Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 397-402

Received: 25-03-2020
Accepted: 27-04-2020

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Effect of improved nutrition and improved shelter on growth performance of Magra lambs in two lambing seasons under arid zone

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Abstract
The present experiment was conducted in phased manner to observe the effect of improved nutrition and improved shelter either alone or in combination on growth performance in Magra lambs. In phase-I, fifteen days old Magra lambs (n=40) born in autumn-winter season were used for growth study in a randomized block design upto the six month of age (Season-1) at ARC-CSWRI and divided into four groups of 10 lambs in each group (T_1-T_4). In Phase-II, similar experiment was followed with the lambs born in spring-summer season (Season-II) Groups included T_1-Sole grazing with traditional shelter (tree shade); T_2-improved shelter (asbestos sheet-thatched roof/with curtains) with grazing; T_3-improved nutrition and traditional shelter and T_4- improved nutrition and improved shelter. There was diurnal variation in temperature and THI during the study period, which indicated that lambs were under thermal stress during various months of trial. Thermal stress reduced growth rate which might be improved, by amelioration of the negative effects of thermal stress by provision of improved nutrition and shelter either alone or in combination.

Keywords: Growth, improved nutrition, improved shelter, Magra, thermal stress

1. Introduction
In the arid region of Rajasthan, sheep graze mainly on stubbles and on community rangeland. In the community rangelands, there is low biomass yield and high stocking density (Sankhyan *et al*., 1999) [15] which causes nutritional stress. In arid and semi-arid region, majority of the sheep farmers do not provide concentrate supplement to their sheep in any physiological stage (Chaturvedi *et al*., 2001) [5]. As a result, lamb mortality is found to be as high as 20-30% and an average daily gain of 50 g in native breeds (Naik, 2014) [13]. In addition to nutritional stress, there is wide climatic variability in arid and semi arid regions of our country. There is wide variation in ambient temperature, which is from below 3 ºC in winter to above 48 ºC in summer seasons. In this way small ruminants, which are on grazing alone, expose to nutritional and environmental stress (Maurya *et al.*, 2004) [12]. When sheep is exposed to elevated temperature, there is reduction in body weight, growth rate and total solids of body which consequently reduce reproduction rate of animal (Marai *et al*., 2000; Abdel-Hafez, 2002) [10, 1]. Wide variation in the environmental conditions affects physiological functions and productivity of farm animals (Singh and Upadhyay, 2009) [20]. So, to optimize sheep production in variable climatic conditions, the negative effects of thermal stress should be minimized by adopting suitable strategies. Nutrient deficiency along with heat stress imposes severe effects on livestock production and production performance is dependent on growth of lambs. Birth weight, weaning weight and pre-weaning weight gains of lambs are associated with weight at market, so these all are important components of production at sheep farm. Therefore, present study was planned to investigate the effect of improved nutrition or improved shelter alone and in combination on growth performance of lambs.

2. Materials and Methods
Phased experiment was conducted on 15 days old male Magra lambs at the sheep farm of ARC-CSWRI, Bikaner. In phase-I, fifteen days old Magra lambs (n=40) born in autumn-winter season were used for growth study in a randomized block design upto the six month of age during the. Autumn-Winter season (Season-1) at ARC-CSWRI and divided into four

groups of ten lambs in each group (T_1-T_4). In Phase-II, similar experiment was followed with the lambs born in spring-summer season (Season-II) Groups included T_1-Sole grazing with traditional shelter; T_2-improved shelter with grazing; T_3-improved nutrition and traditional shelter and T_4- improved nutrition and improved shelter. The traditional shelter means an enclosure without roof structure under tree shade. Improved shelter was in the form of asbestos sheet-thatched roof. Additional protection was provided with curtains in winter period to save the lambs from direct cold waves. In groups of (T_3-T_4) varying plane of nutrition was supplemented with creep mixture @1% of their body weight from 15 days of age to weaning while multinutrient mixture @1% of their body weight was provided from weaning upto six month of age in both seasons. Lambs were kept in their respective sheds with their dams upto weaning and thereafter they were separated from their dams and let loose for 8 hours grazing in all groups. The lambs of all groups were supplemented with *ad lib* groundnut fodder during the whole trial. All experimental lambs reared under strict management and proper hygienic conditions throughout the study period. Deworming was carried out for both ecto and endo parasites using suitable anthelmintics before the beginning of the experiment. A digital data logger was used to record air temperature and relative humidity inside and outside of the shed. The data logger was hanged at 1.5 meter above the ground in the middle of inside and outside the shed. Climatic variables were observed from September 2016 to August 2017. THI values were calculated from recorded meteorological variables by formula given by Marai *et al.* (2007) [11]. The body weight was recorded at weekly intervals before feeding and watering. Individual body weight of all the lambs were recorded with hanging digital balance on the first day of the experiment and thereafter, regularly at weekly interval up to the end of the experiment. The weekly body weight gain was calculated by difference between weight recorded during the present and previous week. Average daily gain (ADG) in grams was estimated by dividing the total body weight gain by number of days. The data obtained in the present experiment were analyzed statistically for main effect of treatment or season alone as well as interaction (Treatment x Season) in factorial design (4x2) as per Snedecor and Cochran (2004)[21] and significance of mean differences was tested by Duncan's New Multiple Range Test (DNMRT) as modified by Kramer (1956) [8].

