NICRA PROJECT

On

Assessing Resilience of Small Ruminant Production under Changing Climatic Condition in Semi-arid Zone

ANNUAL PROGRESS REPORT
(2012-2013)

Dr A. Sahoo
PRINCIPAL INVESTIGATOR

Central Sheep and Wool Research Institute
Avikanagar, Rajasthan

Co-operating Center
Division of Animal Physiology and Biochemistry
Central Sheep and Wool Research Institute
Avikanagar, Rajasthan - 304501

NICRA PROJECT

On

"Assessing Resilience of Small Ruminant Production under Changing Climatic Condition in Semi-arid Zone"

ANNUAL PROGRESS REPORT
2012-2013

Dr A. Sahoo

PRINCIPAL INVESTIGATOR

CO-OPERATING CENTRE

DIVISION OF ANIMAL PHYSIOLOGY AND BIOCHEMISTRY
CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE
AVIKANAGAR, RAJASTHAN- 304501

Contents Page

1. Reporting year: 2012-2013

2. Title of the project: Assessing resilience of small ruminant production under changing climatic condition in semi-arid zone

3. Name of the institute: Central Sheep and Wool Research Institute Avikanagar, Rajasthan-304501

4. Name of P.I.: Dr A. Sahoo

5. Name of the Associates with responsibilities:

Dr Davendra Kumar	Management of animals and shelter and experiment on reproductive profile, data interpretation and report writing
Dr S.M.K. Naqvi	Planning and guidance on shelter and stress management
Dr O.H. Chaturvedi	Implementation of nutrition related experimental protocol, laboratory analysis, compilation and reporting
Dr Kalyan De	Implementation of experimental protocol, laboratory analysis, compilation and reporting

6. Brief Technical Program implemented

Objectives

1. Documenting information on availability and quality of water accessible to sheep/goat in arid and semi-arid areas.
2. To study the adaptive capability of ewe and ram to compound abiotic stresses (thermal and water restriction) based on growth, physiological, endocrine and biochemical responses and reproductive performance
3. To identify the feeding and water managemental strategies to combat environmental stresses in sheep.
4. Evolving shelter management startegies to combat environmental stresses in small ruminants

Objective 1

Documenting information on availability and quality of water accessible to sheep/goat in arid and semi-arid areas.

Reported in the previous year (AR 2011-12)

Objective 2

To study the adaptive capability of ewe and ram to compound abiotic stresses (thermal and water restriction) based on growth, physiological, endocrine and biochemical responses and reproductive performance

Experiment 1: ***The effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment***

The experiment to study resilience in native Malpura ewes was conducted during peak summer season (May – June) for a period of 7 weeks including 5 weeks restriction covering two oestrous cycles and 2 weeks recuperation. Twenty-eight ewes were randomly divided into four groups with 7 animals each viz., G-I (Control: water ad libitum), G-II (20% water restriction of ad libitum), G-III (40% water restriction of ad libitum) and G-IV (water ad libitum on alternate day). The animals were stall fed ad libitum with the diet consisting of 70% roughage and 30% concentrate. All the ewes were maintained under well ventilated shad. Individual feed and water intake was recorded on daily basis. Physiological responses were recorded twice daily at weekly intervals.

Parameter studied

- Physiological responses: Body Weight (BW), Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT),
- Feed and Water Intake,
- Reproductive profile: Estrus percentage, Estrus Duration, Estrus Interval, Estradiol, Progesterone
- Metabolic profile: Haemoglobin (Hb), Packed Cell Volume (PCV), Plasma Glucose, Chloride, Albumin, Total plasma cholesterol,
- Stress profile: Cortisol, ldoesterone,
- Water and Nitrogen Balance.

