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The Promotion of Prolific Strains of Sheep by Crossbreeding and by Nutritional and Managerial Means

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SUMMARY

Following the establishment of prolific crossbred genotypes (Finn x Mutton Merino and Awassi), efforts were made in the present study to complete the assessment of their productive potential under an intensive accelerated lambing program and to expand their distribution into commercial flocks. In addition, an attempt was made to diversify the germ plasm by producing 3/4 and 1/4 Finn x Awassi stock and to test their performance under experimental and commercial conditions.

The performance of lambs of different genotypes was compared under the effect of varying environmental factors. The most important findings were: 1) very small differences in fattening performance between genotypes and between lambs out of different litter sizes; 2) Assaf rams in Israel and Suffolks in the U.S.A. had a small advantage over Finn-cross rams as sires for top crossing; 3) of environmental factors tested, only season was important. Early summer, with its rising temperatures, had a depressant effect on growth rate.

Seventy-two carcass dissections (32 Finn crosses and 33 and 7 Mutton Merino and Awassis, respectively, done in past work) yielded a series of useful correlations between body weight, whole carcass weight or partial dissection results and whole carcass composition.

The use of crop and animal by-products as sole feeds and in combination with conventional feeds was tested in a series of intake and digestion trials and short-term production experiments. Wheat straw (WS), ammoniated WS, alfalfa hay, cotton gin-trash and lint, poultry litter and cattle manure were successfully used for maintenance and early pregnancy. During advanced pregnancy and lactation additional grain was needed to meet requirements. Edible domestic waste substituted concentrate pellets for growing ewe lambs. Guidelines were drawn up for safety limits for the use of some of these products, and basic information required for the development of appetite-regulated complete rations has been acquired.

The seasonal patterns of sexual activity in the Finn (and Romanov) crosses were assessed and the effects of hormone treatments and day length manipulations to overcome the seasonal anestrus were studied. It was shown, both by behavioral studies and by blood progesterone patterns, that anestrus is not complete and therefore it was possible to breed successfully during all seasons of the year.

The study was followed up by field and laboratory veterinary examinations. The only definitely identified infectious disease was pneumonia (Pasteurella haemolytica) which was responsible for about 20% of lamb mortality. It was noted that management factors may be more important in maintaining high rates of lamb survival than medical care. The use of artificial rearing of the lambs and early weaning was shown to be effective in reducing lamb mortality.

This report consists of a series of papers grouped according to several main topics, each of which is preceded by an abstract with more details than given in this general summary.

GENERAL INTRODUCTION

Mutton forms about only 1.0 and 1.6% of the yearly per capita consumption of meat in the U.S.A. and Israel, respectively, allowing a wide scope for expansion. In the Middle East as a whole, pork is largely rejected, for religious reasons, stimulating increased red meat production through ruminants. Ruminants also possess the advantage that they can utilize pastures and farm by-products and wastes.

In order to promote meat production attempts were made in recent years to increase the litter size of indigenous breeds of sheep by crossing them with rams of the Finnish Landrace or Romanov breeds. In Israel, the crossbreeding experiments to increase the litter size started in 1970/71, when Mutton Merino ewes were mated to Finn rams; in 1972/73 Awassi ewes were added and in 1975/76 Romanov rams, from France, started to be used.

Results of the various efforts were encouraging, but the expansion of the newly formed crosses and of frequent lambing systems was hampered by:

- a. The lack of well formulated practices, to exploit the productive potential of prolific sheep, that they may fit into an industrialized agricultural environment where land, labor and feed are costly.
- b. Insufficient knowledge about factors acting on the resumption of post-partum reproductive functions for early rebreeding.
- c. Inadequate knowledge of feed requirements and intake regulation as a basis for mechanized, self-regulated feeding.
- d. High rates of lamb mortality.

The objectives of the present study, as suggested in the research proposal, were:

- a. To increase and improve populations of newly developed strains of high fertility sheep and to evaluate their productive potential.
- b. To determine nutritional requirements and to develop rations for incorporation into a management program.
- c. To develop management systems for increased lamb production through increased lambing frequency.
- d. To develop a health program using managerial procedures and veterinary practices to reduce lamb mortality.

The main body of the report is presented in parts 1 to 5, each of which includes a series of research reports on specific subjects.

There were many participants in this multi-disciplinary project, and several institutions in Israel, as well as the U.S., were involved. It was therefore considered appropriate to handle each subtitle as a separate chapter presented in the form of an article with the names of authors directly involved and their affiliations. The following abbreviations were used for the names of the institutions in each chapter:

ARO Agricultural Research Organization, Bet Dagan, Israel.
ISGI International Sheep and Goat Institute, Logan, Utah, U.S.A.
KVI Kimron Veterinary Institute, Bet Dagan, Israel.
Cornell Dept. of Animal Science, Cornell University, Ithaca, N.Y., U.S.A.
FAHU Faculty of Agriculture, Hebrew University of Jerusalem, Rehovot, Israel.

Finally, it is a pleasure to acknowledge the help of organizations and individuals who contributed to the successful accomplishment of the project.

First, we are grateful to BARD for the generous support which enabled us to carry out this project and which constituted a major contribution to the strengthening of the sheep research unit and its facilities as well.

Mr. I. Dimmerman was responsible for the care of the experimental sheep flock at Bet Dagan, with which most of the work was done. We thank Dr. A. Genizi, Division of Statistics and Experiment Design, ARO, for statistical advice and computer programming for chapters 1.3 and 1.4, and Mrs. Lucia Kornhauser and Mrs. Mina Wax for recording, statistical work and help in dissection of the carcasses. We are grateful to Messrs. M. Falk of Sede Warburg and G. Goldstein of Red-Gables (Pty) Ltd. near Tal-Shahar, for their cooperation. Most of the chemical analyses for the feeding trials were done by the Department of Biochemistry and Nutrition, Institute of Animal Science, ARO.

Further acknowledgments are included in conjunction with specific chapters.

PART 1. DEVELOPMENT AND PROPAGATION OF NEW STRAINS OF SHEEP FOR MEAT PRODUCTION UNDER HOT AND SEMI-ARID CONDITIONS

1.1 THE REPRODUCTIVE PERFORMANCE OF FINN CROSSES IN ACCELERATED LAMBING PROGRAMS

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ABSTRACT

Within an accelerated lambing program (ALP) of three lambings in two years, 121 Finn-Mutton Merino (FM), 91 Finn-Awassi (FA) and 29 3/4Finn1/4Awassi (3/4FA) ewe-lambs, most of them hormone treated, were mated at the age of 244 ± 48 d, 265 ± 42 d and 219 ± 7 d and lambled at the age of 479 ± 101 d, 463 ± 85 d, and 425 ± 71 d, respectively; 48-62% conceived in the first possible mating season, 34-52% in the second and 4% in the third. The number of lambs born per ewe lambing was 1.75 for FM, 1.73 for FA and 1.41 for 3/4FA ewe-lambs.

Within once-yearly lambing, none of the differences in contemporary comparison of the reproductive performance of 22 1/4Finn3/4Mutton Merino and 30 1/4Finn1/4Awassi1/2Assaf (ASFA) ewe-lambs was statistically significant.

The reproductive performance of 203 1/4Finn, 408 Finn-Mutton Merino (FM), 325 Finn-Awassi (FA) and 29 3/4Finn ewes in an ALP, with postulated 1.5 lambings per ewe per year, was analyzed.

In all crosses the number of ewes eligible for rebreeding (EEL/EP/Yr) varied from 1.6 in 1/4F and 1/2F to 1.75 in 3/4F, but the frequency of lambing (LMBG/EP/Yr) was considerably lower: in 1/4F, FM, FA and 3/4F it was 1.4, 1.2, 1.4 and 1.5, respectively. The average number of lambs born (LB/EP/Yr) was 2.2, 2.3, 2.7 and 3.0, respectively.

Within the halfbreds, the effect of year, age and season, and the monthly frequency distribution of mating and lambing, were also analyzed; these were based five to eight years, six age groups and two seasons. Year and age were partially confounded and the variability was relatively small. For the three key fertility measurements, the lambing performance of ewes in November-February, was significantly better than that in May-September: EL/EEL - 89.3% vs. 70.2%; LB/EEL - 1.74% vs. 1.25%; and LB/EL - 1.95% vs. 1.79%, respectively.

The halfbred ewes were mated in four mating periods, centered around June, September, December and April, and consecutively had four lambing peaks, in October/November, January/February, May/June and August/September. The percent of dry ewes was lower out of June and September matings than of December and April matings. The unweighted yearly mean was $18.1 \pm 9.5\%$.

INTRODUCTION

With the increasing demand for meat and diversification of farm structure and output, it was thought that the income of small farmers could be augmented, without hired labor, by the establishment of flocks for fat lamb production under intensive management. With this aim in mind, import of Mutton Merinos from West Germany was started in 1959. However, their prolificacy was found wanting and therefore Finnsheep and Romanov rams were imported from Finland and France, respectively, and crossed with Mutton Merino and Awassi ewes. The halfbreeds performed satisfactorily irrespective of paternal sire breed (Goot et al., 1979).

Under intensive management early sexual maturity, too, is important by generating extra income from sale of lambs out of hoggets, but also indirectly as it can speed up genetic improvement by shortening the generation interval and by enabling progeny-testing for early recognizable traits (Goot and Eyal, 1971). Direct selection for life-time lamb production would also be enhanced, as earliness of sexual maturity is positively correlated with prolificacy in subsequent years (Chang and Rae, 1972). Dyrmondsson (1973) gives a number of definitions of puberty, none of which is applicable to our data relevant to first mating and first lambing of ewe-lambs, particularly under an accelerated lambing system. He, too, tabled the percentage of ewe-lambs lambing and lambing percentage, but no lambing age was given, and most of the breeds we are working with are missing. The following are the mean ages and mean percentages of ewe-lambs lambing at their first lambing, in once-yearly lambing:

Awassi: 466 ± 31 d and 18% (Finci, 1957) and 457 ± 29 d and 30% (Goot et al., 1976; Goot et al., 1980); Assaf: 427 ± 22 d and 98% (Eyal and Goot, 1968); Finn sheep (in Finland): 378 ± 22 d and 99% (Goot, 1973); Mutton Merino: 440 ± 50 d and 55%; Finn-MM F_1 : 431 ± 48 d and 84%; Finn-MM F : 424 ± 44 d and 89% (Goot, unpublished); Finn-Awassi F_2 : 404 ± 64 d and 84% (Goot et al., 1980); Finn-Awassi F_2 : 397 ± 27 d and 66% (Goot et al., 1980).

The reproductive performance of Finnsheep and Romanov ewes and of their various crosses is well documented and reviewed by Maijala and Oesterberg (1976) and Goot et al. (1980), but mostly in once-yearly lambing. There are but a few references on their performance under an accelerated lambing system (Goot and Maijala, 1977; Goot et al., 1980; Hulet, 1978; Maijala and Oesterberg, 1976).

The purpose of the present study - which is in part a continuation of work previously communicated (Goot et al., 1980) - was to collect more information on Finn and Romanov crosses, particularly on the performance of generations beyond the F_1 , for which information was not abundant in the past.

An attempt was also made to study $1/4$ and $3/4$ Finn crosses as an opening of new options in the process of promoting the development of

commercial sheep units suitable for different environmental conditions, but mainly under more than once-yearly lambing.

This chapter and the three following ones include results that were obtained in the course of the present project, but hitherto unpublished data from previous years were used as well.

MATERIALS AND METHODS

Although most of the data are derived from the records of the Bet Dagan experimental flock (Goot *et al.*, 1980), some of the halfbred ewe-lambs were born and reared at the Migda Dryland Experiment Farm, near Beer Sheva, and transferred to Bet Dagan prior to breeding. The remaining ewes were bred at Tal Shahar and Sede Warburg. Red Gables (Pty) Ltd. at Tal Shahar is a private commercial farm which recently started lamb production by buying any Finn cross-ewe lambs available, and during the last 3 years has kept their own ewe-lambs. Another private farm, that of Mr. M. Falk at Sede Warburg, is a typical moshav farm that keeps about 60 ewes as a side line to avocado growing. Here, the flock is being enlarged to some 150 breeding ewes. The original Mutton Merino ewes are gradually being replaced by ewe-lambs bred on the farm and sired by Finn-Mutton Merino rams.

Genotype refers to the ewe-lambs and ewes and not to their progeny, which can be by rams of different breeds.

At Migda, the flock was kept on grass and paddock mated for once-yearly lambing; the Bet Dagan, Tal Shahar and Sede Warburg flocks were intensively managed and geared to an accelerated lambing program (ALP) for three lambings in two years (Amir, Schindler and Genizi, 1981). Early weaning, especially of lambs born during September-November, was practised and feeding was based on concentrates. The feeding of ewes, too, was based on concentrates at Bet Dagan, but on citrus pulp with addition of soya cake at Sede Warburg and of poultry litter at Tal Shahar, where the ewes were grazed in winter for a few hours daily.

The management of ewes at Bet Dagan was described previously (Goot *et al.*, 1980). At Tal Shahar and Sede Warburg, the ewes were hormone-treated as at Bet Dagan but not always so prior to September breeding; a few were handserved and the remainder were paddock mated.

At Bet Dagan, most of the ewe-lambs were hormone-treated prior to mating. As the mating was set for June, September and January (Amir and Schindler, 1977; Amir *et al.*, 1981), the ewe-lambs were mated as close to these months as possible. The cycling ewes were detected by teasers and hand-served one to three times per estrus period; usually two estrus cycles were allowed for a mating period. Ewes which failed to conceive within the first mating period would be re-bred again within a few months, but such subsequent matings were not analyzed; instead, the lambing data were analyzed according to season of lambing ('s' in appendix, Tables

A.1.1.1 and A.1.1.2). Usually two such seasons were allowed, but occasionally three, for primiparous ewes. Those which failed to lamb were culled.

At Tal Shahar the management of ewe-lambs differed from that at Bet Dagan in several important aspects, viz. (i) the ewe-lambs were incorporated into the ALP at a later stage, usually after the first lambing; (ii) they were not hormone treated; and (iii) they were paddock mated at 6-7 months of age (hence, age at mating was not recorded), starting in August-September.

The Bet Dagan data refer to Finn-Mutton Merino (FM) and Finn-Awassi (FA) halfbred and 3/4Finn1/4Awassi ewe-lambs born during 1978/79 - 1981/82. Tal Shahar data are confined to two groups of 1/4Finns with different genetic make-up, i.e., 1/4Finn3/4Mutton Merinos (1/4FM) and a triple cross of AssafxFinn-Awassi (1/4Finn1/4Awassi1/2Assaf), all born in 1980/81.

The ewe data at Bet Dagan go back to 1975/76 lambing season. In 1981 most of the FA, and a few of the FM and 3/4F ewes were withdrawn from the ALP and were used in other experiments described in Part 4 of this report.

The ewe data from Tal Shahar and Sede Warburg are based on two and three lambing seasons, respectively.

The primary purpose of the statistical analyses was to establish and define a set of reproduction parameters for ewes of different genotypes and ages within the ALP. The parameters were based on weighted and unweighted means, s.d. and C.V.; the differences between means were t-tested.

The following abbreviations are used throughout chapters 1.1 and 1.2:

A	Awassi
ALP	accelerated lambing program
As	Assaf
AsFA	crossbred by As ram out of FA ewe
EE	ewes exposed to rams
EEL	ewes eligible for breeding
EL	ewes lambed
EP	ewes present
F ₁	first halfbred generation
F ₂	F ₁ x F ₁
F ₃	sire F ₁ or F ₂ , ewe F ₂
FA	Finn-Awassi
FM	Finn-Mutton Merino
Fin	Finnsheep
LMBG	lambing
LB	lambs born
MM	Mutton Merino
MuB	multiple birth

Pres present
 RA Romanov-Awasssi
 RM Romanov-Mutton Merino
 Rom Romanov
 s season, lambing season in the ALP

RESULTS AND DISCUSSION

Ewe lambs in ALP. Out of 11 breeding groups (appendix, Table A.1.1.1) of FM, seven, with 76 ewe-lambs, were born between November and February, and four, with 45 ewe-lambs, between March and June. At the first mating the former were 258 ± 52.8 and the latter 222 ± 23.7 days old. The difference of 35.9 days was highly significant ($P < 0.001$) and plainly affected by the time of breeding. The seven groups, with 60 ewe-lambs born in Nov.-Feb., lambed at 484 ± 85.1 days of age and the four groups with 43 ewe-lambs born in April-Sept. lambed at 472 ± 119.5 days of age. The age difference at lambing, 11.6 days, was statistically not significant. The season of lambing, too, was not affected by season of birth (Table 1.1.1). The percentage of fertile matings (abortions

Table 1.1.1 REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO (FM), FINN-AWASSI (FA) AND 3/4FINN-1/4AWASSI (3/4FA) PRIMIPAROUS EWES, BORN 1978-1982 IN AN ACCELERATED LAMBING PROGRAM AT BET DAGAN (DETAILS IN APPENDIX TABLES A.1.1.1 AND A.1.1.2).

Genotype	FM		FA		3/4FA	
	n	days	n	days	n	days
First mating	121	244 ± 48	91	265 ± 42	29	219 ± 7
First lambing ¹						
1st season	60	417 ± 58	56	422 ± 48	13	359 ± 22
2nd season	39	549 ± 67	31	502 ± 63	14	481 ± 34
3rd season	4	739 ± 51	4	715 ± 41		
Total/Mean	103	479 ± 101	91	463 ± 85	27	425 ± 71
Aborted	10		0		1	
Culled and stolen	8		0		1	
<u>LB/EL</u>						
1st season		1.62		1.63		1.39
2nd season		1.95		1.87		1.43
3rd season		1.75		2.00		-
Total/Mean		1.75		1.73		1.41

¹Seasons refer to consecutive lambing seasons in the ALP, i.e., season 1 = first season in ewe-lambs' life in which they were eligible for lambing.

included) was slightly better in the "out of season" groups - 100% against 90%; on the other hand, the number of lambs born per ewe lambing (LB/EL) was slightly but not significantly in favor of ewe-lambs born in November-February (in season), viz. 1.65 ± 0.03 ($n = 7$ seasons) vs. 1.53 ± 0.05 ($n = 4$ seasons) lambs born per ewe lambing. Thus, it seems that time of birth, i.e., May/June-September and possibly temperature and day length associated with it, did not affect the lambing age and percentage, and the number of lambs born per FM ewe lambing in an ALP. Because of a set mating time and use of hormones, the present results cannot be compared with those of once yearly lambing, particularly as to the seasonality of breeding activity in ewe-lambs and its relationship with time of birth, as found inter alia by Dyrmondsson and Lees (1972) and Goot and Maijala (1977).

Within FA and 3/4FA very few ewe-lambs happened to be born out-of-season (Table A1.1.2). At first mating, as well as at first lambing (Table 1.1.1), the 3/4FA were youngest, followed by FM and last by FA. The mean ages of 3/4FA were highly significantly ($P < 0.01$) and significantly ($P < 0.05$) lower than those of FM and FA ewe-lambs, respectively. The differences between FM and FA halfbreds were not significant.

Differences in the percentage of fertile matings - abortions included - pooled over the seasons, as well as the number of lambs born (LB/EL), were statistically not significant (Table 1.1.1). Surprisingly, prolificacy in 3/4FA was lower than that in the halfbreds, but this may have been due to the fact that they were 2 months younger than the other genotypes when they conceived.

Ewe-lambs in once-yearly lambing. At Tal Shazar in 1980/81, contemporary comparison was made between two groups of 1/4Finn ewe-lambs, of similar age and type of birth, but dissimilar genetic background. As seen in Table 1.1.2, all the differences tested were statistically not significant. The age difference at first lambing may be due to AsFA being slightly older than 1/4FM when mated; their prolificacy was slightly lower, especially the percent of multiple births (MuB). On the other hand, they were marginally better in rearing their lambs, as judged by the percent of lambs artificially reared. In comparison with results at Gilat with FAF₁ and FAF₂ ewe-lambs (Goot et al., 1976), the 1/4Finn crosses lambed at a slightly older age (a difference of 25 days) but their prolificacy was higher by 0.2 LB/EL.

It should be noted that the statistical treatment of data pertaining to ewe-lambs in ALP differed from that in once-yearly lambing. In the former, the ewe-lambs, having a short mating period followed by another for re-breeding, could lamb in season as well as out-of-season, whereas in the latter the ewe-lambs had an extended breeding and they could lamb, as ewe-hoggets, in-season only. Although it is still difficult to assess any advantages of incorporating ewe-lambs into ALP and hormone treatment, it seems that the percentage of FM and FA halfbreds lambing during the first season, 60% at the age of 419 days (Table 1.1.1), is low when compared with 1/4Finns in once-yearly lambing, without hormone treatment, viz. 75% at the age of 427 days (Table 1.1.2), or 80-81% for FM and FA

Table 1.1.2 CONTEMPORARY COMPARISON BETWEEN THE PERFORMANCE OF 3/4FINN 3/4MUTTON MERINO AND 1/4FINN1/4AWASSI1/2ASSAF (AsFA) EWE-LAMBS BORN 24.X.79 - 9.III.80 AND LAMBING AT TAL SHAHAR IN 1980/81 LAMBING SEASON (ONCE-YEARLY LAMBING WITHOUT HORMONE TREATMENT).

Genotype	1/4Finn ¹	AsFA ²
Present	22	30
Birth date, days±s.d.	5.I.80±25	19.XII.79±49
Type of birth	2.1	2.0
Age of first lambing, days s.d.	420±22	432±49
Lambled, %	77.2	73.3
LB/EP	1.27	1.17
LB/EL	1.65	1.59
Lambs art. reared, %	17.9	11.4
Lambs died 0-150 d, %	25.0	20.0
Birth weight, kg	3.4±1.0	3.1±1.1
Rate of growth, g/day s.d.		
Birth - weaning	220±41	233±51
8 weeks after weaning	300±52	303±60
150 d weight, kg	43.8±5.8	44.2±7.0

¹3/4Merino

²1/4Finn1/4Awassi1/2Assaf

ewe-hoggets (Goot *et al.*, 1976; Goot *et al.*, 1980). Prolificacy in the halfbreds, and indeed in the 1/4Finns, was higher than expected, and in the 3/4FA - lower. In the primiparous Finnsheep there was a positive correlation between age and litter size (Goot and Maijala, 1977). A similar tendency is evident in the present data (Table 1.1.1). In addition, one should expect a positive correlation between age and rate of survival of lambs. Further work should be undertaken in order to establish the optimum age at first lambing and factors affecting it, so that the net reproductive efficiency could be further enhanced.

Finn versus Romanov halfbreds. In spite of the published data on contemporary comparisons between halfbred sires by rams of these breeds (Goot *et al.*, 1979), there are still strong opinions in favor of one or the other, and therefore further contemporary comparisons are presented in Table 1.1.3. The small differences in favor of the Romanov cross were due to the first year's results; in the remaining 2 years the results were, if anything, in favor of the Finn cross: for instance, in FA the figures for LMBG/EP/Yr were similar to those in RA and also

Table 1.1.3 CONTEMPORARY COMPARISONS BETWEEN FINN-AWASSI (FAF₁) AND ROMANOV-AWASSI (RAF₁) HALFBRED EWES AGED 1 3/4 - 6 YEARS IN AN ACCELERATED LAMBING PROGRAM IN 1977/78, 1978/79 AND 1981/82

Genotype	FAF ₁	RAF ₁
Mean EP	41.5	33.5
EEL/EP	1.69	1.52
EL/EEL	0.80	0.94
LB/EEL	1.54	1.84
LB/EL	1.93	1.96
LMBG/EP/Yr	1.35	1.43
LB/EP/Yr	2.60	2.81

LB/EP/Yr were slightly better than those for RA. As mentioned previously, all the data presented here on FA and RA were pooled and presented as Finn-Awassi (FA), which formed most of the population.

Mating and lambing of ewes in ALP at Bet Dagan and season effects. The original ALP, with three lambings in 2 years, or 1.5 lambings in a year, postulated June, September and December-January matings so that the ewes could lamb in November, February and June (Amir and Schindler, 1977). The expected lambing-to-lambing intervals should range from 7 to 9 months. However, within the first 2 years studied, the interval in FA ewes ranged from 7 to 12 months (Goot *et al.*, 1980). There was too big a gap between January and June breeding, and in 1980/81 April matings were added as well (Amir *et al.*, part 4). The lambing frequency followed very closely the mating season except for a slight delay due to repeat breeders, which was particularly evident following the December-January period. Out of 924 ewes mated, 758- or 82%-lambled and 147 - or 15.9% - were dry; abortions, culling, etc., accounted for the remaining 2.1%. The percent of dry ewes (those which failed to lamb), based on ewes mated in each period, was: 10% in June, 15% in September, 18% in December/January and 23% in April. Amir *et al.* (Part 4) stress high yearly variability and call for further studies. Be that as it may, if a ewe is in heat the chances of getting her in-lamb from an April mating appear to be quite high (see part 4).

Ewes mated in June-September ("in-season") lambled November/December - January/February, and those mated in December/January and April ("out-of-season") lambled in May/June and August/September. Their performance (Tables 1.1.4 and 1.1.5) was analyzed on four measurements possible; as

Table 1.1.4 REPRODUCTIVE PERFORMANCE OF FINN×MUTTON MERINO F₁ (FMF₁) AND F₂₊ (FMF₂₊) EWES IN DIFFERENT LAMBING SEASONS IN AN ACCELERATED LAMBING PROGRAM AT BET DAGAN (MEANS±BETWEEN YEARS S.D.)

Lambing season	EP	EEL	EL: EEL, %	LB: EEL	LB: EL	EEL: EP:Year	LMBG: EP:Year	LB: EP:Year
FMF ₁ (1975- 1982)								
Nov.-Feb.	198	178	87±8.5	1.83±.33	2.08±.21	-	-	-
May-Sept.	184	99	70±14.3	1.35±.27	1.92±.20	-	-	-
All	382	277	79±14.3	1.59±.39	2.00±.21	1.48±.21	1.17±.12	2.35±.21
FMF ₂₊ (1975 - 1983)								
Nov.-Feb.	222	198	89±12.3	1.76±.36	1.98±.19	-	-	-
May-Sept.	212	157	64±27.7	1.23±.23	1.69±.29	-	-	-
All	434	365	76±24.3	1.42±.54	1.84±.28	1.53±.20	1.24±.14	2.34±.33

Table 1.1.5 REPRODUCTIVE PERFORMANCE OF FINN×AWASSI F₁ (FAF₁) AND F₂₊ (FAF₂₊) EWES IN DIFFERENT LAMBING SEASONS IN AN ACCELERATED LAMBING PROGRAM AT BET DAGAN (MEANS±BETWEEN YEARS S.D.)

Lambing season	EP	EEL	EL: EEL, %	LB: EEL	LB: EL	EEL: EP:Year	LMBG: EP:Year	LB: EP:Year
FAF ₁ (1977 - 1983)								
Nov.-Feb.	296	284	91±7.7	1.74±.26	1.92±.21	-	-	-
May-Sept.	182	153	74±12.0	1.49±.34	2.02±.14	-	-	-
All ¹	365	327	84±13.6	1.68±.32	1.99±.21	1.72±.18	1.45±.12	2.90±.21
FAF ₂₊ (1977 - 1982)								
Nov.-Feb.	148	142	92±9.3	1.61±.18	1.76±.13	-	-	-
May-Sept.	138	90	76±10.9	1.15±.12	1.54±.24	-	-	-
All	266	232	84±12.7	1.38±.28	1.65±.22	1.62±.25	1.36±.22	2.31±.35

¹The 1979/80 data and part of the 1980/81 data were excluded, as the ewes were used in other experiments.

the differences between genotypes and generations were not significant, the data were pooled (Table 1.1.6). On the average, the out-of-season performance of ewes was significantly reduced in comparison with that of in-season: 19% fewer ewes lambed and 0.49 fewer lambs were born out of ewes eligible, or 0.16 fewer lambs out of ewes lambing. Only the percent of multiple birth was not affected. In all measurements the variance reflecting yearly variability was considerably higher out-of-season than in-season.

Table 1.1.6 BETWEEN-SEASON DIFFERENCES IN REPRODUCTIVE PERFORMANCE OF FINN HALFBRED (FM AND FA) EWES IN AN ACCELERATED LAMBING PROGRAM (BASED ON 690 NOV.-FEB. LAMBINGS AND 362 MAY-SEPT. LAMBINGS).

Criteria	Season	n groups	Means $\pm$ s.d.	Difference
EL:EEL, %	Nov.-Feb.	27	89 $\pm$ 9.4	19.1**
	May-Sept.	24	79 $\pm$ 18.4	
LB:EEL	Nov.-Feb.	27	1.74 $\pm$.30	0.49**
	May-Sept.	25	1.25 $\pm$.37	
LB:EL	Nov.-Feb.	27	1.95 $\pm$.21	0.16*
	May-Sept.	24	1.79 $\pm$.29	

*P<0.05; **P<0.01

Genotype and generation. EEL/EP/Yr. In spite of overlapping of suckling and mating and of 'slip-overs', at least 50% of the ewes should be eligible for re-breeding, or 1.5 ewes per year. As shown in Tables 1.1.4 and 1.1.5, the number of ewes eligible was, on the average, slightly in excess of 1.5: 1.62 in FA and 1.51 in FM. All the year differences between genotypes and generations were statistically not significant.

LMBG/EP/Yr. There was a sufficient number of ewes eligible for 1.5 Lambings per year. However, actual yearly lambing frequencies averaged 1.4 and 1.2 lambings per ewe per year for FA and FM, respectively. All the year differences were statistically not significant except for the difference between FAF₁ (1.45) and FMF₁ (1.17) (P<0.01) (Tables 1.1.4 and 1.1.5).

LB/EP/Yr. The number of lambs born to FA ewes, 2.60, was higher than, but not significantly so, than to FM ewes, 2.34. Within the FM ewes there was no difference between generations, but within the FA ewes there was a significant (P<0.05) drop in the number of lambs born per ewe present per year from 2.90 in F₁ to 2.31 in F₂+

EL/EEL. All the differences between genotypes and generations were statistically not significant, although slightly more FA than FM ewes lambed

- 84% vs. 78%, respectively. The yearly variations were considerable, as shown by the C.V. of 22% (range 18-32%).

LB/EEL. Here again all the differences were statistically not significant, although the number of lambs born out of F_1 ewes was greater (1.61) than that out of F_{2+} ewes (1.41).

LB/EL. The difference between genotypes was not significant, 1.92 and 1.82 for FM and FA ewes, respectively. Within the FM ewes the generation difference was not significant, but within the FA ewes the number of lambs born out of F_1 ewes (1.96) was significantly higher ($P < 0.01$) than that out of F_{2+} ewes (1.65).

MuB/EL. All the genotypic differences were not significant, but within the FA ewes the multiple birth in F_{2+} generation was significantly lower ($P < 0.01$) than in F_1 : 56% vs. 75.2%.

Age. Although 'age' is partially confounded with 'year', it seems desirable to regroup the data according to age, especially as most of the age-groups were present in the same years (see Tables A1.1.3 - A1.1.6). The results based on pooled data for the key measurements are summarized in Table 1.1.7 (see also Tables A1.1.7 - A1.1.10). It should be noted

Table 1.1.7 BETWEEN-AGE-GROUP COMPARISON OF YEARLY REPRODUCTIVE PERFORMANCE OF FINN HALFBRED (FM AND FA) EWES IN AN ACCELERATED LAMBING PROGRAM AT BET DAGAN (MEANS $\pm$ S.D.)

Age (years)	Number of ewes	EEL:EP:Yr	LMBG:EP:Yr	LB:EP:Yr
1	47 ¹	1.75 $\pm$.08	1.25 $\pm$.04	2.00 $\pm$.00
2	125	1.57 $\pm$.31	1.35 $\pm$.28	2.53 $\pm$.45
3	135	1.61 $\pm$.19	1.40 $\pm$.14	2.75 $\pm$.33
4	115	1.53 $\pm$.22	1.20 $\pm$.16	2.74 $\pm$.34
5	111	1.54 $\pm$.10	1.33 $\pm$.10	2.52 $\pm$.44
6-9	99	1.58 $\pm$.18	1.26 $\pm$.16	2.57 $\pm$.28
Total/mean ²	632 ³	1.59 $\pm$.18	1.31 $\pm$.17	2.47 $\pm$.39

¹FMF₂₊ and FAF₂₊ only.

²Based on 21 groups: two of yearlings, 16 of 2-5-year-old ewes, and three of 6-9-year-old ewes.

³59 x 1½- and 24 x 2½-year-old FMF₂₊ ewes were excluded (Table A.1.1.8).

that in age 1 only FMF₂₊ and FAF₂₊ are represented and age-group 6-9 is without FAF₂₊. The age-group means in Table 1.1.7 are based on 21 groups, so that the variances measure not only variations due to age but also due to genotype and generation, with the exception listed above.

The age of ewes does not seem to influence much their reproductive performance. In each age, the number of ewes eligible for breeding, EEL/EP/Yr, was higher than the minimum of 1.5 postulated; the yearly frequency of lambing, LMBG/EP/Yr, varied at random from 1.25 to 1.40 lambings per year. The number of lambs born, LB/EP/Yr, ranged from 2.00 to 2.74. It was highest in age groups 3 and 4, and lowest in the 1-year-olds and, finally, the percent of multiple births, MuB/EL, was highest in the oldest age group. In all these measurements, the extreme age groups might have been affected also by the missing generations, as explained above.

The results confirm the previous finding (Goot, 1973) that the effect of age on fertility is much smaller in prolific than in less fertile breeds. For instance, in N.Z. Romneys, age accounted for 58% and 62% of the total variance for LB/EL and MuB/EL, respectively (Goot, 1951), whereas in Finnsheep the number of lambs born was lower only in ages 1 (1.86) and 2 (2.58), and in ages 3 - 9 it ranged from 2.8 to 3.1 lambs born per ewe (Goot, 1973). The above results are at variance with those of Ercanbrack (1978), who reported increased prolificacy with age: 1.53, 1.96, 2.16 and 2.43 lambs born per ewe lambing in Finn halfbreds aged, 1, 2, 3 and 4 years, respectively.

Other Finn Crosses. 3/4Finn1/4Awassi (3/4FA). Owing to unforeseen circumstances, some of the 3/4FA ewes were taken to other experiments and all were shifted in January 1983 from Bet Dagan to Tal Shazar. Therefore, the data presented in Table 1.1.8 do not reflect the full potential of the cross. In addition, during the first year in the ALP (1981/82), all the ewes were only 1-1½ years of age, and they lambed save one, between January 20 and February 9, 1982. Ten of them, out of 11 eligible, were again hormone-treated and mated on April 1 or 2, 1982, and half of them lambed. In spite of such handicaps, the results are very encouraging. Averaged over 2 years, 1.74 ewes were eligible for re-breeding and 1.46 ewes actually lambed and produced nearly three lambs per ewe present per year.

The frequency distribution of litter size at birth, given below, in comparison with FA ewes (Goot et al., 1980), has shifted mostly from twin to triplet births, but in comparison with pure Finnsheep (Goot, 1973) there is still a high proportion of single births.

Table 1.1.8 REPRODUCTIVE PERFORMANCE OF DIVERSE FINN CROSSES IN TWO LAMBING SEASONS IN THREE FLOCKS IN AN ACCELERATED LAMBING PROGRAM

Age (years)	Lambing season	EP	EEL	EL: EEL, %	LB: EEL	LB: EL	EEL: EP:Yr	LMBG: EP:Yr	LB: EP:Yr
3/4Finn1/4Awassi (Bet Dagan)									
1-1½	Nov. 81-Feb. 82	14	14	100.0	1.86	1.86			
	Sept. 82	14	11	54.6	1.00	1.83	1.79	1.43	2.64
1-2½	Nov. 82-Feb. 83	25	19	73.7	1.53	2.07			
	Sept. 83	24	23	95.7	2.13	2.23	1.71	1.47	3.18
1/4Finn3/4Mutton Merino (Tal Shahr)									
2	Nov. 81-Feb. 82	20	20	100.0	1.35	1.35			
	May-Sept. 82	20	16	87.5	1.19	1.36	1.80	1.70	2.30
3	Nov. 82-Feb. 83	19	19	89.5	1.68	1.88			
	May-Sept. 83	18	6	50.0	.83	1.67	1.35	1.08	2.00
1/4Finn3/4Mutton Merino (Sede Warburg)									
2-4	Nov. 80-Feb. 81	53	53	88.7	1.21	1.36			
	May-Sept. 81	52	22	77.3	1.68	2.18	1.43	1.22	1.92
3-5	Nov. 81-Feb. 82	27 ¹	27	66.7	1.30	1.94			
	May-Sept. 82	27	22	86.4	1.23	1.42	1.81	1.37	2.30
1-6	Nov. 82-Feb. 83	34	34	94.1	1.77	1.88			
	May-Sept. 83	34	21	85.7	1.48	1.72	1.62	1.47	2.68
1/2Assaf1/4Finn1/4Awassi (Tal Shahr)									
2	Nov. 81-Feb. 82	26	26	96.2	1.23	1.28			
	May-Sept. 82	26	26	69.2	1.04	1.50	2.00	1.65	2.27
3	Nov. 82-Feb. 83	25	25	92.0	1.52	1.65			
	May-Sept. 83	25	8	62.5	1.00	1.60	1.32	1.12	1.84

¹26 ewes were sold

Litter size	3/4FA		FAF ₂	Finn
	no.	%	%	%
1	16	28.6	39.0	6.3
2	24	42.9	50.0	31.8
3	13	23.2	9.0	45.1
4	3	5.4	2.0	14.2
5-8	-	-	-	2.6

1/4 Finns. At Tal Shazar the 1/4Finn ewe lambs (Table 1.1.2) were incorporated into ALP and their contemporary reproductive performance in the two subsequent years is given in Table 1.1.8. It will be recalled that one group consisted of 1/4Finn3/4Mutton Merino (1/4FM) and the other of 1/4Finn1/4Awassi1/2Assaf (AsFA); in addition, the performance of 1/4FM at Sede Warburg is also given. All the differences were small and the performance of all three groups of 1/4Finn ewes was very similar.

Although completely contemporary comparisons were not possible, some conclusions may be drawn with regard to the reproductive performance of ewes with a different proportion of Finn blood. Assuming that prolificacy is the key measurement, the following comparisons are instructive:

Lambing program:	Once-yearly		ALP	
	LB/EL		LB/EL/Yr	
Measurement:	no.	diff.	no.	diff.
Genotype:				
1/4F	1.58		2.18	
1/2F	1.88	0.30	2.46	0.28
3/4F	1.96	0.08	2.96	0.53

In once-yearly lambing the difference between 1/4F and 1/2F was slightly smaller than that found by Ercanbrack (1978) and that between 1/2F and 3/4F was considerably smaller than expected. On theoretical grounds and according to our figures, as well as those of Ercanbrack (1978), there should be a linear increase in prolificacy with the increase of Finn blood, and therefore it was expected that the 3/4F would average about 2.3 lambs per ewe lambing instead of the actual 1.96. Possibly, the discrepancy was due to the young age of ewes. Many of them, aged 1-1½ in 1981/82. With slightly older ewes, as in 1983, the prolificacy increased to 2.23 (Table 1.1.8). In the ALP ewes the differences between 1/4F and 1/2F and 3/4F should have been 0.41 lambs instead of 0.28 and 0.53 lambs, assuming again that the increase is linear, as our data seems to indicate. No reference could be found to prolificacy of 3/4Finn ewes.

The reproductive performance of FA ewes was either equal to, or better than, that of FM ewes, and it was significantly so in frequency of lambing and prolificacy (compare Tables 1.1.4 and 1.1.5). On the whole, the performance of F_2 and F_3 generations within FM ewes was equal to that of F_1 ewes, but significantly lower within FA ewes, and further data would be of interest.

A number of workers reported the results of accelerated lambing in Finn crosses (e.g., Dickerson, 1978; Hulet, 1978), but valid comparisons could not be made because programs, breeds and localities differed.

Variations due to year and age were relatively small: 7-15%, except for EL/EEL, LB/EEL and MuB/EL: 14-38%.

The differences in MuB/EL were not significant and it is suggested that this measurement be discarded in highly prolific breeds in favor of LB/EL, because in MuB the litter size larger than 1 is not differentiated.

Further work similar to that on twice-yearly lambing in Finnsheep (Goot and Maijala, 1977) should be encouraged, especially as the present results are in line with conclusions reached some time ago, viz., "It would appear that the 'short day' photoperiodic theory is not applicable to all breeds of sheep and it is suggested that in sheep with a long sexual season, genetic heterozygosity may be responsible for regulating the breeding season by allowing other environmental stimuli, besides light, to trigger off sexual activity." (Goot, 1969) (see also Amir et al., part 4 of this final report).

Finally, it should be pointed out that any discrepancy between parameters, as for instance in 'year' and 'age' data, is due to the fact that the statistics were based on unweighted means of year groups, age groups and season groups. Whenever a sub-class number was small, as in yearling age groups (Tables A1.1.7 and A1.1.9), it was discarded. However, whatever was lost in precision was gained in quantitative information hitherto unavailable, as regards variations due to year, age and season under ALP.

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1.2 LAMB PERFORMANCE AND WOOL PRODUCTION IN FINN-CROSS SHEEP IN ACCELERATED LAMBING PROGRAMS

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ABSTRACT

The performance of more than 2100 Finn-cross lambs in an accelerated lambing program was analyzed. The lambs were born in three or four yearly crops in the Bet Dagan experimental flock and in two commercial flocks over a period of 2-6 years. Birthweight (BW), rates of growth to weaning at 6-8 weeks of age (RG1) and at approximately 8 weeks after weaning (RG2), and 150-day weight were analyzed.

Very few genotypic differences were statistically significant; within halfbreeds: Finn-Awassi (FA), and within a triple cross: Assafx Finn-Awassi (AsFA), seemed to be marginally better than Finn-Mutton Merino (FM) and Assafx Finn-Mutton Merino (AsFM); the performance of 3/4Finn 1/4Awassi (3/4FA) lambs was equal to, or better than, that of halfbreeds and AsFA lambs.

The effect of type of birth was significant ($P < 0.01$) in BW and in RG1 of both sexes and in 150-d weight of males, but not significant in RG2 or between triplets and quadruplets for all traits; thus, the ranking was: (i) singles; (ii) twins; and (iii) triplets and quadruplets.

Ram-lambs grew significantly faster ($P < 0.05$) than ewe-lambs within the same type of birth, except for quads in RG1.

Neither age nor genotype of Finn-cross dams older than one year affected the performance of (male twin and triplet) lambs, but within younger ewes (ewe-lambs) the BW of lambs out of AsFA dams was significantly ($P < 0.01$) higher than out of 1/4FM dams. The RG1 of lambs out of ewe-lambs also was significantly lower ($P < 0.01$) than that out of older ewes.

Correction parameters are given to adjust lamb performance to that of twin males.

Mortality in lambs, from 0 to 150 d of age, averaged 22% in the experimental flock, and 11.5% in a small commercial flock. In the former, 63%, 28% and 9% of lambs died when 0-7, 8-70 and 71-150 days old, respectively. 3/4FA and AsFA had the lowest mortality, 10% and 11%, followed by FA with 18%; FM and AsFM had the highest with 29% and 31%, respectively.

Mortality to weaning in lambs out of younger dams (ewe-lambs), was twice as high as in lambs out of older ewes: 17 vs. 8%; singles were not affected.

The fleece weight of FM, FA and 3/4FA ewes was 3.1, 3.3 and 3.1 kg, respectively.

INTRODUCTION

Although the performance of Finnsheep and its crosses is well documented (Dickerson, 1978; Goot, 1973; Goot and Maijala, 1977; Goot et al., 1976, 1979, 1980; Maijala and Oesterberg, 1976). The comparisons of results are often spurious when it comes to economically important traits which are greatly affected by environmental factors. Even comparisons of results from the same flock may be spurious because of the changes in the management. Thus, in the present experimental flock the weaning age up to 1978/79 varied from 50 to 69 days (Goot et al., 1980), whereas in the present data it ranged from 39 to 47 days. Improved nutrition since 1978/79 brought about a statistically highly significant increase in weight and gains of lambs at Bet Dagan (Goot et al., 1980). Another difficulty in making valid comparisons is the lack of uniformity in measurements of productive traits as reported in the literature (Maijala and Oesterberg, 1976).

In part 1.1 the reproductive performance of Finn cross ewes was reported. Now it is proposed to analyze the production under two sections: A. Performance of lambs and B. Fleece weight.

MATERIALS AND METHODS

The description of the flocks and their management was given in part 1.1 (for the Bet Dagan flock, see also Goot et al., 1980); the following are additional details specific to this part.

Lamb performance was analyzed according to four traits: (i) birth weight (kg), taken within 24 hours after birth, and included the weight of stillborn lambs; (ii) rate of growth (g/d) from birth to weaning (RG1); (iii) rate of growth (g/d) from weaning to approximately 8 weeks after weaning (RG2); and (iv) 150-d weight. The last mentioned was taken close to the age of 5 months and adjusted to 150 days by calculating the rate of growth from birth to the last weight, multiplying it by 150 days, and finally adding the birth weight. At Bet Dagan and Sede Warburg, but not at Tal Shazar, lambs reared artificially were included.

In the accelerated lambing program (ALP) three or four crops of lambs were born per year. The lambing dates varied somewhat between years but remained within the following ranges:

<u>Crop</u>	<u>Dates</u>		
1	2.X	-	18.XII
2	11.I	-	1.IV
3	8.IV	-	26.VI
4	8.VIII	-	30.IX

The 1428 lambs born at Bet Dagan were analyzed according to their genotype, sex and type of birth. The genotypes were grouped as follows: F₂-F₅ halfbreds, born 1978/79 - 1982/83 (5 years); 426 Finn-Mutton Merinos (FM) and 577 Finn-Awassi (FA); the latter included some Romanov-Awassi and Finn-Awassi and Romanov-Awassi crosses. 143 3/4Finn1/4Awassi (3/4FA) born in 1979/80 - 1982/83 (4 years), either out of FA ewes by Finn rams, or out of young 3/4FA ewes by 3/4FA rams, and finally the triple (commercial) crosses: 161 AsFM lambs out of FM ewes by Assaf rams and 121 AsFA lambs out of FA ewes by Assaf rams. The triple crosses were born 1977/78 - 1982/83 (6 years) and the Assaf rams were born, reared and performance-tested at the Neve Ya'ar dairy flock.

Lamb mortality data are based on lambs born in 1980/81, 1981/82, and part of 1982/83.

At Sede Warburg, records of 182 lambs born in an ALP during 1980/81 and 1981/82 were analyzed. The lambs were out of Mutton Merino and 1/4Finn3/4Mutton Merino ewes by Finn-Merino (FM) rams, so that their genotypes were either 1/4Finn cross or 3/8Finn cross and the results were pooled together as 1/8Finn-Mutton Merino cross (1/8FM).

At Tal Shazar the performance of lambs was analyzed according to the genotype and age of dams. This was done for two reasons: (i) the flock comprised dams of six genotypes (FM, FA, 1/4FM, AsFM, AsFA and FX - the last being ewe-lambs which either lost their ear-tags or for other reasons their genotypes could not be ascertained). Most of the ewes were paddock mated and most of the lambs were either by Finn Halfbred or 3/4Finn Merino or 3/4Romanov-Merino rams; the mating groups were based on blood lines rather than genotypes and it would be impossible to sort out the genotypes of their lambs; (ii) as the flock was rapidly expanding in numbers, a large proportion of the flock consisted of ewe lambs and hoggets; it was therefore opportune to analyze the effect of the dams' age on the performance of the offspring. The data refer to lambs born in an ALP during 1980/81 and 1981/82, out of ewes which were at mating (a) under 1 year; (b) 1-1½ years old; and (c) 2-4½ years old. The considerable discrepancy between the number of lambs at birth and later on was due to loss of identification. Not all the lambs were weighed at weaning. Because of the last two reasons, mortality is given to weaning only.

The management and feeding were described in part 1.1. During the last 2 years the composition of lamb concentrates No. 2 (Goot et al., 1980) had to be changed because alfalfa meal was not obtainable; at Bet Dagan and Tal Shazar the 3% alfalfa meal was excluded and at Sede Warburg it was replaced, in 1981/82, by 3% fish meal.

The differences between means were tested in most cases by the t-test and the means are defined by s.d.'s.

הספדית המדעית
למב - 1982
1982-1981

RESULTS AND DISCUSSION

A. Performance of Lambs

1. Weight and rate of growth

Genotype. The performance of Bet Dagan lambs was analyzed first within sex and type of birth (Table 1.2.1), with a view to (i) finding differences, if any, between FM and FA lambs in order to decide the future breeding policy; (ii) comparing the 3/4FA with halfbreds; (iii) comparing the triple crosses with the halfbreds; and (iv) suggesting correction parameters for sex and type of birth.

The performance of FM and FA halfbreds was very similar, with perhaps a slight but consistent bias in favor of Finn-Awassi lambs, particularly in birth weight and 150-day weight. However, the RG1 results are baffling, as one would expect the Finn-Awassi lambs to grow faster, from birth to weaning, than the Finn-Mutton Merino lambs, because in early weaning lambs (they were weaned at 44 days [Table 1.2.2]) rate of growth is very highly correlated with milk production (Folman, Eyal and Volcani, 1966). Therefore, it was expected that FA dams, with 50% Awassi blood, would have plenty of milk as measured by the RG1, in contradistinction to FM dams with 50% Mutton Merino blood. Of course, there may be a confounding effect due to supplementing some lambs with bottled milk, but both in the Tal Shazar data, based on lambs suckled (Table 1.2.3), and in the previous Gilat data (Goot et al., 1976), the differences between the RG1 values of FM and FA were not significant statistically.

On the other hand, the performance of 3/4FA lambs was much better than expected (Table 1.2.2). In all cases, it was equal to that of the halfbreds and in some cases to that of AsFA, but further data, based on 3/4FA dams, should be analyzed when available.

The performance of the triple cross (Table 1.2.1) was similar to that of the other lambs, with AsFA appearing to have a slight edge over the others, but more data are needed to be statistically tested.

Type of birth. It is well known that the performance of lambs is affected by sex and type of birth to various degrees. The results, pooled over Bet Dagan genotypes, are quantified in Table 1.2.4. The grading was similar in both sexes: singles were the best, followed by twins and finally by triplets and quadruplets. Two points are of practical interest: the performance of quadruplets was on a par with that of triplets (except for the B.W. of females), and the RG2 within sexes was the same in all types of birth. Similar results were obtained at Sede Warburg (Table 1.2.5), although the RG2 and 150-d weight were lower than those at Bet Dagan.

Sex. Within the same type of birth, the Bet Dagan ram-lambs were heavier at birth and grew faster than the ewe-lambs; all the differences were statistically significant save the RG1 of quadruplets (Table 1.2.6).

