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Effect of shearing on growth performance, water balance, thyroid activity and heat production of crossbred rams

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Key words: shorn, unshorn, growth rate, water turnover, thyroxine, triiodothyronine, heat production and crossbred rams

Abstrak

Kesan pencukuran bulu terhadap prestasi pembesaran bebiri kacukan F_1 antara bebiri tempatan (ISM) dan bebiri Dorset Horn (DH) telah dikaji pada dua kumpulan bebiri jantan yang sedang membesar. Bebiri ini dibiar meragut pada siang hari (pukul 8.00 pagi–3.00 petang) dan dikurung di dalam kandang pada sebelah malam. Bulu bebiri daripada salah satu kumpulan dicukur selepas bebiri tersebut mencapai umur 8 bulan dan terus dicukur pada setiap 6 bulan sehingga percubaan ini tamat.

Berat badan dan kadar pembesaran bebiri (yang berumur 16 bulan) yang dicukur (36.7 kg dan 50.7 g/hari) lebih tinggi daripada yang tidak dicukur (34.4 kg dan 44.0 g/hari). Bebiri yang dicukur mempunyai pulangan air (108 mL/hari/$kg^{0.82}$) yang lebih besar dibandingkan dengan bebiri yang tidak dicukur (87.1 mL/hari/$kg^{0.82}$). Aras hormon triiodotironin dan tiroksin dalam plasma bagi bebiri yang dicukur (0.80–1.08 dan 49.60–56.10 ng/mL) juga lebih tinggi daripada bebiri yang tidak dicukur (0.62–0.82 dan 39.8–42.0 ng/mL). Haba yang dihasilkan bagi bebiri yang dicukur (3.77–6.58 kcal/jam/$kg^{0.82}$) lebih tinggi apabila dibandingkan dengan bebiri yang tidak dicukur (3.38–5.38 kcal/jam/$kg^{0.82}$).

Kajian ini menunjukkan bahawa pencukuran bulu bebiri boleh meningkatkan prestasi pembesaran bebiri yang sedang membesar. Pencukuran bulu telah meningkatkan daya penyesuaian terhadap persekitaran dan keseimbangan hormon tiroksin dan triiodotironin yang telah dapat meningkatkan kadar metabolisme. Akibat daripada peningkatan proses-proses fisiologi tersebut, kadar pembesaran bebiri yang dicukur menjadi lebih baik. Oleh itu, adalah disarankan bahawa pencukuran bulu bebiri patut diamalkan sebagai salah satu komponen pengurusan bebiri kacukan F_1 terutama pada bebiri yang dipelihara dalam pastura terbuka.

Abstract

The effect of shearing on the growth performance of F_1 DH and ISM crossbreds was studied on two groups of growing rams. The sheep were released for grazing in the open pasture during the day (0800–1500 h) and kept in the shade at night. In one of the groups, the rams were shorn after they had reached the age of 8 months and then at 6 months intervals.

Body weight and growth rate of shorn rams up to the age of 16 months were significantly higher (p <0.05) than unshorn rams with the respective

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value of 36.7 kg and 50.7 g/day; and 34.4 kg and 44.0 g/day. The water turnover rate of the shorn rams (108 mL/day/$kg^{0.82}$) was higher (p <0.05) compared to the unshorn rams (87.1 mL/day/$kg^{0.82}$). The shorn rams also had significantly higher (p <0.05) plasma triiodothyronine and thyroxine (0.80–1.08 ng/mL and 49.60–56.10 ng/mL respectively) compared to unshorn rams (0.62–0.82 and 39.8–42.00 ng/mL respectively). The mean values of heat production were similarly higher (p <0.05) in shorn rams (3.77–6.58 kcal/h/$kg^{0.82}$) than the unshorn rams (3.38–5.38 kcal/h/$kg^{0.82}$).

