SOME UNIQUE FEATURES OF FAT-TAIL SHEEP

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An obvious question to be addressed is why someone from the U.S. should be talking about Fat-tail sheep. There are a number of possible explanations for this. One of these is that the writer lived for two years in the Arab Middle East early in his career, and developed an interest in this type of sheep. Also, in the writer's view this may be the most important type of sheep in the world in terms of their contribution to mankind. This derives from their prevalence and to the fact that they are in most cases triple- or multi-purpose animals and that many people are near self-sufficient based on products obtained from these sheep. They are also produced in less developed countries of the world where the products obtained from sheep are critical to mankind. Another point of interest is that in many or most areas where they are available, meat from fat-tail sheep is considered preferable to that from other types, especially Merino. In view of the fact that consumption of lamb or sheep meat is low and/or declining in much of the rest of the world, any potential differences favoring a particular type of sheep must be of interest. A theoretical interest in the explanation for the presence of the fat-tail and their unique adaptation to arid environments was also of interest.

The only fat-tail type of sheep known to be present in the U.S. is the Karakul. The interest in these was not in pelt production, but to use them as an example of the larger population of fat-tail sheep. However, the Karakul, along with the Awassi, are among the most prevalent or most widely known breeds of this type of sheep. At least as contrasted to the breeds found in the western world, most fat-tail types have a great deal in common. These include, in addition to the accumulation of fat in the tail, adaptation to arid environments, carpet wool, low twinning rate, high lamb survival, etc.

Experimental

A small flock of Karakul ewes were established by the Texas Agricultural. Experiment Station at San Angelo in 1979. They were run on the same property as Rambouillet, Finnish Landrace and, at times, a number of crossbred types, but were not necessarily managed as a part of an experimental comparison with these animals. However, some distinctive features of Karakuls were evident:

1. They tended to be easy-care animals.
2. They were wilder.
3. They had low twinning rates (1.17 lambs per ewe),
4. Good lamb survival,
5. Low fleece weights and low value wool compared to Rambouillet (wt. 6.3 lbs vs. 10.0 and diameter 29.2 μm compared to 20-22). Color and variability of the fleece presented problems in marketing, but this may not be true in marketing to the handicraft trade.

A wide variety of experimental studies were undertaken with these animals, and this will be reviewed under various headings. Much of this has previously been summarized in SR-CRSP Report No. 91 (1987).

Relationship of the Fat-tail to Reproduction

The fat tail obviously constitutes an impediment to mating, and for this reason it is difficult to visualize the fat tail as being derived from totally natural selection.

Tests of Mating Success - A total of 22 rams of four different breeds (including the Karakul) were exposed to restrained fat-tail ewes for 10 minutes. In a total of 230 mounts or attempts to mate, no ram was successful in serving the ewe.

Table 1. Reproductive Performance of Docked vs. Undocked Ewes.

	No. Ewes year	Body wt. of ewes (lb)	Percent lambing	Percent lambs born per ewe	Average lambing date	Lamb survival (%)	Weaning wt. per day (lb)
Docked	111	117.6	92.9**	1.234*	174.7**	78.5	0.601
Undocked	120	116.4	78.9**	1.125*	182.5**	80.1	0.603
LS Mean	- -	- -	85.0	1.177	178.9	79.3	0.602

* Significant at .05 level of probability.
** Significant at .01 level of probability.

One-half the ewes raised in the flock and added to the flock were docked and one-half left undocked. These were exposed each year to two yearling or older rams, used either concurrently or consecutively. The results of these matings are shown in Table 1 (from Shelton, 1990). More of the docked ewes lambed, they lambed an average ½ estrus cycle earlier and they had a higher lambing rate. The first two observations would be expected, assuming some impediment to mating. The latter is more surprising, and based on the small numbers, may need verification. It has been reported that docked ewes have a heavier uterus and ovaries. Other possible explanations are - more services by the ram, lower body temperatures or that the fleshier in the undocked group having been less likely to be successfully mated and to lamb.

Grazing Behavior - Since Fat-tail (Karakul) sheep evolved and are adapted to arid environments with sparse vegetation, it appeared to be of interest to explore the possibility that they may have had different grazing habits, particularly with respect to the many problem plants found on Texas ranges. There is no evidence they differed from Rambouillets in this respect, although some breed differences did exist in respect to other genotypes included in the study (from Warren, *et al.*, 1982). Barbado blackbelly sheep tended to browse more than Rambouillet and Fat-tail, and Spanish goats browsed more extensively than Angora. In a related study, significant sire differences were observed in respect to intake of a number of individual plant species.

