

Physiological Responses of Lambs Maintained on Varying Levels of Energy Under Heat Exposure

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Abstract: An experiment was conducted to assess relationship between dietary energy and heat tolerance in lambs fed to gain @ 100 ADG as per standard during summer in animal shed (G₁) or in sun (G₂) or fed 115% (G₃) and 130% (G₄) of their requirement under sun. Same DMI was maintained in all the groups. Water intake was higher in sun-exposed G₂, G₃ and G₄ compared to that of animals in shade (G₁). During summer, the respiration rate (RR) of lambs was 51 beats min⁻¹ in the morning, which increased by 129% to 116 beats min⁻¹ in the afternoon. The RR was higher in sun-exposed groups compared to animals in the shed. Among the sun-exposed groups, it was higher in G₃ and G₄. The pulse rate increased from 88 to 108 counts min⁻¹ from morning to peak hot period, but was lower in G₁ and G₂ than in high-energy-fed G₃ and G₄. Sweating rate was higher in sun-exposed animals, compared to those in the shed. It was higher when RH and ambient temperature were high. Blood sugar content was also higher in G₃ and G₄ than in G₁ and G₂. The results indicated that water consumption and physiological responses of sun-exposed groups were higher compared to animals in shade. Among the sun-exposed groups, the responses were less pronounced in high-energy-fed groups than in the lambs fed as per requirement.

Key words: Lamb, energy, growth, heat tolerance.

Summer season in semi-arid environment is characterized by progressive withering of vegetation and concomitant reduction in DMI and nutrient availability. The heat mediated depression in DMI due to inhibitory effect of hypothalamic center (Brobeck, 1960) further reduces the DMI. Simultaneously, the physiological responses elicited by heat-exposed sheep are dynamic in nature, requiring higher energy expenditure for maintaining homeothermy resulting in diversion of energy from production to priority function of thermolysis. Thus, higher energy requirement and its lower availability is reflected in compromise of production, resulting in lower growth per-

formance of tropical sheep (Ames and Brink, 1977). Since the prevailing agrometeorological conditions and animal's response under such environment can not be changed, it is envisaged that increasing energy density of the diet compensating heat mediated depression in DMI will meet the enhanced requirement for desired production traits.

The reported experiment was, therefore, conducted to assess the relationship of dietary energy levels and heat tolerance in order to devise methods to counter direct negative effect of heat exposure on growth performance of weaner lambs in active phase of growth.

Table 1. Physical and chemical composition of the experimental rations. (%)

Rations	R ₁	R ₂	R ₃
Physical composition			
Ground <i>Cenchrus</i> hay	55	31	7
Maize	21	50	79
Groundnut cake	22	17	12
Mineral mixture	1.5	1.5	1.5
Common salt	0.5	0.5	0.5
Chemical composition			
Dry matter	93.23	91.83	91.10
Crude protein	12.68	13.62	15.75
Ether extract	2.76	2.69	3.72
Crude fibre	20.92	12.19	7.02
Nitrogen-free extract	57.37	65.96	69.39
Ash	6.27	5.54	4.12
Calculated nutritive values			
DCP	9.2	9.2	9.3
TDN	58.0	66.7	75.4

Materials and Methods

Thirty two mutton synthetic (Dorset x Malpura half-bred) weaner (2.5 month old) lambs adopted from institute flock, were divided into four equal groups and fed to gain @ 100 g ADG as per ICAR (1985) standards inside an open animal shed (G₁), or under the sun (G₂), or fed 115% (G₃), and 130% (G₄) of their requirement under the sun. The experimental energy variation was effected with similar DMI in all the groups by feeding R₁ to G₁ and G₂ and R₂ and R₃ (Table 1) containing 15 and 30% more energy to G₃ and G₄, respectively. The offer of individual animal was adjusted based on weekly body weight changes. Chain link fencing enclosures were erected in open space and G₂, G₃ and G₄ lambs were exposed to summer sun throughout the experimental period of 90 days. Similar enclosures in a side-open animal shed were used to protect the G₁ lambs from direct sun.

