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# Energy requirements for pregnancy and some reproductive characteristics of Kedah-Kelantan, Brahman x Kedah-Kelantan crossbred and buffalo heifers

(Keperluan tenaga untuk kebuntingan dan beberapa ciri pembiakan lembu dara Kedah-Kelantan, kacukan Brahman x Kedah-Kelantan dan kerbau)

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Key words: energy requirements, pregnancy, reproductive characteristics, Kedah-Kelantan, Brahman x Kedah-Kelantan, buffalo, heifers

**Abstrak**

Perbandingan persamaan-persamaan yang diterbitkan daripada kajian-kajian perbezaan baka dan keadaan persekitaran menunjukkan bahawa peningkatan berat badan dan jumlah tenaga terkumpul sebagai fetus dan tisu-tisu yang berkaitan dengan lembu bunting mempunyai corak yang sama. Dengan menggunakan persamaan-persamaan ini, keperluan tenaga metabolisme (ME) semasa bunting bagi baka tempatan Kedah-Kelantan (KK), baka kacukan Brahman x KK (BK) dan kerbau sawah (SB) dara telah dianggarkan dan diselaraskan untuk berat fetus serta tempoh bunting. Berat anak semasa lahir dan tempoh bunting ketiga-tiga baka telah ditentukan dan kedua-dua parameter ini didapati berbeza secara ketara ($p$ <0.05). Selain mempunyai hubungan, kedua-dua parameter ini berkait secara langsung dari segi saiz baka. Baka KK, iaitu yang paling kecil, melahirkan anak yang paling kecil dalam tempoh bunting yang paling pendek (15.6 kg dan 280 hari) diikuti oleh BK (22.1 kg dan 286 hari) dan SB (29.7 kg dan 330 hari). Keperluan ME harian pada 3 bulan terakhir bunting untuk ketiga-tiga baka telah dianggarkan dan keperluan ME semasa bunting ialah 15.1, 19.9 dan 27 MJ/hari bagi KK, BK dan SB. Keputusan ini menunjukkan bahawa keperluan harian ME semasa bunting bagi KK, BK dan SB masing-masing dianggarkan sebanyak 37, 50 dan 48% daripada keperluan saraan badan ibu. Nilai-nilai ini lebih rendah daripada 75–80% yang biasa dilaporkan untuk lembu kerana perbezaan berat anak.

**Abstract**

Comparison of published equations derived from experiments based on different breeds and environments, indicated that liveweight development, amount of energy deposited as fetus and the associated tissues of pregnancy in cattle, followed similar patterns. Based on this result, the metabolisable energy (ME) requirements for pregnancy of the indigenous Kedah-Kelantan (KK), Brahman x KK crossbred (BK) and swamp buffalo (SB) heifers were estimated using published equations, adjusted for fetal weight and gestation length. Calf weight at birth and gestation length of the three breeds were determined, and the two parameters were found to differ significantly ($p$ <0.05) between breeds. Besides

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being related to each other, these two parameters were directly related to their breed size. KK, being the smallest breed, produced the lightest calf in the shortest gestation length (15.6 kg and 280 days) followed by BK (22.1 kg and 286 days) and SB (29.7 kg and 330 days). The daily ME requirements at different stages during the last trimester of gestation for the three breeds were estimated and the requirements at term of pregnancy were 15.1, 19.9 and 27.6 MJ/day respectively for KK, BK and SB. These results suggested that the daily ME requirements for pregnancy at term of pregnancy were 37, 50 and 48% for KK, BK and SB respectively for maintenance of the respective maternal body. These values were lower than the 75–80% generally reported for cattle because of differences in the calf weights.

## Introduction

A research programme was initiated at MARDI to establish the nutrient requirements for the common breeds of cattle and buffalo, with the objective to examine the relevance of information derived from overseas to the local situation. The results of several experiments which centered on the energy and protein requirements for maintenance and growth have been reported earlier (Devendra and Wan Zahari 1981; Liang et al. 1988). This study aims to continue to provide information on the energy requirements for pregnancy of local cattle and buffaloes.

Energy requirements for pregnancy of cattle have been extensively studied (Jakobsen et al. 1957; Hashizume et al. 1965; Moe and Tyrrell 1972; Ferrell, Garrett and Hinman 1976; Ferrell, Garrett, Hinman and Grichting 1976; Koong et al. 1982; Yoshida et al. 1983). Ferrell, Garrett and Hinman (1976), and Yoshida et al. (1983) further suggested mathematical equations to describe the weight development and energy gain of fetus, and the associated materials of pregnancy (fetal fluid, fetal membrane and uterus) for cattle. It was also suggested that the estimates from the different equations resemble each other if adjustments were made for differences in weight of fetus at birth and gestation length (Ferrell, C. L., USDA, pers. comm. 1988).