3. Results and Discussion

The monthly mean values of average temperature, relative humidity and temperature humidity index (THI) of different months of inside and outside shed of both seasons are presented under in Table 1. The monthly mean values of temperature, relative humidity and THI of daytime (7 a.m.-7 p.m.) and night time (7 p.m.-7 a.m.) during different months of inside and outside shed of both seasons have been presented in Table 2. The formulated creep mixture and multinutrient mixture were analysed for proximate composition as per AOAC, (2005). The per cent composition (% DM) of experimental feed mixtures has been tabulated in Table 3. The mean values of body weight of lambs under different treatment groups at weekly intervals of experiment have been presented in Table 4 (a&b). The mean values of live body weight of lambs were increased in twenty four weeks of trial from 5.69±0.16 to 18.20±0.24 kg in T_1 (Control), from 5.59±0.15 to18.88±0.25 kg in T_2, from 5.68±0.20 to 22.30±0.64 kg in T_3 and, from 5.70±0.20 to 22.92±0.76 kg in T_4 in season 1, while, from 5.30±0.21 to 19.25±0.38 kg in T_1 (Control), from 5.42±0.18 to 20.31±0.35 kg in T_2, from 5.31±0.17 to 24.01±0.45 kg in T_3 and, from 5.30±0.17 to 25.0±0.23 kg in T_4 group during season 2. Statistical analysis of variance due to main effect of treatment revealed significant effect ($P<0.05$) on the average body weight of lambs during 3rd week and highly significant ($P<0.01$) effect was observed from 4th week up to the end of experiment. Likewise, due to main effect of season, significant ($P<0.05$) effect was observed at initial day of experiment, 1st week and at 17th week and highly significant ($P<0.01$) effect from 18th to 24th weeks of experiment but remained non-significant in rest of the weeks. The mean values of average daily gain of lambs under different treatment groups at weekly intervals of experiment have been presented in Table 5(a&b). Due to main effect of treatment the mean values of overall average daily gain of lambs were recorded to be 81.94±1.50 g, 86.71±1.47g, 108.46±2.57 g and 113.25±2.64 g in T_1 (Control), T_2, T_3 and T_4 groups, respectively. Likewise, as a resultant to the main effect of season, average daily gain of lambs of whole study period were recorded to be 92.51±2.43 g during season 1 and 102.94±2.55 g during season 2. Statistical analysis of variance due to main effect of treatment and season revealed highly significant ($P<0.01$) effect and on average daily gain of whole period of study. Results of present findings showed that the calculated temperature humidity index (THI) for both seasons was observed to be in wide variation, which were either higher or lower than recommended values *i.e.* <22.2 is absence of heat stress, 22.2 to < 23.3 is moderate heat stress, 23.3 to< 25.6 is severe heat stress and 25.6 and more is extreme severe heat stress as reported for sheep by Marai *et al.* (2007) [11]. Looking into the results of meteorological variables of day-night, it is indicated that there was diurnal variation in temperature and THI, when animals were exposed to severe climatic stress in almost all daytime hours in extreme summer and in almost all night time hours during extreme winter. Wide variation in temperature and THI as evident from present findings indicated that lambs were under stress during various months of both seasons of study period. Results of present findings of growth rate showed that there was improvement in body weight and ADG in all treatment groups over control group during both seasons at the end of trial. The body weight and ADG of treatment groups was found statistically significant in comparison to control group receiving either improved nutrition (T_3) or improved nutrition with improved shelter (T_4) on overall ADG. The body weight and ADG of group T_2 having only improved shelter revealed non-significant variation but certainly achieved higher numerical values over control. The present findings of significant improvement in body weight and ADG of group (T_3-T_4) are in agreement with Malisetty and Yerradoddi (2013) [9] who reported that supplementation of concentrate @ 1 % of body weight in lambs has significant effect on ADG. Further, the results are well supported with the findings of Santra *et al.* (2002) [16], Girish *et al.* (2012) [7], Shinde *et al.* (1995) [19] and Chaturvedi *et al.* (2000) [4] who reported better ADG on supplementation of concentrate mixture along with grazing. Supplementation of concentrate mixture has the beneficial effect in the utilization of low-grade roughages in Marwari sheep, which increases the voluntary feed intake and feed utilization efficiency as reported by Bhatia (2004) [2]. Although there was no significant effect of improved shelter

