure recorded herein represents the average breaking strength of 100 fibers.

Production records were kept separately by breeds and for the several groups and lots assigned to the various phases of these experiments. These records included feed eaten, weights of ewes and lambs at various seasons and at various ages, number of lambs born and raised, flock mortality, rate of growth, fattening ability of wether lambs, dressing percentages, grade of carcass, and palatability of meat.

METHODS OF OBTAINING DATA

OBJECTS 1 AND 2

Experimental groups of sheep.—To attain the first two objects of this series of experiments, four groups or eight lots of Merino sheep were used. One lot each of six yearling ewes and six yearling wethers which were closely related was placed on test, during the 1927-1928 wool growing year, to determine the normal periodic or seasonal rate of growth of fine wool by American Merino sheep kept under practical feeding and housing conditions. By including both ewes and wethers, this test also showed the influence of sex upon the periodic rate of growth of wool fiber during each of the eight periods into which the wool growing year was divided.

Two groups or four lots of sheep were on experiment, during the 1928-1929 wool growing year, the first to determine the influence of pregnancy and yeaning and the second the influence of breed on the periodic rate of growth of wool fiber. The first group contained six bred and six unbred American Merino yearling ewes. The second group contained ten American Merino and ten Tasmanian Merino breeding ewes. Since the ewes in the second group were bred ewes and since the lambing period came within the span of the test, the data from the breed comparison checked again the influence of pregnancy and yeaning on the periodic rate of growth of wool fiber.

One lot each of American Merino and Tasmanian Merino females was used, during the next two wool growing years (1929-1930 and 1930-1931), to study the influence of age and incidentally to repeat the observations of the influence of breed on the periodic rate of growth of the wool fiber. These females were started on test as lambs and continued on test throughout their yearling year.

Periodic or seasonal divisions in the wool growing year.—The experimental wool growing year, which started soon after shearing in April, was divided into eight periods. The first period, of 4 weeks' duration, started on or near May 3 and ended on or near June 1, varying slightly with each year. The remaining seven periods were each of 6 weeks' duration and followed successively until March 21 of the following year, at which time the sheep were essentially in full fleece. The first shorter period was occasioned by the fact that the lock-tying, fiber-clipping procedure, which is described later, required that enough wool be present so that the ties when made would hold fast. Also, it was thought desirable that the wool growing year should start with the advent of the pasture season. In the tables of data the growth of fiber for this 4-week period was converted by direct computation to represent a 6 weeks' growing period.

The eight calendar divisions into which the wool growing year was divided were arranged so as to coincide in a general way with certain seasonal conditions which maintain in Ohio and thus make it possible to observe the influence of seasonal conditions on the rate of growth of the wool fiber. The manner in which the calendar periods coincide with the seasonal conditions of feed supply, as well as with breeding, pregnancy, and yeaning, may be more clearly shown thus:

May 3-June 1. Period of abundant and nutritious spring grazing.
June 1-July 13. Period of good early summer pasture.
July 13-August 24. Period usually characterized by dry, midsummer pasture.
August 24-October 5. Period of good fall pasture and flushing for breeding.

October 5-November 16. Period of late fall pasture.
November 16-December 28. Pregnant period, ewes barn fed.
December 28-February 8. Advanced pregnancy, ewes barn fed.
February 8-March 21. Lambing season, ewes barn fed.

Method of determining the periodic rate of lineal or length growth of wool.—Periodic growth of wool fiber was determined by tying two small locks of wool on each side of each sheep at the heart girth and midway between the breast bone and the withers at regular 6-week periods throughout the wool growing year, except that the actual length of the first period following shearing was 4 weeks, as already explained. At the time these four locks were tied, four other locks of known period of growth were clipped from a marked area of skin and measured to determine the actual growth that had occurred during the given period. This area was then prepared for the next succeeding period by clipping all wool fibers close to the skin so that it had a shaved appearance.

OBJECT 3

The experimental sheep.—To determine the influence of various factors on the growth and quality of wool through a comparison of the fleeces produced by American Merino and Tasmanian Merino sheep (Object 3), a flock of ten purebred C-type American Merino ewes was selected from among the 2-year-old Merinos owned by the Ohio Agricultural Experiment Station (see Fig. 2).

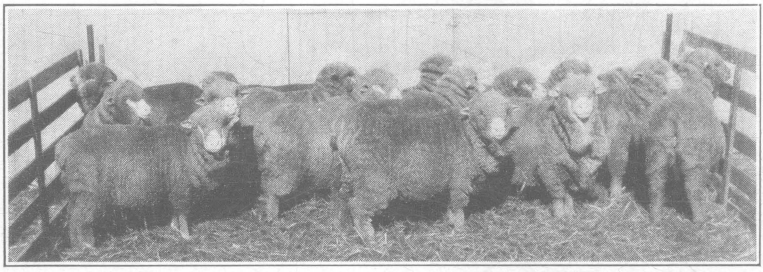

Fig. 2.—American Merino ewe flock of the breed comparison experiments, March, 1931

The flock of Tasmanian Merinos, imported especially for this study, consisted of ten purebred, coming 2-year-old ewes and one 3-year-old ram. They were selected from the flock of Mr. Chas. Goulter, Blenheim, Marlborough, New Zealand. These sheep were imported for the Federal Bureau of Animal Industry and were delivered to the Ohio Agricultural Experiment Station on September 22, 1927. One additional 2-year-old ram was selected from the Belle Vue Stud, in Tasmania, and arrived at the Ohio Experiment Station on July 2, 1928. This flock was maintained as a purebred Tasmanian Merino flock and no additions were made, except to add the offspring resulting from mating these ten foundation females with the two foundation rams.

Comparison of the sheep.—Briefly, these two breeds were selected because they present a contrast in wool production and fleece quality. American Merinos of the C-type represent an effort on the part of breeders to develop a fine wool producing sheep of reasonable size, substance, constitution, feeding

capacity, and lamb raising ability, together with a maximum number of pounds of raw or grease wool per individual. A liberal grease content in the fleece has been fostered by breeders on the basis that a fairly high grease content is necessary under Ohio conditions to protect the growing fleece from the influence of climatic factors. A 36 per cent yield of clean wool is common, although some fleeces yield higher than this; others are extreme in grease content, with a decidedly lower yield. It is common practice in the breeding of purebred C-type Merinos to resort to infusions of the wrinklier, greasier-fleeced B-type Merino to maintain the grease content of the fleeces and also increase density of the fleece.

History of Merino production in Australia and its adjacent island states and British commonwealths indicates that those responsible for the present development of the Tasmanian Merino aimed for a high quality, fine wool fleece grading 70's or higher and measuring at least 3 inches unstretched. A high yield of clean wool was paramount. Oil or grease only in sufficient quantity to bathe the growing wool fiber and offer it protection was tolerated. A yield of 50 per cent clean wool is usual although it is reported that yields up to 70 per cent clean wool have been obtained. In the history of Australian Merino production, little can be found that would indicate that breeders had given much attention to the meat qualities of the Tasmanian Merino breed.

When the Tasmanian Merinos arrived on September 22, 1927, they were carrying nearly one year's growth of wool, although the exact date of previous shearing was not accurately known. The flock of American Merinos at the Ohio Experiment Station had been closely and evenly shorn with power clippers during the period of April 11 to 14, 1927, and the 2-year-old ewes selected were carrying actually 194 days' growth of wool. In order to have the fleeces of both breeds go under identical growing conditions without delay, both flocks were closely and evenly shorn on October 11, 1927, at which time the sheep were scored for wool production and body type and subjected to various body measurements. Table 1 presents the results of this first shearing and fleece scoring; Table 2 presents the results of scoring the sheep for body type and conformation; and Table 3 summarizes the body measurements which were taken. An interpretation of these tables will aid in clarifying the contrast which existed between these two breeds. It should be remembered that the Tasmanian Merinos had recently arrived from a trip which carried them half way around the world, had been transferred from the southern hemisphere to the northern, and were put under a system of production foreign to them in many ways. Naturally, they had the handicap of adjustment and acclimation to overcome. However, they did not evidence any illness on arrival or later which might be ascribed to the transfer and shipping. There was, however, a pronounced difference in condition of flesh between the two breeds which will be discussed later.

It is evident from Table 1 that, on the basis of a full year's growth of wool, the American Merinos were decidedly in the lead in the production of pounds of unscoured wool. With respect to fineness of fiber, the Tasmanian Merinos averaged approximately nine spinning counts finer than the American Merinos. In uniformity of fleece, measured in terms of fineness at the shoulder, side, and thigh, there was little difference since both flocks averaged two to three spinning counts finer on the shoulder than on the thigh. The Tasmanian Merinos slightly excelled the American group in character of fleece, although the difference here was slight. The density of the fleeces of the Tasmanian Merinos appeared to be less than that for the typical American Merinos. The Ameri-

can Merino group showed better closure, probably due to the shorter fleeces they carried, than the imported group. With respect to the under or belly covering, both flocks received practically the same score, showing that both types were equally efficient in using all skin areas for wool growth. The score for face covering showed that the American Merinos were considerably woolier faced than the Tasmanian sheep, which had decidedly open faces.

TABLE 1.—Wool Score Record of Sheep, October 10-11, 1927

Sheep number	Weight of fleece Lb.	Length of staple* In.	Fineness and uniformity			Character at side	Density	Distribution		
			Shoulder	Side	Thigh			Back	Belly	Face
Foundation flock of American Merino ewes										
448	7.4	1.50	66's	64's	60's	2—	1—	1	2+	3
453	8.1	1.87	66's	70's	62's	1	2	2	2+	5+
454	8.1	1.50	66's	68's	64's	2—	1—	1—	2	3—
461	6.3	1.62	66's	66's	68's	1—	1—	1	1	4
465	8.3	1.37	70's	70's	66's	2	1	1	1—	5+
466	7.4	1.75	70's	70's	70's	1+	2	1	2	5+
468	7.0	1.50	74's	76's	70's	2	2	1—	2—	4—
472	7.7	1.75	66's	68's	64's	1—	1	1	2	4—
477	6.6	1.50	70's	68's	64's	1	2	1—	2	3
498	5.3	1.50	70's	68's	64's	2	2—	2	2—	3
Σ of ewes	72.2	15.86	684	688	652	15.99	16.32	12.99	18.33	39.33
M. of ewes	7.22	1.59	68.4's	68.8's	65.2's	1.60	1.63	1.30	1.83	3.93
% perfect						89.0	88.7	92.0	86.7	65.7
Foundation flock of Tasmanian Merino ewes										
22	10.9	3.50	80's	78's	74's	1—	2—	1—	3	4—
23	10.3	3.00	80's	80's	78's	1	2+	1—	2+	2
24	10.6	4.00	80's	80's	76's	1—	2—	3+	2—	2—
25	10.4	4.00	76's	74's	72's	2	1—	2	2+	3—
26	11.1	3.00	72's	76's	74's	1	2+	1—	1—	3
27	9.5	3.50	80's	80's	80's	1	2	2	2	3
28	10.3	3.37	80's	74's	74's	2—	2+	2	2	2+
29	9.1	3.00	70's	68's	64's	1	2+	2—	1	4
30	8.7	3.50	76's	80's	80's	2+	2—	3—	1	2—
31	7.8	3.00	80's	80's	78's	1—	1—	2—	2—	2—
Σ of ewes	98.7	33.87	774	770	750	13.99	18.33	20.65	18.33	28.32
M. of ewes	9.87	3.39	77.4's	77's	75's	1.4	1.83	2.07	1.83	2.83
% perfect						91.0	86.7	84.3	86.7	76.7

*Length of staple for American Merino ewes was approximately 6 months' growth and for Tasmanian Merinos, slightly over 12 months.

An analysis of Table 2 shows that the American Merino ewes were in higher condition of flesh than the Tasmanian ewes. In levelness of the back and rump, the home-bred ewes were superior to those imported, and the former also excelled the latter in plumpness of the leg of mutton. In skin folding, the American Merino ewes carried definitely more wrinkles on the neck and body than the Tasmanians. Only one of these imported ewes (No. 28) showed any marked degree of wrinkling on the neck. Just one of the American Merino ewes could be classed as a perfectly smooth-bodied Merino; three could be classed as possessing perceptible skin folding, although not sufficient to classify them as B-type. Generally, the Tasmanian ewes were practically smooth-bodied while the American Merino ewes were classed as C-type, with a smooth body and a definitely folded neck.

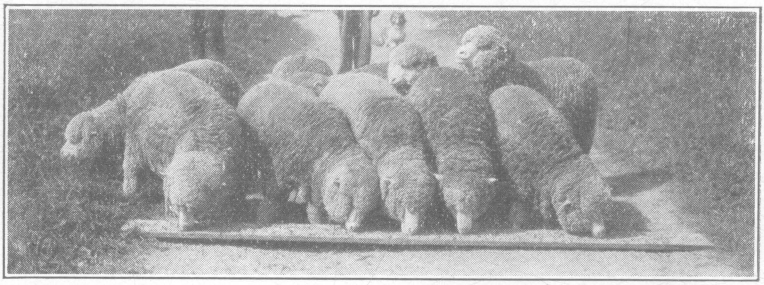

Fig. 3.—The flock of 10 imported Tasmanian Merino ewes soon after arrival at Wooster, Ohio, in September, 1927

TABLE 2.—Body Score and Skin Folding, October 10-11, 1927

Sheep number	Body score					Skin folds	
	Type	Condition	Back	Rump	Leg	Neck	Body
Foundation flock of American Merino ewes							
448	1	2+	1—	2	2	4—	3—
453	2—	1—	1—	2—	3+	3—	4
454	2	1—	2+	2	2	4—	4+
461	1—	1—	1—	1	1	3	2
465	1	1—	1	1—	2+	3—	2
466	1	1	1—	1	3+	3+	2+
468	2+	2+	2+	1—	2—	3+	2—
472	2	2—	1—	2	2—	3+	2—
477	2	1	1—	1—	1	2—	2—
498	1	1	1	1—	1	1—	1
Σ of ewes	15.33	13.99	13.32	15.65	18.67	29.99	24.66
M. of ewes	1.53	1.40	1.33	1.57	1.87	3.00	2.47
% perfect	89.7	91.0	91.7	89.3	86.3	75.0	80.3
Foundation flock of Tasmanian Merino ewes							
22	1	1	1	3+	2	1—	1
23	2+	2	1—	2—	2	1—	1
24	2—	2	1—	3—	2	2+	2+
25	3—	4—	2	3—	4	2	2+
26	2—	2—	2+	2—	2+	2	2
27	2	3+	2	4	2—	2+	1—
28	3	3—	2	3+	3+	3	2—
29	2	2—	2+	3	3	2+	2+
30	2—	2—	2	3—	3+	2	1—
31	3	3—	2—	3	3+	1—	2+
Σ of ewes	22.99	25.65	17.33	29.99	25.01	18.00	15.67
M. of ewes	2.30	2.57	1.73	3.00	2.50	1.80	1.57
% perfect	82.0	79.3	87.7	75.0	80.0	87.0	89.3

Fig. 4.—Tasmanian Merino rams on the farm of Chas. Goulter, Blenheim, Marlborough, N. Z. It was from this flock that the Tasmanian Merinos used in this study were selected

From the data of the body weights and measurements presented in Table 3 it is apparent that at the start the American Merinos were nearly 30 pounds heavier than the Tasmanians—probably a part of this greater weight being due to a higher condition of flesh. Moreover, the American Merinos were proportionately larger in all body dimensions than the Tasmanians. If, in each case, the depth of chest is deducted from the height at withers, it is found that the American Merinos, even though larger, were set on slightly shorter legs than the Tasmanian Merinos.

Feeding and management.—All of the sheep used in these tests were maintained under the usual routine of feeding and management followed at the Ohio Experiment Station, which was similar to, if not identical with, that followed by many prominent breeders of fine wool sheep in Ohio.

Summer feeding.—The summer feeding schedule placed the sheep on pasture the last few days of April or early in May. Except for the flushing period of 6 weeks, which started 10 days before actual breeding was begun, pasture, water, and salt *ad libitum* constituted their fare until late November or early December, when winter feeding was started in the barn. The sheep were kept in a barn and adjoining dog-proof lot each night during the grazing season as a precaution against stray dogs which might cause damage. It was optional with the sheep whether they bedded down at night outside in the dog-proof lot or under roof.

TABLE 3.—Body Measurements of Sheep Expressed in Inches; Weight in Pounds

October 31, 1927

Sheep number	Width of chest	Depth of chest	Length—shoulder point to hip bone	Height—floor to withers	Circumference of barrel	Length—tip of nose to end of dock	Weight of sheep
Foundation flock of American Merino ewes							
448	9.0	12.0	19.3	24.4	43.7	46.2	113
453	8.7	11.4	17.9	24.1	41.9	47.7	104
454	8.7	11.4	19.1	22.5	42.6	47.2	102
461	9.0	11.2	18.0	22.1	40.6	43.6	91
465	9.1	12.4	19.9	24.6	43.9	49.2	111
466	8.1	11.7	18.3	24.2	41.7	46.9	99
468	8.5	12.3	17.3	22.5	40.6	45.7	93
472	8.3	11.8	19.4	23.0	41.7	47.3	96
477	10.3	11.4	19.5	22.9	44.7	46.5	111
498	10.3	12.9	19.0	25.2	41.2	48.3	117
Av. of 10 ewes	9.0	11.8	18.8	23.5	42.3	46.9	103.7
Foundation flock of Tasmanian Merino ewes							
22	8.7	11.5	19.7	25.1	40.5	47.1	105
23	7.6	11.0	19.2	24.6	37.2	47.6	88
24	7.0	10.5	17.4	22.7	36.3	44.8	79
25	6.4	10.4	18.2	22.2	33.5	43.6	68
26	7.1	10.1	17.1	21.2	37.6	44.4	74
27	6.3	9.4	17.0	21.8	33.8	42.8	64
28	6.9	10.2	17.7	23.6	34.2	44.1	73
29	6.4	10.1	17.1	21.3	34.3	43.2	66
30	6.4	10.1	17.6	22.7	35.2	43.1	66
31	6.4	10.0	17.5	22.7	34.6	43.8	63
Av. of 10 ewes	6.9	10.3	17.8	22.8	35.7	44.4	74.6

Winter feeding.—During the winter feeding season the sheep were kept in the barn with access to an adjoining outside lot. During the first 3 years one-half pound of grain per head per day was allowed to the ewes during preg-

nancy. A similar quantity was fed to the lambs and breeding rams throughout the winter. The grain allowance for the ewes after lambing was increased to 1.1 pounds per head per day to stimulate milk flow. In addition, 2 to 2.5 pounds of corn silage were fed daily to mature sheep and 1 to 1¼ pounds daily to lambs, along with whatever quantity of legume hay the sheep of the various age classes would consume when fed on a once-daily basis. Salt and water were accessible at all times. The actual feed and pasture consumed per ewe per year are presented in Table 14.