The study concluded that shearing increased the growth performance of growing rams. The shearing had improved the heat and thyroid hormone balance which then improved the metabolic processes. It is therefore recommended that shearing should be practised as part of management system of F_1 crossbreds especially when they are managed under open grazing system.

Introduction

Dorset Horn (DH) is one of the exotic breeds of sheep that has been used in crossbreeding to improve the Indigenous Sheep of Malaysia (ISM). The F_1 DH x ISM crossbred has many superior characteristics over the indigenous animals. It has higher growth rate and subsequently bigger body size compared to the ISM while the adaptability to the hot tropical climate and diseases is better compared to the DH. However, the optimum genetic potential for production of this crossbred could not be exploited unless they are provided with good management system such as better quality feed, better health programme and low heat stress.

The growth of an animal is the result of many biochemical processes and it is controlled by hormones such as triiodothyronine (T3) and thyroxine (T4), secreted by the thyroid gland. The synthesis and secretion of the thyroid hormones are depressed by thermal stress (Johnson and Vanjonack 1976) and the poor performance of the animal under hot environment is associated with the depressive effect of thermal stress on endocrine glands.

Exotic sheep and their crossbred with thick wool raised in the hot-humid environment experienced heat stress as the wool became a body insulator which reduced the body heat transfer to its surrounding. Thus, increasing the heat dissipation rate by reducing the body insulation in sheep through frequent shearing will reduce the heat stress and improve the condition of the animals. Earlier studies indicated that low insulation increased water consumption (Dollah 1986; Dollah and Zakaria 1986) and the excess of water consumed was possibly used to dissipate the excess heat through evaporative cooling via the skin and the respiratory tract.

An experiment was conducted on growing F_1 DH x ISM crossbred rams managed in an open pasture to further understand the effect of climatic heat stress on the growth performance of sheep. The effect of wool shearing was studied in this experiment. Heat production estimated from oxygen intake and the levels of the plasma thyroid hormones (T3 and T4) were measured to study the metabolic status of the animals, while the water balance was studied by measuring the water turnover rate.

Materials and methods

Animals

Twelve 3-month-old F_1 DH x ISM male sheep, averaging 11.0 kg in body weight, were randomly chosen and used in the experiment. The animals were then randomly divided into two groups of equal numbers. One group was sheared (treatment group) when they reached about 8 months old whilst the other group was left intact (control). The shearing was carried out every 6 months.

All the animals were released for grazing between 0800 h and 1500 h on the same paddock of nitrogen fertilized Mardi digit (*Digitaria setivalva* Stent) pasture. No concentrate supplementation was given to the animals. Mineral licks were given in the shade while water was provided both in the shade and in the pasture. No shade was provided in the pasture. At night, the animals were kept in the shade.

Body weight

The animals were weighed every month until about 18 months old. The body weight of the control group (8–18 months) was subtracted from the weight of wool for comparison of weights between groups. The weight of wool was estimated using the data collected from another group of animals of the same breed and sex at various ages.

Heat production

The heat production of the animals was estimated by measuring the oxygen intake using an open circuit technique, before (0800 h) and immediately after grazing (1500 h). The animals were trained before any measurement was taken. The measurement was repeated at 6-month intervals.

In this method, a mask with one way air flow was attached to the face of the animals. The expired air was then measured for 4 min using a gas meter and the sample of the expired gas was taken immediately before the end of the measurement. The oxygen content in the gas samples was analysed using digital oxygen analyser (Morgan, Model 02–0A–500D, England). The oxygen content in the air (20.9%) was used as the standard to calibrate the analyser. The expired gas temperature and the atmospheric pressure were also recorded concurrently with the gas sampling. The total oxygen consumed by the animals per hour was calculated and the heat production was then estimated using the following equation (McLean 1972):

$$H = 4.89\ Vo\ X.$$

where

H = heat production (kcal/h)

Vo = volume of exhaled gas per hour at standard pressure and temperature

X = the difference (%) of oxygen in inhaled and exhaled gas

Thyroid hormones i.e. triiodothyronine (T3) and thyroxine (T4)

The blood samples were collected through jugular puncture using heparinised tubes in the morning (before the animals were released for grazing) and in the afternoon (immediately after the animals returned from grazing). The plasma was isolated from the blood by centrifugation at 3 000 rpm and 5 °C and frozen at −5 °C for later analysis. The samples were collected for two consecutive days at 6-month intervals.