Individual lambs were daily offered their calculated amount of respective rations in the morning and watered free choice at 1400 h. Records of feed and water intakes were maintained throughout the experiment. Physiological responses, viz., respiration rate by counting flank movement, pulse rate by palpation femoral artery, rectal temperature using Aplab multichannel telethermometer at 0730 and 1430 h, and sweating rate (Schleger and Turner, 1965) at 1430 h were recorded on all the animals at fortnightly intervals. The animals were also bled by jugular vein puncture in fortnightly intervals at 0730 and 1430 h and blood glucose (Cooper and McDaniel, 1970) was estimated in whole blood and total protein and albumin (Wotten, 1964) in separated serum. The dry bulb temperature, relative humidity (at 0730 and 1430 h), minimum and maximum temperature, wind velocity and hours of sunshine were recorded daily

Table 2. Feed and water intake, physiological and biochemical responses of lambs fed on different energy levels during summer

	G1	G2	G3	G4	SEm
Dry matter intake (g/kg BW)	33.4	34.2	34.4	33.1	0.38
Dry matter intake (g/kg W ^{0.75})	66.2 ^a	67.3 ^a	69.9 ^b	66.6 ^a	0.92
Water intake (ml/kg BW)	135.6 ^A	158.4 ^C	149.2 ^B	147.0 ^B	2.40
Water intake (L/kg DMI)	4.198 ^A	4.750 ^B	4.498 ^A	4.477 ^A	0.0837
Respiratory frequencies/min					
AM	43.0 ^A	40.1 ^A	57.1 ^B	62.2 ^B	2.28
PM	89.6 ^A	121.3 ^B	125.3 ^B	126.6 ^B	2.52
Increase	46.3 ^A	81.6 ^C	65.8 ^B	62.8 ^B	3.58
Increase/ $\Delta^{\circ}\text{C}$ RT	94.4 ^A	172.9 ^B	114.5 ^A	154.4 ^A	42.44
Pulse rate/min					
AM	77.9 ^A	84.1 ^B	92.4 ^C	95.9 ^C	1.41
PM	99.4 ^A	103.1 ^A	112.3 ^B	115.6 ^B	1.59
Increase	20.5 ^A	19.6	19.2	20.2	1.74
Increase/ $\Delta^{\circ}\text{C}$ RT	39.4	25.5	34.9	39.7	6.21
Rectal temperature ($^{\circ}\text{C}$)					
AM	38.78 ^A	38.64 ^A	38.98 ^B	39.22 ^C	0.038
PM	39.55 ^A	39.77 ^B	39.77 ^B	39.75 ^B	0.033
Increase	0.77 ^B	1.10 ^C	0.78 ^B	0.51 ^A	0.045
Increase/ $\Delta 10^{\circ}\text{C}$ RT	1.85 ^{AB}	2.43 ^B	2.06 ^B	1.28 ^A	0.168
Sweating rate (g/m ² /h)	220.1 ^A	306.9 ^B	286.0 ^B	308.0 ^B	15.45
Blood sugar (mg/100 ml)					
AM	60.8 ^A	60.2 ^A	67.3 ^A	77.4 ^B	4.07
PM	59.9 ^A	59.5 ^A	67.9 ^B	65.6 ^B	1.08
Serum total protein (g/100 ml)					
AM	5.95 ^C	5.92 ^{BC}	5.65 ^A	5.75 ^{AB}	0.052
PM	5.91 ^B	5.91 ^B	5.66 ^A	5.90 ^B	0.053
Serum albumin (g/100 ml)					
AM	2.47	2.54	2.54	2.45	0.046
PM	2.55 ^B	2.45 ^A	2.47 ^A	2.40 ^A	0.031
Serum globulin (g/100 ml)					
AM	3.48 ^B	3.38 ^B	3.11 ^A	3.30 ^{AB}	0.068
PM	3.36 ^{AB}	3.46 ^B	3.20 ^A	3.50 ^B	0.060
Albumin/globulin ratio					
AM	0.76	0.78	0.87	0.78	0.039
PM	0.78 ^A	0.72 ^A	0.80 ^B	0.71 ^A	0.020

For superscripts in G1 to G4: Capital letters indicate $P < 0.01$; small letters $P < 0.05$.

at local observatory and solar radiation (global radiation) data were obtained from Jaipur observatory of India Meteorological Department (Table 2). The generated data

were subjected to least squares analysis of variance (Harvey, 1975) and significant group differences were compared by Duncan's Multiple Range Test (Duncan, 1955).