Eating Qualities of the Meat - The alleged differences in eating qualities of the meat were of special interest (at least to the writer). Two studies were conducted using taste panels and another investigating the fatty acid content of the subcutaneous fat.

In the first experiment wether and ram lambs of Rambouillet, Rambouillet x Blackface and Karakul were fed to produce U.S. Choice grade lamb carcasses. Taste panel comparisons were conducted on loin chops and leg steaks. No significant differences were observed, but such differences as did exist tended to favor the Karakul. In a second study, taste panel studies were conducted with leg and loin chops from lean carcasses (young growing males/or aged

Table 2. Mean values for fatty acid composition stratified according to age/sex and breed.

FATTY ACID	YOUNG MALES			AGED FEMALES		
	Rambouillet sheep (n = 12)	Barbado sheep (n = 11)	Karakul sheep (n = 21)	Rambouillet sheep (n = 13)	Barbado sheep (n = 11)	Karakul sheep (n = 10)
C14:0	3.12^{bc}	2.15^{d}	2.74^{cd}	2.20^{c}	2.05^{c}	2.25^{abc}
C15:0	0.53^{b}	0.56^{b}	0.85^{a}	0.49^{ab}	0.46^{b}	0.52^{ab}
C16:0	22.78^{b}	19.26^{c}	21.87^{b}	23.08^{bc}	20.96^{c}	22.84^{bc}
C16:1	2.44^{c}	2.61^{bc}	3.21^{ab}	3.19^{ab}	2.77^{ab}	2.62^{b}
C17:0	1.85^{b}	1.71^{b}	2.35^{a}	1.86^{a}	1.72^{a}	2.04^{a}
C17:1	0.85^{bc}	1.15^{ab}	1.41^{a}	0.66^{a}	0.47^{a}	0.69^{a}
C18:0	20.81^{a}	22.45^{a}	14.80^{b}	27.50^{a}	30.46^{a}	29.47^{a}
C18:1	41.84^{a}	43.40^{a}	44.89^{a}	36.47^{a}	37.14^{a}	35.55^{a}
C18:2	4.25^{a}	4.06^{a}	3.80^{a}	2.99^{a}	1.99^{b}	1.65^{b}
Unidentified peak	0.16^{b}	0.91^{ab}	1.58^{a}	0.00^{a}	0.35^{a}	0.47^{a}
Remainder	1.32^{b}	1.74^{ab}	2.59a	1.70^{a}	1.63^{a}	1.92^{a}
Total saturated	49.09^{bc}	46.13^{cd}	42.61^{d}	55.13^{b}	55.64^{ab}	57.11^{ab}
Total unsaturated	49.39^{a}	51.22^{a}	53.31^{a}	43.32^{a}	42.38^{a}	40.50^{ab}

[a,b,c,d] Means in the same row and for the same age and sex bearing a common superscript letter are not different ($P<0.05$).

females) of several different breeds of sheep and goats. Again, no significant differences were observed, and such differences as did exist did not favor the Karakul (from Griffin, *et al.*, 1982). To the extent that the non-significant observations are meaningful, which appears to the be case, the amount of fat on the carcass may be related to eating quality. In summary, these studies failed to confirm or explain any superior eating quality for the meat of these animals, but this may not be the final answer.

Dock fat samples from the latter study were analyzed for fatty acid content in the C14 to C18 range. A number of significant differences were observed in this data, but the significance or interpretation of these data is not clear. Some of these results are shown in Table 2 (from Wu, *et al.*, 1985). In this comparison, the fat-tail animals in the young intact male group had significantly less saturated fats than the others to which they were compared. Most of this difference was explained by a lower level of stearic acid (C18.0). These results were not found in aged females. A lower level of saturated fats would tend to lower the melting point of the fat and it appears significant to note that this higher melting point is one of the complaints sometimes heard about sheep meat.

