AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

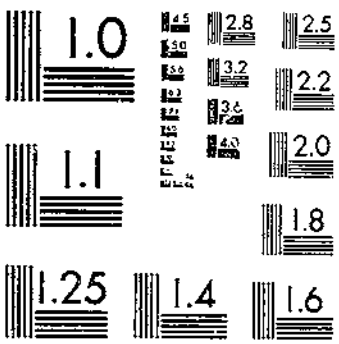
*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

TB 85 (1928) USDA TECHNICAL BULLETINS UPDATA

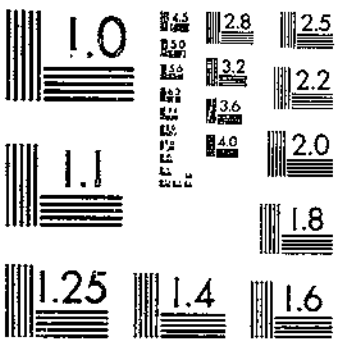
FACTORS THAT INFLUENCE WOOL PRODUCTION WITH RANGE RAMBOUILLET SHEEP.

SPENCER, D A.; HARDY, J I.; BRANDON, M J. 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

1 85 Agri

TECHNICAL BULLETIN No. 85 OCTOBER, 1928

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FACTORS THAT INFLUENCE WOOL PRODUCTION WITH RANGE RAMBOUILLET SHEEP

By D. A. SPENCER, *Senior Animal Husbandman;* J. I. HARDY, *Senior Animal Husbandman;* and MARY J. BRANDON, *Junior Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry*

CONTENTS

OBJECT OF INVESTIGATION

The object of the investigation here described was to determine by a definite, systematic, and well-controlled study of the characteristics of Rambouillet sheep the factors which influence the production of wool by this breed under typical conditions of the western intermountain ranges. The practical value of this study lies in the development of information for the betterment of the sheep and wool-growing industry. This particular study analyzes the influences of the following factors: Age of sheep; weight of fleece; weights of moisture, grease, and dirt in the fleeces; length of staple; fineness of fiber; character of the fleece; density of fleece; face covering of sheep; skin folds on sheep; body weight of sheep; and the mutton conformation or type, condition, back, rump, and leg of the sheep. The influences reported have reference entirely to wool production.

This bulletin contains the basic data and technical discussion. A popular discussion is planned for later publication.

HISTORY OF THE WORK

The Bureau of Animal Industry began breeding Rambouillet sheep in 1903 at Laramie, Wyo., and continued there until 1917, when

the flocks were transferred to the newly established United States sheep experiment station near Dubois, Idaho. In 1915 President Wilson, acting under authority previously granted by Congress, withdrew from settlement about 28,000 acres of typical spring-fall grazing land for the specific purpose of developing a sheep experiment station where the Bureau of Animal Industry could conduct definite investigations of problems relating to the range sheep industry. These lands were at that time wholly undeveloped and constituted merely a sagebrush desert at an elevation of about 5,900 feet. A preliminary period of about three years was devoted to building up the equipment of the station needed for conducting definite experiments with large range bands of sheep. (Fig. 1.) It was necessary for the investigators to blaze their trail, as no one had gone before them in this particular field of endeavor. Much time has

FIG. 1.—United States sheep experiment station, Dubois, Idaho. The ewes in the foreground are Rambouillets. At the left are sheep sheds, shearing shed, and corrals; at the right is the horse barn. In the background, from left to right, are the superintendent's cottage, the office and commissary building (at the left of the silo), the ice house, garage, well house, shepherd's cottage, and laborers' cottage. The elevation at this location is 5,900 feet. The well is 750 feet deep and provides an abundance of excellent water. Lambing and most of the precise experimental operations with the sheep are conducted at these headquarters

been required for working out original methods of studying problems under open range conditions and for bringing the results of the experiments to the stage of maturity essential for publication.

The requirements of the work also extended to the development of a wool laboratory at the United States animal husbandry experiment farm, Beltsville, Md., where the experimental fleeces were analyzed for their content of moisture, grease, dirt, and clean wool. This phase of the work proved to be one of the most difficult, and it took several years of vigilant research to develop a satisfactory process of wool scouring for use in making these specific determinations.

METHODS OF OBTAINING DATA

MANAGEMENT OF THE SHEEP

All the sheep used in these experiments were well-bred Rambouillet ewes. They were purebred, although some of them were not officially registered in the American Rambouillet Sheep Breeders' Association.

The sheep were handled in bands under typical range conditions and by practical methods. They were sheltered only at lambing time and were required to graze on the range from the opening of spring in March or April until almost snow-bound in December or January. From December or January until March or April they were fed in the irrigated valleys on alfalfa hay. From about one month before lambing until good grazing was available on the range they were fed a limited allowance of corn in addition to their hay. Ewes that lambed at the lambing shed before good grazing was available were fed 1 or 2 pounds of sunflower silage a head daily, together with about one-half to three-quarters of a pound of grain (corn, barley, or oats) daily for each ewe and as much alfalfa hay as they would clean up readily.

In the spring and fall these ewes grazed on typical spring-fall range of the sagebrush type near Dubois, Idaho. Their summers were spent in the Targhee National Forest, about 40 or 50 miles west of Yellowstone National Park, where they usually found an abundance of lush, palatable forage. During the late fall and winter they were allowed to graze in the deep canyons of the Lemhi National Forest about 40 miles southwest of Dubois until snowstorms made it necessary to drive them back toward the headquarters of the sheep experiment station, stopping in the irrigated valley about 10 miles west of Dubois. There they fed on alfalfa hay until lambing time when they were moved to the lambing sheds of the station, 6 miles north of Dubois.

The fleeces used in these studies were sheared during the first week of June in 1921, 1923, and 1924. The fleeces from ewes older than the yearlings were of exactly one year's growth, whereas the fleeces from the yearling ewes had grown for a period of from 12 to 14 months.

SCORING, SAMPLING, MEASURING, AND WEIGHING SHEEP AND WOOL

A few days before shearing, the fleeces of the yearling ewes were scored individually for fineness, character, density, and face covering of wool. During the process of shearing a sample of approximately 1 pound of wool was taken from the side of each fleece, both from yearlings and mature ewes, placed in a lacquered tin container, and capped with a tight-fitting lacquered tin lid as shown at the extreme left of Figure 2. After all sheep were sheared the samples were first used for measuring the length of the staple of the fleece of each ewe used in this investigation.

The live weight of the yearling ewes was taken each year after they were sheared. As soon as each of these yearling ewes was weighed she was scored for mutton conformation or type, condition, back, rump, and leg, and the folding of the skin.

The fleece samples which were used for measuring length of staple were shipped to the animal husbandry experiment farm, Beltsville, Md., and used for determining the weights of moisture, grease, dirt, and clean wool in the respective fleeces. The fleeces were all weighed individually as soon as they were sheared and these weights were used in calculating the weights of moisture, grease, dirt, and clean wool of each entire fleece by application of the percentages of these various constituents found in the samples of the respective fleeces.

DETERMINING CONTENT OF MOISTURE, GREASE, DIRT, AND CLEAN WOOL IN FLEECES

A 250-gram portion of wool was taken from each fleece sample for use in the laboratory determinations of moisture, grease, dirt, and clean wool per fleece. These samples of 250 grams each were placed in wire-mesh baskets and dried in a conditioning oven (fig. 3) for a period of three hours at a temperature of 50° C., after which they were weighed before removing from the oven. The weight of the conditioned (dried) wool subtracted from the original, unconditioned weight of the same sample gave a difference which represented the weight of the moisture removed by this drying process. However, it should be understood that drying these wool samples for three hours at 50° was not sufficient to remove all the moisture that actually existed in the wool. Some tests were conducted to determine how much moisture

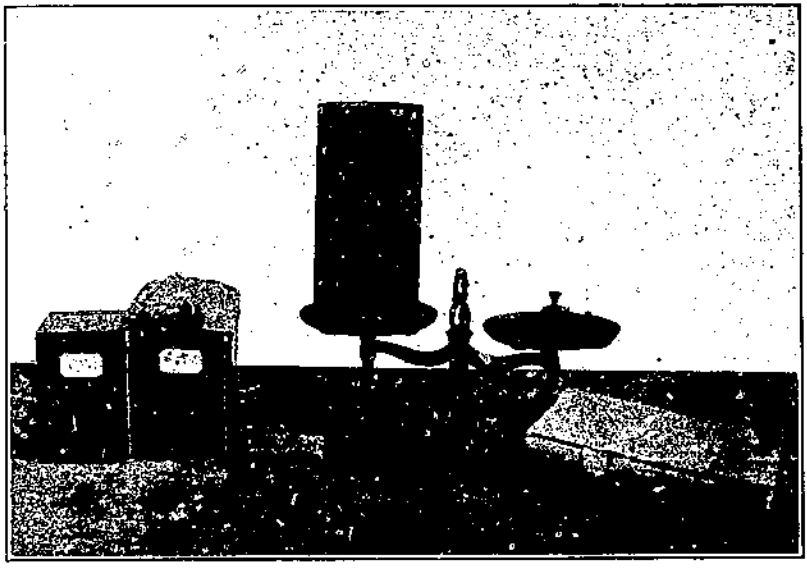


FIG. 2.—Wool containers, balance, and record book. The square containers show the kind of receptacle used for shipping samples of wool and storing them at the wool laboratory, Beltsville, Md. When the wool is to be prepared for scouring, the container is opened and wool placed in the basket shown on the balance

still remained in the wool at the close of the three hours of drying at 50°, and it was found to average approximately half of the weight of moisture that existed in the original, unconditioned samples. Although this conditioning process did not give moisture-free weights, the amount of drying practiced brought the moisture content down to what seemed, to the investigators, to be sufficiently constant for this particular study of large numbers of fleeces.

After this conditioning of the unscoured samples of wool they were placed in extraction containers and washed with high-test gasoline to remove the grease. (Fig. 4.) Three extractions or washings with gasoline were made on each sample, the gasoline being allowed to filter off through filter paper after each extraction, thus saving the dirt with the wool and removing the grease. The grease removed in this way was considered the grease content of the wool. After

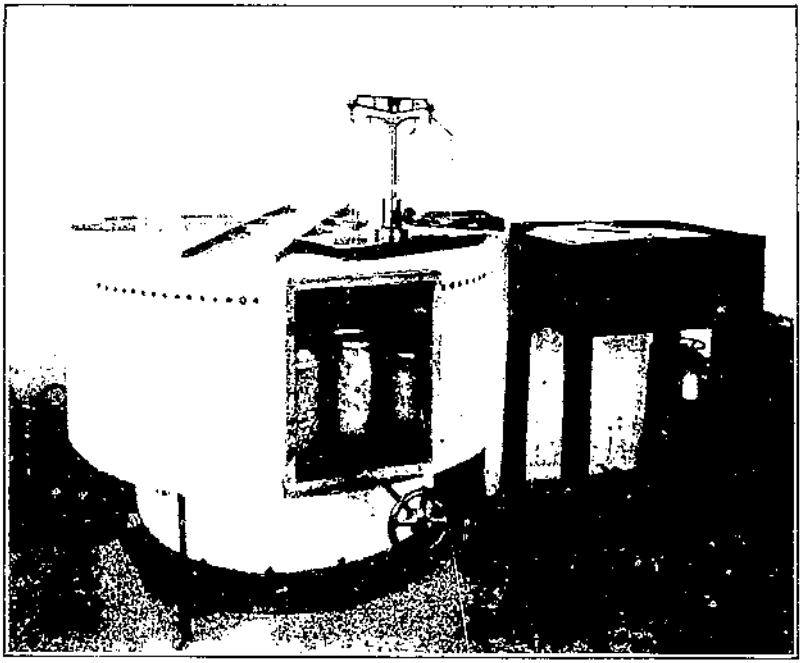


FIG. 3. Wool-conditioning oven. Note the method of weighing wool baskets without opening the glass door. Baskets are brought into position for weighing by turning the wheel shown below the oven door. When in position the basket is hooked into the weighing apparatus

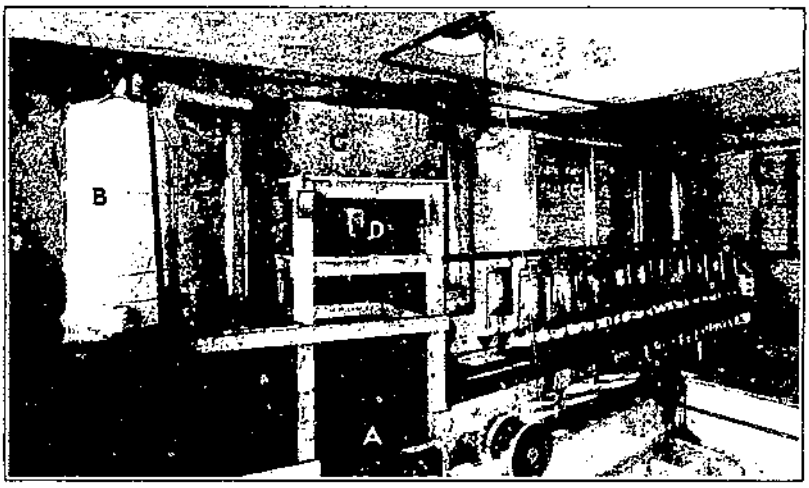


FIG. 1.—Grease-extraction apparatus. Extraction containers are shown in the right half of this illustration with filter papers beneath. The baskets of wool were placed in these containers and gasoline was poured into the containers until it was within 2 inches of the tops. Lids were placed on the containers after the wool had been gently agitated in this gasoline bath, and the gasoline was allowed to stand 45 minutes. After filtering, the gasoline was returned to the pressure tank, A. It was then forced into the distillation tank, B, condensed in tank C, and returned through collecting tank D and the upper pipes into E. At F is shown the card file bearing the weekly schedule of work. A card was used for each day's program

being degreased the samples were placed in a hot-air blower-drier for an hour, where air heated to approximately 60° C. was forced to circulate through the wool. (Fig. 5.) The samples, including the respective filter papers and dirt, were then dried in the oven again for a period of three hours at a temperature of 50° C. and then weighed before being removed from the oven. The difference between this second conditioned weight and the first conditioned weight of the samples represented the weight of the grease removed by gasoline extraction.

The samples were next washed in a solution of water and a neutral soap, at 40° C., and rinsed at the same temperature. (Fig. 6.) The excess moisture was driven off by the use of a centrifugal drier and by drying in the blower at about 60° C. for eight hours, after which they were conditioned in the oven at 50° C. for three hours. The weight of the clean wool was then taken at the end of this period of three hours. This weight of clean wool, subtracted from the weight taken after the degreasing process, gave the weight of the dirt that was washed out of the sample. The weights of moisture, grease, dirt, and clean wool were then used in calculating the percentages of those constituents in the 250-gram sample of greasy wool. These percentages were applied to the weights of the entire fleeces as a means of determining the calculated weights of moisture, grease, dirt, and clean wool in the respective fleeces.

FIG. 5.—Degreased wool airing after three treatments of gasoline. The two large cans shown in the foreground collect the gasoline from the gasoline still in the rear. Air pipe A connects lower and upper parts of the blower-drier used for drying wool after washing

This method was tested at all stages and was found to be sufficiently accurate for use when considering averages of large numbers of fleeces. In order to determine the reliability of this system, 98 whole fleeces of wool produced at the sheep experiment station were divided into the seven parts—viz, neck, shoulder, back, sides, belly, rump, and breech—and each part of each fleece was scoured separately by the process above described in an effort to determine which part of the fleece would be the most representative sample of the entire fleece with respect to the content of grease, dirt, and clean wool. Fifty of these fleeces were from Rambouillet ewes and the other 48

were from ewes of the longwool-finewool crossbred types. The results from the 50 Rambouillet fleeces are illustrated in Figure 9. The part found to be most satisfactory was the side of the fleece.