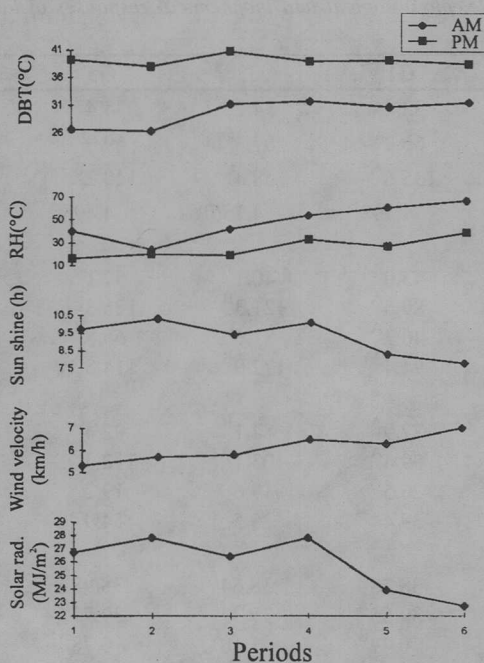


Fig. 1. Meteorological variations during exposure of lambs to hot summer.

Results and Discussion

The overall DMI was similar in all the groups (3.4% of BW), whereas, initially the lambs did not fully consume the calculated offer. Hence, the DMI was lower ($P < 0.01$), i.e., 2.2% of BW which gradually increased to 3.4% of BW by 5th week and stabilized there after. Water consumption as per cent of BW was lower ($P < 0.01$) in G₁ animals in the shed (13.6) compared to those in the sun: G₂ (15.8), G₃ (14.9) and G₄ (14.7). Among the sun-exposed group, it was higher in G₂ ($P < 0.01$) compared to G₃ and G₄. Since water intake is proportional to DMI (MacFarlane, 1976), with similar DMI higher water consumption in sun-exposed groups compared to animals in shed was obviously used in respiratory and cutaneous evaporative cooling (Karim *et al.*, 1984). Among the sun-exposed

groups, higher water consumption in G₂, compared to high energy-fed G₃ and G₄, could be due to higher roughage content in G₂, favoring higher acetate production in rumen fermentation and heat increment, thus adding to their heat load (Weldy *et al.*, 1964).

Respiration rate (RR) of the lambs was 51 beats min^{-1} in the morning which increased ($P < 0.01$) to 116 beats min^{-1} at 1430 h, amounting to 129% increase from morning to peak hot period. The RR of sun-exposed G₂, G₃ and G₄ was higher than the G₁ maintained in shed as solar radiation in terms of heat component is additive to heat load on the animals (Azmel *et al.*, 1987). Among the sun-exposed groups, RR was higher ($P < 0.01$) in high energy fed G₃ and G₄. The finding is in agreement

with reports of Blaxter *et al.* (1959), indicating higher RR in sheep fed on higher energy levels. During morning hours, the RR of lambs was similar in G₁ and G₂ and higher in G₃ and G₄, whereas, in the after-noon, RR was significantly lower in G₁ as compared to sun-exposed G₂, G₃ and G₄ (Table 2). Further, morning to peak hot period increase in RR was more in G₂, followed by G₄ and G₃ and the rise was least in G₁. The increase in RR for unit rise in RT was, however, similar in G₁, G₃ and G₄, and higher in sun-exposed G₂. Generally, the afternoon RR's of the animals were higher in periods of high temperature (Fig. 2) due to direct effect of ambient temperature (Singh, 1980), whereas, morning RR's were higher in pe-

riods of high humidity and high temperature (Fig. 1). This is because higher RH at high ambient temperature hampers evaporative cooling (Bouvier *et al.*, 1974). It was also evident that periods of high AT and RH brought about greater respiratory distress in G₂ at period 6 as evinced from rise in RR for unit rise in RT (Fig. 2).

The rectal temperature (RT) increased from morning (38.9°C) to peak hot period (39.7°C), amounting to 1.9°C rise in RT with each 10°C increase in ambient temperature. During morning, RT was similar in G₁ and G₂ and higher in G₃ and G₄, whereas, in the afternoon, the animals in shed exhibited lower RT (39.5°C) compared to the sun-exposed G₂, G₃ and G₄ (39.8°C). The morning to peak hot period increase