Table 1.2.1 PERFORMANCE OF BET DAGAN FINN CROSS LAMBS ACCORDING TO GENOTYPE, SEX AND TYPE OF BIRTH (WEANING AGE 43.7±8.2 DAYS; SEE TABLE 1.2.2)

Genotype	Sex and T.B.	n ¹	B.W. kg	R.G.1 g/d	R.G.2 g/d	150 d w kg	Sex and T.B.	n	B.W. kg	R.G.1 g/d	R.G.2 g/d	150 d w kg
Male												
FM		55	4.2 ^{a2}	282 ^{ab}	349 ^a	51.5 ^a	Female	41	3.7 ^a	239 ^a	256 ^a	39.6 ^a
FA		60	4.5 ^{ab}	300 ^{ab}	343 ^a	54.0 ^a		48	4.1 ^{ab}	276 ^b	266 ^a	42.6 ^a
3/4 FA	1	14	4.5 ^{ab}	293 ^{ab}	383 ^{ab}	53.5 ^a		27	3.9 ^{ab}	270 ^{ab}	294 ^a	44.4 ^a
AsFM		15	4.7 ^{ab}	254 ^a	382 ^{ab}	53.2 ^a	1	16	3.9 ^{ab}	278 ^{ab}	319 ^b	45.3 ^a
AsFA		13	5.1 ^a	356 ^b	432 ^b	60.8 ^a		15	4.6 ^b	281 ^{ab}	385 ^b	47.0 ^a
Total/Mean		157	4.5	293	360	53.6		147	4.0	264	284	42.3
S.D.			1.1	78	80	8.0			1.2	63	78	7.6
FM		130	3.3 ^a	252 ^a	354 ^a	49.0 ^a		108	3.3 ^a	220 ^a	276 ^a	39.3 ^a
FA		182	3.7 ^b	247 ^a	350 ^a	50.8 ^{ab}		157	3.3 ^a	224 ^a	281 ^a	41.5 ^a
3/4 FA		45	3.4 ^a	235 ^a	384 ^{ab}	49.9 ^{ab}		39	3.3 ^a	221 ^a	292 ^a	40.1 ^a
AsFM	2	36	3.5 ^{ab}	238 ^a	394 ^{ab}	54.4 ^{ab}	2	38	3.5 ^{ab}	208 ^a	305 ^b	42.8 ^a
AsFA		34	4.1 ^c	260 ^a	402 ^b	54.5 ^b		31	3.9 ^b	240 ^a	327 ^b	44.8 ^a
Total/Mean		427	3.6	248	362	50.5		373	3.4	222	286	41.0
S.D.			.9	64	71	7.6			.8	68	51	7.3
FM		32	2.8 ^a	242 ^a	362 ^{ab}	46.0 ^a		43	2.5 ^a	202 ^a	259 ^{ab}	36.1 ^a
FA		61	3.0 ^a	214 ^{ab}	314 ^a	45.8 ^b		50	2.8 ^b	197 ^a	256 ^a	38.3 ^a
3/4 FA		10	2.8 ^a	242 ^{ab}	340 ^{ab}	46.1 ^a		8	3.0 ^{ab}	208 ^a	271 ^{ab}	41.1 ^{ab}
AsFM	3	16	3.1 ^{ab}	179 ^b	311 ^{ab}	45.4 ^a	3	24	2.9 ^{ab}	205 ^a	299 ^b	41.5 ^{ab}
AsFA		10	3.7 ^b	258 ^a	382 ^b	54.3 ^a		18	2.9 ^{ab}	226 ^a	321 ^{bc}	46.4 ^b
Total/Mean		129	3.0	225	337	46.8		143	2.7	204	272	38.9
S.D.			1.0	73	79	9.0			.7	59	63	6.9
Total/Mean	3	32	2.8	208	356	49.0	4 ³	20	2.2	173	285	38.2
S.D.	4		.9	50	51	5.4			.6	60	56	6.2

¹Number of lambs born dead or alive. ²Means in the same column and of the same sex and type of birth, with different superscripts differ significantly (P<0.01).

³FM, FA and AsFM

Table 1.2.2 WEANING WEIGHT (WW) AND WEANING AGE (WA) OF BET DAGAN FINN CROSS LAMBS ACCORDING TO SEX AND TYPE OF BIRTH (POOLED DATA OF FIVE GENOTYPES LISTED IN TABLE 1.2.1).

Sex	Type of birth*	WW			WA ¹	
		n	Mean kg	S.D.	Mean d	S.D.
Male	1	141	17.3	4.9	42.8	7.4
	2	386	14.7	3.8	44.0	8.6
	3	109	12.5	4.1	42.8	7.0
	4	23	11.4	2.3	40.8	4.6
Female	1	139	15.9	4.6	44.3	8.2
	2	359	13.4	3.8	44.3	7.8
	3	128	11.4	3.7	42.6	10.3
	4	13	9.3	2.2	43.3	5.8
Total	1-4	1298	14.1	4.4	43.7	8.2
range			9.0 - 20.1		38.8 - 46.8	

¹None of the differences in the column is statistically significant (P<0.05)

*1,2,3,4 = singles, twins, triplets and quadruplets, respectively.

Table 1.2.3 PERFORMANCE OF TAL SHAHAR TWIN AND TRIPLET RAM-LAMBS ACCORDING TO AGE AND GENOTYPE OF DAMS

Age	Genotype	BW		RG1		RG2		150-d weight	
		n	kg	n	g/d	n	g/d	n	kg
2-4½	FM	58	3.4	41	200	32	346	37	45.7
	FA	13	3.5	12	199	12	342	12	46.6
	AsFM	7	3.4	7	229	7	371	7	50.8
	Mean	78	3.4	60	203	51	348	56	46.5
	S.D.		.9		54		60		6.6
1-1½	FM	16	3.4	13	251	11	353	12	47.2
	FA	65	3.4	57	203	44	354	50	46.2
	1/4FM	31	3.2	24	229	21	353	20	48.1
	Mean	112	3.3	94	216	76	354	82	46.8
	S.D.		.8		65		63		7.2
Under 1	FM	21	3.3 ^{ab}	13	186	9	359	13	43.7
	1/4FM	42	3.2 ^a	22	194	16	334	19	44.5
	FX	17	3.4 ^{ab}	12	174	9	305	13	47.3
	AsFA	24	3.8 ^b	18	188	13	315	10	44.3
	Mean	104	3.4	65	187	47	328	58	44.9
	S.D.		.9		57		86		6.8

Means in the same column and of the same age, with different superscripts, differ significantly (P<0.01).

Table 1.2.4 PERFORMANCE OF BET DAGAN FINN CROSS LAMBS ACCORDING TO SEX AND TYPE OF BIRTH (POOLED DATA OVER FIVE GENOTYPES LISTED IN TABLE 1.2.2)

Sex	Type of birth*	BW			RG1			RG2			150-d weight		
		n	Mean kg	S.D. kg	n	Mean g/d	S.D.	n	Mean g/d	S.D.	n	Mean kg	S.D.
Male	1	157	4.5 ^a	1.1	143	293 ^a	78	131	360 ^a	80	109	53.6 ^a	8.0
	2	427	3.6 ^b	.9	373	248 ^b	64	324	362 ^a	71	275	50.5 ^b	7.6
	3	129	3.0 ^c	1.0	100	225 ^c	73	91	337 ^a	79	79	46.8 ^c	9.0
	4	32	2.8 ^c	.9	24	208 ^c	56	28	356 ^a	51	17	49.0 ^c	5.4
Total/Mean		745	3.6	1.1	640	253	73	574	357	74	480	50.6	8.1
Female	1	147	4.0 ^a	1.2	142	264 ^a	63	129	284 ^a	78	100	42.3 ^a	7.6
	2	373	3.4 ^b	.8	349	222 ^b	68	343	286 ^a	51	299	41.0 ^a	7.3
	3	143	2.7 ^c	.7	124	204 ^c	59	107	272 ^a	63	107	38.9 ^{bc}	6.9
	4	20	2.2 ^d	.6	13	173 ^c	60	16	285 ^a	56	7	38.2 ^{ac}	6.2
Total/Mean		583	3.3	1.0	628	227	68	595	283	60	513	40.8	7.3

Means in the same column and of the same sex, with different superscripts, differ significantly ($P < 0.01$).

*1,2,3,4 = singles, twins, triplets and quadruplets, respectively.

Table 1.2.5 PERFORMANCE OF SEDE WARBURG 1/4 AND 3/8 FINN-MUTTON MERINO LAMBS ACCORDING TO SEX AND TYPE OF BIRTH (WEANING AGE 39.5 7.0 DAYS)

Sex	Type of birth*	BW			RG1			RG2			150-d weight		
		n	Mean kg	S.D. kg	n	Mean g/d	S.D.	n	Mean g/d	S.D.	n	Mean kg	S.D.
Male	1	23	4.7 ^a	.6	23	306 ^a	59	21	329 ^a	74	21	51.7 ^a	6.8
	2	52	3.5 ^b	.6	48	228 ^b	64	45	310 ^a	51	46	46.8 ^b	5.7
	3+4	13	2.3 ^c	.6	10	196 ^b	58	10	249 ^b	64	10	37.7 ^c	7.4
Total/Mean		88	3.6	.5	81	246	73	76	307	63	77	46.9	7.5
Female	1	29	4.3 ^a	.8	29	248 ^a	67	29	259 ^a	55	29	43.6 ^a	10.1
	2	40	3.2 ^b	.6	38	212 ^b	66	33	263 ^a	52	34	38.8 ^a	5.6
	3+4	19	2.4 ^c	.5	17	217 ^b	53	16	244 ^a	62	17	38.9 ^a	6.0
Total/Mean		88	3.4	1.0	84	238	72	78	258	55	80	40.6	7.9

Means in the same column and of the same sex, with different superscripts, differ significantly ($P < 0.01$).

*1,2,3,4 = singles, twins, triplets and quadruplets, respectively.

Table 1.2.6 DIFFERENCES BETWEEN SEXES, WITHIN TYPE OF BIRTH, IN THE PERFORMANCE OF FLOCK 1 (BET DAGAN) AND FLOCK 2 (SEDE WARBURG) FINN CROSS LAMBS (AS LISTED IN TABLES 1.2.4 AND 1.2.5, RESPECTIVELY)

		Flock	Singles	Twins	Triplets	Quads
BW	kg	1	0.5 ^{xxx}	0.2 ^{xxx}	0.2 ^x	0.6 ^x
		2	0.4 ^x	0.3 ^{xx}	0.1 ^{NS}	
RG1	g/d	1	29 ^{xxx}	26 ^{xxx}	22 ^x	35 ^{NS}
		2	22 ^{NS}	16 ^{NS}	21 ^{NS}	
RG2	g/d	1	76 ^{xxx}	76 ^{xxx}	65 ^{xxx}	71 ^{xxx}
		2	70 ^{xxx}	47 ^{xxx}	5 ^{NS}	

^x $\underline{P}$ <0.05; ^{xx} $\underline{P}$ <0.01; ^{xxx} $\underline{P}$ <0.001

With the 1/3FM lambs at Sede Warburg the pattern, although similar, differed in two important aspects, viz., the RG1 was not affected by sex, and within triplets all the differences were statistically not significant.

Age of dams. Weight and daily gain of twin and triplet ram-lambs were not affected by the age of dams, except for the RG1 in lambs out of ewes under 1 year of age, which was significantly lower (P <0.01) than that in older ewes. Also dam genotype, within each age group, did not affect the performance of these lambs, except for the birth weight of lambs in the youngest age-group (Table 1.2.3).

Correction parameters. The following correction parameters are tentatively suggested for Finn cross lambs under an intensive management system, in order to correct lamb performance to that of twin males:

		BW	RG1	RG2	150-d weight
		kg	g/d	g/d	kg
Male twins:		3.6	248	357	50.5
Correction parameters					
Male	Single	-.9	-45	0	-3.1
	Triplet	+.7	+32	0	+2.6
	Quad.	+.7	+32	0	+2.6
Female	Single	-.4	-16	+74	+8.8
	Twin	+.2	+26	+74	+8.8
	Triplet	+.9	+59	+74	+11.9
	Quad.	+1.4	+59	+74	+11.9

At present, corrections for sex and type of birth only are suggested; if computers are used, further refinement could be achieved by including genotype, year, season and farm.

2. Losses

Mortality from 0 to 150 days of age, stillborns included, in Bet Dagan lambs, is given in Table 1.2.7. The data were pooled over 1980/81, 1981/82 and a part of 1982/83. The average differences due to sex were small, 23% for males and 22% for females. Bigger differences were due to type of birth; especially high mortality occurred within triplets and quadruplets. It is of interest to note that the mortality in twins of both sexes was slightly lower than that in singles, and - even more important - the difference between triplets and quadruplets was very small.

Table 1.2.7 LAMB MORTALITY FROM BIRTH TO 150 DAYS OF AGE ACCORDING TO GENOTYPE, SEX AND TYPE OF BIRTH (BET DAGAN, 1978/79 - 1980/81, AND THREE CROPS IN 1982/83)

Lamb genotype		FM	FA	3/4FA	AsFM	AsFA	All
<u>Males</u>							
Singles	born, no.	50	55	15	18	10	148
	died,%	38	13	7	28	10	22
Twins	born, no.	123	164	39	25	29	380
	died,%	29	16	10	32	3	20
Triplets	born, no.	26	49	6	13	9	103
	died, %	39	33	33	23	11	31
Quads	born, no.	15	10	-	6	1	32
	died, %	33	40	-	33	0	34
Total Males	born, no.	214	278	60	62	49	663
	died, %	32	19	12	29	6	23
<u>Females</u>							
Singles	born, no.	39	40	25	7	16	127
	died, %	36	15	12	14	0	19
Twins	born, no.	104	146	30	29	22	331
	died, %	21	15	7	17	18	17
Triplets	born, no.	35	57	3	20	10	125
	died, %	29	26	0	50	40	31
Quads	born, no.	7	7	-	6	3	23
	died, %	29	57	-	67	0	44
Total Females	born, no.	185	270	58	62	51	606
	died, %	26	17	9	32	16	21
All	born, no.	399	548	118	124	100	1269
	died, %	29	18	10	31	11	22

As for the age of lambs, 14% died when 0-7 days old, 6% when 8-70 days old and 2% when 71-150 days old; out of the 278 lambs which died, 63%, 28% and 9% died within the above age-groups, respectively.

Genotypic differences were striking; 3/4FA and AsFA lambs had the lowest mortality, 10% and 11%, respectively; they were followed by FA, FM and AsFM, with 18%, 29% and 31%, respectively. Very much lower mortality occurred at Sede Warburg. Out of 182 1/3FM born (dead or alive), 21, or 11.5%, died by the age of 150 days; out of 21 lambs which died, 15, or 71%, were either stillborn or died within the first 7 days; 4, or 19%, died between 8 and 70 days of age; and 2, or 10%, died at 71-150 days of age. Here, again, type of birth affected the mortality rates: 4%, 11% and 25% for singles, twins and triplets, respectively. Nine percent of all lambs died in 1980/81 against 15% in 1981/82.

The effect of age of ewes on lamb mortality up to weaning is tabulated in Table 1.2.8. Mortality in lambs out of ewes under 1 year

Table 1.2.8 LAMB MORTALITY, FROM BIRTH TO WEANING AT 5-8 WEEKS OF AGE, INCLUDING STILLBORNS, ACCORDING TO DAM'S AGE, LAMB SEX, AND TYPE OF BIRTH (TAL SHAHAR 1980/81 - 1981/82)

Age of dams		1-4½ years	Under 1 year
<u>Males</u>			
Singles	born, no.	43	58
	died, %	7	7
Twins	born, no.	151	89
	died, %	6	23
Triplets	born, no.	46	12
	died, %	13	58
All Males	born, no.	240	159
	died, %	8	20
<u>Females</u>			
Singles	born, no.	60	53
	died, %	7	4
Twins	born, no.	149	85
	died, %	6	15
Triplets	born, no.	50	12
	died, %	20	50
All Females	born, no.	259	150
	died, %	9	14
All	born, no.	499	309
	died, %	8	17

was twice as high as out of older ewes (1-4½ years): 17% vs. 8%. It was higher in males: 20% vs. 8%, than in females: 14% vs. 9%. Single-born lambs were not affected, but twins and, particularly, triplets, were. Here, again, there was a difference between FM and FA dams older than one year. There were no FA ewes under 1 year of age:

Genotype	FM				FA			
	Males		Females		Males		Females	
Sex								
Type of birth	b.	d.	b.	d.	b.	d.	b.	d.
	n	%	n	%	n	%	n	%
Single	21	5	22	9	14	7	18	6
Twin	52	2	54	6	65	5	55	6
Triplet	22	14	22	36	13	0	23	9
Total	95	5	98	13	92	4	96	6
All lambs	born: 193 died: 9.3%				born: 188 died: 5.3%			

If a comparison is made between the present Bet Dagan results and those published previously on FA crosses (Goot et al., 1980), it appears that the level of production, except for RG2, was not maintained. This may have been due to the shift in the generations, from F₂ and F₃ to F₂ - F₅, but more likely to a change in management of ewes because of a number of experiments in nutrition and reproduction. In this connection two references seem to be pertinent. In Nitter's (1975) experiments the daily gain of lambs up to weaning, at 35-56 days of age, was not affected by dam or sire lines, but when lambs of the same genotype were artificially reared for 4 weeks on milk substitute their gains were not only substantially higher than those of suckling lambs, but there were highly significant differences between dam, but not sire, lines. Although direct comparisons between suckling and artificially reared lambs, at the same weaning age, were not made, it is of interest to note that the differences were well maintained during the post-weaning period, so that the artificially reared lambs reached their slaughter weight, of 34 and 38 kg (females and males, respectively), at 105 days, i.e., 35 days earlier than the other group. The results would suggest that (a) the quantity of milk suckled was not sufficient for optimal growth, and (b) there is a different genetic potential, which is expressed with ad lib. milk supply. Unless all lambs are going to be artificially reared, the ewe's potential for milk production should be specifically investigated under ALP. Possibly the similar gain to weaning of lambs out of FM and FA ewes might be due to nutritional inadequacy. In Finn-Dorset Horns halfbreeds, the daily gain of twin lambs in the first month, from dams fed ad lib. (10 MJ ME/kg), was 290±5 g/d, and the estimated milk yield of the ewes was 2.93±0.51 kg (Robinson et al., 1976). It is difficult to imagine that Finn-Awassi ewes would yield less milk than Finn-Dorset Horns.

The level of performance of Bet Dagan lambs was either equal to, or slightly better than, that of Sede Warburg lambs, particularly the 150-d

weight of twin and triplet ram-lambs. This was thought to be due to the composition of the concentrates. When 3% fish meal was added in 1982, the gains and weights increased, but the better performance came too late to be reflected in pooled results; for instance, in one trial of 36 days (from 12.II - 19.III.1982), 13 ram-lambs gained 418 ± 66 and 14 ewe-lambs gained 342 ± 47 g/d. As the Sede Warburg flock is small, no control was run and therefore it would be too hasty to attribute the better gains directly to the addition of fish meal. All the same, the results are suggestive of such an effect as the gain of the same lambs, from weaning to the start of the trial, was 290 ± 61 and 259 ± 58 g/d for males and females, respectively.

On the other hand, the lamb mortality was much lower at Sede Warburg than at Bet Dagan. It seems that the Sede Warburg flock confirms the Finnish experience (Goot, 1973), viz. that flock size and personal attention are of paramount importance in intensive management of highly prolific sheep. The mortality rates at Bet Dagan were excessive recently, due primarily to manpower and possibly to infections (see veterinary report). As between 63 and 71% of lambs were stillborn or died by the age of 7 days, future work should be focused on neonatal mortality. Although mortality increases with litter size, the increase is not alarming. In Finnsheep in Finland up to 14 days, it averages 2.5, 5.4, 11.1 and 20.2% for litters of 1, 2, 3 and 4 lambs, respectively (Goot, 1973). Mortality in Finnsheep in other countries is much higher (Maijala and Oesterberg, 1976), partly because the statistics are based on differences in age, but most probably due to size and management of the flocks.

The results from two major breed evaluation trials are important because of ranking of Finn crosses vis-a-vis other crosses and native breeds. Dickerson (1978) summarized results of a crossbreeding experiment with Finn and Rambouillet rams mated, in the US, to six breeds of ewes. The losses to weaning at 10 weeks of age, based on some 4,000 lambs born, were: 19% in Finn crosses, 39% in Rambouillet crosses and 37% in parent breeds. In New Zealand (Meyer and Clarke, 1978), 11 sire breeds were mated to N.Z. Romneys. Mean mortality to weaning, based on some 15,000 lambs, ranged from 11% for Finn-Romney lambs to 22% for pure Romneys, and was the lowest among the 11 genotypes tested. Thus, the long lingering belief that in the genotype of high-fertility Finnsheep high mortality is a built-in trait should be discarded. Instead, efforts should be made to improve the management of the flock and possibly to select suitable dam breeds for initial crosses. It seems that both FA and 3/4FA are suitable and that an increase in Finnish genes from 50% to 75% was beneficial.

B. Fleece Weight

The mean fleece weights of FM, FA and 3/4FA ewes are given in Table 1.2.9. The weight was adjusted to 12 month wool growth, and the ewes were neither dagged nor crutched. In 1981/82 the flock was badly afflicted with scabs (Psorergates ovis). The affliction was classified into three grades and the worst grade was excluded. There were nine such fleeces, all FM, with a mean weight of 1.5 ± 0.6 kg. The differences in

Table 1.2.9 FLEECE WEIGHT OF BET DAGAN EWES, 1978/79 - 1981/82

Genotype	Age (years)	n	Mean (kg)	S.D.
FM	1-10	165	3.1	0.7
FA	1-10	253	3.3	0.8
3/4FA	1-2	43	3.1	0.9

Shearing dates:

5.IV.1979
6.III. and 23.III.1979
13.IV.1980
24.III.1981
25.III.1982

the incidence of the disease between genotypes - probably recorded for the first time - were as follows:

32% in FM, 17% in FA and 6% in 3/4FA fleeces.

Chance, fleece type, or resistance ?

As mentioned repeatedly, the FA ewes contained some Romanov-Awassi ewes as well, but their fleece weights over a 2-year period were practically the same: FAF₁ 3.51 kg (n = 63), RAF₁ 3.55 kg (n = 23) and thus confirming again the similarity of their performance (Goot et al., 1979).

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1.3 EFFECTS OF GENOTYPE, SEASON, SHEARING, LIGHT, AND SOURCE AND LEVEL OF DIETARY PROTEIN ON THE PERFORMANCE OF FINN-CROSS RAM LAMBS

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ABSTRACT

Fifteen fattening trials were carried out over 5 years with 429 Finn-cross ram-lambs of seven genotypes.

Daily gain was highly significantly ($P < 0.001$) affected by the initial weight (IW) and age (IA) and trials within season, and significantly affected ($P < 0.05$) by season. During early summer (season 2), when temperatures were rising, the gain was depressed in comparison with the winter (season 1) and the late summer and autumn (season 3). The LSM differences in daily gain between genotypes were statistically non-significant, although the three-breed cross lambs, by Assaf as the terminal breed, might be more efficient in season 2 than the other genotypes tested.

Shearing, light extension by 5-7 hours, adding 3% fish meal to the concentrates, as well as varying the level of crude proteins (18%, 16% and 14%) in the concentrates, had no statistically significant effect on the daily gains, with the possible exception of shearing the 3/4FA ram-lambs.

Both the intake and feed conversion (FC) were affected by season ($P < 0.05$) but not by any of the experimental treatments.

INTRODUCTION

As a corollary to the accelerated lambing program (ALP) described in chapter 1.1 and 1.2, lambs are born in different seasons of the year and this, in turn, can affect their fattening performance. This chapter details the results of all-year-round fattening trials using Finn-sheep crosses of seven genotypes and exposing the ram-lambs - in some of the trials - to different treatments, *viz.*, shearing, extended period of light, and different quality or level of protein. The common denominator in all the trials, or - if treatment was a factor - in the control groups, was the diet, which consisted of high energy and protein concentrates (Folman and Eyal, 1978). The only difference from the diet in the last cited work was that the concentrate pellets did not contain alfalfa meal.

The results of other fattening trials with Finn and Romanov crosses were reviewed by Nitter (1978), Maijala (1980) and Goot *et al.*, (1980). The effects of environmental factors on lamb performance are still inadequately documented (Hutchinson and Wodzicka-Tomaszewska, 1961; Hahn, 1976, 1977). Most of the shearing experiments have dealt with adult sheep (Eyal, 1963; Wodzicka-Tomaszewska, 1963). The effect of long and short photoperiods on lamb performance was recently discussed by Schanbacher and Crouse (1980).

MATERIALS AND METHODS

Genotype

During 1978/79 - 1982/83, 429 Finncross ram-lambs of seven genotypes were fattened in 15 trials. The lambs were out of F₁-F₅ halfbred Finn x Mutton Merino (FM) and Finn x Awassi (FA) - with a few Romanov x Awassi ewes listed as FA by FM, FA, Finnsheep, Assaf (As) and Australian Suffolk (Su) rams. The three-breed cross lambs were sired either by the three Suffolks imported in 1971 from New South Wales, Australia, or by the three performance-tested Assaf rams which were born and reared at the Neve Ya'ar Experiment Station in Israel.

Pre-fattening performance

All lambs were born at the Bet Dagan Experiment Station (chapter 1.1 and 1.2); their type of birth and pre-trial performance, based on unweighted means over the trials and genotypes, were as follows:

	Number of trials	Mean	S.D.	C.V.(%)
Type of birth	15	2.0	0.2	10.5
Weaning weight, kg	15	15.4	2.4	15.8
Weaning age, d	15	43.9	5.1	11.7
Gain, g/d:				
Birth to weaning	14	267	31	11.6
Weaning to start of trial	15	330	64	19.5

Season

The year was divided into three seasons. Season 1, winter and early spring, when the temperatures were relatively low. Season 2, early summer and summer, when the temperatures were high and rising; and Season 3, late summer and early autumn, when the temperatures were still high but declining (Table 1.3.1).

Table 1.3.1 DETAILS OF THE FATTENING TRIALS ARRANGED ACCORDING TO THE SEASON OF THE YEAR

Season	Trial	Onset	Duration		Treat. ³	IW ⁴		IA ⁴	Max.T. ⁵		Min.T. ⁵
			d	Per ²		n	kg	d	From-To	From-To	
1	3	1.I.79	84	6	G	32	18	70	19-23		8-10
	103	29.XII.80	98	7	G	37	19	62	17-20		7-11
	106	22.XI.81	70	5	G	10	23	70	21-19		8-6
	107	3.I.82	84	6	G,L	20	22	60	18-20		7-8
	110	20.XII.82	56	4	D	24	16	48	17-18		7-5
2	4	22.IV.79	82	6	G	25	33	80	21-25		13-21
	101	6.V.80	62	4	G	36	37	93	28-30		14-19
	104	14.IV.81	83	6	G,S	28	28	79	28-31		12-20
	108	18.IV.82	71	5	G,S	42	25	70	26-30		13-17
	111	13.IV.83	70	5	L	42	22	64	23-29		10-17
3	5	27.VII.79	56	4	G	17	25	67	31-29		20-18
	102	5.VIII.80	64	4	G	26	27	78	32-27		21-16
	105	26.VII.81	91	7	G,S	18	21	62	31-29		21-15
	109	22.VII.82	56	4	G,S	31	25	68	30-30		20-19
	113	6.VII.83	75	6	G,D	41	21	64	31-29		19-19

¹Season 1, 2 and 3: November-March, April-June and July-October, respectively.

²From weighing to weighing; most of the periods were 14 days.

³Contemporary comparisons between genotypes (G), diets (D), increased light (L) and shearing (S).

⁴Initial weight and Initial age

⁵First and last periods

Treatment

In addition to straight out contemporary comparisons between two or more genotypes, the effect of three other factors on the fattening performance of lambs was investigated viz., diet, shearing and light extension.

Diet

The concentrate pellets (Diet 2 in the report by Goot et al., 1980) were based on the same recipe of Folman and Eyal (1978), containing (in g/kg) barley - 360, corn - 360, soybean meal - 220, alfalfa meal - 30,

limestone - 18, bentonite - 5, NaCl - 7, and a mineral and vitamin mixture. However, from 1980, alfalfa meal was not always available. In two trials only, either the composition or the level of proteins was altered; in trial 111 (Table 1.3.1), 3% fish meal was added to the concentrates fed to the experimental group and in trial 113 the level of proteins was varied: group A - 18%, group B - 16% and group C - 14% (16% during the first 35 days and 14% during the last 40 days).

Shearing

For comparison between shorn and unshorn lambs in trials 104, 105, 108 and 109 (Table 1.3.1), the lambs were machine-shorn 1 or 2 days before the start of the trial, i.e., when 62-79 d old, and weighing 21-28 kg.

Light

Trials 107 and 111 (Table 1.3.1). Two sets of fluorescent lights, suspended from the ceiling and controlled by a time-switch, were turned on and off at 16.00 and 24.00 hours, respectively. In trial 107 the light intensity 50 cm above floor level was 1100 lux directly beneath the lighting, 600 and 400 lux near the side hurdles of a 4 x 4 m pen, and 150 lux in the four corners. In trial 111 the light intensity was not measured, but it should have been similar. The control groups were exposed to the normal daylength. At the outset and termination of the trials, the hours of added light in the experimental pens were as follows:

Trial no.	107	111
Date	3.I. - 27.III.82	13.IV. - 21.VI.83
Duration, d	84	70
Sunset, hour	16.47 - 18.00	18.05 - 18.45
Artificial light, h	7.13 - 6.00	5.55 - 5.15
Day length, h	10.05 - 12.09	12.43 - 14.11
Total light, h	17.18 - 18.09	18.38 - 19.26

Locality

All the trials were conducted at the Bet Dagan Experiment Station and all, except the first (3) were in an open shed, approx. 60 x 8 m, which was divided into pens, all 4 m wide and 4,6 or 8 m long, allowing 2-3 m² per lamb. The shed, covered with corrugated asbestos, has in part a concrete floor and in part a dirt floor; the former was cleaned by hosing and the latter had to be covered with straw after the first few weeks, but starting with trial 108 sawdust was used in all the trial pens.

Management

After weaning the lambs were removed immediately to the fattening shed and allowed to settle down. During the first trial each genotype was kept in a separate pen but later this was not possible and the lambs

were penned according to treatment, care being taken to have the treatment and control groups as even as possible with regard to birth weight, type of birth, weaning weight and age, and gain from weaning to the start of the trial, as well as the initial weight and age. Before weaning, the lambs had creep access to the concentrates and hay, but after weaning they were fattened on concentrates only (see the diet p. 3) given ad libitum. Water was available from self-filling troughs. In most cases, it was possible to order from the mills enough concentrates for the whole trial. Dry matter was estimated for each trial separately.

Weighing took place in the morning at the end of each fattening period of, in most cases, 14 days. The remaining concentrates were also weighed at the same time.

Data analyses

The maximum and minimum daily temperatures, based on the records of the Central Meteorological Station at Bet Dagan, ca. 2 km from the site of the trials, were calculated for each fattening period; they are shown in Table 1.3.1 for the first and last fattening period of each trial. Feed intake, as dry matter, was calculated per group for each period; similarly, the feed conversion (FC) was based on the group average gain per period.

Each trial was analyzed first on a within-trial basis. The relationships between the pre-fattening performance and daily gain during the trials, within a given genotype and trial, were analyzed by means of a correlation technique. As reported previously (Goot et al., 1982), here, too, most of the results were statistically non-significant and for the few significant ones the *r*-values varied between 0.3 and 0.5. It was therefore decided to exclude the pre-fattening performance so that factors considered for the analysis of individual trials included genotype, treatment, if present, initial weight (IW) and initial age (IA); and when the genotype was pooled over trials, 'season' and 'trials within season' were added. When 'treatment' was a factor, only the control groups were taken for statistical analyses of genotype and of season. Genotype-season interaction was dropped because in preliminary analysis it gave inconsistent results, most probably due to genotypes being unequally represented in a given season, and to small numbers (Table 1.3.3). The least squares analysis of genotypes excluded SuFM and SuFA.

The results of trials 3, 4 and 5 have been published previously (Goot et al., 1980; Goot et al., 1982). They were included in the present report to add strength to the genotype and season effect comparisons.

DISCUSSION

A. Daily Gain

Initial weight and age. When each trial was analyzed separately, the effects of IW and IA on daily gain were statistically significant in only some of them (Table 1.3.2). However, when the data were pooled over trials, the effect of IW and IA became, as expected, highly significant

($P < 0.001$). On the average, each additional kg in IW increased the daily gain by 5.2 ± 1.8 g, whereas each additional day in IA decreased the daily gain by -4.0 ± 1.1 g. Therefore, these two factors were included in all least squares analyses.

Table 1.3.2 EFFECT OF GENOTYPE (G), TREATMENT (T), INITIAL WEIGHT (IW) AND INITIAL AGE (IA) ON THE OVERALL DAILY GAIN (g) IN THE INDIVIDUAL TRIALS AS LISTED IN TABLE 1.3.1

Season ¹	Trial ¹	Genotypes	F values ²				Factors ¹
			G	T	IW	IA	
1	3	FA, AsFM, SuFM, SuFA	NS		NS	NS	G
	103	FM, FA, 3/4FA	NS		NS	NS	G
	106	FM, 3/4FA	NS		NS	NS	G
	107	FM, 3/4FA	NS	NS	*	NS	G, L
	110	Misc.		NS	NS	NS	D (Fish meal)
2	4	FA, AsFA, SuFM	NS		NS	NS	G
	101	FM, 3/4FA, AsFA, SuFA	**		NS	NS	G
	104	FM, FA	*	NS	NS	NS	GS
	108	FM, FA, AsFM	***	NS	**	NS	GS
	111	Misc.		NS	*	NS	L
3	5	FA, AsFA	NS		NS	NS	G
	102	FM, FA, 3/4FA, AsFM	NS		*	NS	G
	105	FM, 3/4FA	NS	NS	NS	NS	GS
	109	FM, FA	NS	NS	NS	**	GS
	113	FM, FA	NS	NS	NS	*	GD (levels of CP)

¹See Table 1.3.1

²NS, *, ** and ***: not significant, significant $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively.

Trials within season. The differences between trials within a given season were very highly significant ($P < 0.0001$). They were no doubt confounded with the year, genotype and variations between different batches of concentrates; as such they are difficult to interpret, except to emphasize the need for strict and reliable adherence to their composition as well as standardized management during such trials.

Genotype. As mentioned previously, if any of the three treatments (diet, shearing and light) was a factor, only the control lambs were taken for genotype comparisons. The results, based on 227 lambs, are given in Tables 1.3.2 and 1.3.3. Out of 15, in only three trials were the differences statistically significant: in trial 104 the gain of FA was higher ($P < 0.05$) than that of FM lambs; in trial 101 the gain of AsFA was higher ($P < 0.01$) than that of FM and 3/4FA lambs; and in trial 108 the gain of AsFM was higher ($P < 0.001$) than that of FM and FA, and the gain of FA was

Table 1.3.3 CONTEMPORARY COMPARISONS OF LEAST SQUARES MEANS (LSM) OF OVERALL DAILY GAINS (g) OF FINNCROSS RAM-LAMBS OF DIFFERENT GENOTYPES (SEE ALSO TABLES 1.3.1 AND 1.3.2)

Season ¹	Trial ¹	Genotype													
		FM		FA		3/4FA		AsFM		AsFA		SuFM		SuFA	
		n	g/d	n	g/d	n	g/d	n	g/d	n	g/d	n	g/d	n	g/d
1	3			12	402			6	429			8	402	6	426
	103	9	335	21	350	7	383								
	106	4	347			6	400								
	107	4	374	6	385										
2	4			6	308					7	314 _b	12	292		
	101	6	279 ^a			9	302 ^a			10	364 ^b			10	330 ^{ab}
	104	7	362 ^a	7	397 ^b										
	108	6	297 ^a	9	348 ^b			6	381 ^c						
3	5			11	430					6	430				
	102	11	278	6	286	6	247	3	299						
	105	4	286			4	263								
	109	4	341	7	339			4	370						
	113	8	315	5	332										

¹See Table 1.3.1

Means in the same trial and on the same line with different superscripts differ significantly (P<0.05)

higher than that of FM lambs. The performance of the five main genotypes (SuFM and SuFA were dropped) was pooled over the trials and the results are shown in Table 1.3.4.

Table 1.3.4 EFFECT OF GENOTYPE ON DAILY WEIGHT GAIN (LSM±SE)

Genotype	Number of		Daily gain ^a (g/d)
	trials	lambs	
FM	10	63	309±14
FA	10	90	302±12
3/4FA	5	32	291±21
AsFM	4	19	343±30
AsFA	3	23	334±31

^aAll differences statistically non-significant

None of the differences was statistically significant; in particular, it is important to note that the fattening gain of 3/4FA was very similar to that of the halfbreds. On the other hand, the gains of the three-breed crosses were consistently higher than those of halfbred lambs (roughly, by 33 g/d, or ~11%). Their better performance, although not established statistically, should be tested further with more lambs on a contemporary basis.

Diet

(i) Fish meal. A trial was designed to substitute 3% fish meal for 3% soybean oilmeal, but the difference in daily gain was statistically non-significant (Trial 110 in Table 1.3.2: 20.XII.82 - 13.II.83; 56 days). Details are given in Table 1.3.5.

Table 1.3.5 EFFECT OF THE INCLUSION OF 3% FISH MEAL IN THE DIET ON THE PERFORMANCE OF FINN-CROSS MALE LAMBS (MIXED FM, FA, AsFM AND AsFA)

	3% Fish meal	Control
Number of lambs	13	11
Initial weight, kg	15.8	16.2
Final weight, kg	34.0	36.1
Initial weight, d	46.6	48.4
Final age, d	102.6	104.4
Daily gain, g	326	355 ^{ns}
Intake, kg DM/lamb/d	0.86	1.06
FC, kgDM/kg gain	2.64	2.99

(ii) Levels of Crude Protein (CP). Here again, the gain was not affected by the three levels of proteins (Table 1.3.6; Trial 113 in Table 1.3.2).

Table 1.3.6 EFFECT OF CRUDE PROTEIN (CP) LEVEL IN THE DIET ON THE FATTENING PERFORMANCE OF FINN-CROSS LAMBS (FM AND FA)

	Level of CP (%)		
	18	16	14 ^a
Number of lambs	14	13	14
Initial weight, kg	20.4	21.6	21.3
Final weight, kg	45.0	46.1	44.6
Initial age, d	63	66	64
Final age, d	138	141	139
Daily gain, g	323	311	311 ^{ns}
Intake, kgDM/lamb/d	1.18	1.23	1.18
FC, kgDM/kg gain	3.65	3.95	3.79

^a16% during the first 35 days and 14% thereafter.

Shearing. Shearing of lambs (Table 1.3.7) in seasons 2 and 3 did not affect the daily gain of FM, FA and AsFM lambs (AsFA were not tested), but it might have benefited the 3/4FA lambs.

Table 1.3.7 EFFECT OF SHEARING ON FATTENING PERFORMANCE OF FINN-CROSS LAMBS (POOLED RESULTS OF FOUR TRIALS: 104, 105, 108 AND 109, IN TABLES 1.3.1 AND 1.3.2)

	Shorn	Unshorn
Number of lambs	63	58
Initial weight, kg	24.2	26.0
Final weight, kg	49.7	48.7
Initial age, d	69.9	69.7
Final age, d	143.3	143.1
Daily gain, g	334	330 ^{ns}
Intake, kgDM/l	1.37	1.39
FC, kgDM/kg gain	4.10	4.21

Daily gain (g) according to genotype					
	Number of trials	Shorn		Unshorn	
		Number of lambs	Mean g	Number of lambs	Mean g
FM	4	23	309	21	301 ^{ns}
FA	3	23	352	23	352 ^{ns}
3/4FA	1	6	300	4	219*
AsFM	2	11	366	10	383 ^{ns}

*P<0.045

The 3/4FA were tested together with FM lambs in trial 105 and the contemporary comparison may be of interest, even though the numbers are rather small:

Genotype	FM		3/4FA	
	Shorn	Unshorn	Shorn	Unshorn
Number of lambs	4	4	6	4
Daily gain, g	281	268 ^{ns}	300	219*

It stands to reason that lambs with 75% Finn blood could be handicapped during the hot summer months, and further trials are needed for a firm conclusion to be drawn.

Light. In two trials (107 and 111 in Tables 1.3.1 and 1.3.2) the extension daylength from sunset to midnight, by approximately 5-7 hours (Table 1.3.8) did not affect the daily gain of lambs. In the first trial (109), with ten lambs in each group, the daily gain in the 'light' group was 27 g greater (393-366 g/d); in the second trial (111), with 21 lambs in each group, it was 14 g greater (343-329 g/d).

Table 1.3.8 EFFECT OF DAYLENGTH EXTENSION BY ARTIFICIAL LIGHT ON THE PERFORMANCE OF FINN-CROSS LAMBS (FM, FA, 3/4FA, AsFM AND AsFA) (POOLED RESULTS OF TWO EXPERIMENTS, LSM)

Treatment	Light	Control
Number of lambs	31	31
Initial weight, kg	22.1	21.8
Final weight, kg	49.7	48.4
Initial age, d	64.5	62.6
Final age, d	139.0	137.1
Daily gain, g	378	355 ^{ns}
Intake, kgDM/lamb/d	1.41	1.35
FC, kgDM/kg gain	3.73	3.80

The overall LSM values for the above discussed treatments are given in Table 1.3.9. In comparison with the control group, the treatments did not affect significantly the daily gain of lambs in these trials.

Table 1.3.9 LEAST SQUARES MEANS OF THE OVERALL DAILY GAIN, INTAKE AND FEED CONVERSION (FC) ACCORDING TO THE SEASON OF THE YEAR AND TREATMENTS. DATA POOLED OVER GENOTYPES AND FATTENING TRIALS AS LISTED IN TABLES 1.3.1 AND 1.3.2

	Daily gain, g		Intake kgDM		FC kgDM/kg gain	
	LSM	S.E.	LSM	S.E.	LSM	S.E.
<u>Season¹: F²</u>	*		*		*	
1	375 ^a	.13	1.32 ^a	.04	3.52 ^a	.08
2	331 ^b	.14	1.47 ^b	.04	4.47 ^b	.09
3	345 ^{ab}	.12	1.31 ^a	.03	3.83 ^c	.07
<u>Treatment: F²</u>	NS		NS		NS	
Control	352	.01	1.37	.02	3.94	.04
Fish-meal	341	.03	1.24	.09	3.67	.19
16% CP	351	.03	1.41	.08	4.07	.19
14% CP	340	.03	1.37	.09	4.08	.19
Shorn	366	.01	1.35	.04	3.70	.09
Light	363	.02	1.44	.06	3.99	.13

¹See Table 1.3.1

²NS and *: not significant and significant $P < 0.05$, respectively.

Means in the same column with different superscripts differ significantly ($P < 0.05$).

Season. As seen in Table 1.3.9, there were statistically significant ($P < 0.05$) differences between seasons. The lambs fattened best in season 1 (November-March), with a LSM of 375 g/d, followed by seasons 3 (July-October), with a LSM of 345 g/d; season 2 (April-June) was the poorest, with a LSM of 331 g/d. Thus, the differences between seasons 1 and 3, 1 and 2, and 3 and 2 amounted to 30, 44 and 14 g/d, respectively.

B. Intake and Feed Conversion (FC)

Season. Both the intake and FC were affected by the season (Table 1.3.9). The intake was highest in season 2 (April-June) and equal in the two other seasons; the greatest difference was 0.15 kgDM/lamb/d.

Within FC values the differences were bigger; the best FC, 3.54 kgDM/kg gain, took place in season 1, followed by season 3, with 3.83 kgDM/kg gain, and the poorest occurred in season 2 (April-June), with 4.47 kgDM/kg gain. Hence, the average difference between season 1 and 2 was 0.95 kgDM/kg gain and between seasons 1 and 3 it was 0.31 kgDM/kg gain, all in favor of season 1; between seasons 3 and 2 it was 0.64 kgDM/kg gain in favor of season 2. Thus, it appears that the most expensive fattening season is season 2 (April-June), because the intake is higher and daily gain lower than in other seasons. Consequently, the FC is nearly 27% lower in comparison with season 1 and approximately 17% lower in comparison with season 3.

Treatments. Neither intake nor FC was affected by treatments (Table 1.3.9). All the differences were rather small except in trial 110; the ad libitum consumption of concentrates with fish meal was approximately 0.2 kgDM/lamb/d, or 19%, lower, and the FC was better by 0.36 kgDM/kg gain (~12%) than in the control group (see p.). As the quality of fish meal can vary and possibly affect the appetite, it is suggested that the trial be repeated with a known source and quality of the fish meal.

DISCUSSION

The present results regarding genotypic differences in daily gain are in general agreement with those based on three-breed cross lambs and lambs sired by up to eight terminal sire breeds (Latif and Owen, 1980; Vesely and Peters, 1972, 1979; More O'Ferrall and Timon, 1977; Wolf et al., 1980) even when genotypic differences were statistically significant, they were rather small. In particular, they agree with the previous findings (Goot et al., 1980), based on the first three trials (3, 4 and 5), with the proviso that the performance of lambs sired by Assaf rams should be investigated further not only because their daily gain was consistently higher (Table 1.3.3) but also because their carcasses contained less fat than in the halfbreeds (see chap. 1.4). Their better gain might have been due to the fact that their sires were tops in performance testing for daily gains, and/or that their summer (season 2) performance was better than their contemporaries of other genotypes. It is noteworthy that, out of seven trials, the two statistically significant differences occurred in the summer (season 2).

As the present data were not suitable for season x genotype interaction, further trials should be run in each season to settle this point. If such an interaction does in fact exist, it seems to favor genotypes with Awassi blood as well; out of seven contemporary comparisons between FM and FA, in two (again in season 2) the latter performed significantly better than the former. In this connection the performance of 3/4FA is of interest; in all five trials it was equal to that of halfbreds, and in one (again in season 2) it was significantly lower than that of AsFA but equal to that of FM (Table 1.3.3).

That hot weather is not conducive to high performance has been well established, particularly for cattle, pigs and poultry (Hahn, 1976, 1977), but few references to lambs were found. The LSM differences due to season (Table 1.3.9) would indicate that daily gain is depressed more by relatively high and still rising temperatures, as in season 2, than by relatively high but declining temperatures, as in season 3. On the other hand, their higher intake in season 2 is rather surprising. If the threshold temperature for intake depression in sheep is 32°C (Hahn, 1977), and if this threshold applies to Finncross lambs, and if their appetite was depressed, none of this was reflected in an average intake for any given period; most probably the feeding pattern was not changed, as there is no evidence that lambs eat more at night, as shown in the daylight extension trial (111) also in season 2; the intake of 'light' and 'normal' groups was 1.55 and 1.51 kgDM per day, respectively.

Further evidence attesting to the suitability of Finn crosses for the summer conditions existing in Bet Dagan, comes from shearing trials. The four main genotypes did not benefit from shearing, the 3/4FA might have, but further trials are necessary to clarify this point. According to Klemm (1962), a hot and wet climate (in parts of the coastal region of Israel) was better tolerated by shorn, than unshorn, Australian Merino (adult) sheep. Eyal (1963) found that the difference in body temperature between shorn and unshorn Awassi sheep is rather small, but after sunset the shorn sheep cooled at a faster rate than did the unshorn ones. Eyal (1963) was of the opinion that the minimum daily temperatures may be as significant as the maximum, in this respect.

Finally, we were unable to show any effect of daylight extension on the daily gain of lambs, as reported by Forbes *et al.* (1979) and by Schanbacher and Crouse (1980) from experiments done in light-tight dark rooms. Our results are similar to those of Hackett and Hillers (1979) with artificial night-lighting in an open shed.

The present study focused attention on the performance of Finncross lambs during the different seasons of the year. Even allowing for lower daily gains during the first three summer months (April-June), the all-year-round fattening performance of ram-lambs containing 25%, 50% and 75% Finn blood was satisfactory, under Bet Dagan conditions, and apparently could not be improved either by artificial lighting - to stimulate growth, or by shearing to reduce the heat stress, with the possible exception of 3/4FA lambs. If the 3/4FA is, in fact, less heat tolerant than the Finn halfbreds, a selection based on performance testing of daily gain in season 2 would no doubt soon rectify the matter. Alternatively, and assuming that lambs sired by the Assaf breed fatten better in season 2, Assaf rams can be used to produce lambs for summer fattening.

Since the estimates of carcass composition can now be made (see chap. 1.4) assessment of carcass composition should be an integral part of fattening trials. These should aim at fat reduction by diet.

Folman and Eyal (1978) concluded that "with toasted soya bean meal it is possible to obtain high growth rates that do not differ significantly from those obtained with herring meal." However, the performance of the lambs receiving herring meal in their experiment showed a trend of superiority over the control lambs. Furthermore, Ørskov et al. (1970) reported considerably greater gains in lambs with fish meal compared with soyabean meal. The explanation for the lack of growth response to fish meal in the present study must probably be traced in the reasons for the reduced intake of the fish meal diet (Table 1.3.5). From the FC results it seems that better utilization attributable to the fish meal should not be disregarded.

Our results with protein levels do not confirm those of Ørskov et al. (1971,1972) within a range of body weights and growth rates similar to those obtained in the present report. According to those authors, 16% protein in the DM of the diet was optimal throughout the range of 15-55 kg liveweights of lambs, compared with 12-14% or 18-19%. Further study would be required to enable a decision as to whether it is advisable to reduce protein supplementation (and cost) during the advanced stages of fattening.

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1.4 BODY AND CARCASS COMPOSITION OF FINN-CROSS LAMBS

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ABSTRACT

Thirty-two Finn-cross ram-lambs of four genotypes were slaughtered serially and dissected in order to ascertain their body and carcass composition, particularly fat. During 1978-1983 they were fattened on a high-energy and -protein diet and slaughtered at a similar body weight (39-62 kg), age (119-177 days) and rate of growth (from birth to slaughter, 214-397 g/d). For comparison, data on maternal parent breeds, slaughtered in previous years, were also analyzed; they consisted of 33 Mutton Merino and seven Awassi ram-lambs and ram-hoggets ranging in weight from 21 to 84 kg, in age from 145 to 453 days, and in rate of growth from 122 to 312 g/d.

The pre-slaughter weight (PSW) affected significantly the weights of the hot carcass (HCW), fat-tail, pluck (lungs, heart, spleen), liver, kidney fat, caul fat and gut fat. HCW analyzed in relation to the carcass dissection weight and the weight of bones, muscle and fat and its effect was found to be highly significant. Similarly, age at slaughter affected significantly the weight of bones, muscle and fat. However, daily gain did not affect body fat or carcass composition, but its effect on PSW was significant and there was a significant genotype x PSW interaction.