During the first three winter feeding seasons, the grain feed allowed the American and Tasmanian Merino ewes was computed on a per-head basis and the two breeds during the second and third years were fed together. Because the American Merinos developed into definitely larger mature sheep than the Tasmanians, the question was raised as to whether the former might not be somewhat underfed and the latter slightly overfed. To check on this probability and to determine what influence this schedule might have had on production, the two breeds, during the winter seasons of 1930-1931 and 1931-1932, were fed separately by breeds and allowed a definite quantity of each kind of feed for each 100 pounds of live weight. For example, during the pregnant period, the concentrate allowance for each breed was 0.5 pound per 100 pounds of live weight of the sheep in each lot. All feeds were allotted in the same manner, the allowance being adjusted each week on the basis of weight taken each week.

Breeding.—The breeding season was begun on September 10 of each year and the lambs were born during February and March of the following year. Teasing and individual mating were practiced in all instances, except in the Tasmanian Merino flock in 1927, when the recently imported ram (U. S. Imp. No. 21) was allowed to run with the ewes because of his shy nature.

The American Merino and Tasmanian Merino flocks were kept purebred, and no additions were made except to add the choice female offspring born to the ewes in these respective flocks.

The policy in breeding the American Merino flock throughout this test was in keeping with the general practice followed by many leading breeders of Merino sheep in Ohio. Resort was made at the outset to moderate use of a B-type ram (Fig. 11) on the basis that breeders consider such infusion essential in breeding C-type Merino sheep in order to hold and improve the density of fleece and maintain its grease content. From this point, line breeding was practiced in order to fix the desirable characters attained. Thus, a family of Merino sheep was established which continued with line breeding on the paternal side of the pedigree. Except for five individual matings, the 70 American Merino matings made during this study were either by the foundation ram described, by a son, by a grandson, or by a paternal half-brother. All of the rams except the foundation sire were C-type rams.

Shearing.—Shearing was done as nearly on the same date of each year as possible, or between April 8 and 11, centering on the date of April 9. Power clippers were used and professional sheep shearers were hired for the work.

Drenching and dipping.—Drenching once each month during the grazing season, using the copper sulfate solution principally, was practiced as a routine control against parasitism with the stomach worm (*Haemonchus contortus*). Also, the sheep were dipped when external parasites were found among any of the flocks on this Station farm.

RESULTS

The data which were obtained during the conduct of these tests and which form the basis of this publication are presented in Tables 1 to 16, inclusive. During the conduct of these tests several thousand individual records were taken; obviously, it is impossible to publish all of them. For the most part, the data presented are averages for the various groups or lots and not records from individual sheep. Even though data from individual sheep or certain groupings of the sheep are not presented in tabular form, reference will be made to them.

WOOL GROWTH

THE PERIODIC OR SEASONAL RATE OF GROWTH OF WOOL FIBERS FROM MERINO SHEEP

Before making an interpretation of the data presented in Table 4, showing the periodic or seasonal rate of growth of fine wool, it should be emphasized that throughout all of these experiments the sheep were kept healthy, thrifty, and in good condition but not necessarily always gaining in weight. At no season were the sheep in any of these tests in want of feed. Fluctuations in body weight did occur. The breeding ewes during the latter part of the nursing period and after weaning and all sheep during the period of dry summer pasture were medium to thin in flesh but they constantly evidenced thrift, health, and vigor. The point for emphasis is that these sheep were maintained under customary feeding and management practices and, hence, in a condition of flesh similar to what would be found among Ohio flocks in the hands of good sheep growers. Thus, the results should fairly represent the normal seasonal rate of growth of fine wool under Ohio conditions. No attempt was made to show the influence of feeds or feed combinations on rate of growth of wool except as seasonal conditions brought a change in feeding and management practices. Also, in studying the data in Table 4, it should be remembered that each group represents one complete experiment. The conditions for any one experiment were not exactly similar in all respects to any other experiment; hence, the data from one group cannot be directly compared with the data from any other group. Consequently, each group of data must receive its own respective interpretation. Occasionally, data obtained in some one period with a particular group will support the data obtained in another group. Due consideration is given such supporting data in arriving at the conclusions drawn from this study of the influence of factors on the periodic or seasonal rate of growth of wool.

The normal rate of growth of fine wool.—The results of the several experiments conducted to determine the rate of growth of fine wool and the influence of outside factors on the rate of growth of wool are presented in Table 4. The sheep on these experiments, under practical husbandry conditions, showed a slight tendency to grow more wool during the first half of the year after shearing than during the second half of the year. Five of the 10 lots of sheep produced from 53 to 54 per cent of the total yearly growth of wool during the first half of the year following shearing. The other five lots showed more nearly a 50-50 percentage for the first and second half of the year, respectively. As shown later, outside factors may accelerate or retard the periodic rate of growth somewhat and these influences may explain the slight variations recorded. In general, the data will support the statement that, under uniform

TABLE 4.—Average Length Growth of Wool Fibers Expressed in Inches, Clipped and Measured at Successive 6-Week Intervals Throughout the Wool Growing Year

Group	Class of sheep	Year	Date of clipping fibers*								Pct. of total length	
			Apr. 20 to June 1	June 1 to July 13	July 13 to Aug. 24	Aug. 24 to Oct. 5	Oct. 5 to Nov. 16	Nov. 16 to Dec. 28	Dec. 28 to Feb. 8	Feb. 8 to Mar. 21	1st four periods, or summer grazing	2nd four periods, or winter feeding
1	Influence of sex:											
	Av. of six yearling ewes	1927-	0.61	0.51	0.51	0.49	0.48	0.44	0.46	0.43	53.9	46.1
	Av. of six yearling wethers	1928	0.57	0.50	0.51	0.48	0.45	0.43	0.43	0.44	54.0	46.0
2	Influence of pregnancy and yeaning:											
	Av. of six bred ewes	1928-	0.48	0.47	0.45	0.47	0.50	0.47	0.47	0.39†	50.5	49.5
	Av. of six unbred ewes	1929	0.46	0.49	0.44	0.45	0.49	0.49	0 48	0.45	49.1	50.9
3	Influence of breed:											
	Av. of ten American Merino ewes	1928-	0.49	0.51	0.46	0.48	0.49	0.48	0.48	0.41†	51.1	48.9
	Av. of ten Tasmanian Merino ewes.	1929	0.51	0.60	0.52	0.52	0.52	0.48	0.48	0.42†	53.1	46.9
4	Influence of age—as lambs:											
	Av. of five American ewe lambs. ..	1929-	0.46	0.47	0.43	0.43	0.41	0.42	0.40	0.43	51.9	48.1
	Av. of four Tasmanian ewe lambs...	1930	0.51	0.53	0.54	0.50	0.41	0.45	0.43	0.47	54.2	45.8
5	Influence of age—as yearlings:											
	Same as above except one year older	1930-	0.45	0.44	0.42	0.45	0.42	0.43	0.45	0.46	50.0	50.0
		1931	0.54	0.52	0.50	0.49	0.50	0.44	0.41	0.41	53.8	46.2
			Period of spring pasture		Dry pasture of mid-summer	Period of fall pasture and flushing ewes to be bred		Period of winter feeding in barn				

*Dates given are for year 1927-1928—no periods varied in successive years by more than 4 days earlier than dates given.
†Indicates periods where full influence of yeaning is measured.

conditions, stage of wool growth does not influence the rate of growth of wool fiber. Under practical sheep raising conditions, some variations in the periodic rate of growth may occur.

The influence of seasonal conditions of feed supply.—It appears from the data of Group 1 that spring and early summer pasture accelerated the rate of growth of wool fiber. In the first period the average growth of wool fiber produced by the six yearling ewes was 23.6 per cent and by the six wethers 19 per cent above the mean average for all periods of the year. Both the ewes and wethers showed this tendency toward accelerated growth of wool and this, in turn, may be closely associated with feed conditions provided by luxuriant spring pasture. Other groups in this series of experiments support the opinion that seasonal conditions of feed supply influence the rate of growth of wool fiber. A rather pronounced example of a retarded rate of growth is found in the data from Group 4 for the period from October 5 to November 16, which was characterized by poor late fall pasture, especially for lambs. Both the American Merino and Tasmanian Merino ewe lambs showed a retarded rate of growth of wool fiber of 5.4 per cent and 15.4 per cent, respectively, in this period. Still another analysis which supports the opinion that seasonal condition of feed supply may influence the rate of growth of wool is the fact that the most constant rate of wool growth occurred during the winter feeding season, when the feed supply was the most constant.

All of the differences observed with respect to retarded or accelerated rate of growth of wool which may be associated with the seasonal condition of feed supply are quite pronounced. In view of the fact that all of the sheep were kept healthy, thrifty, and in good condition throughout the tests, this observation becomes all the more significant.

Influence of sex.—The influence of sex on the periodic rate of growth of wool fiber or upon the total yearly growth of wool fiber is negligible according to the data assembled in this experiment. The mean average growth for the eight periods was 0.49 inch for the six ewes and 0.48 inch for the six wethers. The greatest variation between these closely related ewes and wethers in any 6-week period amounted to only 0.04 inch. The total growth of wool fiber for the eight periods of the experimental wool growing year was 3.92 inches for the ewes and 3.81 inches for the wethers, a difference in total growth of only 0.11 inch. Thus, sex cannot be considered as a factor which influences the periodic rate or total growth of wool fiber among closely related sheep under identical conditions of feed and management.

The influence of pregnancy.—The influence of pregnancy on the periodic or seasonal rate of growth of wool fiber was slight, according to the data obtained from Lots 1 and 2 of Group 2 in this series of experiments. The greatest variation in growth for any of the first seven periods of the year between the six bred and six unbred yearling ewes was 0.02 inch. This difference is not great enough to be significant.

The influence of yeaning.—The influence of yeaning and starting milk flow on the rate of growth of wool fiber, as shown by the data from Period 8, Group 2, Lot 1, or the period from February 8 to March 21 when the bred ewes dropped their lambs, is pronounced. A marked diminution in the periodic rate of growth for the ewes that lambed is noted; this is 16.8 per cent below the mean average of the three immediately preceding periods which are comparable and which are characterized by the same feeding schedule for the ewes. The reduction in rate of growth is 14 per cent less than that of their comparable unbred half-sisters. These differences are deemed significant.

Support for the observation that the processes attendant to yeaning and starting milk flow cause a marked diminution in the rate of growth of wool fiber is found in the data from Lots 1 and 2 of Group 3 and also from Lot 2, Group 5. In Group 3, the diminution amounted to 18 per cent below the mean average growth recorded during the three immediately preceding periods which are comparable. The degree of diminution in rate of growth of fiber was not so pronounced among the yearling ewes of Lot 2, Group 5, and Lot 1, Group 5, did not show this diminution at all. In these two cases the influence of yeaning was not measured fully, due to later lambing, and cannot be considered as measuring the full influence of yeaning on the rate of growth of wool fiber. Thus, from the data assembled it is seen that the processes attending yeaning and starting milk flow brought about a diminution in the rate of growth of wool fiber amounting to 16.8 to 18 per cent below the mean average growth recorded for the three immediately preceding barn feeding periods.

The influence of breed.—According to the data obtained from Lots 1 and 2 in Groups 3, 4, and 5, breed had a pronounced influence on the total yearly growth of wool fiber. The Tasmanian Merinos consistently grew a greater total length of wool fiber during the experimental wool growing year than the American Merinos. Hence, the periodic or seasonal rate of growth was consistently greater for the Tasmanian Merinos than for the American Merinos. Any variation which occurred in the way of accelerated or retarded growth of wool due to outside influences was more pronounced among the Tasmanian Merinos than among the American Merinos. Thus, breed not only influences the periodic rate and total yearly growth of wool but likewise influences the degree of variation which may result from outside influences, such as seasonal condition of feed supply or yeaning.

The influence of age.—The influence of age upon the rate of growth of wool fiber, as measured by Lots 1 and 2 of Groups 4 and 5, was not pronounced. As mentioned above, breed influenced total growth, and, hence, there was a breed difference in the periodic or seasonal rate of growth. The American Merinos as lambs showed a mean average growth of 0.43 inch per period, and as yearlings they showed a mean average of 0.44 inch. The mean average growth per period by the Tasmanian Merinos was identical for the 2 years studied.

THE INFLUENCE OF BREED UPON THE GROWTH AND QUALITY OF FINE WOOL

Unscoured or grease wool production.—In Table 5, under the heading "Weight of Fleece", it will be noted that the foundation flock of American Merino ewes sheared an average of 13.04 pounds of unscoured or grease wool per sheep per year. The foundation flock of Tasmanian Merino ewes, Table 6, sheared an average of 9.36 pounds of unscoured or grease wool per sheep per year. On the basis of these weighted averages and over a 4-year period, the American Merinos sheared 3.68 pounds more unscoured wool per head per year than the Tasmanian sheep. Again, in Table 6, under the same heading, it will be noted that the female offspring from the foundation flock of American Merinos sheared an average of 14.26 pounds of grease wool per head; the offspring from the Tasmanian Merino flock sheared 9.21 pounds of unscoured or grease wool. On this basis, the ewe offspring from the American Merino flock sheared 5.05 pounds more grease wool per head annually than the offspring

TABLE 5.—Fleece Scouring—Grease and Clean Wool Production of American Merino Ewes and Their Female Offspring

Kind of sheep	No.	Year sheared	Weight of fleece	Average percentage of				Ewes weight after shearing	Pounds of wool per 100 pounds live weight of sheep	
				Moisture	Grease	Dirt	Clean wool		Grease basis	Scoured basis
			Lb.					*Lb.*		
Foundation flock: American Merino ewes	10	1929	12.65	9.17	27.91	24.39	38.54	97.2		
	10	1930	13.09	10.41	27.16	27.22	35.21	98.3		
	8	1931	13.55	9.03	25.65	32.15	33.17	115.3		
	8	1932	12.95	13.02	28.80	24.86	33.32	120.4		
Weighted average.	36	4 yr.	13.04	10.34	27.68	27.01	35.26	106.7	12.22	4.31
Ewe offspring from foundation flock: American Merino yearling ewes	5	1929	12.92	8.78	29.15	21.94	40.12	70.0		
	5	1930	12.88	9.03	30.63	22.59	37.75	78.0		
	4	1931	14.43	8.23	23.80	32.08	35.89	83.6		
	4	1932	11.50	13.32	27.19	23.27	36.22	83.0		
Weighted average.	18	4 yr.	12.93	9.74	27.93	24.67	37.67	78.2	16.53	6.23
American Merino 2-year-old ewes	5	1930	14.48	9.20	28.04	26.08	36.68	79.4		
	5	1931	16.42	7.82	26.06	31.67	34.45	96.6		
	4	1932	14.70	14.91	26.61	20.38	38.10	89.6		
Weighted average.	14	3 yr.	15.20	10.34	26.92	26.45	36.29	88.46	17.23	6.25
American Merino 3-year-old ewes	4	1931	16.18	9.25	28.84	26.51	35.40	99.5		
	5	1932	14.60	11.00	31.55	20.94	36.51	106.5		
Weighted average.	9	2 yr.	15.40	10.22	30.35	23.42	36.02	103.4	14.80	5.33
American Merino 4-year-old ewes	3	1932	14.60	14.37	27.54	21.66	36.43	103.8	14.07	5.12
Weighted average for all ewe offspring	44	Ten shearings	14.26	10.34	28.08	24.77	37.03	88.1	16.19	5.99

from the Tasmanian Merino flock. Thus, the American Merinos were found to produce an average of from 3.68 pounds to 5.05 pounds more grease wool per head per year than the Tasmanian Merinos.

