
VOLUME 62 2002

NUTRITION OF FEEDLOT BEEF CATTLE IN NEW ZEALAND

K. T. JAGUSCH and A. R. MCIVOR
Lincoln College, Canterbury

SUMMARY

The principles and practice of feeding beef cattle in feedlots are discussed with particular reference to the New Zealand scene. Reasons for the increasing interest in feedlotting are given, and the composition of common New Zealand feedstuffs presented along with the requirements of standing cattle and examples of feedlot rations. The importance of preconditioning animals to practical feeding programmes is emphasized, as is the need to prepare certain feedstuffs ("hays" and "grains") and supplement animals with particular nutrients.

It is concluded that capital intensive units are required to ensure efficient utilization of nutritional resources and that these should be controlled by co-operatives. Farmers should feedlot only as an adjunct to land-intensive agriculture, namely strategic off-paddock supplementation.

FEEDLOT PRACTICE

The recent upsurge of interest in feedlotting beef stems largely from freezing company managements attempting to operate on a year-round basis and also maintain a continuous supply of chilled cuts for container shipping. Other reasons for the interest in feedlotting are the talked-of demand for marbled beef in Japan, the improvement of winter feeding levels so cattle market earlier in spring when prices are high, and the need to improve the nutrition of cattle during dry summers. This should be distinguished from the initiation and growth of the feedlot industry in the United States which was primarily the result of the ready availability of high energy-density feedstuffs for feeding store cattle. This again could be distinguished from the intensive barley-beef system in the United Kingdom which resulted from scientific research that initially achieved maximum profitability from feeding for high rates of liveweight gain and feed efficiency in very young stock of high inherent merit for these attributes.

Feedlot nutrition practices will vary with the capital intensity of the unit. A farmer feedlot turning over a few hundred animals, perhaps in one period of the year (*e.g.*, winter), feeds low quantities of high energy-density rations and high quantities of roughage. The enterprise is almost entirely dependent on local feed supplies and rations are not processed. It is probably only a little more intensive than strategic off-paddock supplementation or indeed a "sacrifice paddock". The other extreme is the co-operative or custom feedlot that turns over thousands of head several times a year. Beef are finished on high grain, low roughage rations, that have been processed and supplemented with salt, buffer, calcium, micronutrients and vitamins. The source of feed need not necessarily come from the locality of the feedlot although it is easy to envisage a finishing ration based on maize in the North Island, barley in Canterbury, and, to a certain extent, wheat in Southland. Such an enterprise also requires more elaborate feed storage facilities, a feed mill, the balancing of rations, and ration quality control.

There are other forms of feedlotting such as "wetlotting" of lucerne haylage and maize silage from bunker storage or tower silos with auger feed. Also, feedlots can in part utilize the waste material from other industries (*e.g.*, potato sludge, chicken litter, beetpulp).

The responsibilities of a feedlot manager include methods of feeding, frequency of feeding, maintenance of consumption records for each pen, bunk cleaning and maintenance, water reticulation, and specialized feeding for sick and poorly preconditioned animals. Here a basic understanding of the nutritional requirements of cattle and the value of available feedstuffs is important.

COMPOSITION OF NEW ZEALAND FEEDSTUFFS

Energy is of prime importance for the promotion of liveweight gain in beef cattle but optimum conversion efficiencies require a ration to contain adequate protein, minerals, and vitamins. In Table 1 it can be seen that high energy-density feeds include the cereal grains, root succulents, and leafy pasture, all of which can be used in finishing rations. Silage and haylage rations have intermediate energy densities, and although essentially growing rations, they can contribute significantly to the finishing stage, particularly with older cattle. Low energy-density foodstuffs such as the "hays" and "straws" are predominantly associated with growing cattle and the preconditioning of beef to feedlot.

High protein meals are also high energy-density feedstuffs, but it is not economic to feed them for the purposes of supplying energy.