Within the Finn crosses of four genotypes (FM, FA, AsFM and AsFA), differences in slaughter weight, slaughter age and daily gain from birth to slaughter, were statistically non-significant. There were differences among Mutton Merino (MM), Awassi (A) and Finn crosses, i.e., PSW: 56.5, 51.1 and 45.7 kg; age: 300, 263 and 142 days; and daily gain: 199, 277 and 324 g, respectively. When the data for body composition were adjusted to PSW, the genotypic differences among HCW, the liver and gut fat became statistically non-significant, and only the differences among the weight of the pluck (without the liver), kidney fat and caul fat remained significant. The weight of kidney fat was similar in all Finn crosses and it was significantly higher than in MM and A, maternal parent breeds, whereas the weight of caul fat was highest in FA and A lambs and similar in other genotypes.

Similarly, within carcass composition, adjusted to HCW, the genotype did not affect the carcass dissection weight or the weight of bones, but its effect on other tissues was highly significant. The muscle weight was highest in MM and differed significantly from all remaining genotypes. With regard to fat the subcutaneous fat was highest in Awassi and lowest in MM and MM crosses (FM and AsFM), with Awassi crosses (FA and AsFA) intermediate but closer to MM than to A. The highest intermuscular fat was found in Finn crosses and the lowest in the maternal parent breeds, particularly in Awassi, so that the total carcass fat was highest in Awassi (39%) and Finn halfbreds (37%), inter-

mediate in triple-breed crosses, AsFM and AsFA (34%), and lowest in MM (30%).

The contribution of the Finn genotype to the amount of body and carcass fat appears to be in two opposite directions: it reduced the weight of fat tail and subcutaneous fat in FA crosses and increased the weight of kidney fat and intermuscular fat in both FA and FM crosses.

A number of highly significant relationships between either the body weight, carcass weight or right leg composition and various organs and tissues were established. The highest coefficients of determination (R^2) were found between PSW and HCW as well as between HCW and/or leg composition and carcass composition (bone, muscle and fat).

INTRODUCTION

As practically all the income from mutton, and more than half that from dairy sheep, come from the sale of lambs, their weight per ewe per year is the most decisive factor in profitable sheep farming. The weight can be increased by increasing the litter size, frequency of lambing and marketing weight of lambs. Although the first two have been put into practice under more intensive management, the weight increase is the easiest and quickest means, and indeed, the weight of lambs marketed has increased rapidly in recent years, so that few lambs are marketed at present below the 40-50 kg range. At such a weight body fatness may become a handicap, as the demand is for lean meat with as little fat as possible.

The purpose of the present study was to obtain basic data on body and carcass composition of Finn crosses as well as some factors affecting it, to compare their composition with that of maternal parent breeds, and to suggest some prediction equations which could be used instead of expensive and time-consuming dissections.

Bowman (1966), Carpenter (1968) and more recently Black (1983) and Kempster (1983) reviewed work on factors affecting body development and carcass composition in sheep. Data on Mutton Merino (MM) grown in Israel have not been published yet, but some data on Awassi (A) and Finn - Awassi (FA) crosses were reported previously (Goot et al., 1980; Goot et al., 1982).

MATERIALS AND METHODS

The data can be divided into two parts. Out of 72 animals slaughtered, 32 ram-lambs were Finn crosses, of four genotypes (Table 1.4.1). These lambs were born, reared and fattened between 1979 and 1983, on a high-energy and -protein diet (Folman and Eyal, 1978) and slaughtered serially within similar body weights (39-62 kg), age (119-177 days) and rate of growth (214-397 g/d). The second part of the data refer to 33 Mutton Merino and seven Awassi ram-lambs and ram-hoggets. MM data were collected over several years and the animals ranged in weight from 36 to 84 kg and in age from 156 to 453 days (Goot, unpublished). All of them were born, reared and fattened at the Gilat Experiment Station near Beer Sheva (Goot et al., 1980). Their daily gain ranged from 122 to 249 g, and was significantly lower than that of Finn crosses (Table 1.4.1). Similarly, in the seven Awassi ram-lambs and ram-hoggets, the ranges in weight (21-79 kg) and age (145-345 days) were wider than those in Finn crosses.

All the lambs were weighed a day before slaughter (PSW - pre-slaughter weight) and subjected to a 18-24 hour fast, with access to water in summer; they were weighed again the following morning, prior to slaughter, and the weight was recorded as slaughter weight (SW). At slaughter, the lungs, trachea, heart and spleen were weighed together, and the liver, kidneys, tail, caul fat, gut fat and kidney fat separately.

Table 1.4.1 PRE-SLAUGHTER WEIGHT (PSW), SLAUGHTER WEIGHT (SW), AGE AT SLAUGHTER, AND HOT CARCASS WEIGHT (HCW) OF RAM-LAMBS ACCORDING TO THEIR GENOTYPE

Geno- type	PSW		SW		Age		RG		HCW	
	n	kg	n	kg	n	d	n	g/d	n	kg
MM	33	61.3	33	56.5 ^a	33	299.7 ^a	33	199 ^c	33	29.6 ^a
A	7	52.9	7	51.1 ^b	5	262.8 ^a	2	277 ^b	7	25.0 ^b
FM	8	49.1	8	45.4 ^c	8	142.6 ^b	8	321 ^{ab}	8	23.5 ^{ab}
FA	11	48.9	11	45.3 ^c	11	144.9 ^b	11	323 ^{ab}	11	22.3 ^c
AsFM	9	50.1	9	46.2 ^c	9	139.2 ^b	9	332 ^a	9	23.3 ^{ab}
AsFA	4	49.3	4	45.8 ^c	4	141.0 ^b	4	318 ^{ab}	4	23.3 ^{ab}
Total/ Mean	72	55.2	72	51.1	70	225.1	67	261		26.2
s.d.		13.2		1.5		45.9		38		1.7

Within columns, means for the same trait followed by different superscripts differ significantly ($P < 0.01$ or 0.001).

The carcass - without kidneys, kidney fat and tail - was weighed soon after slaughter (HCW). Most of the carcasses or joints therefrom were frozen and taken out for dissection when convenient.

For dissection Hammond's technique, as described by Wallace (1948) was followed, although in Finn crosses half-carcasses were dissected, *viz.* the right half of the neck, thorax, loin and pelvis, and the right shoulder and leg, with psoas dissected separately. Bones were not halved, so that only the weight of the ribs in the left thorax was estimated. Any discrepancy in Table 1.4.2 is due to waste, storage and dissection losses, which were not listed in the table.

Abbreviations used in this chapter:

A	Awassi
A	width of eye muscle
a	intercept in regression equations
As.	Assaf
B	depth of eye muscle
by.x	slope of coefficient of regression
C	depth of back fat over the greatest depth of eye muscle
CCW	cold carcass weight; HCW - 2%
F	crutch or flesh between two legs and the anterior edge of distal tarsal

HCW	hot carcass weight
J	maximum depth of fat over 13th rib
L	body length from anterior edge of symphysis pubis to anterior edge of first rib
PSW	pre-slaughter weight (without fasting)
RG	rate of growth, g/d
SW	slaughter weight, after 18-24 hour fast

RESULTS

Body composition

The performance of lambs until slaughter is summarized in Table 1.4.1. All the genotype differences were statistically ($P < 0.001$), except the PSW, which was significant only at the $P = 0.05$ level. Mutton Merino and Awassi were significantly heavier and older and their rate of growth, of MM in particular, was slower than that of Finn crosses. The latter were very similar as regards weight, age and gain.

The differences between PSW and SW were due to fasting. The fasting losses in Finn crosses were 3.5-3.9 kg, or 7.1-7.8% of the PSW. The losses in Awassis (1.8 kg, 3.4%) and in MM (4.8 kg, 7.8%) might be confounded by other factors, such as period of fasting, and should not be regarded as breed characteristics.

Except for MM lambs, which were docked, the tail weight of other genotypes at slaughter were as follows:

Genotype	n	Mean g	S.D. g	C.V. %
A	7	5,764	3,599	62
FM	8	118	26	22
FA	11	402	158	39
AsFM	9	208	121	59
AsFA	4	674	428	64

Apart from the very high values of C.V. - in Awassi due to a wide weight range, the most striking feature is a drastic reduction of the fat-tail in the crossbreds; in FA by 93% and in ASFA by 88%. The contribution of Assaf rams (approximately 5/8 Awassi and 3/8 East Friesian) was a relatively small increase of 272 g from 402 g in FA to 674 g in AsFA, and of 90 g from 118 g in FM to 208 g in ASFM lambs.

The dressing percentage (HCW in relation to SW), based on figures given in Table 1.4.1, for each genotype is given below:

Genotype	n	%
MM	33	52.3
A	7	48.9
FM	8	51.8
FA	11	49.2
AsFA	9	50.4
AsFA	4	50.9

The low dressing percentage in Awassi was due to the fat-tail.

When the data on body and carcass composition were adjusted to PSW and HCW, respectively (Table 1.4.2), there were no statistically significant differences in the weight of the liver and the gut fat; the latter was very difficult to strip off the intestines at the abattoirs, and consequently the values attributed to genotype may be confounded with the skill of slaughtermen in removing the fat. Within the weight of the caul (omental) fat, the differences were significant at $P < 0.05$ only; its weight was highest in FA and A lambs and the differences among the other genotypes were not significant. The weight of kidney fat was similar in all Finn crosses and was significantly higher ($P < 0.001$) than in MM and Awassi genotypes. Finally, the heaviest 'pluck' (without the liver) was found in FM followed by AsFA, AsFM, FA, MM and A, in that order.

Carcass composition

As seen in Table 1.4.2, the genotypic differences within the weight of muscle and fat were highly significant ($P < 0.001$). The muscle weight was heaviest in MM and differed significantly from all the other genotypes, viz. Awassi and Finn crosses. The weight of subcutaneous fat was strikingly high in A, followed by AsFA, FA, FM, AsFM and MM, in that order. Here the contribution of Awassi blood is very clearly delineated, even more so than that of Finnsheep within the weights of intermuscular fat; Finn halfbreds, FM and FA, with the heaviest deposits, followed by the triple crosses and MM and finally by Awassi. Thus, the total carcass fat could be tentatively graded as light in MM, heavy in A, FA and FM, and intermediate (although overlapping the heavy group) in AsFA and AsFM. The grading can be seen better when the carcass composition is expressed as percentages of dissection weight given in Table 1.4.2.

Genotype	Bone %	Muscle %	Fat %	Waste & losses %
MM	12.4	55.7	30.2	1.7
A	12.8	47.5	38.5	1.4
FM	12.7	48.7	36.6	2.0
FA	13.1	47.7	37.2	2.0
AsFM	13.4	50.7	33.7	2.2
AsFA	14.2	48.9	34.4	2.5

The genotypic differences in carcass measurements were statistically highly significant ($P < 0.001$) except for C. FA carcasses were the longest (L), followed by AsFA and then all the other genotypes. The leg shape (F) was significantly better in Finn crosses than in the maternal parent breeds, although one would expect the MM carcasses to score much higher. The length of the eye muscle (A) was best in MM and FM carcasses; similarly, its width (B) was best in MM, followed by Finn crosses and the poorest in A carcasses. The maximum fat deposit on rib (J) was the lightest in MM and heaviest in A, with the Finn crosses intermediate, but significantly closer to A than to MM.

Table 1.4.2 LEAST SQUARE MEANS (LSM) FOR HOT CARCASS WEIGHT (HCW), EDIBLE ORGANS AND BODY FAT, CARCASS TISSUES AND MEASUREMENTS ACCORDING TO GENOTYPE

a. Weights of carcass, internal organs and visceral fat

Genotype	HCW kg	PLUCK ¹ g	LIVER g	KIDNEY FAT g	GAUL FAT g	GUT FAT g
MM	26.29	1,135 ^a	902	502 ^a	1,023 ^{ab}	519
A	26.19	1,005 ^{ab}	756	602 ^a	1,355 ^b	448
FM	26.78	1,490 ^c	983	1,060 ^b	1,602 ^{ab}	707
FA	25.66	1,178 ^{ab}	852	1,100 ^b	1,728 ^b	688
AsFM	26.07	1,226 ^{ab}	944	1,100 ^b	1,379 ^{ab}	765
AsFA	26.45	1,214 ^{abc}	985	640 ^{ab}	1,144 ^{ab}	585
E-value	n.s.	7.06 ^{xxx}	n.s.	8.60 ^{xxx}	4.18 ^x	n.s.

b. Dissected carcass

Genotype	DISSEC- TION WEIGHT g	BONES g	MUSCLE g	SUBCUT. FAT g	INTERMUS. FAT g	TOTAL FAT g
MM	25,798	3,203	14,366 ^a	3,136 ^a	4,657 ^a	7,793 ^a
A	25,397	3,240	12,057 ^b	6,014 ^b	3,754 ^b	9,769 ^b
FM	25,699	3,261	12,524 ^b	3,428 ^{ac}	5,967 ^c	9,396 ^b
FA	25,638	3,359	12,228 ^b	4,048 ^c	5,490 ^{cd}	9,538 ^b
AsFM	25,658	3,438	12,996 ^b	3,227 ^{ac}	5,430 ^{abd}	8,658 ^{ab}
AsFA	25,602	3,634	12,510 ^b	4,052 ^c	4,757 ^{cd}	8,810 ^{ab}
E-value	n.s.	n.s.	12.95 ^{xxx}	19.31 ^{xxx}	9.67 ^{xxx}	6.58 ^{xxx}

c. Carcass measurements²

Genotype	L cm	F cm	A mm	B mm	C mm	J mm
MM	63.3 ^a	27.2 ^a	64.7 ^a	35.4 ^a	4.4	13.8 ^a
A	63.0 ^a	25.8 ^a	59.1 ^b	28.2 ^b	2.4	23.1 ^b
FM	63.9 ^a	22.1 ^b	60.3 ^{ab}	34.8 ^{ac}	2.8	19.3 ^{bc}
FA	67.4 ^b	24.3 ^b	55.6 ^b	32.7 ^{ac}	3.1	21.7 ^{bc}
AsFM	64.7 ^a	22.3 ^b	58.3 ^b	32.5 ^{ac}	3.8	18.2 ^c
AsFA	65.9 ^{ab}	25.2 ^b	55.0 ^b	30.2 ^{ac}	3.1	19.9 ^{bc}
F value	4.62 ^{xxx}	15.60 ^{xxx}	7.64 ^{xxx}	5.79 ^{xxx}	n.s.	8.81 ^{xxx}

¹The lungs, trachea, heart and spleen

²L, F, A, B, C, J - see Materials and Methods for explanation of symbols.

Within columns, means for the same trait followed by different superscripts differ significantly (P<0.01^x and 0.001^{xxx}, n.s. = non-significant).

Some factors affecting body and carcass weight, composition and measurements

In addition to genotype (Tables 1.4.1 and 1.4.2), some other factors were analyzed using covariance analyses.

Pre-slaughter weight (PSW) was analyzed in relation to SW, HCW and the weights of fat-tail, 'pluck', liver, kidney fat, caul fat, gut fat and all the measurements listed in Table 1.4.2 and its effect was found to be highly significant ($P < 0.001$) for all traits except F measurement. Interactions were not significant.

Hot carcass weight (HCW) was analyzed in relation to dissection weight and the weights of bones, muscle, subcutaneous fat, intermuscular fat and total carcass fat, and its effect was found to be highly significant ($P < 0.001$); again, interactions were not significant. Similarly, age at slaughter had a highly significant ($P < 0.001$) effect on the weight of bones, muscle and fats. However, the effect of rate of growth, from birth to slaughter, was statistically not significant in relation to the weights of bone, muscle and carcass fat, kidney fat, caul fat and gut fat, but highly significant ($P < 0.01$) in relation to PSW, and there was a highly significant genotype x PSW interaction. The quantitative aspects of more important relationships are given in Table 1.4.3. Model's R^2 include genotypes. The slopes ($b_{y,x}$) between genotypes were found not to differ statistically and therefore they are applicable to all six genotypes, but most of the intercepts (a) are intrinsic to each genotype (they were too bulky to be included in the table), so that each regression equation must have an intercept appropriate to a given genotype. The parameters given in Table 1.4.3 are mutatis mutandis similar to those found by numerous other workers (see, inter alia, Barton and Kirton, 1958; Tulloh, 1964; Timon and Bichard, 1965; Carpenter, 1968; Campion et al., 1976; Kempster, 1983).

Prediction

Quite a few of the parameters given in Table 1.4.3 could be used for prediction, depending on the degree of precision required and subject to the limitations discussed by Kempster (1983). Some examples of the most useful ones are given in Table 1.4.4. The estimated values are very close to actual (not LSM) means. The prediction formulae suggested are the most economical. Adding age as another independent variable has hardly increased the precision. Other equations can be worked out from our dissection data but it is useful to bear in mind that prediction formulae are not always suitable scientific tools to be substituted for dissection.

DISCUSSION

In weighing the practical implications of the present results, two basic problems should be amplified, viz. (i) the meaning of breed or genotype, and (ii) justification for comparing the results on the basis of genotype. As pointed out in the preceding section, all the 32 Finn cross ram-lambs, of four genotypes, share a common environmental and programmed background, as reflected in the non-significant differences

Table 1.4.3 SOME OF THE RELATIONSHIPS AMONG EITHER THE WEIGHT OF BODY, CARCASS AND RIGHT LEG, OR THE AGE AND VARIOUS BODY AND CARCASS TRAITS, POOLED OVER THE SIX GENOTYPES

Variables		Slope		R^{2*}	X unit
Depend.(Y)	Independ.(X)	by.x	s.e.		
HCW	PSW	0.54	0.02	0.958	kg
HCW	SW	0.57	0.01	0.971	kg
Diss. W.	HCW	995.64	5.76	0.998	kg
Pluck**	PSW	12.97	1.79	0.645	kg
Liver	PSW	8.37	1.51	0.517	kg
Tail	PSW	48.00	8.35	0.814	kg
Gaul fat	PSW	42.41	4.43	0.617	kg
Gut fat	PSW	21.67	2.52	0.596	kg
Kidney fat	PSW	29.02	3.13	0.616	kg
Bones	PSW	40.25	2.51	0.819	kg
	HCW	71.08	4.83	0.793	kg
	Age	4.12	0.75	0.449	d
	Leg, bones	9.30	0.35	0.926	g
Muscle	PSW	227.81	10.02	0.928	kg
	HCW	414.29	15.92	0.944	kg
	Age	28.93	3.59	0.703	d
	Leg, muscle	8.89	0.27	0.962	g
Subcutaneous fat	HCW	267.00	12.11	0.902	kg
	Age	2.10	0.58	0.491	d
	Leg, subcut. fat	12.51	0.61	0.890	g
Intermuscular fat	HCW	239.78	12.05	0.875	kg
	Age	6.24	1.05	0.386	d
	Leg, interm. fat	24.85	2.02	0.734	g
Total carcass fat	PSW	270.20	14.46	0.858	kg
	HCW	506.77	18.41	0.926	kg
	Age	31.20	5.04	0.463	d
	Leg, total fat	17.44	0.80	0.887	g
L)	HCW	0.53	0.05	0.746	cm
F)		0.01	0.03	0.641	cm
A)		0.52	0.08	0.709	mm
B)		0.39	0.06	0.634	mm
C)		0.14	0.04	0.420	mm
J)		0.72	0.07	0.675	mm

* R^2 = proportion of the total sum of squares in the model including genotypes and the independent variable.

**The lungs, trachea, heart and spleen

Table 1.4.4 SOME EXAMPLES OF REGRESSION EQUATIONS WITH PREDICTIVE POTENTIAL
(SEE ALSO TABLE 1.4.3)

Variables		Geno- type	Regression Equation Y	Values	
Depend. Y	Independ. X			Actual	Estimated
HCW	{ PSW ^a	{ FM	0.543X - 3.18	23.49 kg ^a	23.48 kg
		{ FA	0.543X - 4.29	22.25 kg ^a	22.26 kg
Bones	{ HCW ^a	{ FM	71.08X + 1386	3,055 g ^b	3,056 g
		{ FA	71.08X + 1483	3,080 g ^b	3,065 g
	{ Bones of leg ^c	{ FM	9.30X + 52.29	3,055 g	3,054 g
		{ FA	9.30X + 129.08	3,080 g	3,077 g
Muscles	{ HCW ^a	{ FM	414.29X + 1662	11,396 g ^b	11,394 g
		{ FA	414.29X + 1366	10,585 g ^b	10,584 g
	{ Muscles of leg ^c	{ FM	8.59X - 1014	11,399 g ^b	11,399 g
		{ FA	8.59X - 1084	10,585 g ^b	10,590 g
Total carcass fat	{ HCW ^a	{ FM	506.77X - 3749	8,016 g ^b	8,155 g
		{ FA	506.77X - 3891	7,530 g ^b	7,385 g
	{ Fat of leg ^c	{ FM	17.44X + 1326	8,016 g ^b	8,014 g
		{ FA	17.44X + 799	7,530 g ^b	7,527 g

^aSee Table 1.4.1

^bNot tabulated

^c Right leg	FM	FA
Bones	322.8 g	317.0 g
Muscles	1445.0 g	1590.0 g
Fat	383.5 g	385.8 g

in respect to PSW, age and R.G. (Table 1.4.1). The same cannot be said for the maternal parent breeds, MM and A, which differed significantly from the Finn crosses in the said traits. Also, the quality of concentrates as well as fattening programs and places were different. The concentrates given then to MM at Gilat were such that the daily gain was considerably lower than that on the concentrates fed since 1978/79 and on which the Finn crosses were fattened (Goot *et al.*, 1980). In addition, the growth curve of some of the MM lambs was regulated to conform to a high-medium level of nutrition. Within the seven Awassis the feeding of only three (the heaviest) is known; they were fed on *ad lib.* concentrates (Folman *et al.*, 1967) and the remainder were fattened in dairy flocks.

Although the profound effect of nutrition on body and carcass composition has been known for over half a century (Hammond, 1932), it is still difficult to apply this knowledge to specific cases and to quantify the effect of a given factor on growth of organs and tissues. In particular, it is known that high-high and low-high levels of nutrition encourage late maturing tissues (fat) (Palsson and Verges, 1952; Wallace, 1958), that smaller breeds of sheep are fatter at any given live weight (Searle, 1977), and that most of the differences between the breeds examined were due to their mature sizes rather than to any intrinsic breed characteristics (McClelland *et al.*, 1976). Furthermore, the amount of food eaten can increase the fat content at any given live weight (Knight and Foote, 1965; Goot *et al.*, 1967; Rattray *et al.*, 1973; Searle, 1977). Thus, one would expect *a priori* the Finn crosses to be fatter than the maternal parent breeds because they, the crosses, were on high-high *ad lib.* nutrition and were probably smaller in size. All the same, there is still too little information on the effect of recently developed high-energy concentrates on carcass composition. At Logan, the replica of the concentrates the Finn crosses were fattened on at Bet Dagan, appears to have produced more carcass fat than did other diets (see Chapter 1.5).

On the other hand, a high energy level (3.320 Mcal/kg DM) did not affect significantly carcass fat (but increased kidney and pelvic fat, $P < 0.01$), in comparison with medium (2.911 Mcal/kg DM) and low 2.703 Mcal/kg DM levels (Crouse *et al.*, 1973). The present situation was succinctly summarized by Black (1983): "There is no simple relationship between growth rate and body composition of sheep" which is affected "by sex, breed and stage of maturity of the lamb as well as by energy intake, composition of the diet and climatic conditions." It can be concluded, therefore, that the four genotypes of the Finn crosses can be directly compared, as they conform to the above conditions, including the energy intake (Goot *et al.*, 1982, and Chapter 1.3), but the comparisons with the maternal parent breeds should be viewed with caution. It does not follow that the comparisons are spurious, they are not but they are also not definitive if one bears in mind Bowman's (1966) assertion: "Breeds of sheep should never be considered as static populations but as interrelated populations in continuous evolution caused by artificial and natural selection."

The contribution of each parent breed to the weight of fat in cross-bred lambs can now be attempted. Assuming that the weights of kidney

and caul fat are low in MM and Awassi lambs (Table 1.4.2) and high in Finn lambs (McClelland and Russel, 1972), and further that the weight of subcutaneous fat and fat-tail are high in Awassi lambs, then the contribution of Finn genotype is clearly imprinted in Finn halfbred lambs, fattened to heavy weight on ad lib. high energy and protein concentrates. In comparison with either MM or A, lambs at the same HCW, the weight of (i) kidney fat was nearly doubled in both Finn halfbreds; (ii) the fat tail was reduced by 0.9 in FA; and (iii) the subcutaneous fat was reduced by nearly one-third in FA. At least a part of the increase in the weight of the intermuscular fat (by 22% in FM and 46% in FA) could be assumed to be due to Finn genotype. Insofar as FM are concerned, the assumption is in full agreement with Nitter's (1975) results on dam-lines; the fat proportion in carcasses of 17.8 kg out of pure Merino Land (ML) was similar (25.1%) to that out of ML x MM (25.2%), and both differed significantly from that out of the Finn x ML line (27.8%). Thus, the contribution of Finn genotype -and this is unusual - was twofold: it reduced the weight of the subcutaneous fat in FA carcasses and increased the weight of the intermuscular fat in both FM and FA carcasses and thus brought about the weight of the carcass fat which was not significantly different within FM and FA halfbreds and Awassi, but highly significantly different in relation to MM carcasses (Table 1.4.2).

The breed effect on caul fat was not clear-cut (Table 1.4.2) - although heavier in the halfbreds, the differences were statistically non-significant.

With regard to carcass measurements, FA had significantly longer carcasses (L) and FA and FM had shorter leg length (F) than the maternal parent breeds; the shape of the eye muscle was slightly improved in comparison with that of Awassi, and the maximum fat on rib (J) was deeper in FM than in MM.

As no dissection data on Assaf are available, its 50% contribution to the fat of the triple crosses cannot be assessed. Generally, the triple crosses appear to have less fat than the halfbreds (Table 1.4.2), but most of the differences were statistically non-significant; some of the inconsistencies may be due to a small number of AsFA (four only) and/or greater heterogeneity of this relatively new breed.

As the weight of the fat-tail in Awassis can significantly reduce the dressing percentage (Goot et al., 1967), the impact of crossbreeding on its weight should also be considered. In East Friesian x Awassi crosses, the E.F. long-tail was incompletely dominant over the A fat-tail (Goot, 1966). Similar results were obtained with Finn short-tail (Goot et al., 1980), and the present results are in full agreement with the previous finding. The estimated weights of the fat-tail at 50 kg PSW, are as follows:

Genotype	Weight of fat-tail	
	g	%
Awassi	5,624	100
AsFA	710	13*
FA	456	8*
AsFM	207	4*

*% of Awassi fat-tail.

Finally, and in order to get a wider perspective for the concluding paragraph later on, it is constructive to compare recent figures from New Zealand, the world's biggest producer of fat-lambs (32 million annually, yielding 425,000 tons of bone-in meat, of which 96% is exported). In New Zealand, the carcasses of lambs by 11 sire-breeds, out of Romney ewes, were compared. The percentage fat at 20 kg carcass weight and arranged according to sire-breeds, ranged from 32.9 to 40.1% (Bennet 1983). Some of their results are listed below, together with carcass fat estimates for our six genotypes.

Total carcass fat in 20 kg carcasses (19.6 kg CCW)

Israel			New Zealand	
	kg	%	Sire breed	%
MM	4.64	23.7	Suffolk	32.9
A	6.62	33.8	Hampshire)	33.3
FM	6.25	31.9	Dorset Down)	
FA	6.39	32.6	Border Leicester)	34.3
AsFM	5.51	28.1	Romney)	
AsFA	5.66	28.9	Southdown	38.4
			Reyland	40.1

From the above figures as well as from Nitter's (1975) results with ten British and Continental breeds, Texel included, it seems that any fat reduction, at bio-economically efficient weights, is unlikely to come from the breeds tested, whether because of their genotype or mature size or both. Selection is at present handicapped by lack of precise and easy-to-handle tools for fat estimation on live lambs. However, there is already sufficient data for a computer program to simulate various phases of growth and development of lambs (Black, 1983) which could be used to guide the future strategy aiming at growing leaner lambs. For the present it is suggested to increase further

the number of lambs per ewe per year, so that the weight of lambs sold per ewe could be increased with a reduction in the marketing weight of individual lambs and, hence, in the carcass fat.

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1.5 POTENTIAL OF THE AMERICAN SUFFOLK BREED AS A TERMINAL CROSS WITH
FINN-CROSS EWES

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ABSTRACT

The purpose of this study was to estimate the usefulness of the American Suffolk as a sire breed for top crossing on a Finn-Awassi ewe for lamb production. Because there are no American Suffolk sheep in Israel and no Awassi in the United States and it is not possible to import them, an attempt was made to carry out the study in the United States substituting the Karakul, which is already present in the United States, for the Awassi.

The American Suffolk was superior for trop crossing as compared with Finn x Karakul cross. However, small numbers of ewes and age disparity limit the generalized application of these results. High concentrate rations developed in Israel resulted in improved feed efficiency but an apparent decrease in carcass quality, as indicated by larger amounts of internal fat.

INTRODUCTION

Lamb production can be maximized by terminal crossing to prolific crossbred dam lines using a breed of ram with increased growth rate and improved carcass quality (Matthews et al., 1977). Nitter (1978) suggested that more distinct improvement in favor of terminal crosses is demonstrated when breed differences are larger than 40%, thus indicating that the greater the genotype difference the greater the comparative improvement in growth rate above that of the dam's genotype. Goot et al. (1982) reported good growth rates from half-Finn cross lambs, thus increasing the need to choose sire breeds of greatest growth rate potential to maximize lamb production in the Finn-Awassi cross-breeding system in Israel.

One of the major considerations in this project was the selection of a breed of sire for top or terminal crossing with the Finn (or Romanov) - Awassi cross ewe to increase lamb production. The American Suffolk breed was considered to be the best potential choice because of its large size and rapid rate of growth. Plans to import selected American Suffolk rams were interrupted when permission could not be obtained for their import into Israel on the basis of suspected disease (scrapie) in the U.S. Research in Utah, USA, was therefore designed to estimate the response of the American Suffolk as a top cross by approximating the Finn x Awassi cross using the Finn x Karakul cross. This was necessary because no Awassi are available in the United States.

MATERIALS AND METHODS

This study was conducted during the period from 1980-1983. A major objective of a larger project was to measure the influence of the American Suffolk as a terminal sire breed, on Finn-Awassi crossbred ewe lamb production in Israel. It was not possible to import American Suffolk rams into Israel and no Awassi ewes were available in the United States. This study was therefore undertaken to estimate the influence of the American Suffolk for terminal crossing using the Karakul, which was available in the United States, in place of the Awassi.

Thirty-one Karakul ewes were obtained from small flocks in Colorado, Utah and Texas. Three Finn rams were obtained from the United States Sheep Experiment Station (ARS, MSDA) at Dubois, Idaho. The Karakul ewes were artificially inseminated with semen from the Finn rams because the fat tail was a barrier to natural mating. Each ewe was inseminated two times during estrus.

These crosses were made to produce crossbred Finn-Karakul (FK) females on which American Suffolk rams could be used for terminal crossing to estimate their influence on lamb production. The FK crossbred ewe lambs were docked to facilitate natural mating by the American Suffolk rams. They were exposed to American Suffolk rams for breeding first as lambs.

Rates and efficiency of gain were measured in offspring from three genotypes receiving three different diets. The genotypes of offspring

were: (a) SFK (1/2American Suffolk, 1/4Finn and 1/4Karakul); (b) FK (1/2Finn and 1/2Karakul); and (c) SFT (1/2Suffolk, 1/8Finn and 3/8Targhee).. The three diets were: (i) Alfalfa pellets plus rolled barley, the two ingredients being fed in separate mangers; (ii) alfalfa concentrate pellets containing alfalfa hay 60%, rolled barley 27%, dried beet pulp 10%, cottonseed meal 2%, trace mineral salt 0.5%, and dicalcium phosphate 0.5% (Butcher and Raleigh, 1962). Bentonite was added as required for a pelleting aid; (iii) high concentrate pellet containing barley 36%, corn 36%, soybean meal 22%, alfalfa meal 3.0%, limestone 1.8%, and salt 0.7%. Bentonite was added as required for pelleting. This ration was developed in Israel for intensive lamb feeding and finishing (Folman and Eyal, 1978). Lambs were fed ad libitum in groups of 15 or fewer. All lambs were creepfed the high concentrate pelleted ration beginning at birth until weaning at 8-10 weeks of age, when they were fed in the three groups until ~45 kg live weight.

Data were analyzed by least square means. Data on offspring were adjusted for year, age of dam, sex, and type of birth. However, there was some confounding of age of dam with genotype and year. Offspring from the SxFK genotype were from 1- to 2-year-old dams; from the SxFT genotype from 2-year-old and older dams; and from FK genotypes, from 3-year-old and older dams.

All phases of the research were conducted with animals under confinement. The breeding flocks were fed pelleted alfalfa or alfalfa and rolled barley according to NRC recommendations. Both male and female lambs were docked within 1 week of birth. The males were left uncastrated. All lambs were weaned at 8 weeks of age except one group (SFT) in 1983 was weaned at 10 weeks of age to facilitate another study.

The following data were recorded: dams, lambing rate, lambs, date of birth, sex, type of birth, body weight at birth and at weekly intervals until slaughter, feed consumption per day per pen, slaughter and carcass (live weight at slaughter, warm and chilled carcass weight, back-fat thickness, kidney fat weight, and kidney plus kidney fat weight).

Data for all genotypes were not necessarily included in comparing rations or dates for all rations included when comparing genotypes.

RESULTS

Due to fertility problems in the Finn rams and Karakul ewes, the numbers of offspring resulting from this cross (FK) and the subsequent cross (SFK) were reduced. The younger age of the Finn x Karakul ewes further reduces the effectiveness of comparing genotypes. Lambing data and birth weight of lambs are shown in Table 1.5.1. There was an increase in lambing rate in the crossbred (Finn x Karakul) compared with the straightbred Karakul, as expected (1.2 vs. 2.0). Birth weights did not differ significantly ($P < .05$).

Information on body weight, daily gain and feed efficiency is given in Table 1.5.2. The SFT lambs did have higher average daily gains

Table 1.5.1 SUMMARY OF LAMBS PRODUCED FROM FINN x KARAKUL AND AMERICAN SUFFOLK x FINN-KARAKUL CROSSES DURING 1980-1983¹

Sire	Genotype	Dam	Number of offspring	Females (%)	Prolificacy (lambs/ewe)	Birth weight (kg)	Weight of lambs/ewe born (kg)
Finnsheep		Karakul	25	46	1.32±.13 ^a	3.82±.20 ^a	5.03±.46 ^a
Suffolk		Finn-Karakul	17	33	1.89±.20 ^b	4.29±.24 ^b	8.11±.67 ^b

¹Karakul ewes were mature, Finn-Karakul ewes were 1-3 years old; in addition prolificacy was much higher in crossbred ewes. Both of these factors influence birth weight.

ab

Means followed by different letters are statistically different (P<.05).

Table 1.5.2 WEIGHT, DAILY GAINS AND FEED EFFICIENCY LEAST SQUARE MEANS IN THE SFT, KF, AND SFK LAMB FED A HIGH CONCENTRATE RATION¹

	n	Genotype ²	
		SFT	FK
		50	19
Birth weight, kg			16
Weaning weight, kg		4.37±0.11	4.16±0.24
8 wks' adjusted weaning weight, kg		19.38±0.64	18.26±1.38
		16.11±0.70 ^a	15.48±1.51 ^a
Body weight (kg)			
Initial		24.29±0.76 ^a	19.21±1.64 ^b
2nd week		27.96±1.87 ^a	22.07±1.87 ^b
4th week		32.29±0.97 ^a	25.92±2.10 ^b
6th week		36.22±1.20 ^a	28.40±2.40 ^b
Final		43.57±1.22 ^a	37.11±2.63 ^b
Average daily gain (g)			
Initial to 2nd week		262.1±31.8	203.4±68.3
2nd to 4th week		209.4±22.1 ^a	276.6±47.5 ^b
4th to 6th week		280.9±16.9 ^a	175.6±36.5 ^b
Initial to final		303.5±16.8 ^a	233.0±36.1 ^b
Birth to weaning		209.4±12.2 ^a	206.6±26.1 ^b
Birth to final		260.4±8.8 ^a	212.4±19.0 ^b
Feed efficiency (kg feed/kg gain) ³			
Initial to 2nd week		4.8	-
2nd to 4th week		4.4	3.2
4th to 6th week		6.2	5.3
2nd to 6th week		5.3	4.2

¹All means (except for feed efficiency) are adjusted for age of ewe, sex and type of birth of lambs
²S = Suffolk; F = Finnsheep; K = Karakul; T = Targhee; sire indicated first
³FK and SFK lambs were fed together.
^{a,b,c}Within rows (or columns), means with the same superscript, or with no superscript do not differ statistically (P<.05).

Table 1.5.3 CARCASS LEAST SQUARE MEANS ($\pm$ SE) IN THE SFT, FK, AND SFK LAMB FED A HIGH CONCENTRATE RATION¹

	Genotypes ²		
	SFT	FK	SFK
n	38	6	10
Weight before slaughter (kg)	43.57 $\pm$ 1.22	37.11 $\pm$ 2.63	40.46 $\pm$ 2.22
Hot carcass weight (kg)	23.76 $\pm$ 0.30	23.20 $\pm$ 0.87	22.63 $\pm$ 0.61
Chilled carcass weight (kg)	22.19 $\pm$ 0.26	21.66 $\pm$ 0.78	21.79 $\pm$ 0.55
Dressing percentage	51.02 $\pm$ 0.89	56.19 $\pm$ 2.64	53.92 $\pm$ 1.86
Backfat thickness (mm)	5.34 $\pm$ 0.21 ^a	3.51 $\pm$ 0.61 ^b	5.41 $\pm$ 0.43 ^a
Kidney fat (g)	399.8 $\pm$ 57.1	539.3 $\pm$ 16.8	512.5 $\pm$ 11.8
Kidney fat and kidney (g)	566.9 $\pm$ 30.4 ^a	705.2 $\pm$ 89.5 ^b	428.5 $\pm$ 62.8 ^a

¹All means are adjusted for age of dam, sex and type of birth of lamb.

²S = Suffolk; F = Finnsheep; K = Karakul; T = Targhee; sire indicated first.

a,b,c Means with the same superscript or with no superscript do not differ statistically (P<.05).

Table 1.5.4 WEIGHT, DAILY GAIN, AND FEED EFFICIENCY LEAST SQUARE MEANS ($\pm$ SE) IN THE SFT LAMBS FED THREE DIFFERENT RATIONS¹

n	Ration		
	High concentrate pellet	Alfalfa + concentrate pellet	Alfalfa pellet + barley
Weight (kg)	50	51	50
Initial	24.54 $\pm$ 0.75	24.67 $\pm$ 0.74	24.82 $\pm$ 0.75
2nd week	28.47 $\pm$ 0.84	28.93 $\pm$ 0.83	28.96 $\pm$ 0.84
4th week	32.73 $\pm$ 0.91	33.15 $\pm$ 0.90	33.02 $\pm$ 0.91
6th week	36.63 $\pm$ 0.98	36.18 $\pm$ 0.97	36.25 $\pm$ 0.98
Final	43.49 $\pm$ 1.05	43.78 $\pm$ 1.03	44.83 $\pm$ 1.05
Average daily gain (g)			
Initial to 2nd week	280.7 $\pm$ 26.6	304.0 $\pm$ 26.4	295.7 $\pm$ 26.6
2nd to 4th week	304.1 $\pm$ 22.3	301.2 $\pm$ 22.1 ^b	289.7 $\pm$ 22.3
4th to 6th week	279.0 $\pm$ 16.6 ^a	216.9 $\pm$ 16.5	231.2 $\pm$ 16.7 ^c
Initial to 6th week	298.1 $\pm$ 13.9	285.3 $\pm$ 13.7	289.4 $\pm$ 13.9
Feed efficiency (kg DM/kg gain) ²			
Initial to 2nd week	4.8	5.7	4.3
2nd to 4th week	4.4	5.8	7.8
4th to 6th week	6.2	9.4	10.7
Initial to 6th week	5.1	7.0	7.6

¹All means (except for feed efficiency) are adjusted for age of ewe, sex and type of birth of lamb.

²Includes only 1983 feed consumption.

a,b,c Means with the same superscript or with no superscript do not differ statistically ($P < .05$).

Table 1.5.5 CARCASS LEAST SQUARE MEANS ($\pm$ SE) IN THE SFT LAMBS FED THREE DIFFERENT RATIONS¹

	Ration		
	High concentrate pellet	Alfalfa + con- centrate pellet	Alfalfa pellet + barley
n	38	29	35
Weight before slaughter (kg)	43.49 $\pm$ 1.05	43.78 $\pm$ 1.03	44.83 $\pm$ 1.05
Hot carcass weight (kg)	23.64 $\pm$ 0.29 ^a	21.77 $\pm$ 0.32 ^b	22.19 $\pm$ 0.30 ^b
Chilled carcass weight (kg)	22.13 $\pm$ 0.27 ^a	19.93 $\pm$ 0.30 ^b	20.68 $\pm$ 0.27 ^b
Dressing percentage	51.14 $\pm$ 0.71 ^a	48.82 $\pm$ 0.80 ^b	48.79 $\pm$ 0.73 ^b
Backfat thickness (mm)	5.24 $\pm$ 0.21	4.70 $\pm$ 0.24	4.93 $\pm$ 0.22
Kidney fat (g)	423.0 $\pm$ 19.9 ^a	267.9 $\pm$ 22.5 ^b	301.3 $\pm$ 20.5 ^c
Kidney fat and kidney (g)	580.4 $\pm$ 21.8 ^a	406.3 $\pm$ 24.6 ^b	435.8 $\pm$ 22.5 ^c

¹Means are adjusted for age of dam, sex and type of birth.

a,b,c Means followed by the same superscript or with no superscript, do not differ significantly ($P < .05$).

and body weights, although not significantly different from SFK in birth to final weights. Analysis for differences in feed efficiency was not possible because of group feeding. However, group averages were 6.23 for the SFT and 5.34 for the SFK and FK genotypes. These results indicate an increased growth rate and body size for American Suffolk-sired crossbred lambs but appropriate non-crossbred genotypes were not available for comparison.

Although the carcass data reflect little statistically significant difference, the generally higher dressing percent and kidney fat and lower back fat of the SFK and FK genotypes compared with the SFT (Table 1.5.3), indicate a poorer carcass in these genotypes due primarily to increased internal fat.

Comparison of the three rations indicates no difference ($P < .05$) in body weights or average daily gains during the feeding period (Table 1.5.4). There was some indication, however, of increased feed efficiency in favor of the high concentrate ration (5.1 vs. 7.6).

Carcasses from animals fed on the high concentrate ration were in better condition (more fat) than those from the other two rations, as evidenced by significantly ($P < .05$) higher dressing percentage, thicker backfat and heavier kidney fat and kidney fat plus kidneys. These differences suggest a decrease in quality of carcass in the high concentrate group (Table 1.5.5).

The limited numbers of animals generated in the FxK and SxFK genotypes combined with the differences in age of dams producing lambs made it difficult reliably to estimate the usefulness of the American Suffolk as a sire breed for terminal crossing. Growth rate, body weight and carcass traits indicate little difference in response to a high concentrate ration vs. two rations with 50% or more alfalfa. There was some indication, however, that feed efficiency was greater in the high concentrate ration-fed lambs and that their carcasses contained more fat, including internal fat.

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1.6 A NOTE ON BLOOD LUTENIZING HORMONE (LH) CONCENTRATIONS IN PRE-PUBERTAL FINNxmUTTON MERINO EWE LAMBS IN RESPONSE TO GONADOTROPHIN-RELEASING HORMONE (GnRH) INJECTION, AS A POSSIBLE INDICATOR OF REPRODUCTIVE POTENTIAL

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Following the formation of Finn crosses, which increased prolificacy of less prolific sheep populations, further progress is relatively slow. This is due to (a) low heritability of the trait; (b) the trait being limited in its phenotypic expression to the female; (c) relatively slow reproductive rate; and (d) the trait being measurable only at the age of 2-3 years.

It has been shown that plasma LH concentrations in prepubertal lambs of prolific breeds of sheep in response to the injection of GnRH were significantly higher than in non-prolific breeds. No comparisons within prolific or non-prolific populations were made, or in crosses between the two. Furthermore, repeatability (t) of the LH response to GnRH was statistically significant and on the order of 0.6. However, this is not sufficiently high to be used as an efficient selection tool.

It has been postulated by us that reducing environmental variability could improve the repeatability.

In May 1981, 6 FinnxMutton Merino ewe-lambs were separated from their dams, 24 hours post-partum. They were accommodated in individual pens and artificially reared on a milk replacer. The daily ration was calculated individually on the basis of an equal percentage of body weight to all lambs. Lambs were weaned at 42 days of age onto hay and concentrates adjusted to result in an average daily weight gain of 250 g to the age of 150 days, and of 150 g thereafter.

The LH response to GnRH was measured at the age of 70, 80 and 92 days and the repeatability between these three ages within lambs was 0.86, i.e., much higher than any previously reported results. The coefficient of concordance was 1.0, i.e., the ranking of the lambs according to plasma LH concentration was the same for all three ages. These results were considered promising and it was decided to extend the work to cover more lambs and seasons.

This formed the basis for the application for the BARD F-27-I feasibility study (Eyal et al., 1982). Detailed results also of the present preliminary study are included in a more comprehensive report which is being prepared along with this report.

APPENDIX TO PART 1.

