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Responses of dairy ewes before and after parturition, to different nutritional regimes during pregnancy

I. — Ewe body weight, uterine contents, and lamb birth weight [1]

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Summary

A study was made of the effects of nutritional levels in pregnant dairy ewes in which three basic (maintenance) levels and three levels of late pregnancy allowance (steaming up) were compared.

During the last three weeks of pregnancy inappetance appeared in the high steaming-up groups, mainly among those which had started pregnancy in a fat body condition.

Ewes whose steaming-up ration was adjusted according to the plasma free fatty acids (FFA) concentration (gradual rise of ration) reached a level of feed consumption by the end of pregnancy only slightly higher than that of those receiving the low steaming up level, *i.e.*, 18.4 MJ *vs.* 15.9 MJ/day. There was no difference between these two groups in total feed consumption during pregnancy.

Ewes on the high steaming-up ration gained more weight than those on the other levels. Fat ewes (high basic ration) lost weight during the last three weeks of pregnancy. Twin-bearing ewes gained less or lost more than single-bearing ones. Ewes on the gradually increasing regime (adjusted) maintained a more stable weight throughout pregnancy in spite of their relatively low consumption; differences between single- and twin-bearing ewes were least in this group.

There were no differences in lamb birth weights among the three maintenance levels. Mean litter birth weights of the high (H), low (L) and adjusted (A) steaming-up groups were 9.8 ± 0.7 and 5.3 ± 0.5 kg; 10.1 ± 1.1 and 4.7 ± 1.2 kg; and 8.5 ± 0.3 and 5.6 ± 0.5 kg, for twins and singles, respectively. Both the twins of the adjusted level (lighter) and the singles (heavier) differed significantly from those of the two other steaming-up treatments. Occurrence of disease and inappetance around term was high (43 p. 100) among ewes receiving the high basic ration. Occurrence of peri-term disease for the H, L and A steaming-up levels was 43 p. 100, 33 p. 100 and 0.0, respectively.

It was concluded that the pattern of steaming-up, whether constant or gradually rising, may affect the energy partition among the mother's body and her embryos and that the efficiency of feed utilization was higher in the gradually rising regime.

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Introduction

Increasing rations to females to meet their extra requirements during late pregnancy is a common practice in farm-animal husbandry. This practice of " steaming-up " is necessary for the successful completion of pregnancy (REID, 1960). It may also affect milk production during early lactation. There exists, however, a fair amount of ambiguity in the literature on cows (CASTLE and WATSON, 1961; BROSTER, 1962; HOLMES *et al.*, 1965) and on ewes (GARDNER and HOGUE, 1963; PEART, 1967), as to optimal feeding standards during this period. There is also no clear definition of the body condition or feed composition under which a certain level of steaming-up will have one effect or another. In this respect the case of the pregnant ewe represents only a fragment of the more general problem of defining the factors governing the quantitative partition of energy among the different body functions.

Under deficient food supply, and mainly with twin-bearing ewes, ketosis, commonly known as pregnancy toxaemia, may develop (REID and HOGAN, 1959). Several authors have shown, however, that clinical symptoms similar to those of pregnancy toxaemia (such as loss of appetite, staggering, lambing difficulties, weak lambs and low milk yields) may also appear in overfed ewes (GORDON and TRIBE, 1951; REID and HINKS, 1962; and also unpublished observations of our laboratory). The situation seems to be most serious among ewes which are too fat when they enter the fourth month of pregnancy.

Good body condition and a positive energy balance are required for conception and for high ovulation rates. Under flock conditions this means that ewes will be maintained under a high level of feeding to a stage when most of them have conceived. At this stage many of the ewes will have completed their first or part of the second month of pregnancy. It seems, therefore, that under intensive management the nutritive needs for fertility may be in conflict with those for the successful completion of pregnancy. The problem may be solved by a considerable reduction in the feeding level during the second and third months of gestation. COOP and CLARK (1969) have shown that such a practice is safe from the point of view of embryo-survival.

The aim of the present experiment was to study the effects of various feeding regimes for dairy ewes during different stages of pregnancy on their well being and on their performance in terms of lamb and milk production. Changes in blood glucose, free fatty acids (FFA) and ketobodies were also examined. The present communication deals with the feed intake of the ewes, ewe body weight changes during pregnancy, uterine contents and lamb weights, and the general health of the ewes.

Materials and methods

The experiment was carried out at the Newe Ya'ar Experiment Station. Feeding treatments commenced four weeks before the beginning of mating and lasted until 45 days *post-partum* for each individual ewe. The ewes were kept in groups until about the 45th day of pregnancy, when they were moved into individual pens.

Sheep

The sheep were of the Awassi (fat-tail) and Assaf (East-Friesian × Awassi) breeds. Only sheep in their second, third or fourth pregnancies were included in the experiment.

Experimental Design

Fifty-four ewes were block-randomized before the breeding season according to breed, body weight and milk yield in the previous lactation, into nine treatment groups (3 × 3 factorial). Twelve ewes which were found non-pregnant at parturition time or in which conception was considerably delayed, were discarded so that only 42 ewes were left in the experiment (4-5 in each treatment cell).

