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Climate Change Adaptation: Coping Strategies for Minimizing Constraints of Extreme Climatic Conditions of Thar Desert on Sheep Production

B.K. Mathur, Abhishek Kumar, S.P.S. Tanwar*, Mukesh Barewa, J.P. Singh and R.K. Bhatt

ICAR-Central Arid Zone Research Institute, Jodhpur 342 003, India

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Abstract: Thar Desert is characterized by high ambient temperature, sunshine, desiccating winds and meagre rainfall causing less availability of forage and discomfort to the animals. An experiment was initiated at Chandan area of Jaisalmer district, maintaining sheep of Jaisalmeri breed under continuous grazing system on fenced over mature sevan (*Lasiurus sindicus*) pasture as per the carrying capacity. The objective of study were to develop coping strategies for minimizing impact of extreme climatic conditions on sheep production of Thar Desert. The treatments were: C1 - Stocking of grazing sheep at recommended stocking rate (1 ACU ha^{-1} = 5 female + 1 male) + supplementary feeding of balanced concentrate @ 200 gms $animal^{-1}$ + healthcare as per requirement; C2 - 12 animals per hectare with supplementary feeding and healthcare, C3 - 6 animals ha^{-1} without supplementary feeding and healthcare and C4 - 12 animals ha^{-1} without supplementary feeding and healthcare. Sheep were found more adjusted with feed availability through changes in grazing behavior like increased grazing time, bites per minute, change in grazing spot per 5 minutes, time taken while drinking water etc. Animals preferred shade when THI is above 88 particularly tree shed, because of cooling effect of leaves due to moisture evaporation and free flow air in the pasture area compared to erected thatched shade in Thar region. Sheep provided with supplementary concentrate feed and health management (C1, C2), even with double grazing pressure resulted in increase in live body weight and wool yield (C2) compared to the herds maintained exclusively on fenced over mature Sevan (*Lasiuruss indicus*) grass pasture (C3, C4).Supplementary feeding and healthcare also improved vital parameters like hemoglobin, blood sugar, respiration rate, pulse rate etc. Study showed that when grazing pressure is doubled with no feed supplementation and healthcare (C4) then there is decrease in body weight even though it spends more time for grazing. Thus, it is inferred that only grazing on pastures will not result in realization of actual livestock productivity in extreme hot climatic condition and it could be mitigated by supplementing grazing with balanced concentrates, provision of trees in grazing area and adoption of health management practices.

Key words: Climate change, coping strategies, sheep production, supplementary feeding, Thar desert.

Rise in temperature, erratic rainfall and frequent droughts are the most conspicuous symptoms of climate change. On an average, the region experiences 3 years of drought in every 10 years. The human activities have evolved to cushion themselves against these vagaries. Hence these can be the learning grounds for developing adaptation strategies against climate change in other ecological settings also. Indian hot arid zone which is about 12% of total geographical area of the country has maximum area in western Rajasthan (61%). The most obvious adaptation in these areas against the unpredictable and harsh climate is the dominance of livestock based farming systems. Some of the finest breed of cattle, camel, sheep and goats have evolved in the deserts which are known for their endurance and making much use of the meagre feed resources available such as grasses, herbs, shrubs, tree leaves, cultivated feed and fodder crops. Arid western Rajasthan has a livestock population of 30.18 million (Livestock census, 2012). Of the total livestock of State, large number of sheep (76%) and goats (59%) are present in arid region which is more prominent in Barmer and Jaisalmer districts.

Climate change would affect livestock feed production systems and ecology of the region more severely in marginal areas like deserts. Further, decrease in water availability would result in poor feed resources causing

*E-mail: spstanwar@gmail.com

reduction in carrying capacity of rangelands, rapid desertification processes, and decreasing productivity of arable cropping systems etc. This is likely to exacerbate the vulnerability of livestock production systems.

Under changing climatic variability animal maintains body temperature within physiological adaptation. Due to heat stress they adapt to re-establish thermoregulatory mechanism important for survival, however, production potential may reduce. Additionally, increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases is also expected. The reproductive capability of animal is also affected under changing climate.

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. A systematic approach was adopted to study the traditional adaptation strategies and then enriching them with scientific interventions to make them viable in the present context. Therefore, survey was conducted across the Jaisalmer district in five village clusters. It was observed that increased human population, urbanization, environmental degradation and increased consumption of animal source foods have made some of these traditional coping mechanisms ineffective. In addition, changes brought by global warming happens at such a speed so as to exceed the capacity of spontaneous adaptation by both human and animal species. The grazing/browsing areas are progressively shrinking due to encroachment by ever growing human population. Based on the findings of the survey, an experiment was conducted to develop adaptation strategies through adjusting carrying capacity of grazing sheep, their supplementary feeding, healthcare and other management issues.