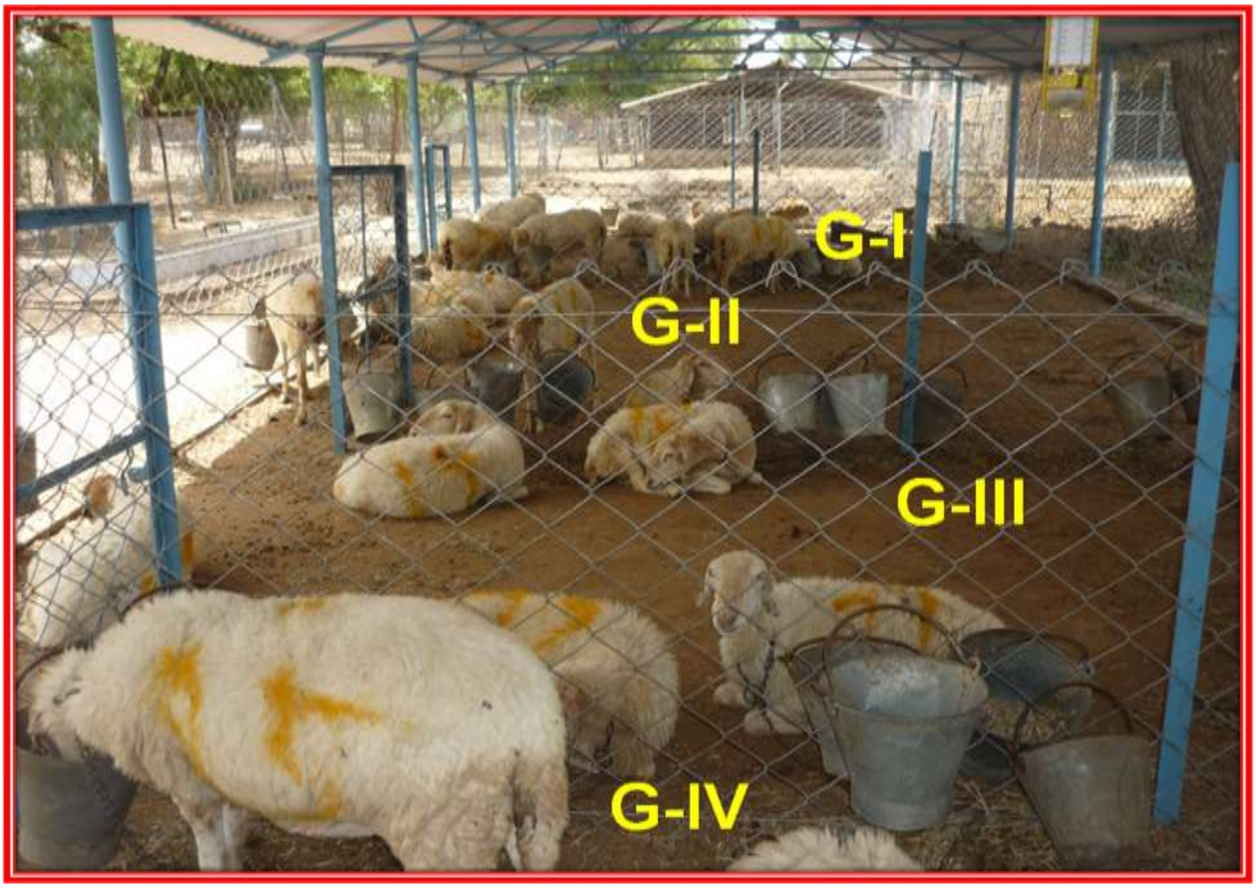


Figure 1: Animals kept in well ventilated shed exposed to water deprivation

Experiment 2: ***Seasonal variation of physiological response in ewes of farmers' flocks under semi-arid tropical environment***

This study was conducted to document the seasonal variation in physiological responses of sheep in farmers' flocks under extreme climatic conditions of semi-arid tropical regions. The study was carried out for one year (2012–2013). Forty-eight ewes of 2–4 year age were selected from three villages (two farmers from each village, eight ewes from each farmer). All the ewes were maintained by the farmers in their own management system. They used to take the animals for grazing morning (07:30 h) to evening (17:30 h). No extra mineral and concentrate supplementation were provided to the animals by the farmers. Farmers used to keep the animals in open areas within a surrounding during the night without any shelter above head. Respiration rate (RR), pulse rate (PR), and rectal temperature (RT) were recorded at morning (08:00 h), after noon (14:00 h), and evening (19:00 h) in summer (May–June), autumn (September–October) and winter (December–January) seasons three times at 15 days interval. The meteorological data in the farmers field were recorded twice daily at 8:00 h and 14:00 h for the entire study period

Fig:-2 Morning (08:00 h, at formers shed), Fig:-2 Afternoon (14:00 h, during resting time), Fig:-3 Evening (19:00 h, at formers shed)

Parameters Studied

- Physiological responses: Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT),
- Climate profile: Dry bulb Temperature (DB), Wet bulb Temperature (WB), Relative Humidity (RH).