This comparison, on the per-head basis, is slightly misleading, since it will be noted in Tables 5 and 6, under "Ewes Weight After Shearing", that the American Merinos were heavier and hence larger sheep than the Tasmanians. Because it was determined during the progress of these tests that for economy of production the feed should be allowed on the basis of live weight of sheep rather than on a per-head basis, the pounds of grease wool were computed per 100 pounds of live weight after shearing. On this basis of comparison, the foundation flock of American Merinos was found to produce 12.22 pounds of grease wool per 100 pounds live weight and the comparable Tasmanian group sheared 10.54 pounds—a difference in favor of the American Merinos of 1.68

TABLE 6.—Fleece Scouring—Grease and Clean Wool Production of Tasmanian Merino Ewes and Their Female Offspring

Kind of sheep	No.	Year sheared	Weight of fleece	Average percentage of				Average weight after shearing	Pounds of wool per 100 pounds live weight of sheep	
				Moisture	Grease	Dirt	Clean wool		Grease basis	Scoured basis
			Lb.					*Lb.*		
Foundation flock: Tasmanian Merino ewes	10	1929	9.07	9.20	19.36	17.50	53.94	76.7		
	9	1930	9.73	10.07	17.93	21.63	50.37	88.2		
	7	1931	9.30	8.43	18.16	21.85	51.56	93.4		
	7	1932	9.37	11.22	19.77	16.53	52.48	102.1		
Average	33	4 yr.	9.36	9.70	18.80	19.34	52.15	88.8	10.54	5.50
Ewe offspring from foundation flock: Tasmanian Merino yearling ewes	4	1929	7.13	11.81	13.24	21.19	53.77	56.1		
	5	1930	8.32	9.33	16.71	20.71	53.25	57.6		
	4	1931	9.00	8.59	12.90	28.81	49.70	62.9		
	4	1932	8.90	14.62	13.96	17.71	53.71	59.1		
Average	17	4 yr.	8.34	10.98	14.35	22.02	52.65	58.8	14.18	7.47
Tasmanian Merino 2-year-old ewes	4	1930	11.48	11.71	13.87	23.90	50.51	74.7		
	4	1931	9.83	9.25	14.53	26.26	49.96	69.9		
	3	1932	10.00	12.91	15.95	16.64	54.50	72.8		
Average	11	3 yr.	10.47	11.14	14.68	21.87	51.40	72.4	14.48	7.44
Tasmanian Merino 3-year-old ewes	1	1931	9.80	10.18	13.42	24.36	52.04	86.0		
	3	1932	8.83	11.57	18.44	16.89	53.10	79.7		
Average	4	2 yr.	9.08	11.22	17.19	18.76	52.84	81.3	11.16	5.89
Tasmanian Merino 4-year-old ewes	1	1932	10.80	16.70	13.96	14.24	55.10	91.0	11.87	6.54
Average for all female offspring	33	Ten shearings	9.21	11.24	14.79	21.34	52.33	67.1	13.73	7.18

pounds of grease wool. Likewise, the average difference among the young females produced by these two foundation flocks, instead of the 5.05 pounds for the American group above the Tasmanian group on a per-head basis, is only 2.46 pounds on the basis of grease wool production per 100 pounds of live weight of sheep after shearing.

FACTORS OF SHRINKAGE

Fleeces, as they come from the sheep at shearing time, are composed of four ingredients—moisture, grease, dirt, and clean wool. Of these, the clean or scoured wool is the only one which has any considerable commercial value, notwithstanding the fact that the lanolin in the grease is sometimes salvaged even though its recovery is not ordinarily profitable. Tables 5 and 6 show the average per cent of moisture, grease, dirt, and clean wool determined from side samples taken at shearing time for the various groups of American and Tasmanian Merino sheep involved in these studies.

Moisture.—Moisture in the fleece at shearing time, according to the data collected, is quite variable. In these tests there was no great variation in moisture content of the fleeces that may be ascribed to breed difference. The average moisture content of the wool, however, varied one year with another. Records of weather conditions immediately prior to and during shearing make it possible to associate the moisture content of the fleeces at shearing with climatic conditions prevailing at shearing time. Table 9 presents the data which show this association.

It will be noted in Table 9 that the average moisture content of the fleeces from the first three groups sheared in 1929 varied from 8.78 per cent to 9.2 per cent while the moisture content of the fleeces of the fourth group rose to 11.81 per cent. Also, it will be noted in Table 9 that the weather had been clear until 11 A. M. on shearing day, when it started to drizzle rain. All groups except Group 4 had been sheared prior to the time rain fell. The fleeces of Group 4 apparently took up about 2.5 per cent of moisture even though the sheep had not been directly exposed to falling rain.

Rain fell on the 2 days preceding the 1930 shearing. A trace of rainfall was measured early on shearing day with the weather turning clear. The fleeces from Groups 1 and 3 were sheared first, followed by 2 and 4, which were sheared during the clear weather conditions. The fleeces from Groups 1 and 3 showed a higher moisture content than the fleeces from Groups 2 and 4. Thus, the moisture found in the wool samples of 1930 seems to be closely associated with prevailing weather conditions.

The weather was clear with no evidence of rainfall on shearing day in 1931 or 3 days prior thereto. The average moisture content of the fleeces of the various groups of sheep varied only 0.8 of one per cent. Since the fleeces of both breeds showed the same average per cent of moisture, it is felt that this 1931 shearing represents the normal moisture content of fine wool as it is taken from Merino sheep under clear weather conditions. Further, the data show that neither breed nor the fleece characteristics of the breed influenced the average percentage content of moisture contained in the fleece.

Shearing day in 1932 was a rainy day, as also were the 3 preceding days. The average moisture content of the fleeces for all groups was from 3 to 6 per cent above the moisture content of the fleeces removed during the preceding year, when clear weather conditions prevailed at shearing time. Again, no breed differences were noted that seemed significant.

It appears from this study of the moisture content of the fleeces in relation to the rainfall table that an excess of moisture may be taken up rapidly by the wool on sheep during rainy weather. Further, it seems that excess moisture in fleeces is given up under clearing weather conditions at a rate almost as rapid as the rate at which it is absorbed. Apparently, weather conditions which maintain at shearing time influenced the moisture content of the wool sheared. The weighted average percentage content of moisture under clear weather conditions was 8.63 per cent of the weight of sheared wool.

Grease or wool oil.—Grease or wool oil in the fleeces of sheep serves the useful and necessary purpose of bathing the wool fiber, so as to prevent weathering and felting of the fibers during growth. Hence, some wool oil or grease in the growing fleece seems necessary. Just how much grease is necessary to protect the growing wool fibers has never been determined.

The weighted average percentage content of grease or wool oil in the fleeces of the foundation flock of American Merino ewes was 27.68 per cent of the weight of sheared wool. In the fleeces from the foundation flock of Tas-

manian Merino ewes, grease or wool oil constituted 18.8 per cent of the weight of sheared wool. Thus, the shrinkage of the fleeces from the foundation flock of American Merino ewes, due to wool oil or grease, was 8.88 per cent greater than the shrinkage due to grease in the Tasmanian Merino ewe fleeces.

Again, the weighted average per cent of grease in the fleeces of all the female offspring from the foundation flock of American Merino ewes was 28.08 per cent; the comparable figure for the corresponding lot of young Tasmanian Merino females was 14.79 per cent. The shrinkage of the wool from the two groups of young ewes, due to wool oil or grease, was 13.29 per cent greater for the American Merinos than for the Tasmanian group. Thus, the percentage shrink of wool on scouring, due to natural grease or wool oil, on the basis of weighted averages, was from 8.88 per cent to 13.29 per cent greater for the American Merino fleeces than for the Tasmanian Merino fleeces.

Analyses of individual fleece scouring records show that the highest grease content in a fleece from an American Merino ewe in this study was 34.82 per cent and the lowest was 20.52 per cent of the weight of the fleece; whereas for the Tasmanian Merino ewes the highest grease content in a single full-year fleece was 29.05 per cent and the lowest was 9.48 per cent of the weight of the fleece shorn.

Among the rams 2 years of age and older which were used for breeding or were raised on this test, the highest grease content found in a full-year fleece from a ram in the American Merino group was 53.18 per cent and the lowest was 35.18 per cent of the fleece weight. Among the Tasmanian Merino rams the greasiest fleece contained 36.70 per cent of natural wool oil; whereas the least greasy fleece contained 23.2 per cent of wool oil.

These records are of interest because they show the extremes in variation in the content of natural wool oil or grease found in the fleeces of these two contrasting breeds of Merino sheep. It is particularly striking that the greasiest Tasmanian Merino ram fleece should have but 1.5 per cent more wool oil or grease than the least greasy fleece among the American Merino rams.

Dirt.—Dirt naturally adheres as fine particles to the tip of a fleece growing on the body of a sheep. Also, larger particles of dirt, such as seeds, chaff, dust, soil, etc., may penetrate into a fleece of wool to a greater or less extent, depending upon the closure and density of the wool fibers. The larger particles usually sift into the fleece from the top line; whereas adhering dirt on the tip of the fleece is found quite uniformly over the entire outer surface of the fleece. Since the determinations for per cent of dirt were made on side samples of wool taken at shearing time, the dirt mentioned in this study was largely the fine-textured dirt which adheres to the tip of the growing fleece and which contributes to make the black-crusted appearance which Merino breeders have termed "top".

By referring to Tables 5 and 6 it is observed that, on the basis of weighted averages, 27.01 per cent of the unscoured weight of the fleece of the foundation flock of American Merino ewes was dirt and that 19.34 per cent of the weight of the sheared fleeces from the foundation flock of Tasmanian Merino ewes was dirt. The young ewes of the two groups of Merinos showed a similar but not as great a difference in the per cent of dirt adhering to the fleece—the weighted average being 24.77 per cent of the weight of the fleece in the American Merino groups and 21.34 per cent of the weight of the sheared fleece in the Tasmanian Merino group. There seems to exist a relationship between the percentage of grease and the percentage of dirt in the fleeces of these two

foundation flocks of Merinos. It is rather striking that the average percentage of dirt in the fleeces from the mature ewes of these two contrasting breeds is almost identical with the average percentage of grease which the fleeces contain. The percentage of dirt in relation to percentage of grease in the fleeces of the young ewes does not remain as nearly identical as with the older sheep. This, however, would seem perfectly logical, since the more open lamb fleeces would have a tendency to gather more of the larger particles of dirt than would fleeces of older, fine wool sheep. It follows, therefore, that the data will support the statement that the percentage of grease in the fleeces from mature Merino sheep probably influences the percentage of dirt which will adhere to the tip of the growing fleece—the higher the percentage of grease the higher the percentage of adhering dirt, or so-called "top". Thus, the quantity of grease or wool oil in a fleece seems to have a two-fold effect on the shrinkage of wool on scouring, since both grease and dirt contribute nearly equally to shrinkage and the quantity of the former seems to influence the quantity of the latter which will naturally adhere.

Clean or scoured wool.—Clean wool represents the actual weight of wool fibers obtained from a fleece of unscoured wool by a scouring process which removes the moisture, grease, and dirt from the fleece. As mentioned earlier, clean wool is the only component part of grease wool which has commercial value.

In Tables 5 and 6 is to be found the average percentage of clean wool obtained from the fleeces of the various groups of the two Merino breeds. The weighted average clean wool content of the fleeces of the foundation flock of American Merino ewes was 35.26 per cent of the unscoured fleece weights and for the comparable flock of Tasmanian Merinos was 52.15 per cent. Thus, the foundation flock of Tasmanian Merinos yielded 16.89 pounds more clean wool for each 100 pounds of unscoured wool produced than the American Merino ewes. The difference between the young females of the two breeds was 15.3 pounds.

Transposing these data into terms of scoured or clean wool produced per 100 pounds live weight of sheep, it is found that the foundation flock of Tasmanian Merinos produced 1.19 pounds more clean wool per 100 pounds of live weight than the foundation flock of American Merino ewes. It is interesting to note that the difference in clean wool yield between the young ewes of the two flocks, on the basis of weighted average for all sheep in the two groups, is the same as that for the foundation flocks, or 1.19 pounds more clean wool per 100 pounds live weight of sheep from the young Tasmanian than from the young American Merino ewes. On the basis of clean or scoured wool production, it must be admitted that the Tasmanian Merinos are more highly specialized wool producers than the American Merinos used in this study.

ADDITIONAL FACTORS INFLUENCING QUALITY OF WOOL

Length of staple.—The length of staple grown annually by each of the two breeds of Merino sheep and their respective female offspring is shown in Column 4 of Tables 7 and 8, respectively. Table 7 shows that the average annual length of staple grown by the foundation flock of American Merino ewes varied from 2.67 inches in 1929 to 2.79 inches in 1931, with a weighted average annual length of staple of 2.74 inches. The foundation flock of Tasmanian Merino ewes produced an average staple length of from 3.12 inches to 3.26 inches, with a weighted average of four full-year shearings of 3.17 inches.

Table 8 gives similar data for the female offspring of these two foundation flocks. It will be noted that the average staple length of the yearling fleeces from these two groups of young ewes exceeded subsequent length measurements. This is due to the fact that most of the yearling fleeces represented more than a full year's growth, since the lambs were born during February and March and were sheared the following year about April 9. The significant fact is that the weighted average length of staple grown in exactly one year by each group of young ewes was nearly identical with that produced by the respective parent flock.

In this connection it may be of interest to the reader to learn that the least length of staple produced by any single mature American Merino ewe in one full year was exactly 2.00 inches and that the greatest annual length of staple was 3.37 inches. For the Tasmanian Merinos, comparable figures were 2.87 inches as the least and 4.00 inches as the greatest annual staple length. These individual data have special significance in that they show that the Tasmanian Merinos produced fleeces all of which were long enough to comb for worsted yarn manufacture; the American Merinos, on the other hand, produced some short wool unsuited for the comb and, hence, salable at a price several cents per pound below top market quotations.

TABLE 7.—Wool Score Record of Sheep. Average of Original American and Tasmanian Merino Ewes

No.	Year	Weight of fleece	Length of staple	Fineness and uniformity Estimated spinning count			Per cent of perfect				
				Shoulder	Side	Thigh	Character	Density	Closure of back	Belly covering	Freedom from face covering
		Lb.	In.								
Foundation flock of American Merino ewes											
10	1927*	7.22	1.59	68.4	68.8	65.2	89.0	88.7	92.0	86.7	65.7
10	1929	12.65	2.67	70.8	71.0	67.4	85.0	87.3	81.7	86.7	68.7
10	1930	13.09	2.77	76.4	77.0	74.4	89.0	83.7	82.7	79.3	71.0
8	1931	13.55	2.79	77.8	77.5	76.0	85.8	86.3	80.9	84.2	65.8
8	1932	12.95	2.73	72.8	73.3	70.0	84.6	82.1	80.8	84.2	72.5
36	Wt. av. last 4 years	13.04	2.74	74.33	74.6	71.8	86.2	84.9	81.6	83.5	69.5
Foundation flock of Tasmanian Merino ewes											
10	1927*	9.87	3.39	77.4	77.0	75.0	91.0	86.7	84.3	86.7	76.7
10	1929	9.07	3.10	77.0	77.6	74.0	93.3	88.0	91.0	86.3	80.4
9	1930	9.73	3.26	78.9	78.4	76.9	93.2	86.1	85.8	78.7	84.6
7	1931	9.30	3.19	79.7	79.7	78.8	94.1	90.3	90.3	82.2	78.8
7	1932	9.37	3.12	74.8	75.4	72.3	93.1	91.2	91.7	89.3	81.2
33	Wt. av. last 4 years	9.36	3.17	77.6	77.8	75.4	93.4	88.6	89.6	84.0	81.4

*Fleeces and scores at start of test inserted for comparison—American Merino fleeces, 6 months' growth, Tasmanians, about one full year. 1928 records omitted because fleeces were only 6 months' growth.

Another interesting feature brought out in this study was the fact that variation in length of staple produced by individual sheep, one year with another, was very small. Sheep which produced short, medium, or long stapled fleeces at one shearing consistently grew similar length of staple in subsequent years. All of these sheep were well fed and maintained in good health and

TABLE 8.—Wool Score Record of Sheep. Average of Female Offspring from Ten Foundation American and Ten Foundation Tasmanian Merino Ewes

No.	Breed, age, and sex of sheep	Weight of fleece	Length of staple	Fineness and uniformity Estimated spinning count			Per cent of perfect				
		Lb.	In.	Shoulder	Side	Thigh	Character	Density	Closure of back	Belly covering	Freedom from face covering
	American Merino ewes										
18	Yearling ewe fleeces	12.93	2.97	75.9	75.6	73.8	87.4	91.3	83.2	90.2	63.3
14	2-year-old ewe fleeces	15.20	2.80	75.1	74.9	73.0	87.6	88.8	84.8	89.8	64.5
9	3-year-old ewe fleeces	15.40	2.90	74.7	74.9	72.2	87.6	88.3	80.9	88.3	58.3
3	4-year-old ewe fleeces	14.60	2.62	75.3	74.7	71.3	82.8	83.9	89.5	91.7	61.7
44	Fleeces from female offspring	14.26	2.88	75.4	75.1	73.0	87.2	89.4	83.7	90.1	62.6
	Tasmanian Merino ewes										
17	Yearling ewe fleeces	8.34	3.40	78.2	78.2	75.9	92.4	87.8	82.1	86.6	66.8
11	2-year-old ewe fleeces	10.47	3.30	77.8	78.3	76.2	90.2	87.4	86.8	81.1	70.2
4	3-year-old ewe fleeces	9.08	3.18	78.0	79 0	75.0	88.3	87.3	84.2	85.8	63.3
1	4-year-old ewe fleeces	10.80	3.37	76.0	76.0	74.0	91.7	88.3	85.0	88.3	55.0
33	Fleeces from female offspring	9.21	3.34	78.0	78.4	75.8	91.2	87.7	84.0	84.7	67.1

thrift throughout the test. Also, in this study age was not a significant factor affecting the annual length of staple produced. However, none of the sheep had attained to an age beyond 7 years; hence, the effect of advanced age on length of staple was not determined.