When the work of sampling the fleeces was begun for these investigations, the samples were taken at the side of the shoulder. The special testing of various parts showed that the shoulder samples were nearly as true representatives of the entire fleece as the side, but as the sides of Rambouillet fleeces averaged almost exactly the same percentage of clean wool as the whole fleeces from which they were taken, while the shoulder samples yielded approximately an

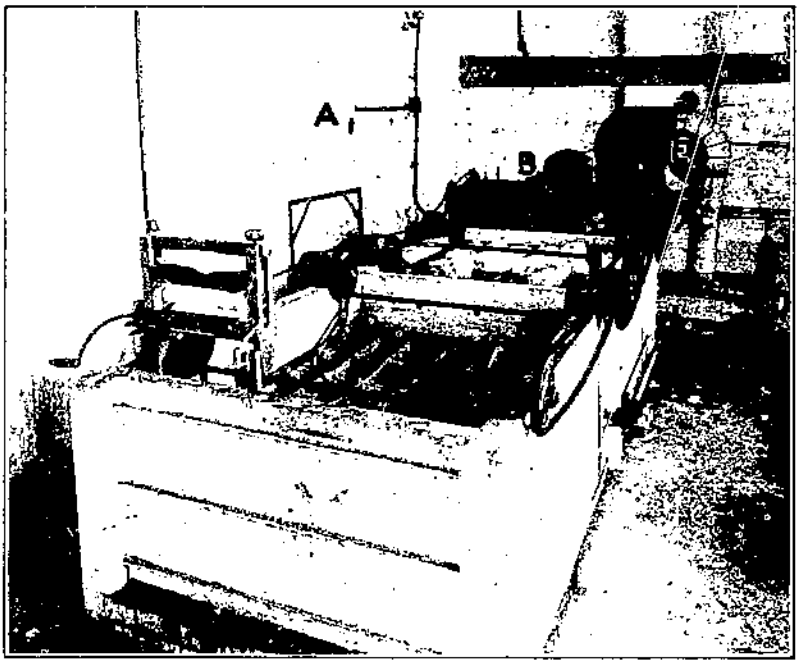


FIG. 6.—Washing apparatus. The empty washing baskets are shown in the first tub and the washing baskets filled with wool in the second tub. When this apparatus was in operation the washing baskets would rise, move from end to end, and fall. Note the holes in the partition between the first and second tubs. Water was allowed to rise almost to these holes in one tub and was then shut off. In case of an overflow the holes prevented flooding. The water was heated by steam pipes in the bottom of each tub. At the right of A is the electric switch button and the motor B that drove the washing machinery. The ordinary clothes wringer shown in the left foreground was used for wringing water from washed, rinsed wool samples. Air pipe C conducted air into heating tank D of the blower-drier. The heated air returned through the upper part of the blower-drier where the baskets of wool were placed for drying and the air passed out of the dryer through pipe shown at E

average of 3 per cent more clean wool, the samples thereafter were taken from the side. Specifically, the sampling was at the side of the shoulder (nearest to the true sample) in 1921 and at the side of the body of all fleeces sampled after that year.

In the study above mentioned for the 50 Rambouillet fleeces the side samples in addition to averaging approximately the same percentage of clean wool, as the whole fleeces also averaged only about 1 per cent more grease and 1 per cent less dirt than the whole fleeces. Correlation studies with the 98 fleeces above referred to revealed that in clean wool there was a positive correlation of 0.75 ± 0.03

between the side samples and the whole fleeces and 0.75 ± 0.03 between the shoulder samples and the whole fleeces. For grease, the coefficient was 0.82 ± 0.02 between the side and the whole fleece and 0.87 ± 0.02 between the shoulder and the whole fleece. In the case of dirt the side correlated 0.68 ± 0.04 with the entire fleece and the shoulder sample 0.69 ± 0.04. In the light of these results the data presented in this bulletin are regarded as thoroughly reliable.

To determine about how large the number of fleeces should be to insure reliable averages a concrete test was made. A total of 50 fleeces was used in this test, 30 of which were from Rambouillet ewes, 10 from Corriedale ewes, and 10 from Columbia ewes. Each of these 50 fleeces was sampled in the regular way at the side and these side samples were put through the standard scouring process. In a separate operation the remainder of the wool of each fleece was also scoured by the standard process. The side samples from the 30 Rambouillet fleeces averaged a yield of 35.62 per cent clean wool and the actual yield of the 30 entire fleeces was 34.79 per cent. The clean-wool yield for the side samples of the 10 Corriedale fleeces was 38.08 per cent, while the actual yield of all the clean wool in these same fleeces amounted to 40.79 per cent. The side samples from the 10 Columbia fleeces yielded an average of 44.46 per cent and all the clean wool in these fleeces amounted to 42.87 per cent of the original raw weight. Combining all the above-mentioned 50 fleeces it was found that the side samples from them averaged a yield of 37.88 per cent of clean wool and all the clean wool amounted to 37.50 per cent of their original unscoured weight.

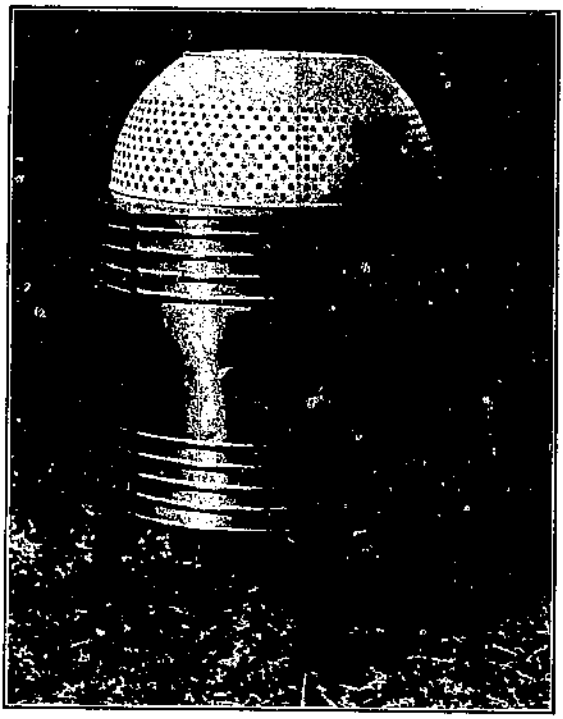


FIG. 7.—A centrifugal type of washing machine which was used for removing water from freshly washed wool. The bowl here shown on top of the cover of the machine is, of course, inside when in operation. The machine is driven by the electric motor shown beneath. Much of the water in the wool is removed through the holes in the bowl so that the wool may be efficiently dried in the oven. This method of removing water from the wool was found to be more satisfactory than depending entirely on the clothes wringer, which occasionally left so much water in certain clumps of wool that it interfered with the oven-drying process

It will be seen from these various comparisons of yields from the samples and their respective entire fleeces that the variations are both positive and negative. Because of these compensating deviations it

is possible to improve the agreements between averages of samples and their whole fleeces by having an increase in the number of fleeces

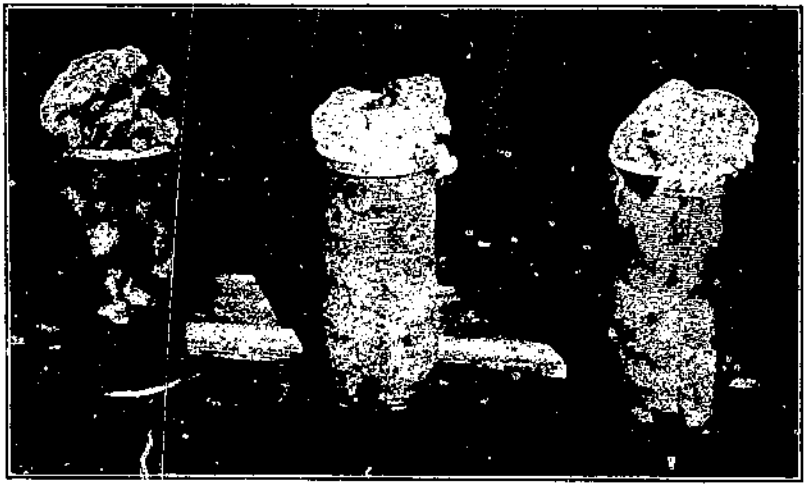


FIG. 8.—Baskets of wool. A, Raw wool before scouring; B, degreased wool, dirt remaining; C, clean scoured wool, free from grease and dirt

averaged. These figures show that as the number of fleeces increase from 10 to 50 there is considerable inprovement in the agreements

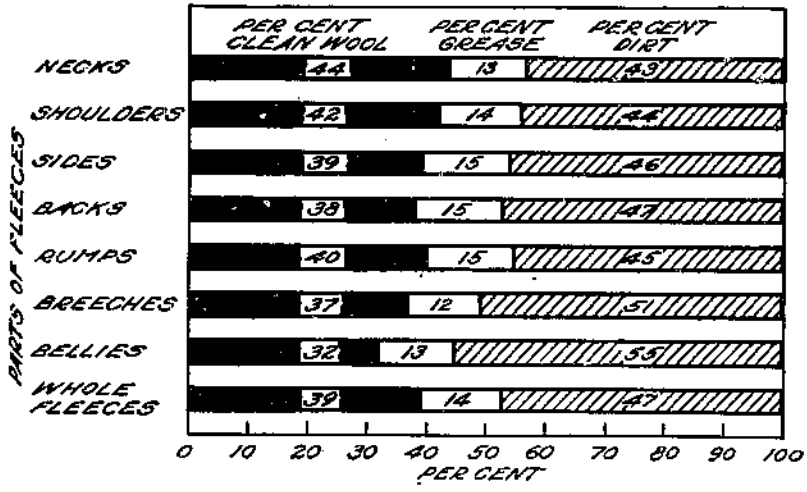


FIG. 9.—The average content of clean wool, grease, and dirt in 50 Rambouillet fleeces. The side samples of these fleeces had practically the same average content of clean wool as the whole fleeces from which these side samples were taken

between averages of the samples and averages of the whole fleeces they represent.

STATISTICAL ANALYSIS OF THE DATA

All the data essential to this investigation were assembled for each individual ewe. A statistical code was developed for the analysis of these data by the Hollerith system of sorting and tabulating, including important steps in correlation studies. This involved the use of punched cards, one card being used for each ewe. These cards were sorted into yearly groups and then for correlation tables which, besides showing frequency distributions, revealed the relation of each wool and sheep factor to the primary wool factors. By decoding these tables the averages of the various factors were determined in their relation to each other. These punch cards were then resorted, each factor being considered separately, and tabulated by the Hollerith tabulating machine in such a manner as to obtain the sum of the items, their squares, and their products. From these tabulations the means, standard deviations, coefficients of correlation, and probable errors were calculated.

DISCUSSION OF FACTORS WHICH INFLUENCE WOOL PRODUCTION

Tables 1 to 18 contain the number of fleeces, weights, measures, and percentages for the various factors that are covered in this investigation, and Table 19 presents the coefficients of correlation determined for each factor. Specialized students of sheep breeding will find the coefficients in Table 19 of interest and useful in obtaining a prompt understanding of the relationships which exist among the factors considered throughout the bulletin. Readers who are not accustomed to thinking in terms of correlation coefficients should be able to get much of the substance of this bulletin from the other tables and discussions, which are presented in a form more readily understood by the majority of readers.

The basic tables (1 to 18) give values in terms of weights, measures, judgments, and relative degrees of perfection, as well as values in percentages which are based on the respective values shown in the headings of the tables. The expression "number of fleeces" in each table refers to the number of fleeces for each respective grouping. The term "per cent of grand average" in these tables expresses in percentage the proportion of the respective values to the grand average value for the one particular line of values in question. For example, in Table 1 the first percentage number at the left side of the top of the table is 85.00. This means that the value of 9.12 pounds, the average weight of the 252 unscoured fleeces from the yearling ewes, is 85 per cent of the grand average weight of 10.73 pounds for all the 1,850 unscoured fleeces in that major group. Thus the figure 85.00 is simply a percentage expression for the respective values based on the grand average, a percentage value of 100 being assigned to each grand average. Therefore the figures along a given horizontal line in the tables show the rise and fall of the various group averages from the respective grand average value.

The variation in the total number of fleeces in the various groups is due to the variation in the amount of data available for the different factors. In Tables 1 to 18 all fleeces for which data were available were used in each group, whereas in Table 19 use is made of only the 990 fleeces for which data are available in all the relationships considered. In Tables 8 and 10 to 18, inclusive, it will be noted that in

the cases of relation of fineness to density of fleece the numbers of fleeces are smaller, ranging from 702 to 827. This was due to the fact that the data for those factors were based entirely on the records for the first or yearling fleeces. For this same reason no coefficients of correlation are shown in Table 19 between age of sheep and fineness of fleece and between age of sheep and density of fleece. Further inspection of Table 19 will show that no coefficients of correlation have been given for moisture nor for dirt in the fleeces as related to the body weight and mutton factors of the sheep. These were regarded as unimportant.

DESCRIPTION OF FACTORS

An explanation of the exact meaning of the various factors studied is essential to a clear understanding of the results. The factor "age of sheep" is recorded in years. As the shearing of the fleeces occurred each year during the week in which June 1 occurred and as the birth of these ewes occurred in March, April, and May their ages at the time of shearing were close to the exact number of years recorded, exceeding that in no case more than three months.

The unscoured-fleece weights were taken at the shearing floor. They represent all the unscoured wool of the respective fleeces except the heavy dung locks. The scoured-fleece weights were calculated by applying the percentages of clean wool found in the samples to the unscoured-fleece weight of each respective fleece. In this same way for each fleece the separate weights of moisture, of grease (extracted by gasoline), and of dirt were calculated on the percentages based, in turn, on the sample analyses and the unscoured-fleece weights.

Length of staple for each fleece was measured to the nearest one-eighth of an inch, using representative staples from the regular side samples of the fleeces.

Fineness of the fleeces was taken at the side of the fleece for the first or yearling fleeces by investigators thoroughly trained and experienced in the judging of fineness of wool by the Bradford spinning count system refined to the point of using every count as shown in Table 8. This Bradford system of Bradford, England, is now essentially the same as the numerical expression of the official wool grade standards of the United States, which ranges from as coarse as 36s to as fine as 80s. The various counts or numbers actually used in commerce are 36s, 40s, 44s, 46s, 48s, 50s, 56s, 58s, 60s, 64s, 70s, and 80s. In this experimental work a refinement of the system or a dividing up of these various steps was found essential but there is a very close resemblance of the experimental system used and the commercial system here described. Grouping these numbers into the old American wool grades one obtains 36s and 40s coinciding with braid wool; 44s is common; 46s low quarter blood; 48s and 50s quarter blood; 56s (including the experimental counts 52s, 54s, and 56s) is three-eighths blood; 58s and 60s are half blood; 64s and higher are known as fine wool.

The character of the wool was judged at the sides of the fleeces, this judging being done by specialists thoroughly trained and experienced in the judging of character of wool. This factor "character of fleece" consists of regularity of crimp, luster or brightness, and evenness of distribution of wool oil or grease from the inner to the outer part of the fleece or staple and throughout the various parts of

that portion of the fleece which is judged for character. This factor "character of fleece" was graded by what bureau sheep specialists have termed the "five count score system." The figure 1 was recorded for character that was judged as having a character of from 90.1 to 100 per cent perfect and the fleeces of this group were assigned a character value of 95 per cent. The group or grade 2 equaled an interval of 80.1 to 90 per cent with an assigned value of 85 per cent; grade 3 represented 70.1 to 80 or a group value of 75 per cent; grade 4 stood for 60.1 to 70 or a value of 65 per cent, and grade 5 was used to include the character values as low as or lower than 60 per cent, with an assigned value of 55 per cent. This lowest group, known as grade 5, seldom contained fleeces of a character value less than about 50 per cent, thus the interval for this grade was regarded as 50.1 to 60 per cent or an average of 55 per cent of perfect. With the spread of 10 per cent of value for each grade there could in theory be 10 different grades, but values for character of fleece that were lower than grade 5 were so very infrequent that further grade distinction beyond grade 5 was not of sufficient importance to make any worth-while impression on the statistical studies of this investigation. This same grading (or five count score) system was also used in the recording of values for the factors known as density of fleece, face covering of sheep, skin folds, and for the mutton factors of type, condition, back, rump, and leg. However, it will be noted in this bulletin that all these grade values for these various factors have been translated into percentage.

Density of fleece was judged by the touch of the hands of trained and experienced judges. For fleeces of unusual length they verified their decision by parting the fleeces and examining the apparent density of the fibers on the skin of the sheep. When a judge grasped a handful of the wool of the fleece on the back or side of the sheep the sensation of extreme fullness or density was experienced with the densest fleeces and when releasing the hand from the grasp the wool would promptly spring back into its original shape. The reverse of this condition was experienced with fleeces that were decidedly lacking in density—i. e., the judge when grasping at an open fleece low in density value would experience a sensation of emptiness or a lack of fullness. Specific tests have proved that judges who were thoroughly trained and experienced in the judging of the density of fleeces were able to render independent judgments that agreed or correlated to a relatively high degree, thus making it possible to determine specific degrees of density of these experimental fleeces with sufficient accuracy for the work of this investigation.

Face covering of the sheep was graded on the basis of a bare face being of greatest value and the extreme of covering or wool blindness being of lowest value. It is recognized that neither of these extremes is most acceptable to all or even a majority of Rambouillet sheep breeders, but this system of grading or evaluating face covering provided an efficient statistical method of recording the degree of face covering found. As practical range-sheep producers prefer freedom from wool blindness the extreme of freedom from face covering was given the highest value. Therefore, in reviewing the tables the reader will need to understand that the expression "per cent of perfect" in the case of face covering signifies "per cent of total absence of face covering." It was found that independent

decisions of the judges on face covering were in very high agreement, and the data on this factor are considered very reliable.

Skin folds of the sheep were graded on the basis of the absence of skin folds being of greatest value—i. e., the highest grade for this character of skin folds was given to the sheep that was smooth and without folds and the lowest grade to the sheep that was most heavily folded. The grades on the neck folds (skin folds on the neck of the sheep) were used for this study, although body folds were actually graded separately from the neck folds. The neck folds were regarded most satisfactory for use in this relationship study because normal Rambouillet sheep of the group studied that had any appreciable amount of skin folding were almost sure to show it on the neck. Some sheep that were smooth on the body had neck folds, but those smooth on the neck were almost sure to be smooth on the body. A special study was made of the correlation between neck and body folds on the same Rambouillet sheep, using approximately 90 individual ewes, and it was found that neck and body folds measure practically the same thing. While most practical sheep producers prefer absence of folds to a rather high degree, it is recognized that many breeders of purebred Rambouillet sheep are opposed to plain bodies absolutely free from any folds. As in the case of face covering, the system used for studying skin folds was designed to determine the facts, and it involves no prejudice whatever concerning the most satisfactory degree of folding.

