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# THE ENERGY REQUIREMENTS FOR MAINTENANCE OF PEN-FED SHEEP IN MALAYSIA

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## RINGKASAN

Keperluan tenaga untuk menyelenggara hidup biri-biri tempatan dewasa yang telah diberi makan di dalam kandang dilaporkan. Ini adalah berdasarkan pengambilan data dari 51 percubaan penghadzaman yang mana melibatkan 671 set data. Data-data ini termasuklah purata pengambilan bahan organik yang dihadzam (D), purata berat badan (W) dan purata perubahan berat badan harian (C). Perkiraan purata keperluan tenaga bagi menyelenggara hidup adalah diperolehi dengan menggunakan formula am iaitu $D = aW^k \times bG$. Data ini pada mulanya dikelaskan ke dalam tiga kategori iaitu G = O, −ve atau +ve dan k dikirakan. k adalah suatu eksponen yang menghubungkan berat badan dengan luas permukaan tubuh, tetapi perbezaan secara statistik telah didapati di antaranya ($P<0.01$). Purata nilai dan susunan nilai ini adalah W = 21.6 kg (15.5 − 27.7 kg) dan G = −0.02 (−0.5 − +0.5 kg).

Perkiraan yang tepat bagi keperluan untuk menyelenggara hidup adalah terbaik bila G = O di mana tenaga di dalam keadaan keseimbangan. Ini memberikan persamaan $D = 0.0301\ W^{0.748} + 0.12\ G$ (± 0.033). Dari kiraan ini adalah didapati bahawa purata keperluan tenaga untuk menyelenggara hidup adalah 471.8 KJ ME/$W^{0.75}$kg/hari. Nilai ini adalah terletak di dalam beberapa nilai yang telah dilaporkan bagi biri-biri dari negara-negara beriklim sederhana dan ianya hampir sama dengan nilai 487.5 KJ ME/$W^{0.75}$kg/hari yang telah dilaporkan bagi biri-biri tropika dari West Indies. Adalah ditegaskan bahawa semasa meragut di luar kandang, keperluan untuk menyelenggara hidup adalah lebih tinggi. Keperluan ini masih memerlukan penentuan. Cadangan ada diberikan bagi kambing biri-biri tempatan di dalam suatu jadual mengenai keperluan untuk menyelenggara hidup bagi kambing-kambing yang mempunyai berat badan di antara 15−40 kg.


## INTRODUCTION

The energy requirements for maintenance, defined as the number of joules required in energy equilibrium, of sheep, is a subject that has received considerable attention in temperate environments because of the importance of sheep in these areas. The reported work has been concerned not only with energy equilibrium but also with both pen-feeding trials and studies under grazing conditions.

Early work in this direction was due to studies on energy equilibrium by KELLNER (1912) and ARMSBY (1917) and more latterly on the same topic by MARSTON (1948) and BLAXTER and GRAHAM (1955). These early studies have been extended considerably by a number of studies to include pen-feeding trials (WATSON *et al.*, 1937, WALLACE, 1948; GARRET *et al.*, 1959; COOP, 1962); COOP and DREW, 1963; LANGLANDS *et al.*, 1963a) and the grazing situation (LAMBOURNE, 1955; GRENALL, 1959; COOP and HILL, 1962; COOP and DREW, 1963; LANGLANDS *et al.*, 1963b; HADJIPIERIS, 1963). In a number of these studies, (see for example WOOD and CAPSTICK, 1926 and LANGLANDS *et al.*, 1963a), the maintenance requirements has been derived by regression analysis of data for feed intake, live weight and live weight gain.

By comparison to these numerous studies in temperate climates, the energy requirements for maintenance of sheep in the tropics has only received very limited attention. Up to the present time and as far as the author is aware, only one deter-

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mination has been reported, that of BUTTERWORTH (1966) for data in the West Indies. In view of this paucity in knowledge, and more particularly in the context of the general objective of establishing nutrient requirements for domestic ruminants in Malaysia, investigations were also conducted on this aspect with sheep: the present paper deals with the energy requirements for maintenance.

