THE NUTRITIONAL REQUIREMENTS OF GRAZING SHEEP

K. T. JAGUSCH and I. E. COOP
Lincoln College, Canterbury

THIS TOPIC has been discussed under different headings several times at the Society's meetings during the past decade (Coop, 1961, 1964, 1967; Lambourne, 1961; Cooper and Drew, 1963). These papers emphasize the fundamental prediction of maintenance and the factors affecting the requirement for maintenance. Management and nutrition together with efficiency of food utilization by sheep have also been discussed.

It is now intended to set out the nutritional requirements in a form that will serve as a guide to profiling the annual pasture demand by sheep. In spite of between-animal variation in food requirement for a specific function, such a stipulation is reasonably easy if referring to hand-fed sheep, but the problem becomes increasingly difficult in the grazing situation because the available energy in a unit of pasture dry matter varies considerably and the energy cost of grazing is also a variable factor as is an assessment of what the animal selects.

This paper examines first the amount sheep eat when they are in the particular physiological states of lactation, growth, or maintenance, and then profiles the annual feed demand by grazing sheep using maintenance as the baseline.

When comparing work from different authors metabolizable energy has been used for evaluating the fodder and in specifying consumption. Factors used in calculations to standardize data from several sources were:

1 kg DM	= 4.4 Mcal Gross Energy (GE)
1 kg DOM	= 3.7 Mcal Metabolizable Energy (ME)
1 kg TDN	= 4.4 Mcal Digestible Energy (DE)
ME	= 0.8 DE
1 kg ewe's milk	= 1.1 Mcal GE

LACTATION

Lactating ewes eat considerably more food than they do at maintenance and the energy available for production is partitioned between energy gain and energy in the milk. This partition in energy varies with the stage of lactation. If maximum potential to produce milk is reached by adequate feeding, then ewes will gain weight, particularly in late lactation. Energy expenditure for the production of 1 Mcal milk increases as the lactation period advances and milk secretion decreases (Modyanov, 1969), and maximum food intake by pen-fed and grazing sheep lags behind maximum milk production by 3 to 4 weeks (Hadjipieris and Holmes, 1966; Hajipieris *et al*, 1966).

An idea of the metabolizable energy intake relative to milk production of adequately-fed ewes is given by the data in Table 1. If allowance is made for differences in body weight, grazing ewes consume approximately 30% more ME than that recommended by recognized feeding standards and ewes suckling twins eat more than those rearing singles. It should be noted that an intake of 6 Mcal

TABLE 1: MEAN VALUES FOR THE METABOLIZABLE ENERGY INTAKE AND MILK ENERGY SECRETED BY EWES DURING A LACTATION PERIOD OF 12 WEEKS

(kg) Liveweight	*No. of Suckled Lambs*	*ME Intake (Mcal/ day)*	*Milk Energy (Mcal/ day)*	*Reference*
Indoor Trials				
70	—	5.3	1.6	A.R.C., 1965
73	—	4.8	1.4	N.R.C., 1968
75	1	5.6	2.4	Hadjipieris and Holmes (1966); Hadjipieris *et al.* (1966)
71	2	6.8	3.1	Hadjipieris and Holmes (1966); Hadjipieris *et al.* (1966)
Grazing Trials				
54	1	6.0	1.5	Coop and Drew, 1963
54	2	6.7	1.8	Coop and Drew, 1963
54	1 & 2	9.4	2.2	Hadjipieris and Holmes (1966); Hadjipieris *et al.* (1966)
54	2	7.5*	2.4	Jagusch and Mitchell, 1970
38	1	4.3	1.0	Corbett, 1968

*Assumed value as ewes were given a higher plane of nutrition than those of Coop and Drew (1963).

ME is equivalent to about 18 kg (40 lb) of fresh spring herbage. Liberal feeding of the ewe during lactation is essential if high milk production is to be maintained (Barnicoat *et al.*, 1949a, b, 1957; Coop, 1950; McCance and Alexander, 1959; Lloyd Davies, 1963). A gain in weight of the ewe of 10 kg during lactation under such feeding conditions is not unusual (Coop and Jagusch, unpubl.).

