Nutrient Intake and Utilization by Range Managed Sheep in Critical Physiological Stages Maintained on Grazing with Concentrate Supplementation in a Hot Semi-Arid Environment

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ABSTRACT : The reported study was conducted on range managed Malpura ewes that were non-breeding empty, were at an advanced stage of pregnancy, and were in early lactation, under a protocol of free grazing with concentrate supplementation at 1.00, 1.25 and 1.50% of their body weight to assess their plane of nutrition and nutrient intake. The biomass yield of pasture plots was 1689, 1820 and 2912 kg/ha in pregnancy, lactation and empty phases, respectively. In addition to natural shrubs and forbs, *Cenchrus ciliaris* (36.4%) and dead litter (31.6%) were the major component of pasture vegetation during pregnancy. The dead litter disappeared during the lactation and empty phase with a concomitant increase in distribution of *Cenchrus ciliaris* to 73.0 and 87.2% respectively. The daily dry matter consumption from supplemental concentrate and free grazing was 70.1, 57.3 and 63.5 g/kg $W^{0.75}$/d with concentrate to roughage ratio of 40:60, 47:53 and 33:67 in pregnancy, lactation and empty phases respectively. Digestibility of DM and OM were similar in the three phases while CP digestibility was higher ($p<0.01$) during lactation than other two phases. Digestibility of NDF, ADF and cellulose were higher ($p<0.01$) in empty than pregnancy and lactation, while hemicellulose digestibility was similar in lactation and empty and lower in pregnancy phase. The ewes in phases of pregnancy, lactation and empty consumed 7.1, 7.7 and 6.1 g DCP and 197.2, 214.6 and 232.5 kcal DE/kg $W^{0.75}$/d respectively. It is concluded that ewes maintained on semi-arid *Cenchrus* dominated pasture with concentrate supplementation during pregnancy, lactation and empty phases consumed 45.2, 45.1 and 35.2 g DCP/Mcal ME respectively. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 9 : 1228-1234*)

Key Words : Sheep, Range Management, Nutrient Utilization, Maintenance, Pregnancy, Lactation

INTRODUCTION

The sheep population of India is found in hot semi-arid and arid regions wherein conventional agricultural production is a gamble due to prevailing unfavorable climatic conditions. The species is traditionally raised by landless laborers and marginal farmers on community grazing land employing self or family labor under a zero input and marginal output system of production management (Karim et al., 1998). Under the prevailing production system, the concept of nutritional inputs commensurating with varying levels of production traits or the critical physiological stages is almost nonexistent except for limited freshly harvested or conserved tree leaf supplementation during lean summer months.

Nutrient intake, its utilization and requirement studies on sheep in the country are mostly conducted on stall fed animals using single or combination feeds and the topic has been extensively reviewed by Kearl (1982). Using the results from a series of feeding experiments conducted at Central Sheep and Wool Research Institute, nutrient requirements of Indian sheep in the critical physiological stages have been worked out (CSWRI, 1998). A recent round the year study on nutrient utilization of sheep covering the three major season of hot semi arid region indicated that the range managed rams on an average consumed 3.1 g DCP and 85 kcal ME/kg $W^{0.75}$ for maintenance (Shinde et al., 1998a) while by gaseous exchange method the energy expenditure was recorded as 70.6 kcal/kg $W^{0.75}$ in stall fed rams which increased to 100.6 kcal/kg $W^{0.75}$ under free range management (Shinde et al., 1998b).

Knowledge of nutrient requirements for various physiological functions forms the very basis for scientific feeding. Studies on nutrient requirements for range managed sheep in the country are relatively few compared to those based on stall feeding while the majority of sheep are maintained exclusively under range management. The critical physiological stages in sheep having significance in practical feeding are maintenance with wool production, advanced stage of pregnancy, and early and late lactation. Assessment of plane of nutrition in these physiological stages for Indian sheep maintained on semi-arid and arid cultivated pasture indicated that grazing alone was adequate to meet their maintenance requirement with wool production, while in the advanced stage of gestation and early lactation, the nutrient intake was lower than the requirement, requiring supplementation (Mali et al., 1984; Thakur and Patnayak, 1985; Bhatta et al., 1996).