The experimental treatments were: three sequences of basic diets from mating to parturition and three steaming-up levels of supplement in the last two months of pregnancy. The treatment period was divided into three sub-periods: (*i*) 1st month of pregnancy, which was a continuation of the last pre-mating month; (*ii*) 2nd and 3rd months of pregnancy; and (*iii*) 4th and 5th months of pregnancy (see fig. 1 for treatment symbols).

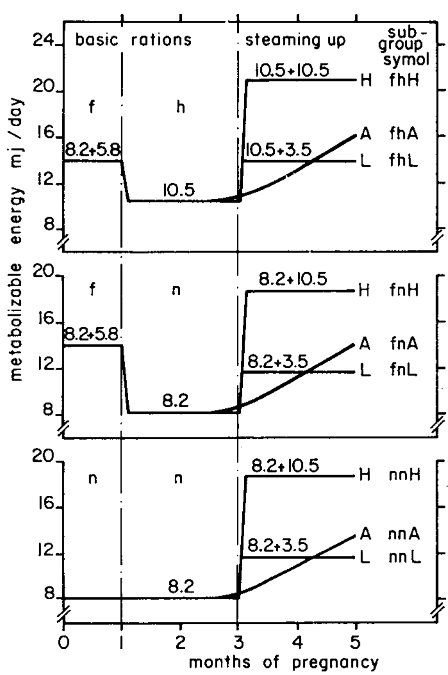

FIG. 1. — *Experimental rations as planned for 60 kg ewes. (Basic rations : f = flushing, h = high, n = normative; steaming-up : H = high, L = low, A = adjusted according to plasma (FFA).*
Rations expérimentales prévues pour brebis de 60 kg. (Rations de base : f = flushing, h = haute, n = normale; supplément alimentaire : H = important, L = faible, A = ajusté en fonction des acides gras libres dans le plasma.

A ration of 8.2 Megajoule (MJ) of metabolizable energy (ME) was taken as the normative maintenance level for an average ewe of 60 kg. The three basic diets thus, were: 1) flushing and high maintenance (fh); 2) flushing and low maintenance (fn); 3) no flushing and low maintenance (nn). The actual rations to individual ewes were adjusted to this level according to their relative body weight (W^{075}).

The three steaming-up levels were: high (H) — 10.5 MJ of ME above the basic ration; low (L) — 3.5 MJ of ME above the basic ration; and adjusted (A) — according to plasma free fatty acid (FFA) concentration. The ration was increased in steps, by adding 0.8 — 1.0 MJ of ME to the ration of a ewe whenever her plasma FFA concentration rose above 0.5 Mequiv. /l. FFA concentration was determined by the method described by DOLE and MEINERTZ (1960). The detailed plan of the experiment is shown in figure 1.

Feeds and Feeding

Each ewe received 0.4 kg of a mixed vetch and oats hay daily throughout the experiment and the rest of the ration in a pelleted concentrate mixture which contained 27.5 p. 100 cottonseed hulls. The hulls were included to balance the fiber content of the ration. The detailed composition of the ration is shown in Table 1. All feeds were weighed and submitted to ewes at 09:00 each day. Refusals were collected and weighed before submitting a new daily ration.

TABLE 1

Ingredients composing pelleted concentrate mixture and chemical composition of hay and pellets (p. 100 in fresh matter)
Composants des granulés et composition chimique du foin et des granulés (p. 100 de la matière fraîche)

Ingredients included in pellets		Chemical composition of feeds used in the experiment			
Ingredient	%	Ingredient	Hay	Pellets	Hay + Pellets (1)
Cottonseed hulls	27.5	Dry matter	88.6	89.1	—
Barley grains	28.0	Organic matter	79.3	82.1	—
Wheat bran	10.0				
Soybean oil meal	10.0	Fiber	22.2	14.5	—
Cottonseed oil meal	8.0	Crude protein	13.2	15.5	—
Alfalfa meal	5.0	Fat	2.4	1.8	—
Molasses	8.0	Ash	10.3	7.0	—
DCP	2.0				
Salt	1.0	Metabolizable energy, MJ/kg (2)	7.20	11.17	10.71
Vit. A + D suppl.	0.5				

(1) 400 g hay + pellets (about 1,200 g) to make up a twice-maintenance-level ration.
(2) The metabolizable energy (ME) concentration of the feeds was assessed in a separate experiment with three mature male lambs at a twice-maintenance-level feeding (ME = Digestible energy — Urine energy — Estimated methane).

Weighing of animals

Each ewe was weighed at mating and at fortnightly intervals after the 45th day of pregnancy, when she was put into an individual pen. During the last three weeks the ewes were weighed at weekly intervals. Each one was also weighed on the third day *post-partum*. It was assumed that by this time the ewes had completed the expulsion of the placenta and of the uterine fluids and also the *post-partum* dehydration.

All lambs were weighed within 3 hours after they were born.

Blood sampling and analyses

Blood samples were taken at fortnightly intervals between about 60 and 120 days after conception and at weekly intervals during the last month of pregnancy. Plasma FFA analyses were completed within 48 hrs after bleeding, at which time adjustment of the rations in groups fhA, fnA and nnA was done.

Calculation of the apparent energy cost of lamb production

To estimate the gross energetic cost of lamb production, the total number of calories of metabolic energy consumed was divided by the total weight of lambs at birth. By subtracting the assumed requirement for maintenance of the mother from the total energy consumed and dividing the remainder by the lamb weight, the approximate net (partial) cost was obtained.