The T3 and T4 were measured by a slightly modified radio-immuno-assay technique using the kits purchased from Amersham International plc. (England). To perform the assay, 50 μL of plasma samples or standard (T4 or T3) was pipetted into assay tubes. An amount of 500 μL of labelled hormone (either T4 or T3) and 500 μL of antibody solution to respective hormone were then added into the assay tubes. After mixing thoroughly for a few seconds, the mixture was left at room temperature for about 45 min. The tubes were later centrifuged at 5 °C at the speed of 3 000 rpm. The supernatant was decanted and the activity of radioiodine in the tubes was determined using the gamma spectrometer. The inter assay variability of the assay was less than 5%.

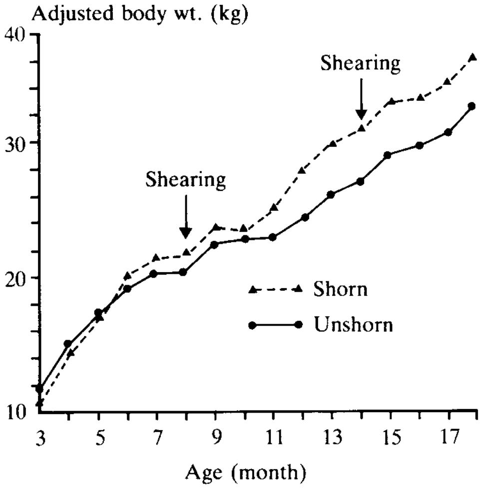

Figure 1. Growth performance of shorn and unshorn F_1 crossbred rams

Water balance

The water balance was studied by measuring the water turnover rate. This measurement was carried out 2 months before and 2 months after the shearing treatment was imposed to the treatment group. The procedure for water turnover measurement was similar to the procedure described earlier (Dollah and Zakaria 1986).

Statistical analysis

Data analysis to compare the difference between treatments was carried out using the statistical analysis package (SAS Institute Inc., Cary, U.S.A.). The value of the growth rate of each animal following shearing (age between 8 and 18 months) was calculated and used in the calculation to compare the treatment effects.

Results and discussion

The growth rate of the sheep in both groups at the early stage of the experiment (before the treated group was shorn) was similar. But 3 months following shearing, the growth rate of the shorn animals (50 g/day) was significantly superior ($p < 0.05$) over the unshorn animals (41 g/day) *(Figure 1)*. The result was consistent with earlier findings in lambs (Kneale and Bastiman 1977) and pregnant ewes (Rutter et al. 1972). It has been suggested that shearing increased the feed intake (Russel et al. 1985) although the time and period for grazing did not change (Austin and Young 1977; Love et al. 1978).

The mean body weight of the treated group at the beginning of the experiment was about 1 kg lighter than the control group but 3 months later, it was about 1 kg heavier than the control group. Following shearing (at 8 months old) the body weight of the treated group continued to increase reaching a plateau which was over 3 kg heavier than the control. There was a delay of about 3 months before the improved effect of shearing could be observed *(Figure 1)*. This delay could possibly be due to the increase in heat production and energy expenditure (Davey and Young 1977). Such effects may account for the initial loss or no change in liveweight (discounting the effect of weight of wool removed at shearing) compared with the unshorn sheep. This period therefore can be considered as the adaptation period to the shorn condition.