Experiment 3: ***Differential expression of genes in sheep under nutritional and climatic stress conditions***

Technical programme

- Identification of stress related genes will be done based on literature survey
- Selection and designing of primers will be done by selecting nucleotide sequences available in GenBank (NCBI).
- PCR reaction conditions will be optimized

Objective 3

To identify feeding and water managemental strategies to combat environmental stresses in sheep

Experiment 1: ***Establishment of cactus field to provide biomass during hot summer***

Work plan:

- Development of a field for cactus implant
- Collection and propagation of cactus

Experiment 2: ***Amelioration of water deprivation stress vide feeding of prickly-pear cactus [Opuntia ficus indica (L.) Mill.] and its nutritional evaluation in the feeding of sheep during summer***

Technical Program: The fallowing feeding schedule was fallowed over the experimental period

Treatments

Control (T1)
Concentrate
+ Cenchrus
Water Ad libitum

T2
T1+Cactus
Water 20% restriction
(T1- amount through cactus or less 1.0 L)

T3
T1+Cactus
Water 40% restriction
(Less 2.0 L as that in T1)

Development of cactus field

Feeding of Cactus to sheep

Parameter studied:
Feed intake: Intake of concentrate, cenchrus and cactus
DM and nutrient intake,
Nutrient digestibility,
Nitrogen balance,
Water balance
Alteration in body weight and body condition

Objective 4

Evolving shelter management strategies to combat environmental stresses in small ruminants

Experiment 1. ***Development of shelter to combat heat and cold stress***

- Preparation of special shelter/ housing for protection of sheep from thermal stress (heat as well as cold stress)
- Preparation of felt coat for lambs to protect against extreme cold

Experiment 2: ***Effect of micro environment manipulation on growth performance, physiological response, blood metabolites and endocrine profile of Malpura lambs in semi-arid region during winter***

Technical program: Twenty one Malpura lambs of 3-5 week age (average body weight 10.0 kg) were used in the present study. The lambs were divided into three groups, viz. GI (control, lambs kept in conventional asbestos roof shed), GII (lambs kept in bamboo dome structure) and GIII (lambs kept in thermocol insulated shed). Asbestos roof shed had side wall wire netted that were covered with curtains at night). Local hand-made bamboo dome structure that had enough space to keep two lambs at night, and the thermocol insulated had roofs and doors made up of asbestos, thermocol and PVC sheet with brick side wall having ventilators for indirect light and wind. The houses were fitted with dry and wet-bulb thermometer to record micro-environment profile inside the shed. Animals were kept in different shed from evening 1830 h to morning 0700 h. The lambs were allowed to stay with their mother in the morning (0700 h to 0730 h) and evening (1730 h to 1800 h) for suckling milk. They were provided with *adlibitum* green fodder, dry roughage and concentrate in an open area 0800 h to 1730 h. The study was conducted for one month during winter (January- February).


Fig:-Dome' type easy to carry shed made of bamboo


Fig:-House with thermocol insulated roof

Parameter studied:-

- Physiological responses: Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Skin Temperature (ST),
- Alteration in body weight (BW),
- Blood metabolic profile,
- Endocrine profile
- Temperature and Humidity: {Dry bulb Temperature (DB), Wet bulb Temperature (WB) and Relative Humidity (RH). Minimum and Maximum Temperature}.

7. Summary of work done

- **Effect of water restriction on the adaptability of Malpura ewes:** Despite significant effects of water restriction on physiological response, blood biochemical, endocrine profile and feed intake, Malpura ewes showed capability to adapt and tolerate up to 40% water restriction. However, alternate day water restriction that simulates periodic water deprivation in arid and semi-arid regions had more adverse effect on feed and nutrient intake including production (growth).
- **Establishment of cactus field:** A cactus field was developed in an area of 0.8 ha and four different types of cactus (*Opuntia ficus-indica (L.) Mill.*) propagated successfully to provide feed biomass during summer scarcity.
- **Amelioration of water deprivation stress through feeding of cactus:** An experiment on Opuntia (prickly pear cactus) feeding was conducted in adult sheep to evaluate water and nutrient metabolism during summer. Three treatment groups involved control G1 (ad lib cenchrus hay + concentrate at 1% of body weight + water ad lib) and two experimental groups G2 (control diet + Opuntia 1.0 kg + water reduced by 1L) and G3 (control diet + Opuntia 1.0kg + water reduced by 2L). In both G2 and G3 Opuntia feeding provided 0.88 L of water. There was reduced DM intake from cenchrus due to Opuntia feeding and thus the effect on total feed intake was non-significant (P>0.05). However, the digestibility was similar between G1 and G2, but reduced in G3 that exposed to water restriction by 2L. Feeding of Opuntia compensated mild water restriction up to 1 L without any significant effect on feed intake. Thus, Opuntia can be successfully fed to sheep during feed scarcity meeting water and nutrient requirement. The native sheep Malpura exhibited adaptability to conserve water in the face of deprivation/scarcity.
- **Development of different shelters for protection against heat and cold stress:** Four different types of shelters were developed, viz. Yangya-type and Silvi-pasture system for protection against summer and portable Bamboo-Dome-type and low-ground Thermocol-insulated-type for protection against winter.
- **Protection of sheep from adverse climatic conditions through shelter management:** Various shade management systems were developed and evaluated. Innovative low-cost 'YANGYA' type shed observed to facilitate heat dissipation and maintains relatively lower temperature at the ground level and could be constructed for rest during grazing in semi-arid and arid regions. Introduction of silvi-pasture system or implantation of fodder trees in grazing area could be a successful integrated-farming type approach that provides feed as well as shelter during summer. To protect the lambs from extremely low temperature at night during winter a 'Dome' type easy to carry shed made of bamboo could be considered useful for migratory sheep flocks. For sedentary sheep flocks a house protected against direct wind-flow (cold wave) with thermocol-insulated roofing could be a very good strategy to conserve day temperature to provide warmth at night.
- **Identifying heat shock protein (HSP):** Amplification of HSP 70 gene of sheep was established which will be helpful for deriving phylogenic relationship among different species and for determining expression and identifying new functions considering its importance in conferring thermotolerance.

