ENERGY UTILIZATION BY SOMALI LAMBS FED NAPIERGRASS *"AD LIBITUM"* AND AN ENERGY SUPPLEMENT AT INCREMENTAL LEVELS[1]

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ABSTRACT - A twelve-week study was conducted to determine the influence of the level of energy supplementation on forage and total diet dry matter intake and energy utilization by growing Somali lambs. Thirty-six male lambs were randomly blocked among four energy levels. To all lambs were offered a daily protein supplement at 0.5% of the body weight and an energy supplement ranging from 0.4 to 1.6% of the body weight. Napiergrass green chop was offered *ad libitum*. Lambs were harnessed for total collection of feces during the last 7 days of the study. Forage and total dry matter intake decreased ($P < 0.05$) with an increase in energy supplementation. Dry matter digestibility, digestible energy intake, body weight and feed efficiency increased ($P < 0.05$) with an increase in the level of energy in the diet. From the regression of metabolizable energy intake (Kcal/kg$^{0.75}$/day) on body weight gain (g/day) the estimated daily ME requirements for maintenance was 73 Kcal/kg$^{0.75}$ and for live weight gain was 0.90 Kcal ME/g gain/kg$^{0.75}$.

Index terms: hairy sheep, energy supplementation, energy requirements.

UTILIZAÇÃO DE ENERGIA POR CORDEIROS SOMALIS ALIMENTADOS COM CAPIM-ELEFANTE *"AD LIBITUM"* E SUPLEMENTADOS COM DIFERENTES NÍVEIS DE ENERGIA

RESUMO - Durante doze semanas foi conduzido um estudo para determinar a influência da suplementação de energia no consumo de forragem e de matéria seca total, bem como a utilização de energia por cordeiros da raça Somalis em crescimento. Trinta e seis ovinos, machos, foram bloqueados, aleatoriamente, em quatro níveis de energia. Todos receberam um suplemento protéico diário na razão de 0,5% do peso corporal e uma suplementação energética que variou de 0,4 a 1,6% do peso vivo dos animais. Capim-elefante verde, picado, foi oferecido *ad libitum*. Nos últimos sete dias do experimento, todos os animais foram arreados e procedida coleta total de fezes. O consumo de matéria seca (MS) de forragem e de MS total decresceu ($P < 0{,}05$) com o aumento da suplementação energética. A digestibilidade da MS, consumo de energia digestível, ganho de peso e a eficiência de utilização do alimento aumentaram com o incremento na densidade energética da dieta dos animais. Com base na regressão do consumo de energia metabolizável (EM), em Kcal/dia/kg$^{0.75}$, sobre o ganho de peso (g/dia) os requerimentos diários de EM foram de: 73 Kcal/kg$^{0.75}$ para manutenção e de 0,90 Kcal EM/g de ganho/kg$^{0.75}$ para ganho de peso.

Termos para indexação: ovinos deslanados, suplementação de energia, requerimentos de energia.

INTRODUCTION

Productivity of ruminants in tropical regions is limited primarily by the high fiber and low energy content of the tropical forages. Research in Brazil (Barros et al. 1986 and Silva & Silva 1976) and in Australia (Minson & McLeod 1970) have shown that the majority of tropical forages studied had apparent digestibility coefficients lower than those normally found with forages grown in temperate zones. Tropical grasses also have a high cell wall content that limits the intake of digestible energy by ruminants.

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In Northeast Brazil, the dry season may extend for as many as 8 months. Confinement feeding of growing lambs during this period of scarce feed in the range, constitutes an alternative for an improvement in productivity (Oliveira et al. 1986). Of the tropical and subtropical forages, Napiergrass produces the highest yields of cut forage (Heath et al. 1973). Napiergrass is generally fed to livestock as green chop. Several studies (Butterworth 1965, Silva & Silva 1976 and Johnson et al. 1973) have reported the chemical composition of Napiergrass (*Pennisetum purpureum*) at various stages of maturity. Reported were also the voluntary dry matter intake, and *in vivo* and *in vitro* digestibilities. However, from a literature search no information was found on the utilization of energy from Napiergrass diets by growing lambs.