GROWTH

Suckling Lamb

The feeding standards published in Great Britain and the United States do not give the requirements for lambs while they are suckling the ewe. However, many workers have shown strong relationships between milk yield of the ewe and the growth rate of lambs in early lactation (Wallace, 1948; Burris and Baugus, 1955; Munro, 1962; Scales, 1968) and artificial rearing schemes are well established (Spedding *et al.*, 1961; Large, 1965a, b; Large and Penning, 1967; Owen *et al.*, 1969). The kind of milk intake required by lambs (birthweight = 4-5 kg approx.) to grow at rates up to 300 g/day during the first 3 weeks of life is given in Table 2. There is good agreement between these reports in the requirement of milk for specific growth rates. Slightly lower values for ewe's milk compared with that for cow's milk could reflect a greater efficiency of utilization of ME (Jagusch and Mitchell, 1971).

TABLE 2: MEAN VALUES FOR THE GROSS ENERGY REQUIREMENTS (Mcal/day) OF LAMBS FED ON MILK DURING THE FIRST 3 WEEKS OF LIFE

Reference	*Liveweight Gain (g/day)*			
	100	*200*	*300*	
Walker *et al.* (1967)	0.8	1.3	1.8	(cow's milk)
Large (1965a)	0.7	—	2.0	(cow's milk)
Jagusch and Mitchell (1971)	0.8	1.1	1.5	(ewe's milk)
Joyce and Rattray (1970)	0.8	1.2	—	(ewe's milk)

The relationship between the requirement of a single lamb (birthweight = 5 kg) growing at the rate of 300 g/day and the milk yield of ewes fully fed at pasture or restricted to intakes of 3.5 and 1.9 Mcal ME/day, respectively, during early lactation is shown in Fig. 1 (Jagusch and Mitchell, 1970). It can be seen that liberally-fed ewes produce sufficient milk to promote such a liveweight gain.

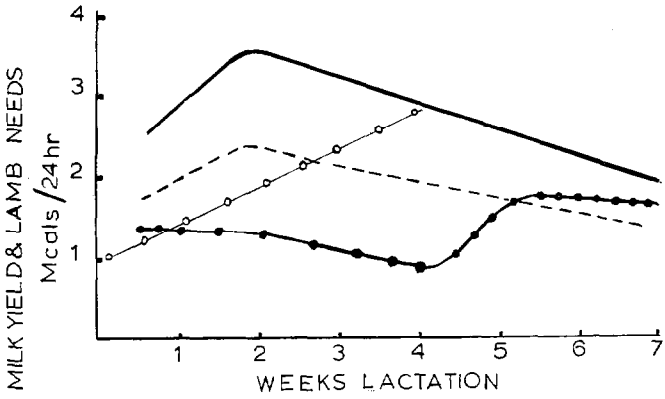

Fig. 1: The requirement for ewe's milk by a growing lamb (o–o–o) *and lactation curves for Romney ewes (suckling twins) fed pasture* ad lib. (———), *or fed lucerne hay and grain at daily intakes of 3.5 Mcal ME (- - -) and 1.9 Mcal ME (.—.—.).*

However, the lamb rapidly outstrips the ewe's ability to produce milk if she is restricted in nutrition and the problem of supply is also enhanced when multiple births occur.

Gardner *et al.* (1964) considered the energy requirements of lambs in the pre-weaning stage of life, and found the suckling lamb utilized 77% of the milk consumed, but only 19% of the solid food eaten for maintenance and gain. Joyce and Rattray (1970) showed that pasture contributed to 35 and 60% of the ME intake when lambs were 6 and 9 weeks old, respectively. In this experiment the average growth rate of lambs was about 150 g/day and intakes at those ages were about 1.0 and 1.5 Mcal ME/day, respectively. On the basis of these results, a lamb growing at 300 g/day to a marketable weight at 8 to 9 weeks of age could be consuming, when it is 6 weeks old, about 3.0 Mcal ME/day of which about 2.0 Mcal ME came from milk.

Weaned Lamb

A guide to the requirements of lambs from time of weaning to the hogget stage is given in Table 3. Ration quality has been graded in terms of the concentration of ME per kg dry matter. Basically, Table 3 represents the requirement of a fattening lamb weaned at 15 kg and grown to a liveweight of 45 kg. Most feeds contain 4.4 Mcal GE/kg DM. Hence a value of 1.8 Mcal ME/kg DM means that for

every 1 kg of dry matter eaten by the lamb 2.6 (*i.e.*, 4.4 −1.8) Mcal are unavailable for maintenance and production, a situation that occurs when poor quality rations are fed. On the other hand, a value of 3.0 Mcal ME/kg DM means that 1.4 (4.4−3.0) Mcal of energy are unavailable.

