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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 405 FEBRUARY, 1930

DIVISION OF RANGE ANIMAL HUSBANDRY

KARAKUL SHEEP

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

†As of February 1, 1930.

The Texas Station has found Karakul sheep to be hardy, vigorous, and long-lived. The ewes are good mothers. The lambs are large at birth and grow rapidly. Difficulty has been encountered in selling the lamb skins in small lots. Wool production is slightly less on the grease basis than that of the Rambouillet. Karakul wool, being coarse and colored, is classed as "carpet wool." It usually sells at a somewhat lower price than other wools (on the unscoured basis), depending upon the strength of the market demand for different grades of wool. There is usually a slight discrimination against high-grade or purebred Karakuls when sold for mutton. Many hereditary peculiarities are to be seen in Karakuls. They add to the fascination of breeding these sheep.

The chief problems to be solved if the raising of Karakul sheep is to be put upon a sound and permanent commercial basis are, first, a marketing system which will give the seller of small lots of skins access to the markets and, second, improvement in their breeding so that a higher proportion of lustrous and beautiful skins will be produced and the number of different types of Karakul skins in each flock may be greatly reduced.

Karakul sheep are native to central Asia. From the young lambs are taken the skins which are known to the fur trade under such names as "Persian Lamb," "Astrakhan," "Broadtail," "Karakul," "Krimmer," etc. These skins are used mainly for ladies' coats, coat collars and the cuffs for men's overcoats, caps, and for children's coats. The introduction of Karakul sheep into the United States began about 1908. The total number of animals imported was small. The industry has not yet been expanded enough to settle down on a commercial basis so that the breeders of these sheep can know whether to expect to make a reasonable return on their investment by selling skins, wool, and surplus sheep through commercial channels.

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BULLETIN NO. 405 FEBRUARY, 1930

KARAKUL SHEEP

By JAY L. LUSH, J. M. JONES and R. E. DICKSON*

Karakul sheep are of interest to American agriculture primarily because the skins of the young lambs are valuable to the fur trade. They are native to central Asia, more especially the region in and around Bokhara. Their exact origin is not known definitely. Valuable lamb pelts were produced in this region in commercial quantities at least as early as 1000 A. D. According to Adametz† karakul-like fur was used in trimming the coats of the Hittite kings as long ago as 1400 B. C. Since the development of these sheep for at least the last few centuries has been in the hands of a semi-civilized nomadic people, little given to making permanent records, it is unlikely that we shall ever know positively just what races and strains are mingled in the ancestry of the Karakul sheep living today. Their superficial resemblance to Angora goats in several points (luster of hair, curliness of hair, long broad ears, Roman nose, extremely drooping rump) attracts attention in view of the fact that both originated in very nearly the same part of the world. This is probably only a coincidence since the mating of present-day goats and sheep is not known ever to produce offspring in spite of the abundant opportunity offered for such matings in the ranges of Southwest Texas, where some two million Angora goats graze in pastures also occupied by a still larger number of sheep.

Karakul sheep have been introduced into many other countries, among which the more prominent are South Africa, Austria, France, Argentina, Germany, Canada, and Peru. Importations into the United States seem to have been made first in 1908. Other importations were made in 1913 and again in 1914. These importations received much publicity and there was considerable speculation in these sheep as breeding animals. The practical closing of the sources of importation by the war‡ gave an added "scarcity-value" to these animals and for years the prices of Karakul sheep ruled at such a high level that the purchaser could expect to make a profit only by selling his increase to other breeders who in turn must make their profits by selling to still other new breeders. Obviously this could not go on indefinitely. A stage must be reached at which the

*To H. E. Evans, C. M. Hubbard, R. A. Brewer, J. H. Jones and W. E. Flint thanks are expressed for preparing the skins and for taking many of the notes.

†Adametz, L., 1927. The ancestry of the Karakul Sheep of Bokhara and the Origin of the Curly Fleece of the Lambs of this Race (translated title). Zeitschrift für Tierzüchtung und Züchtungsbiologie. 8:1-64.

‡Rider, W. M. 1923. "The Karakul" in "The Sheep Industry in New York State." Bulletin No. 157 of the Department of Farms and Markets of the State of New York. Pp. 203-216.

grower of ordinary Karakuls could sell his lamb skins in the commercial fur markets and realize a profit on his investment if the industry was to acquire a permanent and profitable place in American agriculture. The industry is perhaps in that stage of transition at present and it would be premature to predict now whether it will succeed in making that transition or to estimate anything about the prices of ordinary good breeding stock when and if such a transition is accomplished. Many persons have been disappointed in not being able to realize the expected speculative profit from their investment in foundation stock but this has also occurred with some other breeds of livestock, notably in the early history of black-fox breeding.

A description and general discussion of Karakul sheep written at about the time they were receiving the greatest publicity may be found in the Yearbook of the United States Department of Agriculture for 1915 in an article entitled "Karakul Sheep" appearing on pages 249-262. This article, written by F. R. Marshall, L. L. Heller, and V. O. McWhorter, also includes several very clear plates showing some of the principal commercial classes of these lamb skins. It is especially recommended for those who are starting to learn about Karakul sheep.