on ADG on lambs in present trial but improvement in body weight gain was recorded numerically, which is in line with De *et al.* (2017) [6] who recorded non-significant improvement in growth performance by provision of improved shelter. Present findings of effect of shelter on lambs are also in line with Bhatta *et al.* (2004) [3] who reported non-significant difference of shelter on body weight gain within season due to wide variation in temperature and THI during trial. Looking into the results of present study with respect to main effect of season, the periodical live weight and average daily gain were recorded significantly higher in lambs born in season 2 *i.e.* spring summer season as compared to season 1 *i.e.* autumn winter season at the end of experiment. Nehra and Singh, (2006) [14] and Sharma, (1989) [17] also reported seasonal variations for body weight at various stages of growth. Therefore, one of the major challenging issues for sheep production is extreme and erratic pattern of environmental temperature, which adversely affects the sheep production by reducing the body weight, average daily gain, growth rate and body total solids (Marai *et al.*, 2000; Abdel-Hafez, 2002) [10, 1]. The major constraints for sheep production in arid region are less vegetation availability, high ambient temperature and wide climatic variability. Arid zone of Bikaner is known for its erratic variations in the environmental temperature, humidity and THI, which is evident from Table 1 and 2. This erratic variation in temperature and THI with season reflects that lambs need protection during the afternoon hours in summer (Shinde *et al.*, 2002) [18] and during night time of the winter season to maintain their body temperature in order to achieve higher growth performance.

Table 1: Monthly mean values of temperature, relative humidity and THI of season 1 and 2 (inside and outside shed)

Period (months)	Average temperature (ºC)		Average relative humidity (%)		Average THI	
	In	Out	In	Out	In	Out
Season 1						
September	31.65	32.33	49.63	49.16	28.94	29.49
October	27.80	27.81	44.83	45.64	25.56	25.60
November	19.31	19.01	43.27	44.95	18.45	18.22
December	18.76	17.87	48.62	48.05	18.06	17.31
January	14.73	12.84	65.30	65.51	14.72	13.02
Feb.-Mar. (up to 5th march)	18.59	20.19	42.91	39.07	17.74	19.05
Season 2						
February (From 12th feb.)	20.64	21.88	33.65	33.47	19.16	19.95
March	25.26	26.15	33.43	33.83	22.96	23.67
April	32.84	33.31	23.45	23.80	28.47	28.84
May	34.96	34.93	32.41	33.82	30.61	30.66
June	34.44	34.52	49.43	49.63	31.26	31.32
July-Aug (Up to 12th Aug.)	32.58	32.44	59.47	59.50	30.29	30.17

Table 2: Monthly mean values of temperature, relative humidity and THI of day and night of season 1 and 2 (inside and outside shed)

Period (months)	Temperature (ºC)				Relative humidity (%)				THI			
	Day		Night		Day		Night		Day		Night	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Season 1												
September	35.06	37.01	28.22	27.67	40.90	37.86	58.38	60.44	31.24	32.58	26.42	26.02
October	30.72	31.32	24.81	24.23	37.88	37.82	51.84	53.55	27.54	28.01	23.23	22.78
November	20.44	21.04	18.18	16.97	41.50	41.39	45.06	48.52	19.34	19.82	17.53	16.55
December	23.17	24.96	14.30	10.73	37.65	33.72	59.85	62.64	21.39	22.65	14.30	11.13
January	17.95	17.24	11.48	8.39	58.26	54.83	72.45	76.32	17.44	16.78	11.71	8.82
Feb.-Mar. (Up to 5th March)	20.92	24.35	16.27	16.04	37.95	31.66	47.83	46.44	19.65	22.20	15.95	15.77
Season 2												
February (From 12th Feb.)	23.17	25.38	18.11	18.39	27.87	25.90	39.43	41.04	21.09	22.63	17.22	17.27
March	29.06	31.52	21.52	20.84	26.17	24.62	40.65	42.98	25.68	27.47	20.19	19.68
April	37.14	38.90	28.54	27.71	18.18	17.22	28.79	30.44	31.35	32.59	25.40	24.81
May	38.90	39.14	30.97	30.68	25.61	27.24	39.44	40.60	33.23	33.55	27.84	27.66
June	37.28	37.84	31.60	31.20	41.98	41.50	56.91	57.80	33.14	33.56	29.29	28.99
July-Aug (Up to 12th Aug.)	34.54	34.87	30.61	30.00	52.56	52.17	66.39	66.83	31.56	31.82	28.91	28.39