Carcass Traits of Fat-tail Compared to Other Breeds

Several studies have been made which involved comparison of carcass traits of Karakul and other breeds or types. One set of data is shown in Table 3. These data were derived from wether lambs fed to produce U.S. Choice grade lamb carcasses. These data have been reported in more detail by Edwards, *et al.*, 1982. The crossbred animals in this tabulation represent Rambouillet X Suffolk crosses. The overwhelming conclusion from these data is that under comparable feeding conditions and at comparable slaughter weights the Karakul is fatter. This resulted in a carcass fat trim of 15.4% as compared to 6.6% and 6.7%, respectively, for the Rambouillet and crossbred groups. This fat trim was largely associated with the tail as identified as trim from the leg and loin in Table 3. However, the Karakul was fatter overall as evidenced by a significantly higher dressing percentage and a greater fat thickness over the 12th rib. The Karakul also had a markedly lower yield of trimmed wholesale cuts due to the necessary fat trim. Other studies have reported similar conclusions. O'Donavan, *et al.* (1973) reported a carcass fat percentage of 33.3 for Iranian fat-tail sheep. This high level of body fat is perhaps the major factor contributing to survival of these sheep under arid conditions or periods of nutritional stress, but it represents a very serious waste in terms of carcass value in those countries which do not have a ready market for carcasses of this type.

The influence of Docking on Growth and Carcass Traits

The previous section indicated a considerable amount of waste in the fat trim from the Karakul lambs. Most, though not all, of this was that associated with the tail fat or fat tail. Thus a logical question is what would docking do to the accumulation of fat which must be trimmed to make the carcasses acceptable in non-traditional markets.

As mentioned earlier, one-half of the lambs born in the experimental flock were docked with the remainder left undocked. Some of the males (castrated) were processed through a research laboratory along with comparable Rambouillet lambs as controls. Some of these data are shown in Tables 4 and 5.

Death losses and the relative growth rates of the docked vs undocked lambs are shown in Table 4. Differences between years, sex and type of birth were statistically significant. Differences in growth between lambs which were docked and those that were not docked were not significant, but when differences existed, they favored the docked lambs. Other researchers have reported slower growth rates for docked animals. In this study, docked lambs had a higher death loss, although this difference was not statistically significant. Further research on this point seems warranted.

Table 3. Influence of Breed of Lamb on Selected Carcass Traits.

	Breed Group			
Carcass trait	Rambouillet	Crossbred	Karakul	SD
No. observations	20	16	20	
USDA yield grade *	2.7c	2.4^c	3.0^d	.63
USDA quality grade *	11.1	11.5	10.9	1.05
Dressing percentage	52.6^c	53.8^c	56.1^d	2.94
Carcass fat trim (%)	6.6^c	6.7^c	15.4^d	2.21
Trimmed wholesale cuts (%)	78.9^c	80.2^c	72.7^d	2.65
Fat trim from leg (%)	8.7^c	8.1^c	32.1^d	3.69
Fat trim from loin (%)	9.8^c	9.0^c	21.0^d	5.08
Ribeye area, 12th rib (cm^2)	14.3	14.7	14.2	1.91
Leg conformation score *	11.7^c	12.7^d	10.5^e	.92
Fat thickness, 12th rib (mm)	3.2^c	3.1^c	4.4^d	1.40

$^{c, d, e}$Means on the same line concerning all breeds with different superscripts are different (P 0.05). The same applies to other tables in this report.
*These are coded values with the lower values for yield grades representing leaner carcasses. Higher values are more desirable in case of leg conformation or quality grade.

Docking markedly reduced the tail or dock fat trim from 6.5% to 1.7% of the carcass. This reduced the overall fat-trim in the carcass by 5%. In this study, docking did not increase the thickness of the external fat cover and only a marginal increase in kidney and pelvic fat content. In a study conducted by Joubert and Ueckermann (1971), the docked animals showed a slight, but non-significant, increase in kidney and pelvic fat, but no increase in external fat cover. Other studies have shown an increase in subcutaneous and internal (kidney/pelvic) fat deposition, but such an increase was not sufficient to compensate for the total reduction in the tail. Sefidbakht and Ghorban (1972) reported 16% separable fat of docked animals as compared to 27% for non-docked controls. These data suggest a reduced total fat deposition in docked animals. This should be advantageous to carcass value in all cases except potential market outlets where the price received for fat is equal to that of red meat. Other work has shown a tendency for increased intramuscular fat deposition of the loin in docked animals (i.e., 4.5% for docked vs. 4.1% for undocked animals).