The data in Table 1 show that while leguminous feedstuffs have a high content of crude protein, grains, maize silage and root succulents appear borderline for this nutrient, and straw residues are low. It is interesting to note the higher crude

TABLE 1: DRY MATTER, METABOLIZABLE ENERGY, CRUDE PROTEIN, CALCIUM, AND PHOSPHORUS CONTENT OF FEEDSTUFFS GROWN IN NEW ZEALAND

	Dry Matter (%)	*Metabolizable Energy (MJ/kg DM)*	*Crude Protein*	*Ca*	*P*
			(Per cent of DM)		
Leafy pasture	18	10.9	21	0.90	0.40
Lucerne pasture	18	11.7	26	1.40	0.40
Green maize	18	10.0	10	0.54	0.27
Pasture silage	20	8.4	14	0.70	0.33
Pasture haylage	30	8.4	12	0.80	0.38
Lucerne silage	25	8.8	22	1.30	0.35
Lucerne haylage	35	9.2	20	1.50	0.40
Maize silage	30	10.0	8	0.40	0.18
Turnips[1]	10	12.6	11	0.63	0.42
Turnips[2]	8	12.6	18	0.30	0.28
Swedes[1]	12	12.6	9	0.58	0.42
Swedes[2]	10	12.6	18	0.30	0.28
Fodderbeet	18	10.5	8	0.10	0.17
Mangels[2]	14	10.5	10	0.10	0.18
Choumoellier[1]	15	11.7	11	1.61	0.33
Choumoellier[2]	13	11.7	15	1.35	0.25
Barley	87	13.0	12	0.06	0.43
Oats	87	11.7	11	0.10	0.38
Wheat	87	13.8	11	0.03	0.49
Maize	87	13.0	10	0.20	0.24
Potato	21	11.7	10	0.04	0.23
Pea meal	90	12.6	26	0.17	0.45
Linseed meal	90	11.7	40	0.30	0.80
Lucerne meal	90	12.6	22	1.15	0.24
Rapeseed meal	90	10.9	37	0.66	1.04
Soyabean meal	92	11.7	46	0.32	0.69
Meadow hay	86	8.4	12	0.60	0.30
Cowgrass hay	88	8.8	15	1.38	0.20
Lucerne hay	88	9.2	18	1.60	0.24
Wheat straw	90	5.9	4	0.24	0.08
Barley straw	90	6.7	3	0.36	0.10
Oat straw	90	6.7	4	0.40	0.14
Pea straw	88	7.1	9	1.60	0.12
Ryegrass straw	86	7.1	5	0.36	0.19
Chicken litter	82	5.9	16	1.00	0.65

[1] Canterbury data; [2] Otago data.

protein content of turnips and swedes grown in Otago compared with similar crops grown in Canterbury. Leguminous feedstuffs also have a high content of calcium compared with most other feeds, and rations containing a predominance of grain have to be balanced with respect to this element. Phosphorus levels are low in maize silage, some root crops, and in "straws". Otherwise feedstuffs grown in New Zealand appear to have adequate to quite high quantities of phosphorus.

The content of some other important minerals in selected feedstuffs are shown in Table 2. Unfortunately, New Zealand data are scarce in this area so the table includes values given in *Feedstuffs Journal* (U.S.A.), and Morrison's *Feeds and Feeding* (1956).

TABLE 2: MINERAL COMPOSITION OF SELECTED FEEDSTUFFS[1]

	Na (%)	*K* (%)	*Mg* (%)	*Mn* (*ppm*)	*Fe* (*ppm*)	*Cu* (*ppm*)	*Zn* (*ppm*)	*Se* (*ppm*)	*S* (%)
Barley	0.02	0.56	0.12	16	50	8	15	0.10	0.02
Maize	0.03	0.33	0.15	4	35	3	10	0.08	0.16
Oats	0.06	0.37	0.17	38	70	6	—	0.08	0.03
Wheat	0.06	0.50	0.11	62	50	11	14	0.07	0.20
Swedes	0.72	2.85	0.16	—	—	—	—	—	0.55
Choumoellier	—	3.70	0.29	—	—	—	—	—	0.74
Turnips	—	2.70	0.16	—	—	—	—	—	0.49
Mangels	0.74	2.80	0.19	—	300	—	—	—	0.10
White clover	0.20	2.00	0.13	30	60	5	15	—	0.28
Ryegrass	0.30	2.20	0.11	30	60	5	13	—	0.27
Lucerne	0.16	2.24	0.28	—	200	—	—	—	0.28
Maize silage	0.04	1.06	0.21	—	100	—	—	—	0.07
Barley straw	0.14	1.40	0.08	—	300	—	—	—	0.14
Linseed meal	0.13	1.30	0.59	38	250	26	—	0.70	0.42
Rapeseed meal	—	1.25	0.51	43	180	7	66	0.98	—
Soyabean meal	0.30	1.80	0.26	28	130	30	—	0.10	0.50

[1] Source: Morrison (1956).

