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RECENT ESTIMATES OF ENERGY UTILIZATION BY YOUNG DAIRY CALVES

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There are modern reviews (Roy, 1969; 1970; Radostits & Bell, 1970) on the nutrition of the young calf but this paper will cover only more recent findings on the intake and utilization of dietary energy by these animals. I am confining myself to this one aspect. As will become clear, many strongly held beliefs, 'facts' and extrapolations of original data will be shown to be incorrect. Possible reasons for these discrepancies between older work and recent findings may be the small numbers of calves that have been used in experiments, health of the experimental animals, facilities available and, possibly the source of most inaccuracies, is the use of live-mass to assess response to treatments. For example, mass of digesta in calves from three to five months old may vary from 9,5% to 29,5% of live-mass depending on the proportion of roughage included in the diet (Johnson, 1971a). How is it then possible to compare the effects of different diets offered to calves, or for that matter any other ruminant without the aid of comparative slaughter?

Maintenance requirements of the milk-fed calf

During the pre-ruminant stage in the calf's life, data from the literature show large differences between experiments in measured fasting heat losses and estimated, or determined, requirements for maintenance. Most of these figures, based on live-mass measurements or calorimetric studies, vary from 149 kcal (Ritzman & Colovos, 1943) to 103 kcal/kg $W^{0,73}$/day (Roy, Huffman & Reineke, 1957). The Agricultural Research Council – A.R.C. (1965) presents a "preferred" value of 140 kcal/kg $W^{0,73}$/24 h at one month of age. Assuming a net availability of 85 for the metabolizable energy (ME) in milk (Blaxter, 1952), then the maintenance requirements of calves would vary from 176 kcal ME (Ritzman & Colovos, 1943) to 121 kcal ME/kg$W^{0,73}$/day (Roy *et al*, 1957). However, using comparative slaughter and the skinned, digesta-free body, Johnson & Elliott (1972a, b, c) estimated the maintenance needs of milk-fed calves from 4 to 24 days of age were found to vary from 100,8 kcal to 110,1 kcal ME/kg $W^{0,73}$/24 h. The lower estimate was obtained with calves housed in a metabolism room and the higher one with animals kept in crates in an open-sided shed. The latter were exposed to the weather; to wind and larger temperature changes than those kept in the room and it is reasonable to suppose that this exposure to the weather required more energy for thermo-regulation (Blaxter, 1967) and consequently more for maintenance. Using Blaxter's (1952) figure for net availability of ME in milk for maintenance then the fasting heat losses of Johnson & Elliott's (1972 b, c) calves would be 86 kcal to 93,6 kcal/kg $W^{0,73}$/24 h; fasting heat losses of animals are known to decline with age but these estimates are far lower than the "preferred" value of 140 kcal/kg$W^{0,73}$/day suggested by the A.R.C. (1965) for one-month old calves. In fact, they correspond with A.R.C. (1965) values for heat losses of 2 to 4 year old steers. Johnson & Elliott (1972 b, c) were unable to explain this discrepancy but differences in health of calves and environmental conditions may be involved. However, it is interesting to note that in Australia, using comparative slaughter, Walker & Jagusch (1969) found the ME maintenance requirement of milk-fed lambs to be 105 kcal/kg$W^{0,73}$/ day.

In practical terms, a 37 kg calf requires 1537 kcal ME/day for maintenance. ME as a percentage of gross energy in whole milk at the maintenance level of intake is 95,46% (Johnson & Elliott, 1972b). Therefore 2,37 kg whole milk will satisfy maintenance (12% total solids and 3,4% milk fat). A widely accepted rule-of-thumb milk feeding standard for calves is equivalent to 8 to 10% of birth mass i.e. 2,96 kg to 3,70 kg milk per day, and this allowance may or may not be increased as the calf grows heavier. Unfortunately calves in Rhodesia are normally offered 4,5 kg milk, or more daily, which suppresses the voluntary intake of dry food (Johnson & Elliott), 1970) and is an expensive method of rearing calves.