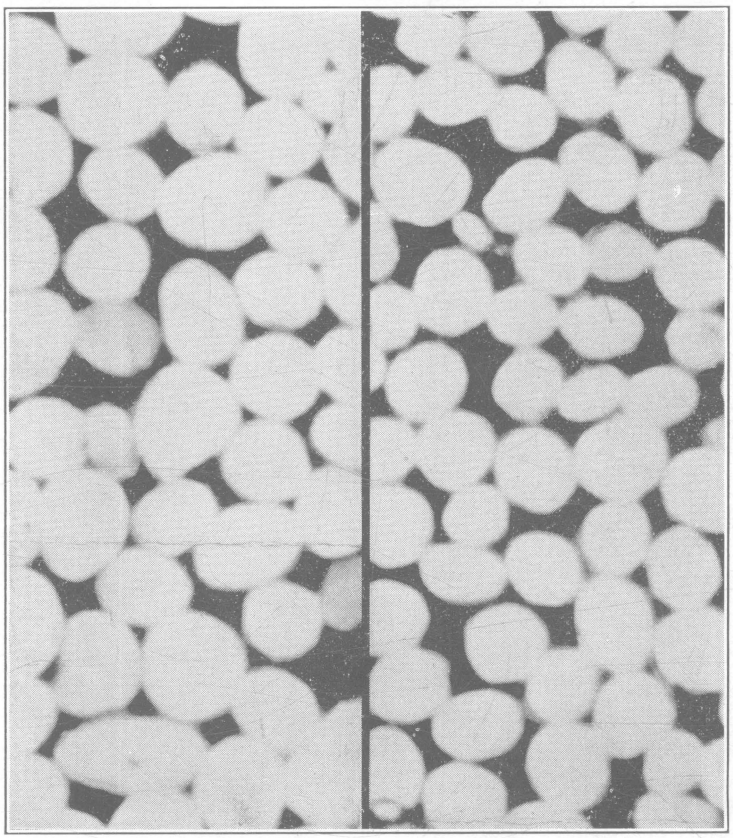

Fig. 5.—*Left*—Cross section of wool fibers, magnified 500 times, from crest of wrinkle. *Right*—Cross section of wool fibers, magnified 500 times, from body fleece. Same ram as *Left*. The ram carried wool of 56's quality on the crest of skin folds and of 70's quality on the body.

Fineness and uniformity.—Fineness[3] and uniformity of the fleece are given, on the basis of averages, for the various flocks and groups in Columns 5, 6, and 7 of Tables 7 and 8 and in terms of estimated spinning count. These data, as well as those recorded in the columns headed "Character, Density, Closure of Back, Belly Covering, and Face Covering" are personal judgments

[3]The wool samples for estimating fineness of fiber on wrinkly sheep were drawn from the skin area between the folds or wrinkles. These samples represent the fineness of the body fleece. They do not include the variation in fiber fineness due to the much coarser fibers which Bosman (2) has found to grow on the crest of the wrinkles of Merinos. To visualize the influence of wrinkles or skin folds on fiber fineness see Figure 5.

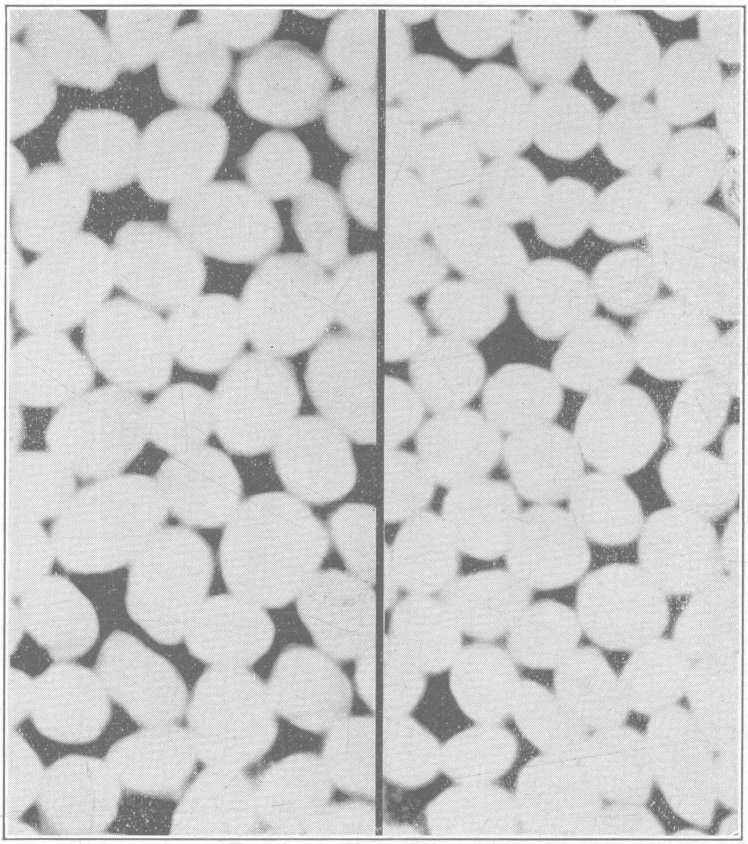

Fig. 6.—Fleeces from the American Merino ewes graded 64's (left) to 70's (right). Cross-section diameters magnified 500 times

and are probably less accurate than data obtained with the aid of highly precise mechanical devices or by mathematical computations. However, data on individual sheep were recorded as the average of the independent judgment of each of the three authors working each year without any reference to previous grading and scoring records. With this acknowledgment it is felt that these scores reflect finer or coarser fiber as the case may be observed on individual sheep and given in the tables on the basis of averages for the respective flocks of the two breeds under comparison. Likewise, these scores reflect the uniformity of fineness of fiber found on the shoulder, side, and thigh of the test sheep.[4]

[4]Since these experiments were initiated, a method has been perfected whereby fineness and uniformity of wool fibers, as well as uniformity of fleece over the body, may be accurately determined.

Figures 6 and 7 show cross-sectional views of wool fibers (magnified 500 times) for representative fleeces from the Tasmanian and American Merino sheep used in these experiments. These illustrations substantiate the judgment of the authors with respect to comparative fineness of fiber. They show, however, that variations in the diameter of adjacent fibers occur within the fleece which the naked eye fails to detect. Figure 8 shows a cross section of fibers from an American Merino fleece in which the diameter of the largest fibers is three times the diameter of the smallest fibers. This fleece definitely lacks uniformity of fiber. Such variations also occurred among the Tasmanian fleeces but were not as pronounced.

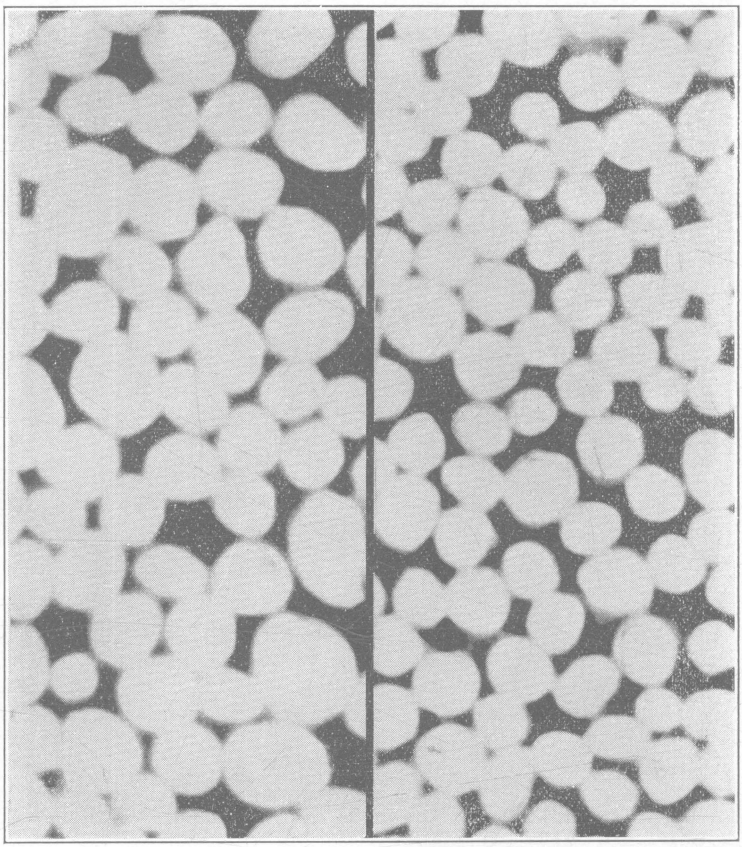

Fig. 7.—Fleeces from the Tasmanian Merino ewes graded 70's (left) to 80's (right). Cross-section diameters magnified 500 times

The first scoring for fineness and uniformity of fleece taken at the start of the test in October, 1927, and inserted in Table 7 for convenient reference showed that the foundation flock of Tasmanian Merino sheep possessed fleeces which averaged nearly nine spinning counts finer than the fleeces from the American Merino ewes. The obvious difference between these two breeds became less pronounced in subsequent years, when feed allowances were approximately the same. After the initial scoring for fineness, the Tasmanian Merino fleeces scored about the same, but there was a slight increase in the fineness of the fleeces of the American Merinos, as they raised lambs and were thereby reduced in condition. It is believed therefore that nutrition may have been the factor responsible for the coarser initial grading for fineness among the American Merinos, since both Hardy (11) and Wilson (14) have shown that there exists a definite relationship between diameter of wool fiber and the plane of nutrition of the sheep. To explain this more completely, the American Merino ewes were 2 years old at the start of the tests. They had been well fed and well grown, were in a high condition of flesh, and had not pre-

viously raised lambs. The Tasmanian Merinos, with one exception, had been raised on native New Zealand pastures without harvested feed or special care and had also to withstand the rigors of trans-Pacific shipment by vessel, as well as transportation by rail from California to Ohio. They were in a lower condition of flesh, which was more nearly comparable to the condition of flesh found under usual management than the high-conditioned American Merino ewes. Thus, the good feeding schedule and the attendant high condition among the American Merinos just prior to the beginning of the experiment may have resulted in the production of wool fibers slightly coarser than what would be normal under breeding flock conditions.

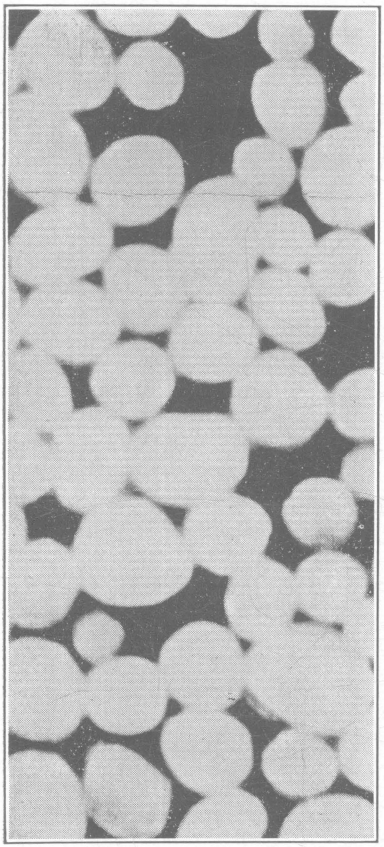

Fig. 8.—Cross section of wool fibers, magnified 500 times, from the B-type foundation American Merino ram. The diameter of the largest fibers is more than three times the diameter of the smallest fibers. This fleece shows a decided lack of uniformity of fibers, which the naked eye fails to detect.

Throughout the test, however, the Tasmanian Merinos, both the foundation flock and their female offspring, produced finer fibered fleeces than the American Merino sheep. A study of the scores of individual sheep brings out the fact that the majority of the Tasmanian Merinos produced fleeces that were graded 80's in fineness; whereas only an occasional fleece among the American Merinos was judged to be of that fineness.

Perhaps the most striking feature brought out by the data on fineness and uniformity of fiber is the similarity in fineness and uniformity between the parent flock and their respective female offspring. Also, the Tasmanian Merinos continued to produce fleeces, both in the parent flock and the flocks of ewe offspring, that were comparable to those the imported ewes were carrying when they arrived at Wooster. Their fleeces did not change under the changed conditions of feed and climate. This lends evidence to the thought that the fineness and uniformity of wool fibers exhibited by strains of Merino sheep are in large measure an inherent characteristic established through breeding.

Character.—Throughout this study the grade for character of fleece was uniformly higher among the Tasmanian Merinos than among the American Merinos, both for the parent flock and for their female offspring. The weighted average grade for character of fleece was 93.4 per cent of perfect among the imported Tasmanian ewes and 91.2 per cent of perfect among their

ewe offspring; whereas the grade was 86.2 per cent and 87.2 per cent of perfect among the American Merino ewes and their female offspring, respectively. This higher average grade for character among the Tasmanian sheep was the result of a consistently higher score among the individual Tasmanian Merinos. Very few individuals received a grade as low as 85 per cent of perfect. Among the American Merinos very few individuals received a grade as high as 90 per cent of perfect or above; moreover, some individuals received a grade for character of fleece as low as 70 per cent of perfect.

It was constantly observed that the obviously less greasy Tasmanian fleeces were brighter in appearance and showed less evidence of weathering from rain and other climatic factors than the obviously greasier American Merino fleeces. In fact, excessive quantities of oil in some American Merino fleeces seemed to be closely associated with low character in the fleece. It will be noted in Table 7 that the character of the Tasmanian Merino fleeces improved under the climatic influences prevailing in Ohio. From comparison with the American Merino fleeces, it seems that the quality, nature, and evenness of flow of wool oil in the Tasmanian Merino fleeces afforded better protection to growing wool fibers from climatic influences than the abundance of wool oil or grease found in the American Merino fleeces. It was, of course, impossible to dissociate entirely the influence of oil from the influence of other factors contributing to fleece protection. Observations, explained later on, indicate that the factors of length of staple and density of fiber probably work together to preserve the fleece from climatic influences which may maintain during the period of wool growth.

Fig. 9.—Tasmanian Merino fleeces uniformly show a character and brightness that is distinctive

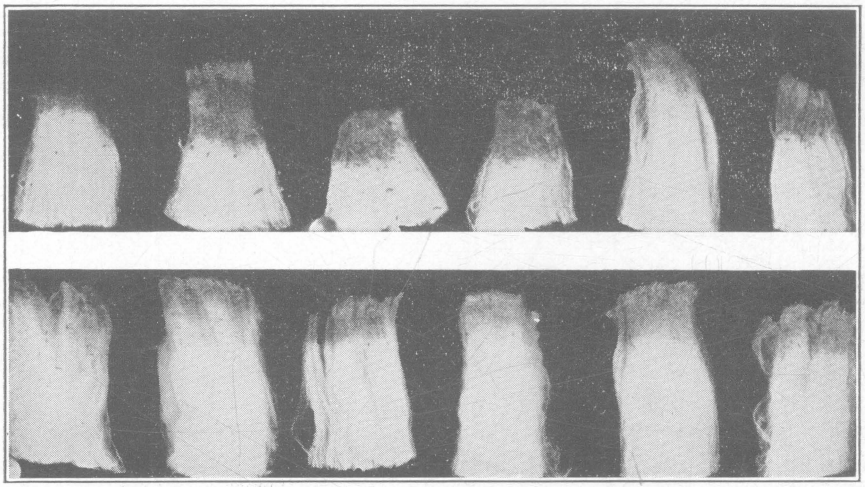

Fig. 10.—*Upper*—Representative samples of wool from the American Merino flock, showing the influence of weather on the wool during growth. *Lower*—Representative samples of wool from the Tasmanian Merino flock, which, in spite of their low grease content, show little effect of weathering influences.

Density of fleece.—Density of the fleece, when judged by the usual method of grasping the wool to feel of its fullness and compactness and parting the fleece to examine the apparent closeness of the fibers, was found to be slightly greater among the foundation flock of Tasmanian Merino ewes—an average of 89.4 per cent of perfect—than among the corresponding flock of American Merino ewes—an average of 84.9 per cent of perfect. Among the ewe offspring from the two foundation flocks, the American Merino group appeared to possess slightly denser fleeces than the Tasmanian group—the average score being 89.4 per cent of perfect for the former and 87.7 per cent of perfect for the latter. The significant point from this scoring is that, when the density of the fleece was estimated by grasping the wool, the difference recorded for the two breeds was not pronounced.

Density of wool fibers.—The data contained in Tables 10 and 11 show the density of wool fibers per square inch of skin area, as determined by the method of Hardy, already described on Page 5. Table 10 shows the number of sheep of each breed tested each year, the average number of wool fibers found per square inch of skin area, and the greatest number and the least number of wool fibers per square inch of skin area found on individual sheep of the two breeds under comparison. Table 11 shows the density of wool fibers per square inch of skin area of eight American Merino ewes and seven Tasmanian Merino ewes when these individual ewes were 2, 3, 4, and 7 years old.

Referring to Table 10, it will be noted in Column 4 that the average density of wool fibers per square inch of skin area at the start of the test in 1927 was 23,985 for the American Merino group of ten ewes and one ram and 40,156 for the Tasmanian Merino group of ten ewes and one ram. These tests were made on the foundation flock of each breed and show a breed difference of 16,171 wool fibers per square inch more for the Tasmanian group than for the American Merino group.

The same ten ewes and one ram of each breed were tested again in 1928, as were also four additional American Merino rams, making a total of 15 American Merinos and 11 Tasmanian Merinos. The average breed difference in this case was 9,444 fibers per square inch of skin area in favor of the Tasmanian Merinos.

Density of wool fiber determinations were made in 1929 on 38 American Merinos, including the ten foundation ewes, their offspring born during the 1928 lambing season, the six bred and six unbred yearling ewes used in the wool growth studies already discussed, and eight rams. At the same time 19 Tasmanian Merinos were tested, including the ten foundation ewes, two rams, and the seven lambs born to the ten ewes during the 1928 lambing season. The breed difference in average density of wool fibers per square inch of skin area was 7,795 in favor of the Tasmanian group.

In 1930 and 1931 only the ewe lambs, at about 12 months of age, from the two foundation flocks were tested for density of wool fibers. These tests again resulted in the Tasmanian Merinos leading by an average of 10,025 and 8,027 wool fibers per square inch of skin area for each of the 2 years, respectively.

The ewes from the foundation flocks which remained in 1932 were subjected to density of wool fiber tests, as were their female offspring and the available rams of both breeds which had any connection with the breed comparison study. Altogether a total of 29 American Merinos and 21 Tasmanian Merinos was tested. Again the Tasmanian group led in density of wool fibers by an average of 9,366 wool fibers per square inch of skin area more than the American Merinos.