Table 3 shows that, for a particular rate of liveweight gain, lambs require a greater dry matter intake of low quality rations compared with those of high quality. Rapid rates of gain cannot be achieved with low quality rations because in general bulk of the food limits intake before sufficient energy has been ingested to achieve high weight gains. Furthermore, the margin between low and high quality rations, in terms of requirement for better performance, becomes more marked with low quality rations because of differences in the efficiency of utilization of metabolizable energy.

TABLE 3: THE METABOLIZABLE ENERGY REQUIREMENTS (Mcal/day) OF WEANED LAMBS (Data: A.R.C., 1965.)

Liveweight (kg)	*ME Concentration (Mcal/kg DM)*	*Liveweight Gain (g/day)*				
		0	*50*	*100*	*200*	*300*
20	1.8	1.00	1.58	2.35	—	—
	2.2	0.97	1.42	1.88	3.42	—
	2.6	0.93	1.29	1.69	2.70	4.20
	3.0	0.87	1.20	1.52	2.32	3.37
30	1.8	1.31	1.91	2.79	—	—
	2.2	1.27	1.76	2.32	3.88	—
	2.6	1.22	1.60	2.06	3.15	4.63
	3.0	1.17	1.51	1.89	2.74	3.82
40	1.8	1.59	2.30	3.20	—	—
	2.2	1.54	2.14	2.71	4.25	—
	2.6	1.48	1.92	2.41	3.54	5.00
	3.0	1.42	1.80	2.21	3.11	4.22

The *ad libitum* intakes of various pasture species and liveweight gains of weaned lambs measured at Ruakura (Joyce and Newth, 1967; Rattray and Joyce, 1969) and Lincoln (McLean *et al.*, 1963) are compared in Table 4 with the standards given previously (Table 3). Although a range of values for the standard requirements had to be given because the concentrations of ME in the various pastures were not specified in these experiments, there is good agreement with the measured values. Within each experiment there is a close correlation between liveweight gain and ME intake. It would appear that high daily rates

TABLE 4: PASTURE INTAKE BY WEANED LAMBS

	Liveweight Gain (g/day)	*Metabolizable Energy (Mcal/day) Experimental*	*A.R.C. Standards*
Ruakura (indoor trials)			
Spring herbage			
White clover	123	2.0	1.7-2.1
Perennial ryegrass	86	1.9	1.8-2.3
White clover and perennial ryegrass	97	1.9	1.8-2.2
Autumn herbage			
White clover	92	2.7	1.7-2.1
Perennial ryegrass	48	2.0	1.6-1.9
Lincoln (grazing trials)			
Spring herbage			
White clover	256	5.3	4.2-4.6
Lucerne	241	4.0	4.0-4.4
Timothy	164	2.3	2.1-2.6
Short-rotation ryegrass	139	2.1	2.0-2.5
Perennial ryegrass	109	2.0	1.8-2.3
Autumn herbage			
White clover	259	4.7	4.2-4.6
Lucerne	240	4.4	4.0-4.4
Timothy	227	3.1	2.9-3.4
Short-rotation ryegrass	236	3.2	2.9-3.4
Perennial ryegrass	186	2.9	2.8-3.3

of gain from pasture by a 25 to 30 kg lamb requires the consumption of over 4 Mcal ME/day, whereas intakes below 2.5 Mcal ME/day will results in poor growth rates.

MAINTENANCE

Adult sheep spend virtually their entire life at maintenance which in respect to the grazing animal cannot explicitly mean zero energy retention. It is well known that within any system of flock management fluctuations in liveweight of the ewes are generated when feed supply is adjusted to the animal's practical requirement in a particular period during the year. However, it is important to measure the specific maintenance requirement of adult sheep in order that some baseline is obtained for predicting the requirements of sheep under the practical conditions of feeding at pasture.

