ENERGY METABOLISM IN RELATION TO GRAZING ACTIVITY IN GROWING PRIANGAN SHEEP AS AFFECTED BY RATIONS

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ABSTRACT

Animal activities can cause variation in energy utilization. The effect of concentrate supplementation on grazing activity compare with housing condition was studied, in relation to energy metabolism. Sixteen growing Priangan Sheep (15 kg) were allotted into four groups, two groups were fed with mix native grass plus 500 $g.d^{-1}$ of concentrate (C+N) and *ad libitum* of mix native grass only (N), in the house using individual pens, whereas other two groups were fed as same as mention above but they spent for a half of day in a grazing area. Concentrate ration contained 17.40 $MJ.kg^{-1}$ of gross energy (GE) and 18.00% of crude protein (CP), while the mix native grass contained 14.00 $MJ.kg^{-1}$ GE and 12.60% of CP. Sheep were fed at approximately two times a day, morning and afternoon, while water were given *ad libitum*. Grazing time was started from 08:00 a.m. to 17.00 p.m., after and before fed by concentrate. Energy balance were measured during a 7-d experimental period, which was preceded by a month adaptation period. Average daily gain (ADG), heat production (HP), metabolizable energy (ME) and retained energy (RE) were measured using balance trial, heart rate (HR) was monitored using Polar Spot Tester and urea space for body composition. Results showed that dry matter intake (DMI) were 3.5% from the body weight (BW) in all groups. The values of ME on sheep fed by concentrate were 5.02 and 6.70 $MJ.d^{-1}$ for housing and grazing groups, respectively, which were significance difference ($P<0.05$) with sheep fed native grass only, 4.73 and 4.86 $MJ.d^{-1}$ for housing and grazing group, respectively. Heat production for grazing groups tended to be higher than for those housing ($P=0.08$), and the data showed that percentage of HP/GE start from 31 till 43%. Values of ADG and RE of sheep fed concentrate were higher than for those without concentrate, whereas the values were 109, 50, 114 and 48 $g.d^{-1}$ and 1.22, 0.56, 1.28 and 0.54 $MJ.d^{-1}$ for housing and grazing, with and without concentrate, respectively. Percentage of fat and protein were around 20.99 and 19.31%. There was a good correlation between HP and HR following the equation $Y=-2.36 + 0.059\ X$, with $r=0.88$, where Y=HP and X=HR. There were significance differences for percentage of body compositions among the groups.

Keywords : Priangan sheep, native grass, grazing, heat production, heart rate

Utilization of feeds by animals is important information. Comparing nutrient requirement with nutrient concentration in tropical forages, suggested that both energy and protein in the diets were insufficient for optimal growth when young animals graze on tropical pasture only (Huston *et al*., 1995). Energy requirements for physical activity can result in differences in maintenance requirement (McCraken and Caldwell 1980). There is a relationship between heart rate and heat production (Purwanto *et al*., 1990), and activity on swamp buffalo which is worked in field (Mahardika *et al*., 1998). Increasing heat production and oxygen consumption by tissues require an increased oxygen arteriovenous difference or increased blood flow. Increased blood flow to the tissues,in turn, requires an increased stroke volume of the heart or an increased heart rate.

Grazing and working animals are very common in Indonesia, but there is still limited information about energy utilization by indigenous animals according to that kind of activities. Therefore, the effect of concentrate supplementation on grazing Priangan sheep in relation to energy utilization was assessed in this study.

MATERIALS AND METHODS

Animal and Housing

Sixteen male growing Priangan sheep (av. 15 kg BW) was used for the two months experiment. The animals were randomly allotted into four groups are presented in Table 1. The experiment consisted of one month for adaptation period (housing and grazing) and a two-weeks preliminary period followed by a 1-week balance period. The adaptation period was applied to allow the sheep to adjust the experimental diets and grazing condition, whereas preliminary period was directed to maintain the animals in the metabolic cages using heart rate detector (Polar Sport Tester). At d-8 of the preliminary period, animals on the grazing group were trained to wear metabolic bag during grazing. The bag is designed to separate feces and urine. Animals were housed in metabolic pens during night balance trial.

In this study, housing animals were kept in individual pens during adaptation period and moved to metabolic cages for balance trial. Grazing area was prepared in a 400 m^2 pasture for eight sheep. Before the animals plotted on the pasture, mix native grass was cut and in a 4 m^2 corner grass was sampled in order to know the grass production and composition during grazing period. That pasture is grown with many kind of grasses which contained difference of amount of nutrient values. All grasses in the pasture was estimated completely fed. Grazing time started from 08.00 a.m. to 5.00 p.m. everyday, after that animals were kept in individual pens during night. The data of relative humidity, environmental temperature and body temperature of this study were measured and shown in Table 2.

