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# Physiological responses of exotic sheep to different management systems in the humid tropics

(Tindak balas fisiologi bebiri eksotik terhadap sistem pengurusan yang berbeza di kawasan beriklim tropika berkelembapan tinggi)

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Key words: temperate sheep, tropics, adaptability, water turnover, thyroid hormones

**Abstract**

A study was conducted on 40 (10 of each breed) newly imported Dorset Horn, Suffolk, Border Leicester and Corriedale rams to evaluate their climatic adaptability in the shed and grazing under orchards in the humid tropics. Measurements on rectal temperature, respiration rate, pulse rate, plasma tri-iodothyronine, thyroxine and the ratio of tri-iodothyronine to thyroxine in the morning and afternoon, water turnover rate, half life and total body water, in the shed and during grazing were taken. These results indicated that Dorset Horn had better climatic adaptability compared with the other breed. The Border Leicester had similar adaptability as Dorset Horn but Suffolk and Corriedale breeds had difficulty maintaining body heat.

**Abstrak**

Satu kajian telah dilakukan terhadap 40 (10 ekor setiap baka) bebiri jantan baka Dorset Horn, Suffolk, Border Leicester dan Corriedale yang baru diimport bagi menilai ketersesuaian iklimnya di dalam kandang dan meragut di bawah pohon buah-buahan di kawasan tropika yang berlembapan tinggi. Bacaan suhu rektum, kadar pernafasan, denyutan nadi, plasma tri-iodotironin, tiroksin, nisbah tri-iodotironin kepada tiroksin, pulangan air, waktu paruhan dan kandungan air tubuh semasa di dalam kandang dan meragut di bawah pohon buah-buahan telah diambil. Data-data ini menunjukkan bahawa baka Dorset Horn mempunyai ketersesuaian iklim yang lebih baik dibandingkan dengan baka-baka lain. Baka Border Leicester mempunyai ketersesuaian yang sama seperti baka Dorset Horn. Baka-baka Suffolk dan Corriedale pula mempunyai kesukaran untuk menetapkan suhu tubuhnya.

## Introduction

Malaysia has imported thousands of sheep from Australia to boost her sheep industry. The sheep are used to produce crossbreds to improve the productivity of the local breed. It is, however, found that the reproductive performance of the exotic sheep is not very encouraging. The rams had poor libido and semen quality (Abdul Wahid, Jaafar et al. 1988; Murugaiyah and Abdul Wahid 1989) and a large number of the ewes were not reproducing (Fazlullah, I., MARDI, Serdang, pers. comm. 1989). These were attributed mainly to anestrous (Dollah, M. A. and Moh

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Salleh, R., Reproductive status and thyroid activity of imported Dorset Horn ewe, MARDI, Serdang, unpublished 1988). One of the underlying causes is environmental heat stress as the result of high environmental temperature, solar radiation and humidity. High humidity causes the animals to have difficulty in maintaining body heat since heat dissipation through evaporation under high humidity is reduced. To maintain their normal body temperature, these animals must dissipate the excess body heat mostly by increasing the evaporative heat lost, i.e., through increased water consumption (Dollah and Zakaria 1986). The metabolic rate of these animals was also reduced as observed by their low plasma thyroxine and tri-iodothyronine values (Dollah and Moh Salleh, unpublished 1988). The secretion of these hormones are depressed by environmental heat (Johnson 1980) and a similar effect was also observed in other species of ruminant (Johnson 1967: Dollah et al. 1986).

A study was conducted on four different breeds of imported rams to evaluate their relative heat balance and metabolic status during the first year of arrival to the humid tropics of Malaysia. The heat balance of these rams was studied by measuring water turnover rate while the metabolic status of the rams was studied by monitoring their plasma tri-iodothyronine and thyroxine levels. Other physiological responses measured were rectal temperature, pulse rate and respiration rate.

## Materials and methods

The four exotic breeds of sheep used were Dorset Horn, Suffolk, Border Leicester and Corriedale. Each breed group consisted of 10 heads of unshorn rams aged 2–3 years. The rams were imported by ship from Australia and were used about 1 month after arrival.