This study was conducted to determine the influence of level of energy supplementation on forage and total dry matter and energy intakes, and weight gains of Somali hair sheep fed Napiergrass *ad libitum*. Energy utilization of Napiergrass diets by lambs for maintenance and growth was estimated.

MATERIALS AND METHODS

The study was conducted at the Goat National Research Center, located in the state of Ceará, Northeast Brazil, at the end of the dry season, during the months of October, November and December. This region is characterized for its elevated temperatures throughout the year. The region's long term annual average precipitation is, approximately, 759 mm.

Thirth-six recently weaned Somali male lambs, weighing an average of 16.6 kg, were randomly blocked by weight among four dietary treatments (L1-L4). Nine lambs were assigned by weight to each of the four diets such that treatment weight means and standard deviations were similar. Lambs were dewormed before being confined in individual pens of 3 m x 1 m for a period of 84 days after a preliminary period of 14 days. Body weights were recorded weekly and for two consecutive days at the beginning and end of the study.

Napiergrass (*Pennisetum purpureum*) green chop (IPN 2-03-158) was offered *ad libitum* (25% more of the previous day forage intake). The forage was chopped, weighed in individual plastic bags and offered three times a day. The grass was in a vegetative stage of growth, during the study, and was cut at about 10 cm above the ground.

All lambs were offered daily a protein supplement at 0.5% of body-weight and an energy supplement (cassava meal, IFN 4-09-598) at 0.4 (L1), 0.8 (L2), 1.2 (L3) and 1.6% (L4) of the body weight (quantities adjusted weekly). The protein supplement was comprised of 80% soybean meal (IFN 5-04-600), 10% urea (IFN 5-05-070) and 10% of a mineral-salt mix (Table 1). The purpose of offering a protein supplement was to prevent a protein deficiency which usually occurs when tropical grasses and energy feeds are the main dietary components. Lambs had free access to water.

Lambs were harnessed the last 7 days of the study for total collection of feces to determine digestibilities of dry matter (DMD) and energy (DE). The last day of the trial, all lambs were slaughtered to determine their empty body (ingesta--free body) weight (EBW) and carcass weight.

Samples of forage, refused feed and feces were oven-dried (60°C) and ground through a 1 mm screen in a Wiley mill before analysis. Samples were then analyzed for 105°C dry matter (DM) (Association of Official Analytical Chemists 1975). Ash content was determined after ashing in a muffle furnace at 550°C. Neutral detergent fiber (NDF), acid detergent fiber (ADF), ADF insoluble ash (AIA), and $KMnO_4$ lignin were analyzed, according to the procedures of Goering & Van Soest (1970). Nitrogen content of feed samples was determined by Kjeldahl (Association of Official Analytical Chemists 1975). Gross energy content of

TABLE 1. Composition of protein supplement.

Ingredient	% Dry matter
Soybean meal	80
Urea	10
Dicalcium phosphate	5
Trace mineral salt*	5

* Minimum analysis: NaCl, 93.20%; Mn, .14%; Zn, .24%; I,.011%; Cu, .12%; Fe, .21%; Co, .003%.

all samples was determined, according to the procedures of Harris (1970). Metabolizable energy (ME) content of the diets was estimated from digestible energy (DE) multiplicated by 0.82 (National Research Council 1985).

Data were analyzed as a randomized complete block design (Snedecor & Cochran 1979). Comparison of means were made by least significant difference test with P < 0.05. Daily ME requirement for maintenance was estimated by extrapolation to zero weight gain, the regression line relating metabolizable energy intake (Kcal/kg$^{0.75}$) and live weight gain (g/day). The slope of the line was considered an estimate of the daily ME requirement for weight gain.

RESULTS AND DISCUSSION

The average chemical composition of the Napiergrass is shown in Table 2. From the time Napiergrass was cut until it was fed, some moisture content was lost. Moisture content of the Napiergrass was that determined on the forage when it was weighed into individual bags for feeding. All chemical components were expressed on a dry matter (DM) basis. Average crude protein (CP) content was low (4%). Neutral detergent fiber (NDF) was higher (76.2%) and acid detergent fiber (ADF) similar (44.9%) to values reported by National Research Council (1982).

