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THE PROTEIN REQUIREMENTS FOR MAINTENANCE OF INDIGENOUS SHEEP OF MALAYSIA

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RINGKASAN

Keperluan zat protein yang dikehendaki bagi menampong kehidupan kambing biri-biri dewasa tempatan di Malaysia, yang mempunyai berat badan lebih kurang 22 sampai 23 kg. telah ditentukan di dalam percubaan 'nitrogen balance'. Sepuluh 'treatments' telah digunakan dan bagi tiap-tiap lima treatment yang diguna mengandungi kadar 20 peratus (%) dan 30% jerami padi. Di dalam tiap-tiap kelumpuk 20 dan 30% jerami itu 6, 8, 10, 12 dan 14% nitrogen makanan yang datangnya dari sumber uria telah dicampurkan.

EUN yang ditentukan itu ialah 92.7 mg./kg.$^{0.75}$ mengikut kiraan regression equation Y = 0.0927 + 0.2728X, r = 0.443 (N.S.). MFN ialah 0.645 g./100 g. bagi bahan kering dimakan (DMI) dan regression equation Y = 0.6450 + 0.0609X, r = 0.713 (N.S.). 'Biological value' bagi protein itu ialah 73.6%. Jika dikira mengikut 'factorial method' didapati keperluan protein bagi asas kehidupan secara purata ialah 8.45 ± 0.54 g. 'digestible crude protein' bagi biri-biri yang berat 22.5 kg. sehari. Protein kasar yang dimakan adalah didapati mempunyai pertalian yang significant ($r = 0.972$, $P < 0.01$) dengan protein kasan yang dapat dihazamkan (DCP). Basal metabolism yang dianggarkan bagi kambing yang berat badannya 25 kg. ialah 725 kcal./sehari ataupun 29.0 kcal./kg.

Angka nilai yang diperolehi ini didapati sangatlah kurang daripada keperluan protein bagi biri-biri yang sama berat badannya sepertimana yang dicadangkan bagi di negeri berhawa dingin. Hasil penyelidikan ini menyokong dan menetapkan pendapat-pendapat dari lapuran penyelidikan yang serupa ini bagi kambing biri-biri dan binatang menceroh yang lain di dalam aklim tropika. Kelebihan di dalam penggunaan nitrogen adalah terang bersangkutan dengan kurangnya kehilangan nitrogen di dalam badan dan juga tingginya nilai protein (BV) yang didapati. Hasil penyelidikan ini adalah besar maknanya dan penyelidikan yang mendalam lagi sepatutnya diteruskan bagi mencapai darjah pemakanan yang sesuai bagi negeri tropika adalah dibincangkan.

INTRODUCTION

The protein requirements of ruminants in the tropics is a subject of considerable interest, since proteins are often the main limiting factor for maximising response, and therefore productivity from them. Unfortunately however, only few studies have been directed at a critical examination of protein requirements. Consequently, it has been fashionable to apply the protein requirements recommended for temperate environments such as those of WOODMAN (1957), MORRISON (1959), Agricultural Research Council (A.R.C., 1965) or the National Research Council (N.R.C., 1971).

In the absence of nutrient recommendations specific to tropical situations, the use of these standards is perhaps justifiable. However, this has the serious disadvantages of firstly, conveniently assuming that these temperate nutrient recommendations are applicable to the tropics. Secondly, the continued use of these temperate standards tends to often ignore the need for investigations into nutrient requirements specific to a tropical environment.

The tendency towards indiscretionary application of these standards is, however, of doubtful validity since, there is growing evidence that the protein requirements for maintenance for example are lower for tropical ruminants than temperate recommendations. Confirmation of this fact comes from the reports of KEHAR, MUKHERJEE and SEN, (1943), GOPAL KRISHNA (1971) and PATLE and MUDGAL (1975) for cattle in India; ELLIOTT and TOPPS (1963a, 1963b) for cattle in South Africa; GUPTA *et al.* (1966) for buffaloes in India and sheep in South Africa (ELLIOTT and TOPPS 1963c, 1964).