The mean body weight at 12 months old for unshorn and shorn sheep were 25.0 kg and 28.0 kg respectively. It has been reported that the body weights of F_1 crossbred of the same age under rubber and oil palm plantation were 35.6 kg and 30.8 kg respectively (Mohd. Khusahry, MARDI, Serdang, *pers. comm.* 1985). Higher environmental temperature and solar radiation in the pasture in this study possibly caused the lower growth rate (Hafez 1968; Terril 1968). In addition, the minimum feed inputs given (no concentrate) also contributed to the lower growth rate of these animals as compared with those previously reported.

Sheep, unlike other ruminants, is capable of storing high body heat during grazing and releases the excess heat when the environmental temperature is low. This phenomenon has been observed by Brown (1971) who indicated that the rectal temperature of sheep could reach 41.6 °C without showing any sign of hyperthermia. However, shearing which reduces the body insulation might improve the animals' capability to dissipate the excess body heat to the environment at night. This could off-set the effect of high body temperature occurred during the day. However, Kassim (1987) observed an opposite effect in that the shearing imposed heat stress.

Since the body heat was dissipated through evaporative cooling via respiratory track as well as via the skin, the water requirement therefore could be used to indicate the relative rate of heat dissipation of the animal (Kamal 1982). Thus, the shorn sheep which has higher water turnover rate (108.1 mL/day/kg$^{0.82}$) would have higher rate of heat dissipation as compared with unshorn sheep (87.1 mL/day/kg$^{0.82}$). Similar results were reported earlier on adult rams (Dollah 1986; Dollah and Zakaria 1986). The short wool reduced the body insulation and increased water evaporation through the skin. As a result the shorn sheep were able to maintain better dissipation of the body heat which then increased the feed intake and subsequently stimulated the improved growth performance. Although the feed intake of these animals was not monitored, a previous study confirmed that shearing increased the feed intake (Wodzicka-Tomaszewska 1963; Austin and Young 1977). The depressive effect of heat stress on feed intake has been well documented in small as well as large ruminants (Hafez 1968; Terril 1968).

The improved heat balance condition for the shorn sheep had been found to stimulate the thyroid gland activity. The T4 and T3 levels of the plasma in the morning (56.1 and 1.08 ng/mL respectively) and afternoon (49.6 and 0.80 ng/mL respectively) of the shorn sheep *(Table 1)* significantly ($p < 0.05$) higher than the unshorn sheep (42.0 and 0.82 ng/mL for morning and 39.8 and 0.62 ng/mL for afternoon, respectively for T3 and T4). The ratio between the T3 and T4 for shorn and unshorn groups (0.019 and 0.020) however was not significantly different. The result indicated that the shorn sheep had higher thyroid hormone levels in the morning and afternoon and this was the result of higher thyroid activity in synthesizing and releasing T3 and T4. On the contrary, the unshorn sheep experienced high heat stress especially during grazing which suppressed thyroid function (Premachandra et al. 1958; Gual 1973; Vanjonack and Johnson 1975a, b; Johnson and Vanjonack 1976).

Lower thyroid hormone levels in the afternoon for both shorn and unshorn sheep were possibly due to the heat stress during grazing. Although the physiological parameters to indicate the severity of heat stress were not recorded, the observation by Abdul Wahid et al. (1988) confirmed that rams had higher heat load in the afternoon compared with the morning. In cattle, the depressive effect of heat stress on thyroid gland function occurs one day after heat exposure (Johnson and Vanjonack 1976). However in this study, the heat response of thyroid gland was faster i.e. after 8 h heat exposure during grazing. It was possible that the solar radiation gave a faster inhibitory effect on the thyroid activity as compared with the high temperature effect in the climatic laboratory. Hafez (1968) reported that the solar radiation gave better response to increase body temperature as compared to the high environmental temperature.

