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Maintenance and Growth Requirements for Energy and Nitrogen of Baluchi Sheep

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ABSTRACT

Twenty eight Baluchi male sheep [12 months old with mean body weight (BW) of about 35 kg] were used to measure maintenance (zero growth) and growth requirements of nitrogen and metabolizable energy (ME). The lambs were divided into two equal groups: maintenance (T) and a growth (G) group. The experiment had duration of 24 days adaptation period and 60 days treatment period. All animals were offered a diet based on pelleted concentrate mixture consisting of alfalfa, barley, cottonseed meal and barley straw and were individually placed in metabolism cages. During the experiment, animals of group G gained 222.4 g d^{-1}, while the sheep of group T maintained a relatively constant live weight (- 0.2 g d^{-1}). Nitrogen (N) and energy requirements were determined by both measured and regression methods. Animals of the T group stayed at about zero N balance (0.002 $g.kg^{-0.75}.d^{-1}$), whereas the N retention of G group was about 0.65 $g.kg^{-0.75}.d^{-1}$. Digestible organic matter intake (DOMI) and energy requirement for maintenance were measured by both constant weight and regression method by regressing N balance on DOMI and ME intake on daily weight gain (DWG). The DOMI measured during constant weight and the DOMI calculated from regression equation were 21 and 20.81 $g.kg^{-0.75}.d^{-1}$, respectively. There was no significant difference between both measured and regression techniques. The measured ME for maintenance for T group during constant weight and the calculated ME for maintenance from regression method were 294 and 342 $kJ.kg^{-0.75}.d^{-1}$, respectively. The metabolizability values obtained in this experiment were 0.35 and 0.54 for groups T and G, respectively.

Key Words: Energy; Nitrogen; Maintenance; Growth; Sheep; Requirements

INTRODUCTION

Sheep and goats are the major livestock in Iran. Small ruminants (Sheep & goats) are mainly managed under village system (Kamalzadeh, 2005). There are 27 different breeds of sheep in Iran and it alone account for about 50% of the livestock production. The indigenous sheep breeds are of a fat-tailed type. Baluchi fat-tailed sheep is the major common native breed and account for about 12.5% of total sheep population. This breed is small in size and mainly pastured in lowlands on arable farms and around villages during cold period and migrates to the higher mountain grazing areas during spring and summer. Data on energy and protein requirements of Iranian sheep breeds are scarce. For this reason, the Agricultural Research Council (ARC) and National Research Council (NRC) feed allowance tables are being used to formulate diets for breeding sheep. The energy required to maintain an animal could be estimated from the relationship between energy intake and energy retention. Similarly, from the relationship between intake of digestible organic matter (DOMI) and nitrogen retention, the digestible organic matter (DOM) requirement at zero nitrogen retention can be estimated. According to ARC (1980), the maintenance requirements for metabolizable energy (ME) in sheep amount to 420 - 450 kJ $kg^{-0.75}$ d^{-1}, whereas, Kamalzadeh (2004) reported values of 340 and 480 kJ $kg^{-0.75}$ d^{-1} for maintenance requirements of ME intake for Swifter sheep at zero energy balance and growth, respectively. Values derived from studies of Mohammad *et al.* (1989) and Al-Jassim *et al.* (1996) on Iraqi Awassi sheep also ranged between 350 and 490 kJ $kg^{-0.75}$ d^{-1}. ARC (1980), suggested a range of 0.42 to 0.60 for metabolizability of energy when sheep fed ad libitum feed. Kamalzadeh (2004) also reported a range of 0.40 to 0.58 for metabolizability of energy in sheep. The values reported by ARC (1980), Ketelaars and Tolkamp (1991) and Kamalzadeh *et al.* (1997), for DOMI at zero nitrogen retention (N balance) are 26, 26.4 and 24.4 $mg.kg^{-0.75}.d^{-1}$, respectively. The present experiment was designed to measure the energy and nitrogen requirements and energy metabolizability during maintenance and continuous growth of fat-tailed Baluchi sheep.

MATERIALS AND METHODS

Twenty eight Baluchi male lambs (12 months of age having live-weight of about 35 kg) were randomly selected from a flock. The animals were equally divided into two groups: maintenance (T) and growth (G) group in a completely random experiment. The lambs of the groups T and G were placed alternatively in metabolic cages, for 24 days adaptation period and 60 days treatment period.