FEEDLOT RATIONS

Table 3 lists a number of feedlot rations that could be used in this country. They are listed as grain, maize silage, root succulent or pasture-based rations including lucerne.

Roughage characteristics in high grain diets are maintained by feeding a small proportion of hay or straw. Such rations can be pelleted. However, very high grain rations should not be pelleted because such processing reduces physical fibrosity, particularly if the grain is ball milled. Oats are added to very high grain rations to keep a certain fibre balance.

TABLE 3: RATION COMPOSITION (DRY MATTER BASIS)

(1) *Low-grain rations*:

1a	%	1b	%	1c	%	1d	%
Barley	40	Barley	40	Barley	40	Barley	40
Lucerne hay	30	Lucerne hay	59	Meadow hay	59	Lucerne hay	30
Meadow hay	29	Supplement	1	Supplement	1	Ryegrass	29
Supplement	1					Supplement	1

(2) *High-grain rations*:

2a	%	2b	%	2c	%	2d	%
Barley	80	Wheat	40	Barley	60	Wheat	40
Roughage	18	Oats	40	Oats	20	Barley	30
Supplement	2	Roughage	18	Roughage	18	Roughage	28
		Supplement	2	Supplement	2	Supplement	2

(3) *Very high-grain rations*:

3a	%	3b	%	3c	%
Wheat or barley	50	Maize	90	Maize	80
Oats	48	Protein supplement	4	Lucerne hay	18
Supplement	2	Roughage	4	Supplement	2
		Supplement	2		

(4) *Maize silage rations*:

4a	%	4b	%
Maize silage	56	Maize silage	38
Grain	40	Grain	60
Protein supplement	2	Protein supplement	2
Supplement	2	Supplement	2

(5) *Lucerne based rations*:

5a	%	5b	%	5c	%
High moisture or dried lucerne	80	Lucerne haylage	50	Lucerne haylage	60
Roughage	19	Maize silage	49	Grain	20
Supplement	1	Supplement	1	Roughage	19
				Supplement	1

(6) *High root rations* (including choumoellier):

6a	%	6b	%
Fodderbeet or swedes or turnips	60	Choumoellier	60
Lucerne hay	20	Grain	20
Grain or roughage	19	Roughage	19
Supplement	1	Supplement	1

(7) *Grass rations*:

7a	%	7b	%	7c	%
Grass	90	Grass	50	Grass	50
Roughage	9	Roughage	20	Roots	30
Supplement	1	Barley	29	Roughage	19
		Supplement	1	Supplement	1

The maize plant in silage rations contains 40 to 50% grain by weight of maize silage and this, like high maize grain rations, requires protein supplementation unless fed with lucerne hay or haylage.

High root-succulent rations have interest in Southland where good yields are regularly obtained.

It should be noted that high grain intakes are difficult to achieve when cattle are fed on leafy pasture and that such rations, if high in legume (clover and lucerne) can generate a feedlot bloat problem.

FEED REQUIREMENTS

The dry matter requirements of feedlot beef as set out by the U.K. Agricultural Research Council (A.R.C., 1965), and the U.S. National Research Council (N.R.C., 1970), are given in Tables 4 and 5, respectively. Both sets of data are rather similar in respect to requirements of dry matter for a certain performance with a given quality of feed. However, the United Kingdom standards recognize a wide range of feed quality while the United States table takes cognisance of different types of "feeders" and stipulates a rate of gain at a given feed quality rating. On these rations heifers grow slightly less fast than steers, and "feeder calves", particularly the "fleshy" type, do not finish quite as well as yearling or 2-year-old steers. The former animals are often difficult to get on to concentrate feed and do not have the capacity for high intake.

TABLE 4: DRY MATTER REQUIREMENTS (kg per day)[1]

Liveweight (kg)	*Energy (MJ ME/kg DM)*	*Rate of Gain (kg/day)*		
		0.5	*1.0*	*1.5*
	9.2	5.2	7.4	—
200	10.9	4.1	5.5	—
	12.6	3.3	4.3	5.8
	9.2	6.3	8.9	—
300	10.9	4.9	6.6	—
	12.6	4.0	5.2	7.0
	9.2	7.5	10.4	—
400	10.9	5.8	7.8	—
	12.6	4.7	6.1	8.3

[1] Source: A.R.C. (1965).