In the past there have been several associations for registering Karakul sheep and for promoting the interests of breeders of those sheep. Four of these associations united in December, 1929, to form a single association: "Karakul Fur Sheep Registry," A. G. Granger, Secretary, Kadoka, South Dakota.

HISTORY OF EXPERIMENTS AT THE TEXAS STATION

First Experiment

In keeping with its policy of promptly investigating new animals and plants which show any reasonable prospect of filling a profitable place in Texas agriculture, the Texas Agricultural Experiment Station acquired a Karakul ram and three Karakul ewes in 1912 and began studying them and their crosses at Substation No. 10, College Station. The object of this experiment was to see whether inheritance of Karakul characteristics took place in Mendelian manner and, if possible, to combine the best fur qualities of the Karakuls with the best mutton and wool qualities of the breeds on which they were crossed, thus producing a new breed. Twenty-six half-blood Karakul lambs were born in the spring of 1913, of which 13 were out of Lincoln ewes, 6 were out of Hampshire ewes, 3 were out of Shropshire ewes, and 4 were out of Southdown ewes. These lambs were growthy and vigorous and the quality of the fur was such as to make those in charge feel optimistic as to the possibilities. However, there were severe losses from heavy infestation with stomach worms later in that year and in the annual report for the year ending August 31, 1914, we read that the experiment

had necessarily been discontinued on account of lack of material. A picture of the sheep used and some of their first lambs is shown on page 59 of the Twenty-fifth Annual Report (1911-1912) of the Texas Agricultural Experiment Station. A brief statement of the purposes and early results of this experiment on page 59 of the Twenty-sixth Annual Report (1912-1913) is the only other published record of this first experiment. Professor G. S. Templeton, who was in immediate charge of this experiment, had resigned in the spring of 1913 and it appears that for over a year after his departure there was no one taking an active interest in the management of these sheep.

Second Experiment

In 1914 the sheep-breeding investigations of the Texas Station were transferred to Substation No. 7, Spur. That fall a half-blood Karakul-Lincoln ram purchased from Mr. Alex Albright of Dundee, Texas, was used along with rams of the Rambouillet, Shropshire, Hampshire, Southdown, and Lincoln breeds to determine which would produce, when bred to fine-wool ewes, the most desirable lambs for feeding and marketing. The half-blood Karakul ram and his progeny constituted a minor part of this experiment and attention was concentrated on the adaptability of the lambs for mutton production with little reference to other Karakul characteristics. The results are printed in Texas Station Bulletin 205, Sheep Breeding and Feeding. The quarter-blood Karakul lambs were fifth in birth weight, third in weight when they went on feed, third in gains, and third in price received per lamb as compared with the other five lots. All six lots sold at the same price per pound of live weight. All differences were small. Some lambs from each lot were held on feed longer and were shown at Fort Worth in March, 1916. The quarter-blood Karakuls among these were excelled by three other lots in selling price per pound and in price received per lamb.

Third Experiment

Six purebred Karakul ewes and a Karakul ram were purchased for renewed experimental work in November, 1915, from Mr. W. T. Watt at Waco, and were sent to Substation No. 7 at Spur. The ram broke his neck in a fight with another ram soon after arrival. Other rams during the following ten years were secured from Mr. Alex Albright of Dundee, Texas, and from Mr. L. M. Crawford, Topeka, Kansas. No new females were added. A few crosses (most of them accidental) were made with the Rambouillet and Southdown ewes kept at the Station. But the main effort was devoted to increasing the pure Karakul flock to such size that definite studies could be made of the fur-bearing qualities of different families and of the characteristics in a mature sheep which indicated what kind of a fur value it had had as a lamb.

Ultimately it became clear that definite results in regard to the inheritance of valuable fur qualities could not be attained without the

almost constant attention of a man well acquainted with even the small differences in furs which have so much bearing on their commercial value. Since it was not feasible to employ such a man, it was decided to discontinue this work entirely so as to provide more facilities for work with the breeds of sheep more common in Texas and for the fattening of lambs. Accordingly the last of the Karakuls were sold in the spring of 1929. The findings from this experience with Karakul sheep are presented herewith.

INFORMATION OBTAINED

The Lamb Skins Taken for Furs

The primary reason for keeping Karakul sheep is the furs which the young lambs produce. Pelts are usually taken when the lambs are one to three days old although it is sometimes wise to let lambs with thin and light skins get a little older before killing them. Pelts of still-born lambs are sometimes quite desirable but (contrary to some popular ideas) rarely if ever so desirable as to justify killing the dam or producing an abortion so as to get the skin of the premature lamb.