The value obtained is not exact, since, while lambs were produced, changes also took place in the ewe's body weight. These changes, at least in part, resulted from a deficit or excess of energy in the ration but they could also have been partly a result of changes in the contents of the digestive system or in tissue hydration. In the latter case, they have nothing to do with the energy balance. The results of these calculations should be regarded, therefore, as being primarily of comparative value. Differences in average body weight of ewes in the various groups were, however, taken into account. A correction was made after KNOTT, HODGSON and ELLINGTON (1934), as cited by MAYNARD and LOOSLY (1969), who suggested that the balance should be credited with an energy equivalent of 3.53 kg of TDN or 12.4 Mcal of metabolizable energy for a gain of 1 kg of body weight, and debited with an equivalent of 2.73 kg TDN (8.6 Mcal) for every 1 kg of body weight loss.

Results

Feed intake

Changes in feed intake during the last three months of pregnancy are shown in figure 2. A drop in food intake at the end of gestation was marked both in the highest (fhH) and in the lowest (nnL) feeding groups. In the former group, the decrease began 3 weeks before lambing, and in the latter group, about 10 days

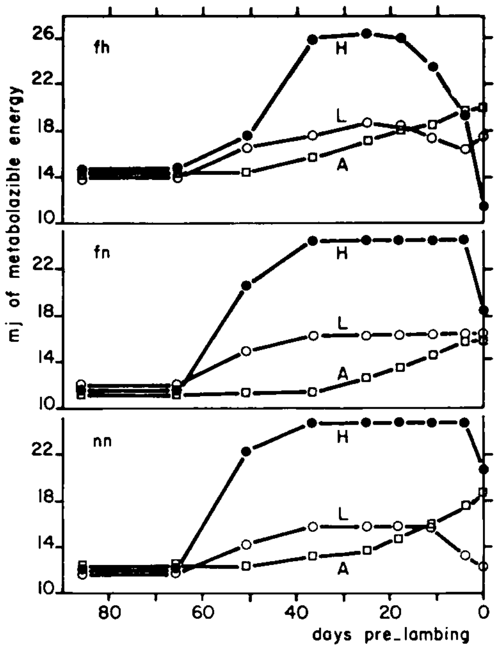

FIG. 2. — *Average daily feed intake of ewes in the different experimental treatments (see text in fig. 1 for explanation of symbols).*
Consommation journalière moyenne des fourrages par les brebis des différents groupes expérimentaux (pour l'explication des symboles, voir la liste, fig. 1).

before. A slight drop in food intake was also seen in the high steaming-up regime (H) when it followed the lower (nn) maintenance levels.

The greatest reductions in food intake among fhH and fhL ewes (high maintenance levels = fat ewes) occurred in single-bearing ewes, as may be seen in figure 3. In the nnL group (lowest feeding level), mainly twin-bearing ewes went off their feed.

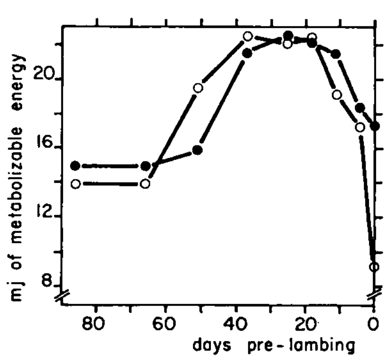

FIG. 3. — *Average daily feed intake of twin (●) and single (○) bearing ewes of the high (fh) basic ration fed constant steaming-up levels (H and L) during the last 60 days of pregnancy.*
Consommation journalière moyenne de fourrage par les brebis portant des jumeaux (●) et unipares (○). Ces brebis ont reçu une haute ration de base et un supplément alimentaire fixe (important ou faible) pendant les 60 derniers jours de gestation.

Ewes' body weight changes during gestation

Weight changes recorded in the first two months of pregnancy are presented in Table 2. Twin-bearing ewes were heavier at mating than either single-bearing or non-pregnant ewes. Differences in body weight changes between feeding levels were significant ($P < 0.05$). A trend toward greater weight increase in twin-bearing *vs.* single-bearing ewes was apparent already at this early stage of pregnancy. This difference was statistically not significant ($P < 0.10$) but was consistent at all feeding levels.

TABLE 2

Body weight changes (kg) of twin (T) and single (S) bearing ewes during the first two months of pregnancy, and of nonpregnant (N) ewes
Changement du poids corporel des brebis vides (N) et de celles portant 1 agneau (S) ou des jumeaux (T) pendant les deux premiers mois de la gestation

Type of pregnancy (1)	Feeding levels (2)									SE
	fh			fn			nn			
	T	S	N	T	S	N	T	S	N	
n at mating	7	6	2	7	8	2	5	9	3	
Weight at mating	76	63	65	72	68	60	71	68	57	9
Weight change, mating to 60 days (*)	+ 3	+ 2	0	+ 1	0	0	— 1	— 3	+ 2	2

(1) T: twin; S: single; N: nonpregnant.
(2) See text for explanation of symbols.
(*) Significance of differences of weight change between feeding levels $P < 0.05$; between types of birth, $P < 0.10$.

Ewes' net body weight changes from day 60 to the end of gestation are shown in Table 3. The rate of change was obtained by subtracting the weight at day 60 from the weight recorded 3 days after lambing.