Materials and Methods

The experiment was conducted in Chandan experimental of ICAR-Central Arid Zone Research Institute located in Jaisalmer district. It lies in the hot arid zone where the maximum temperature during the experiment was 50.02 - 47.3°C during May-June and minimum temperature was (-)0.5 - 1°C. The annual rainfall received was 249.1, 107.1, 185.0, 111.8 mm during 2015, 2016, 2017 and 2018, respectively. The thermal heat index during the experimental period represented in Fig. 1. The experiment consisted of 4 treatments (C1 to C4) details of which are mentioned in Table 1. Sheeps were maintained under continuous grazing system on sevan (*Lasiurus sindicus)* dominated pasture and one hectare paddock was specified for each treatment. An extra paddock with no animal grazing was kept as control. The biomass of the pastures was assessed by recording forage availability in 4 m^2 area from five places in each paddock. The grazing behavior of animals as per treatment was assessed by recording observations on grazing time taken, no. of bites taken per minutes, change of spot per 5 minute and time taken for drinking water. Physiological parameters i.e. respiration, pulse and body temperature were recorded in morning and evening periodically. Hemoglobin, blood sugar and body weight were also recorded. All

Table 1. Treatment details and herd characteristics

Treatment	Treatment Details	Average age of herd at the beginning of experiment	Age at first lambing
C1	Stocking of grazing sheep at recommended stocking rate (1 ACU ha^{-1} = 5 female + 1 male) + supplementary feeding of balanced concentrate @ 200 gms $animal^{-1}$ + healthcare as per requirement.	12.3±3.2	17.3±0.8
C2	Stocking of grazing sheep at double of recommended rate (2 ACU ha^{-1} = 11 female + 1 male) + supplementary feeding of balanced concentrate @ 200 gms $animal^{-1}$ + healthcare as per requirement.	12.3±3.3	18.4±0.9
C3	Stocking of grazing sheep at recommended stocking rate (1 ACU ha^{-1} = 5 female + 1 male) without supplementation and healthcare.	12.1±2.8	17.9±0.7
C4	Stocking of grazing sheep at double of recommended rate (2 ACU ha^{-1} = 11 female + 1 male) without supplementation and healthcare.	12.3±3.1	19.5±0.7

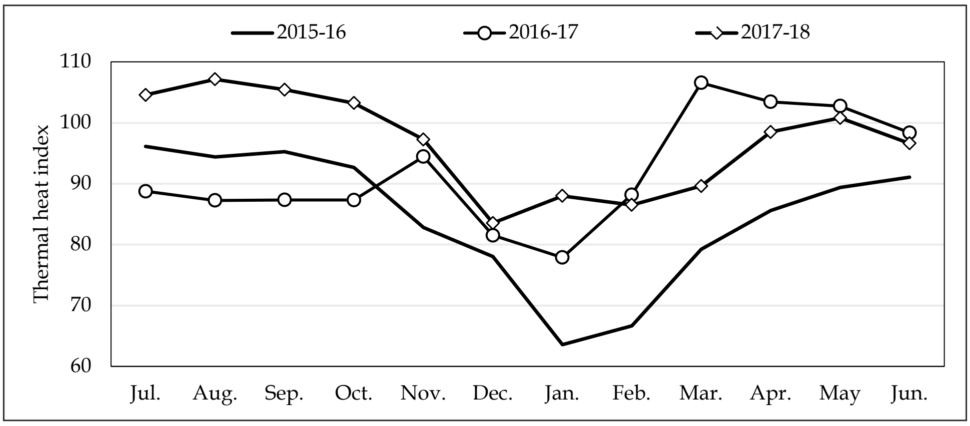

Fig. 1. Thermal heat index during the experimentation.

the above parameters were recorded monthly. Wool production was recorded in March and September every year and lambing percentage was observed annually. The shade seeking behavior of animals was also observed i.e. their preference for thatched roof kachcha structure *v/s* tree in the pasture in terms of duration for which they seek the shade and number of animals seeking shade

Results and Discussion

Biomass availability in the paddocks

During monsoon season (July to October), the biomass availability was maximum (Fig. 2). Deficit rainfall caused decrease in biomass productivity during 2017-18. Highest biomass was maintained in control block as no grazing was allowed in it. Comparatively smaller herds i.e. C1 and C3 (6 animals per hectare) had more biomass available at field as compare to C2 and C4 (12 animals per hectare).

Grazing behavior of sheep herds

The grazing time started increasing from the month of July up to January and then decreased (Fig. 3). Irrespective of herd size, the groups that were not given supplementary feeding of balanced concentrate healthcare i.e. C3 and C4 took more grazing time and had more number of bites per minute (Fig. 4). They also changed the grazing spot more frequently (Fig. 5). This might be due to the reason that these groups of animals had to meet all their requirement from grazing only contrary to C1 and C2 which were daily given supplementary feeding. There was an upward trend in frequency of changing the spot over the years specially in larger herds (2015 to 2018). This might be due to reduced availability of biomass over the time (Fig. 5).