Epstein (1982) reports a total body fat content of undocked Awassi lambs at 14.0%, compared to 12.4% for docked lambs. These values are of interest in that this researcher reports much lower fat percentages. This could potentially relate to the breed used, but much more likely is explained by lower slaughter weights (approximately 27 kg as compared to 50+ kg in the Texas study). Observations indicate that fat stores increase, both in actual terms and as a percentage as the animal matures. This is true for all types of sheep, but appears to be more marked for the fat-tail types.

Table 4. Least Square Means for Weaning Weight (kg) and Lamb Survival (%) by Treatment Groups.

Year	Type of Birth	Sex	Type of tail	Weaning weight	% Lamb survival
1981-29.4[b]					
1982-30.9[b]	Single-34.7[a]	Male-34.8[a]	Docked	33.4	84.3
1983-25.0[c]					
1984-39.6[a]	Twin-38.1[b]	Female-31.5[b]	Undocked	33.0	90.7
1985-39.4[a]					

Table 5. Comparison of Rambouillet and Docked vs Non-Docked Karakuls with respect to Certain Carcass Traits.

Trait	Rambouillet	Karakul	
		Docked	Undocked
Dressing percentage	54.03[a]	57.63[b]	57.13[b]
Cooler shrink (%)	6.23	6.94	7.35
Fat thickness, 12th rib (mm)	3.81	6.10[c]	6.85
Ribeye area (cm²)	14.19	14.45	13.09
Total fat (%)	9.00[a]	15.53[b]	19.76[c]
Rack fat (%)	0.68	1.14	1.11
Dock fat (%)	0.25[a]	1.68[b]	6.49[c]
Kidney/pelvic fat (%)	4.44	4.34	4.00

What is the Significance or Explanation for the Accumulation of Fat in the Tail?

Fat-tail sheep tend to be concentrated in arid environments, and more specifically, arid environments which are characterized by low humidity and large temperature variations between day and night and between seasons. One rarely sees fat-tail sheep in humid environments. The generally advanced explanation for the fat in the tail is that it is necessary to provide an energy source during extended periods of nutritional stress. This could theoretically be true only if the fat in the tail is physiologically different to that at other points on the body or if depositing the fat in the tail facilitates adaptation in the broader sense. Certainly a fat tail is not an absolute requirement in that goats and thin-tailed sheep can be observed under the same production conditions. The absence of fat-tail under more tropical conditions is theoretically due to the absence of a need. Also, there is some suggestion that the fat tail causes problems in a humid environment.

In the simplest terms, an accumulation of fat in the tail must result from natural or artificial (that imposed by man) selection. There is actually a tendency for accumulation of fat in the posterior regions in many breeds or species. For instance, there are several breeds of sheep characterized by deposition of fat around the rump. Thus, fat-tail sheep differ from other types of sheep only in the degree and specific location of their fat deposition. If man has actually selected for the fat tail it may be hypothesized that: (a) such animals were thought to be more adaptable or productive, (b) the meat of this type was preferred, and (c) the fat of the sheep was needed for cooking, seasoning or for use in preservation of other food products. This use might be comparable to that made of pork fat by farm families in the U.S. in earlier years. A quotation cited earlier that the tail fat was "the butter of Central Asia, and ideal for cooking purposes" emphasizes this point. There is an important distinction in that these sheep evolved and were used in the Middle East over thousands of years. In an arid or desert environment, animal fat (from sheep) could be collected much more easily if it was concentrated at one place in or on the body. The author is of the opinion that this is the most likely explanation for selection/propagation of sheep with this unique accumulation of fat. With the widespread availability and use of vegetable oils and changes in dietary habits, the fat tail or tail fat is no longer in great demand and in many markets it is removed from the carcass before delivery to retail outlets. In some cases, it has almost no value or is used for industrial purposes at very low prices. Thus, heavy fat accumulation constitutes considerable loss or waste for up to one-third of the world's sheep population involved. Many carcasses which are exported to the Middle Eastern market have the fat tail removed before shipment, suggesting some resistance to the excess fat present there. In this case, however, the buyer can still identify the carcass as being of fat-tail origin.