Our experience with the pelts began with the lamb crop of 1923. Previous to that the flock had been small and the ram lambs were saved for breeding and a few were marketed as wethers. Eleven ram pelts were taken in 1923, of which four were from purebreds and the other seven were from grades. The four skins from purebreds are shown in Figure 1, where they are folded along the mid-dorsal line and overlap each other so as to show central portions of the pelts adjacent to each other. Of the seven skins from grades, four were rather lacking in luster, one of them decidedly so, one was rather coarse and "doggy" while the remaining two had some very nice curls quite suitable for trimmings but hardly tight, even, and beautiful enough for use in large garments. We began correspondence with various other breeders of Karakuls and with various fur dealers in an effort to market these skins for the highest price. They were sent to New York City and dressed and dyed, but no sale was found at first. In December, 1923, the senior author, being in New York City on other business, went to the firm at that time holding our Karakul skins for sale and through them obtained introductions to other fur dealers who at times handled Karakul skins. An entire day was spent in interviewing these men and in learning about the commercial channels through which Karakul skins normally reach the public in various garments. All these men were unanimous that there was no market for Karakul skins in small lots. The reasons for this are two: first, the number of skins annually produced in America is so small that it has not yet been worth any dealer's trouble to cultivate the American trade in small lots; second, the variation in style, shape, and tightness of curl, luster, heaviness, etc., in Karakul skins far exceeds that found in the furs of other species. The furs being used at that time were received from Asia in bales of about 500

skins each, laid down in New York City at an average cost of around $4.00 per skin. All the dealers agreed that in such a bale of 500 skins they would expect to find not less than 40 to 60 kinds of skins so different from each other that two different kinds could not be used in the same garment. Consequently they must buy in large quantities in order to get enough of each sort to make the proper use of them. Naturally they would not care to bother with the American skins in small lots unless these could be bought enough more cheaply to repay them for the trouble of assembling and handling the small lots. Truly beautiful skins do occur, and the dealers showed a number then in stock for which they would gladly have paid as much as $20.00 to $25.00, but stated that they could not expect to find more than one or two such in each bale while, on the other hand, they would find perhaps a hundred

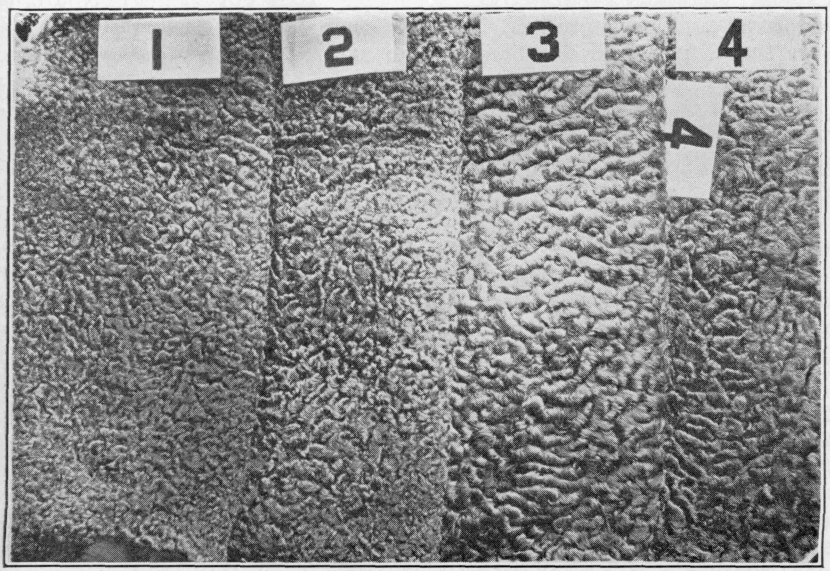

Figure 1. Skins of four purebred Karakul ram lambs born at Spur in 1923.

or more worth less than $3.00 each. They were very complimentary about the Texas Station's furs and stated that these were the equal of any lot of American-grown furs which they had yet seen—but they did not buy!

The marketing problems of the Karakul business in America may be summed up as two problems: first, how to provide a market for the man with a small number of skins just as the trapper can today find a ready market for a half dozen skunk or mink or muskrat hides and, second, for the breeders to select and purify their stock so that the uniformity of the furs will be very greatly increased. The two problems

are not independent of each other, for the marketing problem would be much simpler if the breeder could so reduce the variation in the furs that the buyer would expect only a half dozen different kinds instead of the present half-hundred or so. Whether or not the breeder can thus reduce the variation will depend primarily upon how much of it is really hereditary at base and how much is due to what we might call accidents of development. From our observations we hazard the guess that while the breeder can accomplish much along this line, he can never hope to make Karakul skins as uniform as those of skunk or muskrat. The various types and arrangements of curls in Karakul skins offer many more possibilities for differences than there are in straight-haired skins.