By referring to the data in the last two columns of Table 10, it may be noted that the densest Tasmanian Merino fleece tested in any particular year exceeded the densest American Merino ewe fleece. Likewise, the least dense fleece of a Tasmanian Merino ewe tested possessed far more wool fibers per unit of area of skin than the least dense fleece of an American Merino ewe. In the first test on the foundation flock the densest fleece of a Tasmanian Merino exceeded the densest fleece of an American Merino by as many as 20,098 wool fibers per square inch of skin area.

The two imported Tasmanian Merino rams were tested for density of wool fibers at the time of their arrival at the Ohio Experiment Station and subsequently. The ram from the Chas. Goulter flock of New Zealand (U. S. Imported No. 21) was found in 1927 to possess 44,495 wool fibers per square inch of skin area. The Tasmanian ram (Imported Belle Vue No. 24) was found in 1928 to possess 38,420 wool fibers per square inch of skin area. The same rams in 1932, as an 8-year-old and a 7-year-old, were found to possess 29,822 and 28,506 wool fibers for No. 21 and No. 24, respectively.

During this study 24 density of wool fiber tests were made on 11 individual American Merino rams. The average density of wool fibers per square inch of skin area as determined in these 24 tests on American Merino rams was 22,812. The greatest density of wool fibers found on an American Merino ram in this study was on a smooth-bodied, Station-bred ram which possessed 37,523 wool fibers per square inch of skin area. The American Merino ram showing the least density of wool fibers was a B-type ram, definitely dense fleeced when judged by feeling of the fleece but actually possessing only 13,915 wool fibers per square inch of skin area. The foundation B-type ram of excellent merit, possessing a fleece judged 95 per cent of perfect for density, was found as a 4-year-old to possess only 15,039 wool fibers per square inch of skin area. The

scouring record on the first-mentioned B-type ram showed that his fleece possessed 50.86 per cent grease and yielded 23.06 per cent clean wool; whereas the scouring record of the fleece from the B-type foundation ram possessed 44.4 per cent grease and yielded 33.2 per cent clean wool.

Fig. 11.—The B-type American Merino used as the foundation ram in this study. He was judged 95 per cent of perfect for density of fleece. Density of fiber determinations showed him to possess only 15,039 wool fibers per square inch of skin area.

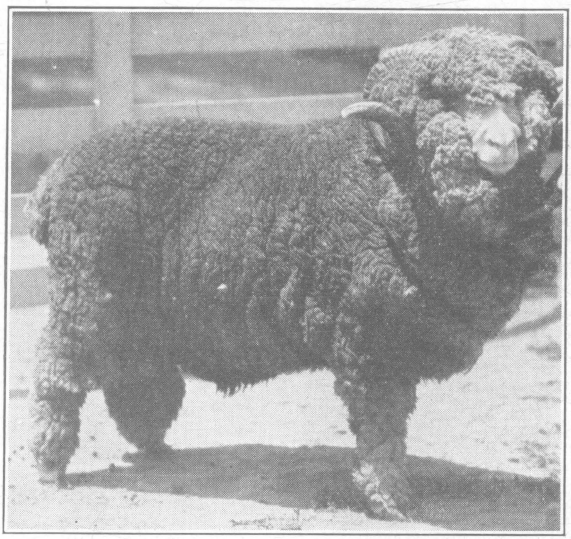

Fig. 12.—Tasmanian Merino ram, Imported Belle Vue No. 24. Density of fiber determinations showed him to possess 38,420 wool fibers per square inch of skin area.

These data on density of wool fibers per square inch of skin area with respect to the two B-type rams mentioned appear to be an indictment against these two greasy-fleeced, wrinkly-skinned American Merinos. Whether all of the greasy-fleeced, wrinkly-skinned American Merino sheep would show a similar lack of density of wool fibers is undetermined. In this connection, however, density tests were made on 27 American Merino ewes sheared in 1929. Of these, 16 possessed smooth bodies and slightly folded necks, and 11 possessed perceptible skin folds over the body and could be classed as moderately to definitely wrinkled. By grouping the data on density according to whether the individual sheep was smooth or wrinkly, it was determined that the average density of the smooth-bodied group was 27,487 wool fibers per square inch of skin area whereas the comparable figure for the wrinkly group was 23,898.

These results are not presented as proof that all wrinkly American Merino sheep possess fewer wool fibers per unit area of skin surface than smooth-bodied American Merinos. However, this situation prevailed among the smooth and the wrinkly-skinned American Merino ewes and rams used in these tests.

The difference in density of the fleece of these two breeds of sheep (Tables 7 and 8), when judged by grasping the fleece to feel of its fullness, was not pronounced; but, when density of wool fibers per unit area of skin was determined, a striking breed difference was found. The individual scores for density of fleece agree closely with the results found on determination of fiber density, so long as each breed is considered singly. However, American Merinos were misjudged as to actual density of wool fibers. Apparently, this misjudgment of actual density of wool fibers was due to the higher grease and dirt content in the fleeces of the American Merinos, which imparted to the fleece a feeling of fullness and compactness.

TABLE 9.—Rainfall (Inches) on Shearing Day and 3 Days Preceding and Average Moisture Content (Per Cent) of Wool at Shearing Time

	1929	1930	1931	1932
Rainfall				
Date: April 5	0	0	0	0
April 6	0	0.20	0	0
April 7	0	0.49	0	0
April 8	0.15*†	Trace†‡	0	0.83
April 9	0	0	0†	0.26
April 10	0	0	0	0.21
April 11	0	0	0	0.29†
Moisture content of wool				
Group 1—Foundation American Merinos	9.17	10.41	9.03	13.02
Group 2—American Merino offspring	8.78	9.03	8.23	13.32
Group 3—Foundation Tasmanian Merinos	9.20	10.07	8.43	11.22
Group 4—Tasmanian Merino offspring	11.81§	9.33	8.59	14.62
Weighted average all groups	9.48	9.88	8.63	12.80

*Rainfall began 11 A. M.
†Indicates shearing date.
‡The trace indicated fell during early morning, with weather turning clear early in the forenoon.
§Sheared after rainfall began.

Influence of density on length of staple.—It is frequently contended by Merino breeders that great density of fiber is, in a large measure, incompatible with the production of a long staple. Using the records from the mature ewes in the breed comparison which were subjected to density of fiber studies in 1929 and 1932, an analysis was made to determine whether density influenced the length of staple grown by the sheep. This analysis shows that the densest fleeced half of the American Merino ewes, averaging 23,369 fibers per square inch, grew an average of 2.73 inches of staple annually and the least dense fleeced half of the ewes, showing an average density of 17,298 fibers, also grew an average of 2.73 inches of staple. Among the Tasmanian Merinos, the densest fleeced group, averaging 37,320 fibers, grew an average of 3.12 inches of staple; the least dense fleeced half, averaging 27,461 fibers, grew an average of 3.19 inches of staple. Individual records show that the Tasmanian Merino ewe, No. 31, showing the greatest density in 1929 and the ewe, No. 41, in 1932 with 45,820 and 44,651 fibers, respectively, sheared fleeces that were longer in staple than the group average, or 3.25 inches and 3.62 inches, respectively. Obviously, a great density of wool fiber does not necessarily mean that the fleece will be short in staple.

Influence of density on percentage of dirt.—In the 1929 and 1932 shearing seasons a total of 30 mature American Merino ewes and 23 mature Tasmanian Merino ewes was tested for density. These two groups of mature sheep of mixed ages allowed a limited study of the influence of density of fibers upon the percentage of dirt in the fleece. In the American Merino group, the least dense fleeced half of the ewes, averaging 17,298 fibers per square inch, sheared fleeces containing an average of 22.68 per cent of dirt. The densest fleeced ewes showed an average density of 23,369 fibers per square inch and their fleeces contained an average of 23.58 per cent of dirt. In the Tasmanian Merino group, the least dense fleeced ewes showed 27,461 fibers per square inch and their fleeces contained 17.56 per cent of dirt. The densest fleeced ewes showed an average of 37,320 fibers per square inch of skin area and their fleeces contained an average of 16.01 per cent of dirt. In view of this analysis, it would seem that the density of wool fibers on the skin did not influence materially the percentage of dirt. However, those individual ewes of superior density uniformly showed a low percentage of dirt. In the case of great density, the fleece was offered considerable protection from dirt.

Influence of length of staple on percentage of dirt.—Since it is frequently contended that long-staple fleeces are dirty fleeces, an analysis was made of the 1929 and 1932 fleeces from the sheep in this breed comparison to show the influence of length of staple on the percentage of dirt contained in the fleece. Among the American Merinos the half of the ewes shearing fleeces with the greatest percentage of dirt (an average of 24.78 per cent) grew an average of 2.54 inches of staple. The least dirty American Merino fleeces contained an average of 21.48 per cent of dirt and averaged 2.92 inches in length of staple. Among the Tasmanian Merinos the dirtiest fleeces showed an average of 19.15 per cent dirt and averaged 3.11 inches in length of staple; the least dirty fleeces showed an average of 14.14 per cent dirt and averaged 3.20 inches in length of staple. Thus, in both breeds the fleeces with the highest percentage of dirt were the shortest in length of staple and the cleanest fleeces were generally the longest fleeces. This reverses the frequently expressed contention that long-staple fleeces are dirtier fleeces.

Influence of density of fibers on percentage of grease.—When both the American and Tasmanian Merino ewes involved in the 1929 and 1932 density of fiber study were allotted into two groups of each breed according to the density of fiber, it was found that the group of American Merino ewes having the densest fleeces, averaging 23,369 fibers per square inch, had an average of 27.92 per cent of grease. The least dense fleeced sheep showed an average of 17,298 fibers per square inch and had an average of 29.16 per cent of grease. Among the Tasmanian Merinos, the densest fleeces which contained an average of 37,320 fibers per square inch, showed an average of 17.17 per cent of grease. The least dense fleeces showed an average of 27,461 fibers and 20.14 per cent of grease. The three densest Tasmanian Merino fleeces in 1932, showing 44,652, 40,067, and 32,910 fibers per square inch, showed, respectively, 13.82, 13.96, and 16.90 per cent of wool oil or grease in their fleeces. On the other hand, the least dense American Merino fleece showed 11,834 fibers and contained 34.82 per cent of wool oil, which was the highest percentage of grease in any of the American Merino ewes in the group studied. Occasionally, a sheep would be found that showed a low density and a low grease content in the fleece. The reverse was not true, however; the densest fleeces were uniformly in the least greasy group. Those few which showed low density and low grease may be classed as poor fleeced individuals, due to breeding. Otherwise, the remaining sheep reveal that a great density of fiber is not compatible with a high grease content or, conversely, that a high grease content is not compatible with great density. Apparently, individual sheep do not produce an abundance of wool fibers and also an abundance of wool oil.

TABLE 10.—Average Density of Wool Fibers per Square Inch of Body Surface for Groups of American and Tasmanian Merino Sheep

Breed of sheep	No. of sheep	Year observed	Av. number of fibers per sq. in. of body surface	Greatest number on any individual	Least number on any individual
American Merino	11	1927	23,985	28,192	18,576
Tasmanian Merino	11	1927	40,156	48,046	34,157
American Merino	15	1928	25,720	30,178	19,637
Tasmanian Merino	11	1928	35,164	41,997	29,177
American Merino	38	1929	24,433	35,622	17,348
Tasmanian Merino	19	1929	32,228	45,821	22,797*
American Merino	8*	1930	18,173	22,990	11,970
Tasmanian Merino	8*	1930	28,198	40,515	18,621
American Merino	5*	1931	20,605	27,211	15,426
Tasmanian Merino	5*	1931	28,632	33,850	23,367
American Merino	29	1932	19,410	37,523	11,834
Tasmanian Merino	21	1932	28,776	44,652	20,355*

*Lambs.
This table gives weighted average of all sheep of each breed tested for density of fibers per square inch of body surface.

Influence of age on density of wool fibers.—The results of the density of fiber studies brought to light an interesting relationship between the age of sheep and the density of wool fibers these sheep produce. Table 11 shows this association for eight American Merino ewes as 2-, 3-, 4-, and 7-year-olds. Advancing age, even though not beyond the period of usefulness for the sheep,

caused a marked diminution in the number of fibers the ewe produced. The American Merinos as 7-year-old ewes possessed an average of only 68.6 per cent as many fibers per unit of skin area as they did as 2-year-olds. The Tasmanian Merinos grew an average of only 66.1 per cent as many wool fibers per square inch of skin area as 7-year-old ewes as they grew as 2-year-old ewes. With both breeds the loss in density of wool fibers was practically as great between the fourth year and seventh year of age as between the second year and seventh year of age. Apparently, young ewes in their prime, from 2 to 4 years of age, exhibit a reasonably constant density of wool fiber production which is markedly diminished by the time they reach 7 years of age. What happens in fiber density at a more advanced age than 7 years was not determined; neither was the year at which the decline started determined. It was found, however, that the density of fibers on a lamb at a year of age was an accurate indication of subsequent density in four out of every five instances, or approximately 80 per cent.

TABLE 11.—Density of Fibers per Square Inch of Body Surface of Merino Ewes

Ewe No.	Two-year-olds 1927	Three-year-olds 1928	Four-year-olds 1929	Seven-year-olds 1932
American Merinos				
448	18,576	23,101	17,348	11,834
453	24,552	28,599	21,270	15,086
454	24,552	25,085	22,318	15,692
465	20,638	25,673	21,369	16,079
466	28,073	26,876	29,440	21,860
468	28,192	23,956	22,891	19,775
477	26,130	28,967	28,441	16,548
498	20,150	19,637	18,707	14,813
Average	23,983	25,237	22,723	16,461
Tasmanian Merinos				
23	36,412	34,725	29,242	24,071
25	34,157	31,704	28,995	22,568
26	34,587	35,904	44,771	27,377
28	38,166	41,707	40,724	30,968
29	46,995	34,620	41,357	29,785
30	42,441	35,692	35,104	23,082
31	48,046	37,528	45,821	27,785
Average	40,115	35,983	38,002	26,519

This table based only on ewes remaining on test throughout the 5 years.

Closure.—A more desirable closure of the fleece was found among the imported ewes than among the American-bred females, even though the Tasmanian Merinos possessed longer staple which practical sheep growers usually associate with less desirable closure of the fleece along the back. The probable foundation for this observation is brought out rather strikingly by comparing the 1927 shearing and scoring record of the American Merino ewes, when these ewes were in short fleece, with the subsequent shearing and scoring records of the same ewes. When the ewes were in short fleece, they exhibited an average closure 92 per cent of perfect; whereas the subsequent score for closure when the ewes were in full fleece averaged only 81.6 per cent of perfect.

A study of the records from individual ewes, however, does not verify this practical observation that shorter fleeces invariably show more desirable closure. As an extreme example, American Merino ewe No. 466 in 1932 sheared 14.3 pounds of unscoured wool which measured 3.5 inches in staple length and graded 91.7 per cent of perfect with respect to closure; whereas ewe No. 465 sheared 13.9 pounds of unscoured wool which measured 2.25 inches in length, with closure only 78.3 per cent of perfect.

A further study of individual records shows that closure of the fleece along the spine of American Merinos seems to be definitely associated with density of fibers and grease content of the fleece. Those sheep which lacked density of fibers but possessed a high grease content in their fleeces invariably showed very poor closure. On the other hand, those sheep which showed a high density of fibers and a reasonably low grease content invariably exhibited a highly desirable closure along the spine.

DISTRIBUTION OF WOOL

Belly covering.—The belly covering, or the extent to which the under surface of a sheep's body is given over to wool production, averaged nearly the same for the two foundation flocks of ewes. On the basis of score record, the American Merino ewes showed a belly covering 83.5 per cent of perfect and the Tasmanian Merinos, 84.0 per cent of perfect. Among the young ewes produced on the test the American Merino group seemed to possess definitely thicker and denser belly fleeces than the Tasmanian Merino group, the average score being 90.1 per cent of perfect for the former and 84.0 per cent of perfect for the latter. Little significance is attached to this possession of a seemingly thicker belly fleece by the young American Merino ewes, since such possession did not add to any of the factors relating to quality or superiority in wool production, except perhaps the weight of unscoured wool produced. Both breeds of sheep devoted the under surface of their bodies to wool production in a satisfactory degree.

Face covering.—Among the foundation flock of American Merino ewes the face covering averaged 69.5 per cent of a perfect open face; the comparable figure for the foundation flock of Tasmanian Merino ewes was 81.4 per cent of perfect. Among the young ewes from the two flocks, the average score was 62.6 per cent of perfect for the American Merino group and 67.1 per cent of perfect for the Tasmanian Merino group. These data mean that the American Merino sheep possessed faces most of which were definitely covered with wool while the Tasmanian Merinos were to a greater or less degree open-faced sheep.

STRETCH OF WOOL FIBERS

Table 12 shows the per cent of stretch, or the elongation possible between the point of tautness to remove crimp and point of rupture, exhibited by wool fibers from the individual ewes in the foundation flocks of American and Tasmanian Merinos.

Elasticity was somewhat variable one year with another for individual ewes but the average per cent of stretch was quite constant within each breed. The Tasmanian wool was slightly more elastic than the American Merino wool.