8. Results in detail

Objective 1

This activity was completed during the previous year and presently, more data compared with earlier observations to find out concentration of salt, minerals and toxicity levels if any. The water samples from different sources available for livestock were analyzed from five districts (water dark zone) of Rajasthan and found that specific conductivity, chloride magnesium, sodium, silica and total solids were above the range of maximum permissible limits, while calcium was lower (Table 1).

Table 1. Water quality parameters above maximum permissible limit in five districts of Rajasthan

Districts	**Parameters**
Bikaner	pH, Chloride, Sulphate, Nitrate, Total hardness, Ca, Mg, Na, Fluoride, Fe, Colour, turbidity, alkalinity
Jodhpur	pH, Sulphate, Nitrate, Mg, Na, Fluoride, Fe, Colour, turbidity, TDS.
Jalor	pH, Sulphate, Nitrate, Mg, Na, Fe, Colour, turbidity, Total hardness, Calcium , TDS.
Bhilwara	pH, Chloride, Fluoride, Sulphate, Na, Fe, Colour, Calcium
Tonk	pH, Cl, Sulphate, Total hardness, Na, Fe, Colour, Ca, Mg, TDS.

Objective 2

Experiment 1: ***The effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment***

Effect on physiological responses and endocrine profile

In addition to high temperature and deficient nutrition, water scarcity is another important limiting factor to small ruminants during summer season in semi-arid tropical environment under changing climatic scenario. Water is considered as an essential nutrient and is involved in every metabolic function of the body. Considering its importance in sheep productivity we have conducted a study to examine the effect of water restriction on physiological responses, blood metabolites and growth of Malpura sheep. The results of this study (Tables 2-6, Fig) indicate that despite of significant effects of water restriction on physiological response, blood biochemical and feed intake, Malpura ewes have capability to adapt and can tolerate up to 40% water restriction as well as alternate day water restriction with little effect on growth performance of animals during summer season under semi-arid tropical environmental conditions.

Table 2. Effect of water restriction on RR (breaths/Min), PR (beats/Min), and RT (^oF) of Malpura ewes

Items		**G-I**	**G-II**	**G-III**	**G-IV**	**S.E.M**
Respiration Rate (Breath/Min)	Morning	46.23^a	38.23^b	40.40^{ab}	37.03^b	2.54
	Afternoon	67.26^a	59.43^b	62.87^{ab}	60.69^{ab}	2.63
Pulse Rate (beat/Min)	Morning	64.46^a	62.86^{ab}	59.57^b	61.43^{ab}	1.55
	Afternoon	71.37^a	66.11^b	68.60^{ab}	68.80^{ab}	1.32

Rectal Temperature(°F)	Morning	101.35	101.39	101.22	101.43	0.13
	Afternoon	101.85	101.63	101.84	101.73	0.1

Table 3: Effect of water restriction on body weight and feed intake of Malpura ewes

Items	G-I	G-II	G-III	G-IV	S.E.M
Body Weight (Kg)	38.42	38.81	39.51	38.05	1.36
Feed Intake (DMI)	59.68[a]	57.34[ab]	54.94[ab]	51.24[b]	2.15