The lambs were fed a pelleted feed, consisting of 33% alfalfa, 28.5% barley, 13% barley straw, 20% cottonseed meal, 5% sugar beet molasses and 0.5% minerals and vitamin mixture (Table I). The dry matter (DM) content of the diet was 884 g kg^{-1} and formulated to provide 17.04 MJ of gross energy (GE) kg^{-1} DM and 148 g crude protein (CP) kg^{-1} DM. The composition of the diet is presented in Table II. The choice of pelleted diet was to inhibit possible selectivity and waste and to accurately measure feed intake.

At the onset of the experiment, all lambs were treated against endoparasites. Animals were weighed weekly. The amount of feed offered was adjusted once every week, based on metabolic weight. During the adaptation period, lambs of group T were fed at a level adequate for maintaining constant weight, and during treatment period, were maintained at the same level of feed intake to measure the maintenance requirements. However, during both adaptation and treatment periods, lambs of group G were fed ad libitum to achieve their normal growth. Fresh water and salt licking blocks were freely available. Feeds were offered twice a day at 07:00 and 16:00, and refused were collected daily prior to the morning feeding. Environmental temperature was kept constant at approximately 20°C. Relative humidity was maintained at approximately 50%. A lighting regime was imposed of 12/12 day/night to avoid seasonal effect of day length. The experiment consisted of a 24 day adaptation period followed by two consecutive 30 day balance trials. Each balance trial consisted of a preliminary period of 20 days and a collection period of 10 days. During each collection period, representative samples of the feed offered were taken. Daily feed intake for each lamb was recorded. The residues, faeces and urine were collected daily. The feed residues, faeces and urine of each lamb were pooled over each collection period, weighed, while representative samples were taken and retained for subsequent chemical analyses. A small amount of 30% formalin was added to the faeces container for preservation. Before collection of urine, one litre of water acidified by 20 ml (6N) HCL was put in the collection bucket, to prevent evaporation of ammonia.

The collected samples of feed, refuses and faeces were analyzed for DM, ash, N and energy contents. Urine was analyzed for N and energy contents. Samples of feed offered and refused, and faeces were dried at 50°C until they attained a constant weight before chemical analyses. The DM content of the feed offered and refused and faeces was determined by drying representative sub-samples to constant weight at 103°C, while OM was calculated as weight loss of the same sub-samples during ashing at 550°C for 3h. The N content of the feeds, refusals, faeces and urine was determined according to the Kjeldahl method (A.O.A.C, 1989).

Gross energy (GE) contents were determined using an adiabatic bomb calorimeter. Digestible energy (DE) and metabolizable energy (ME) intake, energy metabolizability (ME/GE) per lamb were determined from the energy contents of feed eaten and the amount of energy losses through faeces, urine and methane. The amount of energy loss through methane was set at 5% of the GE intake (CSIRO, 2001).

Data were subjected to analysis of variance (Steel & Torrie, 1982), and comparison between groups means were made using the Duncan Multiple Range Test. Prediction equations were derived by regression linear models.

RESULTS

The means of live-weight, intake of dry matter (DM), organic matter (OM), digestible organic matter (DOM), nitrogen (N), nitrogen retention (N balance), and daily weight gain (DWG) are presented in table III.

During the experiment, the lambs of group T maintained a relatively constant live weight (-0.2 g d^{-1}), while the animals of group G gained 222.4 g d^{-1}. Animals of group T had a significantly ($P < 0.001$) lower intake of DM, OM, DOM and N than animals of group G. There was a liner relation between the amount of N retained in the body and DOM intake (Fig. 1). The regression equation of N balance on DOMI estimated a zero N balance at DOMI 20.27 $g.kg^{-0.75}.d^{-1}$. The following equation was found:

$$Y = -428\ (33.6) + 21.1\ (0.86) * X,\ (n = 28 \text{ and } R^2 = 0.96)$$

in which: Y = N balance ($mg.kg^{-0.75}.d^{-1}$)
X = DOMI ($g.kg^{-0.75}.d^{-1}$)

Table I. Percentage ingredient composition of the diet (on dry matter basis).

Alfalfa (%)	33
Barley (%)	28.5
Barley straw (%)	13
Cottonseed meal (%)	20
Sugar beet molasses (%)	5
Minerals and vitamin mixture (%)	0.5
Total	100

Table II. The Dry matter (DM), organic matter (OM), gross energy (GE), crude protein (CP) and ash contents of the diet.