TABLE 12.—The Average Per Cent of Stretch of Wool Fibers

American Merino ewe number ☞	448	453	454	461	465	466	468	472	477	498
1927 sample.....	28.48	29.08	28.25	32.31	31.38	35.55	33.68	33.45	31.23	35.03
1928 sample.....	35.48	42.75	34.80	35.59	40.70	39.58	42.18	40.88	37.36	44.93
1929 sample.....	38.27	46.59	40.24	42.62	46.81	48.78	46.65	43.65	42.56	46.60
1930 sample.....	40.63	43.10	42.31	46.63	49.13	43.84	41.52	40.61	39.58	42.51
1931 sample.....	33.37	38.28	33.67	... .	39.53	27.67	38.28	.....	31.83	37.18
Average.....	35.25	39.96	35.86	39.29	41.51	39.08	40.46	39.65	36.51	41.25

Average 38.85 per cent

Tasmanian Merino ewe number ☞	22	23	24	25	26	27	28	29	30	31
1927 sample.....	33.90	35.13	35.80	33.28	32.58	32.23	37.25	32.50	26.13	33.28
1928 sample.....	48.42	41.05	48.36	43.65	45.08	48.15	42.48	49.34	47.03	43.75
1929 sample.....	49.49	35.54	43.13	42.55	46.50	45.85	40.78	45.70	41.90	41.13
1930 sample... ...	55.78	48.39	48.64	41.92	50.68	44.97	51.58	47.20	47.39	44.89
1931 sample.....	.....	39.13	.....	46.98	54.39	.....	40.59	50.03	46.33	44.09
Average.....	46.90	39.85	43.98	41.68	45.85	42.80	42.54	44.95	41.76	41.43

Average 43.15 per cent

BREAKING STRENGTH OF WOOL FIBERS

The breaking strength of wool fibers was determined for each individual ewe in both foundation flocks at the outset of the test in 1927 and for 4 years thereafter. These data are recorded in Table 13 and show that the average breaking strength of 100 wool fibers from the American Merino ewes was 4.40 grams and from the Tasmanian Merino ewes was 3.56 grams.

TABLE 13.—Breaking Strength of Wool Fibers in Grams

American Merino ewe number ☞	448	453	454	461	465	466	468	472	477	498
1927 sample.....	5.74	6.39	4.06	3.62	4.46	3.68	3.61	4.28	3.08	4.04
1928 sample.....	6.48	6.38	4.41	4.19	4.65	3.87	3.98	5.08	3.11	5.10
1929 sample..... .	6.00	5.75	4.00	4.33	5.00	4.44	4.07	5.12	3.73	4.81
1930 sample	4.65	4.92	3.59	3.25	4.49	4.06	3.27	4.21	2.98	4.27
1931 sample.....	4.78	5.74	3.83	.....	4.85	3.29	4.14	.....	2.78	4.71
Average.....	5.53	5.84	3.98	3.85	4.69	3.87	3.81	4.67	3.14	4.59

Average 4.40 gm.

Tasmanian Merino ewe number ☞	22	23	24	25	26	27	28	29	30	31
1927 sample.... ...	2.79	3.54	4.28	6.83	3.44	3.42	4.49	3.79	3.20	2.22
1928 sample.....	3.35	3.52	3.74	4.37*	3.63	3.40	3.19	3.55	3.18	2.92
1929 sample.....	3.28	3.26	3.43	5.55	3.39	3.10	3.46	3.91	3.32	2.68
1930 sample.....	2.61	3.11	2.86	3.65*	3.53	.....	2.57*	3.26	2.88	2.82
1931 sample.....	.....	3.97	.....	4.82	5.44	.....	3.54	2.84	3.85	3.82
Average.....	3.01	3.48	3.58	5.04	3.89	3.31	3.45	3.47	3.29	2.89

Average 3.56 gm.

*Sick.

A further study of Table 13 reveals that ewes, irrespective of breed and barring sickness, consistently produce fibers possessing about the same breaking strength one year after another.

It is interesting to note that the breaking strength of wool fibers seems to be associated closely with the estimated fineness of the wool fibers. Ewes No. 448 and 453 of the American Merino group were half-sisters and definitely possessed the coarsest-fibered fleeces; these fibers, in turn, showed the highest breaking strength.

Among the Tasmanian Merinos, ewes No. 22 and 31 possessed what were judged to be the finest, crimpiest fibers of all the sheep in these tests and these fibers had the lowest breaking strength. Tasmanian ewe No. 25 possessed the coarsest-fibered fleece of all the Tasmanian Merinos in these studies and showed the highest breaking strength among this group.

Another interesting feature brought out in this study of breaking strength of wool fibers was the fact that Tasmanian ewe No. 25 was definitely ill for a period in 1928 and again in 1930, as also was Tasmanian ewe No. 28 in 1930, with the result that the breaking strength of the wool fibers produced by these ewes during illness dropped very definitely lower than that recorded for these ewes during years of good health.

FLOCK PRODUCTION, REPRODUCTION, AND MAINTENANCE

Table 14 summarizes the essential data obtained from the American Merino and Tasmanian Merino ewe flocks with respect to feeds and feeding, ewe performance, breeding capacity, lamb production, and lamb growth. While this study was essentially one of wool production, factors of flock production are indispensable to a complete knowledge of the ability of any strain or breed of sheep to fill the needs of areas engaged in a particular type of sheep growing. Hence, an analysis of the economic adaptability of the two breeds is given.

Feeds and feeding.—During the first 3 of the 5 years covered by this test, all feeds were allowed on a per-head basis. The first winter the American Merino and the Tasmanian Merino flocks were fed separately. The second and third years they were housed together and fed from the same trough or rack; hence, Table 14 shows exactly the same feed intake per head during the second and third years. During the last 2 years, 1930-1931 and 1931-1932, each kind of feed was allowed on the basis of quantity per 100 pounds live weight of sheep; the sheep were weighed each week and the quantity of feed adjusted accordingly. Throughout this period the ewes of each breed were fed separately by lots. The total feed eaten during each year was then computed to a per-head basis. Table 14 shows that on the basis of live weight American Merino ewes during the year they were fed on the basis of weight consumed an average of 154.2 pounds of mixed grain, 320.3 pounds of alfalfa hay, 350.3 pounds of corn silage, 15.3 pounds of salt per ewe, and pasture. The Tasmanian Merino ewes consumed an average of 127.9 pounds of mixed grain, 264.4 pounds of alfalfa hay, 286 pounds of corn silage, 12.3 pounds of salt per ewe, and pasture. Since each flock gave what was judged as maximum performance in health and gains and wool production, this appears as the equitable basis for comparing these two flocks as to feed requirements. On this basis, the American Merino ewes, because of their larger size, required 26.3 pounds more of mixed grain, 55.9 pounds more alfalfa, 74.3 pounds more of corn silage, and 3 pounds more salt per head per year than the Tasmanian Merinos.

Basing the conclusion on this evidence, it is logical to believe that during the first 3 years of the test, when the feeds were allowed on a per-head basis,

the feeds for the American Merinos were less than should be assessed against them, and those for the Tasmanian Merinos were higher than their actual need would be for maximum production.

Pasture seasons varied somewhat in length one year with another, depending almost entirely upon the advent of severe late fall and early winter weather, which made grazing impracticable. However, pasture for the two flocks under comparison was identical, since the flocks were grazed together during the pasture season.

Ewe performance.—The average weight per ewe at the start of each sheep year in September, as given in Table 14, shows that the American Merino ewes were definitely heavier sheep than the Tasmanian Merino ewes. At the outset of the test period there was an average difference in weight of 28.5 pounds per ewe; whereas in subsequent years the average difference was 10 to 15 pounds per ewe. The greater difference at the start of the test is partly a reflection of a much higher condition of flesh among the American Merino ewes, as well as some advantage in age.

Subsequent weights at comparable seasons show that ewe performance was essentially the same. The American Merino group made greater average gains during the various pregnant periods than the Tasmanian Merinos, but the former showed a greater average loss in weight during nursing than the latter. No attempt is made to attach significance to this greater fluctuation by the American Merino group, except that it may be a reflection of a greater inherent ability among the American Merinos to use harvested feed for the production of meat and fat, similar to the ability in this direction exhibited by lambs in the fattening lot.

In all instances, the ewes of the two groups showed, respectively, nearly the same average weight at the close of the sheep year as they showed at the start.

In this analysis of average weight of ewes, a word of explanation as to why the average weight was sometimes less at the start of a certain sheep year than it was at the close of the immediately preceding sheep year may be necessary. All yearling ewes were added to their respective flock at the start of each sheep year and such young ewes were invariably lighter in weight than the more mature ewes which previously had been in the breeding flock.

Lamb weights.—Table 14 shows that the American Merino lambs averaged in weight at birth during the various years from 8.16 pounds (1929) to 9.36 pounds (1931). The weighted average birth weight of all American Merino lambs born during the 5 years (4 years shown in the table) was 8.72 pounds. The Tasmanian Merino lambs averaged in weight from 7.59 pounds (1929) to 8.58 pounds (1930) at birth. The weighted average birth weight of all the Tasmanian Merino lambs born during the five successive lambing seasons was 7.97 pounds.

This difference in the weighted average birth weight of the lambs from the two breeds of sheep may be considered as a breed difference but it appears to have little significance. An analysis of the lambing records reveals that 80 per cent of the American Merino lambs was average to strong at birth, and 20 per cent was either weak (needing assistance at first nursing), very weak, (needing special attention), or still born. Among the Tasmanian Merinos 84.4 per cent of the lambs was average to strong at birth, and a total of 15.6 per cent was either weak, very weak, or still born. With respect to sex, the American Merino lamb crop consisted of 48.3 per cent males and 51.7 per cent females; whereas among the Tasmanian Merino lambs 56.5 per cent was males and 43.5 per cent females.

TABLE 14.—Summary of Feed Consumption and Lamb Production of American and Tasmanian Merino Ewes

	American Merinos				Tasmanian Merinos			
	1927–1928	1928–1929	1929–1930	1930–1931	1927–1928	1928–1929	1929–1930	1930–1931
Number in lot at start	10	10†	16	17	10	10†	14‖	13
Days in year	366	365	365	365	366	365	365	365
Grain—6-3-2-1§, lb.	134.96	.....	.....	.....	123.5	.....	.....	.....
Grain—3-3-1§, lb.	12.70	184.3	142.9	154.2	13.8	184.3	142.9	127.9
Mixed hay, lb.	450.25	28.65	99.2	.....	416.8	28.65	99.2	.....
Alfalfa hay, lb.	236.6	311.0	240.3	320.3	216.96	311.0	240.3	264.4
Corn silage, lb.	.....	283.5	292.8	350.3	.....	283.5	292.8	286.0
Salt, lb.	Not recorded	12.44	11.88	15.29	Not recorded	12.44	11.88	12.30
Pasture, days	149.5	194.5	195.3	210.6	139.50	194.5	195.3	210.6
Av. weight of ewe at start of year, lb.	97.1	97.55	87.03	90.01	68.6	82.85	77.4	78.7
Av. weight of ewe at start of winter, lb.	108.7	114.6	102.4	105.9	80.0	88.80	89.07	89.5
Av. weight of ewe at start of lambing, lb.	118.0	130.8	118.3	132.7	85.4	99.5	102.04	111.3
Av. weight of ewe at start of pasture, lb	97.4	101.3	93.4‡	99.6	79.5	78.7	86.08‖	85.2
Av. weight of ewe at weaning, lb.	92.15	92.85	89.6	99.5	78.9	77.85	82.75	88.18
Av. weight of ewe at close of year, lb.	97.55	94.3	93.8	91.8	82.85	80.4	83.8	82.2
Number of ewes yeaning	10	9†	13†	16	7	9†	13†	12
Number of lambs born	10	13	18*	19**	7	9	14	16
Av. birth weight (all lambs), lb.	8.38	8.16	8.61	9.36	7.66	7.59	8.58	7.94
Number of lambs raised to weaning	9	13	15	18	7	8	11	15
Av. weight at weaning (living lambs), lb.	45.78	47.15	53.83	45.2	38.36	47.22	48.82	42.2
Av. daily gain (birth to weaning), lb.	0.311	0.300	0.330	0.312	0.33	0.303	0.290	0.288
Days old at weaning	121.0	129.9	136.8	116.0	93.0***	130.9	138.5	118.8
Weight of ewe lambs, lb.; Dec. 17, 1928, Dec. 23, 1929, Dec. 18, 1930, Dec. 22, 1931	74.5	71.5	80.25	60.38	55.5	55.8	56.75	49.62
Weight of above ewe lambs as yearlings, lb.; Sept. 10, 1929, Sept. 10, 1930, Sept. 10, 1931	75.9	84.0	83.88	.....	71.75	67.7	69.5	.....

*Includes one born dead and one killed by vicious dam.
†One ewe not bred in each lot.
‡One ewe died in dipping.
§6-3-2-1 indicates grain mixture: 6 parts oats, 3 parts corn, 2 parts bran, 1 part linseed oil meal. 3-3-1 indicates grain mixture: 3 parts oats, 3 parts corn, 1 part linseed oil meal.
‖Five ewes died in dipping—1 ewe everted uterus.
**One born dead, carried 7 days over time.
***Two lambs not weaned until later.

Further analysis of the lambing record for five successive lambing seasons reveals that there were 71 breedings of American Merino ewes, 66 of which resulted in pregnancies, 80 lambs were born, and 72 lambs were raised to weaning age (about 130 days).

In the Tasmanian Merino flock, there were 58 breedings of ewes, 55 pregnancies resulted, 64 lambs were born, and 57 were raised to weaning age. On the basis of the number of lambings, the American Merino group lambed at the rate of 121.2 per cent and raised to weaning 109.1 per cent of the lamb crop; the Tasmanian Merino group lambed at the rate of 116.4 per cent and raised to weaning 103.6 per cent of the lamb crop. On the basis of 5-year production, there was little difference in the reproductive capacity of the two breeds of Merino ewes; likewise, there was little difference in the ability of the ewes to raise their lambs to weaning age.

The rate of gain of lambs from birth to weaning is not only a measure of growth but indirectly a measure of milk production by the dam. In Table 14, under the item "Average daily gain of lambs, birth to weaning", it will be noted that there was little difference in the average rate of gain of the nursing lambs; hence, milk production by the ewes of the two breeds must have been quite comparable.

The next item in Table 14, "Weight of ewe lambs at close of the grazing season", is quite unfavorable to the Tasmanian Merinos. In the successive years, starting with the lambs born in 1928, the American Merino ewe lambs averaged 19 pounds, 15.7 pounds, 23.5 pounds, and 10.76 pounds heavier, respectively, at the close of the grazing season than the Tasmanian lambs.

The last item in Table 14 gives the average weight of the young females as yearling ewes. These are the same individuals for which weights are given in the immediately preceding item. As yearling ewes, the American Merinos were heavier than the Tasmanian Merinos, differing by an average of 4.15 pounds, 16.3 pounds, and 14.38 pounds for each year, respectively. However, a comparison of the weights of the young ewes as lambs and as yearlings brings out rather strikingly that the Tasmanian Merinos continued to gain throughout their yearling year in a more pronounced manner than the American Merino group. Apparently, the American Merino group more nearly reached their maximum development as lambs than the Tasmanian group. This is particularly significant in that it emphasizes the more rapid maturity of the lambs from the American Merino group. Since the United States market for sheep meat is largely on a lamb basis, the more rapid development of the American Merino lambs is definitely to their advantage, and the slow maturity of the Tasmanian lambs would be a definite handicap from the standpoint of flock husbandry in the United States.

Feed-lot performance of fattening lambs.—Throughout this study it was constantly observed that the young Tasmanian Merinos showed slower gains on grass after weaning than the lambs from the American Merino ewes. Since the two types of lambs were fed together during winter seasons, because of lack of barn space, the question was raised as to whether the Tasmanian Merinos ate their allotted share of grain and other feeds and, if they did eat their allottment on a per-head basis, whether they were less efficient in converting feed into meat than the American Merino group. This was the object of a feed-lot test involving the wether lambs born in 1931 to the ewes in the two flocks under comparison. Table 15 summarizes the fattening-lot experiment.

TABLE 15.—Fattening Tendencies of American Versus Tasmanian Merino Wether Lambs

Nov. 10 (P. M.), 1931, to Feb. 26 (A. M.), 1932 108 days	American Merino lambs					Tasmanian Merino lambs				
	First 28 days	Second 28 days	Third 28 days	Fourth 24 days	Summary 108 days	First 28 days	Second 28 days	Third 28 days	Fourth 24 days	Summary 108 days
No. lambs in lot	14	14	14	14	14	9	9	9	9	9
Days in period	28	28	28	24	108	28	28	28	24	108
Lamb days	392	392	392	336	1512	252	252	252	216	972
Total initial weight, lb.	821.5	832.0	995.0	1133.0	821.5	462.75	485.5	527.0	570.0	462.75
Total final weight, lb.	832.0	995.0	1133.0	1189.25	1189.25	485.50	527.0	570.00	585.75	515.75
Av. initial weight, lb.	58.68	59.43	71.07	80.93	58.68	51.42	53.94	58.55	63.33	51.42
Av. final weight, lb.	59.43	71.07	80.93	84.94	84.94	53.94	58.55	63.33	65.08	65.08
Total gain, lb.	10.50	163.0	138.0	56.25	367.75	22.75	41.50	43.00	15.75	123.00
Av. daily gain, lb.	0.027	0.416	0.352	0.167	0.243	0.090	0.165	0.170	0.073	0.127
Av. ration:										
Grain (corn 8, l. o. c. 1)*, lb	0.572	1.234	1.304	1.386	1.114	0.512	0.882	0.701	0.678	0.694
Alfalfa hay, lb.	1.424	1.268	1.193	1.091	1.250	1.241	0.987	0.909	0.850	1.002
Salt, lb.	0.046	0.028	0.051	0.023	0.038	0.026	0.024	0.016	0.023	0.022
Feed required per 100 lb. gain:										
Grain (corn 8, l. o. c. 1)*, lb	2136.1	296.8	370.3	827.7	458.12	566.6	535.9	410.6	929.5	548.2
Alfalfa hay, lb.	5316.2	304.8	338.9	652.0	513.8	1375.4	599.4	532.6	1165.1	792.0
Salt, lb.	172.4	6.75	14.5	14.2	15.5	29.0	14.4	9.3	31.74	17.6

*l. o. c.=linseed oil cake (pea size) old process.