Table 4: Effect of water restriction on blood biochemicals

Items	G-I	G-II	G-III	G-IV	S.E.M
Glucose (mg/dL)	51.17[a]	47.38[ab]	46.30[b]	40.88[c]	1.36
Hb (g/dL)	11.27[ab]	10.92[ab]	12.28[a]	10.03[b]	0.52
PCV (%)	41.56[ab]	41.27[ab]	44.01[a]	37.32[b]	1.77
Albumin (g/dL)	3.55	3.35	3.55	3.26	0.11
Chloride (mg/dL)	134.31[a]	124.56[ab]	128.50[ab]	121.16[b]	3.41
Cholestrrol (mg/dL)	65.38[a]	58.39[b]	55.51[b]	55.83[b]	1.62

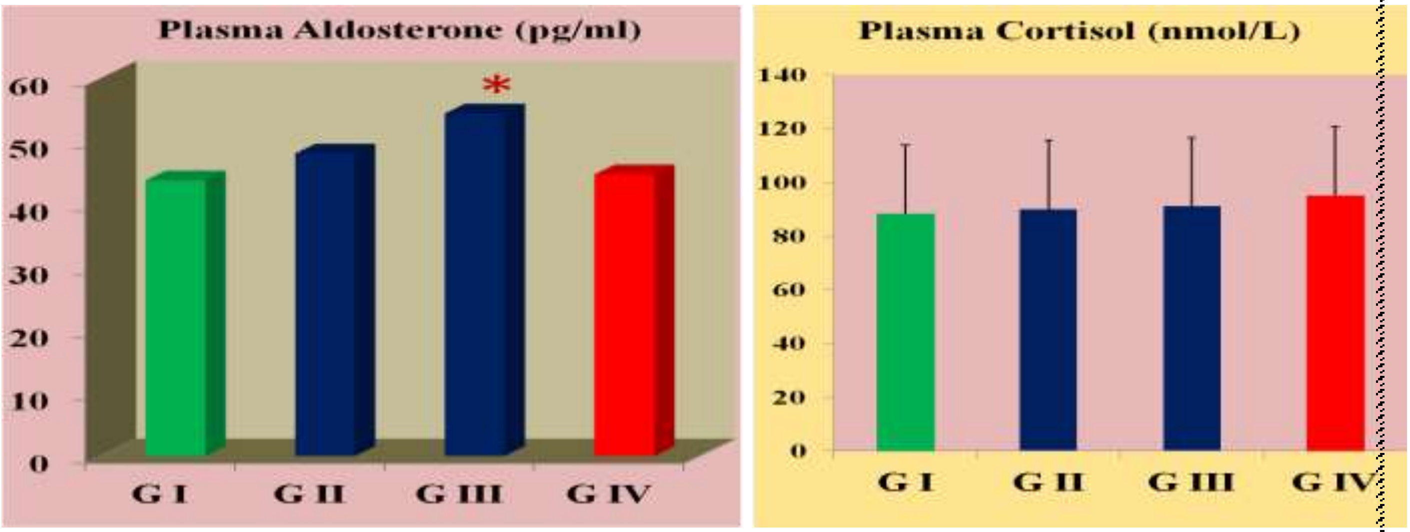
Hb- Hemoglobin; PCV-Packed Cell Volume
Means with different superscripts in a row differ significantly (P<0.05)

Table 5: Effect of water restriction on reproductive parameters

Parameters		G-I	G-II	G-III	G-IV
First oestrous cycle	Estrus %	100 (7/7)	100 (7/7)	85.7 (6/7)	85.7 (6/7)
	Estrus duration (h)	34.3±5.96	27.4±5.96	28.0±6.4	40.0±6.4
Second oestrous cycle	Estrus %	100 (7/7)	85.7 (6/7)	85.7 (6/7)	85.7 (6/7)
	Estrus duration (h)	53.1±6.94	32.0±7.5	38.0±7.5	50.0±7.5
Oestrous cycle length (d)		17.0±0.42	17.0±0.45	17.0±0.45	17.3±0.45