On the other hand, if natural selection is the primary mechanism for the accumulation of fat in the tail, an explanation for the adaptive advantages must hold interest. The most common explanation is that the fat in the tail is necessary for the sheep to survive at times of feed scarcity during dry or cold periods. However, this is a very superficial explanation and has a measure of validity only if the accumulation of fat in the tail has advantages (in terms of speed or ease of catabolism) over fat placed at other sites on the body. This has not been shown to be the case. Other potential sites for fat deposition are internal (kidney and pelvic region), subcutaneous, intermuscular and intramuscular. It could be theorized that presence of large amounts of internal fat interfere with the ability of the animal to consume large amounts of feed when it is available, or that subcutaneous fat would interfere with heat dissipation at times of heat stress. Both of these could possibly be true at some time or some place, but are these factors adequate to overcome the interference of the tail with reproduction under natural mating conditions or to take precedence over natural selection? A series of investigations was carried out to compare Karakul with other sheep in terms of their response to heat stress, and to compare docked vs. undocked animals. It might be expected that docking results in an increase in subcutaneous fat, and thus this comparison should provide some information on the question of tail fat deposition as a factor in dealing with heat stress. These data are shown in Tables 6 and 7.

In summary, the Karakul sheep were less affected by temperature stress than Rambouillet, but were more stressed than meat-type (non-fiber producing) goats. In general, there was little difference between docked and undocked animals; however, in three of the four cases, such differences as did exist favored the docked animals. Juma, Gharib and Eliya (1971) found that docked fat-tail rams maintained significantly lower rectal temperatures and respiratory rates than control animals (not docked). Also, Juma and Dessouky (1969) found that docking improved semen quality of rams. These studies do not support the theory that the accumulation of fat in the tail is beneficial to the animal in dealing with heat stress, and strongly indicate the reverse - that docking is beneficial.

Another suggested potential advantage for accumulation of fat in the tail is that a reduced internal fat storage would permit greater feed intake if intake became a critical factor. this would more likely be critical for the pregnant ewe, particularly for those carrying twins. Also, docking the ewe could theoretically increase the internal (kidney/pelvic) fat deposition Sefidbakht and Ghorban (1972). An experiment was conducted in which ewes of three breeds

(Rambouillet, Karakul and Finnish Landrace), in late pregnancy, were provided *ad libitum* feeding of a mixed and pelleted ration. The Karakul group contained docked and undocked ewes. The ewes were kept on feed for a period of time after lambing to coincide with the early state of lactation. Some of the results of that trial are shown in Tables 8 and 9 and are expressed as total daily intake in grams and as a percentage of body weight. All data for ewes which produced more than two lambs were deleted from the data-set, because of marked breed differences in litter size. For instance, none of the Karakuls dropped more than two lambs. As expected, ewes ate significantly more feed after lambing; this is probably more an expression of need than of body capacity. Also, ewes with twin lambs ate more feed than did those with singles. This was much more marked after lambing than before. There is a distinct tendency for Karakul ewes carrying twin lambs to eat less feed before lambing. Breeds differed significantly from each other in total feed intake before lambing, but when feed intake was expressed as a function of body weight only the Rambouillets, which had lower intake, differed from other breeds. After lambing, Rambouillet ewes differed significantly from other breeds in both total feed intake and feed intake as a function of body weight. These data suggest that Karakuls have a higher level of intake, but the only marked difference is between Karakul and the Rambouillet when feed intake is expressed relative to body weight. It is known from other studies that Karakuls have a higher body fat content; thus, feed intake relative to physiological needs for maintenance would be more for the Karakuls.

Some of the Karakul ewes used in the latter study were docked and some were undocked. Comparative feed intake data contrasting these two groups are shown in Table 10. The differences associated with gestation vs. lactation and single vs. twin births are similar to the data in Tables 8 and 9. Docked ewes consumed less feed, but the differences were not significant. A justification or explanation for this greater intake relates to possible greater internal (kidney/pelvic) fat deposition. Evidence supporting this point is variable (O'Donovan, *et al.*, 1973; Joubert and Veckermann, 1971 and Sefidbakht and Ghorban, 1972).

Table 6. Least Square Means for Body Temperature and Respiratory Rate of Rambouillet and Karakul Ewes.