The study consisted of two parts, each of 3-month duration. In the first part of the study, the sheep were kept continuously in the shed. The animals were fed ad libitum with cut grass in the morning and 1 kg of concentrate supplementation per animal in the afternoon. Drinking water and mineral lick were made available to the animals at all times.

In the second part of the study, the animals were released to graze native pasture under mango trees from 0900 h until 1500 h followed by concentrate supplementation in the shed. Water was available to the animals during grazing and in the shed while the mineral lick was only available in the shed.

### *Measurements*

Rectal temperature, respiration rate, pulse rate, water turnover rate and plasma tri-iodothyronine and thyroxine were measured simultaneously at noon, at weekly intervals. Rectal temperature was measured using an electronic thermometer while respiration rate was measured by counting the movement of the ribs. Pulse rate was measured by counting the pulse felt at the carotid artery.

Water turnover rate was measured once in the middle of each experimental period (Dollah 1989). Plasma tri-iodothyronine and thyroxine were also analysed from morning as well as afternoon samples taken on the same day. Samples were analysed by a radio-immunoassay technique using kits purchased from Ammersham, England.

Dry bulb, wet bulb and black globe (BG) temperatures, and relative humidity were recorded daily. The black globe index (BGI) was then calculated using the formula of Buffington et al. (1985)

$$BGI = BG \pm 0.36 \times DP \pm 41.5$$

where DP = dew point value obtained from a table using the wet and dry bulb temperature values.

### *Statistical analysis*

The analysis of variance was performed separately for each part of the study to compare the breed effect on the following parameters: rectal temperature, respiration rate, pulse rate, water turnover rate, half life

of water and total body water (water space). The effects of breed and time of sampling were only analysed for plasma tri-iodothyronine, thyroxine and the ratio of tri-iodothyronine to thyroxine values. Duncan multiple range test was performed to compare the mean differences between breeds when breed effect was found to be significant.

## Results and discussion

### *In shed*

Black globe index value in shed (79.2 °C) was slightly higher than the comfort value (75 °C) suggested for temperate breeds (Buffington et al. 1985). The black globe index was also higher than the value reported under different types of roofing such as asbestos and aluminium (Engku Azahan, E.A., MARDI, Serdang, pers. comm. 1989) which indicated that radiant heat in the shed with asphalt roofing was high and possibly could be reduced by using a different roofing material.

There were significant differences among breeds ($p<0.05$) with regard to rectal temperature, respiration rate, pulse rate, tri-iodothyronine, thyroxine levels and water turnover rate *(Table 1)*. Plasma levels of tri-iodothyronine and thyroxine were significantly higher in the morning than in the afternoon in these animals. The ratio of tri-iodothyronine to thyroxine, half life of water and total body water content were similar for all breeds ($p>0.05$).

The animals in the shed probably responded to the high body heat by transferring the internal body heat to the peripheral areas as indicated by the high rectal temperature and pulse rate as compared with those of the local breed of sheep (Abdul Wahid 1986; Abdul Wahid, Dollah et al. 1988). The Dorset Horn had the highest heat load, followed by Border Leicester and Suffolk while Corriedale had the lowest body heat (low both in rectal temperature and pulse rate, *Table 1*). Body heat of Dorset Horn was high possibly due