Growth requirements of the milk-fed calf

Blaxter (1967) maintains that within normal maxima of voluntary ME intakes by cattle, efficiency of ME utilization for fattening appears to remain constant. With milk-fed calves up to 24 days old, efficiency of ME use, above maintenance is linear and approximately 63% (Johnson & Elliott, 1972b, c). This is similar to the 63,9% found for heifers under 200 kg live-mass by Ritzman & Colovos (1943). Van Es, Nijkamp, van Weerden & van Hellemond (1969) reported the efficiency to be 68% with a milk replacer, whereas earlier work by Blaxter (1952) and Gonzalez-Jimenez & Blaxter (1962) suggested values of 77% to 85% for ME use above maintenance in milk-fed calves.

In the A.R.C. (1965) publication, the estimated calorific values for digesta-free body-mass gains in calves (less than one month old) varied from 2,30 Mcal to 2,88 Mcal/kg. Reid & Robb (1971) have shown the energy content of dairy heifers, between one day and 14 months of age, increased by 2,55 Mcal/kg empty body-mass gain. The values obtained by Johnson & Elliott (1972b, c) corresponded well with these estimates and, although excluding hide and hooves, it was 2,68 Mcal/kg skinned, digesta-free body-mass gain. The ME requirement for gain was thus 4,25 Mcal/kg (63% efficiency) which is higher than other published estimates. For example, calves given a milk replacer required 3,70 Mcal digestible energy (DE) per kilogram live-mass gain (Bryant, Foreman, Jacobson & McGilliard, 1967). This latter result was higher than most other estimates, for example 2,68 Mcal DE (Brisson, Cunningham & Haskell, 1957) and 3,07 Mcal DE (Blaxter & Wood, 1951) per kilogram live-mass gain.

These recent results (Johnson & Elliott, 1972b, c) presented above confirm that published estimates and standards of dietary energy for maintenance of young calves are too high. In contrast, it appears that the published dietary energy requirements for gain in empty body-mass of the month-old calf are low, when compared with modern results (Johnson & Elliott, 1972b, c).

Energy requirements of the ruminant calf

There is no evidence, according to Roy (1964), that the net energy requirements for growth or maintenance differs between the pre-ruminant and ruminant calf, although there are marked variations in estimated energy requirements of both pre-ruminant and ruminant calves (see review by Jacobson, 1969). In fact, Jacobson (1969) found there were marked differences in the requirements of calves due to rate of gain, body size, age and composition of the diet (i.e. a difference in net availability of ME for gain). Possible reasons for these differences are that the variation in fasting heat production from animal-to-animal is ± 10% (A.R.C., 1965), and maintenance requirements in terms of ME are subject to a between animal variation of ± 10% (Van Es & Nijkamp, 1966). Further, gains in alimentary tract contents may be considerable and thus mask the true digesta-free-body-mass gain (Stobo, Roy & Gaston, 1966; Johnson & Elliott, 1959) and as the digesta-free body increases in mass so the dry matter content of that body increases (O'Donovan, 1968; Johnson, 1971a).

Calorific contents of gains in mass of beef cattle, based on slaughter data, show that live-mass gains made by cattle from 50 kg to 100 kg contain between 1,60 Mcal and 200 Mcal/kg and that calorific value of the live-mass gain increased with rate of gain (A.R.C., 1965). Equations relating calorific values of gains in digesta-free mass to the proportion of calories stored as fat indicated that these values can vary from 200 Mcal to 7,50 Mcal/kg (A.R.C., 1965). For example, calves less than one month old given whole milk, were estimated in this way to gain between 2,07 Mcal and 2,59 Mcal/kg live-mass gain or 2,30 Mcal to 2,88 Mcal/kg digesta-free gain, assuming gains of gut contents to be 10% of live-mass (A.R.C., 1965). The A.R.C. (1965) has also derived equations from slaughter and calorimetric data which relate calorific value of gains in body-mass to daily energy retention. Live-mass gains may then be computed directly from energy retention. Basing most of the above assessments on live-mass and/or assumptions, renders these findings invalid or at best wild approximations.