		Respiration rate	Rectal Temperature °F
Breed:	Karakul	151.3[a]	103.0
	Rambouillet	161.3[b]	103.2
Fleece:	Wooled	142.1[a]	103.0
	Shorn	170.5[b]	103.2
Tail:	Docked	150.0	103.0
	Not docked	152.7	103.1

The Relation of the Fat-Tail to Adaptation to Arid Environments

It has been previously stated that this type of animal tends to be adapted to, or at least located in, arid regions and, more specifically, to arid regions subjected to wide ranges in temperature where both heat or cold stress may be encountered. Limited data have been presented which suggest that such sheep handle hot weather better than do Merino types. Since

Table 7. Least square means for respiration rate and body temperature measurements for five types of male small ruminants.

	Rambouillet rams	Barbados Black-belly rams	Docked Karakul rams	Fat-tail Karakul rams	Meat-type Goat males
	n = 10[1,2]	n = 10	n = 10	n = 10	n = 10
Rectal Temperature (F°)	104.5±0.12^{ab}	104.1±0.12^{b}	104.1±0.12^{b}	104.1±0.12^{b}	104.1±0.12^{b}
Respiration Breaths/minute	200.5±4.96^{a}	167.5±5.09^{b}	148.2±5.02^{c}	143.6±4.96^{c}	116.9±4.95^{d}

[1] Leastsquare means with different superscripts differ by (P .05).
[2] Four observations per animal.

Table 8. Total Feed Intake (grams per head per day) by Breed.

	Finnish Landrace	Karakul	Rambouillet
<u>Before lambing</u>			
Single	2178	2775	2421
Twins	2278	2537	2629
<u>After lambing</u>			
Single	3352	3743	3470
Twins	4532	4159	4432

Table 9. Ratio of Feed Intake to Body Weight by Breed and, Number of Lambs

	Finnish Landrace	Karakul	Rambouillet
Before lambing			
Single	.040[abc]	.049[a]	.037[a]
Twins	.043[ab]	.041[b]	.036[a]
After lambing			
Single	.061[bc]	.065	.054[a]
Twins	.070[abc]	.069	.063[a]

Table 10. Total feed Intake (grams per head per day) for Docked and Undocked Karakul Ewes Pre- and Post-Lambing Relative to Number of Lambs Born[1]

	Pre-Lambing	Post-Lambing	Overall
All ewes	2661.9	3670.7	3292.4
Docked ewes	2526.7	3659.4	3234.6
Undocked ewes	2786.5	3749.4	3388.3
Single births	2781.2	3506.6	3195.7
Twin births	2484.8	3934.6	3313.3

[1] Differences between pre- and post-lambing periods are statistically significant; other differences are not significant. Not all comparisons are completely orthogonal since date of lambing and number of ewes carrying twin fetuses could not be controlled. Data are included from a total of 22 ewes.

fat-tail sheep would spend much of their time in environments with high radiant heat loads with little access to shade, it seems likely that their coarse fleece would benefit the animal in both hot and cold climates. The data presented earlier in Tables 6 and 7 were collected with black Karakuls whereas lighter-colored animals may have actually had a greater advantage with respect to radiant heat load. There is at least a theoretical basis for the belief that dark-colored animals would have an advantage in cold seasons (Shkolnik, Maltz and Gordin, 1980). It was suggested earlier that the Fat-tail types of sheep do not possess any unique adaptations to humid environments. One of the suggested reasons for lack of adaptiveness to humid environments could be overcome by docking, and thus, if they are to be produced in tropical environments they should be docked.

Carcass studies have shown that one difference between Fat-tail and other types of sheep, with which they have been compared, is a high level of total body fat content. It is suggested that this is the reason for their unique adaptation to long periods of nutritional stress. The fact that they almost universally produce single lambs also probably contributes to ewe and lamb survival under conditions of nutritional stress, and contributes to the use of ewes for partial milking following limited suckling or early weaning.

The high level of body fat could simply result from a higher metabolic priority for fat deposition as contrasted to other body functions — including reproduction. However, limited data suggest an additional or alternative explanation. Data presented in Tables 8 and 9 suggest a higher level of feed intake by the Karakul when given *ad libitum* access to feed. An additional study which more directly addresses this point is summarized in Table 11.

Table 11. Comparative levels of Feed Intake of Barbados Blackbelly (a tropically adapted hair-sheep), Karakul and Rambouillet Sheep.