Based on these assumptions, the metabolizable energy (ME) requirements for pregnancy of the indigenous Kedah-Kelantan cattle (KK), Brahman x KK crossbred (BK) and swamp buffalo (SB) were estimated using published equations adjusted for birth weights and gestation lengths. It is hoped that the results obtained from this study would provide information on the pregnancy requirements of cattle and buffalo under local conditions. In addition, the results would also enable us to compare how the requirements may differ from those recorded for similar animals in other countries.

## Materials and methods

### *Comparison of published equations*

The assumption that the physical weight development, the amount of energy deposited as fetus and the associated tissues of pregnancy in cattle follow similar patterns irrespective of breed type, was tested by comparing the fetal fresh weight (FFW) and gravid uterus energy content (GUE) using the following equations.

$$\text{FFW (g)} = 5.839\, e^{(0.0512 - 0.0000707T)T} \text{ ...... (Ferrell, Garrett and Hinman 1976)}$$

$$\text{FFW (kg)} = 0.00050013 + 0.054234T - 0.00087628T^2 + 0.0000040557\, T^3 \text{ ...... (Yoshida et al. 1983)}$$

$$\text{GUE (kJ)} = 291.75\, e^{(0.0323 - 0.0000275T)T} \text{ ...... (Ferrell, Garrett and Hinman 1976)}$$

$$\text{GUE (kJ)} = 3\,169.593 + 552.769T - 7.59329T^2 + 0.0296277\, T^3 \text{ ...... (Yoshida et al. 1983)}$$

Where $T$ = day of gestation

The FFW was selected for this comparison because fetus forms the major part of the total tissue development while the GUE represents the total energy deposited in pregnancy.

***Determination of calf weight and gestation length***

Koong et al. (1982) suggested the use of a correction factor for calf weight, when adopting published equations to calculate requirements for pregnancy. For this purpose, 11 KK, 10 BK and 12 SB heifers of similar age (approximately 30 months old) were used in this study (*Table 1*).

The heifers were fed daily with 1.5-2.5 kg concentrates (depending on their body weight) and cut grass *(Setaria sphacelata)* ad lib. The crude protein content of the diet was 85 g/kg dry matter (DM) while the ME content, estimated by digestion trial conducted previously (Liang et al. 1988), was 9.26 MJ/kg DM.

The heifers were synchronized for oestrus and mated by one bull per breed. Heifers which were found not pregnant (by rectal palpation) at 90 days after the end of the mating period (which lasted for about 1 week) were bred again in a second mating period following similar procedures as before. A few heifers were allowed to be mated when they showed signs of heat outside the fixed mating periods. At the end of the second mating period, 11 KK, 8 BK and 8 SB were pregnant and data from these 27 animals were used for this study.

Dates of mating and calving of the individual heifers were recorded for the calculation of their respective gestation length. Birth weight of calves was measured within 24 h after birth.

***Estimation of ME requirements for maintenance and maternal weight changes***

It was assumed that pregnant heifers had similar efficiencies of ME utilization for maintenance and growth as non-pregnant heifers did. This assumption was also adopted by Rattray et al. (1974), and Ferrell, Garrett, Hinman and Grichting (1976) for studies on sheep and cattle respectively. The ME requirements for maintenance and growth of KK, BK and SB heifers were estimated using the same animals prior to the start of this study and the results were reported previously (Liang 1987; Liang et al. 1988). Briefly, the heifers within each breed were randomly divided into three groups and were fed individually with low (near maintenance), medium or high (ad lib) energy-level intake. The ME requirements for maintenance and growth were estimated using a simple linear regression equation, ME intake/kg$^{0.75}$ = $a$ + $b$ ADG (ADG = the average daily gain of the heifers; coefficient $a$ and $b$ are the estimates of ME used for maintenance and for each unit of ADG respectively).