TABLE 2. Average chemical composition Napiergrass.

Nutrient	(%)
Maisture	78.2
Dry matter basis	
Crude protein	4.0
Ash	13.9
Neutral detergent fiber (NDF)	76.2
Acid detergent fiber (ADF)	44.9
ADF insoluble ash (AIA)	1.8
$KMnO_4$ Lignin (LIG)	7.9
Hemicellulose (MDF-ADF)	31.3
Cellulose (ADF-LIG/AIA)	35.2

The chemical composition of the ingested DM, lambs according with the experimental energy levels is presented in Table 3. As the level of cassava meal (energy supplement) offered increased from 0.4 to 1.6% of the body weight (BW), ADF and CP decreased (P < 0.05) and digestible energy (DE) and metabolizable energy (ME) increased (P < 0.05). ADF content of DM intake ranged from a high of 21.4% to a low of 11.6%. Although the maximum difference in CP content of DM intake between diets was only of one percentage unit, the difference was significant (P < 0.05). However, intake of CP by lambs on a metabolic body weight basis (kg$^{0.75}$) was not different (P > 0.05) (Table 4).

Means for DM digestibility, intakes of concentrate, forage and total DM, and intakes of DE, ADF and CP are listed in Table 4. Dry matter digestibility increased (P < 0.05) with an increase in the level of energy in the diet. Forage DM intake decreased (P < 0.05) and total DM intake increased (P < 0.05) with an increase in energy supplementation up to 1.2%. The increase in total DM intake was probably in response to a substitution of forage with concentrate. No further increases

TABLE 3. Means for chemical composition of dry matter (DM) intake*.

Item	Energy supplement level (% of BW)			
	0.4	0.8	1.2	1.6
Acid detergent fiber (%)	21.4 c	17.0 b	15.3 b	11.6 a
Crude protein (%)	10.2 b	10.0 b	9.4 a	9.2 a
Digestible energy (Kcal/gDM)	1.76 a	1.80 a	2.17 b	2.21 b
Metabolizable energy (Kcal/g DM)	1.44 a	1.48 a	1.78 b	1.81 b

* Analytically or experimentally determined values;
abc - Means in the same row with different superscript differ (P < .05)

TABLE 4. Means for dry matter (DM) digestibility and DM, digestible energy (DE), acid detergent fiber (ADF) and crude protein (CP) intake*.

Item	Energy supplement level (% of BW)			
	0.4	0.8	1.2	1.6
DM digestibility (%)	48.2 a	50.0 a	57.4 b	59.8 b
DM intake (g/kg$^{.75}$)				
Concentrate	17.1 a	24.9 b	33.6 c	42.3 d
Forage	67.9 b	62.4 b	63.1 b	54.5 a
Total	85.0 a	87.3 a	96.7 b	96.6 b
DE intake (Kcal/kg$^{.75}$)	130.1 a	138.4 a	185.8 b	189.2 b
ADF intake (g/kg$^{.75}$)	21.2 c	17.0 b	16.6 b	12.4 a
CP intake (g/kg$^{.75}$)	10.1 a	9.9 a	10.2 a	9.8 a

abc - Mean in the same row with different superscript differ (P < .05)

(P < 0.05) in DM intake or digestibility were obtained with an increase in the level of energy supplementation from 1.2 to 1.6% of BW. Dry matter digestibilities ranged from a low of 48.2% (L1) to a high of 59.6% (L4) and DM intake from a low of 85.0 g/kg$^{0.75}$ (L1) to a high of 96.6 g/kg$^{0.75}$ (L4). Butterworth (1965) reported that lambs, fed Napiergrass at various stages of maturity as the only feed, had on average DM digestibility of 62% and an average DM intake of about 62 g/kg$^{0.75}$.