With reference to Malaysia no information exists on protein requirements of ruminants. A start has been made, however, to assess these in carefully controlled experiments, using the indigenous sheep of Malaysia. These indigenous sheep have previously been shown to have the capacity to efficiently utilise low levels of dietary nitrogen (DEVENDRA, 1975a, 1975b). The present paper deals with the maintenance requirements for protein of these sheep.

MATERIALS AND METHODS

The experiments were done using balance trials, details of which have been previously described (DEVENDRA, 1975c).

(i) Sheep

The 30 sheep used were adult rams with a mean live weight of about 22.0 to 23.0 kg. These sheep are indigenous to Malaysia and they have recently been described (DEVENDRA, 1975d). The animals were drenched in accordance with normal flock management before the trial commenced, and were also weighed three days before and after the trial.

(ii) Treatments

Ten treatments were imposed, with three sheep per treatment. Five of the treatments had a 20% and the other five a 30% rice straw diet with molasses ranging from 75 to 78% and 65 to 68% respectively. The molasses had a dry matter content of about 70.3%, sucrose 41.4%, reducing sugars 13.3% and crude protein 1.8%. The crude protein levels ranged from 6 to 14.2% and was contributed exclusively by urea (fertilizer grade, 280% crude protein). The diets were fed *ad libitum* and about 550 g. were fed daily to each sheep. Each digestibility trial lasted for 21 days involving 14 of adaptation and a collection period of 7 days. The percentage composition of the diets and their chemical composition is given in *Tables 1 and 2.*

(iii) Analytical methods

The techniques used for chemical analyses were those recommended by A.O.A.C. (1965). Dry matter was determined by drying at 102°C for 24 hours, ash by firing at 600°C for 24 hours, protein by the micro-kjeldahl procedure, crude fibre by successive boiling with alkali and acid and ether extract by gently heating with petroleum spirit (40–60°C B.P.). Ca and Mg were determined by EDTA titration and P was determined by molybdate by colourimetry. Gross energy was determined by a ballistic bomb calorimeter (Gallenkamp, London).

RESULTS

An analysis of variance of the digestibility of dry matter due to level of rice straw inclusion showed that there were no significant differences, confirming previous results (DEVENDRA, 1975c). Consequently, the results for both levels of rice straw inclusion were pooled for the studies reported here.

TABLE 1. COMPOSITION OF THE DIETS FED (% AIR DRY FEED)

Ingredient	Treatments									
	1	2	3	4	5	6	7	8	9	10
Rice straw	20.0	20.0	20.0	20.0	20.0	30.0	30.0	30.0	30.0	30.0
Molasses	77.7	77.0	76.3	75.5	74.8	67.9	67.2	66.5	65.7	64.9
Urea	1.3	2.0	2.7	3.5	4.2	1.1	1.8	2.5	3.3	4.1
Mineral supplement*	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*The mineral supplement provided the following minerals and vitamins when added at the rate of 2.2 kg. per tonne: 5,000,000 IU vitamin A; 1,250,000 IU vitamin D; 1,330 mg. cobalt; 250 g. calcium; 22,570 mg. copper; 41,730 mg. iron; 44,180 mg. manganese; 38,220 mg. zinc and 113,400 mg. magnesium.

TABLE 2. CHEMICAL COMPOSITION OF THE TREATMENT DIETS (% DRY MATTER BASIS)

Constituent	Treatments									
	1	2	3	4	5	6	7	8	9	10
Crude protein (Nx6.25)	6.0	7.9	9.0	12.1	14.0	6.3	8.2	9.7	12.2	14.2
Ash	11.5	12.8	12.9	13.0	12.8	14.1	13.9	13.4	13.9	12.5
Crude fibre	5.3	5.3	5.3	5.3	5.3	8.0	8.0	8.0	8.0	8.0
Nitrogen-free extract	77.2	74.0	71.9	69.6	67.9	71.6	69.9	68.9	65.9	65.3
Ca	0.61	0.56	0.62	0.58	0.55	0.51	0.45	0.56	0.61	0.51
P	0.32	0.21	0.19	0.21	0.13	0.19	0.26	0.25	0.28	0.32
Mg	0.39	0.35	0.39	0.35	0.37	0.35	0.40	0.37	0.41	0.38
Gross energy (Kcal/kg.)	3581.1	3757.5	3571.3	3304.9	3486.9	3595.8	3414.5	3299.5	3248.9	3646.1

(i) Live weight changes

Table 3 presents changes in the live weight of the sheep during the trial. In most instances, the sheep maintained positive live weight gain.