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Table 1. Experimental design of treatments of Priangan sheep fed with and without concentrate in different conditions

Treatments	Housing (H)	Grazing (G)
Concentrate – native grass	(C + N)	(C + N)
Native grass	(N)	(N)

Table2. Body and environmental temperature, and humidity

Parameter	Housing	Pasture
Body temperature (°C)		
- 08.00 a.m.	38.46	38.78
- 17.00 p.m.	38.97	39.30
Environmental Temp. (°C)		
- 08.00 a.m.	26.12	32.05
- 17.00 p.m.	29.75	33.89
Humidity (%)		
- 08.00 a.m.	73.87	53.22
- 17.00 p.m.	61.56	51.89

Feeding

During the experimental period sheep received with and without concentrate and *ad libitum* of mix native grass. Commercial concentrate, named GR-1, was formulated by PT Indofeed (Bogor - Indonesia) using ingredients such as corn, soybean meal, rice bran, fish meal, CaCO3, vitamin and minerals mix. Nutrient composition of concentrate and native grass were shown in Table 3. Animals were fed two times a day (08.00 a.m. and 17.00 p.m) with amount of each feeding 250 g of concentrate and *ad libitum* of mix native grass, while for the grazing group, only once a day for giving the mix native grass during night. In addition, water was available for *ad libitum* intake during the whole day.

Table 3. Chemical compositions of the ration

Calculated content	Concentrate	Native mix grass
Dry matter (%)	87.50	54.80
	-- % DM --	
Crude protein	18.00	12.60
Crude fiber	4.81	19.13
Extract ether	7.63	3.44
Ash	6.73	13.13
GE ($MJ.kg^{-1}$) DM	17.40	14.00

GE = gross energy

Measurements

Individual body weight (BW) was measured weekly, and their metabolic body size was calculated. Data on average daily gain (ADG) obtained from body size was calculated. This ADG data was obtained from body weight changes during the two months experimental period. A-one month adaptation fed period was allowed before energy balance which were measured a week for total collection of feces, urine and unconsumed feed. Feces and urine were collected quantitatively per individual and sampled from the mixture for energy analysis. Gross energy values were determined by Adiabatic Bomb Calorimeter. Energy loss with rumen methane production ($E_{methane}$) was estimated to be 10% of GE intake (Edey, 1983) and urinary energy (EU) loss was calculated by multiplying urinary-N with 34.0 $KJ.g^{-1}N$. Intake of ME was calculated from energy content of feed subtracted by feces, urine and methane production. Body composition was measured using urea space method in order to calculate the RE from total energy of protein plus total energy of fat. Urea space was done in the first and last week of the experimental period. Each sheep was injected with 130 mg urea kg^{-1} MBS in solution of 200 $g.L^{-1}$ of sterile saline through a jugular vein over a one minute period, times were recorded at the start and at the end of injection. The actual quantity of urea infused was determined gravimetrically by weighing syringes before and after injection. Blood samples were obtained before injection and 12 minutes after mean injection time. Plasma was prepared by centrifugation of blood at 5000x g for 10 minutes for analysis of Urea-N using KIT. Urea space was calculated from the dose of urea-N injection divided by the change in plasma urea-N before and after 12 minutes injection, following the equations for Urea space (US) (Bartle, *et al.* 1983), body water (BW) (Rule *et al.*, 1986), and crude protein and fat (Panaretto & Till, 1963), as percentage in live weight (LW) :

$$US (\%) = \frac{\text{[dose of urea-N (mg) infused]}}{\text{Change in plasma urea-N (mg/100ml)} \times 10 \times LW}$$

$$\text{Body water (\%)} = 59.1 + 0.22 \times US (\%) - 0.04\, LW$$
$$\text{Crude protein (kg)} = 0.265 \times BW (L) - 0.47$$
$$\text{Fat (\%)} = 98 - 1.32 \times BW (\%)$$

At the end of the week of experimental period, heart rate (HR) was monitored using Polar Sport Tester for about five hours each animal during daily activities. The detector was placed surrounding thoracic area tightly together with the monitor. In housing animals usually placed the monitor in front of the pen near the body, and for grazing animals, the monitor were placed on the back side of the animals. The data of the HR was analyzed using a program in computer. Heart rate values were correlated with daily heat production (HP) in each animal by linear regression equation. Retained energy as protein was calculated from total protein times 16.74 $KJ.g^{-1}$ protein, while energy retention as fat was calculated from total fat times 37.67 $KJ.g^{-1}$ fat (Powers and Howley, 1990). Daily (HP) was calculated by subtracting RE from ME intake.