These eleven 1923 skins were finally sold for a total of only $12.00. The next year seven skins were taken, all being purebred Karakuls. They are shown in Figure 2, which, however, does not do justice to their real beauty. They were sold for $3.00 each. The following year there were twelve pelts, all purebred but on account of some insect damage they were not as good as the preceding ones and sold for only $1.00 each. Seven pelts were taken in 1926 but were not adequately protected from insects and their value was lost. No more pelts were taken and the flock was sold in 1929. The rather unfavorable financial returns which we received may best be comprehended when it is noted that during the years when these pelts were being taken lambs from range herds could be sold at weaning time for about $5.00 to $6.00 per head. Against this difference must be set down the fact that those which die at or soon after birth are a loss to the lamb market but have full value if the surplus lamb crop is being marketed as pelts. In the part of Texas where these experiments were being carried out—and indeed in most of Texas—there is very rarely a heavy loss at lambing time if reasonable care is given to the flock. However, in semi-desert regions after unusually hard winters, feed is sometimes so scarce that it is actually thought best to kill the lambs as fast as they are born in order to be surer of saving more of the ewes for next season. With other breeds such lambs are a total loss but with the Karakuls they would have the normal pelt value. If such disastrous seasons happen often enough Karakul pelts might prove more profitable over a period of years than market lambs would, even though the lambs would be more profitable in normal or favorable years. It was such considerations as these which led Wahl* in his report on these sheep in South Africa to recommend them for the harsher and more drouth-ridden districts but to say that where Merino sheep could thrive it would be a pity to displace them with Karakuls.

A more recent report† from South Africa gives information about the prices to be expected for Karakul skins both purebred and grade from that country. As his data are much more extensive than ours and

*Wahl, R. O. 1920. Karakul Sheep. Journal of the Department of Agriculture, Union of South Africa, 1:509-527 and 626-642.

†Schurman, G. J. 1924. Export of Karakul Skins. Journal of the Department of Agriculture, Union of South Africa, 8:518-520.

apparently very carefully taken, they are given here. There were 90 purebred Karakul lambs but the best 23 were saved for breeding purposes. Four different grades of Karakul crosses totalling 70 head were included. The skins were sent to London, dressed and dyed, and submitted to commission merchants for appraisal and sale. Those desired for use in exhibitions and to guide in the breeding projects were returned and the others were sold in London. The summarized results (the British money being converted into the American equivalent) were:

67	purebred Karakuls, averaged	$4.19
31	3rd cross Karakul-Ronde Rib Afrikaner, averaged	3.85
22	4th cross Karakul-Ronde Rib Afrikaner, averaged	4.64
6	5th cross Karakul-Ronde Rib Afrikaner, averaged	5.43
11	3rd cross Karakul-Black Head Persian, averaged	3.62

Making the rather liberal estimate that the best 23 Karakul lambs which were not slaughtered would have produced skins worth two

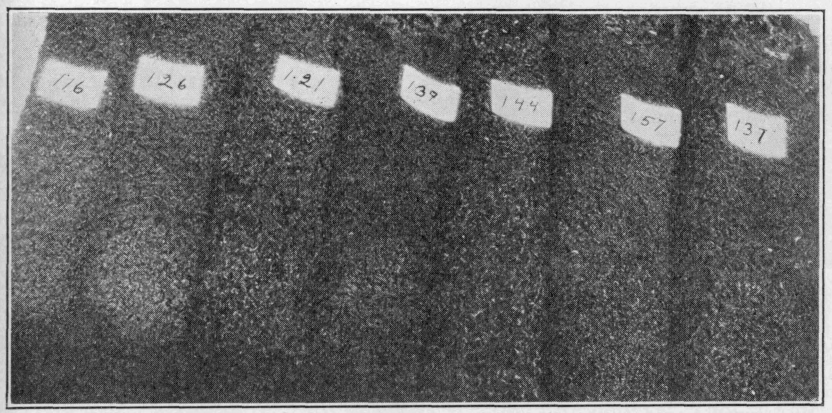

Figure 2. Skins from purebred Karakul ram lambs born in 1924.

pounds ($9.72) each, he estimates an average price of $5.61 for the skins of all purebred Karakuls born. Against these gross returns must be charged an average selling expense (commission, freight, and handling charges) of 24 cents per skin and the expense of preparing and dyeing, which would average 83 cents per skin in London or 33 cents in Leipzig at that time. (We were charged $1.00 per skin in New York.) Schurman also says: "* * * it is useless to export these skins unless in one parcel of at least 200 skins. It would be better still to ship 400 or more skins and instruct the broker to class these into parcels each containing the recognized number." He also says in corroboration of the representativeness of his price data that: "In Southwest Africa two farmers exported to Leipzig last year 800 and 1000 skins and received, respectively, 16s. ($3.89), and 18s. ($4.37), net per skin."

Some of the Karakul breeders believe that the skins from lambs even four months old or older may be sold for fur purposes if tanned, sheared down, and properly dressed. We have had no experience with that ourselves.

Fleece Weight

The Karakul wool is prevailingly coarse and black or dark brown on young sheep, gradually lightening with age until it is a blue or dirty gray on very old ones. White spots on the head and on the tip of the tail are common and occasionally a Karakul sheep with a large amount of white spotting occurs. In 1919 six ram fleeces (three of them from yearlings) averaged 10.4 pounds and sixteen ewes' fleeces averaged 8.0 pounds. The same year the eighteen Rambouillet ewes' fleeces averaged 10.0 pounds.