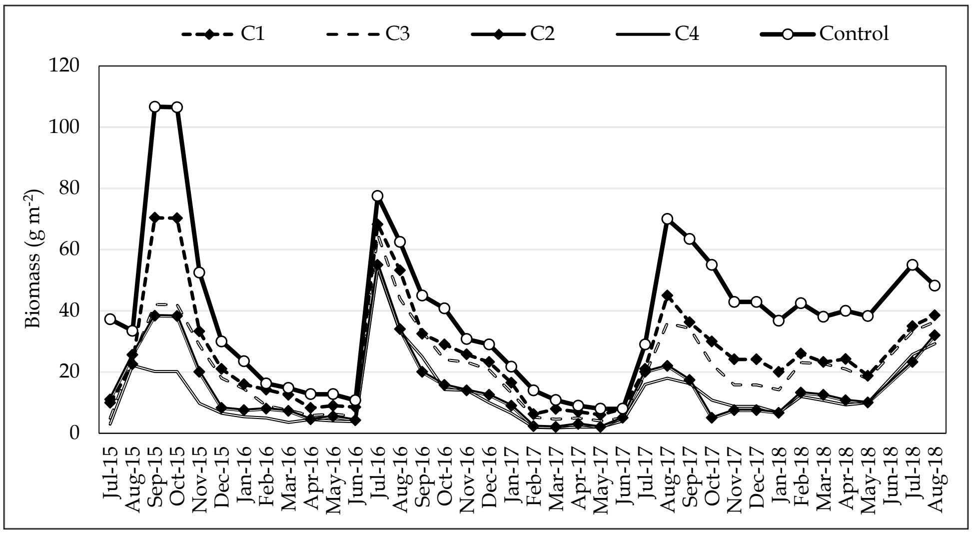

Fig. 2. Biomass (fresh weight of grass) in paddocks for different treatment groups of animals.

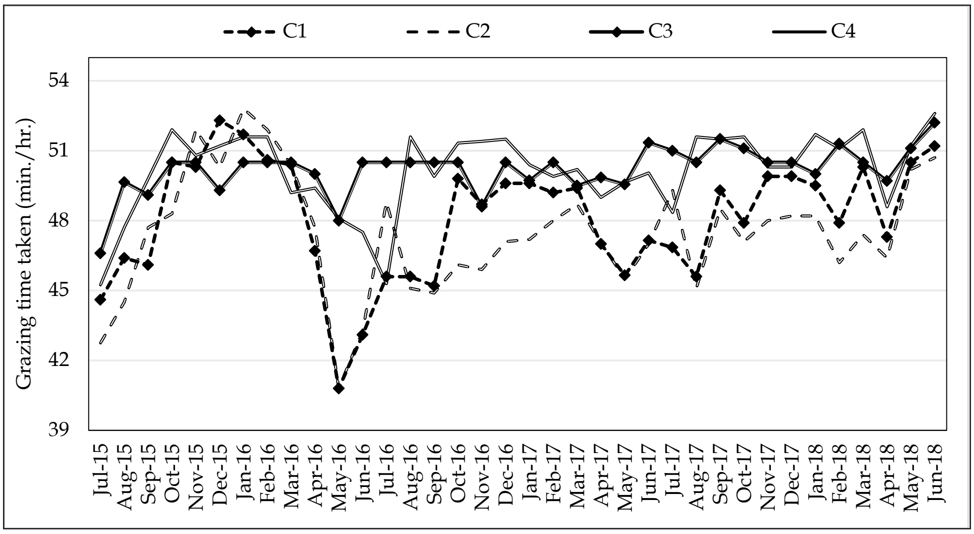

Fig. 3. Grazing time taken by the animals in morning.

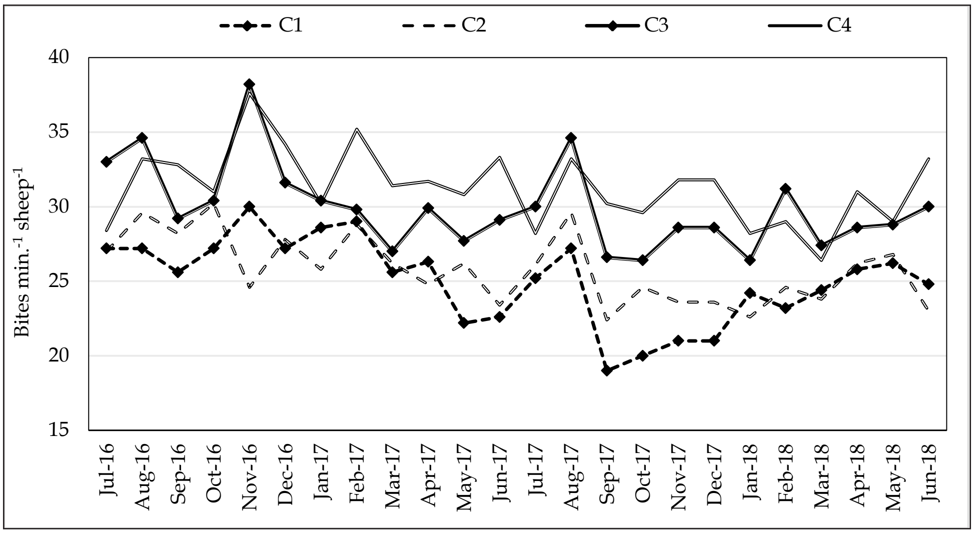

Fig. 4. Average number of bites/minute/sheep.