As mean ADF intake decreased (P < 0.05), mean DE intake increased (P < 0.05) (Table 4). Intake of ADF ranged from a high of 21.2 g/kg$^{0.75}$ (L1) to a low of 12.4 g/kg$^{0.75}$ (L4) and DE intake ranged from a low of 130.1 Kcal/kg$^{0.75}$ (L1) to a high of 189.2 Kcal/kg$^{0.75}$ (L4). The relationship between digestible energy intake (Y) in Kcal/kg$^{0.75}$ was: Y -63.6 + 114 X ($R^2 = 0.81$; P < 0.01) (Fig. 1). This relationship suggests a linear increase in the intake of digestible energy with an increase in the energy density of the diet. Dinius & Baumgardt (1970) reported that digestible energy intake by lambs increased linearly as the energy density of the diet increased from approximately 1 to 2.5 Kcal DE/g DM and decreased linearly above 2.5 Kcal DE/g DM. The linear increase in DE intake with an increase in the energy density of the diets observed in this study may be explained by the fact that the diet with highest energy density had less than 2.4 Kcal DE/g DM.

Means for final live (LBW) and empty (EBW) body weights, carcass yield, LBW gains and feed/gain are reported in Table 5. As the energy supplement level increased from 0.4 to 1.6% of the BW, final LBW and EBW, carcass yield and LBW gain increased (P < 0.05) and feed/gain decreased (P < 0.05). Live body weight gains were 44 (L1), 51 (L2), 72 (L3) and 95 (L4) g/day. Feed/gain ratio decreased from 18.4 (L1) to 10.8 (L4) g of feed DM/g LBW gain. Average LBW gains of the Somali lambs in this study were low. Probablys none of the Napiergrass diets have supplied adequate amounts for DE and CP of maximum growth of lambs of this age and physiological state (Kearl 1982).

The relationship between final LBW (kg) and final EBW (kg) is shown in Fig. 2. Empty

TABLE 5. Means for live body weight (LBW), empty body weight (EBW), carcass yield, LBW gains and feed efficiency*.

Item	Energy supplement level (% of BW)			
	0.4	0.8	1.2	1.6
Final LBW (kg)	18.0 a	18.9 b	20.4 c	22.5 c
Final EBW (kg)	13.1 a	13.9 b	15.7 ba	17.2 b
Carcass yield (%)**	38.1 a	40.4 ab	41.6 bc	43.1 c
LBW gain (g/day)	44 a	51 a	72 b	95 c
Feed/gain***	18.4 b	17.0 b	13.7 a	10.8 a

* Means in the same row with different superscript differ (P < .05).

** Carcass weight as percent of final LBW.

*** Daily g dry matter intake/g of LBW gain.

body weight was accurately predicted ($R^2 = 0.96$; $P < 0.01$) from LBW with the following equation: $Y = -1.677 + 0.834 X$. However, changes in live weight of individual sheep reflect changes in the weight of ingesta in the gastrointestinal tract, which can vary from 60 to 540 g/kg of empty body weight (National Research Council 1985).

Experimentally, the energy requirement for maintenance of growing sheep is the amount of dietary metabolizable energy resulting in zero change in body energy and zero weight gain (National Research Council 1985). Energy maintenance occurs when daily ME intake equals daily heat production. The Agricultural Research Council (1980) uses fasting heat production as a baseline for describing the maintenance energy requirement of the animal independent of diet. Because of the limited data base available and questions about the validity of fasting measurements, particulary on growing animals, an extrapolated fasting heat production (Rattray et al. 1973) is used by the National Research Council (1985) as the reference base for maintenance.