TABLE 3. LIVE WEIGHT CHANGES (Kg.)
(Each value is the mean of 3 sheep)

Treatment	Initial live weight	Final live weight	Mean live weight	Live weight change
1	22.0	22.2	22.1	+0.2
2	21.6	22.1	21.9	+0.5
3	22.4	22.3	22.4	–0.1
4	22.6	22.7	22.7	+0.1
5	22.7	23.3	23.0	+0.6
6	22.6	22.7	22.7	+0.1
7	22.1	22.0	22.1	–0.1
8	22.7	23.0	22.9	+0.3
9	22.1	22.7	22.4	+0.6
10	23.2	23.0	23.1	–0.2

(ii) Endogenous urinary nitrogen (EUN)

Endogenous urinary nitrogen (EUN) was determined by plotting the regression of urinary nitrogen on nitrogen intake. As energy intake lower than the requirement causes higher nitrogen excretion (MACDONALD, GREENHALGH and EDWARDS, 1973), the values of animals in negative energy balance were discarded for this relationship.

The regression equation was found to be:

$$Y = 0.0927 + 0.2728X, \ r = 0.443 \ (N.S.)$$

where Y = urinary nitrogen (g./kg.$^{0.75}$/day) and X = nitrogen intake (g./kg.$^{0.75}$/day). The value of 0.0927 represents the EUN (g./kg. metabolic body size).

(iii) Metabolic faecal nitrogen (MFN)

Metabolic faecal nitrogen (MFN) was determined by plotting faecal nitrogen against nitrogen intake in terms of dry matter intake (DMI).

The regression equation was found to be:

$$Y = 0.6450 + 0.0609X, \ r = 0.713 \ (N.S.),$$

where Y = faecal nitrogen/100 g. DMI and X = nitrogen intake/100 g. DMI. The intercept of 0.645 represents the g./MFN/100 g. DMI.

(iv) Biological value

It is now possible, using the EUN and MFN values, to calculate the biological value (BV) of proteins in the diet. For this purpose, the formula of MITCHELL (1924) was used:

$$BV = \frac{NI - (FN - MFN) - (UN - EUN)}{NI - (FN - MFN)} \times 100$$

where BV	=	biological value of the proteins (%)
NI	=	daily nitrogen intake (mg./kg.$^{0.75}$)
FN	=	daily faecal nitrogen excreted (mg./kg.$^{0.75}$)
MFN	=	daily metabolic faecal nitrogen excreted (mg./kg.$^{0.75}$)
UN	=	daily urine nitrogen excreted (mg./kg.$^{0.75}$)
EUN	=	daily endogenous urinary nitrogen excreted (mg./kg.$^{0.75}$)

Table 4 summarises the calculated BV by treatments in this experiment.

An analysis of variance indicated that treatments had significant effects on the N balance data, apparent digestibility and biological values.

The apparent digestibility increased with increased dietary nitrogen and was maximum at the highest level of crude protein inclusion (14.2%); these values were 69.8 and 61.9% for the 20 and 30% levels of rice straw inclusion. N balance also improved with increased dietary N. Maximum N balance for both the 20 and 30% rice straw levels were associated with the 10% level of dietary crude protein.

The biological values varied from 53.1 to 85.3, giving a mean of 73.6%

(v) Digestible crude protein (DCP) for maintenance

The digestible crude protein requirements for the treatments were calculated using the factorial method suggested by MACDONALD, EDWARDS and GREENHALGH (1973) using the formula:

$$R = 6.25 \ [100/B \ (M \times D + E \times W^{e}) - M \times D]$$

where R	=	requirement for digestible crude protein (g.DCP/day)
B	=	biological value of food protein (%)
M	=	MFN (g./kg. food DMI)
D	=	DMI (kg./day)
E	=	EUN (g./kg. metabolic LW/day)
W^{e}	=	metabolic live weight of the animal (kg.)

