Energy and protein requirements of small ruminants

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Summary

Different systems for calculating energy and protein requirements for goats and sheep are compared and discussed. It is suggested that the Langston University system or the recommendations of Mandal et al. (2004) should be used for goats and the recommendations of Paul et al (2003) for growing sheep. For pregnant and lactating sheep in the tropics there are no recent recommendations, which is why recommendations for temperate regions must be used.

Keywords: energy protein, requirements, goats sheep

Introduction

Several different methods have been used to estimate the nutrient requirements of livestock. Well known methods are respiration calorimetry, which requires metabolism cages with possibilities to measure gas flow, and comparative slaughter of animals at different weights and ages. Both these methods have disadvantages e.g. high costs of equipment and labour and unnatural conditions for the animals in the calorimetry method and that some assumptions must be made e.g. constant rate of energy retention between slaughtering occasions for the slaughter method (Luo et al., 2004)

Another common method is to use body weight gain (BWG) as a measure of retention and to relate BWG to energy or protein intake using regression equations. Factors disturbing these relations are e.g gut fill and variations in the composition of the gain. The advantage is that the data can be recorded in normal production situations (Luo et al., 2004). The degree of explanation of the regression line, the coefficient of variation, reliability and application of the requirements obtained in such an analysis, will depend on the number of experiments that are providing data as the base for the calculations, and whether factors as breed, production type or age can be considered.

In the following some classical systems for requirements of goats and sheep will be compared with other and some more recent calculations and systems.

Nutrient requirements of goats

Energy requirements

Since respiration calorimetry is a costly and labour demanding method the number of experiments using this method is limited. As a result the systems based on respiration calorimetry are constructed based on a few studies only. According to Luo et al. (2004), the values in NRC (1981) for maintenance were obtained as a mean from 10 different publications dating from 1950-1980 and the requirements for growth was based on only three experiments published in 1967 to 1979. Similarly AFRC (1998) used 17 different publications from 1960 to 1990 to estimate requirement for maintenance. Since the results of the experiments may vary with genotype and age of the goats the coefficients of variance for the values derived are high.

The newest system for nutrient requirements for goats has been constructed by Luo et al. (2004) at Langston University in the US. This is a system using regressions to predict the requirements. The databases for different production stages and types of animal are based on a varying number of experiments. E.g. the database for growing animals and lactating animals is based on 70 and 44 publications, respectively. This system is built as a database where by giving certain information to the system you can use different calculators and get the requirements for goats in all production stages. The system recognises 3 genotypes; meat, milk

and indigenous goats, which is also an improvement compared to earlier systems. The background data, calculations, estimations and references list can be found in Nsahlai et al. (2004) and Luo et al. (2004).

In Table 1 the energy recommendations from NRC (1981), Devendra and McLeroy (1982), Nsahlai et al. (2004), Luo et al. (2004) and and a new estimation from Mandal et al. (2004) for Indian goat breeds are compared for some animals at different weights and at different stages of production. This new estimation of Mandal et al. (2004) is also a system based on regressions, including 25 experiments with 93 different dietary treatments. The requirements for growing goats, presenting different growth rates at different BW, is given in more detail in Table 2 (Mandal et al., 2004).

The recommendations of NRC are in general higher than for the other systems, which are both for goats in tropical areas or indigenous goats, while NRC is for goats in temperate areas. AFRC (1998) is not included in the comparison since the requirements in this system are not given directly, but some assumptions concerning degree of concentration of the feed, metabolisability etc. must be made to estimate the requirements. Also AFRC is considered to be giving minimum levels, since it is based on calorimetry and is also meant for goats in temperate conditions.

Protein requirements

The protein requirements for goats according to different systems are presented in Table 3. In this case the recommendations according to NRC are not consistently higher. The requirements for lactation and growth are higher in Nsahlai et al. (2004) and Luo et al. (2004), but requirements for maintenance and pregnancy are lower than both NRC (1981) and Devendra and McLeroy (1982). In the system of Mandal et al. (2004) the protein requirements for growth are considerably higher than in the other systems.