The crude protein requirements are given in Table 6 under two headings, early- and late-maturing cattle. These reflect the type of "feeder" in the States on the one hand, and the intensive ten-month beef production system that was prevalent in the United Kingdom on the other. In New Zealand, protein

TABLE 5: DRY MATTER REQUIREMENTS (kg per day)[1]

Liveweight (kg)	*Energy (MJ ME/kg DM)*	*Rate of Gain (kg/day)*	*Dry Matter Requirement (kg/day)*
Finishing Steer Calves			
200	11.3	1.0	5.0
300	11.3	1.1	7.1
400	11.3	1.1	8.8
450	11.3	1.1	9.4
Finishing Yearling Steers			
250	10.9	1.3	7.2
300	10.9	1.3	8.3
400	10.9	1.3	10.3
500	10.9	1.2	11.5
Finishing Two-year Steers			
350	10.5	1.4	10.3
400	10.5	1.4	11.3
500	10.5	1.4	13.4
550	10.5	1.3	13.7
Finishing Heifer Calves			
150	11.7	0.8	3.5
200	11.3	0.9	5.0
300	11.3	1.0	7.3
400	11.3	0.9	8.7
Finishing Yearling Heifers			
250	10.9	1.2	7.6
300	10.9	1.2	8.6
400	10.9	1.2	10.7
450	10.9	1.1	11.3

[1] Source: N.R.C. (1970).

appears to be limiting only if maize silage or heavy grain diets are fed in finishing rations.

The mineral and vitamin requirements are given in Table 7.

FEED PREPARATION

Feed preparation largely revolves around the need to process the grain and the roughage portion of feedlot rations if

TABLE 6: CRUDE PROTEIN REQUIREMENT (Per cent of dry matter)

Liveweight (kg)	*Early Maturing Cattle*[1]	*Late Maturing Cattle*[2]
200	13	17
300	12	15
400	11	13

[1] Source: N.R.C. (1970).
[2] Source: Preston (1969).

TABLE 7: MINERAL AND VITAMIN REQUIREMENTS OF GROWING AND FINISHING CATTLE EXPRESSED PER UNIT OF DRY MATTER[1]

Vitamin A	IU	2200/kg ration
Vitamin D	IU	300/kg ration
Vitamin E	IU	55/kg ration
Choline	mg	1300/kg ration
Sodium	%	0.1
Calcium	%	0.18—0.60
Phosphorus	%	0.18—0.43
Magnesium	mg	400—1000/kg ration
Potassium	%	0.6—0.8
Sulphur	%	0.1
Iodine	μg	—
Iron	mg	10/kg ration
Copper	mg	4/kg ration
Cobalt	μg	50—100/kg ration
Manganese	mg	1—10/kg ration
Zinc	mg	10—30/kg ration
Selenium	μg	50—100/kg ration

[1] Source: Dyer and O'Mary (1972).

efficient utilization is to be achieved. It could also involve the chopping of root succulents and forage harvesting of pasture.

Older textbooks state that if grain is not rolled or cracked then a certan ratio of pigs to cattle is essential to utilize grain that passes through the animal undigested. Indeed, half of the whole barley that is fed to cattle and eaten can be recovered in the faeces. There is, however, some doubt as to whether the rolling of grain, particularly oats and wheat, has any benefit when fed at low levels (3 to 4 kg) in largely roughage-based feedlot rations.

The most consistent benefits in feed utilization appear to come from thermal and hydrothermal treatment of the grain in capital intensive feedlots using high grain rations for finishing. However, such treatment is not a viable proposition in units of low capital intensity turning over only a few hundred head each intake.

Effective grain processing can be arbitrarily classified as follows:

(1) Rolling, ballmilling or cracking (physical processing by machine);

(2) Reconstitution followed by rolling;

(3) Micronization and popping;

(4) Steam or pressure cooking followed by flaking or rolling.

Reconstitution, whereby water is added to mature grain to bring the moisture content to 25 to 30%, the grain then being stored in oxygen limiting units for 15 to 21 days, improves utilization compared with physical processing. This causes disruption of protein molecule in the grain and permits easier access of rumen micro-organisms to the endosperm.