Selected data for the maintenance requirements of sheep are summarized in Table 5. It is interesting to note that the estimates given for grazing sheep were determined

TABLE 5: METABOLIZABLE ENERGY REQUIREMENT FOR MAINTENANCE OF 45 kg SHEEP

Reference	*ME Intake (Mcal/day)*
Pen-fed sheep	
A.R.C. (1965)	1.70
N.R.C. (1968)	2.00 (some gain)
Coop (1962	1.54
Garrett *et al.* (1959)	1.70
Wallace (1948)	1.80
Grazing sheep	
Coop and Hill (1962)	2.50
Grimes (1966)	2.20
Young and Corbett (1968)	2.30

by three distinctly different techniques and all show the requirement to be higher than that for pen-fed animals. Considering the literature it appears the cost is up to 50% higher. Reasons suggested for this higher maintenance cost include extra energy expended in walking and harvesting the pasture and greater heat losses due to climatic conditions or metabolic stress. The food requirement of shorn sheep is 10 to 20% higher than those in fleece and continuous grazing tends to increase the requirement compared with lax grazing (Coop and Drew, 1963).

Calorimetric experiments designed to measure the energy expenditure of the grazing sheep in its various activities have been conducted (Graham, 1964; Blaxter, 1964), but it is difficult to see how these indoor experiments can simulate precisely all the vagaries of the outdoor environment in a given season.

The physiological state of pregnancy can best be treated as an increased maternal cost to maintenance with allowances being made for changes in liveweight of the ewe. Ewes normally have to be fed at a level 50% above maintenance during the last 4 weeks of gestation.

PREDICTION OF ANIMAL PERFORMANCE

The maintenance requirements of adult sheep, fed rations containing different concentrations of ME, are shown in Table 6. These values are in substantial agreement with the experimentally determined requirements of pen-fed sheep and also the hand-feeding mob trials conducted by Franklin (1952) and Coop (1962). The baseline

prediction of maintenance can be made from Table 6. Then setting the requirement for a grazing ewe as 1.3 times maintenance, late pregnancy as 1.5 times maintenance, and lactation as 3 times maintenance, the average requirement for the grazing sheep can be calculated. Such a calculation for a 55 kg ewe rearing a single lamb is given in Table 7. These values will change for feeds varying in their concentration of ME and for sheep of different liveweights.

During the year sheep are fed rations that differ in quality and it is important that foodstuffs be evaluated in terms of their concentration of ME. Unfortunately, published data for foodstuffs so screened in New Zealand are limited. However, calculated values for some common

TABLE 6: METABOLIZABLE ENERGY REQUIREMENT (Mcal/day) FOR MAINTENANCE OF ADULT SHEEP (Data: A.R.C., 1965.)

Liveweight (kg)	*ME Concentration (Mcal/kg DM)*			
	1.8	*2.2*	*2.6*	3.0
40	1.59	1.54	1.48	1.42
55	1.82	1.76	1.69	1.62
70	2.02	1.95	1.87	1.80

TABLE 7: METABOLIZABLE ENERGY REQUIREMENT (Mcal/day) OF A 55 kg EWE

	Maintenance	*Pregnancy*	*Lactation*
Pen fed	1.8	2.7	5.4
Grazing	2.3	3.5	6.9

New Zealand foodstuffs are set out in Table 8. Their accuracy will improve with further research because they will vary with stage of growth and from district to district. With a given foodstuff a range of values could quite well be the best way to represent the ME concentration of the dry matter.

PROFILE OF FEED DEMAND FOR GRAZING SHEEP

Figure 2 gives the seasonal variation in the level of nutrition and the quality of feed, recommended for a breeding ewe rearing a single lamb, together with the change in liveweight generated by such a feeding programme. Changes in the level of nutrition are expressed in terms of multiples of maintenance and relate to the