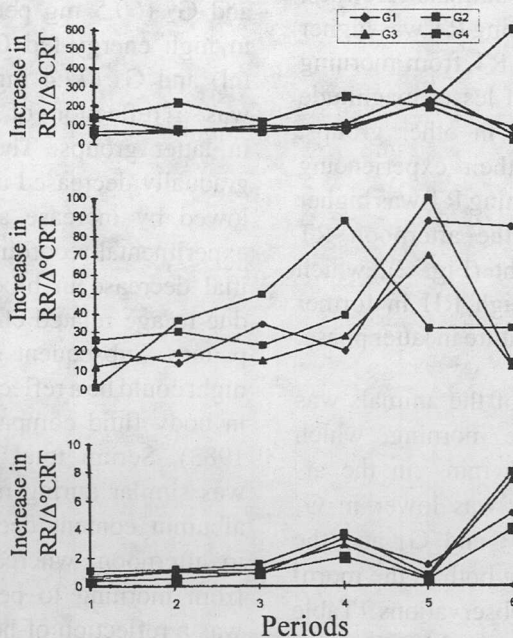


Fig. 2. Physiological responses of lambs maintained on varying energy levels under heat exposure.

in RT was higher in G₂ than in other experimental groups, and among the sun-exposed groups, such increase was lower in G₄ as against that in G₂ and G₃ (Table 2). Under range management, the diurnal increase in RT of sheep is recorded to be 1.0°C (Blight *et al.*, 1976). Our observation of 0.8°C increase is in close agreement with the finding. The animals exposed to direct solar radiation register greater rise in RT (Gupta and Acharya, 1987). It was observed in this study that the sun-exposed lambs, even with enhanced respiratory ventilation and cutaneous evaporation, were unable to lose incident and generated body heat effectively, resulting in increased core temperature. Further, the higher RT in high-energy-fed G₃ and G₄ during morning recording was a reflection of their higher nutrient intake, which in metabolic process adds to heat load of the animals (Holmes, 1974). Although the morning RT was higher in G₃ and G₄, the rise in RT from morning to peak hot period was of lesser magnitude in G₄ compared to that in other groups, which is indicative of their experiencing lesser heat load. The morning RT was higher in 5th fortnight, while the afternoon RT peaked on third fortnight (Fig. 2), which was due to prevailing high RH in former and high ambient temperature in latter phase.

The pulse rate (PR) of the animals was 88 counts min⁻¹ in the morning, which increased to 108 counts min⁻¹ in the afternoon. In general, PR was lower in G₁ and G₂ compared to G₃ and G₄ and the trends remained the same both in the morning and the afternoon observations (Table 2). However, the quantum of PR increase from morning to peak hot period for unit °C rise in RT was similar in all the four groups. The higher pulse rate in high-en-

ergy-fed groups could be due to associated higher metabolic activity with greater circulatory orientation toward periphery (Hales, 1976) to facilitate thermolysis.

The overall sweating rate of the heat exposed animals was 280.3 g m⁻² h⁻¹. The sweating rate was significantly higher in sun-exposed G₂, G₃ and G₄ (300.4 g m⁻² h⁻¹), compared to those under protection, i.e., G₁ (200.1 g m⁻² h⁻¹). It is reported (Murray, 1966) that sweating rate of sun-exposed field animals is higher due to greater sweat gland activity. Higher sweating rate was also observed in periods of high RH, indicating that in such environment, respiratory ventilation alone was not adequate for thermolysis. Hence the animals had to rely on cutaneous evaporation.

Blood sugar content was similar in G₁ and G₂ (60.5 mg per 100 ml) and higher in high energy-fed G₃ (67.3 mg per 100 ml) and G₄ (77.4 mg per 100 ml), which was a reflection of substrate availability in latter groups. The blood sugar values gradually decreased up to 4th fortnight, followed by increase and reaching the pre-experimental recording by 6th fortnight. Initial decrease in blood sugar content was due to age related changes in fermentation pattern. Subsequent increase after 4th fortnight could be a reflection of likely alteration in body fluid compartments (Singh *et al.*, 1983). Serum total protein of the lambs was similar during morning and noon and albumin content decreased from morning to afternoon, whereas, globulin increased from morning to peak hot period, which was a reflection of heat mediated response.

The results indicated that water consumption and physiological responses of sun-exposed animals were of higher mag-

nitude than the lambs in shed, and among the sun-exposed lambs, the responses were less pronounced in higher-fed groups, compared to lambs fed as per requirement. Lower increase of RR for unit rise in RT in high-energy-fed sun-exposed groups indicated that such animals have to be fed at higher level than the prescribed requirement.

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