In 1924 the average fleece weights from the ewes were:

149 Rambouillets	7.65
20 Southdowns	6.05
32 Karakuls	8.59

In 1926 the average fleece weights for ewes were:

Rambouillets	7.69
Southdowns	4.77
Karakuls	5.61

In 1927 the average fleece weights for the ewes were:

75 Rambouillets	8.8
16 Southdowns	6.2
13 Karakuls	5.9

In 1928 the average fleece weights for the ewes were:

Rambouillets	9.15
Southdowns	5.61
Karakuls	5.07

Wool Grade, Shrinkage, and Price

The wool besides being colored is coarse enough that it would practically always grade as "carpet wool." The first fleece seems from inspection to be much more uniform and perhaps a little finer than later fleeces. It is also blacker. Later fleeces show more long very coarse fibers although retaining many which are as fine as in the yearling fleeces. Later fleeces grow lighter in color, especially as regards the long coarse fibers, and at a little distance appear to be blue or dirty gray in color.

Karakul wool has a high yield of clean wool. Three lots totalling 416 pounds of Karakul wool from the flock of Mr. Alex Albright, Dundee, Texas, were scoured in the wool and mohair scouring plant of the Texas Station in 1921 and gave shrinkages of 34.3 per cent, 36.0 per cent, and 33.6 per cent, respectively, or a weighted average of 35.3 per cent. This compares very favorably with average shrinkages of around 50 per cent for mutton breeds and around 60 per cent for the fine-wool breeds in Texas, although it must be remembered of course that there

is great variation in shrinkages from flock to flock and from region to region. One Karakul fleece from the Station flock in 1928 shrank 46.6 per cent. The low shrinkage of Karakul wool goes far to offset the generally low selling price of carpet wool on a scoured basis.

In 1916 and 1917 the Karakul wool from the Station sheep sold at the same price as the other wool. This was probably due to the war conditions and abnormal demand for wool suitable for blankets and coarse woolen clothing. From the 1919 clip the Karakul wool sold at 50 cents per pound while the other wool sold at 62 cents. In 1922 the Karakul wool brought 21½ cents, and the other wool brought 32 and 33½ cents. In 1923 the Karakul wool brought 25 cents while the other wool ranged from 37 cents for quarter-blood combing to 46 cents for fine strictly combing. In 1924 the Karakul wool brought 22 cents, Southdown wool 34 cents, and Rambouillet wool 30 cents. In 1927 the Karakul wool brought 25 cents; the Southdown wool and Rambouillet wool brought 32 cents. These are the prices actually received per pound of unscoured wool by the Station, which always sold through the Wool Growers Central Storage Company of San Angelo, Texas, or through the Southwestern Farm Bureau Wool and Mohair Association. It will thus be seen that the price received for the Karakul wool was normally about two-thirds to three-fourths as much per pound as was received for the Rambouillet wool. During the war demand these wools sold for practically the same price.

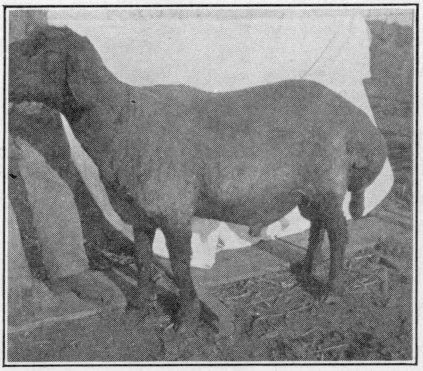

Figure 3. Purebred Karakul ram just after being shorn. This ram was bred by Alex Albright, Dundee, Texas. The very large size of the fat tail may be seen at a glance.

Mutton Price

The prices received for quarter-blood Karakuls in the cross-breeding experiment have already been mentioned. We did not sell enough purebred or high-grade Karakul lambs or wethers to get a fair comparison between them and other breeds. Such as were sold, however, always received severe criticism from the packer buyers. Karakuls have large fat tails which serve as storehouses for fat against the time of famine. When these sheep are fattened the tails get very large and are a waste from the standpoint of the packer, since his customers do not want this. This tail can hardly be used for anything but tallow and, since it weighs several pounds on a fat lamb, seriously affects the price which can be paid for the fat lambs. Figure 3 shows a mature Karakul ram just after shearing and the large size of the tail is very evident.

After a summer season when pastures have been good, the fat tails of the ewes are often so large as to interfere with their being bred, especially if the ram being used is a young one or at all small. We have had trouble of this nature several times when attempting to use rams two years old or younger.

The meat of the Karakul is said by the partisans of the breed to be unusually sweet and tender but we were unable to conduct any careful experiments to test this.