The following is shown in Table 3:

a) Sheep on the " steaming-up " level (H) in the last 2 months of pregnancy gained weight as opposed to the other groups, which maintained or lost weight.

b) The amount of weight loss was more extreme in " steaming-up " low level (L) than in the adjusted (A) groups.

c) There was an interaction between " steaming-up " and maintenance levels. Some ewes on maintenance levels fh lost weight, due, perhaps, to the decline in food intake at the end of pregnancy (see fig. 2 and 3). This is obvious in treatment fhH as compared with the two other groups on this basic level. The large weight loss of twin-bearing ewes on treatment nnL was outstanding.

TABLE 3

Net body weight changes (kg) of ewes during the last three months of pregnancy (weight 3 days post-partum less weight on 60th day of pregnancy; number of ewes is given in parentheses)
Changement du poids net des brebis pendant les 3 derniers mois de la gestation (difference de poids entre le 60e jour de gestation et le 3e jour post-partum; le nombre de brebis est donné entre parenthèses)

Steaming-up levels	Type of pregnancy	Basic levels			Mean (*)
		fh	fn	nn	
H	Twin	— 3.0 (3)	+ 4.3 (4)	+ 4.0 (1)	+ 1.8 (8)
	Single	+ 0.5 (2)	+ 6.0 (1)	+ 8.7 (3)	+ 5.1 (6)
L	Twin	— 2.5 (2)	— 5.0 (2)	— 13.5 (2)	— 7.0 (6)
	Single	+ 0.5 (3)	— 0.7 (3)	— 1.3 (3)	— 0.5 (9)
A	Twin	— 2.5 (2)	— 3.0 (1)	+ 0.5 (2)	— 1.7 (5)
	Single	— 1.5 (2)	— 1.0 (4)	+ 0.4 (3)	+ 0.5 (9)
Mean (*)	Twin	— 2.7 (7)	— 1.2 (7)	— 3.0 (5)	
	Single	— 0.2 (7)	+ 1.4 (8)	+ 3.8 (9)	

(*) Analysis of variance: between steaming-up levels, $P < 0.05$; between basic levels, non-significant; interaction between steaming-up and basic levels, $P < 0.05$; between types of pregnancy, $P < 0.01$.

d) In every case a significant difference was found between twin- and single-bearing ewes; the former gained less or lost more than the latter.

e) Particularly noticeable is the fact that ewes whose feeding was adjusted according to the blood free fatty acids (FFA) levels (treatment A) lost less weight than those in treatment L, and differences between twin- and single-bearing ewes diminished with this treatment.

Birthweights of lambs

Average birth weights of lamb litters born under the various experimental treatments are presented in Table 4. In no group were lambs born small enough to consider the ration as being insufficient for normal development of foetuses.

Total weight loss of ewes at parturition

Weight loss following lambing includes placenta, placental fluids, foetus, and loss of water from tissue dehydration. It is possible to obtain an estimate of all these elements combined by subtracting the ewe's weight 3 days after lambing from the last *prepartum* weight. (Since the ewes were weighed once a week in

TABLE 4

Average litter birth weights (kg)
Poids moyen des agneaux à la naissance

Steaming up levels	Type of pregnancy	Basic levels				SE
		fh	fn	nn	Mean (*)	
H	Twin	9.8	9.3	9.9	9.7	0.7
	Single	5.0	5.1	5.9	5.3	0.5
L	Twin	10.7	10.5	9.0	10.1	1.1
	Single	3.7	5.5	5.0	4.7	1.2
A	Twin	8.5	8.8	8.2	8.5	0.3
	Single	5.7	5.4	5.6	5.6	0.5
Mean (*)	Twin	9.7	9.5	9.0	9.4	0.3
	Single	4.8	5.3	5.5	5.2	0.2

(*) Analysis of variance: overall differences between steaming-up or betwen basic levels were non-significant.

Interaction between the steaming-up and basic levels, $P < 0.05$; Singles of the A treatment were significantly heavier ($P < 0.05$) than those of the H and L treatments.

Twin litters of the *nn* treatment within the L steaming-up level were significantly lighter ($P < 0.05$) than those of the *fh* and *fn* treatments, and twin litters of the A treatments were significantly lighter than those of the H and L treatments.

TABLE 5

Estimated average total weight losses (kg) of ewes following parturition
Pertes moyennes estimées du poids total des brebis après la mise-bas

Steaming-up levels	Type of birth	Basic levels				SE
		fh	fn	nn	Mean (*)	
H	Twin	17.7	17.3	17.0	17.3	0.6
	Single	15.5	15.0	11.0	13.8	2.6
L	Twin	20.5	22.0	26.0	22.8	2.5
	Single	12.5	15.7	13.7	14.0	1.5
A	Twin	20.0	17.0	15.5	17.5	2.1
	Single	14.5	11.8	10.3	12.8	2.5
Mean (*)	Twin	19.4	18.8	19.5		
	Single	14.2	14.2	11.7		

(*) Analysis of variance: between basic levels, non-significant; between steaming-up levels, $P < 0.10$; between birth types, $P < 0.01$.