The factor, body weight, is based upon the shorn-body weight of each ewe when a yearling. This weight was taken promptly after shearing. It was regarded as the most comparable and reliable weight taken during the life of a ewe.

Mutton type is the factor which relates to the general appearance of a sheep from the viewpoint of mutton conformation. The highest development of this mutton type requires a rectangular body outline. The back or top line must be approximately straight and the underline should approach a parallel to it. The body must be relatively deep and broad throughout. The legs and feet should be placed squarely under the body, and in length the legs should be well proportioned to the body. The neck should be snugly joined to the shoulders and only long enough to be in good proportion to the body. The head should be broad but well proportioned and carried with style and alertness. In all respects there should be a high degree of symmetry to the general appearance of the body and the sheep must be strictly typical of the Rambouillet breed.

Mutton condition is the factor which pertains to the degree of fatness. The highest grade of this factor admitted sheep that were fat enough to grade as choice on the slaughter market. Of course very few range sheep would grade as high as prime so that such of them as were found were grouped with those of the choice grade. This highest or choice grade has been assigned an average value of 95 per cent perfect. For breeding ewes a condition that would grade higher than choice is regarded as having no advantage. The second, or No. 2, grade has been assigned a value of 85 per cent and the grades medium, common, and cull were valued respectively as averaging 75, 65, and 55 per cent of perfect.

Mutton back is the factor that includes the entire back from the top of the shoulders or withers to the rear of the loin. High develop-

ment of the back requires straightness, strength, and ribs sufficiently well sprung to give full width to the back in good proportion to the rest of the body. The mutton rump of highest value must be broad, level, and full. Rambouillets, like most fine-wool sheep, have a tendency to a drooping conformation in the rump and a comparison of Tables 16 and 17 shows that the number of the ewes grading high in the rump was much less than the number that graded high in the back. Mutton leg, the last factor considered, was graded on the basis of the plumpness of the thigh. Table 18 shows that the proportion of these ewes that graded choice or 95 per cent perfect in leg is relatively lower than for the other mutton factors. Fullness of development in the leg of mutton sufficient to grade as high as choice is very hard to attain in fine-wool sheep. All the grades and values placed on these mutton factors were in strict accordance with those described for mutton condition.

AGE OF SHEEP

The sheep used were ewes from 1 to 7 years old, only an insignificant number being older than 7 years. Fleeces were taken from the yearlings when they averaged slightly more than a year old. These yearling fleeces averaged a growth of 407 days from the date of birth. The fleeces that were from ewes 2 years old or older were almost exactly of one year's growth, being sheared each year in the week that included June 1.

TABLE 1.—*Age of sheep in relation to other factors in wool production*

Factor	Age of sheep, in years							Total number of fleeces	Grand average
	1[1]	2	3	4	5	6	7 or older		
Fleece weight, unscoured:									
Number of fleeces	252	359	333	274	251	221	160	1,850	
Average weight, pounds	9.12	10.43	11.59	11.14	11.20	11.12	10.22		10.73
Per cent of grand average	85.00	97.20	108.01	103.82	108.38	103.63	95.25		100.00
Fleece weight, scoured:									
Number of fleeces	247	296	251	204	191	178	119	1,486	
Average weight, pounds	3.62	4.11	4.48	3.98	3.76	3.95	3.34		3.95
Per cent of grand average	91.65	104.05	113.42	100.76	95.19	100.00	84.56		100.00
Moisture driven off:									
Number of fleeces	247	296	251	204	191	178	119	1,486	
Average weight, pounds	0.40	0.43	0.49	0.50	0.51	0.47	0.45		0.46
Per cent of grand average	86.96	93.48	106.52	108.70	110.87	102.17	97.83		100.00
Grease:									
Number of fleeces	247	296	251	204	191	178	119	1,486	
Average weight, pounds	1.18	1.40	1.73	1.60	1.71	1.75	1.50		1.54
Per cent of grand average	76.62	90.91	112.34	103.90	111.04	113.64	97.40		100.00
Dirt:									
Number of fleeces	247	296	251	204	191	178	119	1,486	
Average weight, pounds	3.92	4.47	5.08	5.16	5.36	5.12	5.05		4.82
Per cent of grand average	81.33	92.74	105.39	107.05	111.20	106.22	104.77		100.00
Length of staple:									
Number of fleeces	248	298	256	217	194	180	123	1,516	
Average length, inches	2.48	2.31	2.25	2.17	2.06	2.02	1.92		2.21
Per cent of grand average	112.22	104.52	101.81	98.19	93.21	91.40	86.88		100.00
Character of fleece:									
Number of fleeces	248	301	255	217	194	180	116	1,511	
Average per cent of perfect	84.7	84.8	84.6	85.1	84.6	82.0	80.9		84.1
Per cent of grand average	100.71	100.83	100.48	101.19	100.59	97.50	96.20		100.00

[1] Reduce fleeces of yearlings to 365 days' growth by deducting 10 per cent from weights and length.

Reference to Table 1 shows that the average fleece weights increased with the age of the sheep up to 3 years of age and in general there was a decline in fleece weight after that age. The one exception was a very slight increase in the fleece weights of the 5-year-olds over those

of the 4-year-olds. Likewise, the scoured-fleece weights of these same fleeces were heaviest for the 3-year-old ewes, with a general decline after that age except that the fleeces of the 6-year-olds yielded an average of 0.19 pound of clean wool more than the 5-year-olds. (Fig. 10.)

The weight of moisture per fleece was least for the yearlings, and it advanced up to the age of 5 years and then declined. The weight of grease per fleece was least for the yearlings, and it advanced to the age of 3 years, declining rather sharply for 4-year-olds, rising abruptly for ewes that were 5 and 6 years old, and in the 119 fleeces from 7-year-old ewes it declined to slightly below the grand average for the entire group of 1,486 fleeces. The weights of dirt per fleece were least for yearlings, rising steadily to the age of 5 years and then declining.

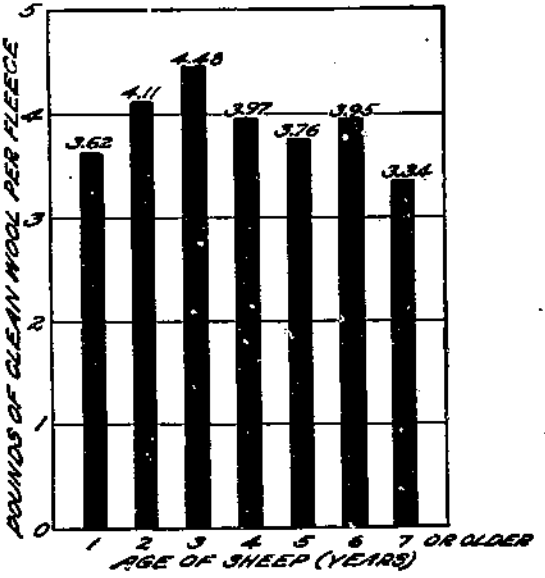


FIG. 10.—Age as a factor in the production of actual, clean wool. The 3-year-old ewes produced the fleeces that averaged the heaviest in clean wool, and the clean-wool fleece weights from ewes as old as or older than 7 years were the lightest. Note the steady increase in fleece weights of clean wool from yearlings to 3-year-olds and the general decline after the age of 3 years. The basic data are shown in Table 1

The length of staple was longest in the yearling fleeces. They averaged 12 per cent longer than the grand average of 2.21 inches for the entire group of 1,516 fleeces. As the age of the sheep advanced there was a steady decline in the length of staple, the 7-year-old ewes averaging only 1.92 inches or about 13 per cent less than the grand average length. This factor, length of staple, was influenced more by age than any of the other factors.

The character of the fleece was not greatly affected by age. However, the fleeces from ewes from 1 to 5 years old averaged slightly better than the grand average and those from ewes 6 and 7 years old were slightly less choice in character.

FLEECE WEIGHT

In analyzing the relationship of fleece weight to the various other factors in wool production the unscoured weights were studied separately from the scoured weights. Table 2 shows that as the weights of the unscoured fleeces increased their weights of scoured clean wool increased. This was also true of the separate weights of moisture, grease, and dirt per fleece as related to the unscoured-fleece weights. The unscoured fleeces that weighed the lightest had the shortest staple and those that weighed the heaviest had the longest staple, but between these extremes of weight and length there were some very

slight fluctuations, and in reality no important significance can be attached to this relationship of unscoured-fleece weight and length. It appears that this must be due to the heterogenous mixture of wool, moisture, grease, and dirt which makes up the unscoured fleece, for the clean-wool content of these fleeces is positively and quite strongly related to the length of staple as shown in Table 3. Likewise fineness and character of fleece have no significant relation to unscoured-fleece weights. Density was least in the lightweight fleeces and greatest in the heavy fleeces and there was a consistent increase in density with the increase in the weight of the unscoured fleeces. However, the increase in density was much less than the increase in weight.

Table 2 shows that in general the lighter unscoured fleeces yielded the higher percentage of clean wool and the heavier ones the lower percentage. The percentage of moisture was greatest in the unscoured fleeces weighing from 8 to 10 pounds, least in heavy fleeces weighing 13 to 14 pounds, and just above the average in those fleeces that weighed the least. Fleeces under 11 pounds (unscoured) contained more than the average amount of moisture and those weighing 11 pounds or more had less than the average amount of moisture. The percentage of grease was lowest in the lightest, unscoured fleeces and greatest in the heaviest fleeces, but it should be remembered that these are unscoured-fleece weights. Table 3 shows that this relationship reverses when the scoured, clean-fleece weight is related to the grease content. That is, the lightest scoured-fleece weights are very strongly associated with the largest percentage of grease when that percentage is based on the scoured-fleece weight and conversely the smallest percentage of grease, on this basis, is associated with the very heaviest scoured-fleece weights. Table 2 shows that when the percentage of dirt is based on the unscoured-fleece weight the lightest unscoured fleeces have the smallest percentage of dirt and the heaviest unscoured fleeces the largest percentage of dirt. However, this relationship is also reversed when the scoured weights of the fleeces are related to the percentage of dirt and when that percentage is based on the scoured weights. Table 3 shows that the proportion of the weight of dirt to the weight of clean wool is greatest for dirt in the lightweight scoured fleeces and greatest for clean wool in the heavyweight scoured fleeces. That is, the greatest proportion of dirt to clean wool came out of the fleeces having a light yield of clean wool, and, conversely, the smallest proportion of dirt to clean wool came out of the fleeces having a heavy yield of clean wool.

Table 2 shows, in the column for grand average, that the fleeces had 36.81 per cent clean wool, 4.29 per cent moisture (driven off), 14.35 per cent grease, and 44.83 per cent dirt. These percentages, which are based on the weights of unscoured fleeces, add to a slight fraction more than 100 per cent on account of using decimals only to the second digit in connection with the numerous operations in multiplication and division required in the computation of the grand-average weights of wool moisture, grease, and dirt per fleece.

TABLE 2.—*Fleece weight, unscoured, in relation to other factors in wool production*

Factor	Range and average weights in pounds of unscoured wool									Total number of fleeces	Grand average [1]
	6 to 6.99	7 to 7.99	8 to 8.99	9 to 9.99	10 to 10.99	11 to 11.99	12 to 12.99	13 to 13.99	14 or more		
	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5		
Fleece weight, scoured:											
Number of fleeces	27	72	174	261	320	278	181	102	81	1,496	
Average weight, pounds	2.72	2.92	3.33	3.52	3.92	4.20	4.38	4.78	5.19		3.95
Per cent of grand average	68.86	73.92	84.30	89.11	99.24	106.33	110.89	121.01	131.39		100.00
Per cent of average weight of unscoured fleeces	41.85	38.93	39.18	37.05	37.33	36.52	35.04	35.41	35.79		36.81
Moisture driven off:											
Number of fleeces	27	72	174	261	320	278	181	102	81	1,496	
Average weight, pounds	.28	.33	.39	.44	.46	.48	.52	.55	.60		.46
Per cent of grand average	60.87	71.74	84.78	95.65	100.00	104.35	113.04	119.57	130.43		100.00
Per cent of average weight of unscoured fleeces	4.31	4.40	4.59	4.63	4.38	4.17	4.16	4.07	4.14		4.29
Grease:											
Number of fleeces	27	72	174	261	320	278	181	102	81	1,496	
Average weight, pounds	.79	.94	1.09	1.32	1.48	1.66	1.88	2.03	2.36		1.54
Per cent of grand average	51.30	61.04	70.78	85.71	96.10	107.79	122.08	131.82	153.25		100.00
Per cent of average weight of unscoured fleeces	12.15	12.53	12.82	13.89	14.10	14.43	15.64	15.04	16.28		14.35
Dirt:											
Number of fleeces	27	72	174	261	320	278	181	102	81	1,496	
Average weight, pounds	2.80	3.33	3.80	4.23	4.64	5.12	5.68	6.15	6.87		4.81
Per cent of grand average	58.21	69.23	78.90	87.94	96.47	106.44	118.09	127.86	142.83		100.00
Per cent of average weight of unscoured fleeces	43.08	44.40	44.71	44.53	44.19	44.52	45.44	45.56	47.38		44.83
Length of staple:											
Number of fleeces	27	72	176	262	320	278	184	108	90	1,517	
Average length, inches	2.11	2.12	2.21	2.21	2.20	2.24	2.21	2.20	2.25		2.21
Per cent of grand average	95.48	95.93	100.00	100.00	99.55	101.36	100.00	99.55	101.81		100.00
Fineness of fleece:											
Number of fleeces	27	85	200	299	367	321	201	115	89	1,704	
Average fineness, spinning counts	61.93	61.69	61.41	61.17	61.21	61.01	61.29	61.32	61.10		61.24
Per cent of grand average	101.13	100.73	100.28	99.89	99.95	99.62	100.08	100.13	99.77		100.00
Character of fleece:											
Number of fleeces	26	69	175	263	319	278	183	108	90	1,511	
Average per cent of perfect	76.5	81.8	84.4	84.4	84.2	84.9	84.5	84.7	82.4		84.1
Per cent of grand average	90.96	97.27	100.36	100.36	100.12	100.95	100.48	100.71	97.98		100.00
Density of fleece:											
Number of fleeces	27	85	199	299	366	321	200	115	89	1,701	
Average per cent of perfect	80.6	83.2	84.4	84.5	85.4	85.4	86.6	86.7	87.2		85.3
Per cent of grand average	94.49	97.54	98.94	99.06	100.12	100.12	101.52	101.64	102.23		100.00

[1] The grand average unscoured-fleece weight of 1,496 fleeces used in the study of scoured-fleece weights and the weights of moisture, grease, and dirt per fleece was 10.73 pounds.

4328°—28——3

TABLE 3.—*Fleece weight, scoured, in relation to other factors in wool production*

Factor	Range and average weights in pounds of scoured wool						Total number of fleeces	Grand average [1]
	2 to 2.99	3 to 3.99	4 to 4.99	5 to 5.99	6 to 6.99	7 to 7.99		
	2.5	3.5	4.5	5.5	6.5	7.5		
Fleece weight, unscoured:								
Number of fleeces	175	673	482	140	22	4	1,496	
Average weight, pounds	8.70	10.13	11.56	12.66	13.95	14.25		10.73
Per cent of grand average	81.08	94.41	107.74	117.80	130.01	132.81		100.00
Per cent of average weight of scoured fleeces	348.00	289.43	256.89	230.18	214.62	190.00		271.65
Moisture driven off:								
Number of fleeces	175	673	482	140	22	4	1,496	
Average weight, pounds	.39	.45	.49	.51	.55	.55		.46
Per cent of grand average	84.78	97.83	106.52	110.87	119.57	119.57		100.00
Per cent of average weight of scoured fleeces	15.60	12.86	10.89	9.27	8.46	7.33		11.65
Grease:								
Number of fleeces	175	673	482	140	22	4	1,496	
Average weight, pounds	1.28	1.44	1.64	1.87	2.11	2.00		1.54
Per cent of grand average	83.12	93.51	106.49	121.43	137.01	129.87		100.00
Per cent of average weight of scoured fleeces	51.20	41.14	36.44	34.00	32.46	26.67		38.99
Dirt:								
Number of fleeces	175	673	482	140	22	4	1,496	
Average weight, pounds	4.27	4.73	5.02	5.03	5.50	6.75		4.81
Per cent of grand average	88.77	98.34	104.37	104.57	114.35	140.33		100.00
Per cent of average weight of scoured fleeces	170.80	135.14	111.56	91.45	84.62	90.00		121.77
Length of staple:								
Number of fleeces	175	658	468	137	18	4	1,460	
Average length, inches	1.95	2.15	2.31	2.38	2.44	2.43		2.29
Per cent of grand average	88.64	97.73	105.00	108.18	110.91	110.45		100.00
Fineness of fiber:								
Number of fleeces	154	608	454	117	18	3	1,354	
Average fineness, spinning counts	61.68	61.43	61.20	60.62	60.89	59.33		61.30
Per cent of grand average	100.62	100.21	99.84	98.89	99.33	96.79		100.00
Character of fleece:								
Number of fleeces	172	655	467	137	18	4	1,453	
Average character, per cent of perfect	80.8	83.5	86.2	85.2	85.6	77.5		84.2
Per cent of grand average	95.96	99.17	102.38	101.19	101.66	92.04		100.00
Density of fleece:								
Number of fleeces	154	608	455	117	17	3	1,354	
Average density, per cent of perfect	81.9	85.8	86.1	85.8	84.4	78.3		85.4
Per cent of grand average	95.90	100.47	100.82	100.47	98.83	91.69		100.00

[1] The grand average scoured-fleece weight of 1,496 fleeces used in the study of unscoured-fleece weights and the weights of moisture, grease, and dirt per fleece was 3.95 pounds.