Statistical Analysis

The significance of difference between means were compared using Duncan Multiple Range Test after ANOVA for two-way classifications (Steel and Torrie, 1986). Using a regression analysis of the HR and HP, correlation between those data were developed. The computer program MINITAB/SPSS release 6.1 (1988) was used in all statistical evaluations.

RESULTS AND DISCUSSION

The results of energy metabolism studies are presented in Table 4. The average of DM intakes were not affected by the treatments and data showed that DMI was around 3.5% from the BW and in an average $85g.kg^{-.75}.d^{-1}$. Daily supplementation of 0.15 $kg.d^{-1}$ of an 18% CP ration did not significantly affect forage DMI of ewes grazing winter range, and also reported DMI values ranging from 971 g to 1,221 $g.d^{-1}$ or 1.6 to 2.0 % of BW. Supplementation intake in that study was approximately 0.2% of BW and it was concluded that the quantity of supplementation fed was probably most great enough to cause a substitution of supplementation fed was probably most great enough to cause a substitution of supplementation for forage (Harris *et al*., 1989).

Table 4. Energy metabolism of growing Priangan sheep fed with and without concentrate on the housing and grazing conditions

Parameters	H		G		SE	P level
	C+N	N	C+N	N		
DMI ($g.d^{-1}$)	741	803	806	704	72	NS
GEI ($MJ.d^{-1}$)	12.01a	11.24b	12.08a	9.85b	1.42	*
DE($MJ.d^{-1}$)	6.91ab	6.63b	8.15a	6.18b	1.06	0.07
$E_{methane}$ ($MJ.d^{-1}$)	1.20a	1.12a	1.28a	0.98a	0.14	*
EU($MJ.d^{-1}$)	0.69a	0.75a	0.17b	0.34b	0.21	*
ME($MJ.d^{-1}$)	5.02ab	4.73b	6.70a	4.86b	1.06	*
ME:DE (%)	73b	71b	82a	78a	5.52	**
HP($MJ.d^{-1}$)	3.80b	4.17b	5.42a	4.32ab	0.90	0.08
HP:GE(%)	31.64b	37.09b	42.34a	43.85a	7.95	0.06
RE($MJ.d^{-1}$)	1.22a	0.56b	1.28a	0.54b	0.26	**
- energy protein ($MJ.d^{-1}$)	0.36a	0.17b	0.37a	0.16b	0.06	**
- energy fat ($MJ.d^{-1}$)	0.86a	0.40b	0.91a	0.38b	0.20	**
Heart rate ($beat.min^{-1}$)	102b	110b	125a	120a	10	**

H = housing; G = grazing; C+N = concentrate plus native grass; N = native grass; NS = non significance; * and ** significance in ($P<0.05$) and ($P<0.01$), respectively

Gross energy intake was higher by 0.20 $MJ.Kg^{-.75}.d^{-1}$ in sheep fed concentrate with final BW around 20 kg (GE =1.31 $MJ.Kg^{-.75}.d^{-1}$) than in native grass groups (GE=1.11 $MJ.kg^{-.75}.d^{-1}$), this was due to the low energy content of negative grass. Percentage of DE in concentrate groups tended to be higher ($P=0.07$) than in native grass groups. Normally, concentrate ration has better digestibility than native grass, but in this case it was suggested that concentrate had high percentage of rice bran, while the native grass had good quality enough.

The ME values in concentrate groups was higher than in native grass groups ($P<0.05$) and from the calculation found that concentrate groups consumed 125% ME intake from the requirements for maintenance, while the native grass group only 100 % (assuming a value is 110 $kcal.kg^{-1}.d^{-1}$ MBS for ME_m; van Es, et al., 1969). The reasoning was, methane production was high in animals fed by grass and also from the DE data. There were no difference between housing and grazing groups to intake ME, but the efficiency of ME utilization (ME:DE) in grazing groups were higher than native grass groups ($P<0.01$). In this case, the pasture was just after cut so that grazing animals could find the best choice for grass to consume surrounding the pasture, rather than just eat the cutting grass on housing group. As a consequence, energy catabolism through the urine in grazing group was lower than in housing group. Other researcher reported that ewes were probably more selective in their grazing during year 1 when winter environmental conditions were less harsh, and thereby consumed a diet of higher quality (Soder *et al*., 1995).