Micronization involves heating the grain to 150°C by gas fired infra-red generators. The process takes 25 seconds. Improved utilization of the grain comes through the rapid increase in heat and the rise in internal water vapour pressure which affects the starch and protein, causing swelling, fracture, and gelatinization. Here the secondary bonds of the starch crystal are broken allowing ready access of high molecular weight starch-reducing enzymes. Any heating of reconstituted or early harvest grain stored for several months might cause gelatinization.

Pressure cooking grain in its own moisture for two minutes at 160°C results in the grain popping and forming a flake when blown by hot air to the rollers. Popped grain alone is utilized more efficiently than that just physically processed but the density of the ration is reduced unless the popped material is rolled or thin-flaked.

Hydrothermal treatment, with adequate steam pressure and subsequent thin flaking, gives a dense grain ration where gelatinization is complete and the substrate is readily accessible to micro-organisms.

With grain preparation, excessive heat can result in unnatural glycosidic linkage between starch polymers, or encapsulation of the starch in a tough rubbery coating of protein, thus reducing digestibility. Similarly, cooking at too high a moisture level can cause retrogradation of the starch molecule and reduce digestibility. It is recommended that with steam-flaking grains be cooked for 12 minutes at 90°C and the water content increased to only 15 to 18%.

Chaffing of the roughage portion of the ration through 30 to 50 mm screen is essential if mixing is to be thorough and wastage reduced, but any improvement in efficiency of utilization of metabolizable energy is likely to be marginal. Pelleting, too, allows uniformity of control of feed levels and flow in the feedlot, reduces dust and waste, and increases efficiency of utilization of metabolizable energy at the same level of energy intake as in non-pelleted roughage.

PRACTICAL FEEDING PROGRAMME

Cattle can be placed on feed according to weight, age, sex, grade, breed and season of the year. Feeding plans will vary with the type of animals available because a balance has to be kept between maintaining maximum liveweight gain in the finishing period and finishing to market specification. Ideal cattle for feedlot finishing have a conformation which is neither blocky nor rangy, are healthy, are effectively pre-conditioned (introduced to feed bunks and small quantities of finisher ration), and do not "burn out" while warming up. Such animals should grade to specification in 100 to 150 days.

Sick, lightweight, or too-forward cattle are introduced to the finishing ration about 60 days later than cattle well pre-conditioned to feedlot. This is done by returning the cattle to pasture or maintaining at high levels the bulk portion of the ration, plus quantity of palatable supplement.

In some cases protein is restricted so that animals do not grow at maximum rates before being fully adjusted to the finishing ration. Care also has to be taken when warming animals up to high grain rations because of persistent and recurrent acidosis. This is exemplified by data in Fig. 1. In some cases it can take 100 days to get finishing beef cattle on to full grain rations.

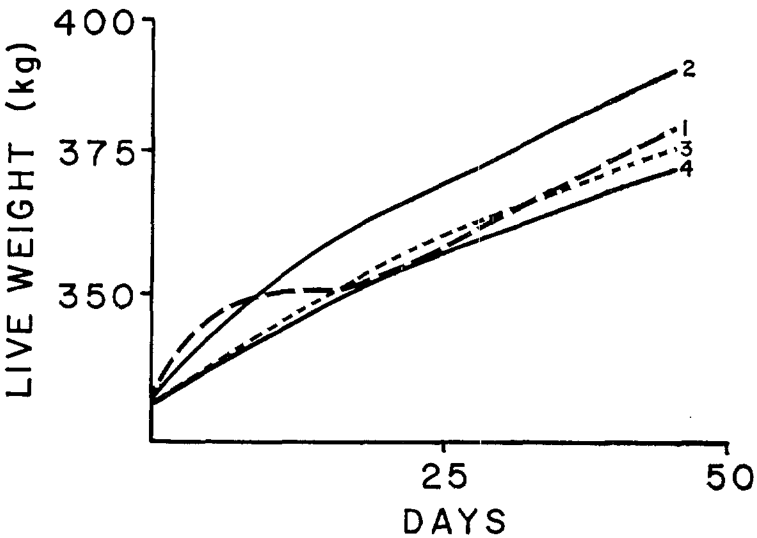

FIG. 1: *Liveweights of yearlings warmed up to barley in 10 (Group 1), 15 (Group 2), 20 (Group 3), and 25 (Group 4) days, respectively.*

SUPPLEMENTATION

All beef feedlot rations require supplementation with loose salt, because of induced urinary excretion through high potassium intake, and the generally low concentration of sodium in ruminant feedstuffs. The requirement increases from 0.5 to 2.0% as the period of finishing increases. Salt deficient cattle become restless. It is also recommended that the salt be iodized. Copper and cobalt should be added if the ration is known to come from areas responsive to these elements.