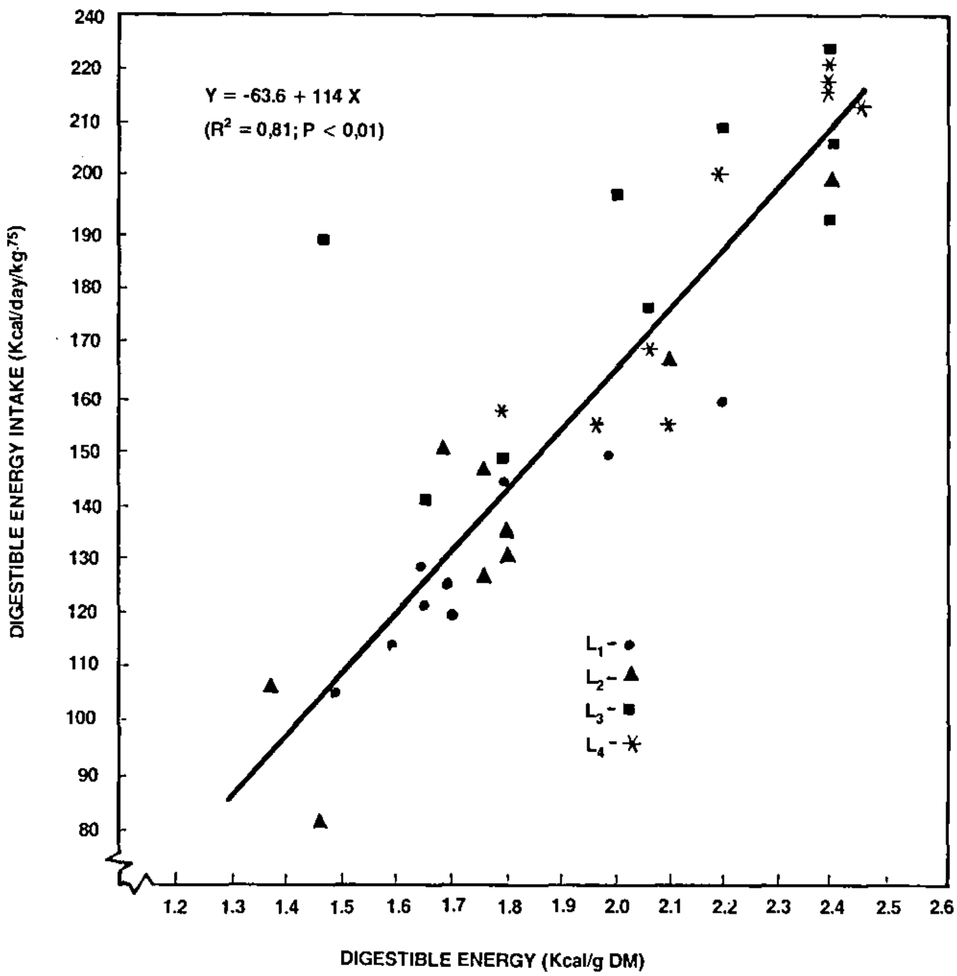

FIG. 1. Relationship between enery density of the diet and energy intake by Somali sheep.

From the response to different levels of energy intake by sheep, estimates of energy required to maintain energy equilibrium and for weight gain have been obtained by Garret et al. (1959) and Oyenuga & Akinsoyinu (1976). Energy requirements for maintenance and weight gain were estimated from data of this experiment using the response curve method. The relationship between live weight gain (g/day) and digestible energy (DE) intake (Kcal/kg$^{0.75}$/day was: $Y = 89 + 1.10\ X$ ($R^2 = 0.47$; $P < 0.01$). The intercept is DEI (Kcal/kg$^{0.75}$) required for energy equilibrium. Daily DE required for maintenance (DEm) was 89 Kcal/kg$^{0.75}$ and for gain (DEg) was 1.10 Kcal DE/g gain/kg$^{0.75}$.

Figure 3 shows the relationship between live weight gain (g/day) and metabolizable energy (ME) intake (Kcal/kg$^{0.75}$/day): $Y= 73 + 0.90\ X$ ($r = 0.69$; $P < 0.01$). The daily