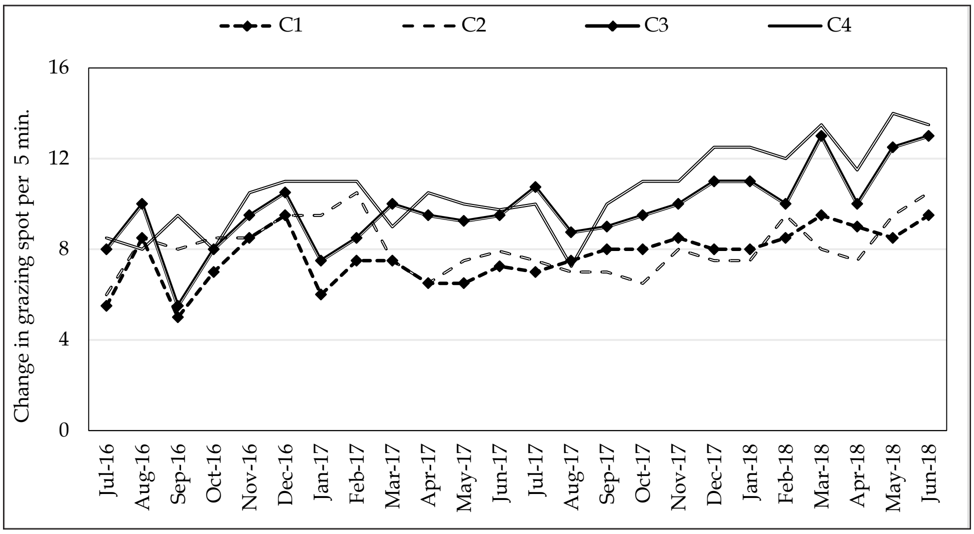

Fig. 5. Change in grazing spot per 5 minute by the animals.

Shade seeking behavior of sheep

It was found that more experimental animals preferred shade when THI (thermal heat index) was above 88. Higher number of animals spent more time under the shade of khejri (*Prosopis cineraria*) than under the erected thatched shade (Fig. 6). This might be due to the reason that animals felt more comfortable under naturally grown khejri trees having cooling effect of

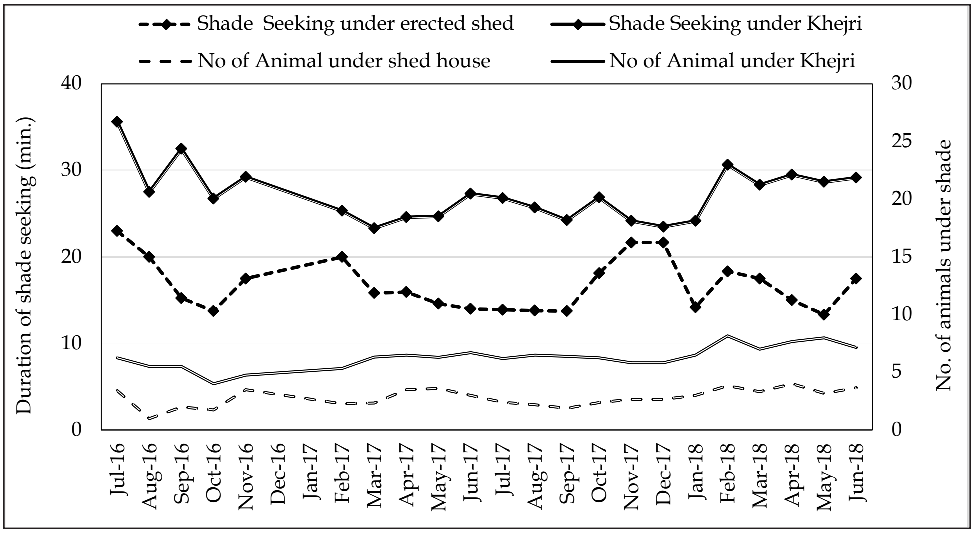

Fig. 6. Shade seeking behavior of animals.