There is an interaction between basic level and steaming-up levels, between basic level and birth type, and between steaming-up level and birth type, $P < 0.05$.

this experiment, the last weighing occurred between 1 and 7 days before lambing.) Data on this parameter are presented in Table 5. In the overall totals there are no differences between basic levels in either twin- or single-bearing ewes. However, basic and steaming-up regimes did interact, as did feeding level and type of birth. Twin-bearing ewes on the L regime lost more weight than those on the two other " steaming-up " regimes ($P < 0.05$). Single-bearing ewes lost less weight in the A group than ewes in the H and L groups. In the A regime, fat ewes lost more than lean ones (fh *vs.* nn) for both twin- and single-bearers. Among twin-bearing ewes on the L regime there seemed to be a negative relationship between maintenance level and birth weight loss. Single bearers on the H regime lost more weight in the fh maintenance level than on the nn level.

Efficiency of lamb production

Most noteworthy in Table 6 is the high efficiency of ewes on the A steaming-up regime, where feed intake was adjusted according to FFA concentration in the blood. This is true for the gross energetic cost of single-bearing ewes only, but for the partial efficiency it is seen for the twin-bearing ewes too. In addition,

TABLE 6

Estimated energetic costs of lamb production during the last three months of pregnancy, in Mcal of metabolizable energy per kg of lamb at term
Estimation du coût énergétique (en Mcal d'énergie métabolisable par kg d'agneau à terme) de la production d'un agneau pendant les 3 derniers mois de gestation

Cost	Type of birth	a) Basic levels		
		fh	fn	nn
Gross	Twin	44	39	39
	Single	83	65	61
Net	Twin	22	17	18
	Single	39	26	25
		b) Steaming-up levels		
		H	L	A
Gross	Twin	43	41	41
	Single	72	76	41
Net	Twin	21	21	17
	Single	35	33	21

the difference between the apparent caloric cost of producing 1 kg of twins *vs.* singles is small in the A regime compared with the constant H and L feeding levels during the " steaming-up " period. In both regimes there was a high negative correlation between lamb weight and the apparent caloric cost of producing 1 kg of lamb (Table 7).

There were no significant differences in this respect between various maintenance levels, yet it appears that on the high (fh) maintenance level, the energetic cost was somewhat higher than on the two other levels, particularly in single-bearing ewes.

TABLE 7

Correlation coefficients (r) *between components of parturition weight loss and components of the apparent energetic cost of lamb production*
Coefficients de corrélation (r) *entre les composantes de la perte de poids à la mise-bas et celles du coût énergétique apparent de la production d'agneau*

	Net weight change of ewe in last 90 days of pregnancy	Metabolizable energy per kg lamb		Weight change of ewe per kg lamb	
		Treatments H and L	Treatment A	Treatments H and L	Treatment A
Parturition weight loss	— 0.770 (*)	—	—	—	—
Lamb weight	—	— 0.948 (***)	— 0.895 (**)	0.453 NS	0.318 NS
Uterine fluids . . .	—	0.355 NS	0.199 NS	0.788 (**)	0.741 (*)

NS: Non-significant.
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Diseases and mortality in ewes and lambs

Table 8 included only incidences of disease which occurred toward the end of gestation, for which no clear diagnosis were made but the symptoms of which seemed similar to those commonly attributed to pregnancy toxaemia, as described in the Introduction. Incidences of mastitis or short episodes of sickness during the course of pregnancy or lactation were not included. The relatively high incidence of disease among ewes on a high maintenance regime, especially in the fhH group, is particularly noteworthy. In the latter regime, 4 out of 5 ewes became sick and two of them died shortly after lambing.

The mortality of lambs did not differ significantly between treatments. Among five lambs which died out of 62 born, there were three singles and one pair of twins. The latter were born dead to the ewe who was the most sick (in the fhH group), and who subsequently died herself. All in all, the trend seems to be toward higher mortality rate in ewes fed on higher levels (fat ewes) in comparison with lower ones.

TABLE 8

Disease and mortality among ewes in the different experimental groups (number of ewes in each group is indicated in parentheses)
Maladie et mortalité parmi les brebis des différents groupes expérimentaux (le nombre de brebis dans chaque groupe est indiqué entre parenthèses)

Steaming-up level	Basic levels						Percentage	
	fh		fn		nn			
	sick	died	sick	died	sick	died	sick	died
H	4 (5)	2	2 (5)	0	0 (4)	0	43 (14)	14
L	2 (5)	1	0 (5)	0	3 (5)	1	33 (15)	13
A	0 (4)	0	0 (5)	0	0 (5)	0	0 (14)	0
% sick	43 (14)		13 (15)		21 (14)			
% mortality		21		0		7		

Discussion

Nutrition, body weight and fertility

Sheep fed on high nutritional levels during mating and the first month of gestation (basic levels fh and fn) bore more twins than sheep on the normative level (nn), as had been anticipated. The fact that in every treatment group the weight of twin-bearing ewes was higher than single bearers also agrees with similar findings in the literature. The subject has been discussed in length by Coop (1966). These facts are important in the present context since they confirm the conjuncture expressed in the Introduction — that in an intensive production system sheep would be in good body condition or even fat in the second month of gestation. This means that reactions to feeding treatments in advancing pregnancy will, to a great extent, depend on this starting point.