Table 1. Physiological responses of rams of four exotic breeds in the shed*

| Parameter | Dorset Horn | Border Leicester | Suffolk | Corriedale |
|---|---|---|---|---|
| Body weight (kg) | 60.8 ± 3.2A | 57.4 ± 5.2B | 56.7 ± 4.2B | 46.1 ± 7.0C |
| Rectal temperature (°C) | 40.3 ± 0.1A | 40.1 ± 0.1B | 39.8 ± 0.4B | 39.6 ± 0.5B |
| Pulse rate (beats/min) | 66 ± 7A | 65 ± 6A | 63 ± 7A | 53 ± 4B |
| Respiration rate (beats/min) | 137 ± 10 | 135 ± 10 | 127 ± 17 | 129 ± 15 |
| Plasma thyroid hormones | | | | |
| Morning | | | | |
| $T_3$ (ng/mL) | 0.70 ± 0.12A | 0.81 ± 0.21Aa | 0.66 ± 0.31A | 0.44 ± 0.14B |
| $T_4$ (ng/mL) | 40.7 ± 5.5A | 39.4 ± 5.6A | 32.7 ± 4.8B | 32.0 ± 7.3B |
| $T_3/T_4$ ( x $10^{-2}$) | 1.7 ± 0.7AB | 2.0 ± 0.7A | 2.1 ± 0.6A | 1.4 ± 0.05B |
| Afternoon | | | | |
| $T_3$ (ng/mL) | 0.75 ± 0.11A | 0.63 ± 0.23ABb | 0.49 ± 0.21B | 0.55 ± 0.19B |
| $T_4$ (ng/mL) | 49.3 ± 7.6A | 37.8 ± 7.8B | 36.3 ± 5.1B | 38.5 ± 8.6B |
| $T_3/T_4$ ( x $10^{-2}$) | 1.5 ± 0.2 | 1.7 ± 0.5 | 1.3 ± 0.3 | 1.4 ± 0.4 |
| Water metabolism | | | | |
| Turnover rate (mL/day/$kg^{0.82}$) | 163.7 ± 33.5A | 181.9 ± 34.8A | 207.6 ± 9B | 211.0 ± 38.8B |
| Half life (days) | 6.7 ± 1.2 | 6.1 ± 1.3 | 5.3 ± 1.6 | 5.5 ± 1.3 |
| Total body water (% bw) | 73 ± 2 | 73 ± 8 | 71 ± 6 | 81 ± 6 |

± = standard deviation, $T_3$ = tri-iodothyronine, $T_4$ = thyroxine

ABCD comparison of means between breeds at the same time significant at $p<0.05$

ab comparison of means between time of the same breed significant at $p<0.05$

*black globe humidity index = 79.2 °C

to the high metabolic rate as indicated by the higher plasma tri-iodothyronine and thyroxine levels compared with the other breeds. The positive relationship between thyroid hormone levels and the metabolic rate has been reported elsewhere (Johnson 1967, 1980). Increased metabolic rate in Dorset Horn was due to increased thyroid activity rather than the conversion of thyroxine to tri-iodothyronine because differences in the ratio of tri-iodothyronine to thyroxine among all breeds were not significant. Similarly, thyroid gland activity in the Border Leicester, Suffolk and Corriedale was the result, presumably, of the physiological changes that occurred during the process of acclimatization to reduce heat production (Johnson 1967).

The water turnover rates differed among breeds, reflecting differences in the water requirements for dissipating excess body heat through evaporative cooling to maintain body temperature. The Suffolk and Corriedale consumed the highest amount of water despite having lower metabolic rates. Furthermore, the total body water of Corriedale which tended to be higher than those of other breeds, probably reduced the heat load in this breed (Dollah et al. 1986). Dorset Horn and Border Leicester consumed less water than the other breeds and the amounts were comparable with the values reported earlier (Dollah and Zakaria 1986). Since there is a positive correlation between water turnover rate and the amount of heat dissipated by the animals (Kamal 1982), it can be concluded that Dorset Horn and Border Leicester kept in the shed had lower heat load but Dorset Horn was able to maintain higher metabolic status without showing signs of chronic heat stress.