DM ($g.kg^{-1}$)	884
OM ($g.kg^{-1}$ DM)	902
GE ($Mj.kg^{-1}$ DM)	17.04
CP ($g.kg^{-1}$ DM)	148
Ash ($g.kg^{-1}$ DM)	98

The regression of daily weight gain (DWG) on DOMI suggested a zero DWG at DOMI 20.81 $g.kg^{-0.75}.d^{-1}$ (Fig. 2). The derived regression equation was:

$$Y = - 8.8 (0.61) + 0.42 (0.02) * X, (n = 28 \text{ and } R^2 = 0.97)$$

in which: $Y = DWG (g.kg^{-0.75}.d^{-1})$
$X = DOMI (g.kg^{-0.75}.d^{-1})$

The relationship between N balance and body weight (BW) for both groups T and G is presented in Fig. 3. The derived regression equations were:

Table III. Means of live-weight, intake of dry matter (DM), organic matter (OM), digestible organic matter (DOM) and nitrogen (N), N losses in faeces and urine, N balance, and daily weight gain of Baluchi sheep.

	Group T (maintenance)	Group G (growth)	Significance of differences
Live-weight (kg)			
Initial	34.85 [a]	34.68[a]	NS
Final	34.83 [a]	53.28 [b]	***
Intake ($g.kg^{-0.75}.d^{-1}$)			
DM	49.5 [a]	87.1 [b]	***
OM	44.7 [a]	78.5 [b]	***
DOM	21.0 [a]	50.7 [b]	***
N	1.17 [a]	2.06 [b]	***
N losses ($g.kg^{-0.75}.d^{-1}$)			
Faeces	0.72 [a]	0.77 [b]	***
Urine	0.45 [a]	0.65 [b]	*
N balance ($g.kg^{-0.75}.d^{-1}$)	0.002 [a]	0.65 [b]	***
Gain ($g.d^{-1}$)	-0.2 [a]	222.4 [b]	***

*** *P < 0.001;* * *P < 0.05; NS*, non significant. [a b] values within line with different superscripts differ significantly.

Table IV. Means of live-weight, intake of gross energy (GE), digestible energy (DE), metabolizable energy (ME), energy losses, and metabolizability of energy (ME/GE) during experiment.

	Group T (maintenance)	Group G (growth)	Significance of differences
Live-weight (kg)			
Initial	34.85 [a]	34.68[a]	NS
Final	34.83 [a]	53.28 [b]	***
Energy intake ($kJ.kg^{-0.75}.d^{-1}$)			
GE	844 [a]	1485 [b]	***
DE	357 [a]	918 [b]	***
ME	294 [a]	795 [b]	***
Energy losses ($kJ.kg^{-0.75}.d^{-1}$)			
Faeces	487 [a]	567 [b]	***
Urine	21 [a]	49 [b]	***
Methane	42 [a]	74 [b]	***
Metabolizability	0.35 [a]	0.54 [b]	***

*** *P < 0.001*; *NS*, non significant.
[a b] values within line with different superscripts differ significantly.

Fig. 1. Relationship between N balance ($mg.kg^{-0.75}.d^{-1}$) and digestible organic matter intake (DOMI) ($g.kg^{-0.75}.d^{-1}$), combined data (■) of both maintenance (T) and growth (G) animals. Line presents the predicted value.

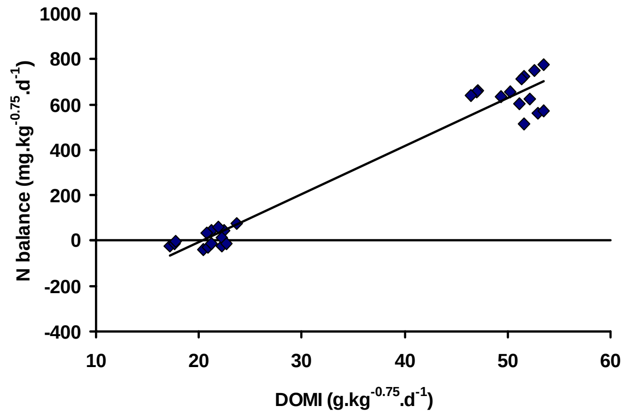
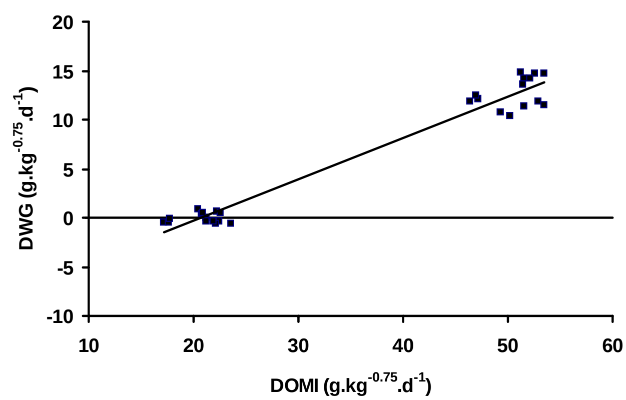


Fig. 2. Relationship between DWG ($g.kg^{-0.75}.d^{-1}$) and digestible organic matter intake (DOMI) ($g.kg^{-0.75}.d^{-1}$), combined data (■) of both maintenance (T) and growth (G) animals. Line presents the predicted value.