Numerous workers have shown that, for maintenance, the efficiency of utilization of ME from different dietary sources varies very little, whether the estimates were computed from calorimetric data or practical feeding trials (e.g. Armstrong & Blaxter, 1957a; Blaxter & Wainman, 1964). However, efficiency of utilization of ME for gain is believed to decrease as the molar proportion of acetic acid in the rumen liquor increases (e.g. Armstrong & Blaxter, 1957b; Blaxter & Wainman, 1964). In contrast, doubt has recently been expressed about the validity of the observations that acetic acid is used with low efficiency for lipogenesis in young animals (e.g. Bull, Reid & Johnson, 1970). But there is fair unanimity that diets of high M/D content (Mcal ME/kg dry matter) are used more efficiently than ones of low M/D content.

Recently, Johnson (1971b) offered calves dry diets containing different proportions of 'low'(4% crude protein) or 'high' (16% crude protein) quality roughages. Johnson (1971b) believed it to be more practical and realistic to assess the gross efficiency of use of the diets for the combined functions of maintenance and growth because the dry diets were offered to calves *ad libitum* and high voluntary intake of ME by calves is both desirable and energetically efficient. For these reasons, it was not deemed necessary to estimate the maintenance energy needs and then partition energy used for growth, as was done by the A.R.C. (1965). Nor was it possible to partition or distinguish between the utilization of ME from milk and dry food when offered together. Because the dry diet was offered *ad libitum*, it was also not thought necessary to estimate the depression in metabolizability associated with increases in level of intake of ME as suggested by Blaxter (1967).

Estimates of gross efficiency of ME utilization in dry diets used by Johnson (1971b) showed that efficiency was highest when largest amounts of ME were eaten voluntarily and so promoted rapid gains in skinned, digesta-free body-mass (Table 1). That there was a depression in the gross efficiency of use of ME in the diets (Figure 1) which contained either more or less ME than 2,82 Mcal/kg dry matter was not completely in agreement with recent findings (Baumgardt, 1970). Dinius & Baumgardt (1970) found that dry matter intake decreased and DE intake (kcal/kg$W^{0,75}$) remained static when the diets, which they offered to sheep contained more than 2,5 kcal DE/g food.

Only half the calves offered the 'high' quality roughage (lucerne hay) alone survived; the remainder died of mal-nutrition (Johnson, 1971b). This suggests that there may be long term adaption to a high roughage diet and, if they survive, calves may eventually be able to consume

Table 1

Voluntary ME intakes of dry food and gross efficiency of utilization of total dietary ME by calves between four days of age and slaughter, when given limited amounts of whole milk and dry diets containing different proportions of 'low' and 'high' quality roughage,* ad libitum.

	Roughage Content (%)							
	'Low'quality				'High' Quality			
	0	10	20	30	0	33	66	99
*First Slaughter***								
Est. ME intake	342,5	314,2	361,0	384,2	357,4	335,4	373,7	445,7
No. of days	103	84	102	108	103	101	117	147
Gross Efficiency	17,8	20,1	17,8	15,5	17,8	18,0	14,7	10,6
*Second Slaughter****								
Est. ME intake	635,7	581,9	699,2	775,6	619,3	693,8	750,1	–
No. of days	144	109	131	150	148	128	157	–
Gross efficiency	21,2	21,4	19,8	17,5	21,8	19,5	17,7	–
Means								
No. of days	124	97	117	129	126	115	137	–
Gross efficiency	19,5	20,8	18,8	16,5	19,8	18,8	16,2	–
Mcal ME/kg DM	3,03	2,82	2,61	2,39	3,01	2,63	2,24	1,86

* Total dietary ME = Estimated ME intake + approximately 34 Mcal from milk.