## MATERIALS AND METHODS

### (i) Digestibility data

The calculation of the maintenance requirements for energy was derived from data obtained from digestibility experiments using adult sheep carried out in Serdang over the period 1973 to 1979. These comprised feeding experiments on grasses, cassava, crop residues or complete diets containing various agro-industrial by-products.

Groups of four adult rams were housed in individual metabolism cages which enabled total collection of faeces and urine during a 14-day adaptation period and seven-day collection period. The quantity of feed offered was generally that which individual sheep would eat without leaving a large residue. The results obtained in these various trials including the techniques used have been variously reported (see for example DEVENDRA, 1975; DEVENDRA, 1977).

In all, 671 sets of data were used from a total 51 digestibility trials. Each set for individual sheep consisted of daily intake of digestible organic matter (DOM), initial, final and mean live weight, the live weight change.

### (ii) Calculation of maintenance requirements.

Calculation of the maintenance requirement was achieved from the general formula:

$$\text{Daily DOM intake (D)} = aW^k + bG$$

where W is the mean live weight,

k is the exponent relation body weight, to surface area

G is the daily change in live weight, and

a and b are constants.

$aW^k$ is the maintenance requirement which is assumed to be proportional to live weight $(W)^{0.75}$. b will vary in relation to whether the energy in the tissues is being stored or lost. In view of the short term duration of the experiments (three weeks) however, b was without physiological significance.

The data was first grouped into three categories: (a) G = 0, (b) G = −ve and (c) G = +ve. Calculations were then made of the k value in the equation for the three groups of G data. Differences in the values of k were then tested for significance, which in turn enabled a consideration of whether the data can be pooled or treated independently. The final step in the calculation was the determination of the maintenance requirement.

## RESULTS AND DISCUSSION

The mean values and ranges of the values were as follows: W = 21.6 kg (15.5 − 27.7 kg) and G = −0.02 (−0.5 − +0.5 kg).

For the three groups of G values (0, −ve and +ve) the corresponding equations were found to be as follows respectively:

$$D = 0.0301\ W^{0.748} + 0.012\ G\ (\pm\ 0.033) \quad -- (1)$$
$$D = -0.0642\ W^{0.563} + 0.013\ G\ (\pm\ 0.094) \quad -- (2)$$
$$D = 0.0220\ W^{0.900} + 0.013\ G\ (\pm\ 0.132) \quad -- (3)$$

It was found that there were statistically significant differences ($P<0.01$) between the k values and also from 0.73 and 0.67. In view of this finding, it was decided that for purposes of the calcula-

tion, only values of D when G = 0 was logically the one to give the most accurate assessment of maintenance, also because the feed consumed was just adequate to maintain body equilibrium without loss or gain in live weight.

Using the mean value of W = 47.6 lb (21.6 kg) in equation (1), it was therefore calculated that the mean maintenance requirement was 0.540 lb or 0.245 kg DOM/day/sheep. This is equivalent to 0.944 lb or 0.429 kg DOM/day for a sheep weighing 100 lb or 45.5 kg. live weight or 471.8 KJ/$W^{0.75}$kg/day.

The value of a daily requirement of 0.429 kg DOM/sheep determined in the present studies compares very well with the value of 0.427 kg DOM/day reported by LANGLANDS *et al.*, (1963a), but is somewhat smaller to the value of 0.464 kg DOM/day reported by BUTTERWORTH (1966). For purposes of further comparison, *Table 1* presents the values determined in this study with other values reported in the literature. The comparison with other reported values, also for pen-fed sheep and particularly for grazing animals in further illustrated in *Figure 1*. It is of interest to note that only two out of a total of 15 values have been reported in the tropics.