Table 3: Proximate composition of experimental mixture and commercial pellets (% DM basis)

S. No.	Proximate principle	Creep mixture	Multinutrient mixture
1.	Dry matter	92.51	86.38
2.	Crude protein	18.23	17.61
3.	Ether extract	04.20	01.87
4.	Crude fibre	05.20	03.35
5.	Total ash	6.09	14.43
6.	Nitrogen free extract	57.80	58.96

Table 4(a): Effect of different treatment groups on body weight (kg) of lambs at weekly intervals in two lambing seasons

Period (Weeks)													
Treatment groups		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Interaction (Treatment X Season)													
Treatment	**Season**												
T_1	1	5.69± 0.16	6.72± 0.20	7.72± 0.23	8.66± 0.25	9.60± 0.28	10.49± 0.31	11.34± 0.35	12.12± 0.38	12.82± 0.41	13.49± 0.45	14.09± 0.48	14.71± 0.53
T_2	1	5.59± 0.15	6.63± 0.14	7.64± 0.14	8.58± 0.17	9.51± 0.19	10.41± 0.24	11.27± 0.28	12.07± 0.32	12.79± 0.34	13.48± 0.34	14.13± 0.33	14.75± 0.33
T_3	1	5.68± 0.20	6.84± 0.22	8.01± 0.25	9.11± 0.28	10.16± 0.31	11.19± 0.36	12.21± 0.40	13.22± 0.44	14.20± 0.49	15.14± 0.53	16.04± 0.58	16.87± 0.63
T_4	1	5.70± 0.20	6.94± 0.23	8.12± 0.27	9.26± 0.31	10.35± 0.37	11.40± 0.44	12.44± 0.50	13.45± 0.55	14.46± 0.6	15.46± 0.66	16.4± 0.71	17.26± 0.78
T_1	2	5.30± 0.21	6.33± 0.21	7.34± 0.21	8.29± 0.21	9.24± 0.22	10.17± 0.22	11.04± 0.23	11.83± 0.25	12.52± 0.26	13.17± 0.28	13.8± 0.29	14.37± 0.31
T_2	2	5.42± 0.18	6.52± 0.2	7.57± 0.22	8.57± 0.25	9.53± 0.28	10.44± 0.31	11.30± 0.34	12.11± 0.36	12.87± 0.38	13.57± 0.38	14.23± 0.38	14.87± 0.37
T_3	2	5.31± 0.17	6.56± 0.18	7.79± 0.2	8.98± 0.21	10.10± 0.23	11.19± 0.24	12.25± 0.25	13.28± 0.27	14.29± 0.28	15.28± 0.29	16.20± 0.30	17.05± 0.32
T_4	2	5.30± 0.17	6.58± 0.17	7.83± 0.17	9.04± 0.18	10.20± 0.18	11.33± 0.18	12.43± 0.19	13.48± 0.19	14.51± 0.18	15.52± 0.17	16.50± 0.17	17.41± 0.18
Main effect of Treatment													
T_1		5.48± 0.14	6.51± 0.15	7.52± 0.16	8.47^{A} ± 0.16	9.41^{a} ± 0.17	10.32^{a} ± 0.19	11.18^{a} ± 0.20	11.97^{a} ± 0.22	12.66^{a} ± 0.23	13.32^{a} ± 0.25	13.94^{a} ± 0.27	14.53^{a} ± 0.29
T_2		5.51± 0.11	6.57± 0.12	7.61± 0.13	8.57^{A} ± 0.14	9.52^{a} ± 0.17	10.43^{a} ± 0.19	11.29^{a} ± 0.22	12.09^{a} ± 0.24	12.83^{a} ± 0.25	13.52^{a} ± 0.25	14.18^{a} ± 0.24	14.81^{a} ± 0.24
T_3		5.50± 0.13	6.70± 0.14	7.90± 0.16	9.05^{B} ± 0.17	10.13^{b} ± 0.19	11.19^{b} ± 0.21	12.23^{b} ± 0.23	13.25^{b} ± 0.25	14.25^{b} ± 0.27	15.21^{b} ± 0.29	16.12^{b} ± 0.32	16.96^{b} ± 0.34
T_4		5.50± 0.14	6.76± 0.15	7.98± 0.16	9.15^{B} ± 0.18	10.27^{b} ± 0.20	11.36^{b} ± 0.23	12.43^{b} ± 0.26	13.47^{b} ± 0.28	14.48^{b} ± 0.31	15.49^{b} ± 0.33	16.45^{b} ± 0.36	17.33^{b} ± 0.39
Main effect of Season													
Season 1 (S1)		5.66^{B} ± 0.09	6.78^{B} ± 0.10	7.88± 0.11	8.91± 0.13	9.91± 0.15	10.88± 0.18	11.83± 0.21	12.73± 0.23	13.59± 0.26	14.42± 0.29	15.19± 0.31	15.93± 0.34
Season 2 (S2)		5.34^{A} ± 0.09	6.50^{A} ± 0.09	7.63± 0.10	8.72± 0.11	9.77± 0.13	10.78± 0.14	11.76± 0.16	12.67± 0.17	13.55± 0.19	14.39± 0.22	15.18± 0.24	15.92± 0.26
Means with different superscripts (a,b) in a column differ significantly (p<0.01), Means with different superscripts (A,B) in a column differ significantly (p<0.05)													