The reported study was therefore conducted on

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range managed ewes in phases of empty with wool production, advanced stage of pregnancy, and early lactation, under a protocol of free grazing with limited concentrate supplementation to assess their plane of nutrition and nutrient requirements.

MATERIALS AND METHODS

Geographical location

The study was conducted at the Central Sheep and Wool Research Institute, Avikanagar located at 75° 2 8′ E latitude, 26° 17′ N longitude and 320 m above mean sea level. The climate of the location is typical hot semi-arid having an average annual precipitation of 257 mm with 93% distributed between June and September and the remaining 7% in the form of short winter showers from January to March. The experiment was started by adopting ewes in advanced stage of pregnancy in the first week of March, 1997. The lambing in ewes was spread over a fortnight period extending from last week of April to first week of May, 1997. The lactation phase of the study was conducted during middle of April to July, 1997 and the study for empty phase was taken during August–September, 1997. The prevailing environmental condition during the experiment is presented in table 1.

Experimental animals and feeding trial

47 Malpura ewes (3-4 years of age) mated as per the approved breeding plan of All India Coordinated Research Project (Mutton) were adopted for the study. Prior to adoption in the experiment, the ewes were maintained on grazing for 8 h/d. on *Cenchrus* dominated range land under supervision of a grazer followed by free choice conserved fodder in hay racks in the animal shed. Before initiation of the study all the ewes were dewormed, vaccinated against common contagious diseases and during the course of the study given veterinary aid as and when required. The experimental flock had free access to clean drinking water twice daily, in the morning before taking them out for grazing and in the afternoon, on their return from the grazing area. The ewes after grazing were housed during the night in a open side asbestos roofed animal shed. Same ewes were used in pregnancy, lactation and empty phases of the study to avoid errors due to individual variation.

The pregnant ewes in addition to free grazing received concentrates individually at 1.25% of their body weight. The concentrate (barley 62%, groundnut cake 15%, wheat bran 20%, mineral mixture 2% and salt 1%) offered to each ewe was revised at weekly intervals, based on their body weight changes (including gut fill and conceptus). The chemical composition of the concentrate mixture and mouth grab vegetation sample are presented in table 3. Three weeks after initiation of the grazing experiment, a digestibility trial by double indicator method (Krishna et al., 1981) was conducted on six range managed ewes of the flock with confirmed pregnancy to assess their plane of nutrition. The ewes were confined to individual pens two to three days before expected date of lambing and during confinement they were offered their calculated concentrate allowance and *ad libitum* *Cenchrus ciliaris* hay.

The ewes after termination of pregnancy were followed up in lactation phase till three months post lambing. The concentrate allowance was increased to 1.5% of ewes' body weight to meet the added requirement of lactation. The composition of the concentrate mixture as well as the grazing and feeding management were similar to those for the pregnancy phase. After lambing, the ewes were initially confined to pens for seven days, followed by grazing and supplementation as in the pregnancy phase. Milk yield of all the ewes was recorded at weekly intervals by

Table 1. Environmental condition of the location during the experiment

Attributes	Pregnancy	Lactation	Maintenance
Dry bulb temperature (℃)			
0830 h	22.7 (14.5 - 28.5)*	28.5 (21.8 - 31.7)	25.3 (22.0 - 29.0)
1430 h	34.5 (20.0 - 41.0)	36.6 (26.5 - 43.0)	31.7 (23.0 - 37.0)
Wet bulb temperature (℃)			
0830 h	16.8 (10.0 - 22.5)	22.9 (16.5 - 27.0)	23.0 (19.0 - 26.0)
1430 h	21.1 (18.0 - 28.0)	25.3 (19.0 - 28.7)	24.8 (20.6 - 27.5)
Relative humidity (%)			
0830 h	55.4 (9.0 - 99.9)	61.2 (18.0 - 96.0)	81.7 (68.0 - 99.9)
1430 h	29.1 (3.0 - 81.0)	40.6 (9.0 - 96.0)	57.4 (31.0 - 96.0)
Wind velocity (km/h)	3.4 (0.0 - 11.1)	2.9 (0.0 - 10.3)	0.4 (0.0 - 1.7)
Total rainfall (mm)	0.78 (0.0 - 9.3)	3.0 (0.0 - 32.6)	6.36 (0.0 - 106.4)
Sunshine hours	9.61 (4.7 - 11.8)	8.4 (2.0 - 12.1)	8.05 (0.5 - 11.1)

* The figures in parenthesis are range.

the lamb suckling method, along with estimation of milk composition. A digestibility trial was conducted in early lactation (under the regimen of grazing with supplementation) by double indicator method on the same ewes earlier used in the digestibility trial of the pregnancy phase.