Birth Weights

Individual birth weights were secured during several years. They averaged as follows:

1916	(5 head)	10.8 pounds
1917	(7 head)	9.7 pounds
1918	(6 head)	10.9 pounds
1919	(8 head)	10.9 pounds
1923	(12 head)	10.8 pounds
1924	(12 head)	10.1 pounds

This may be compared with an average of 8.2 pounds for 48 lambs born in 1916 and used in the cross-bred lamb-feeding test the following winter. Twelve of these were Rambouillets and the others were crosses of Rambouillet and Lincoln, Romney and Shropshire. In 1917, 28 lambs of the same four breedings born at the Spur Station averaged 8.7 pounds. The following year the lambs in the cross-breeding experiment averaged 8.5 pounds for birth weight. It will thus be seen that the Karakul lambs were large. They were vigorous and there were very few weak or sickly ones among them. The ewes seemed to be excellent mothers and the lambs at 3 to 4 months of age were distinctly larger and fatter than those of other breeds at the Station. Twinning is not as frequent in Karakul sheep as it is in Rambouillets or in the mutton breeds.

Hardiness and Longevity

We obtained no figures to test these two attributes but our observations of these sheep from year to year, noting the amount of flesh they carried, the condition of their teeth, and the vigor and alertness with which they carried themselves, all lead us to believe that they are hardy and long-lived and able to take care of themselves under unusually adverse conditions of food supply. They were somewhat wilder and more nervous in temperament than the Southdowns and Rambouillets which we kept in the same flocks. The harsh conditions under which Karakuls were kept in their native land would naturally have tended toward the extermination of the less hardy individuals and strains among them long ago. In driving the flock to and from pasture it was frequently noticed that the Karakuls would tend to bunch together, usually at the front of the flock, very much as if they had some sort of a race consciousness impelling them to associate with each other rather than with the rest of the flock!

Inheritance in Karakul Sheep

There is every reason to believe that inheritance of differences between Karakul sheep and other sheep as well as the inheritance of differences between Karakul sheep takes place according to Mendel's laws but that several factors or genes are concerned in the development of most characteristics. This, of course, where small numbers are involved gives the appearance of what is sometimes called "blending inheritance." Mendelian segregation and recombination of the hereditary units is probably going on as usual but because each visible characteristic (for example, tightness of curl) is affected to various degrees by a considerable number of different hereditary units, there are many different grades of each characteristic, perhaps forming a practically continuous series from one extreme to the other.

In general the Karakul characteristics seem to be dominant but dominance is far from complete. First-cross lambs out of Southdown or Rambouillet dams are unmistakably Karakul and yet to one in the least familiar with Karakul sheep it is evident at a glance that they are not pure Karakuls. Only a small amount of crossing was done in the experiments at the Spur Station. Such cross-bred males were sold—except in the case of the cross-bred Karakul-Lincoln ram used in 1914 and 1915 to sire lambs from Rambouillet ewes for the feeding experiment. Some of the cross-bred ewes were kept for breeding but these were always mated to the purebred Karakul ram. Consequently no F_2 generation was produced at this station but a number of back-crosses to the Karakul and away from it were produced. No quarter-blood Karakul lambs were noted which failed to show any evidence of Karakul blood nor any which showed very extreme Karakul characters, such as an extremely large tail even when fat. Nor were any of the three-quarter-blood Karakuls noted which after a second glance would be mistaken for pure Karakuls. They were, however, much more like the pure Karakuls than the first-cross animals were and there was considerable variation among them. The detailed notes are too fragmentary and are expressed in descriptive terms too general to permit the calculation of any ratios between different types of each character, but the evidence all indicates a very large number of hereditary units in which the Karakul differs from the breeds with which we crossed it. Also most of the commercially important characteristics were probably influenced by several factors.

Ear Length

Ear length was one character which seemed to be governed primarily by only one pair of genes. Some of the pure Karakuls had very long broad drooping ears, more like those of an Angora goat than like those of ordinary sheep. The tips of the ears were 6 to 8 inches from the side of the head. Others had ears about the length of those of a Shropshire sheep, measuring about 3 to 5 inches from the tips of the ears to the side of the head. Some of these were quite pointed at the tip. Others

were rather broad at the tip and in a few cases there was some doubt about whether these ought to be classified as "long" or "short." A few other Karakuls appeared to be quite earless except when freshly shorn. They had stubs of ears which when measured were found to be about an inch long. They were called "earless" in our records. For many of the sheep the notes do not record the length of the ears. The three types of ears are shown in Figures 4 to 7. When the available records where the ear lengths are known for both parents and for the lamb are brought together, we have the following summary of the results of the different kinds of matings:

1. Long × long = 3 long.
2. Long × short = 7 long and 9 short.
3. Long × earless = 2 short.
4. Short × short = 4 long + 13 short + 5 earless.
5. Short × earless = 1 long + 5 short + 1 earless.