** First Slaughter after approximately 35,5 kg mass gain in skinned, digesta-free body.

*** Second Slaughter after approximately 70,0 kg mass gain in skinned, digesta-free body.

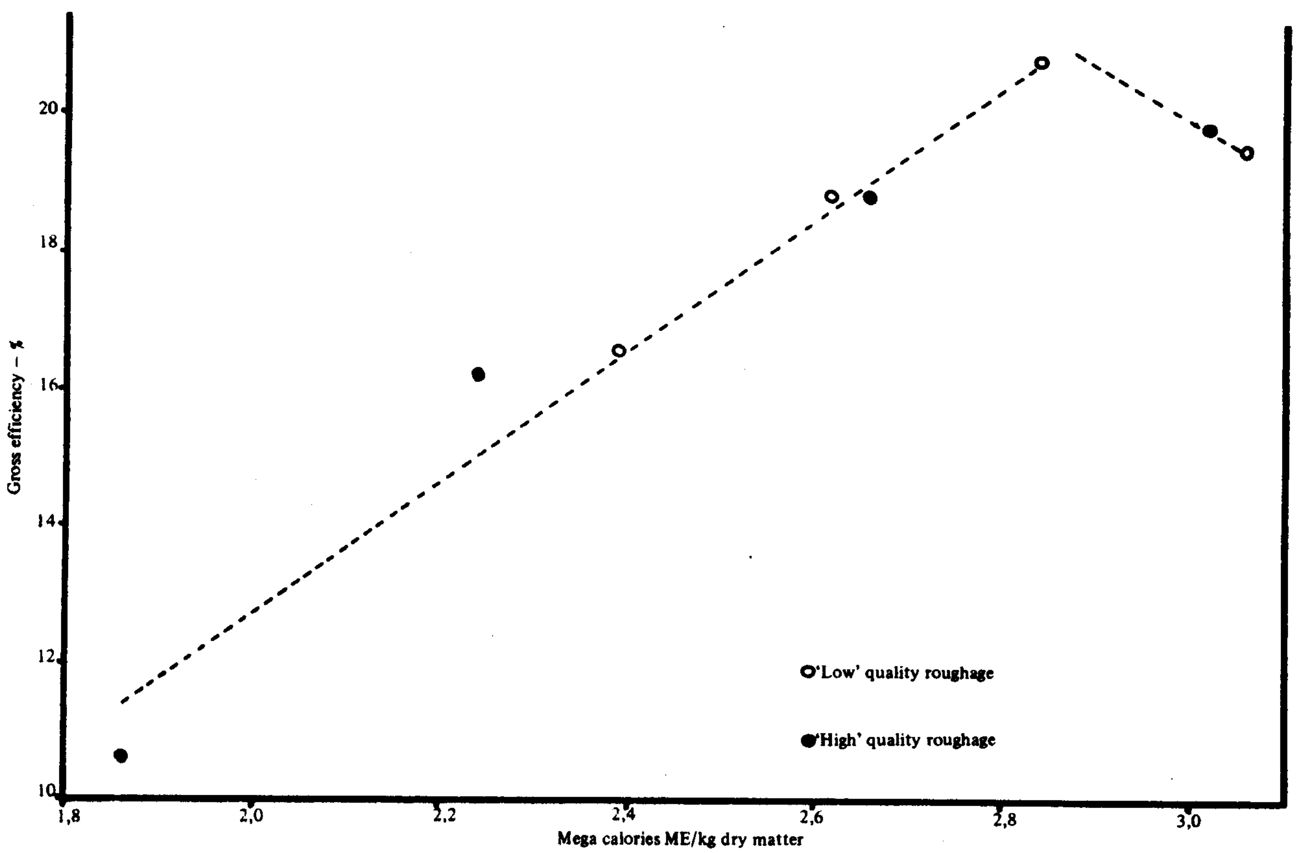

Fig. 1. *Relationship between concentration of ME in diets and gross efficiency of utilization of dietary ME*