Table 4(b): Effect of different treatment groups on body weight (kg) of lambs at weekly intervals in two lambing seasons

Period (Weeks)														
Treatment groups		**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Interaction (Treatment X Season)														
Treatment	**Season**													
T_1	1	15.16± 0.51	15.55± 0.47	15.90± 0.43	16.24± 0.40	16.54± 0.38	16.73± 0.35	16.89± 0.33	17.07± 0.31	17.24± 0.29	17.46± 0.28	17.70± 0.26	17.95± 0.25	18.20± 0.24
T_2	1	15.25± 0.31	15.69± 0.28	16.09± 0.26	16.47± 0.24	16.82± 0.24	17.08± 0.22	17.3± 0.21	17.54± 0.2	17.77± 0.19	18.05± 0.21	18.34± 0.22	18.61± 0.23	18.88± 0.25
T_3	1	17.59± 0.64	18.17± 0.65	18.71± 0.65	19.19± 0.66	19.65± 0.67	20.04± 0.67	20.39± 0.67	20.71± 0.66	21.03± 0.66	21.35± 0.65	21.67± 0.65	21.98± 0.64	22.3± 0.64
T_4	1	17.95± 0.80	18.57± 0.80	19.13± 0.80	19.64± 0.79	20.11± 0.78	20.55± 0.78	20.93± 0.78	21.28± 0.79	21.63± 0.79	21.96± 0.79	22.28± 0.78	22.59± 0.77	22.92± 0.76
T_1	2	14.90± 0.32	15.41± 0.34	15.87± 0.35	16.30± 0.36	16.7± 0.36	17.08± 0.37	17.43± 0.38	17.74± 0.38	18.04± 0.39	18.32± 0.39	18.62± 0.39	18.93± 0.39	19.25± 0.38
T_2	2	15.44± 0.35	15.98± 0.34	16.49± 0.33	16.97± 0.33	17.42± 0.32	17.84± 0.33	18.24± 0.33	18.62± 0.33	18.97± 0.34	19.31± 0.34	19.63± 0.35	19.98± 0.35	20.31± 0.35
T_3	2	17.86± 0.34	18.62± 0.36	19.31± 0.38	19.93± 0.40	20.52± 0.40	21.06± 0.41	21.55± 0.42	22.01± 0.42	22.44± 0.43	22.85± 0.43	23.24± 0.43	23.62± 0.44	24.01± 0.45
T_4	2	18.29± 0.18	19.12± 0.19	19.88± 0.20	20.54± 0.20	21.15± 0.20	21.73± 0.21	22.28± 0.21	22.79± 0.21	23.26± 0.22	23.72± 0.22	24.15± 0.23	24.58± 0.22	25.00± 0.23
Main effect of Treatment														
T_1		15.03^{a} ± 0.29	15.47^{a} ± 0.28	15.89^{a} ± 0.27	16.27^{a} ± 0.26	16.63^{a} ± 0.26	16.91^{a} ± 0.25	17.17^{a} ± 0.25	17.42^{a} ± 0.25	17.66^{a} ± 0.26	17.91^{a} ± 0.26	18.18± 0.26^{a}	18.47± 0.26^{a}	18.75^{a}± 0.26
T_2		15.35^{a} ± 0.23	15.84^{a} ± 0.22	16.29^{a} ± 0.21	16.72^{a} ± 0.21	17.12^{a} ± 0.21	17.46^{a} ± 0.21	17.77^{a} ± 0.22	18.08^{a} ± 0.23	18.37^{a} ± 0.23	18.68^{a} ± 0.24	18.98± 0.25^{a}	19.30± 0.26^{a}	19.60^{a}± 0.27
T_3		17.72^{b} ± 0.35	18.39^{b} ± 0.36	19.01^{b} ± 0.38	19.56^{b} ± 0.38	20.08^{b} ± 0.39	20.55^{b} ± 0.40	20.97^{b} ± 0.41	21.36^{b} ± 0.41	21.73^{b} ± 0.41	22.10^{b} ± 0.42	22.45± 0.42^{b}	22.80± 0.42^{b}	23.15^{b}± 0.43
T_4		18.12^{b} ± 0.40	18.84^{b} ± 0.41	19.50^{b} ± 0.41	20.09^{b} ± 0.41	20.63^{b} ± 0.41	21.14^{b} ± 0.42	21.61^{b} ± 0.42	22.03^{b} ± 0.43	22.44^{b} ± 0.44	22.84^{b} ± 0.45	23.22± 0.45^{b}	23.59± 0.45^{b}	23.96^{b}± 0.45
Main effect of Season														
Season 1 (S1)		16.52± 0.35	17.03± 0.36	17.50± 0.37	17.93± 0.37	18.33± 0.38	18.65^{A} ± 0.39	18.93^{a} ± 0.40	19.21^{a} ± 0.40	19.47^{a} ± 0.41	19.76^{a} ± 0.41	20.06^{a} ± 0.42	20.34^{a} ± 0.42	20.64^{a} ± 0.42
Season 2 (S2)		16.62±	17.28±	17.89±	18.44±	18.95±	19.43^{B} ±	19.87^{b} ±	20.29^{b} ±	20.68^{b} ±	21.0 5^{b}±	21.41^{b} ±	21.78^{b} ±	22.15^{b}±

	0.28	0.30	0.32	0.33	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42	0.42

Means with different superscripts (a,b) in a column differ significantly ($p<0.01$), Means with different superscripts (A,B) in a column differ significantly ($p<0.05$)

Table 5(a): Effect of different treatment groups on average daily gain (g) of lambs at weekly intervals in two lambing seasons