Effect of fatness in early pregnancy

The sheep on the high maintenance level lost weight during the last months of pregnancy. They were marked also by a tendency toward a relatively large weight loss during lambing (lamb + fluids, and possibly plus contents of the digestive system). The apparent energetic cost of lamb production was also high as compared with ewes on other regimes (Table 6). In the group which was also given a high steaming-up level (fhH), the incidence of disease with signs of pregnancy toxaemia was highest. Finally, a tendency (non-significant) toward higher mortality among lambs of the fat ewes was noted.

This general picture agrees with previously described findings (GORDON and TRIBE, 1951; REID and HINKS, 1962). It is noteworthy that ewes on all nutritional levels were fed rations of a uniform composition. Therefore, ewes fed a high level consumed excess protein along with the excess energy. One cannot exclude the possibility that the excess protein also contributed to symptoms resembling ketosis. The results of HIBBITT (1966) on the effect of excess protein on the incidence of ketosis in dairy cows give some support to this hypothesis. HIBBIT'S experiment was, however, carried out under different conditions (including thyroxin injections). No reports on excess protein in sheep were found in the literature. GRAHAM (1969) showed a decrease in appetite in obese wethers.

Effect of steaming-up during the last two months of pregnancy

Interesting results were found in the comparison of effects of the constant steaming-up regimes (H and L) with the regime that was adjusted according to FFA concentration in the blood (A), *i.e., gradually rising* regime. Despite the large difference in the absolute levels of H and L, they are similar in two characteristics: *a*) The level was fixed at the beginning of the fourth month and was not changed to the end of gestation. This led first to an accumulation of excess energy, which was stored in the ewes' bodies as fat. Furthermore, it was apt to lead to an energy deficit as the fœtuses grew, toward the end of gestation. This was indeed the case with sheep on the lower level, and resulted in the only typical case of pregnancy toxaemia in a twin-bearing ewe of this level. *b*) Since the number of foeti carried by each ewe was unknown, twin- and single-bearing ewes received equal rations. The experimental situation in which the ewes were placed in separate pens, was somewhat different from farm conditions. On farms, where sheep are fed in groups, ewes requiring more energy may eat more from the common pool than those requiring less.

In the A regime feed was gradually increased along with the rise in the foeti needs and it was therefore expected that the level would be adjusted to the number of embryos carried by each ewe. It was surprising that these A ewes did not consume more than those in the L regime during the entire pregnancy. A possible cause might be that blood sampling for FFA concentration tests (and, thus, feed adjustments) were not done often enough (every two weeks until the end of the fourth month and once a week during the fifth month of gestation).

It has been shown that lamb weight is affected by feeding levels during gestation (GARDNER and HOGUE, 1963; PEART, 1967; BUTTERWORTH and BLORE, 1969). SYKES and FIELD (1972) showed that a large reduction in lamb weight was caused only when undernutrition in late pregnancy was accompanied by a marked lack of protein and to some degree also of calcium. The slightly lower weight of twins in the adjusted group may, however, be attributed to the insufficient frequency (fortnightly) of adjustment which resulted, perhaps, in a slight undernourishment (RUSSEL, DONEY and REID, 1967a). Results of that study are in agreement with this finding.

The proportion of twin births, which was particularly low in ewes of the adjusted group, illustrates the random distribution of ewes bearing different numbers of embryos when they were allocated to the various treatment groups. Several researchers have shown that the effect of severe undernourishment on embryo mortality after the third week of pregnancy is nil (COOP and CLARK, 1969; EDEY, 1970). There is no reason, therefore, to relate this fact to the experimental treatments.

Correlations between the components of the birth weight loss and the components of the apparent energy cost of lamb production

The birth weight loss is composed of the lamb's weight and other elements which, for the sake of this discussion, will be called " pregnancy fluids ". The energetic cost includes, as previously explained, the energy consumed in food, less the energy of weight loss or gain in the ewes. The correlations between these components provide information on the quality of body weight changes during the last 90 days of pregnancy. The correlation coefficients are presented in Table 7. The highly significant correlation coefficients between lamb weight and the energy cost coming from feed, and those between weight of the pregnancy fluids and the cost arising from the mother's body weight, confirm the assumption that an appreciable part of the ewe's body weight changes at the end of pregnancy originates in the degree of tissue hydration.

Requirements of the pregnant dairy ewe

The predicted maintenance ration used for the present experiment was 8.2 MJ for a 60 kg ewe. This was increased or decreased according to the metabolic body weight of ewes of different weights.

Single-bearing ewes whose feed allowance was adjusted according to plasma FFA in late pregnancy maintaining a constant body weight, produced the largest lambs and, it seems, produced them most efficiently. It may therefore be assumed that the maintenance feed they received was the correct amount for ewes of the breeds used here. DONEY and RUSSEL (1968) and RUSSEL and DONEY (1969) tried to determine ewes' maintenance requirements using correlations between body weight changes and feed intake, and body weight changes and plasma FFA concentrations. They showed a difference in the maintenance requirements of three different breeds ranging from 8.4 g digestible organic matter (DOM) /kg body weight to 13.7 g /kg. If the feed provided in this experiment is expressed as DOM, one finds that ewes on a normative maintenance ration consumed 11.4 g / kg (the feed included 400 g hay and 700 g concentrates, 1,100 g total. This included an average of 83 p. 100 organic matter with a digestibility coefficient, determined in a metabolism experiment, of 75 p. 100, or 62 p. 100 DOM. Therefore, a 60-kg ewe consumed $\frac{1{,}100 \times 62}{100 \times 60} = 11.4$ g /kg).