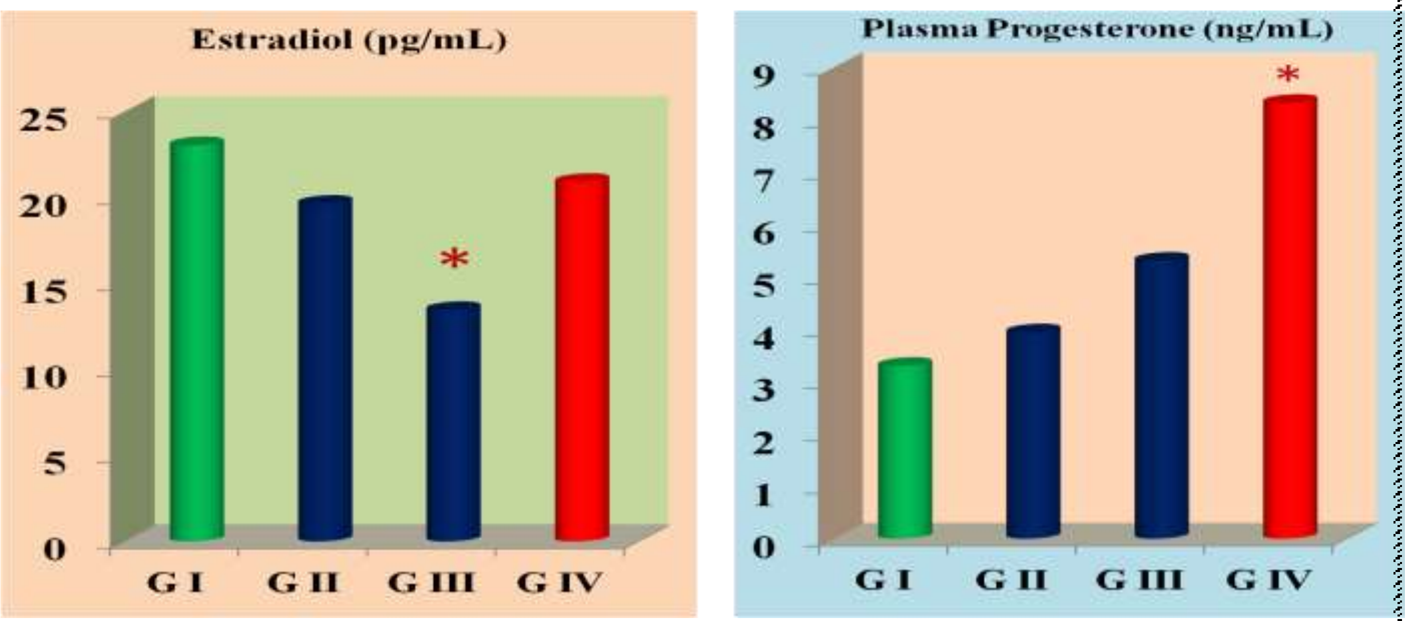
Table 6. Effect of water restriction on reproductive and stress hormones

Parameters	G-I	G-II	G-III	G-IV	SEM
Aldosterone	60.9[a]	46.1[b]	42.9[b]	48.9[ab]	4.16
Cortisole	87.5[a]	81.5[ab]	69.3[b]	91.7[a]	5.93
Progesterone	3.30[b]	3.94[ab]	3.59[ab]	4.18[a]	0.30
Estradiol	27.7[a]	21.4[ab]	19.2[b]	20.5[ab]	3.09



* (P<0.05)

Fig 2:- Effect of water restriction on plasma estradiol and plasma progesterone level



* (P<0.05)

Recuperative response after withdrawal of water restriction

Physiologically the animals showed recovery during the next 2 weeks of recuperation with ad libitum water to all the groups. This was evident from the non-significant variation in all physiological measurements between control and stress groups after withdrawal of water restriction (Table 7). Although, the animals showed signs of recovery from the water restriction within 2 weeks post exposure, still the higher values of stress hormone (cortisol) in treatment groups indicating more time required (>2 wks) for complete recovery from water stress. The reproductive hormone profile (Table 8) also came back to normal during this recuperation period.

Table 7. Physiological response of animals following recuperation with ad libitum water

Parameters		**G-I**	**G-II**	**G-III**	**G-IV**
Respiration rate/min	Morning (8.00AM)	38.67	38.00	37.00	36.33
	Afternoon (14.00PM)	73.71	71.86	75.17	73.00
Pulse rate/per min	Morning (8.00AM)	64.86	63.33	64.33	65.14
	Afternoon (14.00PM)	71.29	68.00	68.83	69.29
Rectal temperature (°F)	Morning (8.00AM)	101.60	101.35	101.59	101.54
	Afternoon (14.00PM)	101.71	101.70	101.88	101.80
Body Weight (kg)		38.86	38.61	38.96	37.43

Table 8. Hormonal profile of animals following recuperation with ad libitum water

Items	**G-I**	**G-II**	**G-III**	**G-IV**
Cortisol (nmol/l)	32.96	47.66	44.82	46.49
Aldoestrone (pg/ml)	60.57	64.64	63.43	63.04
Progestrone (ng/ml)	3.39	2.63	2.83	3.01
Estradiol (pg/ml)	13.39	13.83	13.54	13.08

Effect on feed intake and nutrition

A metabolism trial was conducted at the end of restriction phage of experiment to assess feed and nutrient intake, nitrogen and water balances in different groups exposed to variable degree of water restriction. The results are presented in tables 9 to 12.