The estimated ME requirements for maintenance of KK, BK and SB heifers were 662, 494 and 584 kJ/kg$^{0.75}$ respectively. These values were used for calculating the daily ME requirements for maintenance of

Table 1. Some reproductive characteristics of the Kedah-Kelantan (KK), Brahman x KK crossbred (BK) and swamp buffalo (SB) heifers

| Parameter | KK | BK | SB |
|---|---|---|---|
| No. of heifers used | 11* | 10 | 12 |
| No. of pregnancy | 11* | 8 | 8 |
| Wt. of heifers at mating (kg) | 209.9(11.5)c | 312.4(49.8)b | 383.4(44.2)a |
| Wt. of heifers post-partum (kg) | 247.2(15.3)c | 344.6(27.3)b | 459.9(28.1)a |
| Av. daily gain (g) | 120* | 120 | 220 |
| Calf wt. (kg) | 15.6(2.6)c | 22.1(5.5)b | 29.7(4.8)a |
| Gestation length (days) | 279.9(2.9)c | 285.9(6.2)b | 330.3(2.2)a |

Values ( ) indicate standard error

Values in the same row with different letter differ significantly ($p$ <0.05)

*Values in the same row not statistically compared

Table 2. Estimated daily ME requirements for maternal maintenance and pregnancy during the last trimester of pregnancy for Kedah-Kelantan (KK), Brahman x KK (BK) and swamp buffalo (SB) heifers

| Breed | Body wt. (kg) | Daily ME requirement (MJ) | Pregnancy at weeks before parturition | | | | |
|---|---|---|---|---|---|---|---|
| | | | 16 | 12 | 8 | 4 | At term |
| KK | 250 | 41 | - | 3.5 | 6.1 | 9.8 | 15.1 |
| BK | 350 | 40 | - | 4.7 | 8.0 | 13.0 | 19.9 |
| SB | 450 | 57 | 4.5 | 7.7 | 12.5 | 19.1 | 27.6 |

*Maintenance for KK, BK and SB = 662, 494 and 584 kJ ME/$kg^{0.75}$ respectively

maternal body (*Table 2*).

Maternal liveweights (MLW) of the heifers at times of mating, mid and late gestation were recorded to monitor maternal body weight change of individual animal. Since MLW measured at different times of the gestation period represent those of the maternal body weights plus their respective conceptus weights, these MLW values were later corrected for this bias. The corrected maternal weight (CMW) was calculated as MLW minus conceptus weight (1.5 x FFW) estimated at different times of gestation, corresponded to the particular MLW measurement. The factor 1.5 was used to represent the ratio of conceptus to fetal weight and was previously used by Koong et al. (1982).

### *Estimation of ME requirements for pregnancy*

The equations suggested by Ferrell, Garrett and Hinman (1976) were adopted for this study because of the larger number of animals used in their experiment, compared with that of Yoshida et al. (1983) (46 animals vs. 12 animals). These equations which estimate the dynamic growth of the different parameters of pregnancy over time were developed from data obtained from 46 heifers slaughtered at different stages of gestation. The fetal weight at parturition (286 days of gestation) was estimated as 41.1 kg. Therefore, a correction factor, $Q$, based on the birth weight of the calves as suggested by Koong et al. (1982) was used in the estimations. $Q$ = Calf birth weight ÷ $[5.839 \times e^{(0.0512 - 0.0000707T)T}]$. The denominator represents the calculated birth weight as a function of gestation length *(T)* as shown by Ferrell, Garrett and Hinman (1976). The following equations were used to calculate FFW and GUE of the individual animals.

$$\text{FFW (g)} = [5.839\ e^{(0.0512 - 0.0000707T)\,T}]\ Q$$
$$\text{GUE (kJ)} = [291.75\ e^{(0.0323 - 0.0000275T)\,T}]\ Q$$

The rate of energy storage in the gravid uterus was used as a measure of the total energy requirements for pregnancy. This energy represented the net energy requirements of pregnancy ($NE_{preg}$). To calculate metabolisable energy for pregnancy ($ME_{preg}$), the $NE_{preg}$ values were divided by the efficiency of ME utilization for pregnancy. A 14% efficiency, as reported by Ferrell, Garrett and Hinman (1976), was used for the calculation of $ME_{preg}$.

### *Statistical analysis*

Differences between breeds were compared using an analysis of variance on the observations for the weight of heifers at mating, weight of heifers at post-partum, calf weight and the gestation length.