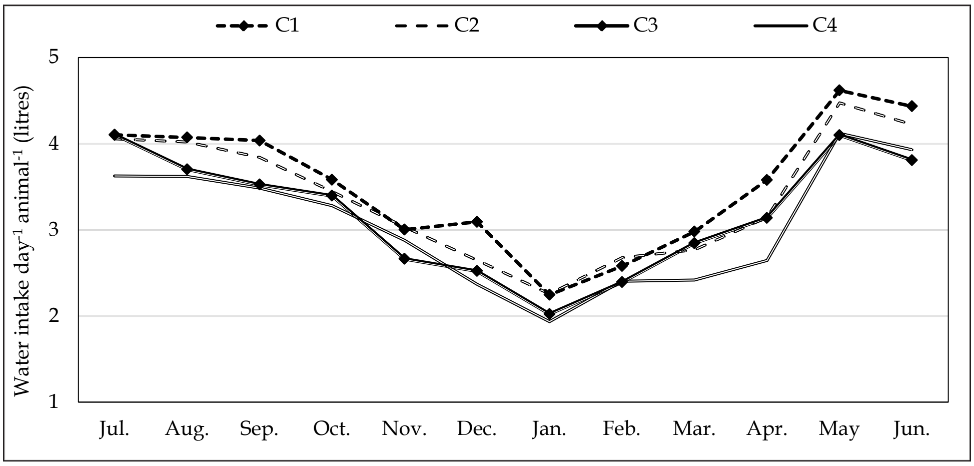

Fig. 7. Daily water intake by the animals (average data of 3 years).

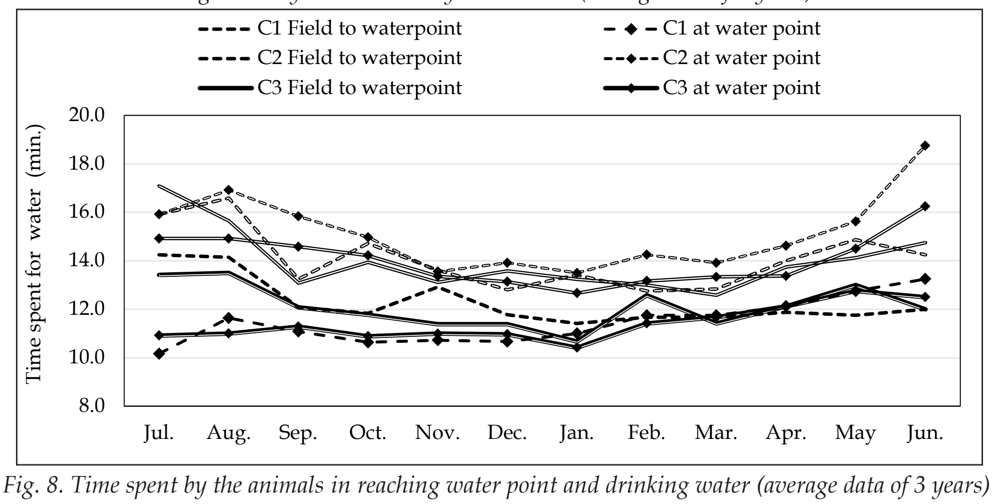

Fig. 8. Time spent by the animals in reaching water point and drinking water (average data of 3 years).

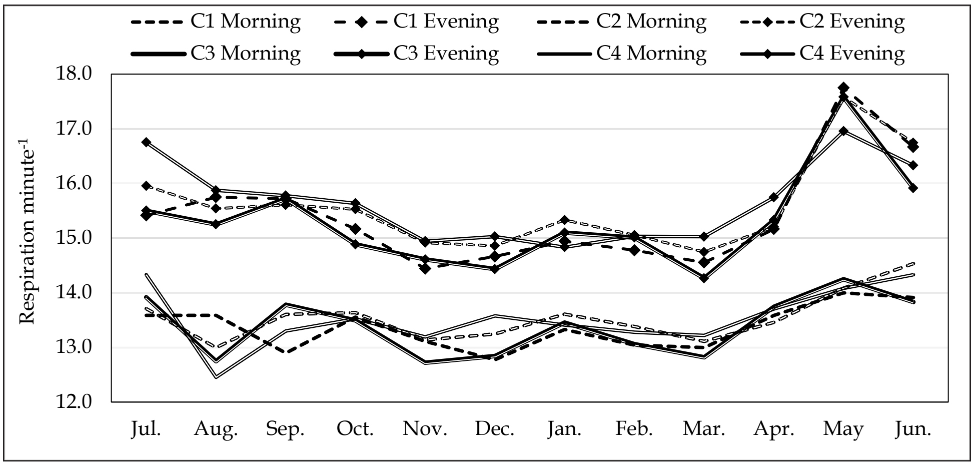

Fig. 9. Respiration rate of animals maintained under different conditions in morning and evening (average data of 3 years).

leaves due to evapotranspiration and free flow air compared to erected thatched shade under hot arid conditions. Maiti *et al.* (2014) while studying adaptation strategies of cattle rearers of coastal Odisha and West Bengal to climate change also inferred that the change in microclimate in shade/grazing area are most preferred adaptation strategy.