Table 3 shows that the unscoured wool in these same 1,496 fleeces weighed 271.65 per cent, or about 2.72 times as much as the clean wool from them. The moisture driven off from these fleeces weighed 11.65 per cent as much as the clean wool in them. There was 38.99 per cent as much grease as clean wool and 121.77 per cent, or about 1.22 times, as much dirt as clean wool.

The influences of the scoured-fleece weight as shown in Table 3 indicate again that the fleece weights of the unscoured or greasy wool are positively and strongly related to the average weights of clean wool in them. The moisture in the fleeces increased as the weights of the clean wool increased, but the increase in moisture was much less than the increase in weight of clean wool. The grease increased as the weight of the clean wool increased, but the increase in grease was considerably less than the increase in the weight of clean wool, for again, by referring to Table 2 it will be seen that this relation is reversed when the grease content is expressed in a percentage based on the weight of clean wool. For example, the 175 fleeces that averaged a clean-wool weight of 2.5 pounds had, accord-

ing to Table 3, an average of 1.28 pounds of grease per fleece, which amounts to 51.2 per cent of the 2.5 pounds of clean wool. Again referring to Table 3 it will be noted that the four fleeces having the heaviest weight of clean wool and averaging 7.5 pounds had 2 pounds of grease per fleece, but this was only 26.67 per cent of the 7.5 pounds of actual wool. Thus, the proportion of grease to clean wool is nearly twice as much of grease for lightest scoured-fleece weights as for the heaviest ones. The old tradition of the heavy grease content being associated with heavy fleece weights of greasy, unscoured wool seems to hold in this investigation, but here one sees that when it is a matter of relating the proportion of grease to actual clean wool the tradition of favoring excess grease is not correct if one undertakes to calculate fleece yields on a scoured basis, which is of course the only right way to figure the actual yield of wool. In other words, the fleeces of this study which had the smallest weight of grease per pound of clean wool in the fleece were the ones that produced the heaviest yields of clean wool, and, conversely, the fleeces having the greatest weight of grease per pound of clean wool were the fleeces yielding the lightest weights of clean wool.

Table 3 reveals the fact that the lightest scoured-fleece weights were related with the heaviest proportion of greasy, unscoured wool, and consistent with this the heaviest scoured-fleece weights were associated with the lightest proportion of greasy wool. The 175 fleeces, averaging only 2.5 pounds of scoured wool, weighed before scouring 3.48 times as much as the clean wool in them. As the yield of clean wool per fleece increased, the proportion of the unscoured weight decreased and the 4 fleeces yielding an average of 7.5 pounds of clean wool weighed before scouring only 1.9 times as much as the clean wool which they contained.

The proportion of moisture to clean wool was about twice as large in the lightest scoured fleeces as it was in the heaviest, and substantially this same tendency will be noted in Table 3, for grease and for dirt.

MOISTURE IN WOOL

In the early stages of this investigation it was thought that the moisture in the wool was not of sufficient importance to warrant special consideration. It was, of course, recognized from the beginning that the weights of both greasy wool and scoured wool in order to be reliable required the drying of the wool to a considerable degree before taking the weights. In the analysis of the data it was promptly found that the weights of moisture driven off, in the standard drying of three hours at 50° C., were large enough to necessitate a definite accounting for this constituent of the fleece.

In general, Table 4 shows that the heavier weights of moisture per fleece were found in the heaviest fleeces, both unscoured and scoured, and in the fleeces that contained the heaviest weights of grease and of dirt. There seemed to be no important relation between moisture and length of staple. There was a very slight tendency for a trifle more moisture to be in the coarser fleeces than in the finer fleeces, but this was unimportant. The character of the fleeces did not seem to be associated with the moisture variations. There was an extremely slight tendency for the greater weight of moisture to be found in the denser fleeces, but this was so slight that it can not be regarded as important.

TABLE 4.—*Moisture in relation to other factors in wool production*

Factor	Range and average weights in fractions of a pound of moisture										Total number of fleeces	Grand average [1]
	Less than 0.10	0.10 to 0.19	0.20 to 0.29	0.30 to 0.39	0.40 to 0.49	0.50 to 0.59	0.60 to 0.69	0.70 to 0.79	0.80 to 0.89	0.90 or more		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95		
Fleece weights, unscoured:												
Number of fleeces	6	28	126	332	461	313	155	46	21	8	1,496	
Average weight, pounds	11.83	10.11	9.48	9.74	10.60	11.31	12.27	12.41	12.50	12.63		10.73
Per cent of grand average	110.25	94.22	88.35	90.77	98.79	105.41	114.35	115.66	116.50	117.71		100.00
Per cent of average weight of moisture	23,660.00	6,740.00	3,792.00	2,782.86	2,355.56	2,056.36	1,887.69	1,654.67	1,470.59	1,329.47		2,332.61
Fleece weights, scoured:												
Number of fleeces	6	28	126	332	461	313	155	46	21	8	1,496	
Average weight, pounds	4.83	4.21	3.72	3.63	3.85	4.08	4.41	4.59	4.79	4.88		3.95
Per cent of grand average	122.28	106.58	94.18	91.90	97.47	103.29	111.65	116.20	121.27	123.54		100.00
Per cent of average weight of moisture	9,660.00	2,806.67	1,488.00	1,037.14	855.56	741.82	678.46	612.00	563.53	513.68		858.70
Grease:												
Number of fleeces	6	28	126	332	461	313	155	46	21	8	1,496	
Average weight	1.75	1.50	1.36	1.39	1.54	1.56	1.82	1.84	1.89	1.56		1.54
Per cent of grand average	113.64	97.40	88.31	90.26	100.00	101.30	118.18	119.48	122.73	97.40		100.00
Per cent of average weight of moisture	3,500.00	1,000.00	544.00	397.14	342.22	283.64	280.00	245.33	222.35	157.89		334.78
Dirt:												
Number of fleeces	6	28	126	332	461	313	155	46	21	8	1,496	
Average weight, pounds	5.17	4.32	4.13	4.34	4.79	5.18	5.47	5.46	5.31	5.63		4.81
Per cent of grand average	107.48	89.81	85.86	90.23	99.58	107.69	113.72	113.51	110.40	117.05		100.00
Per cent of average weight of moisture	10,340.00	2,880.00	1,652.00	1,240.00	1,064.44	941.82	841.54	728.00	624.71	592.63		1,045.65
Length of staple:												
Number of fleeces	4	26	121	323	455	398	152	45	19	8	1,461	
Average length, inches	2.55	2.24	2.21	2.19	2.18	2.21	2.27	2.27	2.30	2.24		2.21
Per cent of grand average	115.38	101.36	100.00	99.10	98.64	100.00	102.71	102.71	104.07	101.36		100.00
Fineness of fiber:												
Number of fleeces	6	26	111	298	413	287	144	44	19	8	1,356	
Average fineness, spinning counts	61.67	60.54	61.66	61.27	61.45	61.32	60.94	60.77	60.84	61.25		61.30
Per cent of grand average	100.60	98.76	100.59	99.95	100.24	100.03	99.41	99.14	99.25	99.92		100.00
Character of fleece:												
Number of fleeces	4	25	122	318	451	309	152	45	19	8	1,453	
Average character, per cent of perfect	85.0	83.4	82.9	84.2	84.3	84.7	84.2	83.0	81.3	91.2		84.2
Per cent of grand average	100.95	99.05	98.46	100.00	100.12	100.59	100.00	98.57	96.56	108.31		100.00
Density of fleece:												
Number of fleeces	6	25	110	298	413	287	144	44	19	8	1,354	
Average density, per cent of perfect	88.3	84.2	83.1	85.3	85.0	85.3	86.7	84.1	85.0	86.2		85.4
Per cent of grand average	103.40	98.59	97.31	99.88	100.59	99.88	101.52	98.48	99.53	100.94		100.00

[1] The grand average weight of moisture per fleece for the 1,496 fleeces used in the study of the weights of fleeces and of the grease and dirt per fleece was 0.46 pound.

Table 4 shows that as the weight of moisture per fleece increased the proportionate weights of unscoured wool, scoured wool, grease, and dirt decreased. For example, the 6 driest fleeces had 236.6 times as much unscoured wool, 96.6 times as much scoured wool, 35 times as much grease, and 103.4 times as much dirt as the weight of moisture driven off in the drying processes. Comparing with this the 8 wettest fleeces, one finds that they had only 13.29 times as much unscoured wool, 5.14 times as much clean wool, 1.58 times as much grease, and 5.93 times as much dirt as moisture. In calculating the grand average for all the 1,496 fleeces one finds that they contained 0.46 pound of moisture (driven off) per fleece and that the average of all these fleeces contained 23.33 times as much unscoured wool, 8.59 times as much scoured wool, 3.35 times as much grease, and 10.46 times as much dirt per fleece as this 0.46 pound of moisture per fleece that was dried out of the unscoured wool.

GREASE IN WOOL

When grouping the fleeces on the weights of grease they contain, as reported in Table 5, it was found that as the weight of grease per fleece increased there was a general tendency for the weights of unscoured wool, scoured wool, moisture, and dirt to increase but for the length of the staple to get slightly shorter. Fineness of the fiber was practically unaffected. The fleeces having the greatest weight of grease were a trifle less choice in character but slightly more dense.

TABLE 5.—*Grease in relation to other factors in wool production*

Factor	Range and average weights in pounds of grease								Total number of fleeces	Grand average[1]
	Less than 0.50	0.5 to 0.99	1 to 1.49	1.5 to 1.99	2 to 2.49	2.5 to 2.99	3 to 3.49	3.5 to 3.99		
	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75		
Fleece weight, unscoured:										
Number of fleeces	16	200	591	413	181	69	20	6	1,496	
Average weight, pounds	9.13	9.02	10.06	11.34	12.17	13.21	13.55	13.50		10.73
Per cent of grand average	85.09	84.06	93.76	105.68	113.42	123.11	126.28	125.82		100.00
Per cent of average weight of grease	3,652.00	1,202.67	804.80	648.00	540.89	480.36	416.92	360.00		696.75
Fleece weight, scoured:										
Number of fleeces	16	200	591	413	181	69	20	6	1,496	
Average weight, pounds	3.63	3.53	3.81	4.05	4.28	4.75	4.40	4.33		3.95
Per cent of grand average	91.90	89.37	96.46	102.53	108.35	120.25	111.39	109.62		100.00
Per cent of average weight of grease	1,452.00	470.67	304.80	231.43	190.22	172.73	135.38	115.47		256.49
Moisture driven off:										
Number of fleeces	16	200	591	413	181	69	20	6	1,496	
Average weight, pounds	.38	.40	.45	.48	.50	.49	.54	.53		.46
Per cent of grand average	82.61	86.96	97.83	104.35	108.70	106.52	117.39	115.22		100.00
Per cent of average weight of grease	152.00	53.33	36.00	27.43	22.22	17.82	16.62	14.13		29.87
Dirt:										
Number of fleeces	16	200	591	413	181	69	20	6	1,496	
Average weight, pounds	4.69	4.30	4.55	5.06	5.33	5.50	5.40	5.33		4.81
Per cent of grand average	97.51	89.40	94.59	105.20	110.81	114.35	112.27	110.81		100.00
Per cent of average weight of grease	1,876.00	573.33	364.00	289.14	236.89	200.00	166.15	142.13		312.34
Length of staple:										
Number of fleeces	16	192	580	405	178	65	19	6	1,461	
Average length, inches	2.55	2.26	2.25	2.17	2.11	2.20	2.06	2.05		2.21
Per cent of grand average	115.38	102.26	101.81	98.19	95.48	99.55	93.21	92.76		100.00
Fineness of fleece:										
Number of fleeces	16	186	547	367	159	57	18	6	1,356	
Average fineness, spinning counts	61.13	61.63	61.36	61.13	61.28	60.91	61.78	59.33		61.30
Per cent of grand average	99.72	100.54	100.10	99.72	99.97	99.36	100.78	96.79		100.00
Character of fleece:										
Number of fleeces	16	188	575	406	178	65	19	6	1,453	
Average character, per cent of perfect	81.9	83.4	85.2	84.5	82.8	82.8	78.2	78.3		84.2
Per cent of grand average	97.27	99.05	101.19	100.36	98.34	98.34	92.87	92.99		100.00
Density of fleece:										
Number of fleeces	16	186	546	366	159	57	18	6	1,354	
Average density, per cent of perfect	81.9	84.6	84.7	85.8	87.5	86.8	90.0	85.0		85.4
Per cent of grand average	95.90	99.06	99.18	100.47	102.46	101.64	105.39	99.53		100.00

[1] The grand average weight of grease per fleece for the 1,496 fleeces used in the study of the fleece weights and weights of moisture and dirt per fleece was 1.54 pounds.

In drawing conclusions from the data of Table 5 reference is made to the fact that the fleeces with smallest weights of grease per fleece have the largest proportions of wool, moisture, and dirt. The 16 fleeces having the smallest weight of grease had 36.52 times as much unscoured wool, 14.52 times as much clean wool, 1.52 times as much moisture, and 18.76 times as much dirt as the average 0.25 pound of grease they contained. These proportions decrease without any group reversals until in the 6 fleeces with the heaviest weights of grease one finds only 3.6 times as much unscoured wool, 1.15 times as much scoured wool, 0.14 times as much moisture, and 1.42 times as much dirt as the average 3.75 pounds of grease per fleece. The 1,496 fleeces averaged 6.97 times as much greasy wool, 2.56 times as much clean wool, 0.3 times as much moisture, 3.12 times as much dirt as the 1.54 pounds of grease in the average fleece.

A grouping of these same 1,496 fleeces on the basis of percentage is shown in Figure 11. This percentage is, of course, based on the unscoured-fleece weights. These 1,496 fleeces averaged 3.95 pounds of clean wool, whereas the 534 fleeces of this group that had an average of 10 per cent grease averaged 3.97 pounds of clean wool, or only 0.51 per cent above the average for the 1,496 fleeces. The 656 fleeces averaging 15 per cent grease had an average of 3.89 pounds of clean wool, or 1.52 per cent less than the average. The 267 fleeces averaging 20 per cent grease had an average of 4.08 pounds of clean wool, which was the highest average of clean-wool weights and 3.29 per cent greater than the average of the 1,496 fleeces. The fleeces having 20 per cent grease were apparently greasy enough for maximum yields of scoured wool, because when one accounts for the other 39 fleeces averaging 25 per cent grease they show yields of only 3.71 pounds of scoured wool per fleece, which is 6.08 per cent less than the average for all the 1,496 fleeces. In the light of these findings about grease in wool it appears that there is more danger of having the fleeces of Rambouillets of the intermountain range country too greasy than not greasy enough. This investigation produced no reassuring evidence that the presence of oil in the fleece has much to do with such qualities as fineness of fiber or the character of the

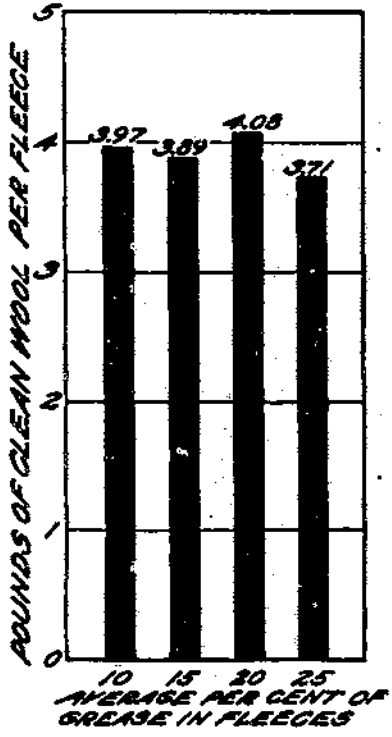


FIG. 11.—Grease as a factor in the production of actual, clean wool. These results indicate that for range Rambouillet ewes the percentage of grease in the fleece does not greatly influence their weights of clean wool, and that it is not profitable, when dealing on a clean-wool basis, to have more than about 20 per cent of grease in the unscoured fleece. Here one sees that the weight of clean wool per fleece declined three-eighths of a pound when the grease content averaged 25 instead of 20 per cent

fleece. In fact such minor influences as were discovered in this connection are negative. That is, excess grease seems to be a very slight hindrance instead of a help in the matter of getting finer fiber or more excellent character in the fleece. It appears to be associated with a little more density, but this influence in favor of density is not quite so great as the hindrance of excess grease to length of staple.