It can be seen that the mean maintenance requirement of 471.8 KJ ME/$W^{0.75}$ kg/day determined in the present experiments falls within the range of values reported by other workers. In particular, this value is approximately similar to the reports of WATSON *et al.*, (1937), CARRETT *et al.*, (1959), COOP (1962) and LANGLANDS *et al.*, (1963a), based on functional analysis. This value is also similar to the mean energy requirement for maintenance of pen-fed indigenous Kambing Katjang goats in Malaysia of 444.4 KJ ME/$W^{0.75}$ kg/day published previously (DEVENDRA, 1967).

Based on the present finding, it is relevant to suggest practical recommendations concerning the maintenance requirement of adult sheep in Malaysia. For this purpose, the daily maintenance requirements for energy are given for the live weight range 15 to 40 kg. It is emphasised that the recommendations are for stall-feeding conditions, and should therefore be considered minimum.

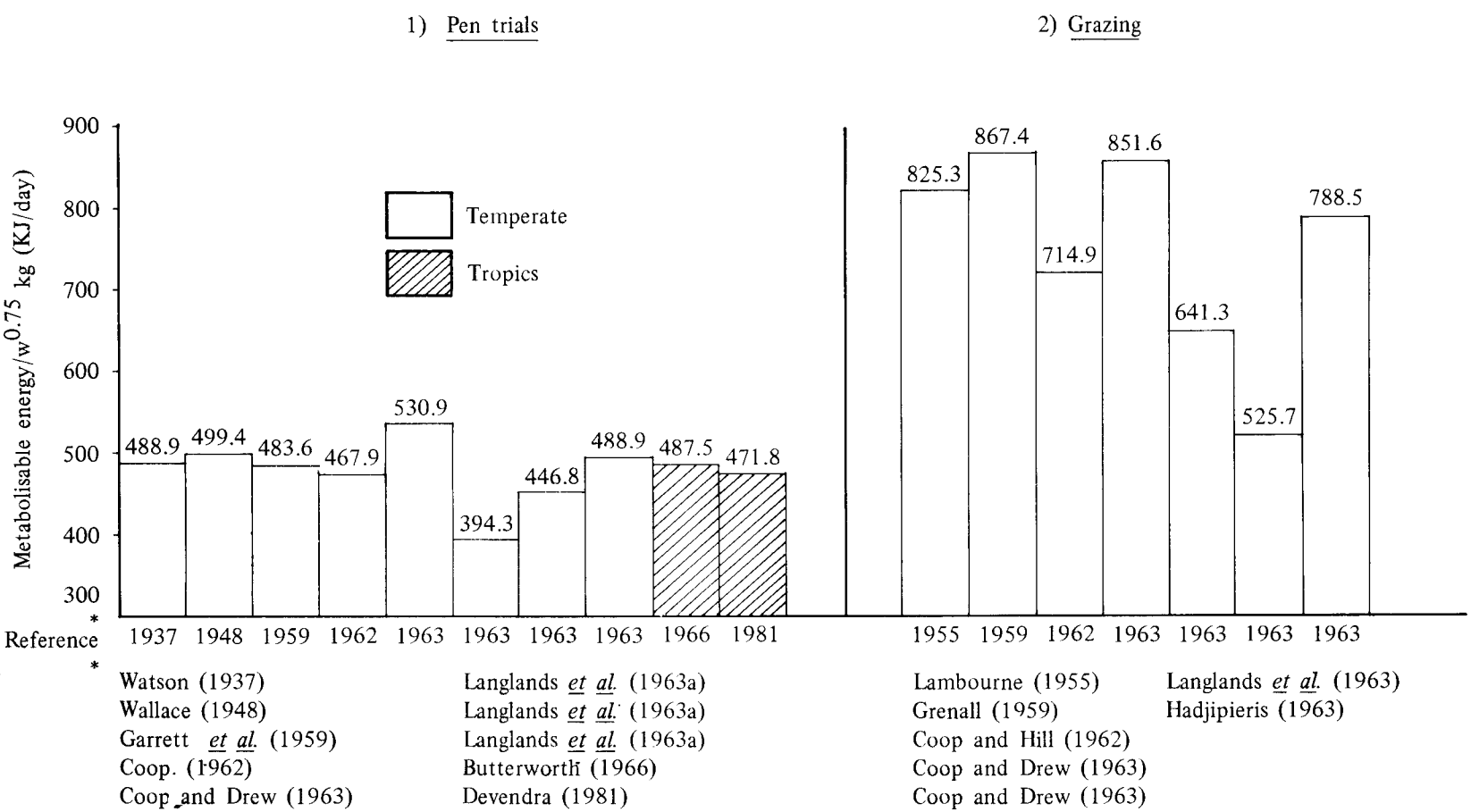
For grazing sheep, the maintenance requirement is considerably higher due to the extra muscular activity and also environmental influences. Thus for example, COOP (1962) found that the DOM required for maintenance of a 45 kg sheep was 0.92 lb. Out-of-doors however, the requirements were 1.36 to 1.63 lb DOM, an increase of between 48 to 77 % (COOP and HILL, 1962). While some of the discrepancy could be due to difficulties in measuring DOM of grazing sheep, the high maintenance requirements have been associated with elevation of metabolism by environmental stress and of course increased muscular activity.