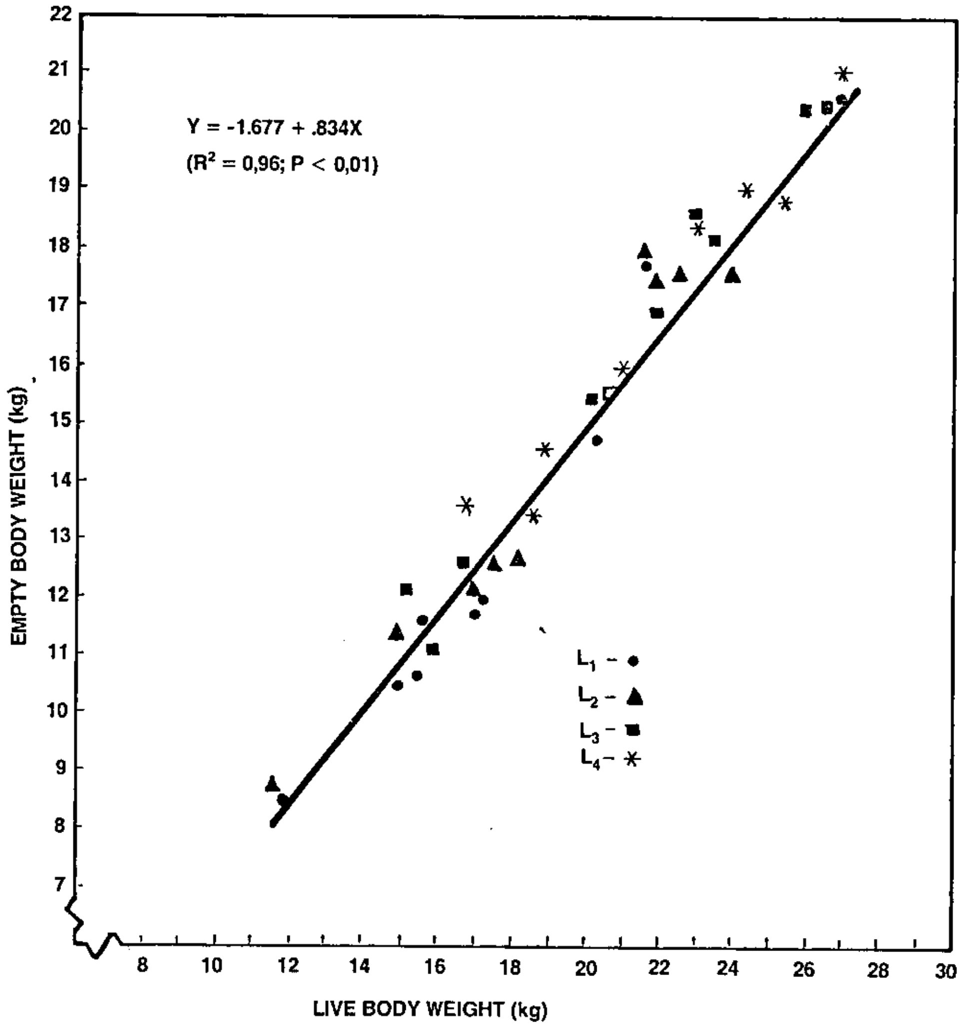

FIG. 2. Relationship between live body weight and empty body weight for Somali sheep fed different energy levels.