Except for the one "long"-eared lamb from mating No. 5, the results conform almost perfectly to the idea that ear length in this flock is determined by a single pair of Mendelian factors. When length is inherited from both parents the ear is "long." When shortness is inherited from both parents the sheep is "earless." When length is inherited from one parent and shortness is inherited from the other parent the sheep has "short" ears. The exceptional lamb was not described alive but was described from the pelt which had been dried and sent to College Station some five months after it was killed. Its ears were certainly very wide at the end and were classified as "long" although the possibility cannot be ruled out that it may have been one of the unusually long "short" ones. There can be no question of mistaken paternity, since only one ram was used this season. Moreover, in this case it was the dam which was "earless."

In appearance and manner of inheritance ear length in these sheep is very similar to that reported by Ritzman* for some grade sheep studied at the New Hampshire Station and presumably without any Karakul blood whatever. Also Wriedt† reports a very similar condition and similar type of inheritance in sheep from a number of different regions in Norway. Adametz‡ reports studies on the inheritance of ear length in Karakul sheep which lead him to the conclusion that ear length tends to be dominant over shortness but that several factors are involved. The ear length of his Karakul rams varied from 4.7 to 5.8

*Ritzman, E. G. 1920. Breeding Earless Sheep. Journal of Heredity, 11: 238-240.

†Wriedt, C. 1925. The Hereditary Relationship of Earlessness and Short Ears in Sheep and the Production of this Type in Norway. Zeitschrift für Induktive Abstammungs und Vererbungslehre, 36:430-437.

‡Adametz, L. 1917. Studies on the Mendelian Inheritance of the Important Racial Characteristics of Karakul Sheep in Pure Breeding and in Crossing with Rambouillets (translated title). Leipzig: Borntraeger Brothers, pp. VII+258, pls. 16 (see especially pages 151-165).

inches and for the Rambouillet ewes from 3.3 to 3.7 inches. Ear length in F_1 varied from 4.1 to 5.6 inches. Hence it seems certain that he was not dealing with the same kind of extremely long and extremely short ears which we observed and which were reported by Ritzman and Wriedt. Wassin* reports earlessness to be very common in Karakul sheep in the Caucasus region and eastward and to exist although less frequently in flocks of other sheep far to the north in Soviet Russia. His pictures and the manner of inheritance which he found are exactly like those

Figure 4. Three unshorn Karakul ewes showing "long," "short," and "earless" types.

observed by us. He also observed a few cases of earlessness of the same kind in flocks of goats in the region where it is most common in sheep. He is inclined to believe this came from occasional crosses with sheep but admits that there is yet no certain case in which a union between sheep and goats produced issue.

Wattles

Many of our Karakul sheep possessed wattles on one or both sides of their throats just a little behind the lower jaw. Wattles occur very frequently in goats and have also been reported in swine, Merino sheep, rabbits, and man. In goats and swine they are inherited as a simple Mendelian dominant character.† We have seen no report of their in-

*Wassin, B. 1928. Earlessness in Sheep and Goats (translated title). Zeit f. Induk. Abstam. u. Vererbungslehre. 49:95-104.

†Asdell, S. A., and Buchanan-Smith, A. D. 1928. Inheritance of Color, Beard, Tassels and Horns in the Goat. Journal of Heredity, 19:425-430.

Lush, Jay L. 1926. Inheritance of Horns, Wattles and Color in Grade Toggenburg Goats. Journal of Heredity, 17:72-91.

heritance in sheep other than these Karakuls. The presence or absence of wattles can be determined accurately only when the live lamb is examined before the first shearing time. The wattles are slender and can very easily be cut off by the shearer when he is cutting the wool which surrounds them so closely. That happened to a number of our mature sheep. Our notes on the presence of wattles are incomplete especially in the earlier years, and some of the later ones were made not on the live lamb but on the pelts which had been dried several months and which had also suffered some insect damage. As the records actually stand, ewes thought not to have had wattles when mated to rams thought not to have had wattles produced 8 lambs without wattles and 3 lambs with wattles, whereas none with wattles were to be expected if inheritance of wattles is the same in sheep as in goats and swine. Matings where one parent possessed wattles and the other was thought not to possess them produced 12 lambs without wattles and 16 with wattles where equal numbers had been expected. Matings where both parents had wattles produced 2 lambs with wattles and 6 lambs without wattles where a proportion of 3:1 had been expected. The 3 lambs with wattles but out of matings where neither parent was thought to have had wattles may be explained if it is assumed that one or both parents in these cases had lost their wattles at some shearing time before they were described with regard to this. This assumption of course cannot now be verified. If it is admitted we should probably conclude that wattles are inherited in Karakul sheep in the same way that they are in goats and in swine, that is, as a simple Mendelian dominant. If this assumption is not admitted, then the mode of inheritance must be more complicated in this case.

Figure 5. Close view of "long"-eared purebred Karakul ewe with wool clipped away.

Figure 6. Close view of "short" pointed ear on purebred Karakul ewe with wool clipped away.