The ewes after weaning of the lambs were continued in same grazing management practice in their empty phase for another one month. During this phase the ewes were maintained on grazing with 1% concentrate supplementation. A digestibility trial was conducted by indicator method on the same six ewes, 20 days after weaning of their lambs.

Biomass yield and chemical analysis

The biomass yields of the pasture plot in the three phases of the study were estimated by the method of Tadmor et al. (1975). Percent contribution of the plant species and vegetation yield on DM basis was assessed by the method of Holechek et al. (1986). Dry matter intake/day and nutrient utilization of the ewes in pregnancy, lactation and maintenance phases were determined by double indicator method (Krishna et al., 1981). Diet samples of vegetation consumed by the animals were collected by the mouth grab sampling. The samples of diet, concentrate offer and faeces were analyzed for DM, CP (AOAC, 1990), cell and cell wall constituents (Goering and Van Soest, 1970).

Statistical analysis

The generated data were subjected to least squares analysis of variance (Snedecor and Cochran, 1967) and significant group differences were compared by Duncans Multiple Range Test (Duncan, 1955). The ewes were weighed at weekly intervals in the three phases of the study. The body weight changes of the ewes in advanced pregnancy and empty phases could not subjected to statistical analysis due to short period and variable date of lambing. However, body weight changes of individual ewes during the 90 days lactation phase were charted by fitting polynomial curves and the pooled constants are presented graphically (figure 1).

RESULTS AND DISCUSSION

Biomass yield and botanical composition of pasture

Biomass yield of the pasture plot during the pregnancy phase of the experiment was 1689 kg DM/ha. The dominant plant species on the pasture plot were *Cenchrus ciliaris* (36.4%), *Sorghum helepense* (14.7%) grass, *Vermonia cineraria* (11.5%), *Comelina forskalei* (1.8%), *Achyranthes aspera* (1.6%) forbs and *Zizyphus nummularia* (1.0%) shrub, while the dead litter formed a major portion of the biomass (31.6%). The biomass yield of the pasture plot increased to

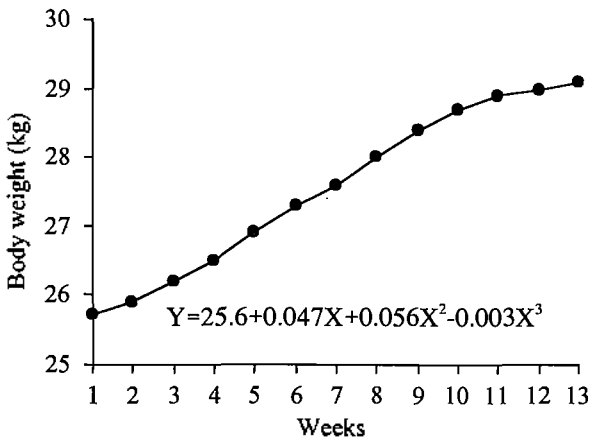

Figure 1. Polynomial distribution of body weight changes in ewes during lactation phase

1820 kg DM/ha in the lactation phase along with a sizeable increase in distribution of *C. ciliaris* (73.0%) and a concomitant decrease in *S. helepense*. The dead litter, which formed a major portion of biomass of the pasture in the pregnancy phase disappeared in the lactation phase while the distributions of forbs and shrubs were more or less similar in the two phases. Pasture yield further increased to 2,912 kg DM/ha in the maintenance phase of the study, mostly dominated by *C. ciliaris* (87.2%) while the shrubs, forbs and dead litter made negligible contribution (table 2). The pregnancy phase of the study was conducted in early May representing the hot dry conditions of the semi-arid region (table 1); the lactation and maintenance phases were in the last week of July and middle of October, respectively. The observed increases in biomass yield during lactation and maintenance phases were due to the prevailing climatic conditions, being pre-monsoon shower in late July in