TABLE 8: FOOD VALUES OF COMMON NEW ZEALAND FOODSTUFFS

Foodstuff	*Dry Matter (%)*	*Metabolizable Energy (Mcal/kg DM)*
Poor-quality hay	86	1.6-1.9
Medium-quality hay	86	1.8-2.0
Good-quality hay	86	2.0-2.2
Clover hay	84	2.2
Lucerne hay	84	2.1
Wheat straw	86	1.4
Oat straw	86	1.6
Ryegrass straw	86	1.7
Leafy pasture	20	2.6-3.0
New pasture	16	2.8-3.0
Winter pasture	35	2.4-2.6
Brown summer pasture	60	2.1-2.4
Silage	20	1.8-2.3
Green oats	20	2.7
Italian ryegrass	20	2.8
Choumoellier	15	2.7-2.9
Kale	15	2.9
Lupins	15	2.8
Rape	14	3.0
Green maize	25	2.4
Swedes	12	2.9-3.1
Turnips	9	2.9-3.1
Fodder beet	15	2.9-3.1
Barley	87	3.1
Oats	87	2.8
Wheat	87	3.3
Maize	87	3.1
Linseed meal	88	3.2
Meat meal	89	2.6
Sheep nuts	89	2.9
Skim milk	9	3.5
Butter milk	9	3.5
Cow's whole milk	13	4.4
Whey	7	3.4

date and distribution of mating, lambing and weaning. It also illustrates the maximum and minimum feeding levels one could have under conditions of abundance of feed or if pasture is in short supply.

Grass eaten by the lamb could account for an additional half of the maintenance requirement during October and November.

The seasonal liveweight change is given in terms of actual liveweight and true body weight (actual less fleece,

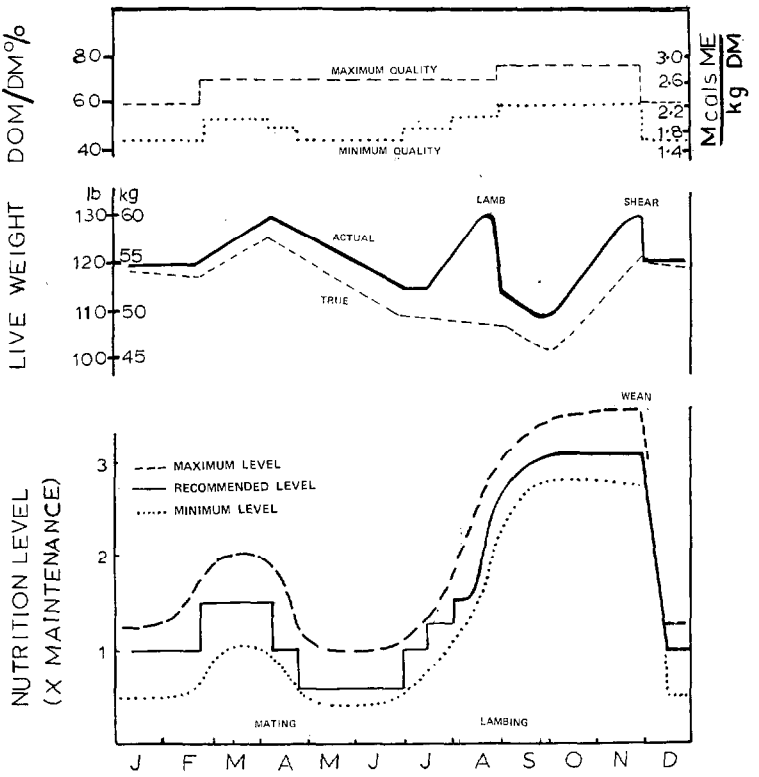

Fig. 2: Seasonal variation in level of nutrition, liveweight and feed quality recommended for the breeding ewe.

foetus, and foetal fluids). The maximum feed quality available and the minimum feed quality allowable to achieve the recommended feeding policy is also given in Fig. 2.

It is not possible to feed or ration grazing sheep with any degree of exactitude. Fortunately the ewe is an adaptable animal and except for certain critical periods can tolerate wide variations in the level of nutrition. In the interests of minimizing the effects of highly seasonal pasture growth, it is quite acceptable, and in fact to be recommended, that sheep be subjected to a varying seasonal feeding regime.

REFERENCES

A.R.C. [Agricultural Research Council], 1965: *The Nutrient Requirements of Farm Livestock. No. 2. Ruminants.* Tech. Comm. Agric. Res. Counc. Lond. 264 pp.