TABLE 4. BIOLOGICAL VALUES IN THE NITROGEN BALANCES
(Each value is the mean of 3 sheep)

Treatment	DMI (g./kg.$^{0.75}$)	Daily N metabolism (g./kg.$^{0.75}$)				Apparent** digestibility (%)	Biological** value (%)
		Intake*	Faeces	Urine**	Balance**		
1	43.47	0.417	0.207	0.214	–0.004	50.4	82.1
2	39.37	0.498	0.261	0.236	+0.001	47.6	83.8
3	52.68	0.834	0.414	0.254	+0.166	50.5	84.4
4	43.81	0.849	0.362	0.392	+0.105	57.4	64.7
5	41.70	0.940	0.284	0.604	+0.052	69.8	53.1
6	43.67	0.441	0.215	0.245	–0.019	51.2	79.4
7	58.52	0.767	0.372	0.250	+0.145	51.5	84.8
8	52.16	0.810	0.365	0.252	+0.193	54.9	85.3
9	47.82	0.933	0.376	0.514	+0.157	59.7	56.6
10	52.49	1.193	0.454	0.633	+0.106	61.9	61.0
Mean	47.57 ± 0.94^{+}	0.768 ± 0.78	0.331 ± 0.27	0.359 ± 0.05	+0.078 ± 0.02	56.9 ± 2.15	73.6 ± 4.13

* Significant at $P<0.05$
** Significant at $P<0.01$
\+ Standard error

Table 5 summarises the DCP requirements for individual treatments.

The mean DCP requirement for sheep with a mean live weight of 22.5 kg. was found to be 8.45 ± 0.54 g./day. DMI was not correlated significantly with nitrogen intake (r = 0.457) and likewise DCP with nitrogen retention (r = 0.515). However, nitrogen intake was strongly correlated with DCP (r = 0.972, $P<0.01$).

(vi) Basal metabolism

The basal metabolism of sheep can be calculated by first calculating the utilisable protein requirement for maintenance. This is achieved by use of the formula adopted by SMUTS (1935) in studies on protein requirements of sheep:

$$P = k.W^{0.734}$$

where P is the utilisable protein requirement (g./day)
k is a constant and
$W^{0.734}$ is the metabolic live weight (kg.).

Using the DCP requirements calculated in *Table 5* and the corresponding metabolic live weight, the mean value of k was found to be 0.81. The formula is thus $P = 0.81\ W^{0.734}$.

TABLE 5. DIGESTIBLE CRUDE PROTEIN (DCP) REQUIREMENTS OF THE INDIGENOUS SHEEP OF MALAYSIA
(Each value is the mean of 3 sheep)

Treatment	DCP requirement for maintenance (g/day)
1	7.23
2	7.24
3	7.22
4	9.40
5	11.53
6	7.55
7	6.93
8	6.97
9	10.50
10	9.95
Mean	8.45 ± 0.54*

*Standard error

Using this formula $P = 0.81\ W^{0.734}$, the basal energy output was calculated for indigenous sheep of various live weights, since SMUTS (1935) has shown that an approximately constant relationship exists between EUN and basal energy output of several species of animals. *Table 6* presents this calculation for sheep weighing 10 to 45 kg. The calculations assume that 2 mg. of endogenous N or 12.5 mg. of protein is equivalent to 1 calorie of basal heat.

It was estimated that the basal metabolism for sheep with 45 kg. (100 lb.) live weight was 1125.6 kcal./day or 25.0 kcal./kg. or 64.8 kcal./$W^{0.734}$.

TABLE 6. PREDICTION OF ENERGY REQUIREMENT OF THE INDIGENOUS SHEEP

Live weight (kg.)	Metabolic live weight (kg.)	Utilizable protein from equation $P = 0.81\ W^{0.734}$ (g.)	Basal metabolism (kcal./day)	Basal metabolism (kcal./kg.)
10	5.62	4.55	364.0	36.4
15	7.62	6.17	493.8	32.9
20	9.46	7.66	613.0	30.7
25	11.18	9.06	724.5	29.0
30	12.82	10.38	830.7	27.7
35	14.39	11.66	932.5	26.6
40	15.91	12.89	1031.0	25.8
45	17.37	14.07	1125.6	25.0