The effect of time of the day (afternoon vs. morning) on thyroid hormone levels in this study was comparable to the condition of shorn vs. unshorn. This result further supports the fact that the low level of thyroid hormones

Table 1. Growth performance and some physiological parameters of shorn and unshorn sheep

Parameter	Shorn	Unshorn
Body weight		
Initial weight (kg)	21.4 ± 1.7^{A}	21.2 ± 5.4^{A}
Final weight (kg)	36.7 ± 2.0^{A}	34.4 ± 4.1^{B}
Growth rate (g/day)	50.7 ± 5.6^{A}	44.0 ± 8.3^{B}
Hormones		
Triiodothyronine (ng/mL)		
Morning	1.08 ± 0.40^{Aa}	0.82 ± 0.24^{Ba}
Afternoon	0.80 ± 0.20^{Ab}	0.62 ± 0.12^{Bb}
Thyroxine (ng/mL)		
Morning	56.1 ± 1.29^{Aa}	42.0 ± 1.13^{Ba}
Afternoon	49.6 ± 1.22^{Ab}	39.8 ± 1.24^{Bb}
Ratio		
Morning	0.019 ± 0.005^{Aa}	0.020 ± 0.004^{Aa}
Afternoon	0.016 ± 0.003 ^{Ab}	0.016 ± 0.003^{Ab}
Heat production (kcal/h/kg$^{0.82}$)		
Morning	3.77 ± 0.95^{Aa}	3.38 ± 0.93^{Aa}
Afternoon	6.58 ± 0.49^{Ab}	5.38 ± 0.88^{Bb}
Water turnover (mL/day/kg$^{0.82}$)	108.1 ± 15.2^{A}	87.1 ± 12.5^{B}

^{ab}comparison of means within column significant at $p < 0.05$
^{AB}comparison of means between column significant at $p < 0.05$
± = standard deviation

in unshorn rams was due to high heat load.

The levels of thyroid hormones influenced the status of metabolic rate of the animal. As expected, the shorn sheep which had higher levels in both T3 and T4 had higher metabolic rate (Mixner et al. 1962) as compared to unshorn sheep. The result on the heat production measured in these animals support this relationship. The heat production of shorn sheep before grazing, estimated from the oxygen intake, was significantly higher than the unshorn sheep. The finding was consistent to the result reported previously (Graham 1964; Farrell and Corbett 1970; Farrell et al. 1972) which indicated that the heat production of fasting sheep increased following shearing.

The heat production of both groups after grazing was significantly higher compared to the heat production before grazing. This increment in heat production was possibly contributed by the heat of digestion as reported by Hashizume et al. (1967) and by the increased in energy requirement for heat dissipation during grazing (Johnson and Vanjonack 1976).

The heat production of shorn sheep in the afternoon however was significantly higher than the unshorn rams. This difference actually reflected the extra energy used for heat dissipation rather than due to the difference in the level or status of heat stress received by the animals. The shearing reduced the insulation and as suggested earlier, this possibly enhanced the evaporative and non-evaporative cooling processes that occurred through the skin. Since the evaporative cooling is an active process, the animals then can be expected to have an increase in heat production as compared to unshorn sheep. Another possibility for the shorn animals to have higher heat production was that the shorn animals might have higher activity such as for food gathering. It has been suggested that the shearing increased the feed intake (Russel et al. 1985) although the time and period for grazing did not change (Austin and Young 1977; Love et al. 1978).

The shorn sheep had better heat and thyroid hormonal balance as well as heat production and these were possibly the reasons that the shorn sheep had better growth rate compared to the unshorn sheep.

Conclusion

The study indicated that shearing in growing F_1 DH x ISM crossbred rams increased the growth rate. The shearing resulted in the following effects:

The shearing reduces the body insulation and allows higher water evaporation (high water turnover) to occur possibly through the skin which then help to reduce body heat.

Lower body heat stimulates the thyroid gland to synthesize and release more T3 and T4.

High levels of circulating thyroid hormones increase the metabolic rate as indicated by heat production.

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