Table 2. Biomass yield of pasture and botanical composition of mouth grab sample

Attributes	Pregnancy	Lactation	Maintenance
Biomass yield (kg DM/ha)	1,689	1,820	2,912
Botanical composition (%)			
Cenchrus ciliaris	36.4	73.0	87.2
Sorghum helepense	14.7	4.5	2.5
Achyranthes aspera	1.6	4.0	1.0
Commelina forskalei	1.8	1.5	0.7
Vigna sinensis	0.8	1.1	0.4
Vermonia cineraria	11.5	0.4	5
Zijyphus numularia	1.0	3.8	0.8
Dead litter	31.6	Nil	Nil
Others	0.60	11.7	2.4

the former, and favorable environmental condition in middle of October during the later phase of study. The biomass yield of the pasture and its vegetation composition were comparable to earlier studies at same location on a similar type of pasture (Shinde et al., 1996). Dead litters, comprising shed leaves of shrubs, trees and dried fallen foliage of grasses and forbs, contributed 31.6% to biomass in pregnancy phase of study whereas it disappeared during lactation and empty phases in the natural seasonal cycle. The observation is in agreement with earlier findings of Shinde et al. (1998a). Further, the DM yield of *C. ciliaris* dominated, protected and ungrazed pasture is reported to range from 29-47 quintal/ha (Rao et al., 1993; Roy et al., 1995) whereas in this study the observed lower biomass yield of the pasture was due to continuous grazing.

Nutrient intake and nutrient digestibility

All the 47 ewes were mated as per approved plan of breeding project; 39 were found pregnant and 8 were empty, hence the percentage of confirmed pregnancy in the flock was 83%. Among the pregnant ewes one aborted, while one lamb was lost in dystokia, hence the lambing rate of the flock was 78.7%. The reproductive efficiency of the experimental flock was comparable to earlier reports for the genotype maintained under similar breeding and management practices (CSWRI, 1998).

The ewes in advanced stage of pregnancy, maintained under the regimen of 8 hours of effective grazing on *Cenchrus* dominated pasture with concentrate supplementation at 1.25% of their body weight, consumed 909 g DM/day amounting to 2.98% of body weight or 70.1 g/kg $W^{0.75}$. Ewes in early lactation receiving concentrate at 1.5% of their body weight under similar grazing condition consumed 789 g DM/day amounting to 2.93% of their body weight or 57.3 g/kg $W^{0.75}$. The DMI during maintenance phase with grazing and 1% concentrate supplementation was 803 g/day amounting to 2.73% of body weight or 63.5 g/kg $W^{0.75}$ (table 4). The ratios of concentrate to roughage under the regimen of free grazing and the regulated concentrate supplementation in DMI of pregnant, lactating and empty ewes were 40:60, 47:53 and 33:67 respectively. Although the DMI differed between physiological stages it did not achieve statistical significance due to wide individual variation. Compared to empty phase with wool production, the DMI of the ewes in terms of unit metabolic weight increased by 13% in advanced pregnancy while it decreased by 10% in the lactation phase. The observed DMI in the three phases of the study was lower than the prescribed DM requirement for the defined physiological stages (Kearl, 1982; CSWRI, 1998) but compared favorably with the reported values of Patnayak (1978) and Rattray (1974). The reduction of DMI in lactation compared to pregnancy and empty phases could also be ascribed to higher level of concentrate supplementation. The mouth grab sample of pasture vegetation consumed by the ewes contained 8.02, 8.31 and 9.17% CP in the pregnancy, lactation and empty phases of study while the concentrate mixture offered had 15.7% CP (table 3). The ADF content of mouth grab pasture vegetation sample was 66.31, 54.25 and 43.37% in pregnancy, lactation and empty phases of study respectively. The NDF, ADF and cellulose content of mouth grab pasture vegetation sample was highest in pregnancy phase of study conducted during peak summer. The ADF content decreased during lactation and more so in the empty phase because of pre-monsoon shower in the former and full blown monsoon in the later phases of study. The changes in chemical composition of pasture vegetation observed in the present study is in agreement with the finding of Shinde et al. (1998a).