Table A1.1.1 REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO (FM) PRIMIPAROUS EWES ACCORDING TO BIRTH DATE (H = HORMONE TREATMENT; O = NO TREATMENT; s = LAMBING SEASON)

Born date	Treat ment	Mated				Lambed				Dry abort.		LB		
		Date	Age (d)			S	Date	Age (d)			n	%	n	LB/ EL
			n	$\bar{X}$	s.d.			n	$\bar{X}$	s.d.				
XII.78-I.79	H	XII.79	9	352.6	16.3	1	V.80	8	499.6	13.3	1	11	16	2.0
						2	X.80	1	638		0		3	3.0
						Total/Mean		9	515.0	47.8	0		19	2.1
V-VI.79	H	XII.79- I.80	18	221.5	19.6	1	V-VI.80	7	381.1	17.2	11	61	10	1.4
						2	X.80-II.81	8	549.4	40.6	3	27	12	1.5
						3	V.81	1	722.0		0		2	2.0
						Total/Mean		16	486.6	109.0	0		24	1.5
X-XI.79	H	VI.80	15	234.8	3.8	1	XI.80-I.81	3	430.3	52.3	12	80	7	2.3
						2	V-VI.81	5	572.4	14.2	3	60	6	1.2
						3	I.82	1	813.0		0		2	2.0
						Total/Mean		9	551.8	122.9	0		15	1.7
I-II.80	H	IX.80	8	221.9	11.2	1	II.81	0	-	-	8	100	-	-
						2	V-VI.81	6	476.3	12.2	2	25	10	1.7
						3	I.82	1	697		0		2	2.0
						Total/Mean		7	507.9	84.1	0		12	1.7
III-V.80	O	XII.80- I.81	12	243.6	24.4	1	V-VI.81	7	406.0	45.4	5	42	10	1.4
						2	II.82	5	645.4	19.5	0		8	1.6
						Total/Mean		12	505.8	128.0	0		18	1.5
X-XI.80	H	VI.81	10	227.6	10.1	1	X.81-II.82	7	412.6	61.6	3	30	10	1.4
XII.80-II.81	H	IX.81	27	236.3	14.0	1	I-II.82	13	414.6	18.3	14	52	21	1.6
						2	V.82	8	480.8	43.4	5	38	9	1.1
						Total/Mean		21	439.9	44.1	0		30	1.4
V-VI.81	O	XII.81	11	204.4	8.5	1	V+VIII.82	8	392.6	31.7	3	27	12	1.5
						2	XI.82+II.83	2	588.6		1	33	5	2.5
						3	V.83	1	724.0		0		1	1.0
						Total/Mean		11	458.4	128.0	0		18	1.6
IX.81	H	XI-XII. 82	4	385.4	46.5	1	II.83	0	-	-	4	100	-	-
						2	IV-VI.83	4	596.8	2.2	0		8	2.0
I-II.82	O	XII.82	3	308.0	11.4	1	V.83	3	457.7	19.4	0		5	1.7
V.82	O	XII.82	4	206.8	17.5	1	V.83	4	354.3	15.3	0		6	1.5

Table A1.1.2 REPRODUCTIVE PERFORMANCE OF FINN-AWASSI (FA) AND 3/4FINN1/4AWASSI (3/4FA)
PRIMIPAROUS EWES ACCORDING TO BIRTH DATE (H = HORMONE TREATMENT;
0 = NO TREATMENT; s = LAMBING SEASON)

Finn - Awassi															
Born date	Treat-ment	Mated					Lambled					Dry abort.		L	LB/EL
		Date	Age (d)			S	Date	Age (d)			n	%			
			n	$\bar{X}$	s.d.			n	$\bar{X}$	s.d.					
X-XI.78	H	VIII.79	23	299.7	5.1	1	I-II.80	16	441.9	40.0	8	33	24	1.50	
						2	V.80	6	556.5	13.1	2	25	6	1.00	
						3	X-XI.80	2	735.5	16.3	0		3	1.50	
						Total/Mean		24	495.0	95.3	0		33	1.38	
X-XI.80	H	VI.81	20	228.3	5.1	1	XI.81	14	386.2	32.9	6	30	22	1.57	
						2	V.82	5	563.2	7.7	0		10	2.00	
						Total/Mean		19	411.7	161.2	0		32	1.08	
I-II.81	H	IX.82	17	233.1	10.8	1	II-III.82	8	386.9	7.5	9	53	16	2.00	
						2	IV-VI.82	7	470.7	20.3	2	29	11	1.57	
						3	XI.82-I.83	2	694.0		0		5	2.50	
						Total/Mean		17	457.5	99.7	0		32	1.88	
X-XI.81	H	IX.82	4	314.3	4.5	1	I-II.83	3	455.0	1.7	1	33	9	3.00	
						2	IX.83	1	692.0				2	2.00	
						Total/Mean		4	514.3	119.0	0		11	2.75	
	0	XI.82	3	391.0	3.6	1	IV-V.83	3	537.7	3.1	0		4	1.33	
XII.81-II.82	0	IX-XI.82	18	250.2	30.6	1	II.83	6	406.2	33.4	12	67	9	1.50	
						2	IV-V.83	12	452.4	23.6	0		29	2.42	
						Total/Mean		18	437.0	34.5	0		38	2.11	
	0	XII.82	6	296.6	6.3	1	IV-VI.83	6	445.0	9.8	0		7	1.16	
3/4Finn1/4Awassi															
I-II.80	H	IX.80	12	222.3	10.1	1	II.81	1	372.0		11	92	1	1.00	
						2	V-VI.81	11	471.1	9.0	0		16	1.45	
						Total/Mean		12	462.8	29.3	0		17	1.42	
V.80	H	XII.80	3	229.7	4.5	1	V.81	3	386.0	9.5	0		4	1.33	
X.80	H	VI.81	6	230.3	2.8	1	X-XI.81	2	368.0		4	67	2	1.00	
						2	V.82	2	555.5		2	50	3	1.50	
						Total/Mean		4	461.8	108.0	0		5	1.25	
V-VI.81	0	XII.81	8	201.1	10.5	1	IV-V.81	7	342.6	13.1	1	13	11	1.57	
						2	XI.82	1	526.0		0		1	1.00	
						Total/Mean		8	365.5	66.0	0		12	1.50	

Table A.1.3a REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO F₁ EWES (FMF₁) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1975/76-1979; CONTINUATION IN TABLE A1.1.3b)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig.	Lamb	1	2	3	4-5	LB	MuB
		(number)			lambs					
1975/76	2	13	8	5	2	2		1	11	3
	3	7	5	5	1	2	2		11	4
	4	7	4	4		3	1		9	4
	5	3	3	3		2		1	8	3
1976	2	13	8	7	1	5	1		14	6
	3	7	7	6	1	3	2		13	5
	4	7	6	3		2	1		7	3
	5	3	2	1		1			2	1
1976/77	1	4	1	1	1				1	0
	3	13	13	13	2	7	4		28	11
	4	7	7	5	1	2	2		11	4
	5	7	6	6		2	2	2	18	6
	6	3	3	3	1	1	1		6	2
1977	1	4	3	3	2	1			4	1
	3	13	3	1		1			2	1
	4	7	3	3	1	2			5	2
	5	7	4	3		1	2		8	3
	6	3	0						0	0
1977/78	2	9	7	7	4	3			10	3
	4	13	13	10	2	5	2	1	22	8
	5	7	6	6	1	4	1		12	5
	6	7	5	5		2	2	1	14	5
	7	3	3	3		1	2		8	3
1978	2	9	2	2		2			4	2
	4	13	6	2		1	1		5	2
	5	7	3	3		2	1		7	3
	6	7	2	1		1			2	1
	7	3	2	0					0	0
1978/79	3	9	9	9	4	4	1		15	5
	5	13	13	11	3	4	4		23	8
	6	7	7	6	2	4			10	4
	7	7	7	7	2	2	2	1	16	5
	8	3	3	1		1			2	1
1979	3	9	4	4		3		1	10	4
	5	13	7	6	1	5			11	5
	6	7	2	1		1			2	1
	7	7	5	5	2	3			8	3
	8	3	3	3	1	1	1		6	2

Table A1.1.3b REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO F₁ EWES (FMF₁) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1979/80-1982; PRECEDING YEARS IN TABLE A1.1.3a)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig. (number)	Lamb	1	2	3	4-5	LB	MuB
1979/80	4	7	7	6	2	4			10	4
	6	13	13	9	3	6			15	6
	7	5	5	4		1	3		11	4
	8	6	5	4		4			8	4
	9	2	2	1	1				1	0
1980	4	6	3	2	1	1			3	1
	6	8	3	3	1	2			5	2
	7	4	2	1		1			2	1
	8	5	3	2		2			4	2
	9	0							0	0
1980/81	5	6	6	6	2	4			10	4
	7	6	6	5	2	2		1	11	3
	8	3	3	2	1	1			3	1
	9	4	4	2	1	1			3	1
1981	5	5	3	3	1	1	1		6	2
	7	5	5	2	1		1		4	1
	8	3	2	1	1				1	0
	9	2	2	0					0	0
1981/82	2½	2	2	2	1		1		4	1
	6	2	2	2		1	1		5	2
1982	2½	2	2	2	1		1		4	1
	6	2	2	1	1				1	0

Table A1.1.4a REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO F₂ AND F₃ EWES (FMF₂₊) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1975/76-1980; CONTINUATION IN TABLE A1.1.4b)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig. (number)	Lamb	1	2	3	4-5 lambs	LB.	MuB
1975/76	2	6	4	4	1	3			7	3
	3	1	1	1			1		3	1
1976	2	6	4	3	2	1			4	1
	3	1	1	1	1				1	0
1976/77	3	6	5	5	1	2	2		11	4
	4	1	1	1		1			2	1
1977	3	6	2	1		1			2	1
	4	1	1	1	1				1	0
1977/78	2	2	2	2	1	1			3	1
	4	6	6	6	2	3		1	12	4
	5	1	1	1			1		3	1
1978	2	2	0							
	4	6	1	0						
	5	1	1	0						
1978/79	3	2	2	2		1	1		5	2
	5	6	6	5	1	3	1		10	4
	6	1	1	1		1			2	1
1979	3	2	2	0						
	5	6	4	4		4			8	4
	6	1	0							
1979/80	4	4	4	4		2	2		10	4
	6	6	6	6	1	4	1		12	5
	7	1	1	0						
1980	4	4	3	3	2	1			4	1
	6	6	3	2		2			4	2
	7	1	1	1	1				1	0

Table A1.1.4b REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO F₂ AND F₃ EWES (FMF₂+) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1980/81-1983; PRECEDING YEARS IN TABLE A1.1.4a)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig. (number)	Lamb	1	2	3	4-5 lambs	LB	MuB
1980/81	1	17	17	13	7	6			19	6
	1½	7	7	5		4	1		11	5
	4	7	7	5		5			10	5
	5	8	8	6	4	2			8	2
	7	4	4	3		3			6	3
	8	1	1	1			1		3	1
1981	1	17	12	8	4	3	1		13	4
	1½	7	6	3	2		1		5	1
	4	7	5	3	2	1			4	1
	5	7	2	1	1				1	0
	7	3	2	1			1		3	1
	8	1	1	1		1			2	1
1981/82	1	3	1	1		1			2	1
	1½	24	24	21	10	9	1	1	35	11
	2	17	14	11	4	5	1	1	21	7
	5	5	4	4	2	2			6	2
	6	2	2	2	2				2	0
	9	1	0							
1982	1	3	3	1			1		3	1
	1½	24	17	12	4	6	1	1	23	8
	2	17	11	6	1	3	1	1	14	5
	5	5	2	2	1	1			3	1
	6	2	2	2		2			4	2
	9	1	1	1		1			2	1
1982/83	1	12	10	5	2	1	1	1	11	3
	1½	31	26	16	8	3	5		29	8
	2	3	2	2	2				2	0
	2½	24	22	15	4	9	2		28	11
	3	13	9	7		6	1		15	7
1983	1	12	11	11	7	3	1		16	4
	1½	25	21	18	5	11	2		33	13
	2	2	2	2		2			4	2
	2½	23	23	17	4	12	1		31	13
	3	13	13	12	2	5	4	1	28	10

Table A1.1.5a REPRODUCTIVE PERFORMANCE OF FINN-AWASSI AND FINN-ROMANOV F₁ EWES (FAF₁) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1977/80-1980; CONTINUATION IN TABLE A1.1.5b)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig.	Lamb	1	2	3	4-5	LB	MuB
		(number)			lambs					
1977/78	1 3/4									
	2	27	27	26	7	18	1		46	19
	3	14	14	12	2	10			22	10
	4	25	25	22	6	14	2		40	16
	5	3	3	3	2	1			4	1
		2	2	2	1			1	5	1
1978	1 3/4	9	9	6	2	4			10	4
	2	27	27	22	5	10	7		46	17
	3	14	14	8	2	5	1		15	6
	4	22	22	10	2	4	3	1	23	8
	5	2	2	1		1			2	1
1978/79	1	8	4	4	1	3			7	3
	2	4	4	4		1	2		8	3
	3	27	27	27	8	11	7		51	18
	4	14	14	14	4	8	2		26	10
	5	21	21	18	4	10	3	1	37	14
	6	2	2	1	1				1	0
1979	1	8	4	4	2	2			6	2
	2	3	3	2		2			4	2
	3	27	22	20	3	15	2		39	17
	4	13	7	6	3	2	1		10	3
	5	21	12	10	4	5	1		17	6
	6	2	1	1		1			2	1
1979/80	2	9	9	7	4	3			10	3
	3	3	3	2	1	1			3	1
	4	25	25	24	9	14	1		40	15
	5	12	12	12	3	8		1	23	9
	6	18	15	11	6	2	2	1	22	5
	7	2	2	2	1	1			3	1
1980 ¹	2	7	3							
	3	3	1							
	4	20	0							
	5	11	1							
	6	12	1							
	7	1	0							

¹Not mated; used in other experiments

Table A1.1.5b REPRODUCTIVE PERFORMANCE OF FINN-AWASSI AND FINN-ROMANOV F₁ EWES (FAF₁) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1980/81-1983; PRECEDING YEARS IN TABLE A1.1.5a)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig. (number)	Lamb.	1	2	3	4-5 lambs	LB	MuB
1980/81	2	8	8	7	4	2	1		11	3
	3	4	4	4	1	2	1		8	3
	4	2	2	1		1			2	1
	5	10	10	9	1	8			17	8
	6	10	10	6	3	2	1		10	3
	7	9	9	6	2	4			10	4
	8	1	1	0						
1981 ¹	3	4	1							
	4	1	0							
	5	10	5							
	6	7	3							
	7	8	5							
1980/81 ²	3	3	3	3	1	2			5	2
	4	1	1	1	1				1	0
	5	10	10	9	2	3	2	2	22	7
1981 ²	3	3	2	1	1				1	0
	4	1	1	0					0	0
	5	9	7	5	1	3	1		10	4
1981/82	4	3	2	2	1	1			3	1
	6	12	10	9		5	4		22	9
1982	4	3	2	2		2			4	2
	6	12	9	6		6			12	6
1982/83	5	2	1	1	1				1	0
	7	5	4	4	1	2	1		8	3
1983	5	2	2	2		1	1		5	2
	7	4	4	3		2	1		7	3

¹Not mated; used in other experiments

²Only RomanovxAwassi F₁

Table A1.1.6 REPRODUCTIVE PERFORMANCE OF FINN-AWASSI AND ROMANOV-AWASSI F₂ AND F₃ EWES (FAF₂₊) ACCORDING TO LAMBING SEASON AND AGE (ACCELERATED LAMBING PROGRAM AT BET DAGAN, 1977/78-1982)

Lambing season	Age (yrs)	Ewes			Type of birth				Total number	
		Pres.	Elig. (number)	Lamb.	1	2	3	4-5 lambs	LB	MuB
1977/78	1	7	7	7	5	2			9	2
	2	20	20	20	8	11	1		33	12
	3	2	2	1		1			2	1
1978	1	7	7	4		4			8	4
	2	18	18	12	4	6	2		22	8
	3	1	1	0					0	0
1978/79	2	7	7	7	2	3	2		14	5
	3	18	18	18	7	9	2		31	11
	4	1	1	1			1		3	1
1979	2	7	4	3	3				3	0
	3	17	11	9	5	4			13	4
	4	1	0	0					0	0
1979/80	1	8	8	3		2	1		7	3
	3	7	7	6	3	1	1	1	12	3
	4	17	17	15	6	8	1		25	9
	5	1	1	1		1			2	1
1980	1	8	5	5	4	1			6	1
	3	6	1	1	1				1	0
	4	14	1	1		1			2	1
	5	1	1	0					0	0
1980/81	2	18	18	16	8	5	3		27	8
	4	6	6	6	3	3			9	3
	5	15	15	14	5	8	1		24	9
1981	2	18	13	10	5	5			15	5
	4	5	3	1	1				1	0
	5	14	8	5	1	4			9	4
1981/82	3	15	10	9	3	4	1	1	18	7
	5	2	2	2		2			4	2
	6	4	3	3	2	1			4	1
1982	3	15	13	10	4	6			16	6
	5	2	1	1		1			2	1
	6	4	3	3	2		1		5	1

Table A .1.7 SUMMARY OF REPRODUCTIVE PERFORMANCE OF FINN-MUTTON MERINO F₁ EWES (FMF₁) ACCORDING TO AGE (POOLED DATE 1975/76 - 1981/82; ACCELERATED LAMBING PROGRAM AT BET DAGAN; SEE ALSO TABLES 1.1.5 AND A1.1.3a AND A.1.1.3b)

Age (years)		1	2	3	4	5	6	7-9	$\bar{x} \pm s.d.$ ¹
Ewes	no.	4	24	29	33.5	35.5	29.5	35.5	187
EEL/EP/Y	no.	1.00	1.21	1.41	1.46	1.49	1.32	1.75	1.44±0.18
EL/EEL	no.	1.00	0.86	0.93	0.71	0.91	0.74	0.69	0.81±0.11
LB/EEL	no.	1.25	1.62	1.93	1.47	1.98	1.54	1.42	1.66±0.24
LB/EL	no.	1.25	1.88	2.08	2.06	2.19	2.06	2.05	2.05±0.10
MuB/EL	%	25	64	76	80	83	79	65	74.5±8.10
Lambings/ EP/Y	no.	1.00	1.11	1.33	1.05	1.39	1.02	1.24	1.19±0.15
LB/EP/Y	no.	1.25	1.95	2.72	2.14	2.96	2.03	2.48	2.38±0.41

¹Yearlings excluded

Table A1.1.8 SUMMARY OF THE REPRODUCTIVE PERFORMANCE OF FINN-MUTTON
MERINO F₂ AND F₃ EWES (F₂+) ACCORDING TO AGE (POOLED DATA
1975/76 - 1979/80; ACCELERATED LAMBING PROGRAM AT BET
DAGAN; SEE ALSO TABLES 1.1.6 AND A1.1.4a AND A1.1.4b)

Age (years)		1	1½	2	2½	3	4	5	6-9	$\bar{X} \pm \text{s.d.}$
Ewes	no.	32	59	27.5	23.5	22	18	19.5	15.5	217
EEL/EP/Y	no.	1.69	1.71	1.42	1.91	1.59	1.56	1.44	1.61	1.62±.16
EL/EEL	no.	0.72	0.74	0.77	0.71	0.83	0.82	0.82	0.84	0.78±.05
LB/EEL	no.	1.19	1.35	1.77	1.31	1.89	1.54	1.39	1.64	1.51±.24
LB/EL	no.	1.64	1.81	2.30	1.84	2.24	1.87	1.70	1.95	1.92±.24
MuB/EL	%	46	61	77	75	86	57	50	81	67±15.1
Lambings/ EP/Y	no.	1.22	1.27	1.09	1.36	1.32	1.28	1.18	1.36	1.26±.09
LB/EP/Y	no.	2.00	1.81	2.51	2.51	2.96	2.39	2.00	2.65	2.35±.38

Table A1.1.9 SUMMARY OF THE REPRODUCTIVE PERFORMANCE OF FINN-AWASSI F₁ EWES (FAF₁) ACCORDING TO AGE (POOLED DATA 1977/78 - 1978/79 AND 1980/81 - 1982/83; ACCELERATED LAMBING PROGRAM AT BET DAGAN; SEE ALSO TABLES 1.1.7 AND A1.1.5a AND A1.1.5b)

Age (years)		1	2	3	4	5	6-7	$\bar{x} \pm s.d.$ ¹
Ewes	no.	8	38.5	44	41	35	18.5	177
EEL/EP/Y	no.	1.0	1.79	1.86	1.81	1.66	1.62	1.75 $\pm$.10
EL/EEL	no.	1.0	0.90	0.83	0.77	0.85	0.80	0.83 $\pm$.05
LB/EEL	no.	1.63	1.70	1.62	1.45	1.69	1.73	1.63 $\pm$.11
LB/EL	no.	1.63	1.89	1.87	1.88	2.00	2.17	1.96 $\pm$.13
MuB/EL	%	63	74	75	70	71	92	76 $\pm$ 9
Lambings/ EP/Y	no.	1.0	1.61	1.61	1.39	1.40	1.30	1.46 $\pm$.14
LB/EP/Y	no.	1.63	3.04	3.02	2.61	2.80	2.81	2.86 $\pm$.18

¹Yearlings excluded

Table A1.1.10 SUMMARY OF THE REPRODUCTIVE PERFORMANCE OF FINN-AWASSI F AND F EWES (FAF) ACCORDING TO AGE (POOLED DATA 1977/78 - 1981/82; ACCELERATED LAMBING PROGRAM AT BET DAGAN; SEE ALSO TABLES 1.1.8 AND A1.1.6)

Age (years)		1	2	3	4	5-6	$\bar{x} \pm s.d.$
Ewes	no.	15	37	40.5	22	21.5	136
EEL/EP	no.	1.80	1.87	1.56	1.27	1.58	$1.62 \pm .24$
EL/EEL	no.	0.70	0.84	0.86	0.86	0.85	$0.82 \pm .07$
LB/EEL	no.	1.11	1.41	1.48	1.43	1.47	$1.38 \pm .15$
LB/EL	no.	1.58	1.67	1.72	1.67	1.72	$1.67 \pm .06$
MuB/EL	%	53	57	59	58	66	58.6 ± 4.7
Lambings/ EP/Y	no.	1.27	1.57	1.33	1.09	1.35	$1.32 \pm .17$
LB/EP/Y	no.	2.00	2.62	2.30	1.82	2.33	$2.21 \pm .31$

PART 2. THE DEVELOPMENT OF COMPLETE RATIONS FOR PROLIFIC SHEEP BASED ON RECYCLED BY-PRODUCTS AND WASTES

2.1 THE INTAKE OF RATIONS, BASED ON ANIMAL AND CROP BY-PRODUCTS, BY FINN-MUTTON MERINO AND FINN-AWASSI EWES AT DIFFERENT REPRODUCTIVE STAGES

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ABSTRACT

A series of experiments were conducted with the aim of beginning the formation of a database required to plan appetite-regulated complete rations for maintenance, pregnancy and lactation of Finn cross (prolific) ewes. Crop by-products and animal wastes were used in combination with grain (corn =maize), concentrate mixtures, and alfalfa and vetch-oat hays.

The materials used were: wheat straw (WS), cotton by-products, i.e., lint (LT) and gin trash (GT), poultry litter (PL) and cattle manure (CM).

Adult ewes of the Finn x Mutton Merino (FM) and Finn x Awassi (FA) F₁-F₅ generations were used. Mean body weights ranged between 60 and 70 kg.

Seven short-term intake experiments were carried out with dry ewes or with ewes in early pregnancy (more than 8 weeks prepartum), and five performance experiments were done comparing different rations in the last 7 weeks of pregnancy and during 7 weeks of lactation. The intake results from those experiments are reported here.

In each of the rations used, there was one or more rationed components and one component that was offered ad lib.

When WS was offered with a concentrate mixture or with PL + Corn, there were no differences in energy intake between the two rations. This was so in all reproductive stages, in spite of the fact that the PL-corn ration had a considerably lower ME concentration of 8.97, 9.24 and 9.73 kg/g (at 7-5, 4-1, weeks prepartum and 1-7 weeks postpartum, respectively), as against 10.15, 10.98 and 10.90 for the WS-concentrate rations.

Cotton lint was found to be a relatively high-quality feed (13% protein, 8.5% fat, 8.45 kJ of metabolizable energy (ME)/g). This type of feed was studied only with dry sheep and early in pregnancy. Sheep consumed up to 1.6 kg DM of this material when fed alone and up to 1.9 kg daily when fed with PL (73-80 g/W^{0.75}, 618-650 kJ/W^{0.75} per day), which is much above their requirement. GT with PL formed a ration adequate for maintenance of ewes and with rations including 20-30% corn grain pregnancy requirements were met. During lactation, rations including 30-36% corn together with GT and PL were consumed at a rate nearly meeting the NRC or ARC allowances. GT intakes ranged between 600 and 1,200 g/ewe/day during pregnancy and between 900 and 1,400 g during lactation. Feeding GT involves the problem of a large proportion of orts composed of soil and plant parts other than the cotton wool.

With CM a long period (2 weeks) was required until the ewes reached maximal intake. A minimal quantity of grain (50 g/kg) had to be mixed with the CM to induce the ewes to eat this material in significant quantities. About 20% corn was required to achieve a maintenance ration. CM with WS and PL was consumed in quantities slightly short of the maintenance requirement. Alfalfa hay (AH) as sole feed was nearly adequate in supplying the ARC requirements for pregnancy, but the addition of concentrates was needed to supply lactation requirements. The addition of concentrates at rates of 700 to 1,500 g/ewe/day caused a reduction in dry matter (DM) of AH intakes from 50-60, 60-80 and 80-107 g/W^{0.75}/day at 7-5 and 4-1 weeks prepartum and 1-7 weeks postpartum, respectively, to 28-34, 20-25 and 35 g/W^{0.75}/day.

There were no significant differences between FA and FM ewes in intake or digestibility of the different rations.

The correlations (*r*) of DM intakes of g/W^{0.75} on ME concentration were 0.652, 0.594, 0.428 and -0.431 for dry ewes, for ewes 7-5 and 4-1 weeks prelambling, and weeks 1-7 of lactation, respectively, and the correlations of ME intake kJ/W^{0.75} were 0.893, 0.874, 0.904 and 0.366, respectively.

With rations having a ME concentration of more than 9 kJ/g at high energy demands (late pregnancy and lactation), there was a tendency for DM intake to diminish with increasing ME concentration and for ME intake to remain constant.

INTRODUCTION

High levels of production dictate the use of high quality, expensive feeds. However, prolific (high producing) sheep, like other ruminants, have the capacity to utilize as feed, products such as straws (high in fiber) or animal wastes (low energy, high nitrogen, partly non-protein, and rich in minerals). Such products may be incorporated into their rations at least during periods of low energy expenditure, when they are dry (maintenance) or early in pregnancy. In other situations, the feasibility of the incorporation of such feeds in the ration will depend on how much the animals will be willing to eat. Thus, the actual rates of inclusion of low quality feeds in the ration will vary with the intensity of production, the feed quality, and dry matter intake.

The efficiency of feed utilization, and of the feeding process and its convenience, could be considerably improved by the development of appetite-regulated complete rations (e.g., Owen, 1976) adjusted to the changing requirements of the animals according to changing physiological state.

To enable the formulation of such rations, more knowledge is needed about the voluntary intake of materials supplied, either as the sole feed or in combinations. It has been shown that intake by ruminants is largely controlled by the fiber contents (digestibility) of the diet (i.e., Blaxter et al., 1961; Golding et al., 1976). With our present knowledge there seems, however, to be no way to predict the exact intake of a mixture of feeds other than by feeding it to the animals in question. The general rule, that intake increases with increasing energy concentration, holds true probably when digestible energy concentration is less than about 2.5 MCal (10.5 MJ) per kg dry matter (Clancy et al., 1976; Dinius and Baumgardt, 1970). The inclusion of unconventional feeds, such as animal excreta, garbage, agricultural or industrial by-products, imposes further complications as these materials vary in their composition (Bhattacharia and Taylor, 1975; Kali et al., 1975; Tagari, 1978), and their energy concentration is determined not only by the digestibility of the organic matter but also by the mineral (ash) concentration.

MATERIALS AND METHODS

Sheep

All the experiments were done with mature sheep of the Bet Dagan experimental flock, which is composed of similar numbers of Finn x Merino (FM) and Finn x Awassi (FA) crossbred ewes (F_1 - F_5). Some of the ewes were Romanov crosses but, since it was found earlier (Goot et al., 1979) that there were no differences in performance between Finn and Romanov crosses, they were not handled separately in these experiments. Some consideration was, however, given to possible differences in feeding behavior between the Merino (German Mutton Merino) and Awassi cross genotypes. All experimental groups were balanced for age, reproductive state, body weight, and condition scores (Jeffries, 1966). Average body weights ranged between 60

and 70 kg but variation within groups was rather large, with standard deviations ranging between ± 4 and ± 12 . This is probably a result of the fact that selection for uniformity within the newly formed genotypes was not done before the beginning of these experiments.

Feeds

The feeds used in the experiments are listed in Table 2.1.1, which also shows their chemical composition and estimated metabolizable energy (ME) concentration. Which feed, or batch of feed was used in each experiment is also indicated in Table 2.1.1. A brief description is given here of the different feeds used, and their preparation.

Wheat straw (WS). Two batches of wheat straw were used, one in experiments 1, 2 and 3, and the other in exps. 10 and 11 (Table 2.1.2). Differences between samples were very small. Save for exp. 1, in which the straw was chopped into 5-10 cm particles, it was fed in long form.

Hay. All hay was fed in long form. In exps. 2 and 3 (Table 2.1.1), small amounts of vetch oat hay were used in late pregnancy, replacing most of the straw. The alfalfa hay was sun-cured mid-bloom; batch 1 was cut in early summer, and batch 2 was the last autumn harvest (November).

Poultry litter (PL). Three batches of broiler litter and one of turkey litter on sawdust bedding were used in the course of the experiments. All batches were purchased from commercial farms and contained ~20-25% moisture when obtained. The litter was spread on concrete floors to be sun-cured immediately upon arrival, in a 10-15-cm deep layer. Every other day, the material was thoroughly turned up for uniform drying and samples were taken for dry matter (DM) assessment until a level of at least 85% DM was reached. Samples were also sent for bacteriological examination to reduce pathological risks. High counts were not found for any pathogenic factor. No further treatment was given and repeated chemical analyses over several months showed that PL preserved in this form did not show any apparent changes in its composition. The rate of inclusion of PL in a ration was calculated not to exceed estimated protein requirements of the ewes at any reproductive stage. However, this still leaves a considerable excess over minimum recommended requirements of Ca and other minerals.

Cotton wastes (CW). One batch of cotton linters (LS) and one of gin trash (GT) were used. No special treatment was given to these materials before they were fed to the sheep. The GT is a mixture of cotton wool fibers, particles of other parts of the cotton plant, and much dust and earth. It was found previously that when fed in dry form, a large proportion of the offered material (all of the non-cotton wool fraction) was left in the trough as refusals (orts). Therefore, in order to obtain a good estimate of ad lib. intake by sheep, quantities offered were always about double (dry weight) of those expected to be consumed by the sheep in question.

Table 2.1.1 CHEMICAL COMPOSITION (PROXIMATE ANALYSIS) OF FEEDS USED IN INTAKE AND PERFORMANCE TRIALS (MEANS±S.D.)

Feed ^a and batch no.	Exp. no.	% DM	% of DM				g/kg				mg/kg		ME MJ/kg
			Nx6.25	Fiber	Fat	Ash	Ca	P			Ca	Cu	
WS (3)	(1,2,3,10,11)	92.0±1.18	4.2±0.67	40.2±1.91	2.0±0.47	9.6±2.06	-	-	-	-	-	-	6.30
Hay													
Vetch+oats (1)	(2,3)	89.8	15.9	30.2	2.2	10.9	-	-	-	-	-	-	8.37
Alfalfa 1 (1)	(10,11)	90.0	13.8	28.7	2.4	14.4	-	-	-	-	-	-	8.41
Alfalfa 2 (1)	(12)	88.2	18.1	30.8	2.5	10.5	-	-	-	-	-	-	8.12
PL													
Broilers 1 (3)	(2,3,6,9)	90.4±0.79	30.4±0.42	12.3±1.65	1.7±0.15	19.2±3.98	27.6±2.69	18.8±2.07	47±1.5	6.50			
Broilers 2 (2)	(10,11)	90.4±0.64	27.1±0.64	11.6±0.78	1.5±0.07	22.5±0.57	-	-	-	6.15			
Broilers 3 (3)	(12)	86.0±1.73	23.8±0.40	16.2±0.85	2.1±0.35	18.2±0.76	-	-	-	6.40			
Turkeys (3)	(1,4,5,7,8)	87.2±0.55	28.0±0.17	11.7±0.42	1.9±0.12	16.1±0.38	26.4±1.97	19.9±0.78	15±1	6.65			
CW													
Lint (1)	(4,5)	93.1	13.2	39.4	8.5	4.5	2.1	3.2	10	8.45			
Gin trash (4)	(6,10,11,12)	91.6±0.55	11.2±0.82	25.7±3.69	3.9±0.88	17.3±1.17	-	-	-	6.89			
CM (5)	(7,8,9)	85.7±1.70	16.8±1.29	22.1±1.45	1.0±0.22	24.7±0.35	30.7±3.30 (2)	11.6±0.33 (2)	25 (1)	3.35			
Corn grain (3)	(all)	86.6±0.76	10.0±0.81	1.8±1.01	3.2±1.34	1.33±0.17	0.2 (1)	3.5 (1)	-	13.80			
Concentrate mix (3)	(2,3,10,11,12)	88.4±1.21	18.2±0.46	3.6±0.26	2.9±0.44	8.2 ±0.67	13.0 (1)	3.3 (1)	-	12.10			

^a WS=Wheat straw; PL=Poultry litter; CW=Cotton waste; CM=Cattle manure.

^b Figures in parenthesis refer to number of samples tested.

Cattle manure (CM). The manure was collected from lactating dairy cows held in concrete-covered yards, and sun-dried until it contained about 85% DM. It was found in earlier work with Awassi ewes (Benjamin et al., 1982) that only fine particles of cattle manure were eaten by the animals, while even small lumps were refused. Therefore, the manure was ground into small particles before being fed to the sheep. It was also known that the inclusion of some ground grain in the manure was required to induce the sheep to eat cattle manure or to maintain intake at any rate that had been arrived at over an extended period of time. Therefore, corn was included in all test rations with this material.

Corn (maize) was supplied by a commercial mill (imported from the USA). It was offered as whole grain in exps. 2 and 7 (Tables 2.1.2 and 2.1.4) and in ground form in all other experiments in which it was included.

Concentrate mixtures. These were supplied as pellets by a commercial mill.

Estimation of nutritive value of feeds

The dry and organic matter digestibility of all rations containing PL, CW or CM was estimated by digestion experiments with at least four sheep per diet. All these trials were done upon termination of intake trials with the same feeds and animals. Thus, the adjustment periods could be relatively short.

Metabolizable energy (ME) values for WS, hay and corn were estimated by comparison with values listed for feeds of similar composition in the National Research Council tables (1975). For PL and CM the estimated digestible energy was multiplied by 0.76, based on results for PL found by Yehuda (1981) and that of the cotton by-products by 0.8.

Experiments

Altogether, 12 experiments were done, seven of them being short-term (21-41 days) intake trial with dry ewes or with ewes in early pregnancy. The others were performance experiments with ewes in late pregnancy and lactation. In some of the latter several rations were compared and they are described in other chapters in more detail. For the purpose of discussing intake phenomena some of the treatments (rations) in these experiments were regarded as separate experiments. In Tables 2.1.2-2.1.5, the experiments in which intake was measured are described and grouped according to the ad lib.-fed component. Those which were part of a larger experiment, in which other rations were compared, are referred to by the number of the performance experiment (exps. 10, 11 and 12, respectively in Tables 2.1.2, 2.1.3 and 2.1.5), of which they were part.

Management

Ewes were maintained in pens adjusted to group size in open sheds. In exp. 2 (Table 2.1.2) they were maintained on a dirt floor; in all other experiments they were kept on concrete floors which were either cleaned

Table 2.1.2 EXPERIMENTS WITH RATIONS BASED ON AD LIB. WHEAT STRAW (WS) AND RATIONED POULTRY LITTER (PL), AND CORN VS. COMMERCIAL CONCENTRATES

Experiment no.	Number of ewes		Reproductive state	Duration (days)	Rationed components and experimental objectives
	Finn Awassi	Finn Merino			
1	10	10	Early pregnancy	25	PL, genotype comparison
2	76		Late preg. and lactation	87	PL+Corn+Hay (37 ewes) vs. Conc.+Hay (39 ewes)
3	15		Late preg. and lactation	95	PL+Corn+Hay, individual (8 ewes) <u>vs.</u> group feeding (7 ewes) ^b
10 ^a	12		Late preg. and lactation	89	Concentrates, rationed or <u>ad lib.</u> - last 3 weeks of gestation
11 ^a	12		Late preg. and lactation	77	Concentrates, rationed (6 ewes) or <u>ad lib.</u> - last 5 wks of gestation (6 ewes)

^aExperiments 10 and 11 are part of ewe performance studies in which other rations were compared. Their numbers refer to the same experiment numbers as in Tables 2.1.3 and 2.1.5.

^bFor the individually fed ewes a breed comparison was done as well (four FA and four FM ewes).

Table 2.1.3 EXPERIMENTS WITH RATIONS BASED ON COTTON WASTES - LINT (LT) OR GIN TRASH (GT) - FED AD LIB., AND RATIONED POULTRY LITTER (PL) AND CORN

Experiment No.	Number of ewes		Reproductive stage	Duration (days)	Rationed components and experimental objectives
	Finn Awassi	Finn Merino			
4 (LT)	9	9	Early pregnancy	21	PL, genotype comparison
5 (LT)	8	10	Early pregnancy	36	PL <u>vs.</u> none, and genotype comparison
	8	8	Dry	36	None, and genotype comparison
6 (GT)	10	10	Early pregnancy	23	PL <u>vs.</u> none, and genotype comparison
	8	8	Dry	41	PL <u>vs.</u> none, and genotype comparison
10 ^a (GT)		12	Late preg. and lactation	89	PL (6 ewes) <u>vs.</u> PL and corn (6 ewes)
11 ^a (GT)		12	Late preg. and lactation	77	PL (6 ewes) <u>vs.</u> PL and corn (6 ewes)
12 ^a (GT)		26	Late preg. and lactation	87	PL (13 ewes) <u>vs.</u> PL and corn (13 ewes)

^aExperiments 10, 11 and 12 are part of ewe performance studies in which other rations were compared. Their numbers refer to the same experiment numbers as in Tables 2.1.2 and 2.1.5.

Table 2.1.4 EXPERIMENTS WITH RATIONS BASED ON CATTLE MANURE (CM) AND WHEAT STRAW (WS) FED AD LIB., AND RATIONED POULTRY LITTER (PL) AND CORN

Experiment no.	Number of ewes		Reproductive state	Duration (days)	Rationed components and experimental objectives
	Finn Awassi	Finn Merino			
7	15	-	Dry	35	Corn at three levels, assess maintenance ration.
8	9	9	Early pregnancy	21	Corn, genotype comparison
9	5	5	Dry	42	PL, corn, genotype comparison

Table 2.1.5 EXPERIMENTS WITH RATIONS BASED ON ALFALFA HAY FED AD LIB.,
WITH OR WITHOUT CONCENTRATES

Experiment no. ^a	Number of ewes	Reproductive state	Duration (days)	Concentrates
10	6	Late pregnancy and lactation	89	None
11	6	Late pregnancy and lactation	77	None
12	19	Late pregnancy and lactation	87	Rationed (6 ewes) <u>vs. ad lib.</u> (13 ewes)

^aThe numbers refer to the same experiment numbers as in Tables 2.1.2 and 2.1.3, in which other rations were compared as well.

daily (exps. 1,4, 5, 6, 7, 8 and 9) or maintained dry by bedding with sawdust or wood shavings (exps. 3, 10, 11 and 12). In exp. 3, eight out of 17 ewes were held in individual pens. Partitions between the pens were made of wire netting; thus, although separated, the ewes were actually not isolated from neighboring individuals.

Feeds were offered daily in the morning (8-10 a.m.) and residues (orts) were weighed before the new ration was fed on the next morning.

All ewes that were allotted to rations with PL or CW were injected with vitamin A + D before the start of feeding these rations. Ewes on PL were also vaccinated against botulism. Fresh water was available at all times.

RESULTS

WS with PL and corn vs. concentrate mixtures

The data in Tables 2.1.6 and 2.1.7 (and appendix A.2.1) show that voluntary intake of straw was negatively correlated with the amount of the concentrated component of the ration. The addition of the commercial concentrate mixture had a greater effect in this respect than that of PL and whole or ground corn, thereby increasing the differences between the two types of ration in the overall energy concentration. Furthermore, the difference in straw consumption was still apparent even when hay was added to the rations. There were no differences in energy intake per kg^{0.75} of body weight (W^{0.75}) between the two types of rations.

Table 2.1.6 DRY MATTER (DM) INTAKE OF FINN-CROSS EWES, DURING DIFFERENT STAGES OF PREGNANCY AND LACTATION, OF RATIONS BASED ON WHEAT STRAW (WS) GIVEN AD LIB. POULTRY LITTER (PL) AND GRAIN (CORN) VS. WS, AND COMMERCIAL CONCENTRATES (CONC.)

Weeks pre- or post-partum	Exp. no.	Composition of rations, %					Daily DM intake, (g)					Total
		WS	PL	Corn	Conc.	Hay	WS	PL	Corn	Conc.	Hay	
14-8 pre-p.	1	71.5	28.5	-	-	-	751	299	-	-	-	1,050
7-5 pre-p.	2	35.0	26.3	38.7	-	-	463	347	511	-	-	1,321
	3	51.2	20.3	28.5	-	-	761	301	423	-	-	1,485
	2	31.5	-	-	68.5	-	324	-	-	705	-	1,029
	4	41.1	-	-	58.9	-	572	-	-	733	-	1,245
	4	39.1	-	-	60.9	-	470	-	-	733	-	1,203
	5	32.5	-	-	87.5 ^a	-	390	-	-	810	-	1,200
	5	23.8	-	-	76.2 ^a	-	400	-	-	1280	-	1,680
4-1 pre-p.	2	18.5	24.0	36.3	-	21.2	312	407	415	-	359	1,693
	3	19.7	22.6	28.5	-	29.2	345	396	500	-	512	1,753
	2	11.9	-	-	64.8	23.3	184	-	-	997	359	1,540
	4	25.2	-	-	74.8 ^a	-	367	-	-	1089	-	1,456
	4	18.9	-	-	81.1 ^a	-	272	-	-	1169	-	1,441
	5	19.5	-	-	80.5 ^a	-	258	-	-	1068	-	1,326
	5	13.8	-	-	86.2 ^a	-	260	-	-	1618	-	1,878
1-7 post-p. (lactation)	2	5.7	24.0	45.8	-	24.5	107	452	863	-	462	1,884
	3	23.5	19.7	29.6	-	27.2	502	419	632	-	580	2,133
	2	5.8	-	-	68.7	25.5	111	-	-	1315	488	1,914
	4	23.1	-	-	76.9	-	459	-	-	1530	-	1,989
	5	18.2	-	-	81.8	-	379	-	-	1706	-	2,085

^a Both WS and concentrates were fed ad lib.

Table 2.1.7 MEAN INTAKE PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) of DRY MATTER (DM) AND METABOLIZABLE ENERGY (ME) BY EWES FED RATIONS BASED ON WHEAT STRAW (WS), POULTRY LITTER (PL) AND CORN VS. WS AND COMMERCIAL CONCENTRATES (CONC.)

Weeks pre- or post-partum	Rations		DM intake		ME
	Components	ME (MJ/kg)	Total g/ $W^{0.75}$	WS only g/ $W^{0.75}$	intake kJ/ $W^{0.75}$
14-8, pre-p.	WS+PL (1) ^a	6.36	47.3	34.3	301
7-5, pre-p.	WS+PL+corn (2)	8.97±0.40	62.7±0.92	27.1±7.64	562±18
	WS+Conc. (5)	10.15±0.40	54.4±7.37	18.4±3.05	554±93
4-1, pre-p.	WS+PL+corn+hay (2)	9.24±0.36	81.5±5.16	15.5±0.28	754±77
	WS+Conc.+hay (1)	10.54	68.8	8.4	725
	WS+Conc. (4)	10.98±0.27	63.9±8.11	12.2±2.48	702±103
1-7, post-p. (lactation)	WS+PL+corn+hay (2)	9.73±0.86	90.9±10.54	14.1±12.45	879±24
	WS+Conc.+hay (1)	10.81	78.4	5.0	848
	WS+Conc. (2)	10.90±0.20	89.4±5.23	18.4±2.05	975±75

^aIn parentheses, number of experiment used for calculation of means and SD's.

Cotton gin by-products, PL and corn

It took the ewes between 3 and 7 days to reach maximal intake whether lint or gin-trash were offered. Levels of intake, once reached, were maintained by the sheep throughout the experiments, which lasted up to 36 or 41 days. This was true both with and without PL.

The addition of PL to either LT or GT increased total dry matter and energy intake but had no effect on the intake of the cotton component (Tables 2.1.8 and 2.1.9). Furthermore, even the addition of corn to GT and PL during advanced pregnancy did not have an effect on GT intake.

Lint was eaten voluntarily in larger quantities than gin-trash, to such an extent that dry ewes eating lint alone consumed amounts of energy resembling those of ewes eating gin-trash together with PL and corn late in pregnancy.

Cattle manure.

Two weeks were required by the ewes to reach maximal intake when the CM was mixed with corn grain, either whole (exps. 7 and 8) or ground (exp. 9). From Tables 2.1.10 and 2.1.11, it is seen that increasing the amount of corn (exp. 7) brought about an increase in DM and ME intake but did not affect the intake of CM itself. It is not clear why the intermediate group in this experiment consumed less food than the low- and

Table 2.1.8 DRY MATTER (DM) INTAKE BY FINN-CROSS EWES DURING DIFFERENT STAGES OF PREGNANCY AND LACTATION OF RATIONS BASED ON COTTON WASTES (CW), POULTRY LITTER (PL) AND CRUSHED CORN GRAIN.

Weeks pre- or post-partum	Exp. no. ^a	Composition of rations %				Daily DM intake (g)				
		LT	GT	PL	Corn	LT	GT	PL	Corn	Total
Dry	5	100.0			-	1,633			-	1,633
	6	-	100.0		-	-	846		-	846
	6	-	78.4	21.6	-	-	938	258	-	1,196
14-8, pre- p.	4	79.6	-	20.4	-	1,296	-	333	-	1,629
	5	100.0	-	-	-	1,556	-	-	-	1,556
	5	84.6	-	15.4	-	1,583	-	289	-	1,872
	6	-	79.1	20.9	-	-	1,200	318	-	1,518
	6	-	100.0	-	-	-	1,138	-	-	1,138
7-5, pre- p.	10	-	68.7	31.3	-	-	826	377	-	1,203
	11	-	65.2	34.8	-	-	600	320	-	920
	12	-	76.2	23.8	-	-	1,057	330	-	1,387
	10	-	56.5	22.1	21.4	-	851	333	321	1,505
	11	-	47.5	25.9	26.6	-	660	360	370	1,370
	12	-	64.1	17.6	18.3	-	1,120	307	320	1,747
4-1, pre- p.	10	-	64.3	35.7	-	-	811	450	-	1,261
	11	-	70.8	29.2	-	-	908	375	-	1,283
	12	-	72.5	27.5	-	-	1,078	408	-	1,486
	10	-	44.3	25.1	30.6	-	771	437	532	1,740
	11	-	42.8	25.5	31.7	-	720	430	533	1,683
	12	-	51.2	22.1	26.7	-	985	425	515	1,925
1-7, post-p. (lactation)	10	-	37.9	25.8	36.3	-	916	623	875	2,414
	11	-	48.4	21.5	30.1	-	1,406	623	875	2,904
	12	-	44.2	23.0	32.8	-	1,157	603	860	2,620

^aAs in Tables 2.1.2-2.1.5.

Table 2.1.9 MEAN INTAKE ($\pm$ SD) PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) OF DRY MATTER (DM) AND METABOLIZABLE ENERGY (ME) BY EWES FED RATIONS BASED ON COTTON LINT (LT), GIN-TRASH (GT) AND POULTRY LITTER (PL) AND CORN GRAIN.

Weeks, pre- or post-partum	Rations		DM Intake		ME intake
	Components	ME (kJ/g)	Total g/W ^{0.75}	CW only g/W ^{0.75}	kJ/W ^{0.75}
Dry - 8 pre-p.	LT (2) ^a	8.45 $\pm$ 0.00	73.2 $\pm$ 3.97	73.2 $\pm$ 3.97	618 $\pm$ 29
	LT+PL (2)	8.14 $\pm$ 0.04	79.5 $\pm$ 6.48	65.8 $\pm$ 7.36	647 $\pm$ 56
	GT (2)	6.69 $\pm$ 0.00	47.0 $\pm$ 1.73	47.0 $\pm$ 1.73	315 $\pm$ 52
	GT+PL (2)	6.68 $\pm$ 0.00	61.8 $\pm$ 9.05	48.7 $\pm$ 7.50	413 $\pm$ 61
7-5, pre-p.	GT+PL (3)	6.60 $\pm$ 0.02	49.6 $\pm$ 10.61	35.1 $\pm$ 9.87	328 $\pm$ 71
	GT+PL+Corn (3)	8.20 $\pm$ 0.29	65.1 $\pm$ 9.55	37.0 $\pm$ 10.75	534 $\pm$ 60
4-1, pre-p.	GT+PL (3)	6.60 $\pm$ 0.01	56.9 $\pm$ 4.89	39.4 $\pm$ 4.98	376 $\pm$ 32
	GT+PL+Corn (3)	8.39 $\pm$ 0.76	74.9 $\pm$ 7.50	34.7 $\pm$ 6.78	609 $\pm$ 11
1-7, post-p. (lactation)	GT+PL+Corn (3)	8.98 $\pm$ 0.22	121.7 $\pm$ 5.78	53.1 $\pm$ 8.67	1091 $\pm$ 37

^aIn parentheses, number of experiment used for calculation of means and s.d.'s.

high-corn groups. Ewes in exp. 8 also consumed much less CM than those in exp. 7 with exactly the same amount of corn. When CM was offered with free straw and restricted PL (exp. 9), the ewes consumed similar quantities of CM and WS.

Alfalfa hay (AH)

The intake of alfalfa hay as the sole food or in combination with concentrate mixtures is shown in Tables 2.1.11 and 2.1.12. The hay used in exps. 11 and 12 was probably somewhat more mature than that used in exp. 10 and this may explain the greater intakes of the former in late pregnancy. The addition of concentrates caused a reduction in voluntary intake to about one-third to one-half of what it was when fed alone.

Genotype effect

There were no consistent differences between FA and FM ewes (Table 2.1.13). The slight tendency for FA to eat more of the ad lib. component (in 9 out of 14 comparisons) which in this study was the fibrous component of the ration, was statistically not significant. Mean intakes ($g \pm s.e.$) per $W^{0.75}$ were 47 $\pm$ 5.1 and 44 $\pm$ 4.7 for FA and FM ewes, respectively.

Table 2.1.10. DRY MATTER (DM) INTAKE BY FINN-CROSS DRY EWES, OR DURING EARLY PREGNANCY, OF RATIONS BASED ON CATTLE MANURE (CM), WHEAT STRAW (WS), POULTRY LITTER (PL) AND CRUSHED CORN GRAIN

Ewes' reproductive state	Exp. no. ^a	Composition of rations (%)				Daily DM intake (g)				
		CM	WS	PL	Corn	CM	WS	PL	Corn	Total
Dry	7	80.4	-	-	19.6	1,235	-	-	302	1,537
	7	72.0	-	-	28.0	999	-	-	388	1,387
	7	72.8	-	-	27.2	1,269	-	-	475	1,744
	9	39.2	37.2	20.9	2.7	450	427	240	31	1,148
Early pregnancy	8	70.8	-	-	29.2	733	-	-	302	1,035

^aSee Table 2.1.4

Table 2.1.11 INTAKE PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) OF DRY MATTER (DM) AND METABOLIZABLE ENERGY (ME), BY EWES FED RATIONS BASED ON CATTLE MANURE (CM), WHEAT STRAW (WS), POULTRY (PL) AND CORN

Ewes' reproductive state	Exp. no. ^a	Rations		DM intake			ME
		Components	ME (kJ/g)	Total	CM	WS	intake
				$g/W^{0.75}$	$g/W^{0.75}$	$g/W^{0.75}$	$kJ/W^{0.75}$
Dry	7	CM+Corn	5.40	73.9	59.4	-	399
	7	CM+Corn	6.28	66.0	47.6	-	414
	7	CM+Corn	6.19	83.8	61.0	-	519
	9	CM+WS+PL+ Corn	5.37	56.0	22.0	20.8	301
Early pregnancy	8	CM+Corn	6.40	46.9	33.2	-	300

^aSee Table 2.1.4

Table 2.1.12 DRY MATTER (DM) INTAKE BY FINN-CROSS EWES DURING DIFFERENT STAGES OF PREGNANCY AND LACTATION, OF RATIONS BASED ON ALFALFA HAY (AH) AND COMMERCIAL CONCENTRATES (CONC.)

Weeks, pre- or post-partum	Exp. no. ^a	Composition of rations (%)		Daily DM intake (g)		
		AH	Conc.	AH	Conc.	Total
7-5, pre-p.	10	100.0	-	1,350	-	1,350
	11	100.0	-	1,230	-	1,230
	12	52.6	47.4 _b	797	717	1,514
		33.3	66.7 _b	673	1,347	2,020
4-1, pre-p.	10	100.0	-	1,773	-	1,773
	11	100.0	-	1,470	-	1,470
	12	35.0	65.0 _b	595	1,105	1,700
		25.8	74.2 _b	478	1,378	1,856
1-7, post-p. (lactation)	10	100.0	-	1,709	-	1,709
	11	100.0	-	2,325	-	2,325
	12	34.4	65.6	780	1,490	2,270

^aSee Table 2.1.5

^bAH and concentrates fed ad lib.

Table 2.1.13 INTAKE PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) OF DRY MATTER (DM) AND METABOLIZABLE ENERGY (ME) BY EWES FED RATIONS BASED ON ALFALFA HAY (AH) AND COMMERCIAL CONCENTRATES (CONC.)

Weeks, pre or post-partum	Exp. no. ^a	Rations		DM Intake		ME
		Components	ME (MJ/kg)	Total g/W ^{0.75}	AH only g/W ^{0.75}	intake kJ/W ^{0.75}
7-5 pre-p.	10	AH	8.41	59.7	59.7	502
	11		8.41	50.4	50.4	424
	12	AH+Conc.	10.00 _b	63.9	33.6	639
			10.77 _b	85.2	28.4	918
4-1 pre-p.	10	AH	8.41	78.5	78.5	660
	11		8.41	60.2	60.2	507
	12	AH+Conc.	10.71 _b	71.7	25.1	768
			11.07 _b	78.3	20.2	867
1-7 post-p.	10	AH	8.41	82.2	82.2	691
	11		8.41	106.7	106.7	897
	12	AH+Conc.	10.73	99.1	34.1	1,063

^aSee Table 2.1.5

^bAH and concentrates fed ad lib.

Relationship between energy concentration of the ration and intake

In Figure 2.1.1, DM and ME intakes per kg $W^{0.75}$ were plotted against the energy concentration of the different rations used in this study. In general, DM and ME intake rose with the increase in energy concentration, but when the level of intake was high, to meet the requirements of advanced pregnancy and lactation, DM intake tended to diminish with ME concentrations beyond 9.0 kJ/g, while ME intake remained unchanged (reached a "set-point") or increased at a low rate.