Water intake & time spent in drinking

Higher water intake of animal was observed during June to October and least during January mainly due to seasonal variations (Fig. 7). Water intake was higher in C1 and C2 than C3 and C4 in all the seasons as they were given additional concentrate along with grazing. Larger sized herds i.e. C2 and C4 (12 animals each) spent more time in reaching the drinking spot and spent more time in drinking water compare to smaller groups i.e. C1 and C3 (Fig. 8)

Physiological response of animals

Physiological parameters like respiration rate, pulse rate and body temperature reflects an immediate response to the climatic stress and consequently indicate the level of discomfort to the animal (Willams *et al.*, 2002). The ability of an animal to withstand the rigors of climatic stress were assessed. The respiration, pulse rate and body temperature of all groups' animals were higher in evening compare to morning (Fig. 9, 10, 11). Highest values of these parameters were recorded in the month of May due to maximum ambient temperature and lower were recorded during December to March due to comfortable environment. It showed a linearity in all the treatments. Respiration and rectal temperature appeared to be more sensitive indicator of heat stress than pulse rate as also shown by Lemrele and Goddard (1996). An evaporative heat loss from respiratory tract is regarded as one of the

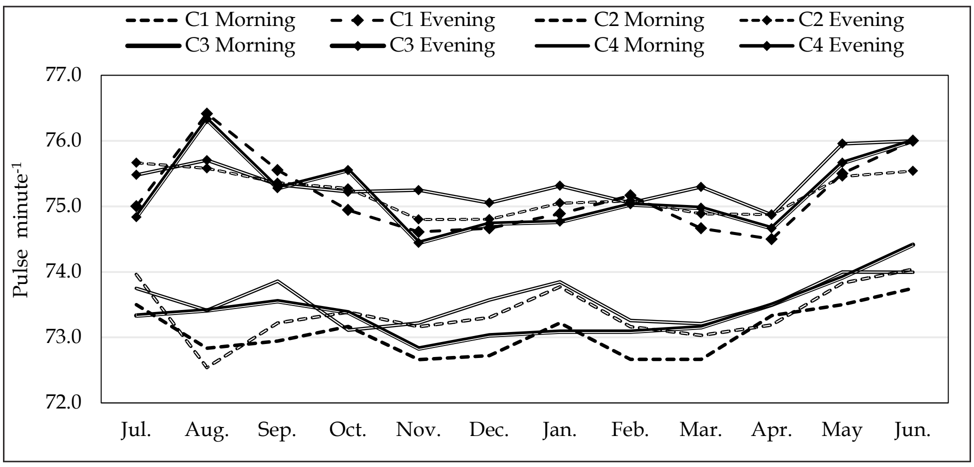

Fig. 10. Pulse rate of animals maintained under different conditions in morning and evening (average data of 3 years).

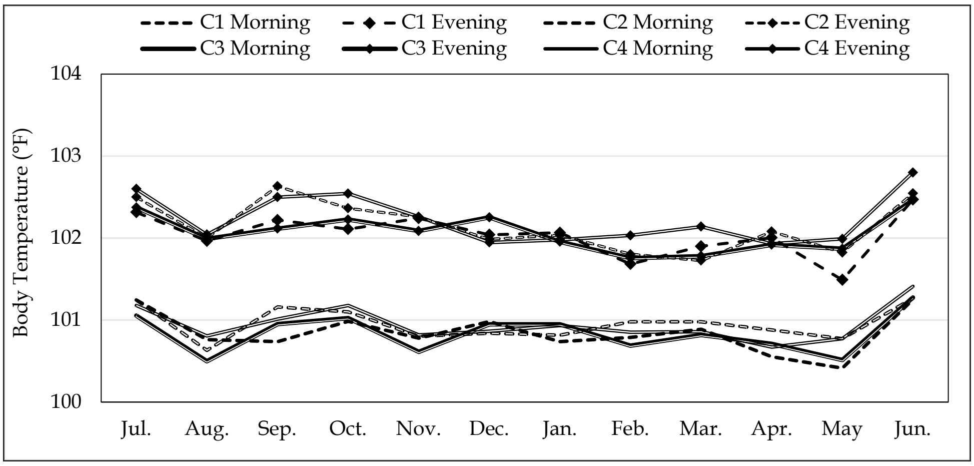

Fig. 11. Body temperature of animals maintained under different conditions in morning and evening (average data of 3 years).

primary mechanisms for maintenance of heat balance (McDowell *et al.*, 1976).

Blood parameters

C1 and C2 groups showed high hemoglobin and blood glucose level during the entire study period (Fig. 12 and 13). The additional feeding of concentrate (energy and protein based) to these groups lead to increased metabolic activity. Irrespective of groups, evening glucose level was higher than morning.