Group T: $Y = 1.18 (3.31) - 0.31 (0.09) * X, (n = 14 \text{ and } R^2 = 0.008)$
Group G: $Y = - 36.3 (5.45) + 0.92 (0.1) * X, (n = 14 \text{ and } R^2 = 0.87)$

in which: $Y = N \text{ balance } (g.d^{-1})$
$X = BW (kg)$

Means for live weight (kg), and the values based on $kJ.kg^{-0.75}.d^{-1}$ for energy intake (GE, DE and ME), energy losses through faeces, urine, and methane, and metabolizabilty (ME/GE) are presented in Table IV. The energy losses through faeces, urine and methane of animals in group T decreased (P < 0.001) compared with animals of group G. The metabolizability of energy for animals of group T was lower (P < 0.001), compared with animals of group G.

Fig. 3. Relationship between N balance (g/day) and body weight (kg) for maintenance (▲) and growth (■) animals. Lines present predicted values.

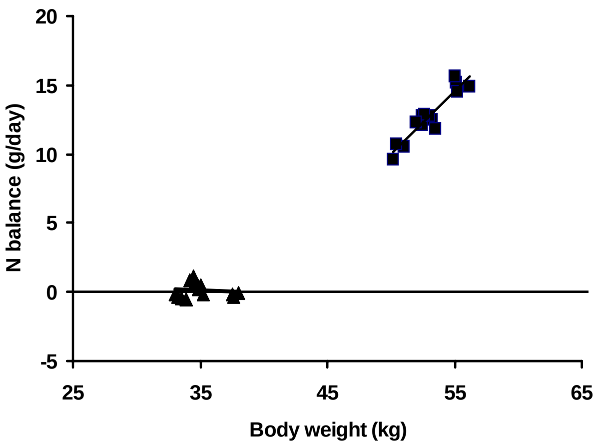
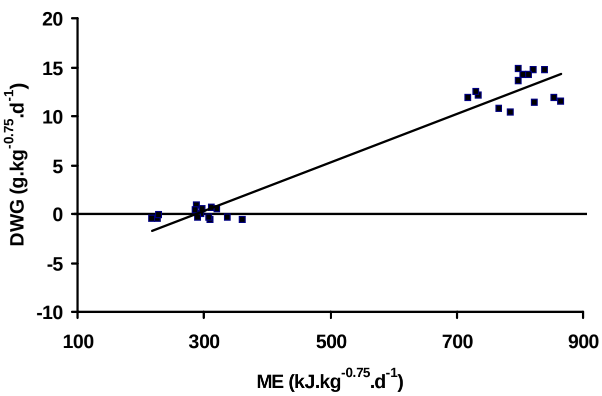


Fig. 4. Relationship between DWG ($g.kg^{-0.75}.d^{-1}$) and metabolizable energy ($kJ.kg^{-0.75}.d^{-1}$) intake, combined data (■) of both maintenance (T) and growth (G) animals. Line presents the predicted value.



The ME of the animals of group G was greater ($P < 0.001$) than the animals of group T. When the combined data of both G and T groups were used, the estimated ME requirement for maintenance (zero growth) was 288 kJ $kg^{-0.75}$ d^{-1}. The relationship between ME and DWG is presented in Fig 4. The derived regression equation was:

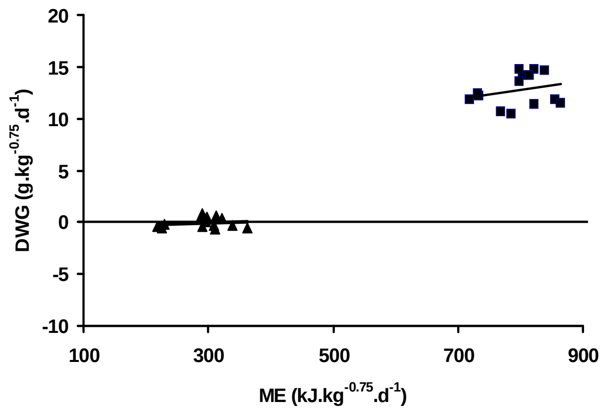
$$Y = -\ 7.15\ (0.64) + 0.02\ (0.001) * X\ (n = 28 \text{ and } R^2 = 0.95)$$

in which: Y = DWG ($g.kg^{-0.75}.d^{-1}$)
X = ME ($kJ.kg^{-0.75}.d^{-1}$)