In Table 2.1.15 ME intakes are grouped according to the reproductive stage of the ewes and the different rations. ME allowances per $W^{0.75}$ were calculated for comparison from tables of the NRC (1975) and Alderman et al. (1977) (based on ARC recommendations). For maintenance and pregnancy, most rations met or surpassed the requirements. Rations based on WS as the ad lib. component or on alfalfa hay as the sole feed did not meet lactation requirements of twin suckling ewes.

DISCUSSION

The role of poultry litter in the formulation of rations

Poultry litter when offered ad lib. is sometimes consumed by sheep in large quantities. Thus, Benjamin et al. (1979) reported mean intakes by Awassi ewes of 1.56 kg DM/day in a digestion trial in which PL was offered as the sole food, and Yehuda (1981) observed a mean intake of 1.1 kg DM of PL when it was a component in a ration with barley-grain and straw. Such quantities impose great surpluses of protein on the animal, but what is more important is the great excess of minerals. Cases of calcinosis in sheep that had been exposed to large quantities of PL were reported by Newmann et al. (1976) and by Yehuda (1981), and of copper poisoning by Suttle et al. (1978) and Fontenot et al. (1972). Non-specific kidney damage has been described by Angus et al. (1978) and other risks involved in the feeding of PL were reviewed by Bhattacharia and Taylor (1975), Tagari (1978) and Egyed (1978).

For the above mentioned reasons, PL was limited in the rations used in the present study to meet the protein requirements of the animals. The free intake of PL was not studied in this work. Rationed intakes ranged between 300 and 450 g DM/day and in most cases formed between 20 and 25% of the DM content of the ration.

There is little information in the literature on the effect of PL on intake of the ration into which it is incorporated. The reviews of Bhattacharia and Taylor (1975) and of Tagari (1978), and also the report of Caswell et al. (1977) suggest a slightly higher DM intake of diets containing PL. However, there is no information as to how PL would affect the intake of a fibrous component. The results reported here clearly indicate that, in spite of being a low energy food, PL had no inhibiting effect on the voluntary intake of the ad lib.-fed roughage components. Thus, at least at the levels used in this study, the inclusion of PL in a ration was accompanied by an increase in DM intake, and the maintenance of the same level of intake of the roughage

Figure 2.1.1 Relationship between dry matter (a) or metabolizable energy (b) intake and energy concentration of the ration, by sheep at different reproductive stages. (○ - dry; ◐ - 0-7.5 weeks pre-lambing; ◑ - 4-1 week pre-lambing; Δ - lactating ewes)

(wheat-straw or cotton waste), as in the animals which did not consume PL. In this context the study of Egan (1972) is worth mentioning. It showed that feeding sawdust to sheep resulted in an increase in fecal output without depressing feed intake. All the batches of PL used in our study were based on sawdust bedding. This is a finely ground material (which may therefore enhance the passage rate through the digestive tract). PL on other types of bedding might behave differently.

The beneficial effect of PL on the intake of WS may also be a result of the nitrogen supply, in which the WS is deficient. Milford and Minson (1965) and Ellis and Lippke (1976) have demonstrated the beneficial effect of supplementary nitrogen on intake and digestibility of forages including less than 7% crude protein.

Finally, it is worth noting the relatively small variability of the composition of the different batches of PL used in the present work.

The effect of the concentrated component on the intake of WS, CW and AH

Van Soest (1982) recently discussed the conflicting rules that seem to regulate intake of concentrate feeds (digestibility higher than 65-70%) as opposed to roughage. The former are regulated mainly by a physiological "set-point" which depends on energy requirements; the latter are regulated by the rate of passage and distention of the digestive tract. Sheep have a highly developed selecting ability, even of fine particles out of a mixture. Therefore, it is difficult to induce them to eat a ration of a predetermined concentration other than, perhaps, by mixing it in wet form such as with silage, or by grinding and pelleting the complete ration.

When offered increasing amounts of grain (corn) or concentrates, the intake of the ad lib. WS or AH as the second component was reduced. The reduction was more extreme with the (lower quality) WS, especially when concentrates were fed ad lib. In this case, the intake of WS fell to a level lower than 20% of the ration. This is in agreement with Owen et al. (1980) who reported of depressed intake by ewes when straw in a barley-straw ration was reduced to form less than 25% of the ration. (2.4 Cal = 10.0 kJ ME/g). The reduction in intake of high quality AH was much less drastic and thus enabled the animals to consume larger quantities of ME. The more balanced concentrate:roughage ratio may be expected to have beneficial implications in meeting production requirements in late pregnancy and lactation.

The results with GT seem to indicate that this material was consumed in a manner similar to that of hay rather than straw, and this is in accord with its digestibility (Table 2.1.14). It must, however, be borne in mind that in our experiments GT was used only in rations with PL and with relatively small amounts of grain, so that a complete comparison with hay or straw must wait until more information is available. The high intakes of LT are indicative of high digestibility and nutritional value. Therefore, the poor digestibilities recorded in Table 2.1.14 were somewhat surprising. However, high intakes, in spite of

Table 2.1.14 DRY MATTER (DM) INTAKE AND ORGANIC MATTER (OM) DIGESTIBILITY OF FEEDS BY FINN-AWASSI (FA) COMPARED WITH FINN-MERINO (FM) EWES, AT DIFFERENT REPRODUCTIVE STAGES

Ration ^{a,b}	Exp. no.	Weeks pre- or post-partum	ME kJ/g	DM intake ($\text{g/W}^{0.75}/\text{day}$) ^c		OM digestibility (% $\pm$ s.d.) ^c	
				Total		FA	FM
				FA	FM		
WS+PL	1	14-8 pre-p.	6.36	50.3(10)	44.3(10)	36.5	32.1
WS+PL+Corn	3	7-5 pre-p.	8.68	62.9(4)	65.0(4)	32.0	31.8
WS+PL+Corn+Hay	3	4-1 pre-p.	8.98	70.7(4)	69.8(4)	14.3	13.4
WS+PL+Corn+Hay	3	1-7 post-p.	9.12	93.7(4)	95.3(4)	22.6	18.5
LT+PL	4	14-8 pre-p.	8.09	75.2(9)	68.8(9)	60.0	54.6
	5	14-8 pre-p.	8.12	93.4(4)	73.7(5)	78.7	61.5
LT	5	14-8 pre-p.	8.45	71.4(4)	64.4(5)	71.4	64.4
	5	Dry	8.45	71.8(4)	75.2(4)	71.8	75.2
GT+PL	6	14-8 pre-p.	6.68	67.7(5)	68.7(5)	53.3	54.6
	6	Dry	6.68	62.1(4)	48.6(4)	49.0	37.8
GT	6	14-8 pre-p.	6.69	51.9(5)	52.9(5)	51.9	52.9
	6	Dry	6.69	40.3(4)	42.9(4)	40.3	42.9
CM+Corn	8	14-8 pre-p.	6.40	48.9(9)	44.9(9)	35.0	31.4
(CM+WS) ^d +PL+ Corn	9	Dry	5.37	54.1(5)	57.2(5)	40.2	44.8
						46 $\pm$ 4.9(3)	43 $\pm$ 1.8(4)
						44 $\pm$ 0.1(2)	46 $\pm$ 0.4(3)

^aSee Tables 2.1.2 - 2.1.5.

^bAd lib. component listed first

^cNumber of ewes is given in parentheses

^dCM and WS were offered ad lib.

high fiber-moderate digestibility levels were recorded (with heifers) also with another cotton by-product, namely cottonseed hulls (Lakes and Davenport, 1973; Kali *et al.*, 1979; Tagari, 1971).

The problem of chemical residues is discussed in a separate chapter. That voluntary intake of a roughage in combination with rationed grain is dependent on the roughage quality, was shown also by others (e.g. Golding *et al.*, 1976).

Intake of cattle manure

The composition of the CM used in the present study resembles that of CM coming from two different sources and reported by Benjamin *et al.* (1982). Our lot was somewhat higher in crude protein and fiber and lower in ash, indicating perhaps more careful preparation and thus smaller losses of organic matter due to degradation during the drying process. The digestibility of the CM-corn ration was 4-6 points lower than what would be expected by calculating the sum of digestibilities of the separate components, that of CM dry matter being 25% (Benjamin *et al.*, 1982). It is possible that the Awassi ewes used by Benjamin *et al.* (1982) digested the CM better and consumed more of it than the Finn crosses included in the present study. This point will be discussed in more detail below. Another possibility is that the material itself was of different quality. An additional explanation could be the faster passage through the digestive tract brought about by the inclusion of corn in the ration. The issue of passage rate and digestibility has been thoroughly reviewed by Van Soest (1982).

The energy values of CM reported here are considerably lower than those included in the review of Bhattacharia and Taylor (1975), and more like those reviewed by Tagari (1978).

It is interesting to note that while some grain was needed to induce CM intake, increasing the quantity of corn to moderate levels (about maintenance) did not affect its intake. This is surprising in the face of its extremely low digestibility.

Effect of genotype

Van Soest (1982) reviewed the literature showing that species differences in digestive ability do exist. However, he pointed out that results of experiments may be conflicting and that they were largely dependent on the type of food being tested. There exists much less information about breed differences within a species. Silanikove (1983) has shown that the Bedouin (desert) goat has considerably higher digestive ability for straw than the Saanon goats. This ability was mainly correlated to longer mean retention times in the rumen and to a greater ability to recycle urea for rumen fermentation.

We postulated that Awassi ewes, being of desert origin, might show similar advantages over the German Mutton Merino, and that in such a case the differences should be taken into consideration in experimental planning. Such a difference, if it does exist, may have also some

important practical consequences, in the design of rations and for future breeding programs. The intakes by Awassi sheep in a series of studies (Benjamin *et al.*, 1979a, b, 1982) of wheat straw and of cattle manure, were considerably higher than those reported in the present study. The differences between the FA and FM genotypes used were minute and inconsistent and if the Awassi could contribute to better utilization of low quality feeds, this will probably have to be shown on a much larger scale than was possible in this study.

Speed of eating

The time spent eating the different feeds or rations was not recorded in this study. The general observation, however, was that cattle manure, poultry litter and, to some extent, also gin trash, were consumed at a much slower rate than concentrates, grain or hay, thus bringing about a more or less regulated consumption over most of the diurnal period. This could have a beneficial effect on efficiency and on rumen fermentation (Van Soest, 1982).

Levels of ME supplied by the different rations and the relationship of intake to energy concentration

The regressions of intake (DM or ME) are in good agreement with those of Dinius and Baumgardt (1970) and Clancy *et al.* (1976). Furthermore, the fact that correlation coefficients for ME intake were considerably higher than those for DM intake, probably indicates adjustment of intake to energy expenditure even with the low energy feeds. Owen *et al.* (1980) also concluded that "even on diets that do physically limit intake the reproductive state, particularly lactation, can overcome this limitation to a significant extent."

The results reported in this paper are not intended to support any energy requirement estimate. To what extent some of these rations have met production requirements is dealt with in other chapters of this report (Benjamin *et al.*, chapter 2.6; Yehuda *et al.*, chapter 2.8). The accomplishments with these rations, however, warrant some discussion. The Finn cross ewes used in this study, unlike Awassi sheep (Benjamin *et al.*, 1979a,b), were not able to consume enough straw, when it was offered with PL or CM, to cover maintenance requirements (see Table 2.1.15). The same was true for GT when it was the sole food. While the addition of ~25% grain is required to ensure sufficient intake of a ration based on CM, with WS and PL much less would probably be enough (about 10%). The ME concentration of such a ration would be about 7.5 MJ/kg.

With WS+PL or GT+PL, rations including 35 or 20-25% grain, respectively, were consumed at levels supplying more than required in weeks 7-5 pre-lambing (ME concentrations of 9.0 and 8.2 MJ/kg). With only slightly higher energy concentrations (9.2 and 8.4 for WS- or GT-based rations, respectively), the requirements during the last 4 weeks of pregnancy were met. A most important point that must be emphasized here is that with PL in the ration, requirements could be met with rations considerably lower in ME concentration than by offering WS or GT just with concentrates. Thus, the danger is reduced of overfeeding

Table 2.1.15 COMPARISON OF ME INTAKES (kJ/W^{0.75}/DAY) ACCOMPLISHED WITH DIFFERENT DIETS AND COMPARED WITH THE NATIONAL RESEARCH COUNCIL, USA (NRC, 1975) ALLOWANCES AND WITH THOSE OF THE BRITISH AGRICULTURAL RESEARCH COUNCIL (ARC), FOR TWIN-BEARING EWES.

Ration ^a	Reproductive state: wks pre- or post-lambing ^b			
	Dry-8 pre-1	7-5 pre-1	4-1 pre-1	1-7 post-1
NRC allowance	425	475	760	1,180
ARC allowance ^c	320	410	590	1,185
WS+PL	301	-	-	- ^d
WS+PL+Corn	-	562±13	754±54	879±17
WS+Concentrates	-	554±42	707±40	933±52
LT	618±21	-	-	-
LT+PL	647±40	-	-	-
GT	315±37	-	-	-
GT+PL	413±43	328±41	376±18	-
GT+PL+Corn	-	534±35	609±6	1091±18
CM+Corn	408±45	-	-	-
CM+WS+PL ^d	301	-	-	-
AH	-	463±39	584±77	794±103
AH+Concentrates	-	779±140	818±50	1063

^aAd lib. component listed first.

^bFor pregnancy and lactation the recommended allowance for twin-bearing ewes was taken.

^cAlderman et al., 1977.

^dCM and WS were offered ad lib.

(and obesity in late pregnancy) (Gordon and Tribe, 1961; Reid, 1963; Stern et al., 1978 and others) concomitant with ad lib. feeding. With WS alone or even with more than 20% hay in the ration, it was impossible to meet requirements with less than 65% concentrates (ME concentration of 10.5-11.0 MJ/kg).

If the NRC and ARC represent a good estimate of the requirements of sheep, then the lactation allowances in this study were somewhat short of meeting the full energy requirements.

Finally, it should be mentioned that cotton lint used in this study only in early pregnancy was shown to be a high quality feed. This product is not available in abundance, but where some quantities of the material can be purchased it would be worth testing its possible role in late pregnancy and during lactation.

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2.2 INTAKE AND DIGESTIBILITY OF AMMONIA-TREATED STRAW BY EWES ON A MAINTENANCE RATION

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ABSTRACT

The nutritive value of ammoniated wheat straw (AWS), compared with untreated straw (WS), was tested with Finn-cross ewes at maintenance level. There were three experimental treatments: WS with 150 g (as dry matter, DM) of soybean oil meal (SBM); AWS with 150 g of SBM; and AWS with 130 g of crushed corn grain. The AWS contained 9.14% crude protein 3-4 days after removal of the plastic cover, of which 2.51% was free ammonia. After termination of the intake and digestion trials 45 days later, the respective concentrations were only 5.68% and 0.19%. There was 3.55% of crude protein in the WS. The intake of AWS by the ewes was 23.5% and 29.9% higher than that of WS, when offered with SBM or corn, respectively. The estimated metabolizable energy concentrations were 7.04, 7.49 and 7.21 MJ per kg DM, for WS with SBM, AWS with SBM, and AWS with corn, respectively.

The production of 1 kg of AWS could save 50 g of SBM + 50 g corn when poultry litter (PL) is not available, or 95 g of corn when PL is supplemented at a rate calculated to meet the nitrogen requirements of a 55-kg Finn-cross ewe.

INTRODUCTION

Ammonia treatment of straw has a double effect on its nutritive value. It increases the energy concentration through improved digestibility and increases the nitrogen content, depending on the bound ammonia retained in the straw (e.g., Arnason, 1976; Sundstøl, Coxworth and Mowat, 1978; Males and Gaskins, 1982). The progress in applying this technique in practice is rather slow, probably due to lack of the information required for its economic evaluation. The overall benefit is a product of the improved digestibility x increased protein equivalent x increased intake. It is the last item for which very little information is available. The benefit will also depend on the alternative supplements available to be fed with the straw.

Herein are presented the results of a comparison of ammoniated vs. untreated wheat straw when offered with iso-energetic supplements of either soybean oil meal (protein sufficient) or corn grain (low protein).

MATERIALS AND METHODS

Feeds

Wheat straw (WS) from the same lot used for feeding the control (untreated) group, was treated by Fertilizers and Chemicals Ltd., Israel, by injection of anhydrous ammonia into straw bales covered tightly with plastic sheets according to the Norwegian method (Arnason, 1976). The plastic cover was removed a few days prior to the beginning of the feeding trials. The composition (proximal analysis) of the treated (AWS) and of the WS was assessed at the onset and at termination of the experiments 45 days later.

Soybean oil meal (SBM) and corn grain were used as protein and energy supplements (see experimental plan below).

Animals

Eighteen dry Finn-Mutton Merino and Finn-Awassi ewes were used. They were divided into experimental groups according to genotype, age, body weight and body condition scores (Jeffries, 1966). Mean body weight at the onset of the experiment ($\pm$ s.d.) was 56 ± 5.2 kg.

Experimental treatments

The plan of the experiment is shown in Table 2.2.1. The ewes were held in three pens on concrete floors. Straw was offered ad lib. The four ewes for the digestion experiment were taken directly from the intake trial so that only a short adjustment period was needed before collection started, after they were put in the individual digestion cages.

Table 2.2.1 EXPERIMENTAL DESIGN

Type of straw	Supplement (DM/ewe/day)	Number of ewes	
		Intake trial	Digestion experiment
Untreated	Soybean oil meal, 150 g	6	4
NH ₃ -treated	" " " "	6	4
NH ₃ -treated	Corn, 130 g	6	4

RESULTS

Composition of the AWS

The nitrogen content of the AWS fell in the course of the feeding experiment (Table 2.2.2), mainly due to loss of free ammonia, but even the apparently bound nitrogen had diminished by 1.15% in terms of crude protein. In terms of protein, the improvement due to the ammonia treatment was not more than 2.0-2.5%.

Table 2.2.2 CHEMICAL COMPOSITION (PROXIMAL ANALYSIS) OF WHEAT STRAW (WS) AND AMMONIATED WHEAT STRAW (AWS)

Type of straw	Composition (%) of DM						
	DM %	Crude protein (CP)			Fiber	Ether extr.	Ash
		Total	Free NH ₃	CP less NH ₃			
WS	93.0	3.55	-	3.55	39.9	2.5	8.8
AWS, start of experiment	91.9	9.14	2.51	6.63	39.9	2.7	7.9
AWS, end of experiment	-	5.68	0.19	5.48	-	-	-

Digestibility and nutritive value of straws

Ammonia treatment brought about a 6 (with SBM) or 4 (with corn) percentage points increase in dry matter (DM) digestibility as compared with untreated straw (Table 2.2.3); this is a 13.2% or 8.5% improvement, respectively. *In vitro* digestion gave similar results. The apparent differences in digestibility of organic matter are smaller. It is, however, noteworthy that the treatment caused a significant increase in N-free extract (NFE) digestibility, and that at least part of the protein of the original straw also became available to the animals, particularly so when SBM was the supplement.

Table 2.2.3 APPARENT DIGESTIBILITY AND ESTIMATED METABOLIZABLE ENERGY (ME) CONCENTRATION OF WHEAT STRAW (WS) AND AMMONIATED WHEAT STRAW (AWS) WHEN OFFERED WITH SOYBEAN OIL MEAL (SBM) OR CORN GRAIN

Type of straw	Dry matter	Mean digestibility ($\pm$ s.d.), %*				ME (MJ/kg)
		OM	Protein	Fiber	N-free extract	
WS+SBM	47.2 $\pm$ 5.50	59.5 $\pm$ 2.86	0.0	70.3 $\pm$ 2.48	52.4 $\pm$ 3.04	7.04
AWS+SBM	53.4 $\pm$ 7.43	62.7 $\pm$ 7.92	45.2 $\pm$ 25.49	71.9 $\pm$ 6.85	57.7 $\pm$ 7.98	7.49
AWS+corn	51.7 $\pm$ 3.41	61.4 $\pm$ 2.08	33.9 $\pm$ 35.19	68.7 $\pm$ 1.53	59.7 $\pm$ 1.91	7.21

*Calculated by difference, assuming 90% and 80% digestibility of protein and carbohydrates, respectively, in SBM, and 77% and 90%, respectively, in corn.

Straw intake and ewe performance

The ewes, in all groups, had reached their maximal intakes immediately at the onset of the experiment. The intake of treated straw was 23.5% (with SBM) and 30% (with corn) higher than that of untreated straw (Table 2.2.4). Due to the low binding level of ammonia in the treated straw, the AWS-corn diet was somewhat deficient in protein. It is impossible to derive a quantitative estimate of the energy or protein balance of the ewes from the present results. The figures included in Table 2.2.4 indicate, however, that the AWS-fed ewes were closer to energy balance than those fed WS.

Table 2.2.4 MEAN DAILY DRY MATTER (DM), METABOLIZABLE ENERGY (ME) AND PROTEIN INTAKE AND BODY WEIGHT (BW), AND CONDITION SCORES (CS) CHANGE IN 25 DAYS ($\pm$ S.D.)

Ration	WS and SBM	AWS and SBM	AWS and corn
Total DM, g	741	880	898
Straw, g	591	730	768
ME, MJ	5.98	7.28	7.33
Protein, g	96	116	57
% of ration	13.0	13.2	6.3
BW change, kg	-0.17 $\pm$ 1.94	1.0 $\pm$ 1.73	1.0 $\pm$ 1.90
CS change	-0.08 $\pm$ 0.38	0.08 $\pm$ 0.20	-0.16 $\pm$ 0.26

DISCUSSION

The product of the 8.5-13.2% improvement of digestibility and the 23.5-30% increased DM intake yielded a 1.3 MJ (22%) increase in energy intake. Results reported in the literature are similar or better (Goren *et al.*, 1980; Sundstøl *et al.*, 1978; Males and Gaskins, 1982).

The improved fiber digestibility, especially in the two diets with the SBM, may be attributed to the beneficial effect of the supplementary nitrogen, as Milford and Minson (1965) and Ellis and Lippke (1976) showed for forages including less than 7% crude protein. The AWS-corn ration in the present study was just marginal in this respect (see Table 2.2.4). The significant increase in the N-free extract (NFE) digestibility is, perhaps, an indication of some breakdown effect of the NH_3 on the WS cell walls.

Some calculations are presented in Table 2.2.5 that may be of help in an economic evaluation of the ammonia treatment. The possible saving in protein and energy supplements may indicate the maximum cost of this treatment that would justify undertaking it.

Table 2.2.5 POSSIBLE SAVING IN SOYBEAN OIL MEAL (SBM) OR CORN AS A RESULT OF SUBSTITUTING AMMONIATED FOR UNTREATED WHEAT STRAW (WS)

Type of straw	Untreated			Ammoniated		
	DM(g)	ME(MJ)	CP(g)	DM(g)	ME(MJ)	CP(g)
PL not available*						
WS intake	591	4.16	21	730	5.47	41
SBM intake	150	1.84	72	100	1.21	48
Corn intake	170	2.35	17	120	1.66	12
Total	911	8.35	110	950	8.31	101
PL available						
WS intake	591	4.16	21	730	5.47	41
PL intake	300	2.01	75	300	2.01	75
Corn intake	160	2.21	16	65	0.90	7
Total	1051	8.38	112	1095	8.38	123

*The production of 1 kg of ammoniated WS can save 50 g DM of SBM + 50 g corn (case a) or 95 g of corn grain (case b) in a maintenance ration of a 55 kg ewe.

(DM = dry matter; ME = metabolizable energy; CP = crude protein; PL = poultry litter)

It may be argued that, at least for maintenance, poultry litter (PL) could fulfill all the requirements for energy and protein. In such a case, the cost of ammonia treatment would have to be very low to be jus-

tified. However, due to considerations explained by Kali et al. (chapter 2.1), it seemed appropriate to make the calculation, under the assumption that a sound practice would be such that PL in rations should not exceed levels required to meet the protein allowances. The saving in concentrate components by feeding AWS at maintenance level is not impressive. It might, perhaps, be greater at higher levels of intake during pregnancy, and mainly in lactating animals.

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2.3 POSSIBLE TOXIC EFFECTS OF GOSSYPOL OR OF MAGNESIUM CHLORATE
(DEFOLIANT) RESIDUES IN EWES FED COTTON GIN-TRASH

H. HEFFER and E. EYAL (ARO)

ABSTRACT

Fifteen adult ewes were included in a 32-week study to evaluate possible adverse effects of feeding gin-trash and to test the hypothesis that such effects are due to chlorate residues. A significant increase in the occurrence of spontaneous haemolysis was observed in the group fed gin-trash, but it could also be attributed to gossypol. Other possible effects of this substance or of magnesium chlorate residues were not confirmed. To arrive at more conclusive results, large numbers of animals, and a more complicated experimental design, are required.

INTRODUCTION

Gin-trash (GT) has been shown to be valuable as a feedstuff for ruminants (Erwin and Roubicek, 1958; Kali *et al.*, chap. 2.1; Yehuda *et al.*, chap. 2.8).

In a feeding experiment conducted at Bet Dagan, haemolytical changes were occasionally observed in a series of centrifuged, heparinized blood samples. Haemolysis occurred spontaneously in all samples from ewes fed GT, but not in the control group. Haematocrit (PCV) values were 23-27% for the experimental group, compared with 30-34% for the controls. No other changes were recorded haematologically, clinically or in urine analysis. Two to 3 weeks after reversion to the normal wheat straw-concentrate diet, haemolysis disappeared and PCV values became similar to those of the control group.

Gossypol toxicity was not considered probable, based on Halverson and Sherwood (1930), Huffman and Moore (1930), Morrison (1951), Reiser and Fu (1962), and Danke *et al.* (1965). Among exogenous materials, magnesium chlorate (MgClO_3) residues seemed most likely to be responsible. In Israel, MgClO_3 (MAG-40, containing 17.5% MgClO_3 ; Palident Ltd., Tel Aviv) is the main defoliant used by the cotton industry. In contrast to the common insecticides, it is chemically very stable and is in fact the last chemical applied in the cotton field.

Acute chlorate intoxication is well documented in the veterinary literature (Jones, 1977; Blood *et al.*, 1983). The main clinical symptoms are non-specific, but there is a marked methaemoglobinaemia. No description of chronic chlorate poisoning was found, but it seemed that the possibility should be checked.

MATERIALS AND METHODS

Experiment design

Fifteen dry Finn cross ewes, 1-3 years old, were allocated according to genotype, age and body weight into three treatments and grouped as shown in Table 2.3.1. The control group was fed the normal diet of wheat straw and concentrates common in the Bet Dagan flock. The MgClO_3 group was fed the same diet as the control, to which a technical 18% magnesium chlorate solution was added to make a chlorate-ion concentration of 160 mg/kg of the ration.

The experiment was started at the end of October 1982 and lasted for 32 weeks, until the end of May 1983. In weeks 5, 6 and 11, the ewes were dipped together with the whole flock against ectoparasites. All ewes were mated during December-January (weeks 5-11). From week 23 and on, 0.5 kg/head of concentrates was added daily as a steaming-up ration and on week 26 all ewes were returned to the control ration until after lambing, when the experiment was terminated.

Table 2.3.1 DESIGN OF THE EXPERIMENT

Treatment group	n	Daily allowance (kg/head)				
		Wheat straw	Gin-trash	Concentrates	SBM	ClO ₃ (mg/kg)
Control	5	<u>ad lib.</u>	-	0.5	-	-
MgClO ₃	5	<u>ad lib.</u>	-	0.5	-	160-170
Gin-trash	5	-	<u>ad lib.</u>	-	0.1	320-360

MgClO₃ and mycotoxins in gin-trash

The concentration of chlorate residues was determined according to Kolthoff and Belcher (1957).

Chlorate ion concentrations in GT, measured before the start of the experiment, varied between 40 and 90 ppm. In a later series, conducted at the end of the feeding period, an improvement in the extraction stage was introduced and the figures reached 320-360 ppm. These are probably good estimates of the true contents, since analysis of the premixed concentrate used for the MgClO₃ group yielded results close to the calculated values (160-170 ppm).

The possible presence of mycotoxins was tested by a modified chromatography test (Peterson and Roberts, 1979). Sampling was done from suspected aggregations in the gin-trash heap. The samples analyzed were all negative for mycotoxins.

Records taken

Food intake was estimated by daily weighing of the offered quantities and weighing of residues on the next day.

Body weight. Ewes were weighed fortnightly until about one week after all of them were mated (week 12).

Reproductive performance. Mating, lambing and lamb survival were recorded.

Routine clinical observations were made weekly and whenever appropriate.

Standard haematology (Schalm et al., 1975). Weekly jugular blood samples were taken from each ewe, and the following tests were made:

Packed cell volume (PCV), in heparinized blood by the standard centrifugation method.

Haemolysis. An estimate for spontaneous in vitro haemolysis was made by visual comparison of plasma samples with a series of haemolyzed blood plasma of known concentration. Fragility tests were not carried out.

Haemoglobin concentration was determined by the cyanomethaemoglobin (Drabkin's) method (Anon., 1980).

Blood cell morphology was determined, first as a routine and then when needed, by microscopy of Giemsa and new methylene blue stained blood films. In addition, blood cell counts and tests for erythrocyte sedimentation rate (ESR) were carried out when needed by standard manual methods.

Methaemoglobinaemia. A single test for the presence of methaemoglobin in the blood of all ewes was carried out in week 19. One ml blood was added to 20 ml phosphate buffer (pH 6.0), and the test was performed by the standard ferrocyanide method.

Blood biochemistry. A single test for some metabolites and enzymes was carried out in week 18, using standard biochemical methods. These included glucose, urea, calcium, magnesium, phosphate, ALP, LDH and GOT.

RESULTS

Sheep performance

Ewes on the GT ration ate more than those on wheat straw (Table 2.3.2), in agreement with the findings of Erwin and Roubicek (1958), Kali *et al.* (chap. 2.1) and Yehuda *et al.* (chap. 2.8). This is also compatible with the evident body weight changes. Between treatment differences of date of conception, lambing rate and lamb mortality were all statistically non-significant.

Table 2.3.2 PERFORMANCE OF EWES ON THREE DIFFERENT RATIONS

Parameter	Treatment group		
	Control	MgClO ₃	Gin-trash
Starting body weight, kg	65.5±5.57	62.3±9.85	64.4±4.16
Body weight change, weeks 1-12, kg ^a	-2.4±2.22	-0.8±3.23	+2.8±4.22
Mean daily DM intake, kg/ewe	1.008	1.041	1.723
Estimated daily energy intake, MJ/ewe	9.14	9.35	12.29
Mean date of conception	14.XII±17	19.XII±12	13.XII±14
Lambs born per ewe lambing ^b	1.75	1.60	1.50
Lamb mortality	none	3	1

^aTo first month of gestation

^bThere was one barren ewe in the control and one in the GT group.

Haematological and clinical observations

General. The first 8 weeks were uneventful, and the records taken during this period should be regarded as the most significant ones.

During the 9th through the 13th weeks, an acute PCV-drop occurred in two control and two chlorate ewes, without any apparent clinical signs. The average drop for these four ewes was 11.5%, compared with the normal 0-4% fluctuations in individual ewes. For the following 12 weeks average PCV values did not return to their pre-drop level. This, no doubt, led to some confounding of the results that followed.

PCV and mean corpuscular haemoglobin concentration (MCHC)

There was a tendency for $MgClO_3$ and GT ewes to have slightly lower values than those of the control groups (Table 2.3.3 and Fig. 2.3.1), but all differences were statistically non-significant. Subperiods are also indicated in Fig. 2.3.1 (see Materials and Methods).

Detectable haemolysis

Visually detectable haemolysis was more than three times more frequent in the group fed gin-trash than in the two other groups (Table 2.3.4). This was the same whether compared over the first 8 weeks or over the whole experimental period.

Table 2.3.3 PACKED CELL VOLUMES (PCV) AND MEAN CORPUSCULAR HAEMOGLOBIN CONCENTRATIONS (MCHC, %) DURING THE EXPERIMENT PERIOD (MEANS $\pm$ S.D.)

Week	Treatment groups					
	Control		$MgClO_3$		Gin-trash	
	PCV	MCHC	PCV	MCHC	PCV	MCHC
1	35 $\pm$ 5.2	34.6	36 $\pm$ 1.7	32.4	34 $\pm$ 4.6	31.8
5	37 $\pm$ 2.8	33.7	33 $\pm$ 2.2	34.9	32 $\pm$ 5.7	27.2
10	34 $\pm$ 7.0	34.1	34 $\pm$ 2.2	32.7	31 $\pm$ 4.8	32.8
15	31 $\pm$ 4.1	-	29 $\pm$ 3.5	-	28 $\pm$ 3.4	-
20	33 $\pm$ 4.9	-	34 $\pm$ 2.0	-	30 $\pm$ 3.9	-
25	33 $\pm$ 6.0	-	31 $\pm$ 5.1	-	31 $\pm$ 3.3	-
30	32 $\pm$ 3.6	-	29 $\pm$ 4.1	-	30 $\pm$ 3.6	-

Other observations

No significant differences were found in methaemoglobin, glucose, urea, calcium, magnesium, phosphate, ALP, LDH and GOT.

Figure 2.3.1 Mean changes in packed cell volume (PCV) throughout the experiment, expressed in relation to the initial values (100%) of each treatment group (1 = control; 2 = MgClO₃; 3 = gin-trash; D = dipping).

Table 2.3.4 FREQUENCY OF OCCURRENCE OF SPONTANEOUS HAEMOLYSIS
DURING THE EXPERIMENT PERIOD (ONE SAMPLE/EWE/WEEK)

Treatment group	Number of haemolytic samples	Hb in plasma of haemolytic samples (mg/ml)
Control	19	0.33
MgClO ₃	18	0.53
Gin-trash	60	0.43

DISCUSSION

No cumulative adverse effects of feeding gin-trash were observed in this preliminary study. There is an insignificant tendency towards a decrease in PCV in both treatment groups, and an increased occurrence of spontaneous haemolysis in the ewes fed GT. Thus, the observation that led to this study was confirmed.

Unexpected changes were observed in PCV, ESR and blood cell morphology at week 9 through 14. Six ewes were affected, two, three and one, respectively, from the three experimental groups. No clinical symptoms were observed and the haematological changes were indicative of an infectious anaemia in the regenerative phase. However, much more time elapsed before PCV values returned to normal, compared with the other values.

Although no blood parasites were demonstrated, the epidemiology and haematology suggest such an infection, caused perhaps by Eperythrozoon ovis (Blood et al., 1983).

Because of the causal incidence and the long recovery period, it is impossible to evaluate the effect of this outbreak on the parameters recorded. It is, however, clear that it contributed to the overall variance among animals and groups.

Two factors contributed to the lack of otherwise possibly significant differences among the groups. One is the large variation among the animals, which may have been due to differences in age and genotype, apart from the disease outbreak early in the experiment. The other is the low dosage of chlorate in the MgClO₃ group, due to false, low values determined at the onset of the experiment (see Materials and Methods).

It is concluded that the hypothesis of effects of chlorate residues was neither confirmed nor disproved.

Recent reports have shown that under certain circumstances gossypol, present in cotton by-products (cottonseed oil meals), had a toxic effect on ruminants (Rogers et al., 1975; Lindsay et al., 1980). In

both of these reports, lowered PCV and Hb concentrations were recorded and also increased mean corpuscular fragility and blood cell haemolysis. Therefore, the possibility that the symptoms recorded in the present study may be attributed at least partly to gossypol, should not be ruled out.

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2.4 FEEDING AT-HOME-SEPARATED DOMESTIC WASTE TO FINN-CROSS EWE-HOGGETS

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ABSTRACT

Edible domestic waste (EDW) was fed to 15 Finn x Awassi and Finn x Merino ewe-hoggets over a period of 142 days beginning 41 days prior to joining the rams at 9 months of age. Thirteen similar ewe hoggets receiving a commercial concentrate mixture served as the control group. There were no differences in feed intake, body weight gain or feed efficiency between the two treatment groups. Initial and final weights were 41.5 ± 3.81 and 55.6 ± 5.10 , and 40.8 ± 3.67 and 54.7 ± 7.50 kg for the EDW and concentrate groups, respectively. Nine of the 15 EDW and 6 of the 13 concentrate hoggets lambd 1.78 and 1.67 lambs per ewe-hogget, respectively.

INTRODUCTION

Goldman (1975) estimated the yearly amount of domestic waste (garbage) produced in Israel to be approximately 300,000 metric tons, about half of which is suitable for consumption by farm animals providing that it is properly separated from non-edible material. Padova *et al.* (1979), in a year-round study with 35 families (136 persons), estimated that per capita production of edible domestic waste (EDW) to be 25 kg of dry matter per year, which would mean more than three times Goldman's estimate, when multiplied by the total population of the country. Hasdai and Ben-Ghedalia (1982) and Ben-Ghedalia *et al.* (1983), in digestion trials with sheep at maintenance level, showed that this material was comparable in its nutritive value to a conventional concentrate mixture. Based on these findings, it seems that recycled EDW may be considered an important potential food for livestock. It was therefore decided, in a preliminary experiment, to compare the growth and reproductive performance of ewe-hoggets fed EDW with that of hoggets fed commercial concentrates. The scale of the experiment was limited to the quantity of separated EDW available.

MATERIALS AND METHODS

Feeds

At-home-separated kitchen garbage was collected daily by a team from the Nahal Soreq Reactor, dried at 100°C for 24 hours, and then ground and gamma-irradiated for sterilization.

The chemical composition of the EDW used in the present experiment, the composition of the pelleted commercial concentrate mixture and that of the average of 12 other analyses of EDW produced by the same team previously, are given in Table 2.4.1. The rations consumed by the experimental groups are shown in Table 2.4.2.

Animals

Twenty-nine 9-month-old Finn x Merino and Finn x Awassi replacement ewe hoggets were allotted to an experimental (EDW) and a control (commercial concentrates) group. One of the control hoggets was lost by accident, so there were 15 and 13 animals in the respective groups.

Procedures

The ewes of the two groups were put in separate pens and fed the experimental ration 41 days prior to joining with the rams (period 1, Table 2.4.2). Upon joining the rams they were given the concentrate component *ad lib.* for one month as flushing to stimulate breeding. Afterwards the ration was reduced to support a moderate rate of weight gain for another 2 months.

a'whea

Days	EDW	WS ^a	Total	Conc.	WS ^a
41	995	180	1,175	945	200
30	1,405	165	1,570	1,340	115
30	1,010	170	1,180	1,075	125
41	700	280	980	700	325

^bN-free extract

Table 2.4.2

Period	Day
--------	-----

^aWheat straw fed ad lib.

^bConcentrate component fed ad lib. during this period as flushing.

RESULTS AND DISCUSSION

There were no differences in overall feed intake and efficiency between hoggets fed EDW or concentrates (Tables 2.4.2 and 2.4.3). The fact that the concentrate-fed group consumed less wheat straw during the *ad lib.* feeding period may be of some importance. This is in agreement with Kali et al. (see chap. 2.1), who showed that high levels of concentrate feeding have a depressant effect on the intake of roughage. The present preliminary study does not supply any evidence as to what component of the EDW could stimulate increased intake of this material.

It is impossible to tell from the results whether the apparent difference in favor of the EDW group in reproductive performance is of real significance. It should, however, be pointed out that the control ration was higher in protein, and has been shown by Eyal et al. (1983) and others that excess protein may somewhat reduce the reproductive performance of sheep.

It may be concluded that EDW can be regarded as a promising substitute for expensive concentrate feeding. Once technical difficulties, which still exist, are overcome in bringing this material from the kitchen to the animal shed, it should be tested also for other stock, such as lactating sheep or fattening lambs.

In the present study, the EDW received quite heavy treatment in preparing it for the sheep. Whether this is required or whether less handling or even feeding it in fresh form can be practised under well-defined circumstances, is worth testing. Several commercial sheep enterprises in Israel are known to be using kitchen garbage, from neighboring army camps, as a routine practice.

Table 2.4.3 FEED INTAKE, BODY WEIGHT CHANGES, FEED EFFICIENCY AND REPRODUCTIVE PERFORMANCE OF EWE-HOGGETS FED EDIBLE DOMESTIC WASTE (EDW) OR COMMERCIAL CONCENTRATE MIX (CONC.)

Treatment	EDW	Conc.
Number of hoggets	15	13
Initial weight, kg $\pm$ s.d.	41.5 $\pm$ 3.89	40.8 $\pm$ 3.87
Final weight, kg $\pm$ s.d.	55.6 $\pm$ 5.10	54.7 $\pm$ 7.50
Average daily gain, g $\pm$ s.d.	99 $\pm$ 4.77	98 $\pm$ 6.28
kg DM per kg gain	10.7	10.7
Number of ewes lambed	9	6
Lambs born: n,	16	10
per ewe lambing	1.78	1.67
per ewe in group	1.07	0.77

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2.5 THE PERFORMANCE OF EWES AND LAMBS KEPT IN INDIVIDUAL PENS AS COMPARED WITH GROUP PENS

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ABSTRACT

Eight individually-penned (IP) ewes were compared with seven group-penned (GP) ewes during the last 7 weeks of gestation and first 7 weeks of lactation. The ration consisted of poultry litter (PL), wheat straw (WS) given ad lib., and corn and hay. The GP ewes consumed more WS and PL, while the IP ewes consumed more corn. Altogether, the group-fed ewes ate on the average 9% more DM/kg $W^{0.75}$, but the difference in energy intake was only 4%. IP ewes lost more body fat and energy during pregnancy than GP ewes, but the opposite was true during lactation. There were no differences in the birth weights or development of Finn-Awassi lambs under the two treatments. However, for Finn x Mutton Merino ewes, birth weights (kg), weaning weights (kg), and growth rates (g/day) (least square means $\pm$ SE) were 2.9 ± 0.20 , 14.0 ± 0.87 and 210 ± 16 , respectively, for IP; and 3.9 ± 0.29 , 17.9 ± 1.50 and 274 ± 28 for GP ($P < 0.05$).

INTRODUCTION

Lines and Pierce (1931) demonstrated that putting Merino sheep in individual pens had a marked effect on their metabolism and activity. Southcott *et al.* (1962) reported reduced productivity associated with changes in grazing behavior when flock size was less than four sheep, and Kilgour (1972) claimed that two sheep are not "sheep" as far as behavior is concerned.

In experimenting with sheep, as with other experimental animals, it is frequently necessary to maintain them in individual pens, especially when the experiments have to be carried out with small numbers of animals and when individual intake measurement is desired to enable statistical evaluation of treatment effects. It is therefore important to acquire some quantitative information about the effect of penning in individual pens on feed intake and productive performance. The degree of isolation between sheep could also play a role and in the present study it was intended, preliminarily, to test whether the maintenance of visual and oral contact with neighboring individually-penned animals or with group-penned ones could minimize abnormalities in feed intake and in performance.

MATERIALS AND METHODS

Sheep

Nineteen Finn x Mutton Merino (FM) and Finn x Awassi (FA) pregnant ewes were used. They were allocated to treatments 7 weeks prior to the expected lambing date.

Feeds

The ration was composed of poultry litter (PL), crushed corn grains, vetch-oats hay and wheat straw (WS). The feeds were of the same lots as those used in experiment 2 described by Kali *et al.* (Chapter 2.1).

Experimental

Eight ewes (4 FM and 4 FA) were individually penned (IP) in 2 m x 2 m pens when they were 7 weeks before their expected lambing date. Eleven similar ewes were maintained as a group (GP). Of this last group, four ewes failed to lamb within the 6 days in which all the rest of the ewes lambed (they lambed only several weeks later), so they were discarded from the experiment and only seven ewes were left for the comparison during the lactation period. Three of these nursed twins and four singles and they were maintained in separate pens accordingly. The pens had concrete floors bedded with sawdust, so that any straw or hay that fell on the floor could be gathered up when orts were collected daily, and weighed before the new meal was fed.

The partitions between pens consisted of iron frames with 10 x 10 cm mesh wire netting, so that isolation was minimal.

Two weeks after lambing, a self-feeder with concentrate pellets (88.1% DM, 22.4% protein) was attached to the outside of each pen with an opening in the partition big enough only for the lambs to reach their heads through for eating. Pellets were added in weighed quantities whenever necessary, and the remains were weighed on the day of weaning at 50 days of age.

Ewes were weighed and their condition was scored (Jeffries, 1961), 7 weeks before lambing and one and 7 weeks after lambing (at weaning). On weighing days, the ewes' body composition was estimated using the tritiated water dilution method (Donnelly and Freer, 1974).

RESULTS

Feed intake

As may be seen from Tables 2.5.1 and 2.5.2, there were differences between the IP and GP ewes both during advanced gestation (Table 2.5.1) and during lactation (Table 2.5.2). The IP ewes tended to eat 20% less

Table 2.5.1 FEED INTAKE DURING THE LAST 6 WEEKS OF GESTATION BY EWES KEPT IN INDIVIDUAL PENS, COMPARED WITH GROUP-FED EWES (MEANS±S.D.)

Type of gestation ^a	Weeks pre-lambing	Feed intake (g/day)				
		PL	Corn	Hay	WS	DM/W ^{0.75}
<u>Individually-penned sheep</u>						
Twin (4)	6	350±0	500±0	-	756±83	63
	3	436±13	500±0	330±136	593±112	72
	1	324±44	663±78	596±64	186±17	68
Single (4)	6	350±0	500±0	-	769±60	63
	3	438±9	500±0	342±87	607±102	73
	1	331±25	651±42	653±18	211±90	71
<u>Group-penned sheep</u>						
Twin & Single (7)	6	350	500	-	880	66
	3	440	500	500	653	79
	1	535	532	653	313	78

(a) Number of ewes is given in parentheses

WS and hay and a bit more corn, compared with the group-penned ewes. Differences were greatest in the last week before lambing, when PL intake was ~60% higher in the GP ewes. Altogether, the GP ewes consumed between

Table 2.5.2 FEED INTAKE DURING LACTATION BY EWES KEPT IN INDIVIDUAL PENS, COMPARED WITH GROUP-FED EWES (MEANS $\pm$ S.D.)

Type of lambing ^a	Weeks post-lambing	Feed intake (g/day)				
		PL	Corn	Hay	WS	DM/W ^{0.75}
<u>Individually-penned sheep</u>						
T (4)	2	407±100	764±25	717±57	564±105	93
	6	506±50	795±5	725±50	398±20	93
S (4)	2	391±20	743±77	686±17	527±66	90
	6	501±31	788±8	700±0	521±220	97
<u>Group-penned sheep</u>						
T (3)	2	550	737	700	624	99
	6	550	790	700	633	101
S (4)	2	550	718	700	560	96
	6	550	770	700	575	98

^aT = twins; S = singles; number of ewes is given in parentheses.

5 and 9% more dry matter (DM) per kg metabolic body weight ($W^{0.75}$) but due to the partial compensation gained by the intake of corn by the IP ewes, differences in energy intake were only ~4-6%. Since individual intake recordings could not be made in this experiment for the GP ewes, it was not possible to evaluate the results statistically.

Body weight and composition change

The results presented in Tables 2.5.3 and 2.5.4 show only small, statistically non-significant differences between treatments. There was a trend for IP ewes to lose more fat (and energy) during the last stage of pregnancy and to gain a little during lactation, while the GP ewes continued to lose during lactation.

Lamb performance

Twelve lambs were born to the eight IP ewes, and 11 to the seven GP ewes. Two twin lambs (one in IP and one in GP) died soon after birth, so there was one lamb born as a twin and reared as a single in each group.

There was a genotype x treatment interaction ($P < 0.002$). FM lambs were significantly smaller at birth and weaning among the IP animals compared with the GP ones. There was no such difference in the FA lambs (Table 2.5.5). However, the litter size had a highly significant effect on birth weight ($P < 0.005$) and there was a nearly significant ($P < 0.06$) litter size x treatment interaction (only for birth weight); most of the twin births in the IP ewes occurred among the FM ewes.

Table 2.5.3 CHANGES IN BODY WEIGHT (BW) AND BODY CONDITION SCORES (CS) FROM 7 WEEKS PRE-LAMBING TO WEANING OF EWES KEPT IN INDIVIDUAL PENS, COMPARED WITH EWES MAINTAINED IN GROUPS (MEAN±S.D.)

Treatment	Weeks relative to lambing					
	-7		+1		+7	
	BW (kg)	CS	BW (kg)	CS	BW (kg)	CS
Individual pens	65.9±8.76	3.25±0.38	63.3±7.17	3.13±0.58	60.1±6.63	2.63±0.52
Group pens	67.9±5.01	2.79±0.57	64.1±6.10	2.86±0.69	60.0±7.83	2.07±0.61

Table 2.5.4 ESTIMATED BODY FAT, PROTEIN AND ENERGY LOSS OR GAIN DURING LAST 7 WEEKS OF GESTATION AND FIRST 7 WEEKS OF LACTATION OF EWES KEPT IN INDIVIDUAL PENS OR IN A GROUP (MEANS±S.D.)

Period:	Gestation			Lactation		
	Fat	Protein	Energy	Fat	Protein	Energy
Individually penned	-8.93±5.56	-0.19±0.21	-356±222	+1.64±2.11	-0.24±0.17	+59±88
Group penned	-7.71±5.58	-0.25±0.42	-310±38	-0.32±6.33	-0.34±0.18	- 21±247

Table 2.5.5 LEAST SQUARES MEANS (±S.D.) OF BIRTH WEIGHT, WEANING WEIGHTS AND GROWTH RATES OF LAMBS FROM BIRTH TO WEANING

Variable	Treatment			
	Individual pens		Group pens	
	FM (7)*	FA (5)	FM (3)	FA (8)
Birth weight, kg	2.9±0.20 ^a	4.0±0.20 ^b	3.9±0.29 ^b	3.6±0.17 ^b
Weaning weight, kg	14.0±0.87 ^a	16.6±0.84 ^b	17.9±1.50 ^b	17.0±0.75 ^b
Growth rate, g/day	210±16 ^a	272±16 ^b	274±28 ^b	276±14 ^b

*FM = Finn x Mutton Merino; FA = Finn x Awassi; number of animals is given in parentheses

^{a,b} Means with different superscripts differ significantly (birth weight, $P < 0.01$; weaning weight, $P < 0.05$; growth rate, $P < 0.05$).

As the FM and FA ewes were kept together in the group pens, it is impossible to analyze lamb concentrate intake according to genotype. The data shown in Table 2.5.6 indicate reduced intake in the IP lambs compared with the GP twins.

Table 2.5.6 ESTIMATED INTAKE (MEANS $\pm$ S.D.) OF CONCENTRATES (KG) BY LAMBS DURING THE LAST 30 DAYS OF THE SUCKLING PERIOD (THE LAMBS WERE WEANED AT THE AGE OF 50 DAYS: NUMBER OF LAMBS IS GIVEN IN PARENTHESES)

Treatment	Singles	Twins ^a
Individual pens	4.070 $\pm$ 0.84 (5)	4.000 $\pm$ 0.838 (6)
Group pens	3.500 (4)	10.000 (6)

^aper litter

DISCUSSION

When sheep are put in individual cages, e.g. for digestion trials, or in respiration chambers, where they are partially or completely isolated from other animals, a varying period of time is required for adjustment. The length of time required for an animal to "settle down" differs with genotype and individual. Thus, Graham (1961, personal communication) met with considerably greater difficulty in getting Australian Merinos to become accustomed to isolation conditions, compared with some of the British Down breeds. Although there has been a hint of a possible genotype difference in the present study, numbers are too small to justify any conclusions in this respect.