## Results and discussion

### *Comparison of published equations*

Results of the comparisons of FFW and GUE using the suggested equations are shown in *Figure 1*. The slight differences between the estimates from the two sources for FFW and GUE were due to breed differences in calf weight at birth (41.1 kg and 38.2 kg respectively for Ferrell, Garrett and Hinman 1976, and Yoshida et al. 1983). In addition, the differences in the GUE values could also be affected by the variations in the determination of the energy content of the fetus and the associated materials of pregnancy by the two groups of workers. However, when the FFW and GUE values were expressed as percentages of the predicted weights at parturition (to correct for weight differences), the curves estimated from the equations of different sources overlapped each other (*Figure 1*). These results agree with the assumption that the rate of weight development and energy deposition of fetus, and the associated tissues of pregnancy in cattle follow similar patterns, irrespective of breed types. Since the two experiments, conducted using different breeds of cattle (Hereford and Japanese beef cattle) which produced calves of different birth weights and were managed under different environments, showed similar results, it is assumed that the same equations could be adopted for this study.

***Reproductive characteristic of different breeds***

Although it was not the primary objective of this study to compare the reproductive characteristics of the different breeds, results of some of the parameters measured provided relevant comparisons because of the uniformity in age and management of

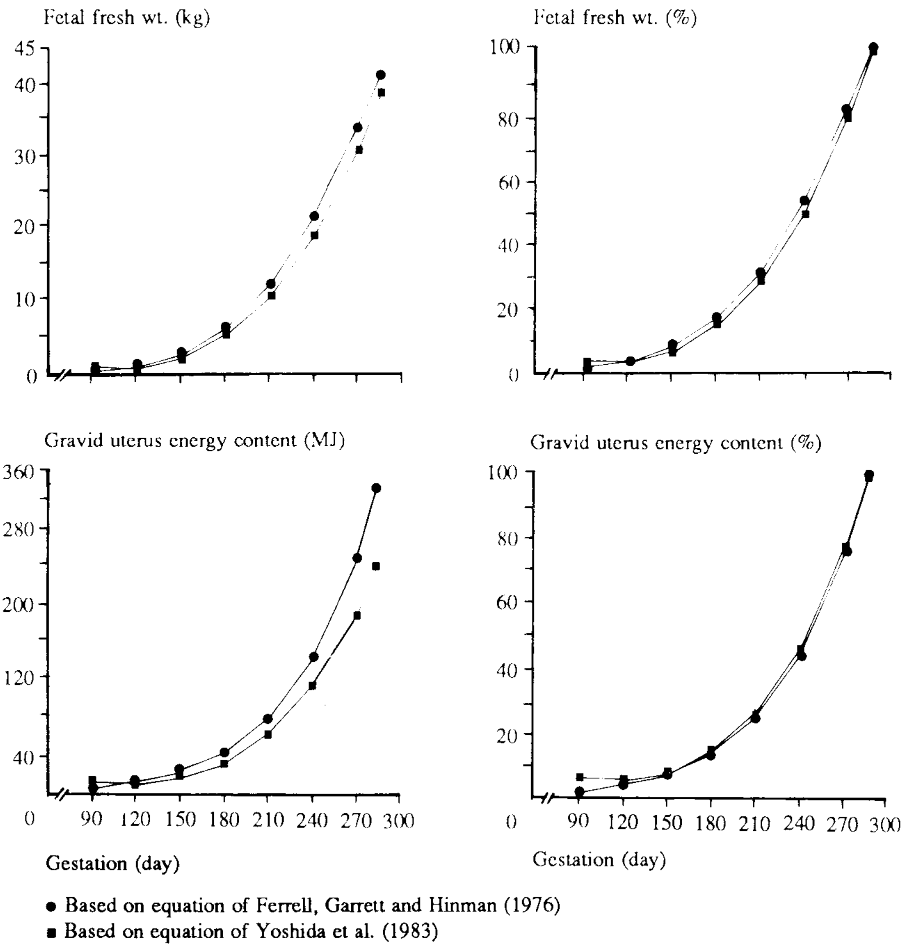


*Figure 1. The estimated fetal fresh weights, fetal fresh weights as percentages of the predicted weights at parturition gravid uterus energy content and gravid uterus energy content as percentages of the predicted energy contents at parturition at different times of gestation period*

the animals. The higher fertility rate of KK over those of BK and SB (*Table 1*) further confirmed the common observation that the indigenous KK is a highly reproductive cattle (Ng 1987). On the other hand, buffalo is generally less fertile than cattle when comparing reproductive traits such as age at puberty, age at first parturition and calving interval (Jainudeen 1985).

The mean calf weights and mean gestation lengths were found to differ significantly between breeds *(Table 1)*. Besides being related to each other, these values were directly related to their breed size. That is, KK, being the smallest breed produced the lightest calf in the shortest gestation length (15.6 kg and 280 days) followed by BK (22.1 kg and 286 days) and SB (29.7 kg and 330 days).