Grazing animals tended to have higher HP ($P=0.08$) than housing animals. The highest HP found in grazing group, which were animals supplement with concentrate, (5.42 $MJ.d^{-1}$). While the other HP values were 0.42 $MJ.kg^{-.75}d^{-1}$ in average. Pigs fed the non-starch polysaccharide (NSP) diet, 14.3% of total HP was related to activity, whereas in pigs fed the starch diet, was 19.1% (Schrama *et al*., 1996). This study found that around 20% of total HP was related to grazing activity. In housing group, sheep in (N) treatment were more excitable for eating, so that the value of HP tended to be higher than in (C+N). Due to its over-alert behavior and lack of feeding, the tropical animals may show higher HP, (Astuti *et al*., 1998).

Retained energy was not similar due to the ration. Concentration groups have higher 5% in RE (from GE) than native grass groups. This was happened because of enough ME supply in concentrate groups. Energy within protein was 31% in concentration groups and 29% (from total RE) in native grass groups, while energy within fat was the remainder.

Heart rate was around 20% higher in grazing groups than in housing groups ($P<0.01$). The daily patterns of HR are shown in Figure 1, at both treatments housing and grazing animals during daily activities (5 hours). The peak at the figure was partially related to the increasing activity (running), which was indicated by the higher HR during feeding time. The linear regression was developed from the HR and HP following the equation as $Y = -2.29 + 0.057 X$, $r = 0.90$, whereas Y and X are HP and HR respectively.

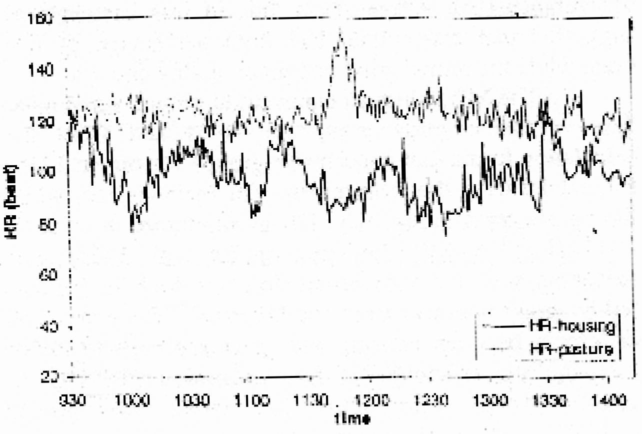

Figure 1. Heart rate on housing and grazing of growing Priangan sheep

Table 5. Body compositions of growing Priangan sheep fed with and without concentrate on the housing and grazing conditions

Parameters	H		G		SE	P level
	C+N	N	C+N	N		
ADG ($g.d^{-1}$)	109a	51b	114a	48b	35	*
Body water (%)	58.32a	58.47a	58.23b	58.29b	0.10	**
Protein (%)	19.31a	19.36a	19.28b	19.30b	0.03	**
Fat (%)	21.00b	20.81b	21.12a	21.06a	0.13	**
Total protein ($g.d^{-1}$)	21.29a	9.81b	22.24a	9.29b	6.98	**
Total fat ($g.d^{-1}$)	22.94a	10.56b	24.14a	10.14b	7.00	**

H = housing, G = grazing, C+N = concentrate plus native grass, N = native grass; NS = non significance; * and ** significance in (P<0.05) and (P<0.01), respectively

Body composition of growing Priangan sheep showed that percentage of protein and fat were difference among the treatments (P<0.01), as presented in table 5. Those values were not very different from those reported previously for sheep, except protein. It was reported that body water and fat were around 60 19.88%, while protein was 13.5% (Panaretto & Till, 1963). However, the ADG in concentrate groups were higher than in native grass groups, so that the total body protein and fat in concentrate groups also higher than in native grass groups (in relations with ADG). The low ADG in native grass groups suggested due to the lack of energy consumption. Indonesian native grass has good quality if be managed well. In this case, even though the quality of native grass was good, but the energy content was low, so that caused the low productivity. Performance of grazing animals in this study could be improved by the energy supplementation, such as feeds which has good utilization of energy. Other researcher reported that unsupplemented ewes were lost more of BW (Soder *et al.*, 1995). Also Alam *et al.*; (1983) reported that values for sheep may decline when given low-quality roughage without supplementation. Those results above supported this experiment, so it was suggested that animal grazing should be enrich with supplementation, in order to increase energy or protein intake.

CONCLUSIONS

This study concluded that there was effect of concentrate supplementation on energy utilization by grazing Priangan sheep whereas the implementation of those matter were increasing of BW. Grazing animals caused to increase the HR and HP almost 20% compare to housing, and for applying those parameters on practical situation, the correlation between HP and HR was developed to find the regression as following

$Y = -2.36 + 0.059\ X$, $r = 0.88$, which X = HR and Y = HP.

It was suggested that native grass on Indonesia pasture should be managed well in order to harvest good quality and utilization of those nutrient contents.

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