In the present experiments three values of k, the exponent relating body weight to surface area, were found: 0.748, 0.563 and 0.900 for situations when G = 0, −ve or +ve respectively. Of these, the value of 0.748 when G = 0 is considered to be the most accurate since the sheep were in energy equilibrium. BUTTERWORTH (1966) found a mean k value of 0.67 for pooled data when G was 0, −ve and +ve, which is lower to the mean value of k = 0.737 from pooled data in the present results. The indication of $a^k$ value of 0.748 when G = 0 and 0.737 for the pooled data suggests that there is a close relationship between metabolism (indicated by intake) and body weight. This point is consistent with the fact that body weight raised approximately to the power of 0.75 is a measure of basal energy produced, and also the point that this value is now used widely to define metabolic size of an animal. It might also be of interest to note that GALVAO (1947) has suggested from studies in Brazil that basal metabolism should be more closely related to body weight.

TABLE 1: THE ENERGY REQUIREMENTS FOR MAINTENANCE OF SHEEP FROM THE STUDY REPORTED COMPARED TO OTHER PUBLISHED EXPERIMENTAL VALUES

| | Type of investigation and location | $ME/W^{0.75}kg$ (KJ/day) | $DE/W^{0.75}kg$ (KJ/day) | Reference |
|---|---|---|---|---|
| (1) | **ENERGY EQUILIBRIUM** | | | |
| | Germany | 436.3 | 538.5 | Kellner (1912) |
| | U.S.A. | 389.0 | 480.3 | Armsby (1917) |
| | Australia | 532.2 | 434.8 | Marston (1948) |
| | U.K. | 399.5 | 493.2 | Blaxter and Graham (1955) |
| (2) | **PEN TRIALS** | | | |
| | U.K. | 488.9 | 603.6 | Watson *et al.* (1937) |
| | New Zealand | 499.4 | 616.5 | Wallace (1948) |
| | U.S.A. | 483.6 | 597.1 | Garrett *et al.* (1959) |
| | New Zealand | 467.9 | 577.6 | Coop (1962) |
| | New Zealand | 530.9 | 655.5 (out doors) | Coop and Drew (1963) |
| | U.K. | 394.3 | 486.7 (by regression) | Landlands *et al.* (1963a) |
| | U.K. | 446.8 | 551.6 (functional analysis) | Langlands *et al.* (1963a) |
| | U.K. | 488.9 | 603.6 (out doors) | Langlands *et al.* (1963) |
| | Trinidad | 487.5 | 601.9 | Butterworth (1966) |
| | Malaysia | 471.8 | 582.5 | Present studies |
| (3) | **GRAZING** | | | |
| | New Zealand | 825.3 | 1018.9 | Lambourne (1955) |
| | New Zealand | 867.4 | 1070.8 | Grenall (1959) |
| | New Zealand | 651.8–778.0 | 804.7–960.5 | Coop and Hill (1962) |
| | New Zealand | 851.6 | 1051.4 (short grass) | Coop and Drew (1963) |
| | New Zealand | 641.3 | 791.8 (long grass for a short time) | Coop and Drew (1963) |
| | U.K. | 525.7 | 649.0 (by regression) | Langlands *et al.* (1963) |
| | U.K. | 788.5 | 973.5 | Hadjipieris (1963) |