Period (Weeks)												
Treatment groups	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Interaction (Treatment X Season)												
Treatment	**Season**											
T_1	1	146.56± 6.01	143.67± 5.25	133.67± 5.03	134.00± 6.11	127.11± 6.31	121.67± 6.70	112.22± 5.86	99.33± 5.82	96.33± 7.30	85.00± 4.17	88.11± 8.98
T_2	1	148.50± 4.03	144.40± 5.02	133.90± 7.64	133.80± 7.25	128.50± 7.39	122.80± 8.23	114.00± 7.06	102.50± 4.22	98.70± 3.69	92.70± 3.76	88.70± 5.17
T_3	1	165.40± 5.40	167.10± 5.58	157.20± 7.79	150.20± 7.6	147.40± 7.92	145.50± 8.61	144.10± 7.39	140.50± 7.24	134.20± 8.03	127.80± 7.16	118.60± 8.65
T_4	1	177.20± 7.42	169.30± 8.28	162.30± 8.26	155.90± 9.73	150.10± 9.52	148.10± 9.18	145.30± 7.92	143.80± 8.53	143.20± 8.13	134.10± 7.73	122.40± 10.98
T_1	2	147.30± 2.84	144.10± 3.55	135.90± 3.47	135.70± 4.41	132.60± 3.83	124.30± 5.54	112.40± 4.54	98.60± 4.12	93.7± 3.27	89.70± 3.08	81.20± 3.93
T_2	2	156.40± 3.96	150.50± 3.65	142.60± 5.98	137.30± 6.67	129.50± 6.59	123.40± 7.31	116.00± 6.93	107.90± 4.30	99.90± 4.36	93.90± 4.38	91.20± 4.91
T_3	2	178.50± 3.75	175.70± 3.21	169.60± 3.89	159.60± 4.23	155.80± 4.55	152.20± 3.61	146.30± 4.19	145.30± 3.28	141.40± 2.60	131.60± 3.25	121.10± 4.64
T_4	2	182.30± 1.41	178.60± 2.70	172.90± 3.10	165.10± 3.96	160.90± 3.42	157.60± 2.05	149.90± 1.89	146.90± 2.59	144.60± 3.07	139.70± 3.39	130.70± 3.88
Main effect of Treatment												
T_1		146.95^a ± 3.12	143.89^a ± 3.02	134.84^a ± 2.93	134.89^a ± 3.61	130.00^a ± 3.56	123.05^a ± 4.20	112.32^a ± 3.56	98.95^a ± 3.41	94.95^a ± 3.76	87.47^a ± 2.54	84.47^a ± 4.66
T_2		152.45^a ± 2.90	147.45^a ± 3.10	138.25^a ± 4.83	135.55^a ± 4.81	129.00^a ± 4.82	123.10^a ± 5.36	115.00^a ± 4.82	105.20^a ± 3.00	99.30^a ± 2.78	93.30^a ± 2.81	89.95^a ± 3.48
T_3		171.95^b ± 3.53	171.40^b ± 3.28	163.40^b ± 4.47	154.90^b ± 4.37	151.60^b ± 4.55	148.85^b ± 4.61	145.20^b ± 4.14	142.90^b ± 3.91	137.80^b ± 4.19	129.70^b ± 3.85	119.85^b ± 4.78
T_4		179.75^b ± 3.72	173.95^b ± 4.37	167.60^b ± 4.46	160.50^b ± 5.22	155.50^b ± 5.08	152.85^b ± 4.70	147.60^b ± 4.00	145.35^b ± 4.35	143.90^b ± 4.23	136.90^b ± 4.16	126.55^b ± 5.75
Main effect of Season												
Season 1 (S1)		159.74± 3.47	156.44± 3.57	147.10± 4.14	143.72± 4.10	138.56± 4.18	134.85± 4.46	129.33± 4.29	122.10± 4.64	118.67± 4.77	110.54± 4.51	104.87± 4.92
Season 2 (S2)		166.13± 2.80	162.23± 2.89	155.25± 3.31	149.43± 3.16	144.70± 3.18	139.38± 3.48	131.15± 3.55	124.68± 3.89	119.90± 4.06	113.73± 3.94	106.05± 3.89

Table 5(b): Effect of different treatment groups on average daily gain (g) of lambs at weekly intervals in two lambing seasons Period (Weeks)