The performance of the two groups of lambs is given by 4-week periods and in summary for the total of 108 days they were on feed. At the outset, the test was planned to have both lots consume the same quantity of feed per lamb. By the end of the first period, however, it became obvious that the Tasmanian wether lambs would not take to grain feeding readily and could not be induced to eat as much as one pound of grain. The American Merino wethers obviously would take more feed. It was then decided to feed each group independently of the other group and thus allow the lambs to exhibit their capacity to consume grain and to convert that grain into meat and fat.

During the first 4-week period, when the amount of grain allowed the American Merino lambs was limited to the same quantity as the Tasmanian lambs were eating, the American Merino lambs averaged only ¾ pound of gain per lamb. On this limited feed the American Merino lambs required an average of 2136 pounds of grain and 5316 pounds of alfalfa to produce 100 pounds of gain. It is obvious, therefore, that the American Merino group was being fed a ration only slightly in excess of maintenance requirements. The Tasmanian lambs performed somewhat better but showed high feed requirements for the gain they produced.

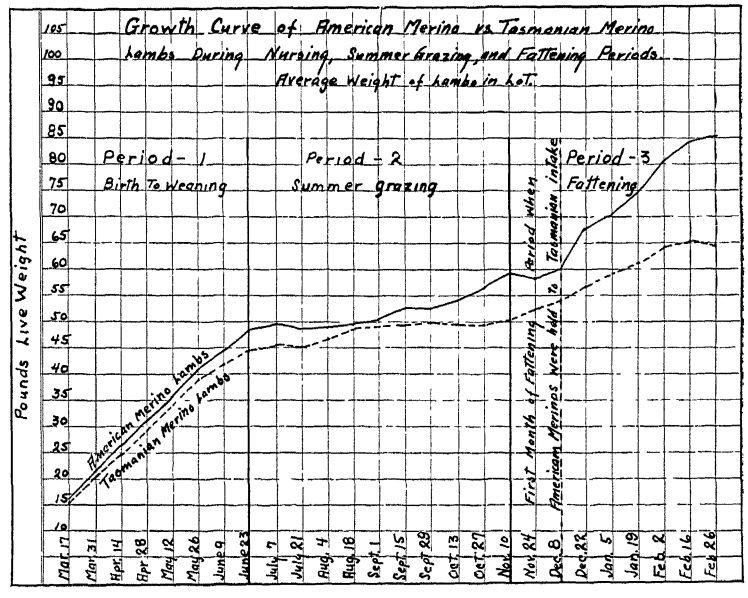

Fig. 13

During the second and third periods, the American Merino lambs, when full fed according to their appetites, consumed nearly twice as much grain as the Tasmanian lambs and responded to that grain to the extent of 0.42 pound and 0.35 pound of gain per day per lamb for the two periods, respectively. The feed required for each 100 pounds gain dropped precipitously and came within the limits of what previous feeding trials with similar lambs indicated was normal for this breed (1).

The Tasmanian lambs showed an increased desire for feed during the second period, but this desire steadily waned throughout the remainder of the feeding trial. They were cautiously fed so as not to throw them off feed, but with all the precautions they could not be induced to consume concentrate feed in quantity and hence made slow gains, which were costly from the standpoint of efficient meat production.

During the fourth period, the American Merino lambs showed high condition, stayed on feed, and manifested good appetites but were obviously reaching the point of diminishing returns from a fattening-lot standpoint. The appetites of the Tasmanian Merino lambs waned during this period and their response to the feed consumed was very low.

Fig. 14.—Fattened American Merino wether lambs at the close of the feeding trial to test feed-lot efficiency

In summary, considering the four periods together, the American Merino lambs, in spite of the very unfavorable first period when they were held back and the fourth period when they were reaching the point of diminishing returns, showed an average daily gain of nearly one-fourth pound per lamb and exhibited a capacity to take feed and convert it economically into meat and wool. The Tasmanian Merino lambs made only one-half as rapid gains, displayed finical appetites, and, in general, exhibited a low efficiency as machines for converting feed into meat.

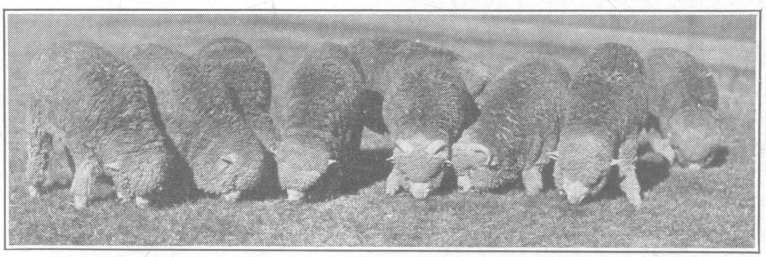

Fig. 15.—Tasmanian Merino wether lambs at the close of the feeding trial. Note that they lack carcass form and evidence of fatness

After the completion of the feeding test the two lots of lambs were shipped to the United States Animal Husbandry Experiment Station, National Agricultural Research Center, Beltsville, Maryland, for slaughter and meat studies. Table 16 shows the more important items of data obtained in this phase of the work.

It will be noted in Table 16 that the average final feed-lot weights of the American Merino and Tasmanian Merino lambs were 84.9 and 65.2 pounds, respectively. The corresponding dressing percentages (chilled carcass basis) were 41.1 and 38.1. It is interesting that the carcasses of the Tasmanian Merino lambs had a considerably higher shrinkage in chilling than those of the American Merino lambs.

The difference between the average carcass grades was small, the American Merino lambs exceeding the others only one-third of a grade. The American Merino lambs surpassed the Tasmanian Merino lambs in plumpness of hind legs, but in this respect also the difference was not great.

TABLE 16.—Average Final Feed-lot Weight, Live Weight at Slaughter, Warm and Cold Dressed Weights and Percentages, Shrinkage in Chilling, Carcass Grade, Index of Plumpness of Legs, Desirability of Flavor of Lean, and Other Palatability Factors of the Roasted Legs of American Merino Lambs in Comparison with Tasmanian Merino Lambs

Item	American Merino lambs	Tasmanian Merino lambs
Number of lambs	14	9
Final feed-lot weight, lb.	84.9	65.2
Live weight at slaughter after shearing, lb.	69.3	54.1
Warm dressed carcass, lb.	36.0	26.2
Warm dressed carcass, per cent	42.5	40.1
Chilled dressed carcass, lb.	34.9	24.8
Chilled dressed carcass, per cent*	41.1	38.1
Shrinkage of dressed carcass in chilling, per cent	3.2	5.1
Carcass grade†	High medium	Medium
Index of plumpness of legs‡	99.6	92.8
Factors of palatability of the roasted legs:		
Aroma: Intensity	5.26	5.33
Desirability	4.20	3.60
Texture	4.67	4.68
Flavor of fat: Intensity	4.30	4.24
Desirability	3.73	3.60
Flavor of lean: Intensity	5.00	4.73
Desirability	4.33	3.51
Tenderness	4.79	4.89
Juiciness: Richness	4.37	4.04
Quantity	4.79	4.87

*Calculated from average chilled dressed carcass and final feed-lot weights.
†Grading done by Bureaus of Animal Industry and Agricultural Economics, U. S. D. A., cooperating.
‡Determined by the method as outlined on Page 166 of the 1927 Proceedings of the American Society of Animal Production.

The left hind legs from the 23 lambs were roasted by a standard method and judged for palatability by a trained committee.[5] The grading chart used provides for recognition of seven grades for each characteristic of the meat. These grades are evaluated—7, 6, 5, 4, 3, 2, 1—from the highest degree of intensity or desirability to the lowest. Careful examination of the average values in Table 16 shows that there was little difference in palatability, except that the American Merino lambs had a more desirable flavor of lean.

[5]The Bureaus of Home Economics and Animal Industry, U. S. D. A., cooperated in the cooking activity and, with the Bureau of Agricultural Economics, cooperated in judging the cooked meat for palatability.

This test, while it involved relatively few lambs and was not repeated, confirmed numerous observations as to comparative feeding capacity of the two types of lambs. The results are accepted and interpreted as a significant breed difference. The Tasmanian Merinos were poor feeders but were highly specialized, fine wool producing sheep, developed to the extreme for the production of clean wool. The American Merinos exhibited a fair degree of efficiency in fine wool production along with a capacity to convert feed into meat.

DISCUSSION

THE NORMAL PERIODIC OR SEASONAL RATE OF GROWTH OF FINE WOOL

For many years the rate of growth of wool has been the subject of frequent discussion. Many sheep raisers have held strongly to the opinion that wool grows far more rapidly during the cold weather of the winter season than during the warmer summer months. On the other hand, several German investigators, according to Burns (3), reported that about two-thirds of the yearly wool production by sheep was grown during the 6 months following shearing and that about one-third was produced during the second 6-month period, with very little growth occurring during the eleventh and twelfth months of the wool growing year.

During the past few years, and largely since the tests reported here were started, periodic or seasonal rate of growth of wool fiber has been the subject of investigation at various experiment stations in the United States, as well as in other wool producing countries. In general, all of the investigations tend to show that if disease is controlled and a natural environment is maintained, the growth of wool, as measured by length, proceeds at a fairly uniform rate throughout each year (3, 4, 5, 6, 7, 8, 11) and will so continue for as many as 4 years, irrespective of whether the sheep are regularly sheared each year or allowed to carry their fleeces for the 4 years (8). Some differences occur which appear to be breed differences, such as those found by Burns (3, 4), who studied the growth of wool by Rambouillet, Hampshire, and Corriedale ewes and found the Rambouillets to be most regular, the Corriedales least regular, with the Hampshires holding a middle place between the other two. Further, these various experiments tend to show that fine-wool sheep, which long have been bred for wool production, are less affected by outside influences than the mutton breeds or the more recently established Corriedale breed.

Hardy and Tennyson (11) found that the rate and fineness of wool growth by Corriedale ewes varied throughout the year. The longest and coarsest growth occurred during the summer and fall and the shortest and finest growth occurred during midwinter. In these studies the longest and coarsest growth was associated with a general thrifty condition, and the period of least growth usually occurred at lambing time and the 45 days preceding.

Wilson (14) studied "The Influence of Plane of Nutrition Upon Various Factors Related to Wool Production by Romney Wethers". In this experiment it was found that the fleeces grown by the wethers when on fattening rations, as compared with the fleeces grown later by the same wethers on a sub-maintenance ration, were:

343 per cent heavier in grease weight.
319 per cent heavier in scoured weight.
172 per cent longer in staple.
206 per cent stronger in mean breaking stress.
Coarser as indicated by the mean diameter of the fiber.
Other factors, such as loftiness, fullness, and crimpiness, were definitely affected by the plane of nutrition.

Thus is shown the very pronounced effect of nutrition or feed supply on the more obvious qualities of wool.

Hardy and Tennyson, as reported earlier, associated their results of rate and fineness with thriftiness, which obviously reflects the plane of nutrition. Burns (4) was able to associate accelerated or retarded rate of growth of wool with the seasonal condition of feed supply.

Duerden and Mare (5) and Duerden, Murray, and Botha (6) report that the rate of growth of wool produced by South African Merino sheep varied with individual sheep and according to the season, climate, pasturage, and other conditions. They attribute some of this variation to the fact that adjacent fibers do not always grow at the same rate, but that most of the variation is to be associated with changes in nutrition, as reflected in body weights and pasturage conditions.

Fraser (7) found that South Australian Merino sheep grazed throughout the year on natural pasture without supplementary feeding grew their fleece at a very uniform rate each month of the wool growing year. He calls attention to the fact that body weight of the sheep fluctuated with the seasonal condition of the pasture but points out further that the sheep were never short of feed.

The experiments herein reported show that American Merino and Tasmanian Merino sheep kept in Ohio under husbandry practices which insured thrift and good condition grew their fleeces at a somewhat irregular rate throughout the wool growing year. Variations in the rate of growth occurred which could be closely associated with the seasonal conditions of feed supply. Fresh and luxuriant spring and early summer pasture [probably because of its high protein content (12)] accelerated the rate of growth of wool fiber by as much as 23.6 per cent. Likewise, the dry pastures of midsummer or the frosted pastures of late fall had a slightly retarding influence on the rate of growth of wool fiber. Under conditions where the feed supply was constant, such as it was during the winter feeding season and when the sheep were not affected by outside influences, the rate of wool fiber growth was quite constant.

The sheep on these tests showed a slight tendency to grow more wool during the summer grazing season than during the winter feeding season. However, the greatest variation in this respect was shown by the group of six yearling wethers which grew 54 per cent of the total yearly growth of wool during the first four periods following shearing and 46 per cent during the second four periods of the wool growing year. Generally, the groups showed more nearly a 50-50 percentage.

THE INFLUENCE OF THE FACTORS OF SEX, PREGNANCY, LAMBING, BREED, AND AGE ON THE PERIODIC OR SEASONAL RATE OF LENGTH GROWTH OF FINE WOOL

Sex does not appear to have any influence, as determined through a comparison of the rate of growth of wool by closely related ewes and wethers, on the periodic or seasonal rate of growth of wool fiber. The greatest variation

found in any 6-week period was only 0.04 inch. Where the influence of outside factors, such as condition of feed supply, was manifest, the ewes and wethers responded similarly.

Pregnancy does not influence the rate of growth of wool produced by well fed Merino sheep, as determined in an experiment to study this factor specifically and as observed in three other groups of ewes. The greatest variation in growth noted in any 6-week period between closely related bred and unbred ewes was 0.02 inch.

Yeaning (commonly spoken of as lambing) and starting milk flow had a pronounced retarding influence on the rate of growth of wool fiber. All groups in which the influence of this factor was noted showed the same result. Those ewes which lambed showed that the rate of growth was retarded as much as 18 per cent. It is common knowledge among wool growers that the fleeces of ewes which lamb before shearing collapse and present a "mushy" appearance. Fleeces of lambed-out ewes lose the loftiness which is characteristic of fleeces removed before lambing or fleeces from sheep not subjected to the lambing process. All of the test sheep showed this characteristic collapse of the fleece. It is suggested that the diminution in the rate of growth of the wool fiber, which occurs during and immediately following lambing, may be responsible for fleece collapse, or, perhaps more accurately, this is a measure of the interrupting or retarding influence occasioned by the sudden physiological changes which occur to the ewe at lambing time. Carrying this a step farther, it has been shown by Hardy and Tennyson (11) and Wilson (14) that coarser fibers of greater diameter are closely associated with rapid rate of growth of wool and that fibers of lessened diameter are associated with a retarded rate of wool growth. Further, the strength of wool fiber is proportional to the area of the cross section of the fibers. Thus, if retarded growth produces a finer wool fiber, it is axiomatic that such fibers will be weaker. Hence, for the production of uniformly strong wool fiber throughout its full annual length growth, shearing and lambing seasons should be so timed as to come reasonably close together.

According to the results of these tests breed exerted an influence on the total yearly growth of wool fiber and hence upon the periodic rate of growth of the fibers. The Tasmanian Merinos grew wool fiber at a rate which totaled nearly one-half inch more for a year than the American Merinos. This greater total length was attained by a more rapid rate during each period into which the wool growing year was divided. It is interesting and perhaps significant that the more highly specialized, wool producing Tasmanian Merinos reacted in a more pronounced manner by way of growth of wool fiber to outside influences, such as seasonal condition of the feed supply and yeaning than the American Merinos.

Age, as determined by rate of growth of wool fiber by American Merinos and Tasmanian Merinos as lambs and as yearlings, did not influence the periodic or seasonal rate of growth of wool fiber and hence did not influence the total annual growth of wool. This should not be interpreted as applicable to sheep of advanced age when they are past the period of maximum production. What influence advanced age may have on the rate of growth of wool was not determined in these experiments. As observed in Table 7, the length of staple was not affected in a pronounced manner by age up to 7 years, either among the American Merino or Tasmanian Merino ewes. Length of staple, however, cannot be considered synonymous to length of fiber as measured with crimp removed in the growth studies.

THE INFLUENCE OF VARIOUS FACTORS AFFECTING GROWTH AND QUALITY OF FINE WOOL

In these experiments the Tasmanian Merino sheep were found to produce fleeces superior to the American Merino fleeces in every respect except breaking strength of the wool fiber and pounds of unscoured or grease wool produced annually. It does not follow, however, that the raising of Tasmanian Merinos should be urged for Ohio, the Tri-State area, or other regions of the United States. Nor is it argued or felt that Tasmanian Merino breeding should be introduced through crossing with the established and well adapted smooth-bodied American Merino. The comparison shows, however, wherein the Tasmanian Merino fleeces are superior, to what extent they are superior, and the influence of various factors on fleece quality. Certain results indicate what seem to be fallacies or misconceptions in connection with the prevailing practices in breeding American Merino sheep, if the production of high quality, high yielding fine wool is the object sought. These tests show by comparison those factors wherein fleece improvement may be made.

Since the very beginning of fine wool production in the Tri-State area, wool has been bought in its unscoured or grease state by wool merchants and dealers. Occasionally, allusion has been made to estimated shrinkage of wools on scouring, but little specific information has been presented to wool producers. To a large extent, the growers' experience has been with wool in its unscoured state. Their object in producing wool, particularly during the period of the World War and subsequently, has been to get the maximum number of pounds of unscoured wool per sheep at shearing time. The result has been that Ohio Delaine wool has increased in shrinkage by from 4 to 10 per cent during the last quarter century. Evidence is increasing that the majority of fine wool from the Tri-State area is losing some desirable qualities which once established its superior position and enabled it to command a premium on the wool markets.