There is little doubt that an abnormally high grease content may make the fleece feel denser than it actually is. Such fleeces should be examined with special care.

When the woolgrower selects sheep on the basis of the grease content of their fleeces he, in getting down to fine points, looks closely into the parted fleeces to get an idea of the apparent proportion of grease to wool (actual wool). Table 3 reports these proportions as they were found in this study, and the data in that table very clearly indicate that if the aim is heavy weights of clean wool per fleece then this proportion of grease should be relatively small rather than too large, but of course sufficient for satisfactory health, density, and protection of the fleeces.

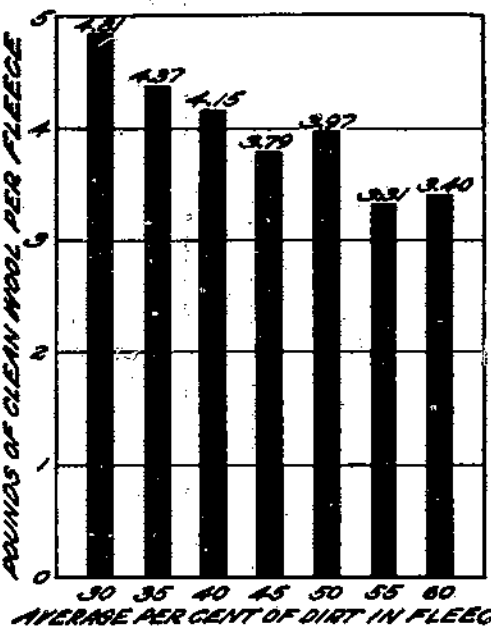


FIG. 12.—Dirt as a factor in the production of actual, clean wool. These results indicate that in general the cleaner fleeces are the ones that yield the heaviest weights of clean wool

DIRT IN WOOL

The weight of dirt per fleece bears a positive and important relation to the unscoured fleece weight. According to Table 6 the weight of the dirt per fleece increased as the weight of the unscoured wool per fleece increased. Dirt also bears this relation to scoured-fleece weights and to the weights of moisture and grease per fleece, although not to such a high degree as for the unscoured-fleece weights. (Fig. 12.) This, of course, is due to the fact that dirt makes up such a large portion in the weight of the unscoured fleece. In referring to the grand averages in Table 2, one observes that the 1,496 fleeces average 44.83 per cent dirt. Of the four different constituents that make up the unscoured wool of these fleeces, dirt was the heaviest, being heavier, even, than the clean wool of the fleeces which amounted to 36.81 per cent. Further study of the grand averages shows that the dirt weighed more than 3 times as much as the grease and 10 times as much as the moisture that was dried out of the wool.

TABLE 6.—*Dirt in relation to other factors in wool production*

Factor	Range and average weights in pounds of dirt								Total number of fleeces	Grand average [1]
	2 to 2.99 2.5	3 to 3.99 3.5	4 to 4.99 4.5	5 to 5.99 5.5	6 to 6.99 6.5	7 to 7.99 7.5	8 to 8.99 8.5	9 or more 9.5		
Fleece weight, unscoured:										
Number of fleeces	46	322	562	340	152	62	9	3	1,496	
Average weight, pounds	7.57	9.62	10.43	11.73	12.66	13.73	14.28	14.50		10.73
Per cent of grand average	70.55	84.06	97.20	109.32	117.99	127.96	133.08	135.14		100.00
Per cent of weight of dirt	302.80	257.71	231.78	213.27	194.77	183.07	168.00	152.63		223.08
Fleece weight, scoured:										
Number of fleeces	46	322	562	340	152	62	9	3	1,496	
Average weight, pounds	3.26	3.71	3.94	4.13	4.07	4.26	4.72	4.59		3.95
Per cent of grand average	82.53	93.92	99.75	104.56	103.04	107.85	119.49	113.92		100.00
Per cent of weight of dirt	130.40	106.00	87.56	75.09	62.62	56.80	55.53	47.37		82.12
Moisture driven off:										
Number of fleeces	46	322	562	340	152	62	9	3	1,496	
Average weight, pounds	.32	.41	.46	.48	.54	.56	.64	.45		.46
Per cent of grand average	69.57	89.13	100.00	104.35	117.39	121.74	139.13	97.83		100.00
Per cent of weight of dirt	12.80	11.71	10.22	8.73	8.31	7.47	7.53	4.74		9.56
Grease:										
Number of fleeces	46	322	562	340	152	62	9	3	1,496	
Average weight, pounds	1.18	1.28	1.51	1.73	1.77	1.76	1.86	1.42		1.54
Per cent of grand average	76.62	83.12	98.05	112.34	114.94	114.29	120.78	92.21		100.00
Per cent of weight of dirt	47.20	36.57	33.56	31.45	27.23	23.47	21.88	14.95		32.02
Length of staple:										
Number of fleeces	45	312	548	331	151	62	9	3	1,461	
Average length, inches	2.20	2.28	2.23	2.18	2.08	2.11	2.02	1.97		2.21
Per cent of grand average	99.55	103.17	100.90	98.64	94.12	95.48	91.40	89.14		100.00
Fineness of fleece:										
Number of fleeces	42	303	502	310	129	59	8	2	1,355	
Average fineness, spinning counts	61.67	61.29	61.23	61.10	61.53	62.00	62.00	63.33		61.30
Per cent of grand average	100.60	99.98	99.89	99.67	100.38	101.14	101.14	103.31		100.00
Character of fleece:										
Number of fleeces	44	310	545	329	151	62	9	3	1,453	
Average character, per cent of perfect	81.1	85.0	84.5	83.8	82.8	86.0	79.4	85.0		84.2
Per cent of grand average	96.32	100.95	100.36	99.52	98.34	102.14	94.30	100.95		100.00
Density of fleece:										
Number of fleeces	42	303	500	310	129	59	8	3	1,354	
Average density, per cent of perfect	81.4	84.9	85.0	86.1	87.1	87.7	85.0	85.0		85.4
Per cent of grand average	95.32	99.41	99.53	100.82	101.99	102.69	99.53	99.53		100.00

[1] The grand average weight of dirt per fleece for the 1,496 fleeces used in the study of the fleece weights and weights of moisture and grease per fleece, was 4.81 pounds.

Table 6 shows that as the weight of the dirt per fleece increases the proportionate weights of unscoured wool, scoured wool, moisture, and grease diminish. The grand average column of Table 6 shows that the 1,496 fleeces contained 4.81 pounds of dirt per fleece. This same column shows that the unscoured weights of these fleeces were 2.23 times as great as the weight of the dirt in them. There was 82.12 per cent as much clean wool as dirt, 9.56 per cent as much moisture, and 32.02 per cent as much grease as there was of dirt per fleece. It should be kept well in mind that these fleeces were produced on ranges typical of the intermountain region of the West. The soil where the sheep grazed is of a lava-ash formation and is not so heavy as the sand and some other soils of the range country. The fleeces in this study, therefore, contained lighter weights of dirt than some fleeces produced in parts of the range country where heavier soil and sand storms load the fleeces with greater weights of dirt than occurred near Dubois, Idaho. On the other hand these fleeces were carrying more dirt than similar fleeces produced in the bluegrass region of the farming States. However, on the whole these fleeces were typical of rather a large portion of the western range wools of the intermountain region.

The data of Table 6 indicate that greater weights of dirt were slightly associated with shorter staple. The fineness and character of the wool did not seem to be appreciably associated with variation in dirt content, but there was a little tendency for the fleeces having the greatest weights of dirt to be the most dense. In the examination of such fleeces the same care should be taken that was previously discussed in connection with high grease content.

LENGTH OF STAPLE

Breeders of Rambouillet sheep in the West are generally aware of the difficulties of producing a satisfactory length of staple in one year's growth under practical range conditions. The data in Table 7 indicate the very strong tendency for the ewes of this study to produce fleeces with staple only 2.1 to 2.5 inches long. It requires vigilance in breeding and range management to produce with Rambouillets a staple of wool that in one year's growth will exceed 2.5 inches. About one-sixth of the fleeces reported in Table 7 measured more than 2.5 inches in staple. The bureau is conducting further studies to determine the possibility of producing longer staple with Rambouillet sheep.

TABLE 7.—*Length of staple in relation to other factors in wool production*

Factor	Range and average lengths of staple, in inches							Total number of fleeces	Grand average
	1.5 or less	1.6 to 2.0	2.1 to 2.5	2.6 to 3.0	3.1 to 3.5	3.6 to 4.0	4.1 to 4.5		
	1.3	1.8	2.3	2.8	3.3	3.8	4.3		
Fleece weight, unscoured:									
Number of fleeces	29	498	740	223	25	1	1	1,517	
Average weight, pounds	9.84	10.72	10.82	10.67	11.34	10.5	14.5		10.76
Per cent of grand average	91.45	99.63	100.56	99.16	105.39	97.58	134.76		100.00
Fleece weight, scoured:									
Number of fleeces	32	483	713	207	25	1		1,461	
Average weight, pounds	3.28	3.61	4.05	4.30	4.82	4.5			3.94
Per cent of grand average	83.25	91.62	102.79	109.14	122.34	114.21			100.00
Moisture driven off:									
Number of fleeces	27	482	713	213	25	1		1,461	
Average weight, pounds	.44	.46	.47	.46	.51	.45			.46
Per cent of grand average	95.65	100.00	102.17	100.00	110.87	97.83			100.00
Grease:									
Number of fleeces	27	482	713	213	25	1		1,461	
Average weight, pounds	1.62	1.66	1.49	1.42	1.47	1.75			1.54
Per cent of grand average	105.19	107.79	96.75	92.21	95.45	113.64			100.00
Dirt:									
Number of fleeces	27	482	713	213	25	1		1,461	
Average weight, pounds	4.69	5.02	4.82	4.43	4.42	3.5			4.82
Per cent of grand average	97.30	104.15	100.00	91.91	91.70	72.61			100.00
Fineness of fiber:									
Number of fleeces	19	433	695	213	23	1	1	1,385	
Average fineness, spinning counts	60.63	61.61	61.33	60.79	60.52	50	64		61.31
Per cent of grand average	98.89	100.49	100.03	99.15	98.71	81.55	104.39		100.00
Character of fleece:									
Number of fleeces	29	496	739	222	25	1	1	1,513	
Average character, per cent of perfect	75.0	81.2	85.4	87.0	89.4	75	95		84.1
Per cent of grand average	89.18	96.55	101.55	103.45	106.30	89.18	112.96		100.00
Density of fleece:									
Number of fleeces	19	431	695	213	23	1	1	1,383	
Average density, per cent of perfect	85.5	86.9	85.2	83.4	81.5	85	95		85.4
Per cent of grand average	100.12	101.76	99.77	97.66	95.43	99.53	111.24		100.00

As was explained under the heading of fleece weight, length of staple shows that its influence on scoured weights is important, but its influence on unscoured fleece weights was not important in this study, as shown in Table 7. Of course, the fleeces of the group with the very shortest staple measuring not more than 1.5 inches were the lightest both scoured and unscoured, but the majority of the unscoured-fleece weights are not much affected by length while the rise in clean fleece weight is well associated with the increase in length of staple. (Fig. 13.) Moisture in the wool seems to be generally unaffected

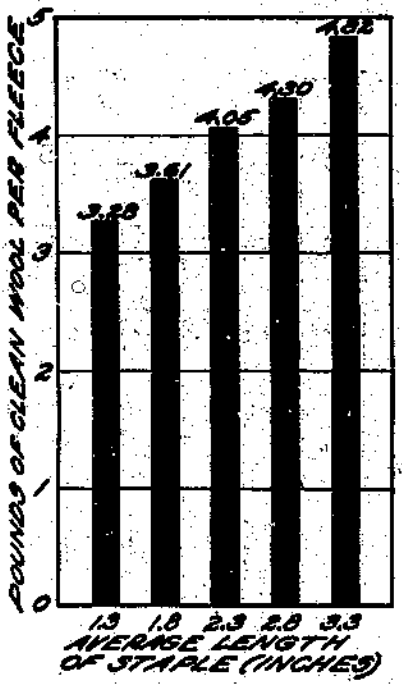


FIG. 13.—Length of staple as a factor in the production of actual, clean wool. There was a definite tendency for longer staple to occur in the fleeces yielding the greatest weights of clean wool. The basic data are shown in Table 7. Woolgrowers should be able to increase profits by breeding and feeding their sheep for longer staple

by length. On the whole the fleeces having longer staple contained a little less grease and dirt and were more satisfactory in character; they were a trifle less dense but this difference in density was not very important. The fineness of fiber was practically unaffected by the length of the staple. A study of Table 7 shows that length of staple is a substantial help for getting greater weights of actual wool and less grease and dirt in the fleeces. This fact is of much greater importance to profits in modern wool growing than the very small decline in density of fleece that was found to be associated with increased length of staple.

FINENESS OF FIBER

As the fibers of the wool became finer (of smaller diameter) there was a very slight tendency for the fleece weights of unscoured wool and clean wool (fig. 14) to decrease; there were also slightly lighter weights of moisture per fleece. Fineness was practically unassociated with grease content and length of staple. The finer fleeces had a trifle the best character and were a little the most dense. In general,

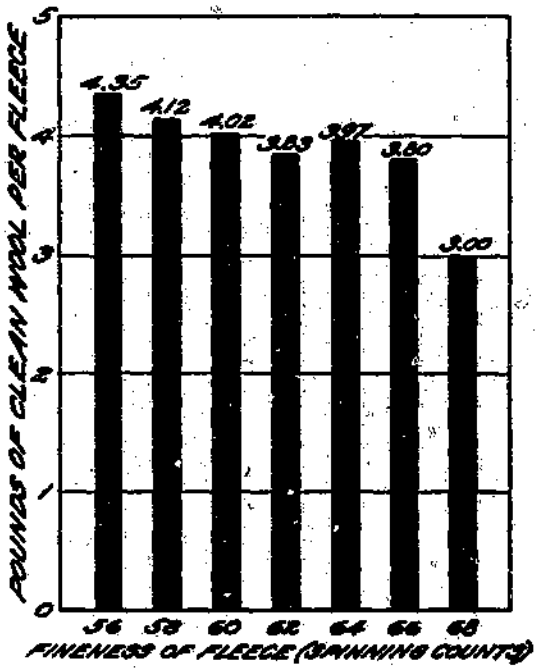


FIG. 14.—Fineness of fleece as a factor in the production of actual, clean wool. The general tendency here shown is for the finer fleeces to yield lighter weights of clean wool, although fleeces of 64s and 66s fineness were slightly above the general line of regression. The basic data will be found in Table 8

the influence of the fineness of fiber on any of the other characters did not amount to very much, as is shown in Table 8. Wool having a spinning count of 56s is classified on the American market as three-eighths-blood wool; 58s and 60s are one-half blood; 62s is midway between one-half blood and strictly fine wool, or what is commonly termed "fine medium," and 64s, 66s, and 68s are strictly fine wool.

TABLE 8.—*Fineness of fiber in relation to other factors in wool production*

Factor	Average fineness, in spinning counts									Total number of fleeces	Grand average
	50s or coarser	54s	56s	58s	60s	62s	64s	66s	68s or finer		
Fleece weight, unscoured:											
Number of fleeces	1	1	27	222	503	638	247	55	10	1,704	
Average weight, pounds	10.5	9.5	10.61	11.06	10.72	10.56	10.81	10.97	8.6		10.71
Per cent of grand average	98.04	88.70	99.07	103.27	100.09	98.60	100.93	102.43	80.30		100.00
Fleece weight, scoured:											
Number of fleeces	1	1	20	177	389	500	208	50	10	1,356	
Average weight, pounds	4.5	3.5	4.35	4.12	4.02	3.83	3.97	3.80	3.0		3.94
Per cent of grand average	114.21	88.83	110.41	104.57	102.03	97.21	100.76	96.45	76.14		100.00
Moisture driven off:											
Number of fleeces	1	1	20	177	389	500	208	50	10	1,356	
Average weight, pounds	.45	.35	.45	.49	.46	.46	.46	.46	.38		.46
Per cent of grand average	97.83	76.09	97.83	106.52	100.00	100.00	100.00	100.00	82.61		100.00
Grease:											
Number of fleeces	1	1	20	177	389	500	208	50	10	1,356	
Average weight, pounds	1.75	1.25	1.28	1.62	1.55	1.51	1.50	1.46	1.10		1.52
Per cent of grand average	115.13	82.24	84.21	106.58	101.97	99.34	98.68	96.05	72.37		100.00
Dirt:											
Number of fleeces	1	1	20	177	389	500	208	50	10	1,356	
Average weight, pounds	3.5	4.5	4.60	4.85	4.75	4.73	5.00	5.20	3.80		4.80
Per cent of grand average	72.92	93.75	95.83	101.04	98.96	98.54	104.17	108.33	79.17		100.00
Length of staple:											
Number of fleeces	1	1	20	181	396	512	211	53	10	1,385	
Average length, inches	3.80	1.80	2.30	2.28	2.28	2.19	2.17	2.15	2.35		2.23
Per cent of grand average	170.40	80.72	103.14	102.24	102.24	98.23	97.31	96.41	105.38		100.00
Character of fleece:											
Number of fleeces	1	1	20	180	395	511	211	53	10	1,382	
Average character, per cent of perfect	75.0	55.0	83.5	82.3	83.3	84.9	85.8	86.1	90.0		84.3
Per cent of grand average	88.97	65.24	99.05	97.63	98.81	100.71	101.78	102.14	106.76		100.00
Density of fleece:											
Number of fleeces	1	1	14	101	245	300	123	32	10	827	
Average density, per cent of perfect	85.0	95.0	86.4	82.8	85.0	85.4	88.8	85.3	80.0		85.5
Per cent of grand average	99.42	111.11	101.05	96.84	99.42	99.88	103.86	99.77	100.58		100.00

CHARACTER OF FLEECE

The factor, character of fleece, seemed to bear its most important relationship to the length of staple. Table 9 shows that with the improvement in the character of the fleeces they improved in length of staple. As mentioned in the preceding paragraph, character was slightly associated with the finer fiber and there was a little tendency for the scoured-fleece weights to increase as the character of the wool improved. The choicest character was very slightly associated with slightly less grease per fleece. Otherwise, the influence of character was unimportant.