The concentration of metabolizable energy in the above ration was 10.71 MJ / kg, *i.e.*, the maintenance requirement reached 11.18 MJ (10.17 × 1.1). Rationing of the feed at the beginning of the experiment was done on the basis of an empirical assessment according to feed components. The intention was to provide 8.2 MJ for maintenance. The ewes thus received considerably more energy than was planned. Since this amount seems not to have been excessive, it appears that the feeding standards for daily maintenance requirements of dairy sheep in Israel are higher than the norm used in the past.

Single-bearing ewes on the plasma FFA adjusted feeding level (A) consumed an average of 5.0 MJ (ME) above the maintenance requirement during the second week before lambing. This amount equals approximately 300 g DOM. If we assume that the average weight of a single lamb two weeks before term was 4.5-5 kg (5.6 kg at birth), it is seen that about 67 g DOM was required per kg of lamb. This amount is low compared with the estimated 80 g mentioned by REID (1963), and the 100 g estimate of RUSSEL *et al.* (1967b). Some of the difference between these results and ours may be attributed to higher energy concentration of the feed used in the present experiments. It may, however, also illustrate the relative efficiency of the adjusted " steaming-up " method. In steaming-up methods where fixed amounts of feed are provided in the last six weeks or two months of gestation, there is an initial energy surplus. This is stored as fat and somewhat increases the ewe's maintenance requirement. The pregnancy supplement of 3.5 MJ, common in Israel, is insufficient for the lamb's requirements in late pregnancy, and the deficit is drawn from the maintenance ration and body reserves of the mother. The average gross body weight of twin lambs was 1.8 times more than that of single lambs. Thus it may be assumed that if the supplement required in the middle of the fifth month of pregnancy was 4.7 MJ for single-bearing ewes, it should be approximately 8.5 MJ for twin bearers. This would probably be true only if the ration were not increased suddenly at the beginning of the 4th month but gradually throughout the last two months of pregnancy.

The results thus indicate that the distribution of energy to the mother's tissues and to the lamb's may be different when the feed is increased gradually from when it is increased all at once at the end of the third month and remains constant thereafter.

Possible breed differences. The least squares analysis of variance did not show significant breed differences for any of the compared variables. The number of ewes, however, of either of the two breeds which were included in the experiment was too small to justify real breed comparisons. This is mainly so as the two breeds differ in the ratio of multiple to single births and it would be impossible to differentiate between eventual breed differences arising from this fact, and those arising from other characteristics, such as possible differences in body composition or in fat deposition.

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Résumé

Réponses de brebis laitières avant et après l'agnelage
à différents niveaux d'apports alimentaires pendant la gestation

I. — Poids des brebis et des agneaux,
et utilisation de l'énergie pendant la gestation

Les effets de 3 séquences d'apports alimentaires de base tout au long de la gestation (*fh*, *fn* et *nn*) combinées à 3 niveaux de supplémentation à la fin de la gestation (H, L et A) ont été étudiés chez des brebis laitières (fig. 1).

Pendant les 3 dernières semaines de la gestation, une diminution des quantités ingérées est apparue chez les brebis recevant le niveau de supplémentation élevé (H) et particulièrement chez celles qui étaient grasses au début de leur gestation.

Lorsque le niveau de supplémentation était ajusté graduellement (niveau A) selon la teneur plasmatique en acides gras libres (FFA), la consommation d'énergie des brebis était légèrement supérieure à celle des brebis recevant le niveau faible de supplémentation (L) (18,4 MJ. Vs. 15,9 MJ. /jour). La consommation totale au cours de la gestation n'était pas différente entre ces deux groupes.

Les brebis recevant un niveau élevé de supplémentation ont gagné plus de poids que celles des autres groupes. Les brebis grasses (séquence d'apports élevés *fh*) ont perdu du poids pendant les trois dernières semaines de gestation. Celles portant des jumeaux ont gagné moins de poids ou en ont perdu plus que celles portant des agneaux simples. Les animaux dont le niveau de supplémentation est ajusté ont eu un poids plus stable durant toute la gestation, malgré une consommation alimentaire relativement basse; dans ce groupe, on a observé les différences les plus faibles entre les brebis portant des jumeaux et des agneaux simples.

Le poids à la naissance des agneaux n'est pas affecté par les séquences d'apports alimentaires de base. On observe, par contre des différences selon les 3 niveaux de supplémentation. Les poids moyens des portées des brebis recevant les niveaux de supplémentation élevé (H), faible (L) et ajusté (A) étaient de 9,8 $\pm$ 0,7 et 5,3 $\pm$ 0,5 kg; 10,1 $\pm$ 1,1 et 4,7 $\pm$ 1,2 kg; et 8,5 $\pm$ 0,3 et 5,6 $\pm$ 0,5 kg, pour les portées doubles et simples respectivement. Dans le dernier niveau (A), aussi bien les agneaux doubles (plus légers) que les agneaux simples (plus lourds), diffèrent significativement de ceux des autres groupes. La fréquence des maladies de type « toxémie de gestation », et des pertes d'appétit à l'approche de l'agnelage, était élevée (43 p. 100) parmi les brebis recevant l'apport alimentaire de base élevé. Ces fréquences étaient de 43 p. 100, 33 p. 100 et 0,0 p. 100 respectivement pour les niveaux de supplémentation H, L et A.