Selenium must be given at the rate of 20 mg/head every time the cattle are drenched if the feedlot is in a selenium responsive area, and particularly if South Island grains are used. Zinc supplementation might also be necessary in New Zealand.

Calcium supplementation is at the rate of 20 to 40 g/head/day with grain maize silage, and roughage-based rations, and probably those containing root succulents. This becomes particularly important if the roughage source is low in legume or such hay has been removed from the ration because of bloat.

Non-protein nitrogen (NPN) sources such as urea, biuret and ammonium salts can furnish 33% of the protein requirement of finishing beef. Such rations have to be supplemented with all obvious micro-nutrients plus sulphur at the rate of one part to every ten parts NPN. Liquid NPN supplementation has a place in grower and preconditioning rations containing low quality roughages particularly when NPN is being used in finishing rations.

In view of recent findings that certain components of feedlot rations can interfere with the conversion of precursor to biologically active Vitamin A, supplementation appears necessary at all times. This means that Vitamin D at about one-eighth of the rate of A supplementation is also necessary because of the known rachitogenic effect of excess Vitamin A in a ration. There is little need to supplement other vitamins although there are claims of constant benefits from choline and B_{12} (in the absence of lucerne) additions.

Differential responses have been obtained with the use of buffers; 50 to 80 g/head/day of sodium bicarbonate can be given with high grain diets.

Carriers used in supplements for feedlots include semolina, molasses and animal fat.

FARMER FEEDLOTTING

There seem to be sound nutritional reasons for intensive feedlot feeding of beef cattle being conducted only by co-operatives where a unique financial structure allows the working of capital intensive units. Here energy management can be completely controlled. For farm feedlotting enterprises to be nutritionally efficient owners should use their units as an adjunct to land intensive agriculture where the important concepts are those of breeding cattle to the flush of pasture growth, using many, and perhaps early maturing cattle to harvest the pasture. If applicable, high moisture silage is "creamed off" early after forward feed budgeting but this depends on stocking rate relative to spring growth.

Dr T. R. Preston, a recent visitor to New Zealand, wrote concerning the utilization of New Zealand pasture on his return to Mexico. He maintained that the problem of not limiting individual animal performance and yet achieving maximum pasture utilization would be overcome if cattle were grazed for 2 to 4 hours each day, and confined to feedlot for 16 to 20 hours each day, where they could be fed low fibre and relatively low protein cereal grain and root-succulent rations. Strict control of grass intake would be maintained by astute use of the electric fence and the problem of surfeit protein nutrition would be alleviated.

It is interesting to note that this thesis recognizes the importance of strict grazing control, and echoes the many observations of Dr J. B. Hutton that beef farmers, and indeed sheep farmers, could look to their dairy counterpart of thirty years or more with respect to efficient use of pasture by the electric fence. Such action is an integral part of producing 18 500 kg dry matter per hectare from Waikato pasture and running close to five cows per hectare, and 900 kg beef meat per hectare from an irrigated lucerne-ryegrass situation producing 19 800 kg dry matter per hectare. In spite of the exigencies of the grazing system a farmer cannot afford to substitute such high production for 12 000 and 6 000 kg dry matter per hectare of maize and barley grain, respectively, to feed to standing cattle. Therefore, farmer feedlotting should be restricted to periods of inadequate pasture supply, to times when one wishes to create a bank of feed ahead of the "finishers", and when grazing would detrimentally affect pasture production.

REFERENCES

A.R.C. (Agricultral Research Council), 1965: *The Nutrient Requirements of Farm Livestock. No. 2 Ruminants.* Tech. Comm. Agric. Res. Counc., London.

Dyer, I. A.; O'Mary, C. C., 1972: In *The Feedlot.* Lea and Febiger, Philadelphia.

Morrison, F. B., 1956: In *Feeds and Feeding.* Morrison Publishing Co., New York.

N.R.C., 1970: *Nutrient Requirements of Domestic Animals. No. 4. Ruminants.* Nat. Acad. Sci., Washington, D.C.

Preston, T. R., 1969: In *Nutrition of Animals of Agricultural Importance* (ed. D. Cuthbertson). Pergamon, Oxford.