DISCUSSION

The mean daily DCP requirement determined in a series of balance trials was 8.45 g. In comparison to the requirement of 29 g. recommended for sheep of 20 kg. live weight, which includes a requirement for wool production (MACDONALD, EDWARDS and GREENHALGH, 1973), the present value is approximately 71 per cent lower or by a factor of about 3.5. Confirmation that the indigenous sheep of Malaysia require low levels of dietary N for maintenance also comes from the study of ELLIOTT and TOPPS (1963c). The latter determined values between 10.6 to 15.2 g. DCP for Blackhead Persian sheep with a mean live weight of 30.7 kg., which for sheep weighing about 23 kg. would be equivalent to 9.8 g. This value of 9.8 g. is comparable to the 8.5 g. determined in the present study.

It is quite clear that the indigenous sheep require very low levels of dietary N for maintenance, and on this premise, it is likely that the corresponding requirement for gain is also likely to be relatively smaller. There is therefore no real justification for using temperate feeding standards applicable to ruminants in the tropics. This statement is further fortified by the reports from elsewhere in the tropics concerning reduced protein requirements for cattle (KEHAR, MUKHERJEE and SEN, 1943; ELLIOTT and TOPPS, 1963a, 1963b; GOPAL KRISHNA, 1971; PATLE and MUDGAL, 1975); and possibly also goats (DEVENDRA and BURNS, 1970).

This argument is also supported by several practical feeding trials where ruminants have been fed diets with varying crude protein levels above and below recommended standards. Evidence for this comes from studies on Murrah buffalo calves (HUSSEIN *et al.*, 1975), Deoni calves (AWATI, TOTTE and BONDE, 1975) and in Malaysia on Local Indian Dairy (LID) cattle (DEVENDRA and SIVARAJASINGAM, 1975). For Hariana heifers, up to 40% decrease in protein requirements from existing standards have been suggested (RATHEE and YADAVA, 1970).

The apparently high efficiency of N utilisation appears to be associated with low endogenous losses and also high biological values of the proteins at N equilibrium. Both aspects have been noted to be true in the present study. The value of 0.0927 g./kg. metabolic body size, while it is comparable to the accepted estimate of 0.12 to 0.10 g./kg.$^{0.75}$/day by the A.R.C. (1965), is lower than the value of 0.149 mg. reported for adult rams (SINGH and MAHADEVAN, 1968). but higher than 0.052 g. for Jamnapâri bucks (MAJUMDAR, 1960). On the other hand, it is comparable to 90.4 mg./kg.$^{0.75}$ reported for Haryana bullocks (KEHAR, MUKHERJEE and SEN, 1943) and 91.7 mg. for buffaloes (GUPTA *et al.*, 1966).

The MFN of 0.645 g/100 g. DMI is comparatively higher than the acceptable value of 0.5 g./100 g. DMI (A.R.C., 1965), 0.214 g. for sheep (SINGH and MAHADEVAN, 1968), 0.41 g. for goats (MAJUMDAR, 1960), 0.341 g. for buffaloes (GUPTA *et al.*, 1966) and 0.502 for crossbred cattle (PATLE and MUDGAL, 1975).

The mean BV for the proteins recorded in this study was 73.6%. From a review of various reports, the A.R.C. proposed that the value for sheep was 65%. The present estimate is well above this value and 61.3% reported by BROSTER, TUCK and BALCH (1963). However, it is approximately similar to the value of 74.8 reported recently for crossbred cattle in India (PATLE and MUDGAL, 1975).

The relatively high biological values determined here are probably due to, in addition to low urinary losses, the presence of the readily available energy in molasses. The carbohydrates in molasses are completely fermented (GEERKAN and SUTHERLAND, 1969), and also has the advantage of being the perfect carrier for molasses (DEVENDRA, 1975b). In cattle for example, carbohydrate addition markedly increased the BV of protein sources (ELLIOTT, FRENCH and FOLKERSTON, 1961). Furthermore, it was noted that the BV increased with increasing availability of dietary energy.