Criterion	BREEDS		
	Barbados Blackbelly	Karakul	Rambouillet
No. of Animals	10	10	10
Live weight, kg. [1]	32.5^{a}	57.0^{b}	59.2^{b}
Live weight $(kg.^{75})$ [2]	13.6	20.7	21.3
Feed Intake (kg/day) [3]	1.48^{a}	3.44^{b}	3.18^{b}
Feed Intake $(g/day/w^{75})$	109.1^{a}	166.0^{b}	149.5^{b}
Energy Intake $(Kcal\ DE/day/w^{75})$	308.0^{a}	468.5^{b}	422.1^{b}

[1] Means in the same row with different letters are significantly different (P .05).
[2] Live weight, $kg.^{75}$ approximates the animal's metabolic body size.
[3] As fed basis.

The differences in feed intake reported in Table 11 are statistically significant only when contrasting the hair-sheep with the other two types. However, there is strong evidence of a difference in feed intake between the Rambouillet and Karakul and there is a need to further investigate this point. If this point is validated with further research, it will help explain the unique relationship of this type of sheep to sparse feed conditions in that a high level of feed intake and a high level of fat deposition at times when feed is available contribute to survival and productivity in times of stress. There appears to be a large difference between the tropically adapted animals and the fat-tail sheep in this respect.

It has been suggested (Table 5) that docking results in a reduced total fat deposition, and thus this could result in reduced adaptation to periods of nutritional stress. The limited data available do not show an adverse effect of docking on animal performance. However, the conditions under which these data were collected were not extreme and there is need to test their response under more extreme conditions.

The above stated theories provide a potential explanation for the superior adaptation of fat-tail sheep to arid environments, but do not provide an explanation for the accumulation of fat in the tail. Some potential biological advantages to this localization of the fat was suggested earlier, but the contribution of these factors would not appear adequate to overcome the interference with reproduction. This still suggests that man has, at least to some degree, selected for this unique accumulation of fat, but at the present this remains largely conjecture.

Crossbreeding of Fat-tail sheep

If the consumption patterns in the Near East continue to shift away from the demand for excess fat, there is a need for production practices to eliminate this waste, and a large number of sheep are involved. Docking and crossbreeding are potential practices. On the other hand, if the traditional consumers of the Middle East continue to demand fat-tail animals or carcasses and the area continues to be a meat deficit area, then areas with surplus production, such as Australia should have an interest in considering the production of fat-tail carcasses.

Two crossbreeding studies have been conducted utilizing Karakul sheep. In one of these, Rambouillet ewes were compared with Finn x Rambouillet, Karakul x Rambouillet and Barbado Blackbelly x Rambouillet in an accelerated lambing program. The results are shown in Table 12.

These data confirm that Karakul crosses had lower lambing rates than the other types, but that they closely approached the Rambouillets. Lamb survival and growth rates favored the Karakul crosses indicating that the F1 ewes would perform favorably, at least in comparison with finewool types.

The second crossbreeding experiment consisted of a study of the influence of docking and castration on growth and carcass traits of fat-tailed (Karakul), Rambouillet and crossbred lambs. The crossbred group consisted of Karakul x Rambouillet and Suffolk x Rambouillet. Lamb growth favored those lambs out of Karakul dams (perhaps due to milking ability) and both crossbred groups grew faster than the Rambouillet. However, the primary interest in this study was in the pattern or amount of fat deposition. These data are included in another report (Shelton, *et al.*, 1987). Karakul or Karakul crosses had more fat at all points measured (back or rib cover as well as kidney and pelvic fat deposits and tail fat trim). Also, both types had lower conformation scores.

Table 12. Mean Lamb Production per Ewe per Year.

Breed group	Number lambings	Number lambs	Lambs born per ewe lambing	Number lambs weaned	% Lambs Raised of lambs born	Total pounds lamb weaned	Average fleece weight	Average body weight
Rambouillet	1.12	1.58	1.41	1.22	77.1	51.9	8.9	112.6
Finn x Rambouillet	0.98	1.77	1.80	1.27	71.4	51.4	6.0	116.9
Karakul x Rambouillet	1.19	1.60	1.34	1.33	82.7	61.1	6.1	121.9
Blackbelly x Rambouillet	1.24	2.11	1.71	1.64	77.7	68.9	3.8	103.1

* Weaning weights represent early weaned weights at approximately 60 days.

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