Nutrient requirements of sheep

Energy requirements

Compared to goats there are numerous systems for sheep, and since they have often been elaborated at the same time or together with systems for cattle they are also very sophisticated and based on a larger number of experiments. The estimates are given in different units, for example net energy, metabolizable energy or digestible energy. In order to be able to compare these systems it is necessary to make a number of assumptions concerning the feed and the diets, and the reliability of these assumptions can be questioned. Also the recommendations are often for sheep with higher body weights than tropical breeds in general.

The comparison for growing sheep has therefore been made with NRC (1985) and two other systems; Kearl (1982), which has been commonly used in India for tropical sheep, and a new estimation from Paul et al. (2003), also for Indian sheep. This new estimation for growing sheep is based on regressions, including 19 experiments with 53 different dietary treatments. Since NRC (1985) starts the tables at 10 kg BW and 200 g gain per day this is the level that has been compared (Table 4).

In general the energy requirements according to Paul et al. (2003) are intermediate between NRC (1985) and Kearl (1982), which are higher and lower, respectively. The requirements for growing sheep, presenting different growth rates at different BW, is given in more detail in Table 4 (Paul et al., 2003).

The energy requirements for mature, pregnant or lactating animals are given in Table 5, comparing some international systems and the Swedish system (Spörndly, 1995). All three systems are intended for sheep in temperate areas and to be able to compare some extrapolations and estimations must be made. ARC (1980) is considered to be a minimum level.

Protein requirements

Protein requirements are still more difficult to compare. NRC (1985) gives the recommendations in CP, the Swedish system in DCP and ARC in rumen degradable and

undegradable protein. The Swedish recommendations for pregnancy and lactation are much higher than for the other systems.

Discussion

How necessary is it to know exactly the nutrient requirements for small ruminants in the feeding systems in the tropics? In view of the fact that the knowledge of the nutrient value, especially the energy value, of the feeds, are only estimates for most tropical feeds, and that there is also a lack of information on digestibility, degradability and metabolisability of protein in tropical feeds, it is debateable whether a very high precision is necessary. In practical feeding the roughages; foliages, straws, grasses etc., are often fed *ad libitium* to ensure a high feed intake. And intake is a very important factor when using tropical feeds, maybe the most important factor, when diets are formulated to meet the nutrient requirements of the animals.

The new system launched as a database by Langston University is well organized and contains corrections for most of the different conditions that can be foreseen. It can be considered to be a good approximation for goats in tropical regions and can be recommended for lactating and pregnant animals until further improvements can be made. For growing animals the Langston University system but also the estimation by Mandal et al. (2004) can be recommended

For sheep the situation is different. There are many systems to choose between and e.g. the system used in the tropical areas of Australia may be possible to use. The breeds are, however, different and the level of production probably higher. The systems from temperate countries are most often based on breeds with higher BW and growth rates, and are using sophisticated calculations and factors and units that in most cases are not available for tropical feeds.

The recommendations for Indian sheep breeds should be possible to use when the growth performance of sheep breeds in SE Asia is studied and adjustments can be done when more data is available. The recommendations for pregnant and lactating sheep from temperate regions should only be used as a guide. These recommendations have to be tested in tropical conditions.

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Table 1. Energy requirements of goats according to different systems

Energy, MJ/day	NRC[1]	Devendra and McLeroy[2]	[3]Langston University System	Mandal et al., 2004
Maintenance, 40 kg	8.4	6.6	6.7	
Maintenance+late pregnancy	14.3	14.3	11.2	
Maintenance 40 kg+lactation, 2 kg/day, 3.5% fat	18.6	15.7	17.8	
Maintenance 20 kg+growth 50 g/day	6.5	5.5	5.6	5.5
Maintenance 20 kg+growth 100 g/day	8.0	7.3	7.0	6.7

[3]Luo et al. 2004, Nsahlai et al. 2004

Table 3. Protein requirements of goats according to different systems

CP, g/day	NRC[1]	Devendra and McLeroy[2]	[3]Langston University System	Mandal et al., 2004
Maintenance, 40 kg	77	48	48	
Maintenance+late pregnancy	159	139	123	
Maintenance 40 kg+lactation, 2 kg/day, 3.5% fat	213	205	245	
Maintenance 20 kg+growth 50 g/day	50	53	62	77
Maintenance 20 kg+growth 100 g/day	74	71	82	100