Treatment groups	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Overall**
Interaction (Treatment X Season)														
Treatment	**Season**													
T_1	1	65.00± 4.68	55.44± 6.19	50.56± 6.70	48.22± 6.25	43.44± 4.99	26.33± 5.60	22.89± 3.85	25.89± 6.12	23.67± 5.11	32.00± 4.37	34.44± 4.21	35.78± 4.90	35.56± 4.28	77.73±0.83
T_2	1	72.30± 4.09	62.50± 5.68	56.90± 5.81	53.80± 5.35	50.60± 4.88	37.30± 4.82	31.60± 3.63	34.50± 5.00	32.90± 5.25	39.80± 5.34	40.50± 4.58	39.00± 3.94	38.60± 4.05	82.18±1.27
T_3	1	102.40± 6.96	83.70± 6.99	77.50± 7.36	68.20± 5.83	65.00± 5.26	56.70± 4.80	49.00± 5.43	46.90± 4.60	45.30± 3.38	45.70± 3.75	45.00± 3.99	44.30± 3.55	45.8± 3.06	102.46±3.75
T_4	1	99.00± 8.75	88.00± 6.67	80.10± 4.49	72.90± 4.17	67.90± 4.44	62.30± 4.64	54.90± 4.24	49.20± 3.88	49.60± 3.41	48.10± 2.34	45.50± 2.45	44.70± 2.93	46.70± 3.22	106.19±3.95
T_1	2	76.60± 4.85	72.00± 3.97	66.60± 3.69	61.10± 3.48	57.40± 3.58	54.10± 2.85	49.20± 2.07	44.90± 1.85	42.00± 1.88	41.10± 1.04	42.10± 0.78	44.90± 0.94	46.00± 0.98	85.73±2.15
T_2	2	82.50± 4.52	77.10± 4.62	72.90± 4.28	68.00± 4.02	64.70± 4.03	59.60± 4.41	57.20± 3.78	54.10± 2.52	50.70± 2.54	47.90± 2.29	46.40± 1.28	49.80± 0.88	47.40± 1.28	91.23±1.73
T_3	2	115.40± 4.60	108.20± 4.30	98.50± 4.15	89.60± 2.67	83.00± 1.99	77.80± 2.34	70.20± 1.78	65.40± 1.89	61.40± 2.20	58.70± 1.40	55.10± 1.11	55.50± 1.90	55.20± 2.24	114.46±2.39
T_4	2	125.80± 2.78	117.80± 2.28	108.60± 2.45	95.30± 2.28	86.70± 1.79	83.20± 2.00	78.20± 2.17	73.10± 2.21	66.90± 2.10	65.60± 1.27	62.20± 1.40	61.30± 2.30	59.90± 2.23	120.32±1.66
Main effect of Treatment														
T_1		71.11^a ± 3.56	64.16^a ± 4.00	59.00^a ± 4.07	55.00^a ± 3.70	50.79^a ± 3.36	40.95^a ± 4.41	36.74^a ± 3.72	35.89^a ± 3.71	33.32^a ± 3.33	36.79^a ± 2.34	38.47^a ± 2.17	40.58^a ± 2.54	41.05^a ± 2.37	81.94^a ±1.50