Digestibility of DM and OM was similar in the three phases while CP digestibility was significantly ($p<0.01$) higher in lactation than in the other two phases (table 4). Improved digestibility of CP during lactation could be ascribed to a higher rate of concentrate supplementation. Additionally it is also established that even on the same diet, digestibility of CP would markedly improve in the lactation phase to support the higher CP drain from the body in milk secretion. Digestibility of NDF, ADF and cellulose were higher ($p<0.01$) in empty than other phases while hemicellulose digestibility was similar in lactation and empty, and lower in pregnancy. The observed changes in digestibility profile of nutrients was the reflection

Table 3. Chemical composition (% DM) of mouth grab samples and concentrate mixture

Attributes	Mouth grab sample of vegetation			Concentrate mixture
	Pregnancy	Lactation	Maintenance	
Crude protein (CP)	8.02	8.31	9.17	15.70
Neutral detergent fibre (NDF)	74.68	70.59	69.21	48.37
Acid detergent fibre (ADF)	66.31	54.26	43.37	18.91
Cellulose	42.96	37.69	34.09	14.17
Lignin	9.09	6.12	4.91	4.14
GE (kcal/g DM)	4.02	4.13	4.21	4.51

of the higher rate of concentrate supplementation in lactation, and quality vegetation availability on pasture after the monsoon in empty phase. Further, under the protocol of grazing with supplementation the digestibility of nutrients observed in this study was better than those reported for sheep maintained on exclusive range management (Shinde et al., 1998b).

The milk yield of the ewes was 500 ml on the day of lambing and reached its peak in the 2nd and 3rd week (575 ml) which was maintained till 9th week, followed by a gradual decrease to 375 ml till weaning i.e. by 12th week of age. The average milk yield/day of Malpura ewes during lactation phase was 496 g which was 30 and 23% lower than average yield of crossbred Bharat merino (Singh, 1997) and Mutton synthetic (Singh and Singh, 1987) ewes. The average daily yield was however higher compared to native sheep (359 g/day) under farmers' management (Riyazuddin et al., 1998).

DCP intake of the ewes was 92.7, 91.8 and 77.6 g/day, respectively in pregnancy, lactation and empty phases which was adequate as per prescribed requirements (NRC, 1975; ICAR, 1985). The intake was similar in pregnancy and lactation and lower ($p<0.01$) in the maintenance phase. Increased DCP intake during pregnancy was due to higher DMI while in the lactation phase it was the reflection of better CP digestibility (table 4). Overall DCP intake of the ewes under the grazing with supplementation schedule was higher than sheep maintained on sole range management (Shinde et al., 1998b).

DE intake/day was similar in pregnancy and lactation (2.546 Mcal) and 8% higher in the empty (2.757 Mcal) phase which could be ascribed to better digestive efficiency of cell and cell wall constituents. Scaled down to unit metabolic body size the DE intake was 197.2, 214.6 and 232.5 kcal/day respectively in pregnancy, lactation and empty phases. DE requirement of sheep with wool production is worked out to be 154.0 kcal/kg $W^{0.75}$ (CSWRI, 1998) and considering that the range managed sheep require 50 % more energy to meet the added requirement of field existence (Kearl, 1982), their DE intake in maintenance phase would be considered adequate which is also in agreement with findings of Benjamin et al. (1977) on range managed sheep. According to

Table 4. Dry matter intake, nutrients digestibility and plane of nutrition of ewes in different physiological stages