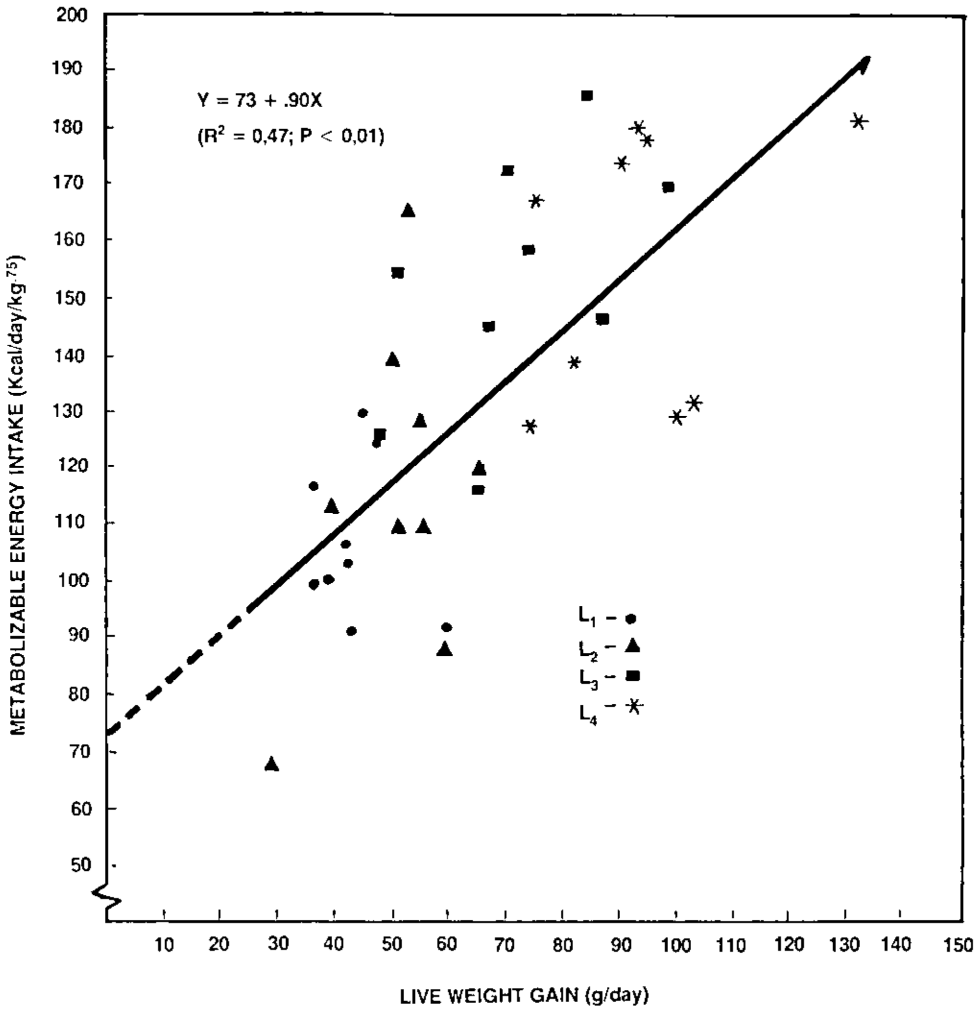

FIG. 3. Relationship between ME intake and live weight gain for Somali sheep fed different energy levels.

ME requirement for maintenance (MEm) estimated by extrapolation of the line to zero weight gain was 73 Kcal ME/kg$^{0.75}$. This value is low compared to some previously reported estimates: 88 (Benjamin et al. 1977), 98 (National Research Council 1975), 100 (Oyenuga & Akinsoyinu 1976), and 73 (Wilke & Merwe 1976) Kcal ME/kg$^{0.75}$.

The daily ME required for live weight gain (MEg) was 0.90 Kcal ME/g gain/kg$^{0.75}$. Oyenuga & Akinsoyiny (1976) reported an MEg of 0.91 Kcal/g gain/kg$^{0.75}$ for lambs of tropical breeds. Kearl (1982) estimated from the literature a growth energy requirement of 0.83 Kcal ME/g gain/kg$^{0.75}$ for all body weights and increments of activity. Therefore, a Somali lamb weighting 20 kg and gaining 100 g/day would require a total of 1.54 Mcal per day, for maintenance and growth, which is comparable to the value of 1.42 Mcal reported for sheep by Kearl (1982).

CONCLUSIONS

1. Somali lambs fed Napiergrass *ad libitum* and cassava meal (energy supplement) at incremental levels had dry matter digestibilities ranging from 48.2 to 59.8%.

2. With an increase in energy supplementation, forage DM intake decreased ($P < 0.05$) from 67.9 to 54.5 g/kg$^{0.75}$ and total DM intake increased ($P < 0.05$) from 85.0 to 96.6 g/kg$^{0.75}$. The increase in DM intake was probably in response to a substitution of forage with concentrate.

3. No increases ($P > 0.05$) in DM intake or digestibility were obtained with an increase in the level of energy supplementation from 1.2 to 1.6 of the body weight.

4. The relationship between live weight gain (g/day) and metabolizable energy (ME) intake (Kcal/kg$^{0.75}$/day) was: $Y = 73 + 0.90\,X$ ($r = 0.69$; $P < 0.01$). The daily ME requirement for maintenance (MEm) was 73 Kcal ME/kg$^{0.75}$ (intercept) and the daily ME required for live weight gain (MEg) was 0.90 Kcal ME/g gain/kg$^{0.75}$ (slope).

5. The protein supplement offered provided the lambs with a diet consisting of approximately 10% CP. However due to the high fibrous nature of the Napiergrass diets, none may have supplied adequate amounts of DE and CP for maximum growth of lambs of this age and physiological state.

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