Table 9. Intake and digestibility of nutrients

Attributes	**G-I**	**G-II**	**G-III**	**G-IV**	**SEM**	**P value**
Intake (g/d)						
DM	1030	1025	1007	891	39.3	0.032
OM	930	926	911	806	35.4	0.032
CP	103.2	102.9	101.0	90.9	3.45	0.032
EE	18.5	18.4	17.8	16.4	0.56	0.035
TCHO	809	809	792	699	31.4	0.032
Digestibility (%)						
DM	65.8	63.1	62.5	61.9	0.79	0.021
OM	66.5	63.7	63.2	62.5	0.78	0.017
CP	64.1	63.1	63.6	63.1	0.81	0.782
EE	76.7	75.9	74.9	75.2	0.87	0.461
TCHO	66.5	63.5	62.8	62.1	0.82	0.011

Mean values with $P<0.05$ are significantly different

Table 10. Nutritive value and plane of nutrition

Attributes	G-I	G-II	G-III	G-IV	SEM	P
Nutritive value						
TDN (g/kg)	618	592	588	582	7.21	0.021
ME (MJ/kgDM)	9.96	9.54	9.46	9.36	0.118	0.017
Nutrient intake/d						
DOM (g)	617	611	576	502	20.8	0.005
DCP (g)	66.1	66.1	64.4	57.3	2.15	0.023
TDN (g)	635	630	592	518	21.3	0.006
ME (MJ)	10.30	10.24	9.54	8.32	0.345	0.005
Intake/kg BW						
DM(g)	26.66	27.04	24.25	24.42	1.599	0.251
CP(g)	2.67	2.73	2.43	2.49	0.152	0.283
TDN (g)	16.46	16.75	14.26	14.18	0.904	0.114
ME (kJ)	271	265	230	228	14.6	0.110
Intake/kgW$^{0.75}$						
DM(g)	66.45	68.56	61.53	59.98	3.484	0.181
CP(g)	6.66	6.82	6.17	6.11	0.325	0.210
TDN (g)	41.0	41.6	36.2	34.8	1.95	0.065
ME (J)	674	661	583	560	31.6	0.062

Mean values with P<0.05 are significantly different

Table 11. Water restriction effect on water balance

Attributes	G-I	G-II	G-III	G-IV	SEM	P value
Water intake						
Free water(L)	2.900	2.611	2.091	2.245	0.1224	0.003
Preformed water(L)	0.049	0.047	0.046	0.040	0.0018	0.031
Metabolic water(L)	0.346	0.344	0.320	0.280	0.0116	0.005
Total water intake(L)	3.295	3.002	2.456	2.565	0.0128	0.003
Excretion						
Excretion via faeces(L)	0.536	0.396	0.252	0.280	0.070	0.050
Excretion via urine(L)	0.253	0.233	0.217	0.208	0.047	0.598
Total excretion(L)	0.789	0.629	0.472	0.488	0.119	0.085
Balance (L)	2.506	2.373	1.984	2.077	0.080	0.001
Balance/Intake(%)	76.3	79.4	79.8	79.9	2.52	0.717
Balance/DMI	3.19	2.83	2.45	2.79	0.108	0.003
Balance/MEI	1.34	1.25	1.08	1.24	0.049	0.001

Mean values with P<0.05 are significantly different

Table 12. Water restriction effect on Nitrogen Balance

N balance	G-I	G-II	G-III	G-IV	SEM	P value
N intake (g/d)	16.51	16.49	16.17	14.54	0.552	0.032
Faecal N (g/d)	5.94	6.04	5.87	5.38	0.267	0.141
Urinary N (g/d)	4.19	4.13	3.93	3.59	0.201	0.199
Total N excreted (g/d)	10.13	10.47	9.80	8.97	0.408	0.109
N retained (g/d)	6.38	6.32	6.36	5.57	0.191	0.008
N retained/N intake (%)	38.8	39.0	39.4	38.3	0.78	0.813
N retained/N abs (%)	60.4	59.7	62.1	59.0	1.43	0.512

Mean values with P<0.05 are significantly different

Conclusion:

- Water restriction had significant effects on physiological response, blood biochemical, endocrine profile and feed intake
- Malpura ewes have shown capability to adapt 40% water restriction but reduction in feed intake & digestibility has concern if restriction/scarcity is prolonged
- Watering on alternate day is more adverse to production as it limited intake and digestibility besides showing more stress response

Experiment 2: ***Seasonal variation of physiological response in ewes of farmers' flocks under semi-arid tropical environment***