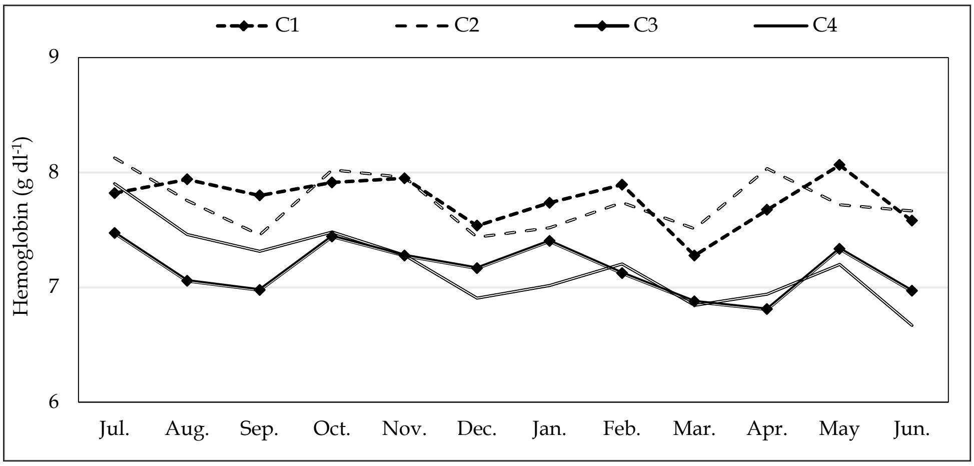

Fig 12. Hemoglobin level in blood of animals (average of 3 years).

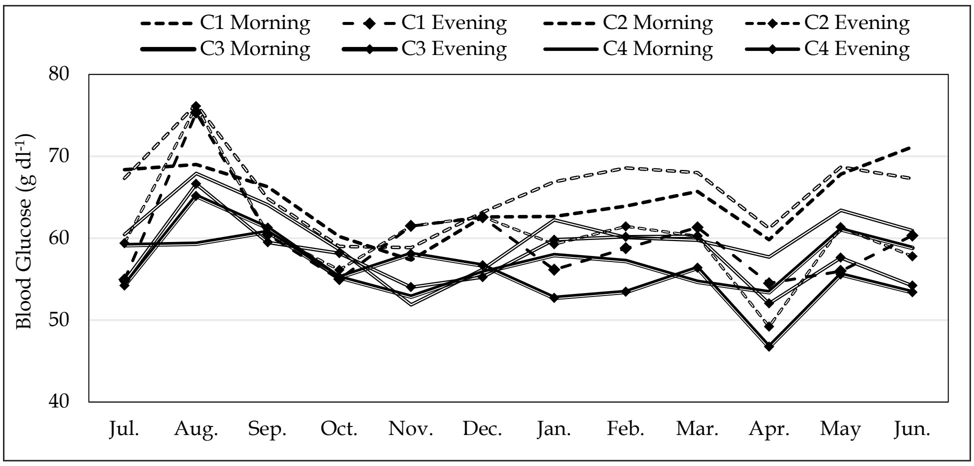

Fig 13. Blood glucose level in animals maintained under different conditions in morning and evening (average data of 3 years).

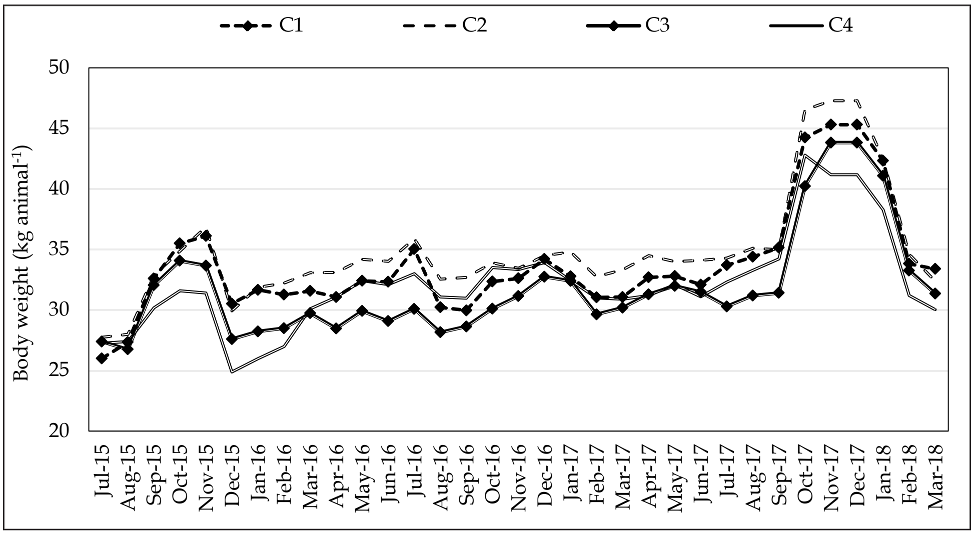

Fig. 14. Average live body weight of animals (kg).

Body weight

During August to November, the live body weight was higher in all the groups (Fig. 14). Female of all groups conceived in July-August and this coupled with more forage availability due to monsoon the body weight increased gradually up to November followed by lambing in December and consequent decrease in body weight. Again, by the end of March body weight of animals increased. The improvement in vital parameters was ultimately reflected as improved body weight of animals more so in those given supplementary feeding of balanced pelleted concentrates i.e. C1 and C2. The individuals of herd managed at double the stocking rate (12 animals per hectare) and provided with supplementary feeding of balanced concentrate @ 200 gms animal^{-1} along with healthcare management (C2) recorded body weight gain at par with those from herd grazed at a stocking rate of 6 animal per hectare. This indicated that more number of animals can be sustained on same pasture when provided with supplementary feed and healthcare. Sejian *et al.* (2014) also reported that under semi-arid condition mineral mixture and antioxidant supplementation were able to protect ewes against heat stress.