T_2		77.40^a ± 3.19	69.80^a ± 3.94	64.90^a ± 3.96	60.90^a ± 3.64	57.65^a ± 3.48	48.45^a ± 4.08	44.40^b ± 3.89	44.30^b ± 3.53	41.80^b ± 3.50	43.85^b ± 2.98	43.45^a ± 2.41	44.40^{ab}± 2.32	43.00^a ± 2.30	86.71^a ±1.47
T_3		108.90^b ± 4.32	95.95^b ± 4.88	88.00^b ± 4.76	78.90^b ± 3.97	74.00^b ± 3.43	67.25^b ± 3.55	59.60^c ± 3.69	56.15^c ± 3.22	53.35^c ± 2.69	52.20^c ± 2.45	50.05^b ± 2.32	49.90± 2.34^{bc}	50.50± 2.14^b	108.46^b ±2.57
T_4		112.40^b ± 5.42	102.90^b ± 4.84	94.35^b ± 4.11	84.10^b ± 3.46	77.30^b ± 3.17	72.75^b ± 3.44	66.55^c ± 3.54	61.15^c ± 3.50	58.25^c ± 2.78	56.85^c ± 2.39	53.85^b ± 2.36	53.00^c ± 2.63	53.30^b ± 2.43	113.25^b ±2.64
Main effect of Season														
Season 1 (S1)		85.18^a ± 4.07	72.85^a ± 3.79	66.67^a ± 3.60	61.10^a ± 3.07	57.08^a ± 2.86	46.15^a ± 3.33	40.03^a ± 2.95	39.46^a ± 2.80	38.23^a ± 2.65	41.64^a ± 2.20	41.54^a ± 1.99	41.08^a ± 1.94	41.82^a ± 1.91	92.51^a ±2.43
Season 2 (S2)		100.08^b ± 3.93	93.78^b ± 3.66	86.65^b ± 3.31	78.50^b ± 2.75	72.95^b ± 2.44	68.68^b ± 2.43	63.70^b ± 2.18	59.38^b ± 2.00	55.25^b ± 1.87	53.33^b ± 1.69	51.45^b ± 1.36	52.88^b ± 1.25	52.13^b ± 1.25	102.94^b ±2.55

4. Conclusion

In arid and semi arid regions of our country, growth of lambs is affected adversely by thermal fluctuations as well as by nutritional challenges. Therefore, for proper growth of lambs, season should be taken into consideration and body weight of lambs can be improved by the use of appropriate managemental and nutritional strategies *i.e.* improved shelter and improved nutrition either alone or in combination.

5. Acknowledgement

We gratefully acknowledge the help offered by Dean, College of Veterinary and Animal Science, Bikaner; Head, ARC-CSWRI, Bikaner; Project coordinator, NWPSI and Director, ICAR-CSWRI for providing facilities to conduct the experiment.

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