The mean calf weights recorded for the different breeds were found to be close to the 15.3 kg reported for KK (Devendra et al. 1973), 21.0 kg for BK (Ariff 1986) and 31.0 kg for SB (Liang et al. 1982) while the values for gestation length were within the range reported for cattle and buffaloes (Andersen and Plum 1965). Therefore, the values obtained in this study could be used as representatives of the mean calf weight and mean gestation length for the respective breeds studied.

Almost all the heifers recorded MLW gain during the experimental period. The overall gains, averaged 0.1 kg for KK and BK, and 0.2 kg for SB were mainly attained during the first, second and early part of the third trimester of pregnancy (*Figure 2*). The CMW gains showed a similar trend to that of MLW gains during the first and second trimester but remained unchange (for BK) or declined (for KK and SB) during the last trimester of gestation (*Figure 2*). It is most unfortunate that intake data were not available to examine the relationships between energy intakes and CMW changes during the course of pregnancy. Nevertheless, feeds were provided in sufficient quantities to animals at all times during the study. Perhaps, the CMW changes would have been more favourable if better quality feeds were used, particularly during the last trimester of pregnancy. In addition, it has been observed that food intake of ruminants tends to be depressed in late pregnancy. This phenomenon which Forbes (1968) attributed to the increasing size of uterus and a resulting lower rumen capacity could also affect the CMW changes of the heifers during the late pregnancy of this study.

***ME requirements for pregnancy***

The estimated FFW and GUE, from 90 days of gestation to parturition, for KK were always lower than those for BK and SB because of the lighter fetal weight *(Figure 3)*. The small fetus of KK could be an adaptation feature unique to the KK to minimize its energy requirements (probably other nutrients as well) and thus, to reduce excessive retrieval of energy and other nutrients from the maternal body during pregnancy.

Although the calf weight of SB was approximately twice that of KK and one-third that of BK, its rate of fetal growth did not increase in the same proportion (*Figure 3*). This is because the growth extends over a longer gestation period (330 days). This feature is again of advantage to the pregnant buffalo cows as otherwise the daily demand for energy would be much higher if the buffalo cows were to produce their calves of the same weight within the same gestation length as that of cattle (280–286 days).

The estimated daily ME requirements for pregnancy are less than 10% of that for maintenance of maternal body up to about the sixth month of pregnancy. Hence, only the requirements during the last trimester of gestation were calculated and presented in *Table 2*. Results of this analysis suggest that the daily requirement for energy at term of pregnancy for KK, BK and SB was 37, 50 and 48% respectively of that for the maintenance of maternal body. The much lower value for the KK was partly due to

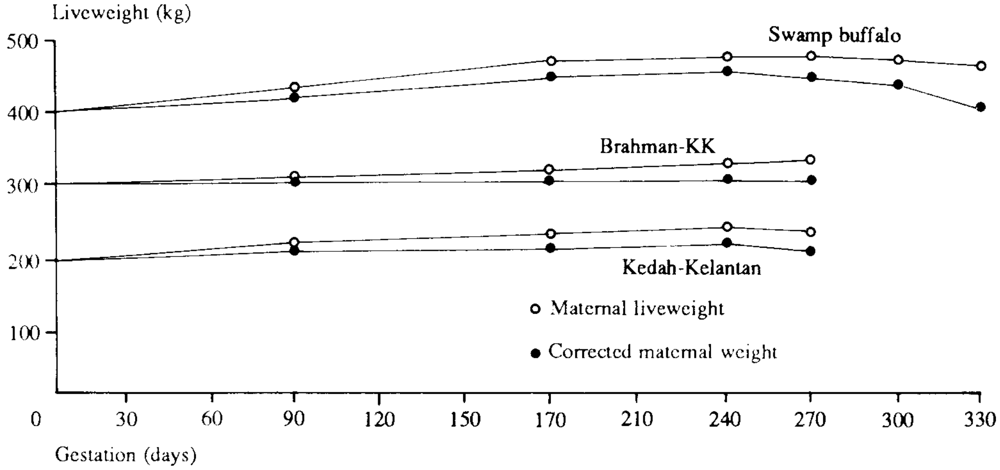


*Figure 2. Maternal liveweight and corrected maternal weight of Kedah-Kelantan, Brahman-KK and swamp buffalo at different times of gestation*