It was noted that the highest N balance and also BV were found for both levels of rice straw inclusion at the 10% crude protein level. This observation suggests that in molasses-urea diets where urea was the sole source of dietary N, this level could be the optimum level for maximum efficiency of protein utilisation. The tendency towards increasing N retention with increasing intake of dietary N confirms a similar report (DEVENDRA, 1975a) also in sheep.

The tendency towards increasing crude protein digestibility with increasing dietary crude protein recorded here confirms the results previously reported (DEVENDRA, 1975a), and is further supported by similar observations in sheep and cattle in Australia (ROBINSON and STEWART, 1968) and also for cattle in Uganda (KARUE, 1973). The highly significant correlation between crude protein and DCP of $r = 0.92$, $P<0.01$ also confirms similar results of the previous study (DEVENDRA, 1975a).

The value of k in the equation $P = k.W^{0.734}$ was 0.81 and compares with 0.74 for sheep (SMUTS and MARAIS, 1939), 0.81 for pigs (DU TOIT and SMUTS, 1941) and 0.89 for goats (MAJUMDAR, 1960). MITCHELL (1929) considers that 0.88 is applicable to all farm animals.

The basal metabolism of sheep weighing 45 kg. was 1125.6 kcal./day, 25.0 kcal./kg. or 64.8 kcal./kg.$^{0.734}$. This value is comparable with the value of 27 kcal./kg. reported by RITZMAN and BENEDICT (1930) for sheep, but is higher than that of 59.2 kcal./kg.$^{0.734}$ by MARSTON (1948) and 58.5 kcal./kg.$^{0.734}$ reported by BLAXTER (1962). On the other hand, it is lower to the value of 35 kcal./kg. for goats (MAJUMDAR, 1960).

The balance trials studied do not take any account of N losses other than in faeces and urine such as hair, skin abrasions and dribbling saliva. It is considered that these are negligible since the sheep are clipped to relieve them of the coarse hair. For Blackhead Persian sheep ELLIOTT and TOPPS (1963c) consider that this loss is about 60 mg. N/day.

DUNCAN (1958) has questioned the validity of using balance trials to estimate nutrient requirements, since sampling and analytical errors are quite considerable. Nevertheless, it is possible to keep these to a minimum in seeking an understanding of relative measurements of the efficiency of nutrient utilisation.

Finally, it is emphasised that studies on energy and protein requirements of ruminants in the tropics are few and far between. They have been done sporadically in various laboratories and specific to certain situations. A correction of this tendency necessitates a more sustained approach towards determination of nutrient requirements in long term studies that aim to eventually provide recommendations applicable to different ruminant species, stage of growth and type of production. These will need the use of both balance studies, feeding trials and carcass analysis. The objective in this approach should be to produce ultimately much needed nutrient requirements specific to, and applicable directly, to ruminants in the tropics.

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SUMMARY

The protein requirement for maintenance of 30 adult indigenous sheep of Malaysia of approximately 22 to 23 kg. live weight was determined in nitrogen balance trials. Ten treatments were used, five each on 20 and 30% rice straw levels respectively. Within each level of rice straw, five crude protein levels were used: 6, 8, 10, 12 and 14%, with the dietary nitrogen coming exclusively from urea.

The EUN was determined to be 92.7 mg./kg.$^{0.75}$ from the regression equation Y = 0.0927 + 0.2728X, r = 0.443 (N.S.). The MFN was 0.645 g./100 g. DMI and the regression equation Y = 0.6450 + 0.0609X, r = 0.713 (N.S.). The BV was 73.6%. Using the factorial method of determining the protein requirements for maintenance, the mean DCP requirement was found to be 8.45 ± 0.54 g./day for sheep with a mean live weight of 22.5 kg. The crude protein intake was significantly correlated (r = 0.972, $P<0.01$) to DCP. The basal metabolism of sheep weighing 25 kg. was estimated to be 725 kcal./day or 29.0 kcal./kg.

This value is considerably lower than the requirement recommended for sheep in a temperate environment at the same live weight, and confirms other reports of a similar tendency of sheep and other ruminants in the tropics. A high efficiency of N utilisation is apparent, which is associated with low endogenous losses and relatively high biological values for proteins. The significance of these findings and the need for sustained research into feeding standards applicable to the tropics is discussed.

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