*Under grazing*

The black globe index (93.5 °C) was much higher than that in the shed (79.2 °C). This was attributed mainly to direct solar radiation. There were significant differences between breeds with regard to pulse rate, respiration rate, plasma thyroxine level and water turnover rate *(Table 2)*. There were no breed differences with respect to rectal temperature, plasma tri-iodothyronine, the

Table 2. Physiological responses of rams of four exotic breeds to grazing conditions*

| Parameters | Dorset Horn | Border Leicester | Suffolk | Corriedale |
|---|---|---|---|---|
| Body weight (kg) | 67.1 ± 1.7B | 62.5 ± 1.3C | 69.9 ± 2.2A | 50.5 ± 3.2D |
| Rectal temperature (°C) | 40.1 ± 0.8 | 40.3 ± 0.9 | 40.4 ± 0 | 40.1 ± 0.7 |
| Pulse rate (beat/min) | 71 ± 7C | 90 ± 5A | 74 ± 4C | 80 ± 5B |
| Respiration rate (beat/min) | 74 ± 10C | 109 ± 9B | 118 ± 10B | 127 ± 8A |
| Plasma thyroid hormones: | | | | |
| Morning | | | | |
| $T_3$ (ng/mL) | 0.81 ± 0.34 | 0.68 ± 0.34 | 0.84 ± 0.23 | 0.73 ± 0.22 |
| $T_4$ (ng/mL) | 40.9 ± 12.2A | 31.6 ± 6.0B | 41.4 ± 9.5A | 38.4 ± 5.6AB |
| $T_3/T_4$ | 2.1 ± 1.1 | 2.2 ± 1.1 | 2.1 ± 0.6 | 2.0 ± 0.7 |
| Afternoon | | | | |
| $T_3$ (ng/mL) | 0.73 ± 0.20A | 0.63 ± 0.18B | 0.64 ± 0.20B | 0.68 ± 0.18B |
| $T_4$ (ng/mL) | 35.4 ± 5.2AB | 32.0 ± 8.3B | 35.5 ± 7.0A | 43.7 ± 10.0A |
| $T_3/T_4$ | 2.1 ± 0.4A | 2.0 ± 0.5A | 1.8 ± 0.4 | 1.6 ± 0.5B |
| Water metabolism | | | | |
| Turnover rate (mL/day/kg$^{0.82}$) | 395 ± 20A | 383 ± 25A | 354 ± 20 | 383 ± 30A |
| Half life (days) | 2.7 ± 1.2 | 2.8 ± 1.1 | 3.1 ± 1 | 2.5 ± 1.1 |
| Total body water (% bw) | 73 ± 6 | 72 ± 9 | 71 ± 7 | 70 ± 5 |

± = standard deviation, $T_3$ = tri-iodothyronine, $T_4$ = thyroxine
ABCD comparison of means between breeds significant at $p<0.05$
*black globe humidity index = 93.5 °C

ratio of tri-iodothyronine to thyroxine, half life of water and total body water.

All breeds were able to maintain similar body temperature although there was a slight difference in the mechanism used to attain this temperature. Corriedale maintained body temperature by increasing body heat transfer through increasing blood circulation i.e. increase in pulse rate, while Border Leicester maintained body temperature by having a slower but deeper respiration to increase evaporative heat lost. Heat dissipation through the respiratory system might lead to alkalosis if it is prolonged. Dorset Horn, on the other hand, showed a moderate increase in pulse rate and a decrease in respiration rate.

Despite the high heat load, all breeds were generally able to maintain a similar metabolic status throughout the day as reflected by the similarity in the thyroid hormones level in the morning and the afternoon except for Suffolk where there was a tendency for the values to be lower in the afternoon. Among these breeds, Dorset Horn showed a relatively high metabolic status while Border Leicester had the lowest possibly because Dorset Horn was able to dissipate heat more efficiently through evaporative cooling. Water consumption of Dorset Horn increased 2.4 times while Border Leicester, Suffolk and Corriedale only increased 2.1, 1.7 and 1.8 times respectively. The increase in water consumption by Dorset Horn allowed this breed to maintain a higher metabolic rate and it could possibly maintain a high production capacity compared with other breeds.

It can be concluded that Dorset Horn had better adaptive performance both under shed and grazing under shady areas than Border Leceister, Suffolk and Corriedale. This superiority in climatic adaptation at the early period of their arrival in the tropics would suggest that among the four breeds studied, the Dorset Horn has a greater potential to be used in crossbreeding studies with the indigenous sheep.

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