The fact that GP ewes ate a little more than the IP ones may be explained partly by their greater requirements due to greater freedom for activity. Benjamin *et al.* (1977) and Coop and Hill (1962) have shown that grazing sheep have a maintenance requirement approximately 1.75 times that of penned animals, and smaller or greater differences were reported also by others. The magnitude of differences to be expected between individually and group-fed sheep when both are penned is, of course, much smaller. The fact that the IP ewes lost more body energy and that their lambs' performance was somewhat inferior, suggests that behavioral emotional elements were involved.

The magnitude of the differences altogether was small. One has, therefore, to conclude that IP sheep under minimal isolation with the FM or FA sheep can represent intake and performance patterns of GP sheep within 4-20% accuracy limits, dependent on the variable measured.

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2.6 THE EFFECT OF REPLACING CONCENTRATE PELLETS BY POULTRY LITTER AND GRAIN IN THE PREGNANCY AND LACTATION RATIONS OF FINN-CROSS EWES

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ABSTRACT

Two experiments were conducted to study the feasibility of replacing commercial concentrates (CON diet) by poultry litter (PL) as a source of protein and minerals, and by corn grain as a source of energy (PLG diet) during the last 6 weeks of gestation and 7 weeks of lactation. Forty-eight and 47 Finn cross ewes (Finn x Mutton Merino and Finn x Awassi) were included in the CON and PLG groups, respectively, in exp. 1 and 30 and 33 in exp. 2.

The daily PL allowance was calculated to comply with the protein requirements of the ewes. Wheat straw (WS) was offered ad lib. and its intake by ewes diminished more markedly in the CON, compared with the PLG treatment when the concentrate component of the diet started to be increased 6 weeks prior to the expected lambing date. There were no differences between the treatments in body weight losses or gains. However, body fat (estimated by the tritiated water dilution method) one week post-lambing was $69 \pm 45\%$ and $42 \pm 14\%$ of that estimated 7 weeks pre-lambing for single and twin-bearing ewes, respectively, for the PLG group ($P < 0.05$), and 79 ± 19 and 75 ± 21 (n.s.) for the CON ewes. The respective values for body energy were 91 ± 32 , 54 ± 13 , 85 ± 10 and 80 ± 29 .

There were no differences in lambing rate or lamb survival between the two treatments. There were no differences in lamb birth weight but PLG twin lambs gained at a rate of 205 ± 7 g/day, compared with 229 ± 8 for the CON lambs from birth to weaning ($P < 0.03$).

There were no differences between treatments in single lambs, and the difference in twin lambs disappeared by the age of 150 days.

There were no post-experimental statistically significant differences in reproductive performance between ewes that had been fed on the two diets.

INTRODUCTION

Poultry litter (PL) is a low-energy, high-nitrogen supplement. During recent years it has been used as a component of rations for ruminants. The main aim of using this material is to reduce feeding costs, mainly those of meeting the protein requirements (Bhattacharia and Taylor, 1975; Tagari, 1978). The energy included (6.5-8.5 MJ/kg DM) is valuable as well.

Uncontrolled feeding of PL may bring about the consumption of excess protein and minerals (both macro- and minor elements) and cases of calcosinosis and of copper poisoning as a result of PL intake by sheep have been reported in the literature (e.g. Neuman *et al.*, 1976; Suttle *et al.*, 1978; Yehuda, 1981).

Under Israeli conditions most intensive sheep enterprises are run under partial or complete confinement. Land use for fodder production is limited and therefore concentrates largely composed of imported grain and soybean oil meal are a common component of rations. Replacing these expensive commercial concentrates by PL and grain (if possible unprocessed; see Ørskov *et al.*, 1977) could reduce considerably the costs of feeding. PL has been used by commercial producers with Finn-crosses under frequent-lambing regimes, but there are no reports in the scientific literature on its use with such sheep.

The aim of this study was to test the feasibility of replacing concentrates by PL and grain in pregnancy and lactation rations of Finn-cross ewes. To avoid undue nutritional imbalances, the rule was followed that PL inclusion in a ration should not exceed a rate sufficient to supply the estimated nitrogen requirements.

MATERIALS AND METHODS

Experiments

Two experiments were carried out with the Bet Dagan experimental flock: exp. 1 during November to March (lambing in January-February) and exp. 2 in March-July (lambing in May-June). The sheep were maintained in a barn on straw bedding in exp. 1 and on a dirt floor without bedding in exp. 2. In exp. 2 the floor was cleaned daily of sheep droppings and straw pieces which fell off the troughs. There were two treatments in each experiment: a control, in which sheep were fed wheat straw (WS), some hay (in advanced pregnancy and through lactation) and a pelleted commercial concentrate mixture (CON); or a ration in which the concentrate mixture was replaced by PL and grain (PLG). Experiment 1 was started when the ewes were 13 weeks, and exp. 2 seven weeks pre-lambing.

Feeds and rationing

The sheep were group-fed. The feeds used and their proximal composition are listed in Table 2.6.1. Whole barley grain was used in

exp. 1 and crushed corn in exp. 2. The choice of the grain was based on their market prices.

The feeding plan in exp. 1 is shown in Tables 2.6.2 and 2.6.3. Refusals were not collected in this experiment and actual intake of the roughage components was less than shown in these tables. The feeding plan in exp. 2 was the same as in exp. 1. Lambs had access to concentrate pellets through a creep from the age of 2 weeks onwards.

Table 2.6.1 CHEMICAL COMPOSITION (PROXIMAL ANALYSIS) OF FEEDS USED IN TWO PERFORMANCE EXPERIMENTS

Feed	Exp. no.	DM (%)	Nx6.25 —— (% of DM)	Fiber	Fat	Ash	Ca* (g/kg)	P* (g/kg)	Cu* (mg/kg)	ME (kJ/g)
Wheat	1	90.0	3.0	39.9	1.4	8.3	1.7	0.8	3	6.30
straw	2	92.3	4.9	38.4	1.6	11.9	1.7	0.8	3	6.30
Vetch hay	1	92.0	16.0	29.9	1.3	10.0	13.6	3.4	10	8.80
Vetch + oats hay	2	89.8	15.9	30.2	2.2	10.9	8.1	3.0	7	8.37
Barley	1	87.6	12.2	5.8	2.3	3.0	0.8	4.6	9	12.55
Corn	2	86.3	10.4	2.7	4.2	1.5	0.2	2.9	4	13.80
Concen- trates	1	88.8	16.9	4.8	2.7	8.4	8.0	6.0	10**	11.70
	2	87.7	17.9	3.7	3.4	8.4	13.0	3.3	10**	12.10
Poultry litter	1	84.7	24.4	12.2	2.1	19.1	34.2	20.0	31	6.40
	2	90.4	30.4	12.3	1.7	19.2	27.6	18.8	49	6.50

*Only PL and concentrate mixtures were analyzed. Other values are estimates taken from NRC (1975) and Morrison (1951).

**Maximum permitted; not chemically analyzed.

Table 2.6.2 MEAN DAILY RATIONS OFFERED TO EWES IN EXPERIMENT 1 DURING WEEKS 13-8 PRE-LAMBING

Components	DM		ME (MJ)	Protein (g)	Ca (g)	P (g)	Cu (mg)
	kg	%					
<u>Poultry litter + corn grain group</u>							
Poultry litter	0.30	20.9	1.92	72	10.1	5.9	9.3
Barley	0.22	15.5	2.76	27	0.2	1.0	2.0
Wheat straw	0.90	63.6	5.67	27	1.5	0.7	2.7
Total	1.42	100.0	10.25	126	11.8	7.6	14.0
Per kg of ration			7.27	89			10.0
<u>Concentrate group</u>							
Concentrates	0.44	33.0	5.15	74	3.6	2.7	4.4
Wheat straw	0.90	67.0	5.67	27	1.5	0.7	2.7
Total	1.34	100.0	10.82	101	5.1	3.4	7.1
Per kg of ration			8.07	75			5.3
NRC (1975) Allowance	1.30		10.88	117	3.1	2.9	

Table 2.6.3 MEAN DAILY ALLOWANCE OF RATIONS OFFERED TO EWES IN EXP. 1 DURING THE LAST 7 WEEKS OF GESTATION (THE RATION OF THE LAST WEEK WAS CARRIED ON THROUGH 7 WEEKS OF LACTATION)

Week pre-lambing	Exp. ration	Dry matter offered (kg)					ME (MJ)		Nx62.5(g) per kg	Ca (g)	P (g)	Cu (mg)		
		Total	PL	Barley	Conc.	WS	Hay	Total					per kg	
7	PLG	1.68	0.30	0.48	-	0.90	-	13.6	8.10	159	95	12.0	8.8	16
	CON	1.70	-	-	0.62	1.08	-	14.1	8.27	137	81	6.5	4.4	9
6	PLG	1.77	0.30	0.57	-	0.90	-	14.7	8.33	170	96	12.1	9.2	17
	CON	1.79	-	-	0.71	1.08	-	15.1	8.44	152	85	7.5	5.1	10
5	PLG	1.81	0.30	0.61	-	0.90	-	15.2	8.40	175	97	12.1	8.8	17
	CON	1.80	-	-	0.80	1.00	-	15.7	8.72	165	92	8.1	6.5	11
4	PLG	1.81	0.34	0.66	-	0.81	-	15.6	8.65	188	104	13.5	10.3	19
	CON	1.78	-	-	0.88	0.90	-	16.0	8.99	176	99	8.6	6.0	12
3	PLG	2.04	0.38	0.66	-	0.72	0.28	17.7	8.68	240	118	18.4	12.0	23
	CON	2.02	-	-	0.98	0.76	0.28	18.7	9.27	233	115	12.9	7.4	15
2	PLG	1.89	0.42	0.79	-	0.31	0.37	17.8	9.42	267	141	20.6	13.4	25
	CON	1.88	-	-	1.11	0.40	0.37	18.8	9.98	259	138	14.6	8.2	16
1	PLG	2.07	0.47	0.96	-	0.18	0.46	19.4	9.38	311	150	23.1	15.3	29
		2.02	-	-	1.33	0.23	0.46	21.1	10.42	307	152	17.3	9.7	19
NRC(1975)allowance		2.10						19.3	9.16	205	95	4.5	4.3	

PLG = poultry litter + corn grain

CON = concentration

WS = wheat straw

Sheep

In exp. 1 there were 47 and 48 sheep, and in exp. there were 33 and 30, in the PLG and CON groups, respectively. The sheep were of the Finn x Mutton Merino and Finn x Awassi crosses and the groups were balanced for genotype, age, expected lambing date and, in exp. 2, also body weight and condition scores (Jeffries, 1961). Mean body weights at the onset of exp. 2 were 58 ± 10.9 and 59 ± 9.3 kg for the CON and PLG groups, respectively. In this experiment 60% of the ewes were primiparous (age 13-19 months at lambing).

All ewes were vaccinated against botulism prior to the start of the experiments and injected with a dose of 200,000 IU of vitamin A and 20,000 IU of vitamin D. The vitamin injection was repeated 2 months later.

Measurements

All feeds were weighed daily. In exp. 2 orts were collected daily and weighed as well. Sixteen sheep of the PLG and 16 of the CON groups in exp. 2 were weighed 7 weeks pre- and 1 and 7 weeks post-lambing. Lambs were weighed at birth, at weaning and at the age of 5 months.

Body composition changes were also estimated in those ewes on the same days on which they were weighed, using the tritiated water dilution method (Donnelly and Freer, 1974).

Post-experimental reproductive activity and performance of those ewes which remained in the flock (i.e., not culled and did not die) were followed up to the subsequent lambing.

RESULTS

Feed intake

As mentioned before, actual intake was not measured in exp. 1. It may, however, be assumed that it did not differ from what was found in exp. 2, namely, that variation from the offered ration occurred only in the intake of WS. The slightly lower apparent ME intakes in the PLG group compared with the CON group in exp. 1 may be attributed to the fact that during planning of the ration, the energy value of PL had been overestimated.

The figures in Table 2.6.4 show that as soon as the concentrates' level in the CON group started to rise above the 0.6 kg level (6 weeks pre-lambing), there started a reduction in WS intake. A similar reduction occurred in the PLG group only upon the addition of hay to the ration. Thus, the ewes in this group managed to maintain ME intake similar to the CON group up to the start of the second week pre-lambing. In the last 2 weeks of pregnancy and during lactation the PLG ewes consumed slightly less energy than the CON group. The amount of crude protein consumed by the two groups was similar. There was about 1.5 to 2 times the amount of Ca, P and Cu in the PLG compared with the CON ration.

Table 2.6.4 MEAN DAILY INTAKE OF RATIONS OFFERED TO EWES IN EXP. 2 DURING THE LAST 6 WEEKS OF GESTATION
(THE RATION OF LAST WEEK WAS CARRIED ON THROUGH 7 WEEKS OF LACTATION)

Week pre-lambing	Exp. ration	Dry matter intake (kg)					ME (MJ)		Nx6.25 g		Ca (g)	P (g)	Cu (mg)	
		Total	PL	Barley	Conc.	WS	Hay	Total	per kg	Total				per kg
6	PLG	1.13	0.32	0.47	-	0.34	-	10.71	9.48	162	143	9.5	7.7	19
	CON	0.98	-	-	0.62	0.36	-	9.77	9.97	122	124	8.7	2.3	7
5	PLG	1.35	0.33	0.52	-	0.50	-	12.47	9.24	169	125	10.4	8.1	20
	CON	0.99	-	-	0.70	0.29	-	10.30	10.40	140	141	9.6	2.5	8
4	PLG	1.48	0.39	0.55	-	0.54	-	13.53	9.14	202	137	11.8	9.4	23
	CON	1.11	-	-	0.79	0.32	-	11.58	10.43	157	142	10.8	2.9	9
3	PLG	1.69	0.39	0.58	-	0.36	0.36	15.82	9.36	254	150	14.4	10.4	25
	CON	1.48	-	-	0.92	0.20	0.36	15.41	10.41	232	157	15.2	4.3	12
2	PLG	1.70	0.45	0.68	-	0.21	0.36	16.64	9.79	275	162	15.8	11.7	28
	CON	1.61	-	-	1.10	0.15	0.36	17.27	10.73	261	162	17.5	4.8	14
1	PLG	1.85	0.45	0.83	-	0.12	0.45	18.90	10.22	301	162	16.4	12.5	29
	CON	1.82	-	-	1.32	0.05	0.45	20.05	11.02	310	170	20.9	5.7	17
Lactation (7 weeks)	PLG	1.88	0.45	0.86	-	0.11	0.46	19.34	10.29	305	162	16.5	12.4	29
	CON	1.92	-	-	1.32	0.11	0.49	20.77	10.82	320	166	21.3	5.9	17

PLG = poultry litter + corn grain

CON = concentration

WS = wheat straw

Body weight and composition changes of ewes

There were no apparent differences in the body weight or condition changes between the PLG and CON groups (Table 2.6.5). Unfortunately, many of the blood samples of the 32 ewes which were tritiated for body composition estimation, were accidentally lost. Therefore, results are shown in Table 2.6.6 for six PLG and 11 CON ewes only (out of 16 treated in each group). These results indicate that the body weight loss during the last weeks of pregnancy was accompanied by a loss of body fat (and energy). In addition, in the PLG groups the loss in twin-bearing ewes was considerably greater than in single-bearing ones.

Table 2.6.5 BODY WEIGHT (BW) AND BODY CONDITION SCORES (CS)^a OF 16 POULTRY LITTER + CORN GRAIN (PLG) AND 16 CONCENTRATES (CON)-FED EWES 7 WEEKS PRE-LAMBING, AFTER LAMBING AND AT WEANING (MEANS±S.D.)

Treatment	Time (weeks relative to lambing)		
	7 pre-	1 post-	7 post-
PLG, BW, kg	58.4±9.44	54.2±9.28	59.4±9.12
CS, scores	3.3±1.03	3.4±0.89	3.3±1.11
CON, BW, kg	64.2±11.67	60.2±10.89	65.7±9.68
CS, scores	3.5±1.08	3.4±1.11	3.4±0.85

^aAccording to Jeffries (1961)

Table 2.6.6 APPARENT BODY FAT AND ENERGY LOSSES IN LATE PREGNANCY (MEANS±S.E. OF ONE WEEK POST-LAMBING VALUES, AS PERCENTAGE OF 7 WEEKS' PRE-LAMBING VALUES)

Treatment	Poultry litter + corn grain		Concentrates	
	Single	Twin	Single	Twin
n	3	3	5	6
Fat	69±45.4 ^{bc}	42±14.4 ^a	79±18.6 ^b	75±20.5 ^b
Energy	91±31.7	54±13.3 ^a	85±9.9 ^b	80±28.6 ^b

^{a,b,c}Values in the same line with different superscripts differ significantly: a < b, P<0.01; a < c, P<0.05.

Survival and performance of lambs

There were no differences in lambing rates and lamb mortality between treatments (Table 2.6.7). Mortality, however, was considerably higher in exp. 2 than in exp. 1 (Table 2.6.7). This may have been due to one of three causes:

1. There was an apparent parainfluenza (PI₃) viral abortion outbreak in the flock during the spring of 1981 when this experiment took place, which led to a large number of still-born and weak lambs.
2. A high proportion of the ewes in this experiment were primiparous.
3. The fact that ewes lambd onto an unbedded dirt floor may have contributed to a higher rate of exposure to contagious factors.

Table 2.6.7 LAMBING RATE AND LAMB MORTALITY (BIRTH TO WEANING) IN TWO EXPERIMENTS

Exp. No.	Treatment	Number of ewes	Lambs born		Mortality ^a (birth to weaning)
			Number	per ewe	
1	PLG ^b	47	77	1.64	9.1
	CON	48	76	1.58	10.5
2	PLG	33	52	1.58	34.6
	CON	30	47	1.57	40.4

^aIncluding stillborn lambs, which accounted for more than 40% of the mortality in exp. 2.

^bPLG = poultry litter + corn grain; CON = concentrates.

The overall performance of lambs was worse in exp. 2 than in exp. 1. However, there was no treatment x experiment interaction and therefore all the data were pooled for analysis of the treatment effects. As shown in Table 2.6.8, there were no differences in birth weight between lambs born to ewes on the PLG, compared with the CON ration. There was, however, a treatment x litter size interaction in weaning weights and in growth rates from birth to weaning. While there were no treatment effects on the development of single lambs, twins reared by ewes fed the PLG ration grew at a significantly slower rate than those reared by ewes fed the CON ration. Triplets showed the same trend. The difference, however, was statistically not significant in this case, due to the small number of lambs involved and the relatively large within-group variability. All the between-treatment differences disappeared by the time the lambs reached the age of 150 days.

Post-experimental reproductive performance

There were no statistically significant differences between treatments in the time required for the post-partum resumption of reproductive activity, in conception and in lambing rates (Table 2.6.9). However, it should be noted that there were slightly fewer lambs born per ewe lambing in the PLG-fed ewes in both experiments, and that in exp. 2 the PLG-fed ewes were somewhat slower to conceive.

Table 2.6.8 LEAST SQUARE MEANS ($\pm$ S.E.) OF VARIABLES DESCRIBING LAMB PERFORMANCE (DATA OF TWO EXPERIMENTS POOLED TOGETHER)

Litter size		1		2		3	
Treatment		PLG	CON	PLG	CON	PLG	CON
Birth weight, n		31	31	76	69	5	7
kg		4.5 $\pm$ 0.16 ^a	4.3 $\pm$ 0.17 ^a	3.5 $\pm$ 0.11 ^b	3.5 $\pm$ 0.11 ^b	3.7 $\pm$ 0.42 ^{bc}	3.8 $\pm$ 0.36 ^{bc}
Weaning weight, n		27	26	73	62	4	6
kg		16.5 $\pm$ 0.66 ^a	16.8 $\pm$ 0.69 ^a	13.0 $\pm$ 0.42 ^b	14.3 $\pm$ 0.47 ^c	14.9 $\pm$ 1.74 ^{abc}	16.5 $\pm$ 1.43 ^{ac}
Birth to weaning, n		27	26	73	62	4	6
Growth rate, g/day		274 $\pm$ 11 ^a	269 $\pm$ 11 ^a	205 $\pm$ 7 ^b	229 $\pm$ 8 ^c	233 $\pm$ 29 ^{acd}	277 $\pm$ 23 ^{ad}
Weight at 150 days, n		25	21	61	63	2	4
kg		47.5 $\pm$ 1.24	46.0 $\pm$ 1.39	44.8 $\pm$ 0.83	44.8 $\pm$ 0.93	43.1 $\pm$ 4.45	48.6 $\pm$ 3.16

*Means with different superscripts differ significantly. Probability levels of significance:

Birth weight, a > b, $P < 0.001$; a > c, $P < 0.08$.

Weaning weight, a > b, $P < 0.0001$; a > c, $P < 0.005$; b < c, $P < 0.03$; ac > b, $P < 0.02$.

Weight, 150 days, all differences are statistically non-significant.

PLG = poultry litter + corn grain; CON = concentrate.

Table 2.6.9 POST-EXPERIMENTAL REPRODUCTIVE PERFORMANCE OF EWES REMAINING IN THE FLOCK (MEANS $\pm$ S.E.; NONE OF THE DIFFERENCES IS STATISTICALLY SIGNIFICANT)

Exp. no. Treatment	1		2	
	PLG	CON	PLG	CON
Ewes remaining	43	40	24	22
Days to 1st estrus	129 $\pm$ 3.7	126 $\pm$ 3.7	109 $\pm$ 5.7	112 $\pm$ 5.5
Days to conception	162 $\pm$ 9.3	162 $\pm$ 9.6	135 $\pm$ 13.5	115 $\pm$ 13.1
Dry ewes, %	16.3	20.0	8.3	0.0
Late to conceive, % ^a	32.6	30.0	16.7	9.1
Lambs born/ewes lambing	1.75 $\pm$ 0.15	1.93 $\pm$ 0.13	1.82 $\pm$ 0.14	2.00 $\pm$ 0.17

^aMore than 150 days post-partum

DISCUSSION

There are no reports in the literature for comparison on the feeding of PL to Finn-cross (prolific) ewes in late pregnancy and lactation. The planning of the present rations was based on earlier results with Awassi ewes (Benjamin *et al.*, 1980). The Finn-cross ewes, however, consumed about 50% less roughage (WS + hay) than the Awassis (WS only) in the CON group, and about 10% less in the PLG group. The possibility of genotype differences in intake (and digestion) has been discussed by Kali *et al.* (Ch. 2.1). In agreement with this report is also the fact that ewes fed on a ration with PL consumed more straw, in spite of the fact that the PLG ration, as a whole, had a lower energy concentration.

Altogether, the PLG ration consumed by the ewes apparently contained less energy than the CON ration in the last 2 weeks of gestation and during lactation, and this is reflected in the greater body fat (and energy) losses in twin-bearing ewes in this group during advanced pregnancy and in the slower growth rate of twin lambs, which is indicative of lower milk yields of their dams. The body composition estimates were arrived at by the tritiated water dilution method. These have to be taken with some reservation, as shown by Robinson *et al.* (1978) and by Cowan *et al.* (1979). However, our results are in agreement with findings of these authors, who also showed that it is very difficult for ewes carrying two or more foetuses to maintain an energy balance. They also confirm the estimates made by Yehuda (1981) on the metabolizability of the digestible energy of PL as being lower (0.76) than the conventional figure of 0.82. Drori (1976) and Bruckenthal and Drori (1980) provided some evidence (with rats) that excess of minerals reduces fat deposition and the efficiency of fat synthesis, all of which means that the energy values attributed to PL when formulating the rations were probably too high. Therefore, more grain should have been included in the PLG ration for it to become equal, on an energy basis, to the CON ration.

In the short run, the energy deficit in the PLG ration was not of practical importance, as it had no effect on the immediate health of the ewes or on lamb survival. Furthermore, the post-weaning development of the lambs was not impaired. Those lambs which were smaller at weaning compensated for the lag, as reflected by the fact that they did not differ in their weights at 150 days of age. This is in agreement with Goot et al. (1982), who also showed that when lambs were weaned onto an appropriate diet, differences of 2-3 kg in weaning weight had no effect on their final age or weight.

This study did not give any clear indications of any long-term effects of the PLG ration. The absolutely non-significant difference in the post-experimental reproductive performance should, however, not be completely overlooked, as they all point in the same direction (Table 2.6.9). Whether they are true or not and, if they are, whether they were a result of the energy deficit or of some specific detrimental factor in the PL, remains to be elucidated in future work. Differences between exp. 1 and 2 may be attributed to the fact that in the former, lambing took place a longer time away from the breeding season (Amir et al., chap. 4).

The present results show that it is possible to save on feed costs by the inclusion of PL in rations for prolific sheep, but care must be taken. Until long-term experiments are carried out, the use of PL may be recommended in small quantities or as a temporary feed, e.g., as a supplement during the dry pasture season with the green season serving as a recovery period from any unforeseen damage.

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2.7 LITTER SIZE DIAGNOSIS IN PREGNANT EWES BY LAPAROTOMY AND BY RADIO-
GRAPHY

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ABSTRACT

In two trials, uterine palpation through laparotomy at 20-25 days of pregnancy resulted in 60 and 63% accurate diagnoses. Most of the apparent inaccuracies were a result of post-operational fetal losses. Apparent total embryonic losses, comparing CL counts with actual number of lambs born, amounted to 36.2% and 47.9%, respectively, in the two trials. Laparotomies during the third month of pregnancy (two trials) resulted in about 90% correct diagnoses, but were followed by difficulties in the healing process of the operational wound.

In another three trials, x-ray radiography resulted in 58-77% accurate diagnoses and 87-93% correct differentiation between single and multiple pregnancies.

INTRODUCTION

In the present series of experiments, as in others dealing with the nutritional requirements of the pregnant ewe, we required an early and accurate diagnosis of fetal number. For this purpose, the technique had to be safe, quick, reliable and not unduly expensive.

Laparotomy or laparoscopy was shown to be practical and fairly accurate for predicting the number of fetuses present at early stages of gestation, e.g., 4 or 8 weeks (Lammond, 1963), 17-28 days (Phillippo *et al.*, 1971), and 30 to 42 days (Phillippo and Rhind, 1977). Radiography has been used with more than 90% accuracy after the 80th day of pregnancy (e.g., Benzie, 1951; Ford *et al.*, 1963; Wenham and Robinson, 1972; Rizzoli *et al.*, 1976). The use of ultrasonics has also been attempted at a similar range of pregnancy stages (Lindahl, 1976).

The only comprehensive work on radiographic pregnancy diagnosis in sheep with a high frequency of fetal numbers greater than two, is that of Wenham and Robinson (1972). There are no reports on the use of laparotomy for pregnancy diagnosis in prolific sheep, but Phillippo *et al.* (1971) and Phillippo and Rhind (1977) studied laparoscopies in such ewes.

Possible advantages of laparotomies include early diagnosis, and the possibility of accurate counting of corpora lutea and eventual palpation of the uterine horns for further verification of fetal number.

The operation is a very simple one. It does not require general anaesthesia and is relatively cheap. The main disadvantages are that when made at an early stage (less than 4 weeks of pregnancy), embryonic losses may occur after the operation, some of which may be a direct result of the operation (Cutten, 1970). Cutten found, however, that post-operational losses were considerably less among twin-ovulating ewes than among single-ovulating ones. Therefore, it may be hoped that the problem might be of less importance in prolific sheep.

The aim of the present study was to help in selecting a diagnostic technique for fetal numbers, compatible with our financial and facility constraints.

MATERIALS AND METHODS

Uterus palpation and visualization via laparotomy

Four trials were made, designated L1-L4. Numbers of ewes involved are indicated in the Tables of the results. In trials L1 and L2, ewes were laparotomized between days 20 and 25 post-mating (trial L1, 20-25 and trial L2, on day 21). In trials L3 and L4, laparotomies were done between days 65 and 88 post-mating.

Ewes were starved (food and water) for 36 hours before the operation and were treated with a tranquilizer (10 mg xylazine* injected i.m.) and eventually another dose of Rompun (0.2-0.4 ml) i.m. or i.v. was given (trials L1, L2 and L3). In trial L4 local anaesthesia was also applied (10 cc of 2% xylocaine**, injected s.c.). The ewes were placed on their backs in

*Rompun-Bayer

**Vitamed-Holon

an operation cradle and tilted head down to an angle of 40° from the horizontal in order to move the abdominal contents away from the pelvic area. The length of the abdominal mid-line incision at 20-25 days of gestation was 20-30 mm and that for the laparotomy at 65-88 days of gestation was 100-200 mm. The surgical wound was closed by either the conventional catgut-silk layer closure or by a single interrupted stainless steel suture through all layers (skin to peritoneum). The latter proved to be faster and resulted in good healing. At 20-25 days corpora lutea were counted and uterine horns palpated and visualized for diagnosis of fetal number. At 65-88 days only palpation of uterine horns took place. Twenty-eight ewes, out of the 42 included in trial L4, were also radiographed.

Radiographic technique

Three trials were conducted, R1-R3. Ewes were x-rayed between the 80th and 100th day of gestation (based on Wenham and Robinson, 1972). They were fastened to a bench by wooden yokes over their shoulders in sternal recumbency. A canvas compression band, tightened over the pelvis, was used to reduce the depth of tissue and to restrain the animal, while the hind legs were stretched on the sides of the bench. The animals were not given food or water on the same morning.

The radiographic equipment used was a Picker x-ray unit with a maximum output of 200 k.v. and 100 mA. The examination was carried out using 43 x 35 cm Camp Lysholm Grid Cassette Picker (Agfa Curvix film R.P.1.) with a distance of 100 cm. from the tube focus. The cassette was positioned as described by Wenham and Robinson (1972). Two assistants positioned the ewe on the bench, and a technician controlled the exposures and processed and examined the radiographs. The exposure factors were 320 mA at 0.24 sec (76.8 mAs), with a voltage varying from 88 for a ewe weighing 50 kg, to 104 k.v. for one weighing 80 kg or more.

RESULTS

Laparotomy

In trial L1 it was found that while palpating the uterine horns, it was easiest to recognize the individual embryonic sacs on day 21 (Table 2.7.1). Transillumination of the uterine horns failed to help in differentiating among fetuses. As the four diagnoses made on this day happened all to be accurate, it was decided to repeat the operation on day 21 on a larger number of ewes in trial L2. In this second trial there were apparently four cases of ewes which lost all their embryos and hence the overall accuracy of diagnosis was reduced to 63.2%. In experiments L1 and L2 corpora lutea (CL) were also counted during the operation and an estimate of total embryonic losses could be made, the results of which are shown in Table 2.7.2. It may be seen that 23-25% were lost between ovulation and 21-25 days, and of those identified during the operation a further 15% (L1) and 32% (L2) were lost.

Laparotomies done during the third month of gestation resulted in a high proportion of correct diagnoses, and of 52 operations made there was only one case of loss of lambs through abortion, and in two cases only

one lamb was born when two were diagnosed. Out of 80 fetuses apparently present at laparotomy, eight were not discovered as evidenced from the lambing record, six of them out of triplets or quads. However, some 30% of the ewes operated on during this stage suffered complications in the healing process of the operation wounds. This was probably due mainly to the great pressure exerted by the growing uterus on the abdominal walls which also resulted in several hernias. All the ewes lambed normally, but some of them had to be culled after they had weaned their lambs.

Table 2.7.1 COMPARISON BETWEEN FETAL NUMBER DIAGNOSIS AND LAMBING RECORD USING THE LAPAROTOMY TECHNIQUE

Trial no.	Days pregnant	Number of ewes	C o r r e c t d i a g n o s e s			
			based on CL count		based on uterine palpation	
			accurate	correct S vs. M ^a	accurate	correct S vs. M ^a
L1	20	1	0	0	0	0
	21	4	1	3	4	4
	22	2	1	1	2	2
	23	6	3	3	2	3
	24	5	1	2	2	2
	25	2	1	1	2	2
	Total	20	7 (35.0%)	10 (50.0%)	12 (60.0%)	13 (65.0%)
L2	21	19	7 (36.8%)	9 (47.4%)	12 (63.2%)	13 (68.4%)
L3	65-88	10	-	-	9 (90.0%) ^b	9 (90.0%) ^b
L4	69-75	42	-	-	32 (76.2%)	37 (88.1%)

^aS = single; M = multiple.

^bThe one "inaccurate" diagnosis is due to a ewe which turned out to be barren. As there was no doubt as to her being pregnant at laparotomy, she must have aborted without it being noticed.

Table 2.7.2 ESTIMATED EMBRYONIC LOSSES IN EWES WHICH WERE LAPAROTOMIZED DURING DAYS 20-25 OF GESTATION

Trial no.	CL present	Fetuses present ^a	Loss (%)	Lambs born	Loss (%)	Total loss (%)	Barren ewes (%) ^c
L1	47	36	23.4	30	16.7	36.2	15.0
L2	48	36	25.0	25	30.6	47.9	31.6

^aTwo CL in trial L1 were not detected during laparotomy.

^bThree fetuses in trial L1 and one in L2 were not detected during laparotomy.

^cThree ewes in L1, all diagnosed pregnant at laparotomy; six in trial L2, two of them diagnosed barren and four diagnosed as pregnant at laparotomy

Radiography

The results are presented in Tables 2.7.3 and 2.7.4. The data in Table 2.7.4 show that most inaccuracies resulted from failure to detect fetuses when more than two were present. It should also be mentioned that in several cases x-rays taken at less than 80 days of pregnancy gave unclear results and had to be repeated for proper diagnosis.

Table 2.7.3 AGREEMENT BETWEEN RADIOGRAPHIC DIAGNOSIS OF FETAL NUMBERS AND LAMBING RECORD

Trial no.	Number of ewes	Percent correct diagnoses	
		accurate	correct S vs. M ^a
R1	28	75	93
R2	53	58	88
R3	89	77	87

^aS = single; M = multiple.

Table 2.7.4 ACCURACY OF RADIOGRAPHIC PREGNANCY DIAGNOSIS IN RELATION TO ACTUAL FETAL NUMBERS AS RECORDED AT LAMBING

Type of birth	Trial No.					
	R1 ^a		R2		R3	
	Number of ewes	Accuracy (%)	Number of ewes	Accuracy (%)	Number of ewes	Accuracy (%)
0	0	-	0	-	5	80
1	2	50	13	92	33	82
2	20	85	25	80	37	84
3	5	60	12	33	13	54
4	1	0	3	0	1	100

^aOut of 42 ewes used in trial L4.

DISCUSSION

Most accurate fetal number diagnosis may be achieved by laparotomy at 65-80 days of pregnancy. The few cases in which fetuses were not detected could probably have been avoided by improved illumination of the uterine horns. The main drawback of this procedure arises from complication in the healing from the incision. The advantages of laparotomy at 21-25 days are offset by post-operational fetal losses. In both cases, an improvement could

perhaps be gained by the application of flank laparotomy, as suggested by Phillippo and Rhind (1977). The fact that post-operational embryonic losses were apparently very different in the present trials is indicative of room for more study of factors acting on embryo survival at this early stage of pregnancy. The actual estimated losses encountered in trial L1 are similar to those reported by Rhind *et al.* (1976), Phillippo and Rhind (1977) and by Cutter (1970). The diagnostic results are similar to those given by Foote (unpublished, personal communication).

The results of the radiographic diagnoses resemble those of Rizzoli *et al.* (1976), which were made under field conditions. They are slightly less accurate than those obtained by Wenham and Robinson (1972). This may be attributed to the lack of facilities under which the radiographs were taken and also to the fact that in most cases there was some degree of panting by the ewes due to elevated air temperatures, making it difficult to attain perfect pictures.

Recent advancements, such as described by Beach (1982), will greatly increase the comfort both to animals and to operators and hence improve the accuracy of diagnosis. The main obstacle to the expansion of the use of radiographic pregnancy diagnosis remains the high cost involved.

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2.8 INTAKE AND PRODUCTION BY FINN-CROSS EWES FED RATIONS BASED ON POULTRY LITTER, GIN-TRASH AND CORN VS. WHEAT STRAW, ALFALFA HAY AND CONCENTRATES

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and

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ABSTRACT

Three experiments were carried out to compare the voluntary intake of low energy-high intake rations based on poultry litter and gin-trash (PLGT) with that of rations based on high energy concentrates (CON) and wheat straw (WS) or high quality alfalfa hay (AH). There were five treatments with 30 ewes in each of experiments 1 and 2: A, PLGT; B, PLGT + corn; C, CONWS; D, CONWS with CON offered ad lib. in the last 3 weeks (exp. 1) or 5 weeks (exp. 2) of gestation; and E, AH. There were four treatments with 37 ewes in exp. 3: A, PLGT (11 ewes); B, PLGT + corn (11); C, CONAH (6); and CONAH (11), in which the CON was offered ad lib. in the last 7 weeks of pregnancy.

In terms of metabolizable energy (ME), ewes on PLGT consumed only 55-57% of the CONWS or CONAH rations during the last 7 weeks of pregnancy, while ewes on AH (in expts. 1 and 2) consumed between 80 and 90%. When corn was added to PLGT at rates not exceeding 33% of the ration, its consumption rose to 90-100% that of the concentrate-based diets. During lactation, PLGT + corn was consumed in larger quantities of both DM and energy compared with the concentrate-based diet. Ewes on AH were unable to consume more than 62% (exp. 1) or 81% (exp. 2) ME compared with the concentrate diet.

Except for the rations in which concentrates were fed ad lib., ewes lost weight during pregnancy. Body energy was lost in all treatments but losses were greater in expts. 2 and 3, when ewes were fatter than in exp. 1. In the PLGT and AH treatments, losses of body fat were greater than in the other treatments and there were indications of some loss of body protein in these groups.

There were no cases of pregnancy toxemia that could be correlated with the nutritional treatments. Blood plasma glucose concentrations in the last 5 weeks of pregnancy were slightly lowered in the PLGT treatment. There were no differences in lambing performance, lamb survival and post-experimental reproductive performance between the experimental groups. Least squares means of birth weight in the PLGT group ranged between 1.9 and 2.4 kg in the three experiments, as compared with 2.6-3.4 kg in the other treatment groups.

Growth rates from birth to weaning were 182-218 g/day in the PLGT group and 198-250 g/day in the other groups. All differences were statistically nonsignificant. It was concluded that it is possible to compose low energy-high intake rations based on cotton gin-trash and poultry litter (2.0-2.2 Mcal of ME/kg) for pregnant and lactating prolific sheep. AH as sole feed was consumed in quantities sufficient to meet requirements only until about 2 weeks prepartum.

Suggestions are given for possible ratios between ration components as a basis for appetite-regulated complete rations.

INTRODUCTION

The relationship between liveweight and/or body condition and reproductive performance is well established. The component of reproductive performance which has the clearest positive relationship with live weight and body condition, is ovulation rate (Gunn, 1983). Therefore, good body condition at mating is of paramount importance, especially in prolific sheep, with whom it is desired to exploit the full reproductive potential. Once the potential number of conceived embryos has been achieved, optimal nutritional conditions are required to ascertain their pre- and postpartum survival. Fetal growth is most rapid in the last 6-8 weeks of gestation and it is during this period that nutritional effects are greatest. However, it was shown that liberal feeding during this period may not always have beneficial results and that it is difficult to maintain a rising intake pattern in sheep which have reached a heavy condition earlier in pregnancy (Gordon and Tribe, 1961; Stern *et al.*, 1976a; Russel *et al.*, 1981). This means that the required intake of food during pregnancy will vary with the previously attained body condition of the ewe. It has also been shown that breed differences in maintenance requirements do exist (e.g. Doney and Russel, 1968). These are probably the reasons for the great variation found in the literature for the estimated requirements of pregnant sheep. As an example, one could compare the works of Langlands and Sutherland (1968), Robinson *et al.* (1971) and Thomson and Aitken (1959), in which energy allowances in the last 8 weeks of gestation for twin-bearing ewes weighing between 50 and 70 kg range between 2.1 and 4.2 MCal of ME per day.

As intake by sheep is regulated both by the energy concentration of the ration and by the energy expenditure (requirement), the introduction of complete appetite-regulated rations may be helpful in supplying the requirements. This has been discussed by Kali *et al.* (chap. 2.1) in more detail. See also Owen *et al.* (1980).

The conventional way of supplying requirements for advanced pregnancy involves the adjustment of energy supply by increasing the energy concentration of the ration through the addition of high-energy grain or concentrate mixtures. As mentioned before, this involves the risk of over-fattening. As it has been shown that different feeds with the same energy concentration (digestibilities) may be consumed at different rates (e.g. Moir *et al.*, 1975), low energy-high intake feeds may help in solving the problem. Poultry litter (PL) and cotton by-products such as gin-trash (GT) have been shown to be such feeds. The feeding of PL in conjunction with wheat straw (WS) during pregnancy and lactation has been discussed in chapter 2.6. One of the objectives of the present study was to compare rations based on GT and PL with those based on WS and concentrates. A ration including *ad lib.* concentrates was included in all the experiments which are reported here, to study further the risks of over-fattening. Aspects of possible metabolic disorders concerning glucose-insulin relationships were also studied but they will be reported elsewhere. Alfalfa hay as the sole feed was included as a control treatment (high quality-high intake roughage).

in treatment C of exp. 3 died of dystocia. There were also three cases of abortion, one in the AH group of exp. 1 and two in the PLGT + corn group of exp. 3. There were five ewes in the three experiments which had only one lamb at lambing (wrong pregnancy diagnosis) and 29 ewes lost lambs between birth and weaning (deaths not correlated with treatments). The final numbers of ewes for comparison at lambing in treatments A, B, C, D and E, respectively were 6, 6, 5, 6 and 4 in exp. 1, and 4, 6, 5, 6 and 6 in exp. 2. In exp. 3 there were 11, 10, 5 and 11 ewes in groups A, B, C and D, respectively. The numbers of ewes left at weaning were, respectively, 2, 1, 3, 3 and 1 in exp. 1; 4, 5, 4, 3 and 4 in exp. 2; and 9, 8, 3 and 7 in exp. 3.

Feed intake

The energy intake in late pregnancy and early lactation is shown in Table 2.8.2. In this table the relative intake of all treatments compared

Table 2.8.2 MEAN METABOLIZABLE ENERGY INTAKES (MCal/day) OF EWES IN LATE PREGNANCY AND LACTATION (5-7 WEEKS PREPARTUM TO 6 WEEKS POST PARTUM) (MEANS±s.d.)

Treatment ^a	Energy intake		Intake, as % of that in treatment C	
	pregnancy	lactation	pregnancy	lactation
Experiment 1				
A. PLGT	1.99±0.2	5.21±0.2	57)	96
B. PLGT + corn	3.37±0.5	5.21±0.2	97)	
C. CONWS _b	3.47±0.6	5.42±0.2	100)	
D. CONWS _b	3.50±0.7	5.42±0.2	101)	100
E. AH	3.18±0.6	3.36±0.2	92	62
Experiment 2				
A. PLGT	1.94±0.4	6.14±0.4	56)	108
B. PLGT + corn	3.46±0.5	6.14±0.4	99)	
C. CONWS _b	3.48±0.5	5.71±0.4	100)	
D. CONWS _b	5.10±0.8	5.71±0.4	147)	100
E. AH	2.84±0.2	4.65±0.6	82	81
Experiment 3				
A. PLGT	2.31±0.3	5.48±0.5	55	92
B. PLGT + corn	3.67±0.5	5.95±0.5	88	100
C. CONAH	4.19±0.6	5.95±0.5	100	100
D. CONAH _b	5.21±0.6	5.95±0.5	125	

^aPLGT = poultry litter + gin-trash; CONWS = concentrates + wheat straw; AH = alfalfa hay.

^bCON was offered ad lib. in final 3 weeks of gestation in exp. 1 and in the last 5 and 7 weeks in exp. 2 and 3, respectively.

Figure 2.8.1 Mean daily metabolizable energy (ME) intakes by ewes fed different rations during the last 7 weeks of gestation and 6 weeks of lactation. (1) Concentrates (CON) were given *ad lib.* during the last 3 weeks (exp. 1), 5 weeks (exp. 2) or 7 weeks (exp. 3) of gestation; in exp. 3 wheat straw (WS) was replaced by alfalfa hay (AH).

with that of treatment C (CONWS = 100%) is also shown. The progressive changes in ME intake throughout pregnancy and lactation are shown in Figure 2.8.1, and that of DM intake in Figure 2.8.2. The energy intakes were also calculated per kg $W^{0.75}$ of the ewes and results are shown in Figure 2.8.3. Energy intakes varied considerably between treatments. Mean intake during gestation was highest with the ad lib. concentrates ration. However, in this group a marked drop in intake was observed in the last 2 weeks of gestation. The lowest intakes were in the PLGT group. Ewes in the AH treatment in exp. 1 managed to consume nearly as much energy as those which had grain or concentrates in their ration. During pregnancy in exp. 2 and during lactation in exps. 1 and 2, ewes on the AH ration consumed only 50-80% of the energy of the WS-concentrate fed group C.

The dry matter intake was lowest with PLGT and highest with PLGT + corn. The high intakes of this last ration were particularly remarkable during lactation when the increased intake not only compensated for its lower energy concentration but even brought about a greater energy intake when compared with the higher energy rations composed of wheat straw or alfalfa hay with concentrate mixtures.

Body weight changes

From the figures given in parentheses in Table 2.8.3 it is evident that the ewes became progressively heavier from experiment 1 to 3. This was due mainly to their heavier condition (more body fat) as reflected also in the body composition data (Tables 2.8.4. - 2.8.7). This has some implications on the patterns of body weight and composition changes throughout pregnancy and lactation.

It is clear that during pregnancy ewes on the lower energy rations lost more weight. The apparently great losses of weight in the high-concentrate rations in exp. 2 are in disagreement with the body energy changes in these groups and probably reflect the errors that may be associated with body weight change as an indicator of nutritional effects. Differences between treatments were statistically significant ($P < 0.01$) only in exp. 3.

Body composition

Data on the ewes' body composition are given in Tables 2.8.4 - 2.8.7. The differences between stages 1 and 2 constitute changes in the ewe's body during the last 7 weeks of gestation, and the differences between stages 2 and 3 are the changes in ewe's body during lactation. Only ewes that suckled two lambs were included. In treatments B (PLGT + corn) and E (AH) of exp. 1 only two ewes (one in each) remained who suckled two lambs, so their data at stage 3 were omitted. No significant effect of the treatment on percent of body protein was found, but there were significant differences ($P < 0.05$) in body fat percent and energy. There was a considerable rise in body fat (and energy) in exp. 2 compared with exp. 1, and a further rise in exp. 3. In the ewes of exp. 3, body protein percent was lower than in exps. 1 and 2. Both these phenomena may be attributed partly to the fact that in exp. 3, most of the ewes were less than 18 months old at mating (see Searle, 1970), and further, that the ewes in exp. 2 were, on the average, ~12 months younger than those in exp. 1.

Figure 2.8.2 Mean daily dry matter (DM) intakes by ewes fed different rations during the last 7 weeks of gestation and 6 weeks of lactation. (1) Concentrates (CON) were given ad lib. during the last 3 weeks (exp. 1), 5 weeks (exp. 2) or 7 weeks (exp. 3) of gestation; in exp. 3 wheat straw (WS) was replaced by alfalfa hay (AH).

Figure 2.8.3 Mean energy intake per metabolic body weight ($W^{0.75}$) in late pregnancy and early lactation by ewes fed different rations.

(1) Concentrates (CON) were given ad lib. during last 3 weeks (exp. 1), 5 weeks (exp. 2) or 7 weeks (exp. 3) of gestation; in exp. 3 wheat straw (WS) was replaced by alfalfa hay (AH).

Table 2.8.3 MEAN BODY WEIGHT CHANGES (KG) OF THE EWES FROM 7 WEEKS PREPARTUM UNTIL WEANING IN THREE EXPERIMENTS

Treatment	Gain or loss in body weight ^a		
	7 weeks prepartum to:		Lambing to weaning (6 weeks)
	1 week prepartum	3 days postpartum	
Experiment 1			
A. PLGT	+ 1.6±5.0	-9.3±6.6 (56±9.6)	+1.7±1.5
B. PLGT + corn	+10.8±3.5	-0.1±3.5 (62±8.3)	+4.5±1.0
C. CONWS ^b	+11.8±7.5	+1.1±4.0 (66±17.6)	-7.0±3.4
D. CONWS ^b	+ 9.9±6.2	+1.6±7.5 (65±14.1)	-1.2±3.2
E. AH	+11.0±1.8	-1.3±2.8 (61±22.6)	-4.5±5.6
Experiment 2			
A. PLGT	- 0.9±7.7	-7.5±8.5 (57±1.0)	-3.4±7.2
B. PLGT + corn	+ 1.9±9.4	-7.4±10.3 (66±8.7)	+5.1±8.9
C. CONWS ^b	+ 2.4±10.3	-10.8±11.4 (67±13.6)	+0.1±9.6
D. CONWS ^b	+ 5.9±5.9	-9.3±6.5 (66±9.4)	-4.4±5.5
E. AH	+ 1.6±7.0	-11.0±7.7 (64±7.6)	-5.4±6.5
Experiment 3			
A. PLGT	+ 2.4±1.5	- 8.9 2.1 (60±7.2)	+0.5±1.2
B. PLGT + corn	+ 9.4±1.5	- 4.0 2.1 (65±7.6)	-0.8±1.2
C. CONAH ^b	+13.8±2.3	- 0.2 3.1 (73±8.2)	-3.5±1.8
D. CONAH ^b	+13.5±1.4	+ 3.5 2.0 (77±11.6)	-4.7±1.2

^aPostpartum body weights (kg) of ewes are given in parentheses.

^bCON was given ad lib. in final 3 weeks of pregnancy in exp. 1, and during final 5 and 7 weeks in exps. 1 and 3, respectively.

Table 2.8.4 BODY COMPOSITION (% OF BODY WEIGHT) OF THE EWES IN EXP. 1 AT THREE STAGES: (1) 7 WEEKS PRIOR TO LAMBING; (2) 3-7 DAYS POST-LAMBING; AND (3) AT WEANING (MEANS±S.D.)