Other Characteristics

Our notes contain evidence of inheritance of other characteristics such as white spots on the head or tail, apparent fineness of the wool, luster of the short hair on ears and face, etc., but that evidence is confined to the noting of striking parent-offspring similarity. We did not devise any system of measuring or grading and recording the variations in each of these characteristic so that the data could later be studied and classified to see what ratios were found and what hereditary factors were at work to produce each such variation. For more detailed accounts in this direction the reader is referred to the works of Adametz and Wahl.* Figure 8 shows the ear of a ewe from Mr. Albright's flock. Near the base of the ear there can be seen a bud of tissue which looks like an abortive start at the development of a double ear very much like that described† in Brahman cattle. Nothing was learned about its mode of inheritance but it was found in enough animals in this flock to indicate that it had a hereditary basis and was not an isolated case of some physiological accident of development. Wassin describes and pictures the same thing and states that it is inherited as a recessive. He states that it occurs very frequently in Turkestan. The unusually long nar-

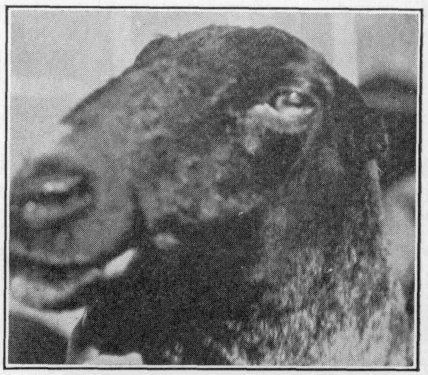

Figure 7. Close view of "earless" purebred Karakul ewe with wool clipped away to show the short stump of ear, which is scarcely visible when the wool has more than a month or two of growth.

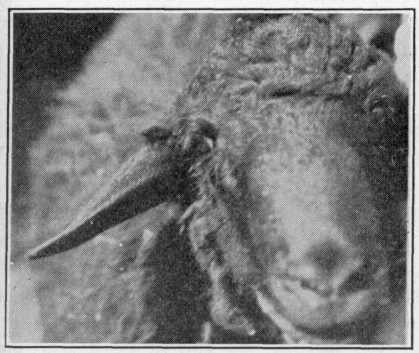

Figure 8. Front view of extra bud of tissue on ear of purebred Karakul ewe.

*Adametz, L. 1917. Hereditary Transmission of the "Curly Wool" Character of Karakul Sheep in Crosses Between the Karakul and Rambouillet Breeds. (translated title). Zeit. f. Indukt. Abstam. u. Vererbungslehre, 17:161-202.

1917. Studies on the Mendelian Inheritance of the Important Racial Characteristics of Karakul Sheep in Pure Breeding and in Crossing with Rambouillets. (translated title). Leipzig: Borntraeger Bros., pp. VII+258, pls. 16.

Wahl, R. O. 1920. Karakul Sheep. Journal of the Dept. of Agriculture of the Union of South Africa, 1:509-527 and 626-642.

†Lush, Jay L. 1924. "Double Ears" in Brahman Cattle. Journal of Heredity, 15:93-96.

row nostril openings and the large well-haired external openings below the eyes seem to be excellent adaptations for life in a region where sandstorms are frequent and severe.

General Conclusions

Karakul sheep are hardy, vigorous, and long-lived. The ewes are good mothers. They are unusually well adapted to taking care of themselves under harsh conditions such as are most frequently encountered in semi-desert regions. The wool is coarse and gray or black and will usually sell at around two-thirds to three-fourths as much per pound as ordinary Rambouillet wool, but this varies with the demand for "carpet wools," and during the war their wool sold at the same price as that of Rambouillets. The lambs are large and growthy, but, if sold for mutton, usually encounter some price discrimination on account of their large fat tails, which are mostly waste from the butcher's standpoint, and also because their carcass conformation is different from the butcher's ideal. They show many hereditary peculiarities and the breeding and improvement of them offers many interesting possibilities. The marketing of the skins on a commercial scale in this country has hardly been established yet. The market has little use for small lots of skins. The variation in appearance of the skins is so great that the matter of uniformity in them is of greater importance than in the other furs of commerce. Great reduction in the variation of these skins, if possible, will greatly simplify the marketing problem, but one would be quite optimistic to expect the time to come when the man with fewer than 100 skins will get nearly as much for his skins as the same kind of skins will bring in bales of 500 and more. From a purely business standpoint, these sheep do not seem to offer as much profit as other breeds in regions where other breeds thrive. If the marketing problem can be solved, and if the uniformity and grade of the skins can be very greatly improved, they may in time more than overcome their handicap in the matter of wool prices and mutton prices, but that is a matter for the future to show. On account of their hardiness and on account of the important fact that the lambs which die at birth or soon afterward have as high a pelt value as if they had been killed intentionally, the Karakul sheep may even now fill a sound economic position in the semi-desert regions which are subject, at irregular intervals, to severe drouths and heavy death losses and sometimes even to the necessity of killing the lambs at birth in order to enable their dams to survive until the drouth is broken. But where other sheep thrive we believe, in view of our experience and of the reported experience of others, that from the business standpoint, the raising of Karakul sheep should be regarded as still in the experimental stage.