Production parameters

Wool weight : The sheep were sheared twice in a year in the months of September and March (Table 2, Fig. 15). The wool production was higher in the month of September than in March. It was higher under the groups that were given supplementary feeding and veterinary care i.e. C1 and C2.

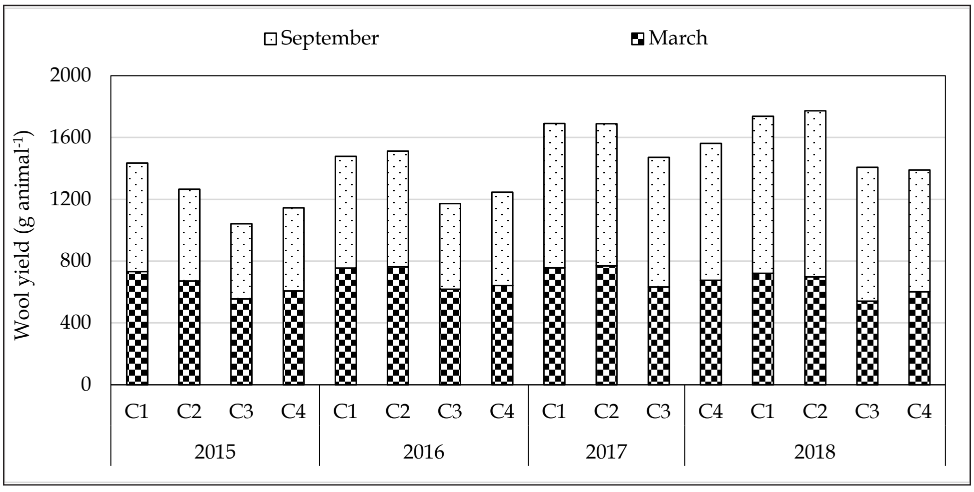

Fig. 15. Average wool production of sheep.

Table 2. Average wool production per animal in the month of March and September (g animal^{-1})

Treatment	C1		C3		C2		C4	
	March	September	March	September	March	September	March	September
2015	733.0	701.8	555.7	486.7	672.3	593.9	606.8	538.7
2016	754.8	723.2	619.1	554.0	763.6	747.9	642.9	603.8
2017	757.7	933.2	633.3	838.3	769.8	919.1	676.0	886.5
2018	721.7	1016.1	540.8	866.7	698.7	1075.0	602.9	787.5
Average	741.8	843.6	587.2	686.4	726.1	834.0	632.2	704.1

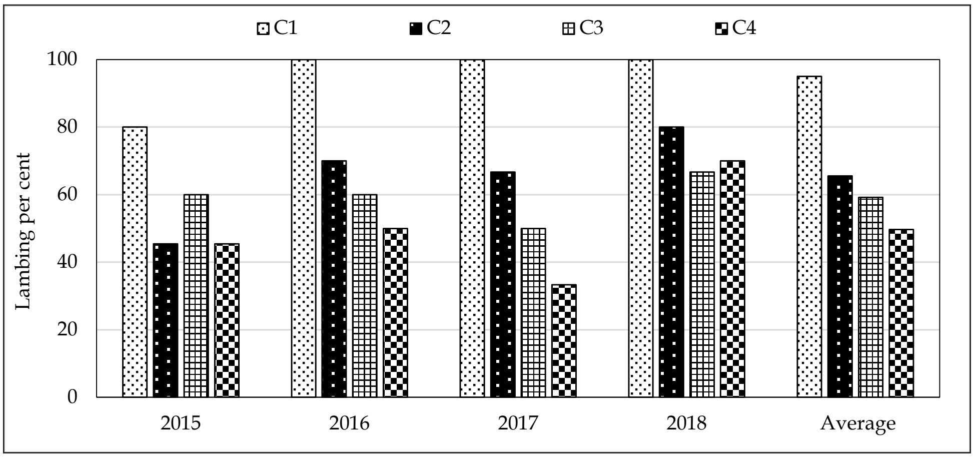

Fig. 16. Lambing per cent of different group of sheep from 2015-2018.

Lambing percentage: Lambing production percentage in treatment group (C1, C2) was higher than control group (C3, C4, Fig. 16). Higher productivity may be due to additional feeding of concentrate in addition to grazing. C1 group with smallest herd size showed more lambing production percentage than all other groups.

Hence, from this study it can be inferred that the sheep is more adjustable to extreme climate through changes in grazing behavior, shade preferences, adjustments in vital physiological parameters etc. Since carrying capacity of pastures in Thar deserts is low, it can be increased by supplementary feeding of balanced concentrates, providing adequate healthcare and provision of trees in the grazing area.

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