Variable	Treatment				
	A. PLGT	B. PLGT + CORN	C. CONWS	D. CONWS	E. AH
Body energy (MCal)					
Stage 1	190±42	170±44	207±92	217±76	173±52
Stage 2	141±55	180±69	196±142	196±96	161±19
Stage 3	124±36	-	140±114	151±107	-
Body fat (%)					
Stage 1	22.5±4.6	20.0±5.9	24.9±6.9	26.6±5.6	21.7±3.9
Stage 2	18.7±7.3	21.9±10.0	21.3±15.0	23.5±8.2	19.8±2.2
Stage 3	17.7±7.9	-	13.5±10.6	16.3±13.7	-
Body protein (%)					
Stage 1	16.3±0.8	16.5±0.3	16.3±1.1	16.4±1.4	16.1±0.4
Stage 2	17.1±0.7	16.6±0.6	16.6±1.3	16.5±1.2	16.2±0.4
Stage 3	17.7±0.1	-	17.0±1.9	16.8±1.1	-

^aCON was given ad lib. in final 3 weeks of pregnancy.

Table 2.8.5 BODY COMPOSITION (% OF BODY WEIGHT) OF THE EWES IN EXP. 2 AT THREE STAGES: (1) 5 WEEKS PRIOR TO LAMBING; (2) 3-7 DAYS POST-LAMBING; AND (3) AT WEANING (MEANS±S.D.)

Variable	Treatment				
	A. PLGT	B. PLGT + corn	C. CONWS	D. CONWS*	E. AH
Body energy (MCal)					
Stage 1	258 ^a ±44	268 ^b ±45	263 ^b ±83	242 ^b ±66	255 ^a ±43
Stage 2	175 ^a ±34	221 ^b ±42	214 ^b ±82	222 ^b ±41	186 ^a ±23
Stage 3	173 ^{ab} ±56	179 ^{ab} ±50	205 ^b ±82	201 ^b ±69	130 ^a ±38
Body fat (%)					
Stage 1	29.6 ^a ±3.6	30.8 ^a ±3.8	30.9 ^a ±5.8	26.5 ^b ±6.6	29.6 ^a ±2.3
Stage 2	23.5 ^a ±3.6	24.4 ^{ab} ±8.0	26.1 ^{ab} ±7.6	27.1 ^b ±3.5	23.4 ^a ±3.0
Stage 3	20.2 ^b ±4.4	20.8 ^b ±5.3	23.8 ^b ±6.2	23.5 ^b ±5.8	14.4 ^a ±4.7
Body protein (%)					
Stage 1	15.6±0.5	15.5±0.5	15.6±0.6	15.6±0.7	15.5±0.5
Stage 2	16.3±0.6	16.1±0.6	16.1±0.6	16.1±0.7	16.4±0.5
Stage 3	16.3±0.6	16.0±0.7	15.9±0.7	16.4±1.1	16.5±0.7

*CON was given ad lib. in final 5 weeks of pregnancy

^{a,b} Means in the same line with different superscripts differ significantly (P<0.05).

Table 2.8.6 BODY COMPOSITION (% OF BODY WEIGHT) OF THE EWES IN EXP. 3 AT THREE STAGES: (1) 7 WEEKS PRIOR TO LAMBING; (2) 3-7 DAYS POST-LAMBING; AND (3) AT WEANING (MEANS±S.D.)

Variable	Treatment			
	A. PLGT	B. PLGT + corn	C. CONAH	D. CONAH*
Body energy (MCal)				
Stage 1	359 ^{ab} ±61	329 ^a ±70	408 ^b ±34	396 ^b ±110
Stage 2	230 ^a ±67	297 ^{ab} ±99	344 ^b ±61	344 ^b ±64
Stage 3	198 ^a ±82	204 ^a ±88	312 ^b ±175	296 ^b ±81
Body fat (%)				
Stage 1	48.5 ^a ±4.7	45.2 ^a ±5.8	52.6 ^b ±1.0	50.2 ^{ab} ±8.4
Stage 2	35.8 ^a ±9.8	43.5 ^{ab} ±14.2	45.2 ^b ±3.9	45.5 ^b ±4.2
Stage 3	29.4 ^a ±10.3	29.5 ^a ±13.5	40.2 ^b ±18.6	39.7 ^b ±8.7
Body protein (%)				
Stage 1	11.9±0.4	12.0±0.5	12.6±0.2	11.7±0.6
Stage 2	12.6±0.5	12.5±0.4	11.8±0.3	11.8±0.5
Stage 3	12.6±0.5	12.5±0.4	11.9±0.5	12.0±0.5

*Concentrate mixture + alfalfa hay. CON was given ad lib. in final 7 weeks of pregnancy.

^{a,b} Means with different superscripts in the same line differ significantly (P<0.05).

Table 2.8.7 BODY FAT AND BODY PROTEIN (KG) OF THE EWES OF THREE EXPERIMENTS AT THREE STAGES: (1) 7 WEEKS PRIOR TO LAMBING; (2) 3-7 DAYS POST-LAMBING; AND (3) AT WEANING (MEANS±S.D.)

Variable	Treatment				
	A. PLGT	B. PLGT + corn	C. CONWS*	D. CONWS**	E. AH
Experiment 1					
Body fat (kg)					
Stage 1	14.4±4.0	12.3±4.3	16.8±8.8	17.3±7.0	13.6±4.6
Stage 2	10.0±5.3	13.4±7.0	18.3±13.7	15.5±9.2	11.6±1.3
Stage 3	8.4±3.8	-	9.3±10.0	10.9±	-
Body protein (kg)					
Stage 1	10.3±1.0	10.0±0.6	10.3±1.8	10.2±2.0	9.6±1.7
Stage 2	8.9±1.0	9.9±0.9	10.1±2.1	10.1±1.7	9.6±1.5
Stage 3	8.4 ^a ±0.1	-	9.6 ^b ±2.6	9.8 ^b ±1.6	-
Experiment 2					
Body fat (kg)					
Stage 1	21.1±4.3	22.2±4.4	21.9 ^a ±8.4	20.2±6.0	20.9±4.0
Stage 2	13.3 ^a ±7.1	17.7 ^b ±4.2	17.0 ^{ab} ±8.0	17.7 ^b ±3.9	14.2 ^a ±2.0
Stage 3	12.7 ^b ±5.2	13.4 ^b ±4.8	16.0 ^b ±7.8	15.5 ^b ±6.5	8.4 ^a ±3.6
Body protein (kg)					
Stage 1	11.1±1.0	11.0±0.9	10.7±1.4	11.2±1.0	10.9±1.2
Stage 2	9.3 ^a ±1.3	10.0 ^{ab} ±0.9	10.1 ^{ab} ±1.4	10.4 ^b ±0.8	9.7 ^a ±0.8
Stage 3	10.0±1.4	10.4±1.3	10.2±1.7	10.3±1.5	9.4±0.8
Experiment 3					
Body fat (kg)					
Stage 1	33.6±6.1	30.6±7.5	38.7±3.4	37.4±11.3	
Stage 2	20.7 ^a ±6.7	29.1 ^b ±12.1	33.3 ^b ±6.0	33.7 ^b ±6.8	
Stage 3	17.6 ^a ±8.0	17.7 ^a ±9.3	28.7 ^b ±18.0	27.1 ^b ±8.3	
Body protein (kg)					
Stage 1	8.1±0.6	8.0±0.7	8.5±0.5	8.5±0.9	
Stage 2	7.5 ^a ±0.6	8.0 ^a ±0.7	8.6 ^b ±0.7	8.7 ^b ±0.9	
Stage 3	7.1 ^a ±0.7	7.3 ^a ±0.5	8.1 ^b ±0.9	8.0 ^b ±0.8	

*In exp. 3, WS was replaced by alfalfa hay.

**CON was given ad lib. in final 3 weeks of pregnancy in exp. 1 and during final 5 and 7 weeks in exps. 2 and 3, respectively.

^{a,b} Means with different superscripts in the same line differ significantly (P<0.05).

Ewes lost body fat during pregnancy and in most cases also during lactation, the loss being proportional to the nutritive deficit. The data in Table 2.8.7 indicate that there was also some apparent loss of body protein, particularly in the low-energy treatments.

Plasma glucose concentration

The concentration of plasma glucose in the last 5 weeks of pregnancy is given in Table 2.8.8. In exp. 2 blood samples were taken only from the fifth and the last week prepartum, and in exp. 3 blood samples from ewes in the PLGT + corn and CONWS treatments were taken in the fifth week. Ewes in treatments A and E (low energy) had significantly ($P < 0.05$) lower plasma glucose levels than the other groups.

Table 2.8.8 MEAN BLOOD PLASMA GLUCOSE CONCENTRATIONS (MG/100 ML) IN THE FINAL 5 WEEKS OF PREGNANCY IN THREE EXPERIMENTS (MEANS $\pm$ S.D.)

Treatment	Week prepartum				
	5	4	3	2	1
Experiment 1					
A. PLGT	65.0 $\pm$ 3.5 ^a	55.8 $\pm$ 5.7 ^a	57.2 $\pm$ 6.8 ^a	62.3 $\pm$ 8.1 ^a	62.4 $\pm$ 6.1 ^a
B. PLGT + corn	65.0 $\pm$ 3.0 ^a	61.2 $\pm$ 6.4 ^b	69.5 $\pm$ 4.3 ^b	69.0 $\pm$ 7.1 ^b	50.8 $\pm$ 3.7 ^b
C. CONWS ¹	63.0 $\pm$ 9.8 ^a	61.3 $\pm$ 7.8 ^b	69.8 $\pm$ 6.5 ^b	65.0 $\pm$ 7.1 ^{ab}	71.4 $\pm$ 12.5 ^c
D. CONWS ¹	61.0 $\pm$ 9.7 ^a	63.3 $\pm$ 9.5 ^b	63.7 $\pm$ 7.2 ^c	74.8 $\pm$ 7.0 ^c	68.3 $\pm$ 10.6 ^{ac}
E. AH	64.0 $\pm$ 6.7 ^a	64.4 $\pm$ 9.2 ^b	67.5 $\pm$ 6.2 ^{bc}	59.0 $\pm$ 2.7 ^a	54.3 $\pm$ 4.0 ^d
Experiment 2					
A. PLGT	51.0 $\pm$ 7.7 ^a	-	-	-	64.8 $\pm$ 2.4 ^a
B. PLGT + corn	57.7 $\pm$ 6.2 ^b	-	-	-	63.5 $\pm$ 2.4 ^a
C. CONWS ¹	57.2 $\pm$ 5.8 ^b	-	-	-	74.4 $\pm$ 8.4 ^b
D. CONWS ¹	60.2 $\pm$ 7.2 ^b	-	-	-	69.8 $\pm$ 9.2 ^{ab}
E. AH	59.5 $\pm$ 6.8 ^b	-	-	-	63.2 $\pm$ 4.1 ^a
Experiment 3					
A. PLGT	62.3 $\pm$ 4.8 ^a	50.2 $\pm$ 6.9 ^a	51.5 $\pm$ 6.2 ^a	59.2 $\pm$ 6.6 ^a	49.4 $\pm$ 4.0 ^a
B. PLGT + corn	-	52.6 $\pm$ 7.6 ^a	57.4 $\pm$ 5.1 ^b	58.8 $\pm$ 6.8 ^a	50.1 $\pm$ 4.4 ^a
C. CONAH ¹	-	54.0 $\pm$ 8.6 ^a	58.3 $\pm$ 10.7 ^b	61.2 $\pm$ 5.8 ^a	49.4 $\pm$ 4.0 ^a
D. CONAH ¹	67.3 $\pm$ 8.9 ^a	65.4 $\pm$ 11.0 ^b	65.8 $\pm$ 7.1 ^c	71.0 $\pm$ 9.5 ^b	56.4 $\pm$ 7.5 ^b

¹CON was given ad lib. in final 3 weeks of pregnancy in exp. 1, and during final 5 and 7 weeks in exps. 2 and 3, respectively.

^{a,b,c,d} Means within a column and an experiment with different superscripts differ significantly ($P < 0.05$).

Lambing rates and lamb mortality

Mean litter size and prenatal lamb mortality are shown in Table 2.8.9. The differences in litter size originate partly in inaccurate pregnancy diagnoses before the sheep were assigned to the treatments (see chap. 2.7) and partly in that some sheep were excluded due to death or abortion, as mentioned above. Twenty-four (63%) of the dead lambs were defined as "weak" at birth and 9 were stillborn or mismothered due to dystocia or lack of attention when lambing occurred during the night. Five other cases were due to accidents or unknown causes. Mortality could not be correlated with treatment. However, it was particularly low in treatments A and E (the lowest energy levels).

Table 2.8.9 MEAN LITTER SIZE AND PERINATAL LAMB MORTALITY IN THREE EXPERIMENTS

Treatment	Litter size			Perinatal lamb mortality (%) ^c		
	Exp. 1	Exp. 2	Exp. 3	Exp. 1	Exp. 2	Exp. 3
A. PLGT	2.50	2.25	2.00	0	11 (1)	5 (1)
B. PLGT + corn	2.17	2.50	2.30	31 (4)	13 (2)	20 (5)
C. CONWS ^a	2.00	2.40	3.00	33 (4)	25 (3)	11 (2)
D. CONWS ^{a,b}	2.17	2.83	2.27	31 (4)	29 (5)	24 (6)
E. AH	2.00	2.16	-	0	8 (1)	-

^aCONAH in exp. 3.

^bCON was given ad lib. in late pregnancy.

^cNumber of dead lambs is given in parentheses; abortions not included.

Birth weights and lambs' growth rates

None of the differences evident in Table 2.8.10 was statistically significant. There is, however, a consistent trend for lambs out of the low-energy treatments (PLGT and AH) to be smaller at birth and to have slower growth rates from birth to weaning.

Table 2.8.10 LEAST SQUARES MEANS OF BIRTH WEIGHT AND GROWTH RATE OF LAMBS (BIRTH TO WEANING) IN THREE EXPERIMENTS

Treatment	Birth weight of individual lambs (kg)	Litter weight (kg)	Growth rate (g/day)
Experiment 1			
A. PLGT	2.4±0.71	5.8±0.84	182±42
B. PLGT + corn	2.6±0.58	5.5±1.44	209±62
C. CONWS ^a	3.1±0.99	5.9±1.76	237±46
D. CONWS ^a	2.7±0.91	5.9±2.33	218±81
E. AH	2.6±1.33	4.7±2.86	192±39
Experiment 2			
A. PLGT	1.9±0.60	4.8±1.33	218±28
B. PLGT + corn	1.8±0.73	4.7±1.61	198±34
C. CONWS ^a	3.0±0.91	6.6±2.02	244±43
D. CONWS ^a	3.2±0.76	7.6±1.68	230±36
E. AH	2.8±0.68	6.7±1.51	165±32
Experiment 3			
A. PLGT	2.5±0.27	6.3±0.71	193±30
B. PLGT + corn	3.4±0.26	8.1±0.70	237±30
C. CONAH	3.3±0.39	8.4±1.03	209±44
D. CONAH ^a	3.1±0.25	7.6±0.67	250±28

^aCON was given ad lib. in final 3 weeks of pregnancy in exp. 1 and in final 5 and 7 weeks in exps. 2 and 3, respectively.

Solid food intake of lambs during the suckling period

Total solid feed intake per lamb, consumed during the suckling period, is shown in Table 2.8.11. In all three experiments lambs of ewes that were fed the PLGT-based ration consumed less solid food than those on CONWS or CONAH and, except in one case, this was in conjunction with lower growth rates (Table 2.8.10).

Table 2.8.11 DRY MATTER INTAKE OF ALFALFA HAY AND CONCENTRATES (G/LAMB) BY LAMBS DURING THE LAST 3 WEEKS OF THE SUCKLING PERIOD

Treatment	Number of lambs	Period (days)	Hay (g DM/lamb)	Concentrates (g DM/lamb)
Experiment 1				
A+B (PLGT + corn)	8	18	580	1,840
C+D (CONWS)	12	18	283	2,398
Experiment 2				
A+B (PLGT + corn)	18	25	260	1,293
C+D (CONWS)	14	25	302	1,598
E (AH)	4	25	178	1,572
Experiment 3				
A (PLGT + corn)	18	24	433	1,378
B (PLGT + corn)	16	24	594	1,325
C (CONAH)	6	24	833	2,767
D (CONAH ^b)	14	24	929	3,136

^aPLGT during pregnancy

^bCON given ad lib. during pregnancy.

Post-experimental reproductive performance

The post-experimental reproductive performance of the ewes which remained in the flock is given in Table 2.8.12. The differences between treatments are statistically nonsignificant. Some of the ewes from exp. 1 were sold soon after their first estrus. Only part of the data about the first estrus of ewes from exp. 3 were recorded.

DISCUSSION

Feed intake

Intake regulation, and its relation to energy concentration and to different feeds and different demands of the sheep, was discussed in detail by Kali *et al.* (chap. 2.1). The main point that should be made here is that the results confirm the assumption made that it is possible to compose low (or medium) energy-high intake rations based on cotton wastes, in this case gin-trash and poultry litter. From seven weeks pre-partum to lactation, energy concentration (MCal of ME* per kg of dry

*The values in MCal are transcribed from MJ given in chap. 2.1.

Table 2.8.12 POST-EXPERIMENTAL REPRODUCTIVE PERFORMANCE OF THE EWES (MEANS $\pm$ S.D.)

Variable ^a	T r e a t m e n t				
	A. PLGT	B. PLGT + corn	C. CONWS ^d	D. CONWS ^d	E. AH
	Experiment 1				
Days to 1st estrus	64 $\pm$ 16 (6)	55 $\pm$ 16 (4)	49 $\pm$ 23 (3)	69 $\pm$ 19 (5)	54 $\pm$ 11 (5)
Days to conception	123 $\pm$ 19 (3)	100 $\pm$ 3 (2)	97 $\pm$ 18 (2)	104 $\pm$ 5 (5)	97 $\pm$ 21 (2)
Lambs born/EL ^b	2.0 $\pm$ 1 (3)	1.7 $\pm$ 0.6 (2)	2.5 $\pm$ 0.7 (2)	2.0 $\pm$ 0.7 (5)	2.0 $\pm$ 0 (2)
Dry ewes, % ^c	0	33	0	0	0
	Experiment 2				
Days to 1st estrus	45 $\pm$ 3 (5)	42 $\pm$ 10 (6)	40 $\pm$ 11 (5)	42 $\pm$ 7 (5)	45 $\pm$ 1 (6)
Days to conception	48 $\pm$ 7 (5)	46 $\pm$ 3 (5)	54 $\pm$ 17 (4)	42 $\pm$ 7 (5)	54 $\pm$ 13 (5)
Lambs born/EL	2.0 $\pm$ 0.7 (5)	2.3 $\pm$ 0.5 (5)	2.2 $\pm$ 1.0 (4)	1.8 $\pm$ 0.7 (5)	2.0 $\pm$ 0.2 (4)
Dry ewes, %	33	17	20	33	17
	Experiment 3				
Days to 1st estrus	79 $\pm$ 3 (3)	81 $\pm$ 15 (6)	73 $\pm$ 16 (4)	68 $\pm$ 30 (3)	
Days to conception	117 $\pm$ 7 (6)	113 $\pm$ 7 (7)	108 $\pm$ 4 (4)	116 $\pm$ 7 (7)	
Lambs born/EL	2.5 $\pm$ 1.0 (6)	2.6 $\pm$ 0.5 (7)	1.8 $\pm$ 1.0 (4)	2.1 $\pm$ 0.7 (7)	
Dry ewes, %	22	30	20	22	

^aNumber of ewes is given in parentheses.

^bEL = ewe lambing.

^cIncluding ewes which failed to conceive within 150 days postpartum.

^dAH instead of WS in exp. 3. In treatment D, CON given ad lib. during last 3, 5 and 7 weeks of pregnancy in exps. 1, 2 and 3, respectively.

matter) ranged between 1.98 and 2.15 in the PLGT + corn ration and between 2.43 and 2.62 in the WS-concentrates rations. Still, the intake of the former rations was nearly the same as that of the latter during advanced pregnancy and surpassed it during lactation, during which time it equaled that of a ration based on alfalfa hay and concentrates (2.39-2.57 MCal ME/kg). Alfalfa hay (of the quality available for the present study) was consumed in quantities sufficient to meet requirements until about 2 or 3 weeks prepartum. After this stage the ewes consumed considerably less than those on rations which included a concentrate component.

Effect of rations on body composition and performance of ewes

Sheep under all nutritional treatments lost body weight, mainly as fat. This is probably unavoidable in sheep carrying two or more fetuses (Robinson *et al.*, 1978; Cowan *et al.*, 1979). The ewes in the two low-energy groups (PLGT and AH), however, lost considerably more than the other groups and there was some indication that they also lost some body protein. This is probably not very serious, as judged by their performance in which they hardly differed from ewes fed the high-level energy rations. The plasma glucose levels, although somewhat lower in the PLGT and AH groups close to term compared with the higher energy groups, did not reach critical levels (Reid, 1968). Although there was an indication (statistically nonsignificant) for lower birth weights and growth rates in the PLGT and AH groups, lamb survival rate in these groups was, if anything, the best. Both these rations were excessive in protein and calcium and it has been shown by Sykes and Field (1972) that a large reduction in lamb weight (and survival) is caused only when undernutrition in late pregnancy is accompanied by a marked lack of protein and calcium. The importance of excess protein in the ration of prolific pregnant ewes has been recently reviewed by Robinson (1983).

Another point which must be stressed is that the undernutrition exerted in the experiments reported here was of only relatively short duration. As PLGT was shown to be adequate for maintenance (chap. 2.1), it may be postulated that the ration started to become progressively deficient only in the last 6 weeks of gestation, after which corn was added to meet the lactation requirements. In the AH ration it was shown that the ration became deficient only from 2 weeks prepartum onwards, and through lactation. There were apparently also no after-effects, as judged by the post-experimental performance of the ewes (Table 2.8.12). It may be concluded that it is possible over one gestation to get away with a PLGT ration, but this should not be recommended over several consecutive pregnancies, before more long-range information on the use of this ration is available. This warning is particularly important for accelerated lambing programs, where the time for recuperation of lost body reserves between pregnancies is relatively short.

The slower growth rate of the PLGT lambs could normally be regarded as an indication of lower milk yield of their dam. However, in this case one would expect these lambs to compensate by the consumption of larger quantities of solid food (see chap. 3.1 for discussion of this point). The fact that the PLGT lambs actually consumed less than the others (Table 2.8.11) would perhaps indicate that they suffered a certain setback due to their initial smaller size. Peart (1967) concluded that a principal effect of malnutrition during pregnancy may be to inhibit the growth potential of

the lamb and that the effect on milk production is a result of the inability of the small lamb to exploit the milking potential of the ewe. It is suggested here that the same may apply also to the lambs' appetite for solid food.

The problem of overfatness in the high-concentrate rations

There were no cases of acute diabetic ketosis of the type described by Reid and Hinks (1962) in any of the three experiments. There were indications in some of the fat ewes of the CONWS and CONAH treatments of increased insulin resistance (Y. Yehuda, unpublished results). That the situation was not severe is probably attributable to the fact that prolific ewes, due to the increased demands of the concepta, are less susceptible to overeating than single-lamb-bearing ewes. This was shown also by Stern et al. (1978b).

High-concentrate rations stimulate fat deposition (see chap. 1.5, where this was shown in a lamb-fattening trial), thus reducing the efficiency of fetal growth (Stern et al., 1978a) and milk production (Peart, 1968; Stern et al., 1978b). Furthermore, it was shown that intake, both in terms of dry matter and of energy, was lower with the CONWS ration than with the PLGT + corn or the CONAH rations. The partial or complete replacement of WS by a higher intake roughage such as GT or hay during advanced pregnancy, must be regarded as sound management.

Toward the development of appetite-regulated complete rations

Poultry litter, in the quantities included in the present study, was calculated to supply the estimated protein requirements (see chaps. 2.1 and 2.6 for considerations leading to this decision). It constituted 33% of the maintenance PLGT ration, and on the average 22, 24 and 23% in weeks 7-5 and 4-1 prepartum and weeks 1-7 postpartum, respectively (chap. 2.1). Corn constituted 0, 22, 30 and 33% for the same periods, respectively, the GT making up the balance. Performance of the ewes on this ration in the three experiments suggests that only fine tuning of these ratios would be needed for them to form the basis for complete rations. This is under the provision that for the time being, only intermittent use of these materials should be recommended until more information is available on the long-term effects of drug, insecticide, defoliant residues or gossypol in the ration (see also chaps. 2.1, 2.3 and 2.6).

Incorporating the findings reported here with the results in chapters 2.1 and 2.6 should enable the formation of complete rations also based on PL, WS and grain or concentrates together with small quantities of high-quality hay when GT is not available.

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APPENDIX TO PART 2.

Table A.2.1.1 INTAKE PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) OF DRY MATTER AND METABOLIZABLE ENERGY (ME), BY EWES FED RATIONS BASED ON WHEAT STRAW (WS), POULTRY LITTER (PL) AND CORN, VS. WS AND COMMERCIAL CONCENTRATES (CONC.)

Weeks, pre- or post-partum	Exp. no ^a	Rations		Intake		
		Components	ME (MJ/kg)	Total g/W ^{0.75}	WS only g/W ^{0.75}	ME kJ/W ^{0.75}
14- 8, pre-p	1	WS+PL	6.36	47.3	34.3	301
7-5, pre-p	2	WS+PL+Corn	9.25	62.0	21.7	574
	3		8.68	63.3	32.5	549
	2	WS+Conc.	10.27	49.0	15.4	503
	10		9.72	53.7	22.1	522
	10		9.83	51.9	22.1	510
	11		10.22	50.2 ^b	16.3	513
	11		10.72	67.2	16.0	720
4-1, pre-p	2	WS+PL+Corn+Hay	9.49	85.1	15.7	808
	3		8.98	77.8	15.3	699
	2	WS+Conc.+Hay	10.54	68.8	8.4	725
	10	WS+Conc.	10.64	62.8	15.8	668
	10		11.00	62.1 ^b	11.7	683
	11		10.97	55.5	10.8	609
	11		11.30	75.1 ^b	10.4	849
1-7, post-p (lactation)	2	WS+PL+Corn+Hay	10.33	83.4	5.3	862
	3		9.12	98.3	22.9	896
	2	WS+Conc.+Hay	10.81	78.4	5.0	843
	10	WS+Conc.	10.76	85.7	19.8	922
	11		11.04	93.1	16.9	1028

^aSee Tables A2.1.2 - A2.1.5

^bWheat straw and concentrates given ad lib.

Table A2.1.2 INTAKE PER KG METABOLIC BODY WEIGHT ($W^{0.75}$) OF DRY MATTER AND METABOLIZABLE ENERGY (ME), BY EWES FED RATIONS BASED ON COTTON WASTES (CW), POULTRY LITTER (PL) AND CORN

Weeks, pre or post-partum	Rations		Intake		
	Components	ME (MJ/kg)	Total g/W ^{0.75}	CW only g/W ^{0.75}	ME kJ/W ^{0.75}
Dry	CW ₁	8.45	77.8	77.8	657
	CW ₂	6.69	41.6	41.6	278
	CW ₂ +PL	6.68	55.4	43.4	370
14-8, pre-p	CW ₁ +PL	8.09	72.0	57.3	582
	CW ₁	8.45	71.4	71.4	603
	CW ₁ +PL	8.17	82.8	70.0	676
	CW ₂ +PL	6.68	68.2	54.0	456
	CW ₂	6.69	52.4	52.4	351
7-5, pre-p	CW ₂ +PL	6.60	53.2	36.5	351
	CW ₂ +PL	6.59	37.7	24.6	248
	CW ₂ +PL	6.62	58.0	44.2	384
	CW ₂ +PL+Corn	8.15	64.9	36.7	529
	CW ₂ +PL+Corn	8.51	55.6	26.4	473
	CW ₂ +PL+Corn	7.94	74.7	47.9	593
4-1, pre-p	CW ₂ +PL	6.59	55.8	35.9	368
	CW ₂ +PL	6.61	52.6	37.2	348
	CW ₂ +PL	6.61	62.2	45.1	411
	CW ₂ +PL+Corn	8.79	75.0	33.2	611
	CW ₂ +PL+Corn	8.87	67.3	28.8	597
	CW ₂ +PL+Corn	7.52	82.3	42.1	619
1-7, post-p (lactation)	CW ₂ +PL+Corn	9.20	115.0	43.6	1058
	CW ₂ +PL+Corn	8.77	125.2	60.6	1098
	CW ₂ +PL+Corn	8.96	124.8	55.1	1118

CW₁ = LT; CW₂ = GT.

3. LAMB REARING

3.1 WEANING ARTIFICIALLY REARED LAMBS AT THE AGE OF 4 OR 3 WEEKS USING MILK SUBSTITUTE RESTRICTION AND "THIRST INDUCTION" AS A MEANS OF STIMULATING WATER AND SOLID FOOD INTAKE

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ABSTRACT

Four experiments were conducted with Assaf lambs and one experiment with Finn cross lambs, reared on daily rations of 180-220 g of milk replacer. The reconstituted milk was offered at a dilution rate of 1:6 (1 part replacer in 5 parts water), and lambs were weaned at 6 vs. 4 weeks (experiment 1), or 4 and 3 weeks (experiments 2-5). Thirst induction was attempted by reducing the dilution rate of the reconstituted milk to 1:3. There was no evidence of increased water or solid food intake during the weaning procedure in the thirst-induced lambs either around 28 or 21 days. Lambs weaned between 27 and 32 days of age did not exhibit a post-weaning growth check. Average daily gain of lambs weaned at 22 days was 150, -125 and 214 g for the pre-weaning, first and second weeks post-weaning, respectively, in exp. 4, and 243, 86 and 271 g in exp. 5. Regrinding and reducing concentrate pellet size from 4 to 2 mm was not of any advantage for lambs weaned between 28 and 29 days of age.

INTRODUCTION

The expanding use of prolific sheep in conjunction with accelerated lambing frequency calls for increased mechanization in the intensive sheep industry. Artificial rearing of lambs is one of the means of achieving this goal. Its expansion, however, is hampered by high costs, due to milk replacer prices and the labor involved.

The main limiting factor to the saving of milk replacer by early weaning is the inability of lambs younger than 4-6 weeks to consume sufficient amounts of solid food to prevent a "growth-check" at weaning (e.g. Walker and Walker, 1961; Barkai et al., 1981). This is so in spite of the fact that the rumen of a 3-week-old lamb is capable of digesting even roughages at an efficiency comparable to that of an adult sheep (Walker and Walker, 1961; Hodge, 1966).

The main means of stimulating solid food intake so far used successfully is daily milk or milk substitute restriction to levels of 180-250 g dry matter, the exact minimum depending on the genotype (Hunter et al., 1972; Penning et al., 1973; Penning and Treacher, 1975; Barkai, et al., 1981).

Insufficient fluid reaching the rumen seems to be an important factor limiting dry food intake. This may be due to insufficient salivation (Wardrop and Coombe, 1961; Wilson and Tribe, 1961), to the failure to learn to drink water early enough (Drori et al., 1976), or both.

The recommended dry matter concentration of reconstituted milk-substitute offered to lambs varies between 16% and 25% dry matter by weight (1:6 to 1:4 ratio of milk-substitute powder to water). There are, however, some indications that 1:6 to 1:5 ratios have some advantages over lower or higher dilution rates (Treacher, 1973). Fredriksen et al., (1980) and most of the European milk substitute producers recommend a 1:6 dilution.

Magee (1978) postulated that lower dilution (1:3) of a milk substitute may increase the lamb's incentive to drink water and that this could improve early intake of solid food. One of us (D.E.H.) suggested that the increased milk concentration would be of importance mainly during the last few days prior to weaning.

Magee (1978) and Pond et al. (1982) have shown that it is possible to wean lambs successfully onto solid food at the age of 10 days. It was, however, evident that success depended to a great extent on a considerable amount of individual care, and a growth check over several days (not compensated for until the end of the fattening period) was evident in all lambs weaned at the age of 21 days or earlier. Although there are many scientific reports showing that weaning at 21-25 days of age is a safe practice, under most commercial situations weaning is not done before 5-6 weeks. It was therefore decided in the present preliminary study to examine the milk replacer quantity - concentrations - weaning age effects on growth patterns in lambs in the age range of 20-30 days.

Magee (1978) and Pond et al. (1982) considered it important to supply the early weaned (pre-ruminant) lambs with a finely ground starter. The possible contribution of regrinding the commonly used 4 mm concentrate pellets and repelleting them into a smaller size (2 mm) was also examined.

MATERIALS AND METHODS

Five experiments were done. Experiments 1-4 were conducted with the Neue Ya'ar experimental flock of dairy sheep using Assaf lambs. Experiment 5 was carried out at Bet Dagan with Finn-Mutton Merino and Finn-Awassi lambs.

Neue Ya'ar experiments

In these experiments lambs were maintained in groups, but the milk was fed individually from separate containers attached to a bar and connected by plastic pipes to nipples mounted on a plywood board, with partitions separating individual lambs while sucking. The arrangement of the group pens and the "nursing bar" was such that each group of up to ten lambs could be released in its turn for a meal that lasted 5-10 minutes.

Lambs stayed with their dams for the first 12-24 h after birth and were then moved into a training pen where they were trained to a nipple bottle, before being moved into their group pen. For the first week they were given three meals and afterwards two meals per day. In the case in which suckling lasted for 6 weeks, their meals were further reduced to one per day in the last week pre-weaning.

The daily milk ration was calculated to supply 180 g dry milk replacer per day, or a total of approximately 4.5 kg in 4 weeks or 6.4 kg in 6 weeks. The reconstituted milk contained one part dry milk replacer per five parts (by weight) water, save for during the weaning process, in the appropriate cases. Different commercial milk replacers were used. Fresh water and a self-feeder with concentrates were accessible to the lambs at all times. The concentrate mixture (pelleted) was prepared by a commercial mill according to Folman and Eyal (1978).

Experiment 1. Twenty-four lambs, all born within one week, were divided into two treatment groups according to date and type of birth, sex, and birth weight. One group was weaned at an average age of 29 days and the other at 43 days. In the group allotted for weaning at 29 days, the milk replacer dilution rate had been gradually reduced from 1:6 (milk to water) to 1:3 starting at the beginning of the last week before weaning. The pellets (4 mm diameter) for the earlier weaned group were ground and repelleted to 2 mm. Before repelleting, 2% soy-bean oil meal was added to compensate for any eventual loss due to the heat of the pelleting process. Two of the control (weaning at 43 days) group died, one at 29 days (diarrhea) and one at 33 days (pneumonia); therefore, only ten remained for the comparison.

Experiment 2. This experiment was undertaken to test the assumption that regrinding of the concentrate pellets was necessary to facilitate weaning at 28 days of age. It was also intended to wean one group at 21 days but, due to an error, the weaning process was delayed and so this group was weaned at an average age of 27 days. The shift from 1:5 to 1:2 reconstituted milk was done abruptly, one week before weaning.

Experiment 3. Fourteen lambs were reared on 180 g of dry milk replacer per day for an average of 32 days and weaned abruptly without any prior thirst induction.

Experiment 4. Twelve lambs were divided into two groups. one to be weaned at 28 days and the other at 21 days. The weaning process was done as in exp. 2.

Experiment 5. (Bet Dagan) Twenty Finn-cross lambs were allotted into three groups. Group 3 lambs, assigned to be weaned at 21 days, were born on the average one week later than those of the two other groups assigned for weaning at 28 days of age. Therefore, all three groups were weaned together.

Unlike exps. 1-4, in this experiment milk was group-fed from a common pail with eight teats attached to its bottom and mounted on an iron frame in each pen.

Milk was fed three times a day in the first week and twice daily from the second week to weaning. It was rationed to supply an average of 220 g of dry matter per lamb per day. Time to finish the meal was not limited and the pail was withdrawn only when the lambs had completed sucking out the milk.

In one of the 28-day weaning groups 11% of the milk replacer was replaced by a mixture of heat-treated (swelling) starch and a soybean protein concentrate. The subject of starch in milk replacers is presently being dealt with in detail outside the framework of the present project and will therefore not be further discussed here. The "thirst induction" system was used 5 days prior to the planned weaning date by abruptly reducing the water-to-milk-replacer ratio from 5:1 to 2:1.

The same pelleted (4 mm) concentrate mixture was used as in the Newe Ya'ar experiments. It was offered ad lib. from the end of the first week onwards. Fresh water was available to the lambs at all times.

RESULTS

Weaning at 28 days

As may be seen in Tables 3.1.1, 3.1.3, 3.1.4, 3.1.5 and 3.1.7, there was no growth check as a result of weaning at this age. Furthermore, in most cases, there was even an enhanced growth rate in the week immediately following weaning. As a result there was no difference in performance between lambs weaned at 4 weeks and 6 weeks (exp. 1).

Weaning at 21 days

There was a sharp growth check in one case (Table 3.1.5) following weaning at this age and a retardation in growth rate in another (Table 3.1.7). There was, however, a quick recovery of the daily gain in the second and third weeks post-weaning. There was even some compensatory growth in weeks 5 and 6, as indicated by the fact that in both cases growth rate in these weeks was faster in the group weaned at 21 days compared with the control.

Effect of "thirst induction"

Lambs weaned at 32 days without thirst induction did not show any growth check (Table 3.1.4). Furthermore, in exp. 4, where water intake was measured on 2 days (Table 3.1.6), lambs weaned at 21 days after the thirst induction exercise did not drink more water than those still receiving milk. This is reflected in their loss of body weight during the following 6 days, after which there was a recovery in growth rate, which must reflect sufficient intake of solid food and increased water consumption. One week after weaning of the 21-day group, the lambs drank more fresh water than the 28-day group, which still received a small amount of water in the milk replacer.

In exp. 1, the lambs going through the "thirst induction" procedure during days 23-29 ate more solid food than those of the control group (Table 3.1.2). This result, however, may be biased, as there was an apparent small difference between the two groups already during the first 3 weeks of their life when they were all under the same milk diet. In exp. 5, the early weaned lambs consumed the same amount of concentrates during week 3 as those weaned a week later (Table 3.1.8).

Table 3.1.1 GROWTH OF ASSAF LAMBS WEANED AT THE AGE OF 29 DAYS AFTER THIRST INDUCTION, COMPARED WITH LAMBS WEANED AT 43 DAYS (EXPERIMENT 1, APRIL 1982)

Age (days)	Variable	Weaning age (days)	
		29	43
0	Number of lambs	12	10
	Weight, kg	4.5	4.5
29	Weight, kg	9.6 ^b	9.2
	GR ^a , g/day	174	166
43	Weight, kg	13.4	12.6 ^b
	GR ^a , g/day	270	247
92	Weight, kg	31.8	31.0
	GR ^a , g/day	377	376

^aGR = growth rate

^bWeaning weight

Table 3.1.2 MEAN INTAKE OF CONCENTRATE PELLETS (g/day/lamb) BY LAMBS WEANED AT 29 OR 43 DAYS (EXP. 2)

Period (days after birth)	Weaning age (days)	
	29	43
3-22	24	13
23-29	85	53
30-43	401	253
44-50	596	581

Table 3.1.3 GROWTH OF ASSAF LAMBS WEANED BETWEEN 27 AND 29 DAYS OF AGE WITH "THIRST INDUCTION" ONTO REGULAR (R) 4-MM PELLETS, COMPARED WITH SPECIALLY GROUND (G) AND REPELLETED TO 2 MM SIZE PELLETS (EXP. 2, OCTOBER 1982)

Age (days)	Subtreatments and variables	Weaning age (days) treatment		
		29	28	27
		Pellet type		
		G	R	G
	Number of lambs	8	8	7
0	Weight, kg	4.0	4.0	3.8
28	Weight, kg	8.3	8.7	8.0 ^b
	GR ^a , g/day	148	169	157
42	Weight, kg	12.3	12.5	12.1
	GR ^a , g/day	286	272	273
93	Weight, kg	30.6	32.5	31.7
	GR ^a , g/day	359	392	384

^aGR = growth rate

^bWeight at 27 days

Table 3.1.4 RESPONSE OF ASSAF LAMBS TO WEANING AT 32 DAYS OF AGE WITHOUT "THIRST INDUCTION" (EXP. 3, APRIL 1983)

Number of lambs	14
Weight at weaning, kg	9.9±1.77
Growth rate, g/day:	
Birth to weaning (W)	166±37
W to 14 days post-W	286±49

Table 3.1.5 GROWTH OF ASSAF LAMBS WEANING AT 22 COMPARED WITH 28 DAYS WITH "THIRST INDUCTION" (EXP. 4, MAY 1983)

Age (days)	Variables	Weaning age (days), treatments	
		22	28
	Number of lambs	6	6
0	Weight, kg	4.7±1.03	4.8±0.62
22	Weight, kg	8.1 (8.7) ^b	8.3
	GR ^a , g/day	150±34	160±23
28	Weight, kg	7.9	9.9
	GR ^a , g/day	-125±182	267±43
42	Weight, kg	10.9	12.5
	GR ^a , g/day	214±93	186±132

^aGR = growth rate

^bOnly four lambs; two lambs died, 6 and 10 days post-weaning.

Table 3.1.6 DAILY WATER INTAKE (WI) PER LAMB ON WEANING DAYS (EXP. 4)

Lambs' age on test days, d	22		28	
Weaning age group, d	21	28	21	28
Water drunk, g/day	720	740	1140	975
WI in reconstituted milk, g	-	900	-	360
Total WI, g	720	1640	1140	1335
WI per kg body weight, g	83	225	180	135

Table 3.1.7 GROWTH OF FINN CROSS LAMBS WEANED AT THE AGE OF 21 DAYS COMPARED WITH 28 DAYS AFTER "THIRST INDUCTION," AND WITH 20% REPLACEMENT OF COMMERCIAL MILK REPLACER (CMR BY HEAT-TREATED STARCH + SOYBEAN PROTEIN CONCENTRATE (SBPC) (EXP. 5, FEBRUARY 1983) (MEANS±S.D.)

Age (days)	Subtreatments and variables	Weaning age (days) main treatment		
		28	28	21
	Milk replacer	CMR	CMR+SBPC	CMR
	Number of lambs	8	7	5
0	Weight, kg	3.4±0.61	3.4±0.72	4.3±1.25
21	Weight, kg	8.6±1.52	8.4±1.57	9.4±1.36
	GR ^a , g/day	248	238	243
28	Weight, kg	9.9±1.75	10.2±2.11	10.0±1.25
	GR ^a , g/day	186	257	86
35	Weight, kg	11.4±2.01	11.8±2.67	11.9±1.57
	GR ^a , g/day	214	228	221
70	Weight, kg	22.3±3.36	23.6±4.57	23.3±3.45
	GR ^a , g/day	311	337	325

^aGR = growth rate.

Table 3.1.8 SOLID FOOD (CONCENTRATES) INTAKE (G/LAMB/DAY) BY LAMBS WEANED AT 28 DAYS OR 21 DAYS OF AGE AND FED DIFFERENT MILK REPLACERS (EXP. 5)

Week after birth	Weaning age (days) and milk replacers		
	28 CMR	28 CMR+SBPC	21 CMR
2nd	57	31	20
3rd	95	80	85
4th	156	150	251
5th	391	396	480
6th	559	635	640
7th	736	770	750

DISCUSSION

The present series of experiments was conducted within a lamb-rearing system in which milk and time (number and duration of meals) were restricted. Under these conditions the "thirst induction" exercise seems to have been superfluous with weaning at 28 or at 21 days of age.

The sharp growth check in exp. 4 could be a result of an aggravated water imbalance due to increased evaporative loss, induced by the hot

weather during the days when these lambs were weaned. The results of Pond et al. (1982) indicate that access to water supply through a nipple (given in limited times and quantities) could alleviate any tendency for solid food compaction in the digestive tract and thus, perhaps, improve intake. The role of thirst induction may be different in a lamb-rearing system in which milk is offered ad lib. This is worth testing, as Penning and Treacher (1975) have shown that lambs weaned off a high milk substitute ration and at a late weaning age (40 days) had better post-weaning feed conversion efficiencies than those weaned off lower rations at younger ages. As this may offset some of the advantages of early weaning, efforts to stimulate feed intake are still warranted.

We sincerely appreciate the voluntary help of Miss Susan Seymour who was a guest at the ARO when exp. 5 was being done.

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3.2 THE EFFECT OF INTRAJUGULAR FRUCTOSE INJECTIONS TO NEWBORN LAMBS

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ABSTRACT

Eighty-eight lambs were injected intrajugularly with 0 (n=29), 0.5 (30) or 2.0 (29) g of fructose within 8 hours of birth. In a second experiment, 16 calves were injected with 50 ml of saline + 5 g fructose (n=6), 50 ml saline (6), or not treated (4). There was no treatment effect on survival of animals, growth rate, or (in calves) occurrence of diarrhea in either experiment.

INTRODUCTION

Perinatal disease and mortality cause great losses to the livestock industry. Most conventional means to reduce this loss are aimed at improving the environmental conditions and the care of the newborn animals, or at increasing the immunological resistance to specific diseases. Another attitude is to try and increase the ability of the newborn animal, in a nonspecific manner, to cope with different environmental factors. Thus, Nabuurs *et al.* (1982) reported promising results by increasing the general immunological responsiveness.

In prolific sheep perinatal mortality due to noncontagious causes forms a considerable proportion of the total loss of lambs. The fact that the rate of mortality is proportional to litter size (see e.g. Goot, 1973), points to physiological factors; hence, the importance of gaining a better understanding of perinatal physiology and of means of intervention that will improve lamb survival.

Fructose is the main sugar in the embryonic blood of farm animals but does not exist in the blood of the mature animal (Goodwin, 1956). Blood fructose concentration gradually diminishes toward term (Comline and Silver, 1970; Alexander *et al.*, 1966); at the same time, glucose concentration gradually increases. This process is greatly enhanced at birth (Daniels *et al.*, 1974), and within 24 h post-partum glucose completely replaces fructose, the concentration of which quickly approaches zero.

Fructose does not serve as a source of energy in the fetuses or newborn animals. Its decreased blood concentration is a result of its being excreted by the kidneys (Shelly *et al.*, 1962; Warness *et al.*, 1977). It has been found that the injection of fructose to one-day-old calves reduces the glucose concentration to about one-third or one-quarter (Edwards and Powers, 1967). Such an effect was not apparent at the age of one week.

These findings led to the hypothesis that fructose has a role mainly in regulating the energy exchange of the fetus (Daniels *et al.*, 1981), and that its post-partum reduction is part of a general adjustment to extra-uterine life. It has been further postulated that external supply of fructose to one-day-old animals might improve their ability to cope with environmental hazards. Daniels *et al.* (1979) reported a significant improvement in growth and feed efficiency of one-day-old fructose-injected calves compared with a control group. There are no similar reports on lambs.

The aim of the present study was to test if fructose injections could bring about similar responses in lambs and also to gain some knowledge about possible optimum dosing of fructose.

MATERIALS AND METHODS

Experiment 1

Lambs. The experiment was carried out with the Bet Dagan experimental flock, in the February 1982 lambing. All the lambs born to 53

Finn x Merino and FinnxAwassi ewes were included, with 25 singles, 42 twins and 21 triplets, for a total of 88 lambs (four stillborn and two lambs which died within 2 days after birth were not included). The sheep due to lamb were observed throughout the 24 hours, save for six hours from 12.00 p.m. to 0.600 a.m. Assistance during parturition was given only in cases of dystocia. All lambs were weighed, had their navels disinfected and ears tagged, as soon as licking by the mother was completed. Each ewe with its lambs was put in an individual cubicle for 2-3 days and then joined with the rest of the suckling ewes.

Treatments. The lambs were allotted to the treatments serially as they were born, in cycles (one lamb per treatment in each cycle). Thus, the partition into treatments according to litter size, sex, genotype and birth weight was random.

The solutions for injection were prepared by filtration of a solution of crystalline fructose (Sigma No. F-0127) in infusion-saline (Travenol Laboratories, AWB 1324). The injected dose was 3 ml, with 0, 0.5 or 2.0 g fructose per treatment, as shown in Table 3.2.1. All injections were given into the jugular vein within 8 hours of birth.

Table 3.2.1 ALLOTMENT OF MALE (M) AND FEMALE (F) LAMBS TO EXPERIMENTAL TREATMENTS AND RELATIVE GROWTH RATES FROM BIRTH TO 7 DAYS OF AGE (MEANS±SE)

	Treatment no.					
	1		2		3	
	0.5 g fructose		2.0 g fructose		no fructose	
Sex	M	F	M	F	M	F
N	20	10	19	10	18	11
Birth weight, kg	3.7±.22	3.2±.22	3.2±.20	28±.20	3.4±.21	3.2±.25
Growth to 3 days, %	114±2.3	113±4.3	117±2.6	110±3.8	118±2.3	117±2.7
Growth to 7 days, %	146±4.0	145±6.6	147±5.4	136±6.2	151±3.9	148±4.2

Measurements. All cases of disease were recorded. Each lamb was weighed daily in the first week. From some of the lambs, among those which were attended from birth, blood samples were taken for the assessment of sugars' concentration.

Experiment 2

Sixteen female calves born in April-May 1983 in the herd of Kvuzat Schiller, near Rehovot, were used. The fructose solutions were prepared by the same procedure as for the lambs, in doses of 50 ml, containing either 5 g fructose (treatment 1) or none (treatment 2). Calves whose exact time of birth had been observed were injected within 8 hours after birth (six calves in treatments 1 and 2) and another four calves were used as an untreated control.

Calves were weighed on the day of birth and at weekly intervals to the age of 28 days. Blood samples were taken as in experiment 1.

RESULTS

Results are presented in Tables 3.2.1, 3.2.2 and 3.2.3. Growth of lambs or calves is expressed as percentage of birth weights. Multiple range analysis of variance was applied for statistical evaluation at $P < 0.05$.

All differences between treatments or between sexes within treatments were statistically non-significant.