*Figure 1: Histograms illustrating various estimates of the energy requirements for maintenance of pen–fed and grazing sheep*



The Ministry of Agriculture, Fisheries and Food (MAAF, 1975) have suggested that the minimum requirement for energy for maintenance is equal to the fasting metabolism, and using an efficiency of utilisation of 70% and 0.15 safety margin of the fasting metabolism, the net energy requirements for maintenance can be calculated from the equation:

$$M_m = 1.2 + 0.13\ W^{0.73}$$

It is of interest to compare the values computed in *Table 2* with these recommended by MAAF (1975) and N.R.C. (1975). For a sheep weighing 40 kg fed indoors, the former recommend 6.4 MJ ME/day which is approximately 17% lower than the value for indigenous sheep in Malaysia. The N.R.C. by comparison, recommend a value of 8.3 MJ ME/day for a sheep weighing 50 kg which is equivalent to 7.0 MJ ME/day which compares with the present recommendation of 7.5 MJ ME/day.

TABLE 2: SUGGESTED ENERGY REQUIREMENT FOR MAINTENANCE OF INDIGENOUS SHEEP IN MALAYSIA

| Body weight (Kg) | Kg $W^{0.75}$ | $ME^{+}$ (MJ/animal/day) | $DE^{++}$ (MJ/animal/day) |
|---|---|---|---|
| 15 | 7.62 | 3.60 | 4.44 |
| 20 | 9.46 | 4.46 | 5.51 |
| 25 | 11.18 | 5.27 | 6.51 |
| 30 | 12.82 | 6.05 | 7.47 |
| 35 | 14.39 | 6.79 | 8.38 |
| 40 | 15.91 | 7.51 | 9.27 |

+ Metabolisable energy.
++ Digestible energy calculated according to ME = 0.81 x DE (Armstrong, 1964).

Little is known presently of the maintenance requirements of sheep under outdoors especially under grazing conditions in tropical environments. Obviously, these requirements will be considerably higher than pen-fed values, and the magnitude of this difference is presently unknown. Studies need to be directed at this and other aspects on the nutrition of sheep in Malaysia.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## SUMMARY

The energy requirement for maintenance of pen-fed adult indigenous sheep is reported. This is based on data from 51 digestibility trials involving 671 sets of data which included the main daily intake of digestible organic matter (D), mean live weight (W) and the mean daily change in live weight (G). Calculation of the mean maintenance requirement was achieved from the general formula $D = a\ W^k + b\ G$. The data was first grouped into three categories: G = 0, −ve or +ve and calculations made of k, the exponent relating body weight to surface area, but statistically significant differences ($P<0.01$) were found between these. The mean values and ranges of the values were W = 21.6 kg (15.5 − 27.7 kg) and G = −0.02 (−0.5 − +0.5 kg).

Since an accurate calculation of maintenance is best established when G = 0 in energy equilibrium, the corresponding equation was found to be D = 0.0301 $W^{0.748}$ + 0.012 G (± 0.033). It was calculated that the mean maintenance requirements was 471.8 KJ ME/$W^{0.75}$kg/day. This value falls within the range of several values reported for sheep in temperate environments and is approximately similar to the value of 487.5 KJ ME/$W^{0.75}$ kg/day reported for tropical sheep in the West Indies. It is stressed that under grazing conditions outdoors, the maintenance requirements would be considerably higher, and remains to be determined. Practical recommendations are given for indigenous sheep in Malaysia in a table of maintenance requirements in the body weight range 15–40 kg.

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