Attributes	Pregnancy	Lactation	Empty
Body weight (kg)	30.50 ± 1.15	26.9 ± 2.01	29.4 ± 1.34
Dry matter intake			
Roughage (g/d)	545.4 ± 31.71	417.8 ± 39.63	537.9 ± 44.04
Concentrate (g/d)	363.6 ± 12.65	370.5 ± 15.09	264.8 ± 10.83
Total intake (g/d)	909.0 ± 97.36	788.3 ± 42.53	802.7 ± 59.24
Intake (g/kg body weight/d)	29.8 ± 3.38	29.3 ± 1.71	27.3 ± 1.21
Intake (g/kg $W^{0.75}$/d)	70.1 ± 7.64	57.3 ± 9.12	63.5 ± 2.91
Digestibility coefficient (%)			
Dry matter	67.5 ± 0.63	67.8 ± 4.71	70.1 ± 1.07
Organic matter	71.0 ± 0.84	73.5 ± 2.09	73.5 ± 1.01
Crude protein**	75.0^{a} ± 1.26	87.3^{b} ± 1.33	71.6^{a} ± 1.53
NDF**	60.2^{a} ± 0.83	66.3^{ab} ± 2.40	69.0^{b} ± 1.63
ADF**	47.3^{b} ± 0.80	40.0^{a} ± 3.19	54.8^{c} ± 0.98
Cellulose**	60.2^{a} ± 1.48	61.8^{a} ± 1.75	72.0^{b} ± 1.23
Hemicellulose**	67.4^{a} ± 1.10	79.2^{b} ± 1.93	76.5^{b} ± 2.14
Gross energy	62.3 ± 3.13	65.8 ± 3.40	67.1 ± 2.33
Plane of nutrition			
DCP			
Intake (g/d)	92.7 ± 10.98	91.8 ± 4.70	77.6 ± 5.65
Intake (g/kg body weight/d)	3.0 ± 0.53	3.4 ± 0.16	2.6 ± 0.14
Intake (g/kg $W^{0.75}$/d)	7.1 ± 0.81	7.7 ± 0.31	6.1 ± 0.32
DE			
Intake (kcal/d)	2,545.9 ±219.93	2,545.6 ±121.83	2,757.2 ±160.12
Intake (kcal/kg body weight/d)	84.1 ± 10.35	94.2 ± 2.08	102.1 ± 7.17
Intake (kcal/kg $W^{0.75}$/d)	197.2 ± 22.18	214.6 ± 2.76	232.5 ± 15.02

Different superscript in a row indicates significant difference (** $p<0.01$ and * $p<0.05$).

Shinde et al. (1998b) the DE intake of range managed sheep for empty with wool production in the month of December (declining phase of lush season) was 141 kcal/kg $W^{0.75}$ which is 65% lower than the value observed in the present study. This may be attributed to higher biomass availability on the pasture, its better nutrient density, and concentrate supplementation (1% of BW). Although the DE intake was lower by 15% in pregnancy (about 15 days before expected date of lambing) than empty phase of the study, still as compared to prescribed maintenance requirement of 93 kcal ME/kg $W^{0.75}$ (Kearl, 1982), the ME (80% DE) intake in the study increased by 70% during late gestation. The observed increase in energy consumption was within range of earlier reports of 60 to 70% (Steyn, 1974; Adu, 1974). The observation of Rattray (1974) that ME requirement during pregnancy increases by 50% over maintenance requirement is however lower than is observed in ewes in a tropical environment. The DE intake/kg $W^{0.75}$ increased by 9% in lactation compared with pregnancy phase. The observed 172 kcal ME intake/kg $W^{0.75}$ by the lactating ewes with 0.50 kg average milk yield having 6.1% milk fat would be considered adequate compared to the observation of Kearl (1982) that lactating ewes with 1 kg milk yield having 6.8% milk fat required 212 kcal/kg $W^{0.75}$. Based on the generated data it is apparent that the ewes in empty phase with wool production, advance stage of pregnancy, and early lactation consumed 35.2, 45.5 and 45.1 g DCP/Mcal ME. It is evident that DCP intake increased from empty to pregnancy, and lactation phase of the study due to a progressive increase in rate of concentrate supplementation. The observed DCP intake of ewes in relation to ME consumed was sizably higher than the observation of Kearl (1982) for sheep in developing countries. Thus it is evident that either the biological value of commonly available protein supplement and vegetation was poor or the range managed tropical animals require high energy density supplemental concentrate, largely meeting their protein requirement by intensive selection on plant parts rich in protein (Shinde et al., 1996).

All the ewes showed gain in body weight during the pregnancy phase of the study. The changes in body weight of pregnant ewes could not be subjected to statistical analysis due to variable stage of pregnancy at the time of adoption of the ewes in this study. Body weight changes of the ewes in the lactation phase is presented in figure 1. The ewes in lactation phase maintained their weight in the first week of the study followed by a linear increase in weight till the 12^{th} week or weaning of the lambs. The gain in body weight of the ewes during lactation indicated that their nutrient intake was adequate or more than the prescribed requirement. Although the ewes showed linear gain in body weight during the maintenance phase, the data was not statistically analyzed due to the short span (28 days) of the study.

It is concluded that ewes maintained under a protocol of grazing with supplementation on semi arid pasture during the phases of pregnancy, lactation and empty phases consumed 45.2, 45.1 and 35.2 g DCP/ Mcal ME and were able to meet their nutrient requirement.

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