Table 3.2.2 MEAN ($\pm$ SE) BIRTH WEIGHTS AND RELATIVE GROWTH RATES FROM BIRTH TO 7 DAYS OF AGE IN LAMBS FROM DIFFERENT LITTER SIZES

Litter size	Treatment no.		
	1	2	3
Singles, n	9	9	7
Birth weight, kg	4.2 $\pm$.29	3.2 $\pm$.30	3.2 $\pm$.27
Growth to 3 days, %	114 $\pm$ 1.5	122 $\pm$ 3.8	120 $\pm$ 3.8
Growth to 7 days, %	149 $\pm$ 2.3	163 $\pm$ 7.5	158 $\pm$ 8.3
Twins, n	14	13	15
Birth weight, kg	3.4 $\pm$.23	3.2 $\pm$.19	3.2 $\pm$.20
Growth to 3 days, %	114 $\pm$ 3.6	112 $\pm$ 3.6	112 $\pm$ 3.6
Growth to 7 days, %	146 $\pm$ 6.1	142 $\pm$ 6.4	142 $\pm$ 6.3
Triplets, n	7	7	7
Birth weight, kg	2.9 $\pm$.23	3.0 $\pm$.29	3.3 $\pm$.24
Growth to 3 days, %	111 $\pm$ 4.9	110 $\pm$ 3.0	113 $\pm$ 3.1
Growth to 7 days, %	142 $\pm$ 8.0	133 $\pm$ 4.3	133 $\pm$ 4.6
All, n	30	29	29
Birth weight, kg	3.6 $\pm$.17	3.1 $\pm$.14	3.3 $\pm$.16
Growth to 3 days, %	113 $\pm$ 2.0	115 $\pm$ 2.2	118 $\pm$ 1.7
Growth to 7 days, %	146 $\pm$ 3.4	146 $\pm$ 4.2	144 $\pm$ 2.9

Table 3.2.3 GROWTH RATES OF CALVES AND OCCURRENCE OF DIARRHEA FROM BIRTH TO 28 DAYS OF AGE (MEANS $\pm$ SE)

	Treatment no.		
	1	2	3
	5 g fructose	no fructose	no injection
n	6	6	4
Birth weight, kg	40 $\pm$ 1.3	37 $\pm$ 3.4	33 $\pm$ 2.1
Growth to 28 days, %	114 $\pm$ 4.2	115 $\pm$ 3.7	123 $\pm$ 4.7
g/day	194 $\pm$ 55	179 $\pm$ 34	264 $\pm$ 49
Diarrhea, days	3.8 $\pm$ 1.5	4.7 $\pm$ 1.5	3.3 $\pm$ 1.7

DISCUSSION

The results obtained in exp. 1 differed from those reported for calves (Daniels et al., 1979). Therefore, exp. 2 was undertaken to test if it would be possible to reproduce the calf results; this was not accomplished.

The discrepancy between our results and those of Daniels et al. (1979) could be due to two reasons: (a) Daily growth rates in our calf experiment ranged between 180 and 160 g, compared with only 18 to 112 in Daniels' work. Fructose injection might have an effect only under stressful conditions and not under optimal ones. (b) There is a difference between lambs and calves in the dynamics of sugar exchange (Shelly et al., 1962). In calf blood, glucose levels at birth already exceeded those of fructose. In lambs, this happened only several hours post-partum. The injection of external fructose might have been more effective in this case, had it been applied at a later stage (e.g. 8-16 hours after birth), when endogenous fructose levels are already low.

Another confounding effect arises from the fact that lambs in our experiments were suckled by their mothers, who may differ considerably in their milk yields, while the calves in the experiments of Daniels et al. (1979) were reared artificially on equal rations to all individuals.

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4. THE REPRODUCTIVE RESPONSE OF FINN-CROSS EWES TO NATURAL AND ARTIFICIAL PHOTOPERIOD, HORMONE TREATMENT AND INTRODUCTION OF RAMS

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ABSTRACT

Manifestation of natural oestrus, ovarian activity, response to hormonal treatment for the induction of oestrus, and fertility and prolificacy of Finn x German Mutton Merino (FM) and Finn x Awassi (FA) ewes were studied at different seasons of the year, with the aim of adopting an intensive breeding management in order to increase the lambing frequency.

The sexual season -- the period with cyclic oestrous activity -- was found to extend from July-August to February-March. During sexual quiescence -- the seasonal anoestrus -- from March-April to June-July, spurts of elevated progesterone levels lasting 7 days or more and indicating a functional corpus luteum, were detected in nearly 50% of the ewes.

Following October-November lambings, 90% of the ewes resumed cyclic oestrous activity within 60-75 days post-partum. Most of these ewes had a silent ovulation, indicated by the course of the progesterone profile, within 6 weeks post-partum.

By treating anoestrous ewes during the seasonal anoestrus with exogenous hormones, it was possible to induce oestrus in 90% of the animals.

Mating of the ewes at their natural oestrus in September and December resulted in conception rates of 64% and 74%, respectively. The conception rates of ewes at their induced or synchronized oestrus in June, September and December were 63%, 56% and 67%, respectively. The mean litter size was similar in all cases -- 1.7-2.0 lambs per lambing ewe.

Mating anoestrous ewes after oestrus induction in April resulted in different conception rates in different years. Whereas 47% of 102 ewes bred in 1981 and 1982 lambed, the lambing percentage of 55 ewes bred in 1983 was 85%. This lambing rate was achieved after oestrus induction under natural or artificially decreasing photoperiods either by hormones, as in previous years, or by introduction of rams. The mean litter size in April was similar to that in the other seasons.

The results of this study demonstrate the feasibility of an intensive breeding management with more than one breeding period per year.

INTRODUCTION

Attempts to increase the prolificacy of Awassi and German Mutton Merino ewes have been made in Israel by crossing them with Finnish Landrace rams (Goot, 1975; Goot *et al.*, 1979). Data on some reproductive characteristics of the above crosses were published (Amir *et al.*, 1980, 1981) and a breeding management program to increase the lambing frequency was proposed (Amir and Schindler, 1977). By such a management, a lambing interval of 9.2 months was achieved (Schindler and Amir, 1983). Further increase of the lambing frequency is hampered by the post-partum and seasonal anoestrous periods. In view of the scarcity of available information (Amir *et al.*, 1981), additional data are required on the oestrous and ovarian activities and on the fertility and prolificacy of the ewes during these periods, and in particular of the Finn x Awassi crosses.

In the present work the lengths of the seasonal and post-partum anoestrous periods and the ovarian activity of the Finn cross ewes during these periods were studied. Data on the fertility of the ewes throughout the year were also compiled. Finally, the effect of an artificially decreasing photoperiod on the fertility of the ewes during seasonal anoestrus was examined, in addition to the response of the animals to hormonal treatments or to the effect of joining with rams after a long separation on the induction of oestrus.

MATERIALS AND METHODS

Oestrus

Adult Finn x German Mutton Merino (FM) and Finn x Awassi (FA) ewes were used. The ewes were kept indoors and maintained on a concentrate-straw-hay ration. Starting 1-2 weeks after parturition, oestrus detection was carried out with aproned rams joined with the ewes for 30 min once a day, except for the animals which were separated from the males for experimental purposes, and twice a day after hormonal treatment for induction or synchronization of oestrus. Induction or synchronization of oestrus was carried out with Cronolone (G.D. Searle) sponges inserted for 12-13 days and an injection of 500-600 I.U. pregnant mare serum gonadotropin (PMSG) at the time of sponge withdrawal. The rate of entering the sexual season, *i.e.*, the percentage of ewes starting the seasonal cycle oestrous activity, was determined in 48 FM and 108 FA ewes. The rate of entering the anoestrous season was determined in 32 FM and 30 FA ewes which lambed in October-November, renewed their cycle oestrous activity and entered the anoestrous season.

Ovarian activity

The post-partum and seasonal anoestrous ovarian activities were studied by measuring the plasma progesterone concentrations by radioimmunoassay (Rosenberg *et al.*, 1977) in blood samples taken twice weekly from 1-2 weeks after lambing until the resumption of normal cycle activity. During the seasonal anoestrus the changes in plasma progesterone concentrations were studied in 8 FM and 30 FA ewes. The post-partum ovarian

activity was studied in 17 FM and 23 FA ewes which lambed in October-November. The lambing ewes were allowed to nurse their lambs for 5-6 weeks.

Fertility

The fertility of the ewes was assessed by mating them twice, immediately after detection and again 24 or 12 h later for the natural or induced oestrous ewes, respectively. A total of 1547 mating results from 183 FM and 182 FA ewes mated at different months during a five-year period were compiled. April matings were carried out under natural photoperiod over two years. During that time 35 of the 114 hormonally treated ewes were given a second PMSG injection 16 days after the one given at sponge withdrawal. In the third year the ewes to be bred in April were subjected to an artificial photoperiod before and during the mating period.

Artificial photoperiod

A group of 57 ewes, pregnant after September matings, served the experiment. Thirty-one animals were kept under natural photoperiod (controls). The rest were kept under an artificial photoperiod, which consisted of an abrupt increase to 18 h light in November for 30 days and a gradual decrease in the light period by 30 min every 10 days (Robinson *et al.*, 1975). The average light intensity at the level of the ewes was approximately 200 lux. The exposure of ewes to daylengths shorter than the natural photoperiod was achieved by putting the animals, before the natural darkness, into a darkened enclosure for a time period equal to the difference in daylength between the natural and the artificial photoperiods. During the night these ewes were returned to the natural conditions of the barn.

The ewes lambed in February under natural and artificial daylengths of about 12 and 14.5 h, respectively, and were allowed to nurse one lamb per ewe for a mean period of 35 days.

Within a week after lambing, 10 control and 10 light-treated ewes were exposed once a day for 30 min to an aproned ram, while the remaining control and experimental animals were isolated from the rams' sight (Table 4.4).

After weaning in March, intravaginal sponges were inserted for 12 days and PMSG was injected at sponge withdrawal into the above 20 ewes and into another 10 control and 8 experimental animals from the isolated group. Of the remaining isolated ewes, 11 control and 8 experimental animals were given a single IM injection of 20 mg progesterone (progesterone priming) 2-6 days after weaning and were then exposed to the daily 30 min contact with aproned rams (Lindsay *et al.*, 1982).

Blood samples for examination of plasma progesterone concentrations were taken twice weekly from lambing until sponge insertion from 16 control and 15 experimental animals, and until mating from 11 control and 8 light-treated ewes in which no sponges were used for oestrus induction.

The matings of the light-treated ewes in April were carried out under a 12 h daylength, equivalent to that in October under natural conditions (Robinson *et al.*, 1975). The experimental ewes were kept in the decreasing photoperiod until an artificial daylength of 10 h was reached in May and bred again if they returned to heat, before being returned to the natural photoperiod.

Statistical analysis

The comparison between the conception rates obtained in different months was carried out by normal approximation analysis of the results.

RESULTS

The occurrence of cycle oestrous activity during the year is presented in Fig. 4.1. The period during which such activity occurs -- the sexual season -- is very similar in the two crosses and extends from July-August to February-March. The results (Table 4.1) show that the ewes which lambed from January through March entered the sexual season somewhat earlier than those that lambed in April-May; however, the difference was not statistically significant. During the quiescent period of oestrous activity -- the seasonal anoestrus -- the suspension of oestrus was not always accompanied by a concomitant interruption of ovarian activity as reflected by changes in the plasma progesterone levels. Remarkable differences were found between the different ewes, ranging from complete lack of progesterone changes to uninterrupted changes, both after October lambings with resumption of cycle activity before entering seasonal anoestrus (Fig. 4.2) and after January lambings (Fig. 4.3). Individual profiles of plasma progesterone concentrations during the seasonal anoestrus showed that nearly 50% of the examined animals (3 of 8 FM, and 14 of 30 FA) had spurts of elevated plasma progesterone concentrations for 7 days or more, indicating the presence of a functional corpus luteum.

Table 4.1 RATE OF ENTERING THE SEXUAL SEASON OF EARLY AND LATE LAMBING FINN CROSS EWES

Month of previous lambing	Finn x GMM			Finn x Awassi		
	Cumulative percentage of oestrous ewes by the end of					
	June	July	August	June	July	August
Jan-Mar	20 (20)	35	65	6 (50)	30	84
Apr-May	7 (28)	11	61	0 (58)	28	74

In parentheses, number of ewes

Table 4.2. presents the rate of resumption of cycle oestrous activity after October-November lambings. About 90% of the lambing ewes (43 of 45 FM and 38 of 44 FA) resumed cycle activity within 60-75 days. An

Figure 4.1 The sexual season of Finn x GMM (O) and Finn x Awassi (Δ) ewes.

Figure 4.2 Three individual profiles of plasma progesterone concentrations during seasonal anoestrus among 16 Finn x Awassi ewes that lambed in October and resumed cycling activity in December, showing one ewe with uninterrupted sexual activity (a), a second animal with sustained ovarian activity (b) and a third with prolonged seasonal anoestrus (c). + = oestrus.

Figure 4.3 Two individual profiles of plasma progesterone concentrations during seasonal anoestrus among 14 Finn x Awassi ewes that lambed in January. (a) Uninterrupted ovarian activity and early resumption of the sexual season; (b) Deep and prolonged seasonal anoestrus. ↓ = oestrus.

Figure 4.4 Three individual profiles of plasma progesterone concentrations (a,b), and one of them among 23 Finn x Awassi ewes (c).

- ↓ = oestrus.
- (a) Silent ovulation before resumption of cycling.
 - (b) Resumption of post-partum cycling without silent ovulation.
 - (c) Oestrus occurrence without formation of a functional corpus luteum.

elevated progesterone concentration, showing a silent ovulation, was detected 4-6 weeks after lambing in 10 of 15 FM and in 15 of 20 FA ewes (recycling ewes) (Fig. 4.4).

Table 4.2 RENEWAL OF SEXUAL ACTIVITY AFTER OCTOBER-NOVEMBER LAMBINGS

Breed	FM	FA
No. of ewes	45	44
No. coming into oestrus	43	38
Cumulative percentage of oestrus ewes		
days after lambing: 30	5	10
45	45	71
60	80	100
75	100	-
Parturition to oestrus interval, days (Mean±SEM)	50±1.8	42±1.7

The conception rate and the mean litter size of the ewes bred at different months of the year is shown in Table 4.3. The response of the ewes to exogenous hormones for induction or synchronization of oestrus was 90-95% and was similar in the different months during both the sexual season and the seasonal anoestrus. The conception rate was higher, but not significantly, after matings at the natural than at the synchronized oestrus, and in December-January than in September matings. After oestrus induction or synchronization, the conception rate was significantly lower in April than in June or December. The use of a second PMSG injection 16 days after the one given at sponge withdrawal did not increase the percentage of return to oestrus in the non-conceiving ewes relative to animals given a single PMSG injection.

Table 4.3 LAMBING RATE (% OF MATED EWES) AND MEAN LITTER SIZE PER LAMBING EWE IN DIFFERENT MONTHS

Month	Hormonal treatment	Number treated	Number bred	% lambed	Mean litter size
April	With	114	102	47.0 ^a	1.8
June	With	457	433	63.3 ^{bc}	2.0
September	With	372	359	55.7 ^{ab}	1.8
	Without	-	168	64.2	1.7
December	With	222	205	66.8 ^c	1.8
	Without	-	225	73.3	1.8

^{a,b,c} Within the treated groups means with a different superscript differ significantly ($c > a, b, P < 0.05$; $b, c > a, P < 0.01$).

Fig. 4.5 Individual profiles of plasma progesterone concentrations in 4 control (natural photoperiod) and 4 experimental (artificial photoperiod) ewes after lambing, separated from or joined daily with rams.

Figure 4.6 Individual profiles of plasma progesterone concentrations in 2 control (natural photoperiod) and 2 experimental (artificial photoperiod) weaned ewes after daily introduction of rams from which they were previously separated. ↓ = oestrus.

No significant differences in litter size between the ewes bred at different months were found.

Table 4.4 presents the results obtained by using artificial photoperiod in combination with either hormones or introduction of rams after a long separation, in order to induce fertile oestrus in April. It can be seen that a conception rate of more than 80% was achieved under both natural and artificial photoperiods. Hormonal treatment with intravaginal sponges did not increase the percentage of lambing ewes in comparison with those primed with progesterone and exposed to the rams after a long separation.

Table 4.4 LAMBING RATE (% OF TREATED EWES) AND MEAN LITTER SIZE PER LAMBING EWE IN APRIL UNDER NATURAL AND ARTIFICIAL PHOTOPERIODS

Photoperiod	Natural			Artificial		
	Separated from rams		Exposed to rams	Separated from rams		Exposed to rams
Rams' effect						
Intravaginal sponges	-	+	+	-	+	+
No. of ewes	11	10	10	8	8	10
Bred	9	10	10	8	8	10
Lambd (%)	73	80	90	100	87	70
Litter size	1.9	2.0	2.3	2.0	2.0	2.1

Under both natural and artificial photoperiods, plasma progesterone concentrations in the above ewes during nursing remained at low basal levels both in isolated animals and in those subjected to daily contact with rams (Fig. 4.5). After weaning, exposure of the isolated ewes to the presence of rams resulted in elevated progesterone concentrations within 3-4 weeks, under both natural and artificial photoperiods (Fig. 4.6).

DISCUSSION

The results of the present study show that the sexual season of the FA ewes resembles that of FM ewes, and is very similar to the sexual season of the purebred Awassis (Amir and Volcani, 1965) both in its length and in the rates of entering and ending the season with cycle oestrous activity. The suspension of oestrus during the anoestrous season was not accompanied by a concomitant suspension of ovarian activity. Elevated plasma progesterone concentrations for 7 days or more, indicating silent ovulations, were detected in about 50% of the ewes before entering seasonal anoestrus, in a similar percentage during anoestrus and in 90% before starting seasonal cycle activity. Thimonier and Mauléon (1969), by direct observation of the ovaries of Ile de France and Préalpes ewes, found that ovulations occurred during the anoestrous season. The percentage of ovulating ewes and the frequency of ovulations

were different in the two consecutive years during which the examinations were carried out and in the two breeds. It seems, therefore, that a large number of animals and more than one year of observations are needed in order to determine the reproductive characteristics of a breed during the anoestrous season.

The question arises whether ewes with active ovaries during the seasonal anoestrus have a better chance of conceiving, after treatment for oestrus induction, than animals with non-active ovaries at the time of treatment. Miller *et al.* (1977) reported that normal early development of embryos transferred to vasectomized ewes depended, *inter alia*, on the pretreatment of these animals with progesterone. In dairy cows high levels of circulating progesterone during the oestrous cycle preceding insemination seem to favor conception (Folman *et al.*, 1973; Holness *et al.*, 1981). In some breeds a conception rate of 40-50% in anoestrous ewes was reported by some authors (Cognie *et al.*, 1975; Hackett *et al.*, 1979; see also Table 4.3), whereas in ewes of others a higher conception rate was observed (Cognie *et al.*, 1975; Amir *et al.*, 1980). During the anoestrous season a higher conception rate was found among Préalpes than among Ile de France ewes (Thimonier *et al.*, 1968). In another study (Thimonier and Mauléon, 1969) it was found that a higher proportion of Préalpes than Ile de France ewes exhibited ovarian activity during this season. It seems reasonable to assume that the difference in fertility might have resulted from differences in the percentage of ewes displaying ovarian activity during this season.

If the above assumption is valid, the occurrence of silent ovulations in the majority of the recycling post-partum ewes before the manifestation of their first oestrus in addition to those occurring during seasonal anoestrus, make it feasible to achieve a frequent lambing by breeding after oestrus induction during these periods.

The high conception rate obtained in April 1983, compared to those obtained in April of the two previous years under similar conditions (natural photoperiod and intravaginal sponges), is intriguing. Differences in the seasonality of reproduction in ewes have previously been reported (Riches and Watson, 1954; Thimonier and Mauléon, 1969; Eyal *et al.*, 1978), but the conception rate in April of this particular year was even higher than that obtained during the sexual season. By using artificial photoperiod no further improvement of such high fertility could be achieved. The number of ewes was small and data on additional animals and years are needed in order to determine the need of artificial light during anoestrus to increase fertility in the ewes. The results obtained by the introduction of rams to progesterone-primed ewes for induction of ovarian activity and oestrus (Lindsay *et al.*, 1982) in April are encouraging, although the number of animals used was small. It is intended to pursue this line of experimentation in order to assemble more evidence on the influence of light and on the rams' effect in promoting the fertility of ewes during seasonal anoestrus. From the results of the present study it seems that good conception rates can be obtained by breeding the Finn cross ewe throughout the year. The lambing frequency of this cross could thereby be increased to a greater degree than that suggested by Amir and Schindler (1977) and achieved by Schindler and Amir (1983).

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5. VETERINARY FOLLOW-UP

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ABSTRACT

Post-mortem diagnoses were made on 341 Finn cross lambs which died, out of 1,194 lambs born in the Bet Dagan experimental flock between January 1981 and June 1983. A total of 14.6% of the lambs were still-born, 33.6% of them out of pregnancies shorter than 139 days. In 22.5% of the stillborn lambs, chlamydia-like bodies were diagnosed but their mothers were serologically negative. PI₃ positive serological results were obtained from dams both of stillborn and of live lambs; 16.3% of the lambs born alive subsequently died. There was, however, a considerable improvement (9.4% mortality) in 1983 over the two previous years. Pneumonia, viral (PI₃) as well as bacterial (Pasteurella haemolytica), was the only one definite cause of death (20%), especially in lambs older than 2-3 months, and in early summer. Isolates belonged to strains 1, 2, 3, 5, 6, 7 and 9. Prevalent types changed from year to year, therefore, the examination of a polyvalent P. haemolytica commercial vaccine is recommended.

INTRODUCTION

A major obstacle to the expansion of prolific sheep breeding is the relatively high rate of losses due to disease and mortality of lambs (see General Introduction to this report, and Goot et al., chap. 1.2).

It was therefore considered that a close veterinary follow-up would be useful in elucidating the main causes of lamb losses. It was hoped that this would help to lay the foundation for a general health program and also eventually supply material for the development of a vaccination and therapy program.

MATERIALS AND METHODS

Recording

At the beginning of 1981 forms were prepared for the routine recording of all lambings and of the fate of the lambs from birth to marketing (or transfer, within the flock, from lambs to hoggets in the case of replacement stock). For each lamb the following details were recorded: dam, sire, dam's date of conception, lambing date, birth and weaning weights (in case of death, the corpse was weighed as well), clinical diagnoses, if made, and any remarks about abnormalities or accidents.

Handling of dead lambs

Lambs were delivered immediately upon detection to the post-mortem abbatoir of the Kimron Veterinary Institute. When this was impossible they were stored in a cold room at 4-5°C until delivery. All dead lambs were examined for general pathology and most of them were then transferred for bacteriological and virological examination.

Laboratory diagnosis

A. Aborted fetuses and stillborn lambs

Out of 175 fetuses and stillborn lambs, 111 were examined.

Bacteriological examinations. Routine media were inoculated with material from stomach contents, lungs, liver and spleen. Cultures were incubated at 37°C aerobically and in a 10% CO₂ atmosphere for 5 days. Smears were prepared from the above organs, and placentas, when available, were stained by Stamp's method and examined microscopically.

Examination for mycoplasma. Material from 20 fetuses was also examined for mycoplasma (methods - see under Mycoplasma, below).

Culturing for chlamydia. Attempts were made to isolate chlamydia in McCoy cell cultures.

Serological examinations. To detect possible causes of abortions, maternal sera were tested for Brucella by agglutination and complement fixation (c.f.), chlamydia and Coxiella burnetti, and toxoplasma (immunofluorescence) and parainfluenza 3 (PI₃) virus by hemagglutination inhibition (HAI).

B. Dead lambs, samples of excreta and lungs

One hundred and fifteen out of 166 dead lambs, 14 samples of feces, ten nose and throat swabs, and 19 samples of pneumonic lungs found at routine slaughter were received.

Bacteriological examinations (general). Aerobic and anaerobic cultures made from the lungs, spleen, liver and kidneys were overtly inoculated on nutrient agar and McConkey plates, followed by culturing in tetrathionate and selenite broth for salmonella and inoculation of Minca medium with Isovitol-X for enteropathogenic *E. coli* of fecal material and intestinal contents from all lambs up to the age of 2 weeks.

Examination for mycoplasma. Since pneumonia was the most prevalent post-mortem finding, and in view of the relatively small number of *Pasteurella* strains isolated, we decided to look for other probable causes of disease, mainly mycoplasma.

Attempts to isolate mycoplasma were made by the method described by Jones et al. (1976). We used one liquid medium and three solid media. To the liquid medium 15% swine serum was added. The second medium was similar to the liquid medium, with the addition of agarose. In the third medium the swine serum was replaced by 20% horse serum. The fourth medium was similar to the second, with the addition of arginine and the pH was adjusted to 6.6-6.8.

The cultures were incubated at 37°C aerobically with the addition of 10% CO₂, and also anaerobically. When any change in color or turbidity in the liquid medium was noticed, the culture was inoculated on solid medium.

Attempts to isolate mycoplasma were made by culturing samples from fetuses, lungs of lambs and ewes, and sometimes from tonsillar tissue and the trachea. The isolates were inoculated for four or five passages on mycoplasma media from which all inhibitory factors were omitted. This was done to ascertain that the causal factor was mycoplasma and not bacterial L forms.

To differentiate mycoplasma from acholeplasma, sensitivity to digitin was tested by the disk method. All strains were resistant.

The mycoplasma cultures were not testes serologically.

Typing of *Pasteurella* strains. Preparation of antisera for antigenic typing of *Pasteurella haemolytica*. Standard strains and corresponding antisera were received from the National Animal Disease Center, Ames, Iowa, U.S.A. (Dr. G.H. Frank).

Twelve antisera for identification of *P. haemolytica* were prepared in rabbits using these strains as antigens, by the method described by G.H. Frank (personal communication) based on Biberstein et al. (1958).

Most sera (eight) had a good diagnostic titer, 1/8-1/64. The preparation of the remaining four sera was repeated and the number of injections was increased. Nevertheless, two sera had a low titer of 1/2, but they may be used for diagnostic purposes. All sera were serotype-specific.

From May 1981 until September 1983, 14 strains of P. haemolytica were isolated for identification. Most strains were isolated from lungs only, and two strains from septicemic cases.

Pasteurella was isolated on sheep blood agar plates. It also grew slightly on McConkey agar. Pasteurella fermented glucose and sucrose, but not dulcitol.

In some doubtful cases the H₂S and nitrate reduction tests were also performed (Smith, 1960). First attempts to subdivide the strains into A and T biotypes based on the difference in time of fermentation of arabinose and Trehalose were not successful. In view of the difficulty in obtaining these carbohydrates chemically pure, no further effort was made.

The identification of the strains was done serologically by the slide agglutination method, using sera received from Ames and later sera prepared by us. This method gave usually clear-cut and specific results.

In a few cases the strains could not be typed. An attempt was made to passage the strains through mice by inoculation with granular mucin and isolating these strains from organs of the dead mice. In only one case did we succeed in identifying a previously untypable strain after a mouse passage.

Examination for Clostridium welchii toxin

When clinical symptoms or post-mortem lesions raised our suspicion of entero-toxemias, filtrate of intestinal contents was inoculated intravenously into mice.

Virological examinations

General. Virus isolation was attempted in primary lamb kidney cell cultures. Nasal and throat swabs were examined directly for PI₃ virus by the hemagglutination test and cultured in lamb kidney cells. Additionally, attempts were made to isolate virus from ten carcasses.

Rotavirus. Fourteen samples of diarrhoeic feces were tested for Rotavirus by counter immunoelectrophoresis. Serum and antigen of the Virion Co. served as controls.

Serology. A total of 412 lambs and ewes were examined. From them, 469 serum samples were tested for IBR, BVD and PI₃ antibodies, by the neutralization test (IBR by the micro-method and BVD by tube neutralization) and by the hemagglutination inhibition test (PI₃).

Parasitological examination. Feces samples were examined for coccidia.

RESULTS

A total of 341 dead lambs, out of 1,194 born, were examined. The partition between those which were stillborn and those born alive is shown in Table 5.1. The rate of stillbirths was relatively high through-

out the experimental period and particularly in the first year. Post-natal mortality was considerably reduced during 1983.

Table 5.1 OCCURRENCE OF STILLBIRTHS AND OF MORTALITY AMONG LAMBS BORN ALIVE OVER 3 YEARS

Year	Number born	Stillborn n	%	Born alive	Died (%) ^a
1981 (Jan.-Dec.)	345	59	17.1	286	19.3 (16.2)
1982 (Jan.-Dec.)	536	68	12.7	468	18.2 (15.8)
1983 (Jan.-June)	313	48	15.3	265	9.4 (8.0)
Total and mean	1,194	175	14.6	1,019	16.3 (13.9)

^aIn parentheses, % of all lambs born.

Peri-natal mortality

Stillborn lambs were classified according to the length of pregnancy after which they were born (Table 5.2). Fifteen to 46% (average 33.6%) of the lambs were born out of pregnancies of 139 days or shorter, mostly between 135 and 139 days. These may be regarded as late abortions or premature births. Most of the lambs in this class were small and perhaps not completely developed (between 0.8 and 2.0 kg). There was also a clear relationship between litter size and mortality. The percentage of lambings out of which one or more lambs were stillborn, for ewes with singles, twins, triplets or quads, was 10.2, 15.6, 45.4 and 60.0, respectively. Of the stillborn lambs out of pregnancies longer than 140 days only a few could be regarded as underdeveloped. In most of them no infectious factors were diagnosed. Trauma and suffocation were recorded in several cases, indicating lack of care during lambing, mismothering and dystocia.

Table 5.2 DISTRIBUTION OF STILLBORN LAMBS (%) ACCORDING TO LENGTH OF PREGNANCY

Year	Length of pregnancy (days)		
	<139	140-145	>145
1981	45.7	30.5	23.8
1982	15.4	65.3	19.3
1983	27.1	33.3	39.6

Laboratory results

Laboratory results are summarized in Table 5.3. From eight still-born lambs *Escherichia coli* was isolated, and from one fetus - mycoplasma; all the remaining cultures were negative. Microscopic examination revealed in 25 of them structures indistinguishable from elementary bodies of chlamydia. The percentage of chlamydia findings during the various lambing seasons ranged from 13.3 to 66.6% of the fetuses examined.

Table 5.3 LABORATORY DIAGNOSES FOR ABORTED OR STILLBORN LAMBS IN THE COURSE OF 3 YEARS

Year	Number examined	Findings						Vaccination against chlamydia (date)
		Chlamydia		<u>E. coli</u>		Negative ^a		
		n	%	n	%	n	%	
1981	46	16	34.8	3	6.5	27	58.7	29.III.81
1982	35	7	20.0	4	11.4	24	68.6	11.XI.82
1983	30	2	6.7	1	3.3	27	90.0	
Total	111	25	22.5	8	7.2	78	70.3	

^aThere was one case in which mycoplasma was isolated.

Attempts to isolate chlamydia proved unsuccessful, and serological examinations of aborting ewes were negative for brucella, chlamydia, Coxiella burnetii and toxoplasma. Following the introduction of vaccination against chlamydia, there was no longer any point in testing ewes for chlamydial antibodies.

Post-natal mortality

Of the 166 lambs which died after birth, 43% did so in the first week and 57% at later ages. The post-mortem findings (of 115 lambs) were as follows:

Pneumonia	23
Septicemia and <u>E. coli</u>	30
Enteritis and peritonitis	6
Nephritis	2
White muscle disease	2
Trauma and weak lambs	19
No definable cause	57

The detailed laboratory results are given hereunder.

General bacteriological findings. The relevant data are presented in Table 5.4. One organism isolated with relatively high frequency was Pasteurella haemolytica (9.9%). Typing of 13 strains of the organism yielded the following results: of strains isolated from lungs, two belonged to st 1, one each to st 2 and 6, four to st 5, and two to st 9. Of strains isolated from all organs (septicaemia), one belonged to st 3, one to st 7, and two could not be typed.

Survival and preservation of strains

All strains of Pasteurella haemolytica isolated, died within a few days when stored on blood agar plates or in nutrient broth at 4-8°C. They also died within a few days when stored on agar slope, blood agar slope or Dorst egg medium. They survived for about one month in nutrient broth at room temperature. The survival time differed for different strains.

Due to the relatively short survival, it was not possible to type all the isolated strains.

Table 5.4 NUMBER OF BACTERIOLOGICAL DIAGNOSES MADE OF DEAD LAMBS, LUNGS AND EXCRETA

<u>Mycoplasma</u>	17
<u>Pasteurella haemolytica</u>	16
<u>P. multocida</u>	8
<u>Escherichia coli</u> (nontypable)	8
<u>E. coli</u> 78:80	4
<u>Salmonella dublin</u>	5
<u>Salmonella</u> group B	5
<u>Salmonella</u> group C	2
<u>Diplococci</u>	2
<u>Pseudomonas pyocyanea</u>	2
<u>Klebsiella</u>	1
Negative	108

All standard strains were lyophilized and most local strains suspended in skimmed milk. The bacteria remained viable after 2 years' storage at -18°C (last time tested). There was a 2-3 log reduction in bacterial count.

Mycoplasma was the organism most frequently isolated - 18 isolations from 95 samples (18.9%). Seventeen strains were isolated from lungs or lung and trachea. In one case, we found mycoplasma from trachea only. There was one isolation from a fetus. On first isolation, the colonies usually had varied morphology. Some were smooth, others rough, small or large, and we attempted to purify the cultures by cloning.

Pasteurella multocida was isolated eight times, always from the lungs only. Twelve samples yielded E. coli, four of the isolates belonging to serotype 78:80. The cases are spread over the entire season and there were no outbreaks of coli septicaemia. Pseudomonas pyocyanea was isolated twice and Klebsiella once. In 14 cases, Salmonella was isolated, including four belonging to group B from one group of lambs and an outbreak of S. dublin with four simultaneous cases during the last lambing season. There are no cases of entero-toxemia or of enteropathogenic (K-99) E. coli.

Virological examinations

No viral agents were identified in naso-pharyngeal swabs from ten lambs and none was cultured from the organs of another ten dead lambs. Counter-immunoelectrophoretic examination of 14 fecal samples for Rotavirus also gave negative results.

Serological tests (219) of 126 lambs for IBR and BVD viruses were all negative. Findings with regard to 449 samples tested for PI₃ virus were as follows: very young lambs were completely negative; among four month-old lambs, 42.8% were positive; among seven month-old lambs, 29.1%; among lambs up to 13 months, 60.9%. In another group of lambs, whose

ages ranged from 5 to 9 months, as many as 91.2% reacted positively to PI₃. Generally, the titers ranged from 1:20 to 1:160.

As for adult ewes, in one group one out of 15 had a positive PI₃ titer at lambing, in another group 9 out of 26 (34.6%), and in yet another group none of 14 ewes reacted positively.

DISCUSSION

Perinatal mortality

Of the stillborn lambs, 33.6% were out of ewes in which pregnancy had terminated at less than 139 days. This seemed to indicate that an infective factor could be involved.

No bacterial pathogens such as Brucella, Salmonella abortus ovis or Campylobacter were isolated from aborted fetuses or stillborn lambs, except E. coli in eight cases and mycoplasma in one. However, these latter findings appear to be of little significance. Microscopic examination failed to disclose Coxiella burnetii organisms. Only elementary bodies of chlamydia were found in a number of instances.

About 70% of the stillborn lambs were bacteriologically negative, indicating that most fetal mortality was not due to an infective agent. At first, serological tests for PI₃ virus made to clarify its possible etiological role in cases of pneumonia, raised the suspicion that the virus was implicated as a cause of abortions, as some of the aborting ewes had high PI₃ titers. However, subsequently, it was found that there was no difference in PI₃ titers between aborting ewes and those producing normal lambs. While this factor cannot be completely ruled out, the likelihood of it being involved in premature lambings seems to be low.

The role of chlamydia does not seem to be clear either. Nevertheless, routine vaccination was introduced at the end of 1982, and since the second half of 1983 the rate of occurrence of stillbirths in the flock has declined considerably (see Table 9.1, chap. 9.).

Post-natal mortality

Most infectious agents other than those involved in pneumonia were diagnosed in dead lambs younger than one month. However, there was no one specific factor to be pointed out as playing an important role in the health of the lambs. Septecemia and enteritis, together with trauma and general weakness (starvation?), accounted for approximately 60% of the positive diagnoses. This seems to call for improved management practices.

Pneumonia, which apparently accounted for 20% of the deaths, was more prevalent in lambs older than 2-3 months, mostly among those growing during early summer (rising temperature; see also Goot et al., chap. 1.3).

The P. haemolytica isolates belonged to types 1, 2, 3, 5, 6, 7 and 9, some of the types being more prevalent one year and others the following year; thus, there seemed to be no point in producing an autogenous vaccine. A polyvalent P. haemolytica vaccine has recently been developed at the Moredun Institute (Ovivac P, Hoechst (U.K.) Ltd., Milton Keynes, Buckinghamshire) and its effectiveness should perhaps be examined in the future.

While further attempts to produce an effective vaccine against Pasteurella infection seem warranted, improved management should not be ruled out. Shimsony (1983) suggested that this disease may be transmitted to the lambs by their dams during the suckling period. Therefore, reduced contact between mothers and their offspring by early weaning or introduction of artificial rearing may solve the problem, especially where sheep are maintained in confinement under crowded conditions. Promising results, in the artificial rearing of lambs, have recently been obtained in some large commercial flocks in Israel, and also in the experimental flock at Bet Dagan (see chap. 3.1 and Table 9.1, chap. 9).

Artificial rearing enables better control of individual lambs and would probably reduce losses due to other causes as well.

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6. EVALUATION OF RESEARCH ACHIEVEMENTS

This project is a compound of several subprojects involving different disciplines of study. They are linked by the common genotypes of sheep on which they were employed (see Table of Contents and General Introduction).

The objectives of part 1 were to: (a) multiply high-fertility dam lines and further the evaluation of their productivity; (b) attain preliminary results with 3/4 Finn x Awassi sheep; (c) determine sire breeds for top crossing to improve growth rate and carcass composition in relation to season and nutrition; and (d) initiate studies on genotype-environment interactions as an aid for improvement in management.

The first objective was achieved through the expansion of work into commercial flocks and by further crosses of Finn and Romanov rams with Awassi ewes. The analysis of data collected in the present project and combined with hitherto unpublished results of several years verified previous conclusions, and established the prolific crosses as potential genotypes for Israel's future sheep industry. The encouraging preliminary results obtained with the 3/4 Finn x Awassi cross are of particular value as they point to a potential for further increase in litter size. The fact that due to the accelerated lambing program lambs were born in different seasons of the year, helped to show a way to escape undue lamb losses by avoiding lambing of heat-susceptible genotypes into the hot summer.

An important finding was the small differences in fattening performance found between genotypes and types of birth. However, the relatively poor muscle development among individual Finn-cross lambs reduces the benefit gained by the increased number of lambs. In this respect it is worth mentioning the work done at the ISGI, Utah, where it was shown that diet composition may affect fat deposition. The results with sires for top crossing are of importance as well. In particular, one should be constantly on the watch for an eventual lifting of the veterinary ban on the import of American Suffolk rams (see Chapter 1.5). The lack of effects on lamb fattening performance by varying the protein source or concentration in the diet, confirms previous conclusions arrived at in our laboratory that it would be difficult to improve on the concentrate formula which was used throughout the present project. The good correlations obtained between body weight, carcass weight or right leg composition on the one hand, and carcass composition or various organs and tissues on the other hand, will be of help in future work.

The objectives of part 2 were to form a data base required to develop appetite-regulated complete rations, with special reference to the use of crop and animal by-products. The information gained on the intake by ewes of wheat straw, cotton gin-trash and lint, poultry litter, alfalfa hay and domestic waste as sole feeds and in combination with other feeds at different reproductive stages, is an important research achievement in this project. The same applies also to the production responses of sheep to the different feeds and rations. The definition of cotton gin by-products and poultry litter as low energy-high intake feeds gives them a special role where rising intake is required (advanced pregnancy and lactation) without the risks of overweight that may accompany the intake of high-concentrate diets.

In part 3, the role of milk restriction on solid food intake was confirmed. A thirst-induction procedure has been shown to be superfluous under restricted milk feeding of lambs.

In part 4, the objectives were to determine the seasonal and post-partum patterns of the reproductive activity of the genotypes involved and particularly those of the Finn x Awassi sheep. This has been accomplished. Important information was obtained on the estrous behavior and on ovarian activity (as reflected by blood progesterone levels) during the apparent anestrus period.

The veterinary follow-up (part 5) by definition did not include any experimentally controlled work. It supplied important information on the main factors contributing to lamb mortality, which is required for the development of a general preventive health program for lambs. The formation of a detailed and more specifically directed program would require a more experimentally directed research plan. For the stage of development attained by the prolific sheep population in Israel at the beginning of this project, a broad project seemed to be justified, as it would provide the necessary foundations for its establishment. However, in the face of the limitations of manpower, sheep numbers and facilities, this broad concept also had its shortcomings. For the fine details required for such highly productive and therefore very demanding and sensitive animals, several more specifically aimed research programs are now needed.

7. COOPERATION WITH U.S.A. SCIENTISTS

7.1 The main contribution of W.C. Foote and D.H. Matthews of the International Sheep and Goat Institute is described in chapter 1.5 and the evaluation of the research achievements that resulted from their experiments appears in chapter 6. The details of the original research proposal, mainly those related to breeding, reproduction and lamb fattening trials, were discussed by the Israeli and American participants.

Dr. Foote visited Bet Dagan in the autumn of 1981 to review and discuss the progress made in Israel and Utah. During a second visit, in October 1983, concluding discussions were held on the results of the research and on the preparation of the final report.

7.2 Contributions of D.E. Hogue, Cornell University, Ithaca, N.Y., USA have consisted of:

- Consultation on the development of the original proposal.
- Continued information-exchange with the Cornell sheep research program.
- Visit by D.E. Hogue to Israel in March of the second year to:
 - (a) Review the progress of the project.
 - (b) Observe Israeli sheep production techniques (both meat and milk).
 - (c) Present a seminar on the Cornell research program.
 - (d) Discuss nutritional and managerial treatments and procedures in the project and suggest changes for Israeli sheep producers.

During the visit, Israeli sheep production was observed at sites from northern Israel to the Negev and included both milk- and meat-producing units. The meat units ranged from those utilizing considerable natural forage to those managed in confinement units. The primary discussions centered around three areas, all related to research at Cornell. These were:

1. Accelerated or frequent lambing systems. Cornell has recently developed the CAMAL and the MAGEE systems in which, respectively, six and five lambing periods per year are utilized with no artificial light or exogenous hormone treatment. These systems were discussed and compared with the more customary three-lambing-period system (8-month interval) in use at Bet Dagan and on some Israeli farms.
2. Early weaning of lambs. The Cornell program effectively weans artificially reared lambs to all dry diets at 14 days of age. Especially in milk sheep units, lambs are often fed limited amounts of milk for 6-8 weeks. Much interest in early weaning was expressed as a means of increasing the amount of saleable milk products and

enhancing earlier rebreeding of ewes. These discussions stimulated the undertaking of the experiments described in chap. 3.1.

3. Protein sources for rapidly growing young lambs. In particular, the use of fish meal to supply at least a portion of the supplemental protein was discussed and results compared. An experiment on the effect of fish meal is reported in chap. 1.4.

In addition, several other areas were recognized as needing attention or at least discussed in some detail. These included:

4. Utilization of by-product and waste feeds in intensive sheep production systems.

5. Optimal use of the Finnsheep or the Romanov to increase the reproductive rate of ewes.

6. Housing arrangements in intensive semi-confinement sheep production systems.

7. Preventing lamb losses and controlling diseases and parasites.

8. Urinary calculi in feedlot lambs and the probability of diets being unbalanced relative to their calcium-to-phosphorus ratio.

9. Pasture species and fertilizer rates on semi-arid sheep pastures.

7.3 E. Eyal, in the course of a study tour during July-August 1983 visited both Cornell University and ISGI, Utah State University. At Cornell, discussions were held with D.E. Hogue and other members of the Department of Animal Science staff to review work done at the sheep research unit, especially with Finn sheep, accelerated lambing programs, artificial rearing of lambs, and lamb fattening. Results obtained in Israel were discussed, as was the preparation of the final report.

At Utah the work done by W.C. Foote was reviewed. Dr. J.E. Butcher, who participated in the lamb fattening trials, also joined in the discussion of the results. Preparation of the final report was also discussed in these meetings.

7.4 Dr. M. Davidson spent 6 weeks in the U.S.A. studying work done in various places on health problems of Finn-cross sheep, with special reference to the prevention of lamb mortality. The following places and persons were visited:

W.G. Kvasnicka - Herd Health Veterinarian, Agricultural Research North Central Region, Clay Center, Nebraska - Sheep operation management, epidemiology and preventive medicine.

M. Bruss, Veterinary Medical Office, U.S. Sheep Experiment Station, Dubois, Idaho - Participation in routine health program during lambing in a flock of 4,500 ewes. Ovine obstetrics, neonatal care, pathology and preventive medicine.

N.L. Gates, Extension Veterinarian, Washington State University, Pullman, Washington - Discussions of the impact of management practices on health. Discussions were also held with Veterinary Faculty staff members on various sheep diseases.

D. Bailey, Secretary, U.S. Organization of Veterinarians for Sheep Diseases, Roseburg, Oregon - Routine work and preventive health program.

8. THESES

8.1 An M.Sc. thesis has been started by Mr. E. Gur-Arie. It was continued as a BARD Feasibility Study (F-27). The starting stages are reported in chapter 1.6.

8.2 Ph.D. Thesis. The results reported in chapters 2.7 and 2.8 are parts of a thesis started by Y. Yehuda. The work will include at least one more feeding trial (carried out after the termination of this project) and an analysis of blood samples for fat-glucose-insulin interactions in the context of feed level effects. Therefore, the results reported and discussed, although quite comprehensive, must be regarded as incomplete and inconclusive.

9. BENEFITS TO AGRICULTURE

In evaluating the contribution to the agricultural community, three questions should be answered:

- 1) To what extent did the data collected in the course of this project stimulate the promotion and distribution of prolific genotypes in commercial flocks ?
- 2) What impact did the results have on the improvement of management practices at the farm level ?
- 3) To what extent could the generated information serve for economic evaluations, agricultural planning and decision-making ?

The contribution of this study toward the expansion of Finn or Romanov crossbreds is evident in the first place from the results obtained here on the two cooperating farms (Red Gables and M. Falk). Several farms had already started using Finn-cross ewes and rams before the onset of the present study, but quite a few more decided to introduce these new genotypes into their flocks as a consequence of the confirmation of past results that were transferred directly to the field, or through the assistance of the extension services. The high point of these trends is the recent purchase of five Romanov rams by a private commercial farm and it is expected that at least another 15 will be ordered from France in the coming fall. In all these cases, consultation was requested from us and it is envisaged that work with the new crossbred populations will be coordinated and conducted in cooperation with the Extension Services and with the Department of Dairy and Mutton Sheep of the ARO.

A second stimulating effect has been towards the expansion and better control of the use of recycled wastes, particularly poultry litter and cotton gin by-products. Particularly outstanding are results collected by Benjamin *et al.* in the Kefar haNasi flock in the northern part of Israel (Benjamin, Y., Klein, D., Greenberg, J. and Kali, J., 1981, Department of Sheep and Goats, Extension Services, Ministry of Agriculture, Tel-Aviv, stencil). In this observation, 380 ewes were gradually transferred from dry grass, autumn pasture to a ration based

on poultry litter (PL) and corn plus wheat straw and hay in confinement during the last 6 weeks of gestation and the following 7 weeks of lactation (to weaning). From 2-3 weeks prepartum until weaning, the ration resembled the PL + corn ration described in chapter 2.6. Sixty-six ewes were selected out of the above mentioned group to be divided into an 'experimental' PL + corn and control (concentrates) groups. The main results are reproduced here in Tables 9.1. and 9.2. These results confirm very closely those obtained by us.

Table 9.1 BODY WEIGHT CHANGES OF MUTTON MERINO EWES AT KEFAR HANASI DURING LATE PREGNANCY AND LACTATION (MEANS $\pm$ S.E.)

Treatment ^a	Number of ewes	Time relative to parturition		
		7 weeks pre-	1 weeks post-	7 weeks post-
Poultry litter + corn	32	60.7 $\pm$ 1.53	59.6 $\pm$ 1.86	59.0 $\pm$ 1.68
Concentrates	34	62.7 $\pm$ 1.36	63.0 $\pm$ 1.37	61.1 $\pm$ 1.53

^aFrom 6 weeks to 3 weeks prepartum dry grass pasture was supplemented with gradually increased amounts of poultry litter or concentrates; from 2 weeks prepartum until weaning at 7 weeks post-partum, hay and wheat straw were added and ewes maintained in confinement.

Table 9.2 MEAN BIRTH WEIGHT ($\pm$ S.E.) AND GROWTH TO WEANING OF LAMBS AT KEFAR HANASI

Variables	Treatments			
	Poultry litter + corn		Concentrates	
	Singles	Twins	Singles	Twins
n	18	25	20	29
Birth weight, kg	4.4 $\pm$ 0.18	3.5 $\pm$ 0.14	4.5 $\pm$ 0.22	3.8 $\pm$ 0.16
Weaning weight, kg	21.0 $\pm$ 0.62	14.0 $\pm$ 0.47	18.3 $\pm$ 0.75	1.58 $\pm$ 0.65
Growth rate, g/day	329 $\pm$ 11 ^a	207 $\pm$ 8 ^b	304 $\pm$ 12 ^a	259 $\pm$ 12 ^c

^{a,b,c}Means with different superscripts are significantly different (P<0.05).

Most of the other information included in Part 2 will serve for the development of a more rationalized use of wastes and by-products in the future.

Another important, immediate contribution was in the artificial rearing of lambs. The results obtained and reported in chapter 3.1 were

immediately transferred to the community of shepherds and stimulated what may be described as a massive move toward the application of early weaning and artificial rearing of lambs, especially in large sheep operations - both dairy and mutton - where automatic nursing machines were purchased from France and U.S.A. Substantial improvement in lamb survival is a common feature of all the reports. This is exemplified here in Table 9.3, in which some recent results from the Bet Dagan experimental flock are presented. The study of the reproductive characteristics of the Finn-cross ewe and the results presented in chapter 4 will contribute to an increase in production by the development of accelerated breeding programs through proper combinations of hormone treatment and mating management.

Table 9.3 SURVIVAL OF LAMBS ACCORDING TO TYPE OF REARING IN THE BET DAGAN FLOCK

Lambing season	Number of lambs born		Type of rearing			
	Alive	Dead ^a	Mother		Artificial	
			n	% Survival	n	% Survival
Sept. 1983	114	3	88	75.0 ^b	26	76.9 ^b
Nov. 1983	29	6	-	-	29	96.6 ^b
Jan.-Feb. 1984	183	12	125	87.2 ^c	58	91.4 ^c

^aIncludes deaths within 24 h after birth.

^bTo end of fattening.

^cTo about 2 months post-weaning.

Finally, results generated by the project were evaluated concurrently by an economist of the Planning and Development Authority of the Ministry of Agriculture. One example of the results of this evaluation is given in Table 9.4.

Table 9.4 ESTIMATED COSTS (IN U.S.\$) OF FEEDS REQUIRED FOR THE PRODUCTION OF WEANED LAMB LIVELINE ON TWO TYPES OF RATION AND AT TWO LEVELS OF REPRODUCTION^a

Ration ^b	Reproductive rate (live lambs/ewe/year)			
	2.0		2.5	
	CON	PLG	CON	PLG
Yearly cost/ewe	114.10	54.20	117.50	60.00
Cost per lamb	57.05	27.10	47.00	24.00
Cost per kg liveweight	3.80	1.80	3.13	1.60

^aAssumptions made: 1) lambs weaned at 15 kg liveweight; 2) prices per ton of feed: wheat straw, \$50; hay, \$147; concentrates, \$280; grain, \$170; poultry litter, \$35.

^bCON = Wheat straw, hay and commercial concentrate pellets.

PLG = Wheat straw, hay, poultry litter and unprocessed grain.