However, when only the data of group T was used, the estimated ME intake required for zero growth was 342 $kJ.kg^{-0.75}.d^{-1}$ (Fig. 5). The derived regression equation was:

Group T: $Y = -\ 0.48\ (1.02) -\ 0.001\ (0.003) * X$, ($n = 14$ and $R^2 = 0.01$)

Fig. 5. Relationship between DWG (g $kg^{-0.75}.d^{-1}$) and metabolizable energy ($kJ.kg^{-0.75}.d^{-1}$) intake for maintenance (▲) and growth (■) animals. Lines present predicted values.



in which: Y = DWG ($g.kg^{-0.75}.d^{-1}$)
X = ME ($kJ.kg^{-0.75}.d^{-1}$)

DISCUSSION

Relative to metabolic weight, energy losses through faeces, urine and methane decreased in animals of group T. This might be a result of low level of N intake and decreased N excretion through faeces in this group. The measured DOMI required for maintenance of the animals of group T which were maintained at a constant weight during the experiment, was 21 g $kg^{-0.75}$ d^{-1} (Table III). The regression equation of N balance on DOMI predicts a zero N balance at DOMI = 20.27. There was no significant difference between values for DOMI both in measured and regression methods. These values are lower than the maintenance energy requirements value proposed by ARC (1980) of 26 g DOMI $kg^{-0.75}$ d^{-1}. Ketelaars and Tolkamp (1991) also observed a DOMI of 26.4 g $kg^{-0.75}$ d^{-1} in sheep, while Kamalzadeh *et al.* (1997) reported a value of DOMI = 24.4 g $kg^{-0.75}$ d^{-1} at zero N balance in sheep when imposed to maintain constant weight for 3 months.

The regression of DWG on DOMI also suggested a zero DWG at DOMI of 20.81 g $kg^{-0.75}$ d^{-1} (Fig. 2). This value was less than the range (25-30 g $kg^{-0.75}$ d^{-1}) reported by ARC (1980) and Oosting *et al.* (1995) for sheep at zero DWG. A value of 22.1 g $kg^{-0.75}$ d^{-1} has been reported for sheep during a period of 3 months feed quality restriction (Kamalzadeh *et al.,* 1997). The N balance was increased by increasing BW in animals of group G (Fig. 3).

When the combined data of both T and G groups were used, the regression of ME intake on DWG showed that the estimated ME requirement for maintenance was 288 kJ $kg^{-0.75}$ d^{-1}, but when only the data of T group regressed on DWG of that group, the estimated ME requirement for maintenance was 342 kJ $kg^{-0.75}$ d^{-1}. Graham and Searle (1979) reported a value of 340 kJ $kg^{-0.75}$ d^{-1}. Mohammad *et al.* (1989) reported a range of 350 to 490 kJ $kg^{-0.75}$ d^{-1} and Al-Jassim *et al.* (1996) proposed a range of 342 to 482 kJ $kg^{-0.75}$ d^{-1} for the maintenance requirement of ME intake of fat-tailed Iraqi Awassi sheep. Kamalzadeh (2004) also reported a range of 340 to 480 kJ.$kg^{-0.75}$.d^{-1} for Swifter sheep. These values were in line with the value obtained for T group in this study. ARC (1980) suggested a range of 420-450 kJ $kg^{-0.75}$ d^{-1}, which was not completely in line with these findings. The measured ME required for maintenance of the animals of group T which were maintained at a constant weight during the experiment, was 294 kJ $kg^{-0.75}$ d^{-1} (Table IV). There was no significant difference between both measured and regressed methods. Al-Jassim *et al.* (1996) regressed energy intake on empty body gain and proposed a value of 255 kJ $kg^{-0.75}$ d^{-1} for ME intake at zero growth, which is not completely in line with the above reports. The average daily growth rate of the animals of G group was 222.4 g per day. The measured ME required for growth of the G group was 795 kJ $kg^{-0.75}$ d^{-1}.This value was lower than 1007 kJ $kg^{-0.75}$ d^{-1} calculated for growth rate of 250 g per day by Al-Jassim *et al.* (1996) for Awassi lambs.

The metabolizability values obtained in this experiment was 0.35 for group T and 0.54 for group G. This result support the range (0.40 to 0.60) proposed by ARC (1980), Oosting *et al.* (1995) and Kamalzadeh (2004), when sheep received ad libitum feed. These results show that the requirements of Baluchi sheep are lower than values reported by ARC (1980) and some other literature sources. These differences probably relate to estimation of values in animals of different breeds, sizes and ages.

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