TABLE 9.—*Character of fleece in relation to other factors in wool production*

Factor	Range and average character in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	441	600	377	80	13	1,511	
Average weight, pounds	10.95	10.74	10.52	10.95	11.73		10.77
Per cent of grand average	101.67	99.72	97.68	101.67	108.91		100.00
Fleece weight, scoured:							
Number of fleeces	425	583	360	74	11	1,453	
Average weight, pounds	4.13	3.95	3.73	3.72	4.32		3.95
Per cent of grand average	104.56	100.00	94.43	94.18	109.37		100.00
Moisture driven off:							
Number of fleeces	425	583	360	74	11	1,453	
Average weight, pounds	.47	.47	.45	.45	.55		.46
Per cent of grand average	102.17	102.17	97.83	97.83	119.57		100.00
Grease:							
Number of fleeces	425	583	360	74	11	1,453	
Average weight, pounds	1.49	1.55	1.53	1.79	1.52		1.54
Per cent of grand average	96.75	100.65	99.35	116.23	98.70		100.00
Dirt:							
Number of fleeces	425	583	360	74	11	1,453	
Average weight, pounds	4.87	4.76	4.79	5.08	5.77		4.82
Per cent of grand average	101.04	98.76	99.38	105.39	119.71		100.00
Length of staple:							
Number of fleeces	442	601	377	80	13	1,513	
Average length, inches	2.34	2.21	2.12	1.99	1.80		2.21
Per cent of grand average	105.88	100.00	95.93	89.59	81.45		100.00
Fineness of fiber:							
Number of fleeces	408	557	337	69	11	1,382	
Average fineness, spinning counts	61.74	61.24	61.09	60.64	58.73		61.31
Per cent of grand average	100.70	99.89	99.64	99.23	95.79		100.00
Density of fleece:							
Number of fleeces	408	557	336	68	11	1,380	
Average density, per cent of perfect	85.8	85.7	84.9	84.1	83.9		85.5
Per cent of grand average	100.35	100.23	99.30	98.36	100.47		100.00

DENSITY OF FLEECE

As the density of the fleeces increased the fleece weights increased, both unscoured and scoured (fig. 15); they also increased in weight of grease and dirt and to a slight extent in the weight of moisture; they were a little shorter in staple and on the whole a little finer in fiber. The relationship of density to character of fleece was unimportant. A study of Table 10 shows that none of the influences of density of fleece on the other factors were of more than moderate importance. Of the 1,384 fleeces only 2 were in the group averaging as low as 55 per cent of a perfect density; thus the more abrupt drop of that group in weight of clean wool can not be taken as final; nevertheless it is in general alignment with the trend. Considering the other four groups of fleeces averaging from 65 to 95 per cent in density, the drop of 1 per cent in density coincides with a drop of about one one-hundredths of a pound of clean wool per fleece.

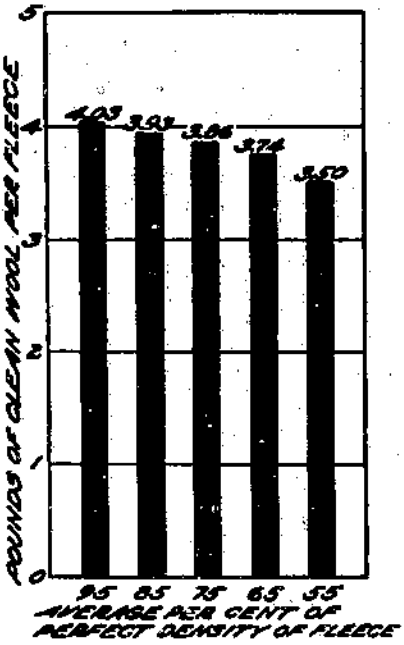


FIG. 15.—Density of fleece as a factor in the production of actual, clean wool. As the fleeces became less dense or more open the weights of clean wool per fleece averaged slightly less. While density is worthy of consideration, length of staple is more important, as is shown in Figure 13. Basic data for density are given in Table 10

TABLE 10.—*Density of fleece in relation to other factors in wool production*

Factor	Range and average density in per cent of perfect—					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	558	680	420	38	5	1,701	
Average weight, pounds	11.09	10.56	10.52	10.13	10.30		10.71
Per cent of grand average	103.55	98.60	98.23	94.56	96.17		100.00
Fleece weight, scoured:							
Number of fleeces	458	530	335	29	2	1,354	
Average weight, pounds	4.03	3.93	3.86	3.74	3.5		3.94
Per cent of grand average	102.28	99.75	97.97	94.92	88.83		100.00
Moisture driven off:							
Number of fleeces	458	530	335	29	2	1,354	
Average weight, pounds	.48	.46	.45	.50			.47
Per cent of grand average	102.13	97.87	97.87	95.74	106.38		100.00
Grease:							
Number of fleeces	458	530	335	29	2	1,354	
Average weight, pounds	1.66	1.42	1.52	1.27	1.25		1.52
Per cent of grand average	109.21	93.42	100.00	83.55	82.24		100.00
Dirt:							
Number of fleeces	458	530	335	29	2	1,354	
Average weight, pounds	4.99	4.73	4.68	4.47	4.5		4.80
Per cent of grand average	103.96	98.54	97.50	93.13	93.75		100.00
Length of staple:							
Number of fleeces	469	540	341	30	3	1,383	
Average length, inches	2.12	2.30	2.25	2.26	2.27		2.23
Per cent of grand average	95.07	103.14	100.90	101.35	101.79		100.00
Fineness of fiber:							
Number of fleeces	287	317	203	18	2	827	
Average fineness, spinning counts	61.55	61.50	60.71	61.78	57.0		61.32
Per cent of grand average	100.38	100.29	99.01	100.75	92.95		100.00
Character of fleece:							
Number of fleeces	469	541	337	30	3	1,380	
Average character, per cent of perfect	84.0	85.5	83.4	79.0	78.3		84.3
Per cent of grand average	99.64	101.42	98.93	93.71	92.88		100.00

FACE COVERING OF SHEEP

The numbers of fleeces in the various groups reported in Table 11 indicate the very strong tendency for the Rambouillet ewes in this study to have considerable covering of wool over the face. As already mentioned these ewes were purebred and typical Rambouillets and it is believed that the following facts about their face covering may be broadly applied to the purebred or high-grade Rambouillet sheep raised in the United States. Those with the barest faces had heavier fleece weights, both unscoured and scoured, than those having heavily covered faces; their fleeces also contained more moisture and grease but less dirt. Between these extremes of bareness of face and the very heavy wool covering there are some fluctuations in the intermediate groups; furthermore, the numbers of ewes having the heaviest face covering (70 per cent or lower freedom from covering) being more numerous than those having only a moderate to light amount of face covering (70.1 per cent or higher freedom from covering), the barefaced ewes are too few to permit the correlations for face covering as reported in Table 19 to be of important significance.

TABLE 11.—*Face covering of sheep in relation to other factors in wool production*

Factor	Range and average face covering of sheep in per cent of absence of face covering					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	212	137	306	281	775	1,711	
Average weight, pounds	10.94	11.15	11.04	10.27	10.72		10.76
Per cent of grand average	101.67	103.62	102.60	95.45	99.63		100.00
Fleece weight, scoured:							
Number of fleeces	173	110	230	208	644	1,365	
Average weight, pounds	4.08	4.08	4.13	3.82	3.88		3.96
Per cent of grand average	103.03	103.03	104.29	96.46	97.98		100.00
Moisture driven off:							
Number of fleeces	173	110	230	208	644	1,365	
Average weight, pounds	.49	.48	.48	.44	.46		.47
Per cent of grand average	104.26	102.13	102.13	93.62	97.87		100.00
Grease:							
Number of fleeces	173	110	230	208	644	1,365	
Average weight, pounds	1.62	1.58	1.71	1.37	1.47		1.53
Per cent of grand average	108.50	103.27	111.76	89.54	96.08		100.00
Dirt:							
Number of fleeces	173	110	230	208	644	1,365	
Average weight, pounds	4.72	5.06	4.86	4.48	4.94		4.84
Per cent of grand average	97.52	104.55	100.41	92.56	102.07		100.00
Length of staple:							
Number of fleeces	174	112	245	214	656	1,401	
Average length, inches	2.26	2.24	2.18	2.31	2.19		2.22
Per cent of grand average	101.80	100.90	98.20	104.05	98.65		100.00
Fineness of fiber:							
Number of fleeces	89	52	137	125	390	793	
Average fineness, spinning counts	60.90	61.15	60.70	61.39	61.77		61.39
Per cent of grand average	99.20	99.61	98.88	100.00	100.62		100.00
Character of fleece:							
Number of fleeces	174	112	242	214	658	1,400	
Average character, per cent of perfect	86.0	82.9	82.5	84.2	84.6		84.20
Per cent of grand average	102.14	98.46	97.98	100.00	100.48		100.00
Density of fleece:							
Number of fleeces	89	52	137	125	390	793	
Average density, per cent of perfect	84.2	82.9	83.9	84.7	87.1		85.6
Per cent of grand average	98.36	96.85	98.01	98.95	101.75		100.00

Referring to Table 11 there seems to be no important relation between face covering and such factors as length of staple, fineness of fiber, character of fleece, or density of fleece.

In brief, the facts indicate that a moderate amount of face covering (not less than about 70 per cent of absolute freedom from covering) and complete freedom from wool blindness are consistent with the most efficient wool production.

SKIN FOLDS

The data regarding skin folds reported in this bulletin are based on the neck folds of the sheep. The reasons for accepting this as a reliable method are given under the heading "Description of factors." The absence of folds is arbitrarily used as the highest value for this factor, but without prejudice on this point. In reading Table 12 one will note that as the presence of folds increased the assigned percentage values of this factor were decreased. A study of this table brings out the fact that as the folds increased (scored lower) the unscoured-fleece weights increased. There was also a general tendency for the scoured-fleece weights to increase as the sheep became more wrinkled, but the highest yield of clean wool was for sheep no more wrinkled than about 60.1 to 70 per cent of absolute freedom from folds. The weights of moisture, grease, and dirt also increased as the folds became more numerous. On the other hand, the length of staple was longest on the smoothest sheep and shortest on the most wrinkled ones. Fineness of fiber was not appreciably influenced by folds, although a careful study of this relation as shown in Tables 12 and 19 indicates a very slight tendency for more fineness in the fleeces from the less wrinkled sheep. Character of fleece was a trifle higher in the fleeces from the smoother sheep, whereas density of fleece was a little greater on sheep with more folds.

A summary of the data of Table 12 indicates that the most productive group of ewes is the one averaging 65 per cent freedom from folds. These ewes had slightly more folds than would be considered medium for range Rambouillets but they were not heavily folded. This folding could be classified as moderately heavy. The number of fleeces was smallest for this group and it is therefore certain that in this representative strain of range Rambouillets there was not a large proportion of them with more than a medium or a moderate amount of folding. Nevertheless, moderate to heavy folding at the neck was in this investigation sufficiently associated with satisfactory fleece weights to justify further study of this question. An investigation of larger numbers of the fleeces from the sheep that are moderately to heavily folded is necessary before definite conclusions on this point can be drawn.

TABLE 12.—*Skin folds in relation to other factors in wool production*

Factor	Range and average skin folds of sheep in per cent of absence of folds					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	340	625	458	125	144	1,692	
Average weight, pounds	9.91	10.60	11.02	11.78	11.72		10.76
Per cent of grand average	92.10	98.51	102.42	109.48	108.92		100.00
Fleece weight, scoured:							
Number of fleeces	266	519	369	93	106	1,353	
Average weight, pounds	3.76	3.91	3.97	4.38	4.25		3.96
Per cent of grand average	94.95	98.74	100.25	110.61	107.32		100.00
Moisture driven off:							
Number of fleeces	266	519	369	93	106	1,353	
Average weight, pounds	.44	.46	.47	.52	.48		.46
Per cent of grand average	95.65	100.00	102.17	113.04	104.35		100.00
Grease:							
Number of fleeces	266	519	369	93	106	1,353	
Average weight, pounds	1.27	1.43	1.64	1.74	2.08		1.53
Per cent of grand average	83.01	93.46	107.19	113.73	135.95		100.00
Dirt:							
Number of fleeces	266	519	369	93	106	1,353	
Average weight, pounds	4.39	4.80	4.98	5.24	5.20		4.83
Per cent of grand average	90.89	99.38	103.11	108.49	107.66		100.00
Length of staple:							
Number of fleeces	274	535	376	93	111	1,389	
Average length, inches	2.34	2.25	2.15	2.17	2.02		2.22
Per cent of grand average	105.41	101.35	96.85	97.75	90.99		100.00
Fineness of fiber:							
Number of fleeces	157	278	219	58	69	781	
Average fineness, spinning counts	61.25	61.82	61.00	61.72	60.64		61.36
Per cent of grand average	99.82	100.75	99.41	100.59	98.83		100.00
Character of fleece:							
Number of fleeces	274	534	374	93	110	1,385	
Average character, per cent of perfect	84.6	85.1	83.6	83.6	81.1		84.2
Per cent of grand average	100.48	101.07	99.29	99.29	96.32		100.00
Density of fleece:							
Number of fleeces	157	278	218	58	69	780	
Average density, per cent of perfect	83.4	85.0	86.8	86.9	88.0		85.6
Per cent of grand average	97.43	99.30	101.40	101.52	102.80		100.00

BODY WEIGHT

The body weights used were taken promptly after shearing when the ewes were 1 year old. They are therefore more comparable than ewe weights taken after that age, because of the variations in weight among ewes that are raising lambs. Table 13 presents data that indicate a fairly positive relation between the body weights and the unscoured-fleece weights. The scoured-fleece weights also increased with increase in body weight up to body weights of about 100 pounds and then the scoured-fleece weights declined as the body weights increased. On the whole there was a little more grease in the fleeces from the heavier sheep but Table 13 shows considerable fluctuation in this relationship.

TABLE 13.—*Body weight of sheep as a factor in wool production*

Factor	Range and average body weights of sheep in pounds								Total number of fleeces	Grand average [1]
	50 to 59 55	60 to 69 65	70 to 79 75	80 to 89 85	90 to 99 95	100 to 109 105	110 to 119 115	120 or more 125		
Fleece weight, unscoured:										
Number of fleeces	9	109	517	509	189	75	70	104	1,642	
Average weight, pounds	10.94	9.99	10.51	10.80	10.68	11.07	10.83	11.32		10.66
Per cent of grand average	102.63	93.71	98.59	101.31	100.19	103.85	101.59	106.19		100.00
Per cent of average body weight of sheep	19.89	15.37	14.01	12.71	11.24	10.54	9.42	9.06		12.47
Fleece weight, scoured:										
Number of fleeces	6	122	405	390	150	61	66	99	1,299	
Average weight, pounds	3.33	3.61	3.91	4.02	4.11	4.06	3.88	3.88		3.94
Per cent of grand average	84.52	91.62	99.24	102.03	104.31	103.05	98.48	98.48		100.00
Per cent of average body weight of sheep	6.05	5.55	5.21	4.73	4.33	3.87	3.37	3.10		4.55
Grease:										
Number of fleeces	6	122	405	390	150	61	66	99	1,299	
Average weight, pounds	1.75	1.43	1.46	1.61	1.45	1.59	1.48	1.70		1.53
Per cent of grand average	114.38	93.46	95.42	105.23	94.77	103.92	96.73	111.11		100.00
Per cent of average body weight of sheep	3.18	2.20	1.95	1.89	1.53	1.51	1.29	1.36		1.77
Length of staple:										
Number of fleeces	7	127	404	392	160	64	68	103	1,325	
Average length, inches	2.09	2.26	2.20	2.23	2.29	2.17	2.10	2.05		2.23
Per cent of grand average	93.72	101.35	101.35	100.00	102.69	97.31	94.17	91.93		100.00
Fineness of fleece:										
Number of fleeces	5	84	262	238	87	28	19	34	757	
Average fineness, spinning counts	61.20	61.19	60.72	61.03	60.97	61.50	62.42	62.41		61.65
Per cent of grand average	100.25	100.23	99.46	99.97	99.87	100.74	102.24	102.23		100.00
Character of fleece:										
Number of fleeces	7	127	403	387	158	65	69	105	1,321	
Average character, per cent of perfect	77.9	83.7	84.1	84.0	84.3	86.4	84.3	83.2		84.1
Per cent of grand average	92.63	99.52	100.00	99.88	100.24	102.73	100.24	98.93		100.00
Density of fleece:										
Number of fleeces	5	84	262	238	84	27	19	8	727	
Average density, per cent of perfect	85.0	82.4	84.7	85.7	85.7	87.2	90.3	86.2		85.1
Per cent of grand average	99.88	96.83	99.53	100.71	100.71	102.47	106.11	101.29		100.00

[1] The grand average body weight per sheep for the group yielding the 1,642 fleeces used in the study of unscoured-fleece weight was 85.51 pounds. The grand average body weight per sheep for the group yielding the 1,299 fleeces used in the study of scoured-fleece weights and the weights of grease per fleece was 86.53 pounds.