En conclusion, la façon d'apporter la supplémentation à la fin de la gestation (niveau constant, ou augmentation progressive des apports) peut affecter l'utilisation respective de l'énergie par la mère et ses fœtus; l'efficacité alimentaire a été plus élevée dans le cas de l'augmentation progressive des apports à l'approche de l'agnelage.

References

ADLER J. H., 1970. Theoretical quantitative approach to the mechanism of hypoglycemic ketosis in ruminants. *J. Theoret. Biol.*, **28**, 101-109.

BROSTER W. N., 1962. Should dairy cows be steamed up? *Agriculture*, **69**, 261-264.

BUTTERWORTH M. H. and BLORE T. W. D., 1969. The lactation of Persian Blackhead ewes and the growth of lambs. The effect of three different nutritional regimes during gestation on subsequent growth. *J. agric. Sci. Camb.*, **73**, 133-137.

CASTLE M. E. and WATSON J. N., 1961. The effect of concentrate feeding before and after calving on the production of dairy cows. *J. Dairy Res.*, **28**, 231-243.

COOP J. E., 1966. Effect of flushing on reproductive performance of ewes. *J. agric. Sci. Camb.*, **67**, 305-323.

COOP J. E. and CLARK V. R., 1969. The influence of nutritional level in early pregnancy of the ewe. *J. agric. Sci. Camb.*, **73**, 387-394.

DOLE V. P. and MEINERTZ H., 1960. Microdetermination of long chain fatty acids in plasma and tissues. *J. Biol. Chem.*, **235**, 2595-2599.

DONEY J. M. and RUSSEL A. J. F., 1968. Differences amongst breeds of sheep in food requirements for maintenance and live weight change. *J. agric. Sci. Camb.*, **74**, 343-349.

EDEY F. M., 1970. Nutritional stress and pre-implantation mortality in Merino sheep. *J. agric. Sci. Camb.*, **74**, 199-204.

GARDNER R. W. and HOGUE D. E., 1963. Studies of the TDN requirements of pregnant and lactating ewes. *J. Anim. Sci.*, **22**, 410.

GORDON J. G. and TRIBE D. E., 1951. The self-selection of diet by pregnant ewes. *J. agric. Sci. Camb.*, **41**, 187-190.

GRAHAM N. Mc C., 1969. The influence of body weight (fatness) on the energetic efficiency of adult sheep. *Aust. J. agric. Res.*, **20**, 375-385.

HIBBITT J. G., 1966. The induction of ketosis in the lactating dairy cow. *J. Dairy Res.*, **33**, 291-298.

HOLMES W. J., JONES G. W., DRAKEBROCKMAN R. M. and WHITE N., 1965. The feed intake of milk cows. I. Intake of winter rations during pregnancy and lactation and the influence of change to pasture. *Anim. Prod.*, **7**, 27-37.

KNOTT J. G., HODGSON R. E. and ELLINGTON E. V., 1934. Methods of measuring pasture yields with dairy cattle. *Bull. Wash. Agric. Exp. St.*, **95**.

MAYNARD L. A. and LOSSLY J. K., 1969. *Animal Nutrition.* McGraw-Hill Book Co., pp. 423.

PEART J. N., 1967. The effect of different levels of nutrition during late pregnancy on the subsequent milk production of Blackface ewes and on the growth of their lambs. *J. agric. Sci. Camb.*, **68**, 365-371.

REID R. L., 1960. Further studies on hypoglycaemia and hyperketonaemia in undernourished pregnant ewes with pregnancy toxaemia. *Aust. J. agric. Res.*, **11**, 346-363.

REID R. L., 1963. The nutritional physiology of the pregnant ewe. *J. Aust. Inst. agric. Sci.*, **29**, 215-223.

REID R. L. and HINKS N. T., 1962. Feed requirements and voluntary feed intake in late pregnancy. *Aust. J. agric. Res.*, **13**, 1092-1111.

REID R. L. and HOGAN J. P., 1959. Hypoglycaemia and hyperketonaemia in undernourished and fasted pregnant sheep. *Aust. J. agric. Res.*, **10**, 81-96.

RUSSEL A. J. F. and DONEY J. M., 1969. Observations on the use of plasma free fatty acid concentrations in the determination of maintenance requirements of sheep. *J. agric. Sci. Camb.*, **72**, 59-63.

RUSSEL A. J. F., DONEY J. M. and REID R. L., 1967a. Biochemical parameters in controlling nutritional state in pregnant ewes, and the effect of undernourishment during pregnancy on lamb birth weight. *J. agric. Sci. Camb.*, **68**, 351-358.

RUSSEL A. J. F., DONEY J. M. and REID R. L., 1967b. Energy requirements of the pregnant ewe. *J. agric. Sci. Camb.*, **68**, 359-363.

SYKES A. R. and FIELD A. C., 1972. Effects of dietary deficiencies of energy, proteins and calcium on the pregnant ewe. II. Body composition and mineral content of the lamb. *J. agric. Sci. Camb.*, **78**, 119-125.