Barnicoat, C. R.; Logan, A. G.; Grant, A. I., 1949a: *J. agric. Sci., Camb., 39:* 49.
———; ———; ———, 1949b: *J. agric. Sci., Camb., 39:* 237.
Barnicoat, C. R.; Murray, P. F.; Roberts, E. M.; Wilson, G. S., 1957: *J. agric. Sci., Camb., 48:* 9.
Blaxter, K. L., 1964: *Proc. Nutr. Soc., 23:* 62.
Burris, M. J.; Baugus, C. A., 1955: *J. Anim. Sci., 14:* 186.
Coop, I. E., 1950: *J. agric. Sci., Camb., 40:* 311.
——— 1961: *Proc. N.Z. Soc. Anim. Prod., 21:* 79.
——— 1962: *J. agric. Sci., Camb., 58:* 179.
——— 1964: *Proc. N.Z. Soc. Anim. Prod., 24:* 129.
——— 1967: *Proc. N.Z. Soc. Anim. Prod., 27:* 154.
Coop, I. E.; Drew, K. R., 1963: *Proc. N.Z. Soc. Anim. Prod., 23:* 53.
Coop, I. E.; Hill, M. K., 1962: *J. agric. Sci., Camb., 58:* 187.
Corbett, J. L., 1968: *Aust. J. agric. Res., 19:* 283.
Franklin, M. C., 1952: *Aust. J. agric. Res., 3:* 168.
Gardner, R. W.; Hogue, D. E.; Bensadoun, A., 1964: *J. Anim. Sci., 23:* 943.
Garrett, W. N.; Meyer, J. H.; Lofgreen, G. P., 1959: *J. Anim. Sci., 18:* 528.
Graham, N. McC., 1964: *Proc. Aust. Soc. Anim. Prod., 5:* 272.
Grimes, R. C., 1966: *J. agric. Sci., Camb., 6:* 211.
Hadjipieris, G.; Holmes, W., 1966: *J. agric. Sci., Camb., 66:* 217.
Hadjipieris, G.; Jones, J. G. W.; Wimble, R. H.; Holmes, W., 1966: *J. agric. Sci., Camb., 66:* 341.
Jagusch, K. T.; Mitchell, R. M., 1970: Paper read to Ann. Conf. N.Z. Nutr. Soc.
———; ——— 1971: *N.Z. Jl agric. Res., 14:* 434.
Joyce, J. P.; Newth, R. P., 1967: *Proc. N.Z. Soc. Anim. Prod., 27:* 166.
Joyce, J. P.; Rattray, P. V., 1970: *Proc. N.Z. Soc. Anim. Prod., 30:* 94.
Lambourne, L. J., 1961: *Proc. N.Z. Soc. Anim. Prod., 21:* 92.
Large, R. V., 1965a: *J. agric. Sci., Camb., 65:* 101.
——— 1965b: *Anim. Prod., 7:* 325.
Large, R. V.; Penning, P. D., 1967: *J. agric. Sci., Camb., 69:* 405.
Lloyd Davies, H., 1963: *Aust. J. agric. Res., 14:* 824.
McCance, I.; Alexander, G., 1959: *Aust. J. agric. Res., 10:* 699.
McLean, J. W.; Jagusch, K. T.; Thomson, G. G.; Lawson, B. L., 1963: Paper read to Ann. Conf. N.Z. Vet. Assoc.
Modyanov, A. V., 1969: In *Energy Metabolism of Farm Animals,* p. 171. (K. L. Blaxter, J. Kielanowski, and G. Thorbek, eds.) Oriel Press, Newcastle-upon-Tyne.
Munro, J., 1962: *Anim. Prod., 4:* 203.
N.R.C. [National Research Council], 1968: Nutrient requirements of domestic animals. No. 2. Nutrient requirements of sheep. *Nat. Acad. Sci., Nat. Res. Counc. Publ. 1693.* 64 pp.
Owen, J. B.; Davies, D. A. R.; Ridgman, W. J., 1969: *Anim. Prod., 11:* 1.
Rattray, P. V.; Joyce, J. P., 1969: *Proc. N.Z. Soc. Anim. Prod., 29:* 102.
Scales, G. H., 1968: *N.Z. Jl agric. Res., 11:* 155.
Spedding, C. R. W.; Large, R. V.; Brown, T. M., 1961: *Vet. Rec., 73:* 1428.
Walker, D. M.; Cook, L. J.; Jagusch, K. T., 1967: *Br. J. Nutr., 21:* 275.
Wallace, L. R., 1948: *J. agric. Sci., Camb., 38:* 93.
Young, B. A.; Corbett, J. L., 1968: *Proc. Aust. Soc. Anim. Prod., 7:* 327.