Length of staple was longest on ewes that had yearling weights ranging from 90 to 99 pounds per head, and shortest on the 103 ewes that weighed 120 pounds or more. Ewes having yearling weights ranging from 60 to 99 pounds had staple averaging as long as or longer than the grand average of the entire group, whereas ewes with yearling body weights below 60 pounds or above 99 pounds had staple averaging shorter than the grand average.

There was a little tendency for increased fineness in the fleeces from the heavier ewes. In general, there was no important relation between character of fleece and body weight. The trend was toward greater density of fleece in the sheep of greater weight.

Considering the most important influences of these body weights it is apparent that the sheared yearling weights of range Rambouillet ewes varying from about 80 to 110 pounds under actual range conditions are positively related to the factors that make the greatest profits in wool production.

The percentages of unscoured and scoured fleece weights and of the weights of grease per fleece, based on body weights, are shown in Table 13. The 1,642 unscoured fleeces were from ewes averaging sheared, yearling body weights of 85.51 pounds. Their unscoured fleeces averaged 10.66 pounds, or 12.47 per cent as great as the yearling body weights of the ewes from which they were sheared. The ewes averaging 55 pounds for body weight yielded fleeces 19.89 per cent as great as their average sheared body weights, and as the body weights of the other groups increased the proportionate weights of their fleeces decreased. The 1,299 scoured fleeces were from yearling ewes averaging 86.53 pounds in sheared body weight. Table 13 shows that these 1,299 ewes average 3.94 pounds of clean wool per fleece or 4.55 per cent as much as their body weights. These same ewes averaged 1.53 pounds of grease in their fleeces, which amounts to 1.77 per cent of their body weights. As in the unscoured-fleece weights the proportionate weights of clean wool and grease decrease as the body weights increase.

MUTTON TYPE

The better mutton type is associated with heavier unscoured-fleece weights except for a few off-type ewes. The advantage of type to clean wool yields was rather small but it was positive for the groups as a whole. The few ewes scoring low in type averaged the heaviest fleeces of clean wool. The ewes of choice type yielded the fleeces with rather heavy weights of grease but the 62 fleeces from ewes scoring as low as or lower than 70 per cent on type had the heaviest weights of grease, and fleeces from ewes of good or medium type were intermediate in grease weights. Length of staple was not much affected, but there was a slight tendency for the better-type ewes to grow a little shorter staple. Fineness was practically unaffected. Character of fleece was lowest in the off-type ewes, but on the whole not greatly influenced, and density of fleece was undisturbed by type. Considering all these facts, selection for good mutton type should be more of a help than a hindrance to profitable woolgrowing.

TABLE 14.—*Mutton type of sheep in relation to other factors in wool production*

Factor	Range and average mutton type of sheep in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	376	698	579	73	11	1,737	
Average weight, pounds	11.16	10.70	10.51	11.09	11.41		10.76
Per cent of grand average	103.77	99.44	97.68	103.07	106.04		100.00
Fleece weight, scoured:							
Number of fleeces	307	583	440	52	10	1,392	
Average weight, pounds	4.02	3.95	3.89	4.25	4.30		3.96
Per cent of grand average	101.52	99.75	98.23	107.32	108.59		100.00
Grease:							
Number of fleeces	307	583	440	52	10	1,392	
Average weight, pounds	1.64	1.45	1.52	1.72	1.70		1.53
Per cent of grand average	107.19	94.77	99.35	112.42	111.11		100.00
Length of staple:							
Number of fleeces	316	597	448	54	10	1,425	
Average length, inches	2.15	2.25	2.22	2.33	2.10		2.22
Per cent of grand average	96.85	101.35	100.00	104.95	94.59		100.00
Fineness of fiber:							
Number of fleeces	168	314	285	32	9	808	
Average fineness, spinning counts	60.90	61.67	61.10	60.88	60.22		61.31
Per cent of grand average	99.43	100.59	99.80	99.30	98.22		100.00
Character of fleece:							
Number of fleeces	314	597	446	54	10	1,421	
Average character, per cent of perfect	83.4	84.9	83.9	82.2	77.0		84.1
Per cent of grand average	99.17	100.95	99.76	97.74	91.56		100.00
Density of fleece:							
Number of fleeces	168	313	285	32	9	807	
Average density, per cent of perfect	86.4	86.0	84.5	84.1	87.2		85.5
Per cent of grand average	101.05	100.58	98.83	98.36	101.99		100.00

MUTTON CONDITION

The mutton condition of the ewes was scored right after their yearling fleeces were sheared. As shown in Table 15, a very large majority of the ewes were in good or medium condition as yearlings. The heaviest fleeces, both unscoured and scoured, were from the ewes that were in choice condition as yearlings; but as will be seen in Table 19, fleece weight is not strongly correlated with condition. Ewes that were in good condition had the lowest grease content in their fleeces, but there was so much fluctuation among the different groups that this relationship is unimportant. Ewes averaging good, or 85 per cent in condition, grew the longest staple, and in general as they declined in condition they grew shorter staple. However, curious as it may seem, the ewes grading choice, or an average of 95 per cent in condition, produced fleeces averaging the shortest in staple. Nevertheless, when all the 1,216 ewes were considered, the better condition seemed to favor length of staple. The 48 fleeces averaging the finest were from ewes grading as low or lower than 70 per cent in condition. In general, there was a very slight tendency for the finest-fleeced ewes to be in the poorest condition, but the 40 fleeces from ewes in choice condition were also relatively fine. The influences of condition on the character and density of the fleeces were of little or no importance.

TABLE 15.—*Mutton condition in relation to other factors in wool production*

Factor	Range and average mutton condition of sheep in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	109	751	517	60	36	1,473	
Average weight, pounds	11.22	10.44	10.77	10.92	11.11		10.65
Per cent of grand average	105.35	98.03	101.13	102.54	104.32		100.00
Fleece weight, scoured:							
Number of fleeces	97	579	417	59	35	1,187	
Average weight, pounds	4.11	3.89	3.94	3.62	4.04		3.91
Per cent of grand average	103.12	99.49	100.77	92.58	103.32		100.00
Grease:							
Number of fleeces	97	579	417	59	35	1,187	
Average weight, pounds	1.56	1.37	1.58	1.48	1.75		1.48
Per cent of grand average	105.41	92.57	106.76	100.00	118.24		100.00
Length of staple:							
Number of fleeces	101	585	432	61	37	1,216	
Average length, inches	2.09	2.30	2.20	2.10	2.12		2.23
Per cent of grand average	93.72	103.14	98.65	94.17	95.07		100.00
Fineness of fiber:							
Number of fleeces	40	344	270	30	18	702	
Average fineness, spinning counts	61.95	61.24	61.19	63.27	62.00		61.37
Per cent of grand average	100.95	99.79	99.71	103.10	101.03		100.00
Character of fleece:							
Number of fleeces	101	586	428	61	37	1,213	
Average character, per cent of perfect	83.6	84.7	83.8	83.7	85.8		84.3
Per cent of grand average	99.17	100.47	99.41	99.29	101.78		100.00
Density of fleece:							
Number of fleeces	40	344	270	30	18	702	
Average density, per cent of perfect	89.5	85.8	86.0	86.3	86.1		86.1
Per cent of grand average	103.95	99.65	99.88	100.23	100.00		100.00

MUTTON BACK

In Table 16 it will be seen that the conformation of the back of the sheep had no significant relation to wool production. Only a very small percentage of the ewes graded as low as 70 per cent on back. Ewes grading good to choice in back had the finest fleeces. Those averaging good or 85 per cent in back had the longest staple, but the differences in length of staple are small. It seems, according to these data, that the selection for good mutton backs in Rambouillet ewes is a wise practice, for in general it does not seem to interfere with good wool production and it is certainly an asset in mutton production.

TABLE 16.—*Mutton back in relation to other factors in wool production*

Factor	Range and average of the mutton backs of the sheep in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	347	693	573	52	72	1,737	
Average weight, pounds	10.94	10.62	10.72	11.48	11.04		10.76
Per cent of grand average	101.67	98.70	99.63	106.69	102.69		100.00
Fleece weight, scoured:							
Number of fleeces	295	559	439	37	62	1,392	
Average weight, pounds	3.91	3.93	4.00	4.45	3.87		3.96
Per cent of grand average	98.74	99.24	101.01	112.37	97.73		100.00
Grease:							
Number of fleeces	295	559	439	37	62	1,392	
Average weight, pounds	1.59	1.43	1.57	1.68	1.77		1.53
Per cent of grand average	103.92	93.46	102.61	109.80	115.69		100.00
Length of staple:							
Number of fleeces	307	569	449	35	65	1,425	
Average length, inches	2.15	2.28	2.21	2.21	2.14		2.22
Per cent of grand average	96.85	102.70	99.55	99.55	96.40		100.00
Fineness of fiber:							
Number of fleeces	147	317	279	20	45	808	
Average fineness, spinning counts	61.51	61.53	61.18	60.20	60.36		61.31
Per cent of grand average	100.33	100.36	99.79	98.19	98.45		100.00
Character of fleece:							
Number of fleeces	310	569	443	35	64	1,421	
Average character, per cent of perfect	84.3	84.8	83.5	82.4	82.8		84.1
Per cent of grand average	100.24	100.83	99.29	97.98	98.45		100.00
Density of fleece:							
Number of fleeces	147	315	279	20	45	807	
Average density, per cent of perfect	87.6	85.4	84.6	81.5	86.6		85.5
Per cent of grand average	102.46	99.88	98.95	95.32	101.29		100.00

MUTTON RUMP

Most of the ewes graded from 70 to 90 per cent on the conformation of their rumps. The ewes that graded choice or 90.1 to 100 per cent in rump were the ones averaging highest in unscoured-fleece weights. They were slightly above average in scoured-fleece weights and substantially above average in grease content per fleece. In all other relationships the rump was unimportant. It therefore appears from Table 17 that the selection of good rumps on Rambouillets will in no way interfere with good wool production.

TABLE 17.—*Mutton rump in relation to other factors in wool production*

Factor	Range and average of the mutton rumps of the sheep in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	192	752	689	75	29	1,737	
Average weight, pounds	11.17	10.69	10.70	10.83	10.84		10.76
Per cent of grand average	103.81	99.35	99.44	100.65	100.74		100.00
Fleece weight, scoured:							
Number of fleeces	145	604	566	50	27	1,392	
Average weight, pounds	4.03	3.92	3.97	4.16	3.80		3.96
Per cent of grand average	101.77	98.99	100.25	105.05	95.96		100.00
Grease:							
Number of fleeces	145	604	566	50	27	1,392	
Average weight, pounds	1.65	1.45	1.56	1.63	1.68		1.53
Per cent of grand average	107.84	94.77	101.96	106.54	109.80		100.00
Length of staple:							
Number of fleeces	156	616	577	49	27	1,425	
Average length, inches	2.23	2.22	2.22	2.22	2.11		2.22
Per cent of grand average	100.45	100.00	100.00	100.00	95.05		100.00
Fineness of fiber:							
Number of fleeces	83	332	338	32	23	808	
Average fineness, spinning counts	60.65	61.73	61.09	61.88	59.91		61.31
Per cent of grand average	98.92	100.69	99.64	100.93	97.72		100.00
Character of fleece:							
Number of fleeces	156	618	573	49	25	1,421	
Average character, per cent of perfect	83.1	84.8	83.9	81.9	82.6		84.1
Per cent of grand average	98.81	100.83	99.76	97.38	98.22		100.00
Density of fleece:							
Number of fleeces	83	332	337	32	23	807	
Average density, per cent of perfect	86.0	86.7	84.6	79.4	87.2		85.5
Per cent of grand average	100.58	101.40	98.95	92.87	101.99		100.00

MUTTON LEG

A choice, plump, full, mutton leg was not found on most of these Rambouillet ewes, as is shown in Table 18. The majority of them graded in leg either good or medium—that is, an average of 85 or 75 per cent, respectively. Length of staple and character of fleece were slightly favored by improvement in the conformation of the leg. Other than those relationships, the influences of leg were not important. It is well to note that a small percentage of the ewes grading as low or lower than 70 per cent in leg averaged the heaviest in fleece weights and in the weights of grease per fleece. However, the ewes grading medium and good in leg were practically as high in fleece weight as the grand average for the whole group and they grew longer staple. The few ewes grading choice in leg were the ones that produced the lightest fleeces and the ones grading good and choice in leg were the ones that produced the lightest weights of grease per fleece. It should therefore be safe to conclude that especially choice, plump leg development in Rambouillets may be comparatively difficult to attain, but that good or approximately 85 per cent leg conformation is consistent with very good wool production, according to the results of this investigation.

TABLE 18.—*Mutton leg in relation to other factors in wool production*

Factor	Range and average of mutton development of the legs of the sheep in per cent of perfect					Total number of fleeces	Grand average
	90.1 to 100	80.1 to 90	70.1 to 80	60.1 to 70	60 or less		
	95	85	75	65	55		
Fleece weight, unscoured:							
Number of fleeces	99	623	798	130	73	1,728	
Average weight, pounds	10.40	10.70	10.77	11.13	11.12		10.76
Per cent of grand average	96.65	99.44	100.09	103.44	103.35		100.00
Fleece weight, scoured:							
Number of fleeces	81	505	641	94	62	1,383	
Average weight, pounds	3.73	3.98	3.95	4.12	4.06		3.96
Per cent of grand average	94.19	100.51	99.75	104.04	102.53		100.00
Grease:							
Number of fleeces	81	505	641	94	62	1,383	
Average weight, pounds	1.47	1.44	1.56	1.70	1.77		1.53
Per cent of grand average	96.08	94.12	101.96	111.11	115.69		100.00
Length of staple:							
Number of fleeces	81	512	667	95	62	1,417	
Average length, inches	2.20	2.28	2.19	2.15	2.16		2.22
Per cent of grand average	99.10	102.70	98.65	96.85	97.30		100.00
Fineness of fleece:							
Number of fleeces	45	284	374	49	48	800	
Average fineness, spinning counts	61.24	61.48	61.34	61.47	60.08		61.32
Per cent of grand average	99.87	100.26	100.03	100.24	97.98		100.00
Character of fleece:							
Number of fleeces	81	514	663	95	61	1,414	
Average character, per cent of perfect	85.5	85.1	83.6	83.0	82.0		84.1
Per cent of grand average	101.66	101.19	99.41	98.69	97.50		100.00
Density of fleece:							
Number of fleeces	45	284	373	49	48	799	
Average density, per cent of perfect	85.7	86.2	85.1	83.6	86.5		85.5
Per cent of grand average	100.23	100.82	99.53	97.78	101.17		100.00

CORRELATION OF FACTORS IN WOOL PRODUCTION

Table 19 presents the 139 coefficients of correlation with which this bulletin is concerned. Each of these coefficients is based on a total of exactly 990 frequencies (fleeces), and throughout these were the same 990 fleeces. It is assumed that many interested in sheep breeding and the facts contained in this bulletin are unaccustomed to thinking in terms of coefficients of correlation and for their benefit a few explanations are here made.

The formula used in determining these coefficients of correlation is as follows:

$$r=\frac{\frac{\Sigma AB}{n}-\left(\frac{\Sigma A}{n}\times\frac{\Sigma B}{n}\right)}{\sqrt{\frac{\Sigma A^2}{n}-\left(\frac{\Sigma A}{n}\right)^2}\times\sqrt{\frac{\Sigma B^2}{n}-\left(\frac{\Sigma B}{n}\right)^2}}$$

In this formula r is the correlation coefficient, A represents the values of one of the factors under consideration, B the values of the other factor, and n the number of frequencies. This formula is used for data that are not assembled into frequency distributions. The probable errors in this table have been determined by the use of the following formula:

$$PE=\frac{0.6745\ (1-r^2)}{\sqrt{n}}$$

Here PE signifies probable error, r is the correlation coefficient, and n the number of frequencies.