Wool production.—As shown under "Results" the American Merino sheep produced more unscoured or grease wool annually per head or per 100 pounds of live weight than the Tasmanian Merinos. However, the average yield of clean wool produced by the American Merinos was from 35.26 per cent to 37.03 per cent of the weight of sheared wool; whereas the yield of clean wool by the Tasmanian Merinos was from 52.15 per cent to 52.33 per cent of the weight of sheared wool. When the factors for shrinkage, moisture, grease, and dirt were applied to the unscoured fleece weights, it was found that the Tasmanian Merinos produced annually 1.19 pounds more clean wool per 100 pounds of live weight than the American Merinos. Clean wool, as previously pointed out, is the only component part of grease wool that manufacturers can profitably use. It is of great economic importance to a wool manufacturer whether he gets 52 pounds of clean wool or from 35 to 37 pounds of clean wool from each 100 pounds of unscoured wool which he purchases.

Another fact brought out in this study was that moisture in wool at shearing time was the most variable of all the factors affecting shrinkage. During rainy weather the moisture content was shown to be as much as 14 per cent of the weight of sheared wool; whereas during clear weather a similar group of sheep showed an average of about 8 per cent of moisture in the fleece. It was further observed that moisture was readily taken up by the fleeces of sheep

during sudden changes from clear to rainy weather and appeared to be given off almost as readily under a reverse of the weather conditions. The fleeces from both breeds in this comparison responded similarly to weather conditions. There was no breed difference, except that the total weight of moisture per fleece was greater in the greasier and heavier American Merino fleeces than in the higher yielding but lighter Tasmanian Merino fleeces of unscoured wool. Since the moisture content of the wool was not associated with breed and could not be associated with the other components of the unscoured wool, moisture can be disregarded as a factor contributing to the wide difference in the shrinkage of the wool produced by the American Merino and Tasmanian Merino fleeces in this study. This leaves to grease and dirt the responsibility for the difference in shrinkage noted.

The fleeces from the foundation flock of American Merino ewes contained an average of 27.68 per cent of grease and 27.01 per cent of dirt while the fleeces of the foundation flock of Tasmanian Merino ewes contained an average of 18.80 per cent of grease and 19.34 per cent of dirt. Thus, 100 pounds of unscoured wool from the American Merinos contained 8.88 pounds more of grease and 7.69 pounds more of dirt than an equal quantity of unscoured wool from the Tasmanian Merinos. In this study grease and dirt contributed almost equally to the difference in shrinkage noted. The greasier fleeces from the American Merinos were also dirtier fleeces. A study of various records indicated that the quantity of grease was responsible in part for the quantity of dirt which adhered to the tip of a fleece as so-called "top", probably due to the grease providing the adhering medium. Because the amount of grease in a fleece appeared to influence the amount of dirt, grease or wool oil can be held responsible directly and indirectly for the increased shrinkage shown by the American Merino fleeces. The contention that a high grease content is necessary is founded on the fact that some grease or wool oil is necessary to protect the fleece from climatic influences during wool growth. Many growers now believe that the present high grease content of Tri-State fine wool is essential to protect the growing fleece from climatic influences as they prevail in Ohio and the Tri-State area. Obviously, if the present high grease content is necessary, then the greasier American Merino fleeces should be better protected from the weathering influences of Ohio's climate than the less greasy Tasmanian Merino fleeces. In this study, however, this was disproved, as shown by the scores for character and closure, which represent the measure of the influence of climatic factors. The less greasy fleeces of the Tasmanian Merinos consistently scored a higher per cent of perfect for both character and closure of the fleece than the greasier American Merino fleeces. A study of the individual records of American Merino fleeces indicates that excessive grease or wool oil is very frequently associated with low scores for character and closure and that excessively greasy fleeces suffer greater damage from weathering influences than the less greasy fleeces. It was apparent, therefore, that some factor or factors other than high grease content contributed to the protection of fine wool fleeces grown under Ohio climate. Whether the nature or character of the wool oil was involved was not determined. Density of wool fiber and length of wool fiber, rather than a high grease content, seemed to be the two factors affording fleece protection.

Two methods of determining density were used in these experiments and were defined as *Density of Fleece* and *Density of Fiber*. Under the former method, where grasping the fleece to feel of its fullness and compactness and parting the fleece to observe the apparent density of fibers was used, the fleeces

of the Tasmanian Merinos seemed very slightly denser than the fleeces of the American Merinos. When this method of estimating fleece density was checked against a technical method, involving accurate laboratory procedures for the determination of density of fibers per unit area of skin, the former was found grossly inaccurate. Actually, the Tasmanian Merinos produced an average of several thousand fibers per square inch more than the American Merinos. When mature sheep of similar ages were compared, the average difference was found never to be less than 10,000 fibers per square inch of skin area in favor of the Tasmanian Merinos and frequently the difference was much greater, as shown by the average difference of 16,071 fibers in favor of the Tasmanian Merinos in the 1927 density tests. Apparently, the feeling of fullness and compactness which was judged as density in the American Merino fleeces was not due to density of wool fibers but was a false density imparted by a higher grease and dirt content. In view of this finding, it seems logical to ask whether excess wool oil or grease, by imparting a false feeling of fullness and compactness, might be indirectly defeating the real purpose of fine wool sheep breeding—the production of the maximum quantity of high quality, fine, Merino wool fiber. Impetus is given to this thought by the records obtained in testing for density of fiber the two B-type breeding rams introduced into the Experiment Station flock for the specific purpose of holding the grease content of the wool and increasing the density of fleece. The fleece of one ram was judged 95 per cent perfect for density and that of the other slightly less dense. The density of fiber test revealed that the former ram possessed an average of 15,039 wool fibers and the latter 13,915 wool fibers per square inch of skin area. Other tests showed that the average density of C-type American Merinos, ewes and rams, is about 25,000 to 27,000 fibers per square inch of skin area.

Another example which furnishes further evidence on this point is a comparison of the first mentioned B-type ram above and Tasmanian Merino ram No. 33, born and raised in Ohio. Both rams were judged 95 per cent perfect for density of fleece. As mentioned earlier, the former when tested for density of fiber was found to possess 15,039 wool fibers per square inch, and the latter, 37,068 wool fibers per square inch of skin area. By applying the fleece scouring records for per cent of grease and clean wool to the weight of wool sheared from each individual, the B-type American Merino was found to produce 9.63 pounds of grease or wool oil and 7.21 pounds of clean wool; the Tasmanian Merino ram was found to produce 3.53 pounds of grease and 8.73 pounds of clean wool. The record of the second mentioned B-type ram makes the comparison more unfavorable since he grew 13,915 fibers per square inch of skin area, produced 11.09 pounds of grease or wool oil, and only 5.03 pounds of clean wool. Obviously, the feeling of fullness and compactness of the fleeces on the wrinkly American Merino rams resulted in gross misjudgment of the density of the fleeces and the estimate of their wool producing capacity was a serious misconception.

The reason advanced for injecting the blood of wrinkly rams with their greasy fleeces into ewe flocks is to increase density. In the light of the results of these tests it would seem that this practice is actually defeating the object sought. The average density found on smooth-bodied ewes was 27,487 wool fibers per square inch of skin area while wrinkly ewes possessed an average of 23,898 wool fibers per square inch of skin area.

Density of wool fibers appeared to be incompatible with a high grease content, since those fleeces which were high in their grease content showed a low density of wool fibers while those fleeces which showed extreme density were uniformly and invariably low in grease content. Apparently, a sheep cannot produce both an abundance of wool fiber and an abundance of oil. The question to be decided is whether to breed sheep for wool, which at present is worth 80 cents per clean pound, or grease which cannot be profitably salvaged.

Length of staple is a very important quality of wool from the manufacturer's standpoint. It is frequently contended among breeders of Merino sheep, however, that great density of fiber is incompatible with the production of long-staple fleeces, and thus length is frequently sacrificed to obtain so-called density. The results of these experiments, as brought out in the study of the influence of density on length of staple, disproved this contention. The fleeces of greatest density were fully as long as the fleeces of least density and individuals were found that possessed as many as 44,651 to 45,820 wool fibers per square inch of skin area and grew this great density to an unstretched length of 3.25 and 3.62 inches. Perhaps the short-stapled, wrinkly, greasy-fleeced rams and ewes, which, because of these qualities, were misjudged as to density of wool fibers, may have led breeders to the false opinion that great density and great length are unattainable on the same sheep.

Another popular opinion which these experiments tend to nullify is the relationship between length of staple and dirt in the fleece. The opinion is that the longer fleeces are dirtier fleeces. In these experiments the fleeces with the higher percentage of dirt were, with both breeds, shorter in their average length of staple than the fleeces with the lower percentage of dirt. Length and density tend to protect a fleece of wool from dirt. Short staple and a high grease content encourage the accumulation of dirt.

These experiments developed the interesting fact that age influenced the density of wool fibers a sheep will produce. Ewes in their prime as 2-, 3-, and 4-year-olds apparently produce the maximum number of wool fibers which they are inherently capable of producing. When they reached the age of 7 years, they were producing only about 66 to 68 per cent as many fibers as they produced in their prime. This has the effect of lowering the amount of clean wool produced. The dirt content, however, increases under the lessened density of wool fiber and there is quite a definite tendency for old sheep to produce a dirtier fleece than they produced previously. This increase in dirt noted, however, did not seem to be due to lessened grease production, since the quantity of this product was maintained with little variation up to an age of 7 years.

FLOCK PRODUCTION

In all phases of wool production except the number of pounds of grease wool produced annually and a slightly greater strength of fiber, the Tasmanian Merinos were found superior to American Merinos of the smooth to somewhat wrinkled type. When the flock production records were analyzed with respect to lamb raising ability, lamb growth, and efficient meat production, the American Merinos were definitely superior. At the close of the grazing season the American Merino ewe lambs averaged during four successive years 19, 15.7, 23.5, and 10.76 pounds heavier per lamb than the Tasmanian Merinos. Not only were the ewe lambs heavier but wether lambs of the American Merino breed exhibited an efficiency for converting farm feed into meat which far surpassed the wether lambs of the Tasmanian breed.

American farmers can no longer profitably produce sheep for wool alone. Profitable sheep must exhibit a balanced combination of utility characters for both carcass and fleece. American Merinos are superior to the Tasmanian Merinos in meat making efficiency, as proven by this investigation; however, the fleece of the American Merino is inferior to that produced by the Tasmanian Merino. The results of these tests indicate the possibility of improving the fleeces of American Merinos by selective breeding for less grease or wool oil, fewer wrinkles, greater and more uniform length of staple, more uniformity of fineness of fiber, greater density of fiber, and greater weight of clean wool per 100 pounds of body weight of the sheep. The methods and equipment necessary for the determination of density or volume yield and uniformity of fiber fineness are available (9, 10). These can be applied with benefit in the selection and breeding of Merino sheep.

SUMMARY

1. Merino sheep kept under a good system of feeding and management produce practically as much growth of wool fiber during the second half as they produce during the first half of the wool growing year after shearing. It appears, therefore, that stage of wool growth exerts only a slight influence, if any, on the rate of growth of wool fiber produced by Merino sheep.

2. An accelerated rate of growth of wool fiber, amounting to 23.6 per cent above the mean average for all periods of the year, was closely associated with luxuriant and highly nutritious early summer pasture. Similarly, poor pasture conditions of late fall retarded the rate of growth of wool fiber produced by lambs by from 5.4 per cent to 15.4 per cent. The process of yeaning and starting milk flow caused a diminution in the rate of growth of wool fiber produced by breeding ewes by from 16.8 per cent to 18 per cent below the mean average growth recorded during the three immediately preceding periods of measurement characterized by barn feeding. Thus, the rate of growth of wool fiber during any period of the year is subject to acceleration or diminution by outside influences, such as seasonal conditions of feed supply and the process of yeaning and starting milk flow.

3. Sex, as shown by the linear measurements of clipped wool fibers which determined the rate of growth of wool fiber produced by closely related ewes and wethers, did not influence the rate of length growth of wool fiber.

4. Pregnancy, as shown by the linear measurement of clipped fibers which determined the rate of growth of wool fiber produced by closely related, carefully selected, bred, and unbred yearling ewes, did not influence the rate of growth of wool fiber.

5. Breed, under the same fiber clipping and measuring method, influenced the total yearly growth of wool fiber and, hence, influenced the periodic rate of growth of wool fiber. Also, breed seemed to influence the extent to which the rate of growth of wool fiber may be accelerated or retarded by outside influences, such as seasonal condition of feed supply or other factors.

6. Age did not seem to influence the rate of growth of wool fiber. In this study the rate and total yearly growth of wool fiber produced during the lamb year provided an accurate index of the rate and total yearly growth produced by the same sheep during their yearling year.

7. American Merino sheep of the smooth-bodied to moderately wrinkled type were found to produce an average of from 3.68 pounds to 5.05 pounds more of unscoured wool per head in 12 months than Tasmanian Merino sheep kept under similar conditions. When the weight of unscoured wool produced was calculated on the basis of unscoured wool per 100 pounds live weight of sheep, the American Merinos outsheared the Tasmanian Merinos only by an average of from 1.68 pounds to 2.46 pounds. When the factors causing shrinkage in wool were applied to the unscoured fleece weights, the Tasmanian Merinos were found to produce 1.19 pounds more of clean wool per 100 pounds live weight of sheep than the American Merinos. The weighted average yield of clean wool produced by the foundation flock of American Merinos was found to be 35.26 per cent of the weight of sheared wool, and for their female offspring, 37.03 per cent of the weight of sheared wool. The corresponding data for the two flocks of Tasmanian Merinos were found to be 52.15 per cent and 52.33 per cent of the weight of sheared wool, respectively. The two flocks of Tasmanian Merinos, therefore, produced 15.3 pounds and 16.89 pounds more of clean wool per 100 pounds of wool sheared than did the corresponding flock of American Merinos. These results show the fallacy of using the pounds of unscoured wool sheared as the measure of a sheep's wool producing efficiency.

8. Of the three factors—moisture, grease, and dirt—which contribute to shrinkage of wool, the grease factor was found directly and indirectly responsible for the pronounced difference in the percentage yield of clean wool between the two breeds. Not only did the fleece from the foundation flock of American Merino ewes, for example, contain 47.2 per cent more grease than the Tasmanian Merino fleeces, but the American Merino fleeces also contained 39.6 per cent more of adhering dirt which accumulated, apparently, because the grease supplied the adhering medium for the dirt.

9. The scores for character and closure show that the higher percentage content of grease in the American Merino fleeces did not afford better protection to the growing wool fibers from the weathering influences of climatic factors than the much lower percentage content of grease in the Tasmanian Merino fleeces. In fact, the evidence indicates that short-stapled fleeces with a high grease content suffered the greatest weathering damage recorded in this experiment. A high percentage content of grease, therefore, does not seem to be the factor that affords protection to a growing fleece from weathering, due to climatic factors.

10. The results obtained in this study indicate strongly that the two fleece qualities which afford protection to growing wool from climatic influences are length of staple and density of wool fiber. The results further showed that improved length of staple and great density of fiber are not incompatible.

11. American Merino sheep in this test were judged to produce fleeces practically as dense as Tasmanian Merino sheep. A laboratory method developed by Hardy for determining density of wool fibers per square inch of skin area showed, however, that Tasmanian Merino sheep possessed from 8,000 to 20,000 more wool fibers per square inch of skin area than American Merino sheep. Apparently, the higher percentage content of grease and dirt in American Merino fleeces imparted a feeling of fullness and compactness that was readily misjudged as density. Among wrinkly, short-stapled, greasy-fleeced, B-type American Merino rams this feeling of fullness and compactness, due to grease and dirt, resulted in gross misjudgment of density to the extent that the estimate of their wool producing capacity was a serious misconception.

12. In this study the greatest density of wool fiber found on any of the sheep was 45,821 fibers per square inch of skin area, which was produced by Tasmanian Merino ewe, U. S. Imported No. 31. The least density of wool fibers, or 11,834 per square inch of skin area, was found on a 7-year-old American Merino ewe. Age of sheep was found to influence density of fibers to the extent that the sheep produced only 66 per cent to 68 per cent as many fibers as 7-year-olds as they produced as 2-year-olds. It was found, also, that the density of wool fiber produced by lambs was 80 per cent accurate in indicating subsequent density of the fleece when the sheep were more mature.

13. Contrary to existing opinion among breeders, the results obtained indicate that wrinkly, excessively greasy-fleeced American Merino sheep may, and in this test actually did, produce fewer wool fibers per square inch of skin area than smooth-bodied American Merino sheep. It seems that individual sheep do not produce an abundance of wool oil and also an abundance of wool fiber. Also, wrinkling does not contribute to density of wool fiber.

14. The method of determining the cross-sectional diameter and uniformity of adjacent wool fibers reported by Hardy (10) showed clearly variations in wool fiber diameter which the naked eye failed to detect. This method clearly demonstrated that Merinos may grow wool of 70's quality on the body and produce wool of 56's quality on the crest of skin folds, in which case wrinkles or skin folds are a detriment to fiber uniformity throughout the fleece. Also, of two wool fibers lying adjacent, one may be three times the diameter of the other.

15. American Merino sheep proved superior to Tasmanian Merino sheep in all phases of meat production and, for this reason, are better adapted to the conditions of sheep husbandry in the Tri-State region and, in fact, throughout the entire United States. The lambs of the highly specialized wool bearing Tasmanian Merino breed exhibited low meat-making efficiency.

16. The results of these tests indicate the possibility of improving the fleeces of American Merinos by selective breeding for less grease, fewer wrinkles, greater length of staple, more uniformity of fineness of fiber, greater density or weight of clean wool per square inch of skin area, and greater weight of actual wool per 100 pounds of body weight of the sheep.

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