[1]Maintenance plus low activity [2]Confined goats, CP digestibility =0.60; [3]Luo et al. 2004, Nsahlai et al. 2004

Table 4. Comparison of some different estimations of energy and protein requirements of growing sheep (after Paul et al., 2003)

BW, kg	ADG, g/day	Energy, MJ/day			CP, g/day		
		Paul et al., 2003	NRC, 1985	Kearl, 1982	Paul et al., 2003	NRC, 1985	Kearl, 1982
5	100	3.25	2.36	2.12	69	NS[1]	45
10	200	5.90	6.05	4.54	132	123	90
15	200	7.02	8.14	6.05	145	134	121
20	200	8.71	10.12	7.56	152	145	150
25	200	9.64	11.94	8.02	164	152	160
30	200	10.50	13.69	10.13	175	154	204

[1]*NS=Not stated*

Table 2. Daily nutrient requirement of growing male sheep (after Paul et al., 2003) and goats (after Mandal et al., 2004) under tropical conditions

Sheep					Goats				
BW kg	ADG g	ME MJ	CP g	DCP g	BW kg	ADG g	ME MJ	CP g	DCP g
5	50	2.55	46	30	5	25	2.13	31	19
5	100	3.24	69	46	5	50	2.73	42	28
5	150	3.93	93	61	5	75	3.36	54	36
10	50	3.83	61	40	5	100	3.96	65	45
10	100	4.51	84	56	10	25	3.17	44	27
10	150	5.19	108	71	10	50	3.78	55	36
10	200	5.88	131	87	10	75	4.39	67	44
15	50	4.94	74	49	10	100	4.99	78	53
15	100	5.62	97	65	10	125	5.6	89	61
15	150	6.31	121	80	10	150	6.21	100	70
15	200	7.00	145	96	15	25	4.08	56	33
15	250	7.68	168	111	15	50	4.69	67	42
20	50	5.95	87	57	15	75	5.31	79	50
20	100	6.86	109	72	15	100	5.91	90	59
20	150	7.78	130	87	15	125	6.52	101	67
20	200	8.70	152	102	15	150	7.12	112	76
20	250	9.61	173	117	20	25	4.91	66	39
25	50	6.87	99	65	20	50	5.52	77	48
25	100	7.78	121	80	20	75	6.14	89	56
25	150	8.70	142	95	20	100	6.74	100	65
25	200	9.61	164	110	20	125	7.35	111	73
25	250	10.53	185	125	20	150	7.95	122	82
30	50	7.74	110	72	25	25	5.70	76	45
30	100	8.65	132	88	25	50	6.31	88	53
30	150	9.57	153	103	25	75	6.93	99	62
30	200	10.48	175	117	25	100	7.53	110	70
30	250	11.42	197	133	25	125	8.14	121	79
					25	150	8.74	133	87
					30	25	6.44	86	50
					30	50	7.05	97	58
					30	75	7.85	109	67
					30	100	8.65	120	75
					30	125	9.45	131	84
					30	150	10.27	142	92

Table 5. Energy and protein requirement of lactating ewes

	Energy, MJ/day			Protein g/day		
	Sweden	NRC, [4]1985	ARC, 1980	Sweden[8]	NRC, 1985[5]	ARC, 1980
Maintenance[1]	6.3	7.5	6.2	85	86	45[6]
Maintenance+pregn. 8 w.[2]	10.3	9.2	7.4	169	103	50[6]
Maintenance+pregn. 2 w.[2]	14.3	15.8	11.7	318	187	90[6] 5[7]
Maintenance+lactation[3]	19.0	21.2	17.9	418	373	140[6] 55[7]

40 kg ewe; [2]2 lambs, weeks before lambing; [3]2 lambs, 1,5 l milk/day; [4]extrapolated to 40 kg; [5]crude protein
[6]rumen degradable protein; [7]undegradable protein; [8]CP digestibility 0.6