TABLE 19.—*Coefficients of correlation of factors in wool production with range Rambouillet sheep, based on 990 fleeces for which the data were complete in all respects*

Factor	Fleece weight, unscoured	Fleece weight, scoured	Weight of moisture	Weight of grease	Weight of dirt	Length of staple	Fineness of fiber	Character of fleece	Density of fleece
Age of sheep	0.3003±0.0195	−0.0307±0.0214	0.2176±0.0204	0.3186±0.0192	0.3579±0.1087	−0.4171±0.0177	(1)	−0.1933±0.0206	(1)
Fleece weight, unscoured		.6238± .0131	.5664± .0145	.6273± .0130	.8023± .0076	−.0110± .0214	−0.1247±0.0211	.0031± .0214	0.2438±0.0201
Fleece weight, scoured	.6238± .0131		.3828± .0183	.2122± .0204	.2931± .0196	.2915± .0196	−.1219± .0211	.1708± .0208	.1696± .0208
Weight of moisture	.5664± .0145	.3828± .0183		.2880± .0196	.4154± .0177	.0580± .0213	−.1331± .0210	.0358± .0214	.1013± .0212
Weight of grease	.6273± .0130	.2122± .0204	.2880± .0196		.4059± .0179	−.2421± .0201	−.0450± .0214	−.1048± .0212	.2002± .0205
Weight of dirt	.8023± .0076	.2931± .0196	.4154± .0177	.4059± .0179		−.1298± .0210	−.0403± .0214	.3082± .0194	−.1675± .0208
Length of staple	−.0110± .0214	.2915± .0196	.0580± .0213	−.2421± .0201	−.1298± .0210			.1136± .0211	.2134± .0204
Fineness of fiber	−.1247± .0211	−.1219± .0211	−.1331± .0210	−.0450± .0214	−.1072± .0212	−.0403± .0214		.1136± .0211	.0467± .0214
Character of fleece	.0031± .0214	.1708± .0208	.0358± .0214	−.1048± .0212	−.0990± .0212	.3082± .0194	.1136± .0211		−.0215± .0214
Density of fleece	.2438± .0201	.1696± .0208	.1013± .0212	.2002± .0205	.1903± .0206	−.1675± .0208	.2134± .0204	.0467± .0214	
Face covering	.0566± .0213	.0421± .0214	.0990± .0212	.0472± .0214	.0214± .0214	.0528± .0213	−.0667± .0213	.0318± .0214	−.2841± .0197
Neck folds	−.2658± .0199	−.0775± .0213	−.1108± .0211	−.2952± .0195	−.2422± .0201	.2508± .0201	.0678± .0213	.0883± .0212	.2408± .0202
Body weight (yearling)	.1618± .0208	.0552± .0213	(2)	.1237± .0211	(2)	−.1328± .0210	.2347± .0202	.0138± .0214	.0295± .0214
Mutton type	.1985± .0206	.0463± .0214	(2)	.0986± .0212	(2)	−.0961± .0212	−.0039± .0214	−.0050± .0214	.0422± .0214
Mutton condition	−.0610± .0213	.0549± .0213	(2)	−.1022± .0212	(2)	.1624± .0208	−.0707± .0213	.0378± .0214	−.0453± .0213
Mutton back	.0492± .0213	.0356± .0214	(2)	.0357± .0214	(2)	−.0027± .0214	.1011± .0212	.0470± .0214	.0653± .0213
Mutton rump	.1720± .0208	.0780± .0213	(2)	.1049± .0212	(2)	−.0220± .0214	−.0393± .0214	.0008± .0214	.0579± .0213
Mutton leg	.0067± .0214	.0415± .0214	(2)	.0477± .0214	(2)	.0879± .0212	.0061± .0214	.0806± .0213	−.0342± .0214

[1] Data not compiled because fineness and density were scored only for yearling fleeces. (See pp. 10 and 11.)
[2] Data not compiled because regarded unimportant. (See pp. 10 and 11.)

If the correlation between two factors is exactly perfect the coefficient would be 1. For example, should the weights of each fleece (unscoured) increase exactly by the same proportionate rate, respectively, as the weights of each of these same fleeces when scoured, such a correlation would be regarded as perfect and by the above formula would be expressed in the coefficient 1. Reference to Table 19 shows that the actual correlation of these two factors is 0.6238, and that the probable error is ± 0.0131. In other words, the correlation between the weights of the scoured fleeces and the weights of the unscoured fleeces is not perfect, but it is sufficiently significant to indicate that the heaviest unscoured fleeces are much more likely to have the greatest weights of actual or clean wool than they are to have the lightest weights of clean wool. Stated in another way, this coefficient 0.6238 means that as the unscoured fleeces increase in weight there is a rather strong tendency for weights of actual or clean wool in them to increase.

The nearer the coefficients get to 1 the more perfect is the correlation. If it should happen that this coefficient 0.6238 was negative it would be expressed as -0.6238, which would mean that as the unscoured fleeces increase in weight their weights of scoured clean wool would tend to decrease, or conversely, there would be a tendency for clean weights per fleece to increase as the unscoured weights per fleece decrease. As this reverse or negative correlation would increase in a negative direction the coefficients which express such a situation would become larger, approaching -1 as they approach an absolute negative correlation. When the coefficients become rather small the consideration of their respective probable errors becomes important, for in order to be significant the correlation coefficient must be at least three times as large as its probable error.

The interpretation of the coefficients in Table 19 are based very largely on the accepted standard which may for convenience be called "the direction of values"—i. e., the value of age increases as the sheep get older, all the values of factors expressed in weights increase as the weights become greater; the values in the factor, length of staple, increase as the lengths become longer; the values in fineness of fiber increase as the fineness becomes greater, which means that the diameter of the fiber becomes less; values in character of fleece increase as the excellence of character becomes greater; values in density of fleece increase as the fleeces become more dense; values in face covering increase as the covering of wool over the face decreases; values in neck folds increase as the folding or wrinkling of the skin about the neck decreases; values in mutton type increase with the improvement in excellence of type; values in mutton condition increase as the sheep become fatter or in better condition of flesh and thrift; and the values in mutton back, mutton rump, and mutton leg increase with improvement in the conformation of the sheep in back, rump, and leg. By keeping this standard of values, or "direction of values," clearly in mind one should have no difficulty in the interpretation of these coefficients.

As the sheep got older there was a tendency for their unscoured fleeces to weigh more. In the case of their scoured fleeces the influence of age was such that for the entire group of 990 fleeces coming from sheep ranging in age from 1 to 7 years there seems to be no appreciable linear correlation. Reference to Table 1 shows that age had a very pronounced effect on the scoured-fleece weight, but that it was positive only up to 3 years of age and generally negative beyond that age

As the sheep became older the moisture in their fleeces had a very slight tendency to increase, the weight of the grease per fleece increased, the weight of the dirt increased, the length of the staple got shorter, and the character of their fleeces had a slight tendency to become less choice.

The unscoured fleeces that weighed the most were the ones that usually had the greatest weights of clean wool, moisture, grease, and dirt. The weight of the unscoured fleeces did not seem to affect the length of the staple to any appreciable extent. There was a slight tendency for the heavier fleeces to be a trifle coarser, but there seemed to be practically no effect of unscoured-fleece weight on the character of the fleeces. As the weight of the unscoured fleeces became greater there was some tendency for their density to be greater.

The scoured-fleece weights became greater as the weights became greater in the unscoured fleeces, and in the moisture, grease, and dirt per fleece. The length of staple was generally longer, the fineness a trifle less, and the character and density of the fleeces slightly more excellent as the yields of clean wool per fleece increased.

Weight of moisture per fleece increased as there was an advance in the weights of fleeces, both unscoured and scoured, and as the weights became greater in grease and dirt. There seemed to be practically no relation between weight of moisture and length of staple. There seemed to be a very slight tendency for the greater weights of moisture per fleece to occur in the coarser but denser fleeces. There was practically no relation between weight of moisture and character of fleece.

Weight of grease per fleece was found to be greatest in the heaviest fleeces, both unscoured and scoured; in the fleeces having the greatest weights of moisture and dirt; in those with a shorter staple; in those having a trifle poorer character; and in those having a slightly greater density. There seemed to be no appreciable relation between the weight of grease per fleece and the fineness of the fiber.

Weight of dirt per fleece was positively and very strongly associated with weight of the unscoured fleeces, and fairly well associated with weight in the scoured fleeces, also with the weight of moisture and grease per fleece. There was a slight tendency for the weights of dirt to be greatest in the fleeces that were a trifle shorter in staple, a trifle coarser, slightly less choice in character, and somewhat the more dense.

Length of staple had no appreciable influence on the weight of unscoured wool per fleece, but increase in the length of staple was associated with a substantial increase in the weight of clean wool per fleece, as shown by the coefficient 0.2915 ± 0.0196, for it will be noted that this coefficient is nearly 15 times as large as its probable error. Greater lengths of staple were correlated with less grease, slightly less dirt, better character, and a little less density. There was no appreciable influence of length of staple on the fineness of fiber or weight of moisture.

As the fineness of wool in these fleeces increased there was a slight tendency toward decreases in weights of fleeces, both unscoured and scoured, and in weights of moisture and dirt per fleece. Fineness of wool did not have a significant influence on the weight of grease nor did it have any definite effect on the length of staple. As the wool became finer there was a very slight tendency for improvement in the character of the fleeces and there was some increase in the density of the fleeces.

The character of the fleeces had practically no influence on the weight of unscoured fleeces nor on the weight of moisture in them.

but as the character improved, the weights of clean wool per fleece increased slightly and there was a trifle lower weight of grease and dirt per fleece. As the fleeces became more excellent in character the length of the staple increased and they became slightly finer. Character had no significant influence on density.

As the fleeces became more dense there was some tendency for the fleece weights to increase. This tendency was a little stronger for the unscoured-fleece weights than it was for the scoured-fleece weights, but it was really significant for both. This same positive influence of density also applied to the weights of moisture, grease, and dirt per fleece. The fleeces of greater density were as a rule slightly shorter in staple and a little finer, but as was implied in the above paragraph density of fleece did not have any significant influence on character of fleece.

Face covering as measured by the coefficient of correlation had no strongly significant influence on any of the nine factors in wool production here considered. Although none of the coefficients that express the relationship of face covering to the various factors in wool production are large enough to justify serious consideration, there is nothing in them that would indicate any worth-while advantage in heavy covering of wool over the face. The practical benefits of freedom from heavy face covering may be seen in Tables 11 and 19.

Freedom from neck folds is associated with lighter weights of wool, moisture, grease, and dirt per fleece, greater length of staple, and somewhat less density. The coefficients that express the correlation between neck folds and fleece weights show that the weight of actual clean wool in the fleece is only very slightly affected by neck folds. In fact, the coefficient -0.0775 is only 3.64 times the size of its probable error, ± 0.0213. Thus, this correlation can not be seriously considered. However, the coefficient -0.2658 is 13.36 times the size of its probable error, ± 0.0199, which makes it really significant and expresses the fact that smooth-necked ewes have rather lighter unscoured-fleece weights than the ewes with more folds about their necks. Lighter weights of grease and dirt per fleece are just about as strongly associated with smoothness about the sheep's neck as are the lighter weights of unscoured wool per fleece associated with smoothness of neck. Stated in another way, it is evident that the smooth-necked ewes yielded fleeces a little lighter in the unscoured state but only very slightly lighter in actual clean wool than the ewes that were more heavily folded about the neck. Furthermore, the smooth-necked ewes yielded fleeces that were freer from heavy weights of grease and dirt, longer in staple, slightly finer, of a little higher character, and less dense than the fleeces from the more wrinkled ewes.

Greater body weight was associated with slightly greater weights of unscoured wool, but there was no real significance in the linear correlation between body weight and actual yields of clean wool. However, Table 13 shows that scoured-fleece weights advance with body weight up to body weight of about 100 pounds and then a slight decline in clean-fleece weights is associated with greater body weights. There was a tendency for the heavier weights to be associated with a little more grease, slightly shorter length of staple, greater fineness, and more density. Body weight did not seem to influence the character of the wool.

Ewes of the better mutton type had slightly heavier fleeces of unscoured wool. This is, however, modified a trifle by the fleeces of greater weight coming from ewes that graded low in type as shown in Table 14. But these heavy fleeces from off-type ewes are relatively so very few that the correlation is quite strongly for heavier fleeces from the better-type ewes. The linear correlation between type and clean-wool yield is really not significant; but, again, one may note in Table 14 that the heaviest yields of clean wool are from the very few ewes scoring low in type. A trifle more grease and a trifle shorter staple came from good-type ewes rather than from ewes less desirable in mutton type. This factor, type, did not have any significant influence on fineness, character, or density of fleece.

Mutton condition was, on the whole, positively associated with a little greater length of staple, only a trifle less fineness, and slightly less grease. Otherwise, condition had no significant influence on the wool factors here considered.

There was a rather weak suggestion that the better mutton backs were associated with a trifle finer wool, and with fleeces having a shade more density, but otherwise the wool factors here considered were practically unaffected by the conformation of the back.

The squarest mutton rumps were found on ewes that yielded slightly heavier weights of wool and grease per fleece. Other wool factors under consideration were not affected by the conformation of the rump to any significant degree.

The plumpest legs of mutton were very slightly associated with greater length of staple and improvement in the character of the fleeces. Other wool factors were not significantly affected by the plumpness of the leg.

SUMMARY

The results reported in this bulletin are based on studies of pure-bred, range Rambouillet ewes that were produced and maintained under practical range conditions of the intermountain region at the United States sheep experiment station, Dubois, Idaho. The scoring of the fleeces and sheep and the shearing and sampling of the fleeces also took place at that station. The determinations of clean wool, moisture, grease, and dirt per fleece were conducted in the wool-scouring laboratory of the animal husbandry experiment farm, Beltsville, Md., and the statistical analyses of these data were worked out in Washington, D. C.

The factor, age of sheep, had its most important influence on length of staple, which became shorter per fleece as the age advanced. The fleeces from 3-year-old ewes averaged the heaviest and those from ewes older than 5 years averaged lowest in character.

The unscoured-fleece weights were very strongly associated with the weights of the dirt they contained, the heaviest fleeces having the greatest weights of dirt. These heaviest fleeces of unscoured wool also contained the most clean wool, grease, and moisture. The correlation between the weights of unscoured wool and scoured wool was quite significant, the weights of unscoured wool being the very best factor for indicating the weight of scoured wool per fleece. As the clean-wool fleece weights increased there was an increase in the weights of moisture, grease, and dirt, and in the length of staple and character and density of fleece, but a very sharp reduction in the proportion of clean wool to moisture, grease, and dirt.

The greater weights of moisture per fleece were found in the heavier fleeces and in fleeces containing the greater weights of clean wool, grease, and dirt. However, the proportion of the weights of wool, grease, and dirt to moisture decreased as the weight of the moisture per fleece increased.

The weights of grease per fleece were heaviest in the fleeces having the greatest weights of unscoured wool and dirt, and to some extent in the fleeces having the most clean wool and moisture, but in general those fleeces with the greatest weights of grease had a tendency to be shorter in staple. On the other hand, the proportion of clean wool, moisture, and dirt to grease decreased very sharply as the weight of the grease increased.

The correlation between the weight of dirt and the weight of unscoured wool per fleece (0.8023 ± 0.0076) was the highest correlation found among all the factors studied. Furthermore, an increase in the weights of dirt was accompanied by increased weights of clean wool, moisture, and grease, but there were consistent decreases in the proportion of dirt to clean wool, moisture, and grease.

Increased length of staple was associated with improved character of fleece, greater weight of scoured wool, less grease and dirt, and a little less density.

The finest fleeces had a little tendency to be more dense and of a little higher character but of lighter weight, both unscoured and scoured.

Improvement in the character of the fleeces was associated with longer staple, a little heavier weight of clean wool, a trifle less grease and dirt, and slightly finer fiber.

Increased density in the fleeces was correlated with greater weights of unscoured wool, scoured wool, moisture, grease and dirt, slightly shorter staple, and a little finer fiber.

Ewes free from heavy face covering or wool blindness yielded slightly heavier fleeces, both unscoured and scoured, and no important advantages were found as a result of heavy covering of wool over the faces of the ewes.

Freedom from folds was correlated with greater length of staple, a trifle greater fineness of fiber, a little higher character of fleece, somewhat lighter unscoured-fleece weights, a very slight reduction in clean-wool weights, considerably less grease and dirt, and less density.

Yearling body weights of the ewes increased with greater density, and fineness of fleece and slightly heavier weights of unscoured wool. The heaviest scoured-fleece weights were from ewes having sheared yearling body weights ranging from 80 to 110 pounds, or medium to moderately heavy for yearling range ewes. The proportion of the body weights to weights of wool and grease decreased as the body weights became heavier.

Mutton conformation in type, condition, back, rump, and leg had no very important influence on the various factors in wool production. Improvement in type and rump was related to a little more weight in the unscoured fleeces. Ewes averaging good or about 85 per cent perfect in mutton condition as yearlings produced the fleeces that averaged slightly the longest in staple. Other influences of mutton factors on wool production were either very minor or insignificant. On the whole these results suggest that good mutton conformation may have some advantages and substantially no disadvantages in efficient wool production.

○

END