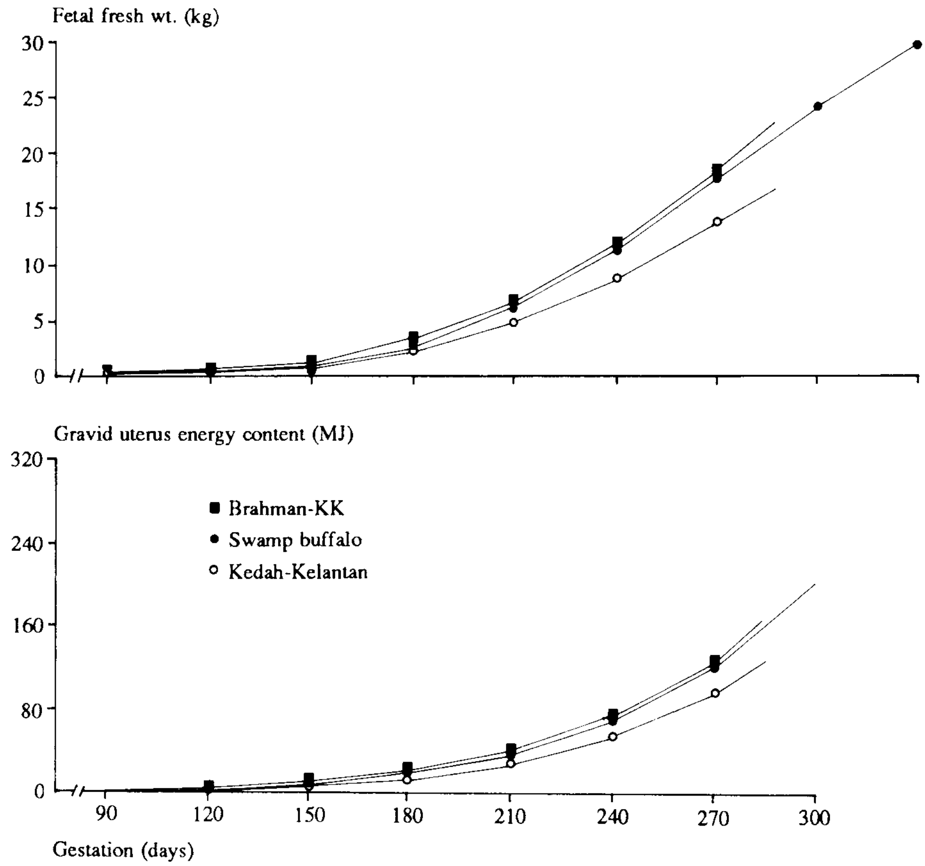


*Figure 3. Estimated fetal fresh weight and gravid uterus energy content of Kedah-Kelantan, Brahman-KK and swamp buffalo at different times of gestation*

Table 3. Comparison of the estimated daily ME requirements for pregnancy above maintenance with published data

| Breed | Calf wt. (kg) | Daily ME requirement (MJ) weeks before parturition | | | | Source |
|---|---|---|---|---|---|---|
| | | 12 | 8 | 4 | At term | |
| KK | 15.6 | 3.5 | 6.1 | 9.8 | 15.1 | This study |
| BB | 22.1 | 4.7 | 8.0 | 13.0 | 19.9 | |
| SB | 29.6 | 7.7 | 12.5 | 19.1 | 27.6 | |
| Standard | na | 7 | 10 | 14 | 20 | Anon. (1984) |
| Standard | 40 | 8.2 | 14.2 | 24.7 | 42.9 | Anon. (1980) |
| Friesian | 42 | 8.6 | 14.9 | 25.9 | 45.0 | Anon. (1980) |
| Ayrshire | 32 | 6.5 | 11.4 | 19.7 | 34.3 | Anon. (1980) |
| Jersey | 24 | 4.9 | 8.5 | 14.8 | 25.7 | Anon. (1980) |
| Hereford | 41.1 | 7.9 | 13.6 | 22.5 | 34.9 | Ferrell, Garrett and Hinman (1976) |
| Japanese beef | 38.2 | 4.7 | 8.6 | 13.6 | 19.7 | Yoshida et al. (1983) |

the high maintenance requirement (on similar body weight basis) estimated for the maternal body. These values are close to the 44% suggested by MAFF (Anon. 1984) but lower than the 75–80% generally reported for cattle which produce much larger calves (Moe and Tyrrell 1972; Anon. 1980). Comparison of the estimated values of this study with published data is presented in *Table 3*. The slight variations in the estimates from the different sources were no doubt due to differences in fetal weights and in the case of SB, the gestation length as well.

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