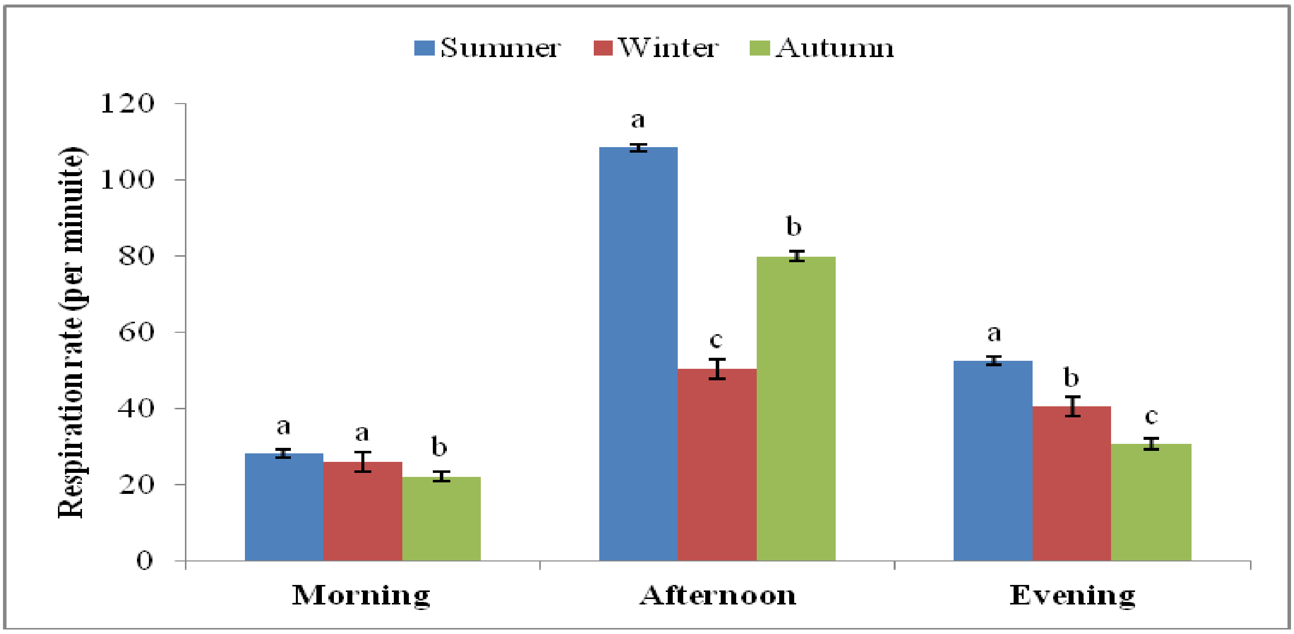
A small survey was conducted to generate information on physiological response of sheep in field conditions during peak summer season in three villages nearby the institute. Flock of one farmer from each village was followed for consecutive two days to observe response parameters. The climatological observations during morning (0800), afternoon (1400) and evening (1900) were presented in table 13. The animals leave shed for grazing (≈5 Km) in the morning at 7.30 h after drinking fresh water, at nearly 12.30 h to 13.00 h the animals reach to water source (pond) and again drinking adlib water take rest under the tree and then returned to shed at about 18.00 h drinking water and take rest during night time. Farmers are not providing any supplemental feeding. The average maximum ambient temperature was recorded as 31.5±0.54, 43.0±1.41, 44.3±1.61 and 38.1±.04 ^{0}C in morning, afternoon under tree, afternoon outside tree and evening respectively. It was observed that animals showed stress response at 1400 h with high pulse, respiration rate and rectal temperature. Only pulse came down to that recorded in the morning and the other two parameters showed only a fall in the evening (1900 h).

Table 13. Climatological data measured during the experimental period.

	THI morning	THI afternoon	THI evening	Max T (° C)	Min T (° C)	RH (%) morning	RH (%) afternoon	WV (m/sec)	Day Length (hrs)
Summer	26.51 ± 0.36	32.77 ± 0.49	31.14 ± 0.29	44.32 ± 1.61	30.75 ± 0.55	61.17 ± 4.19	41.83 ± 1.66	5.90 ± 0.30	10.28± 0.12
Winter	12.13 ± 0.81	18.92 ± 1.19	14.77 ± 1.10	26.07 ± 1.26	9.58 ± 1.95	79.83 ± 1.08	53.33 ± 2.14	1.85 ± 0.09	8.15 ± 0.22
Autumn	18.67 ± 0.65	28.45 ± 0.44	21.63 ± 0.56	36.72 ± 1.19	17.63 ± 0.68	83.67 ± 1.56	63.00 ± 4.07	1.89 ± 0.15	9.51 ± 0.11

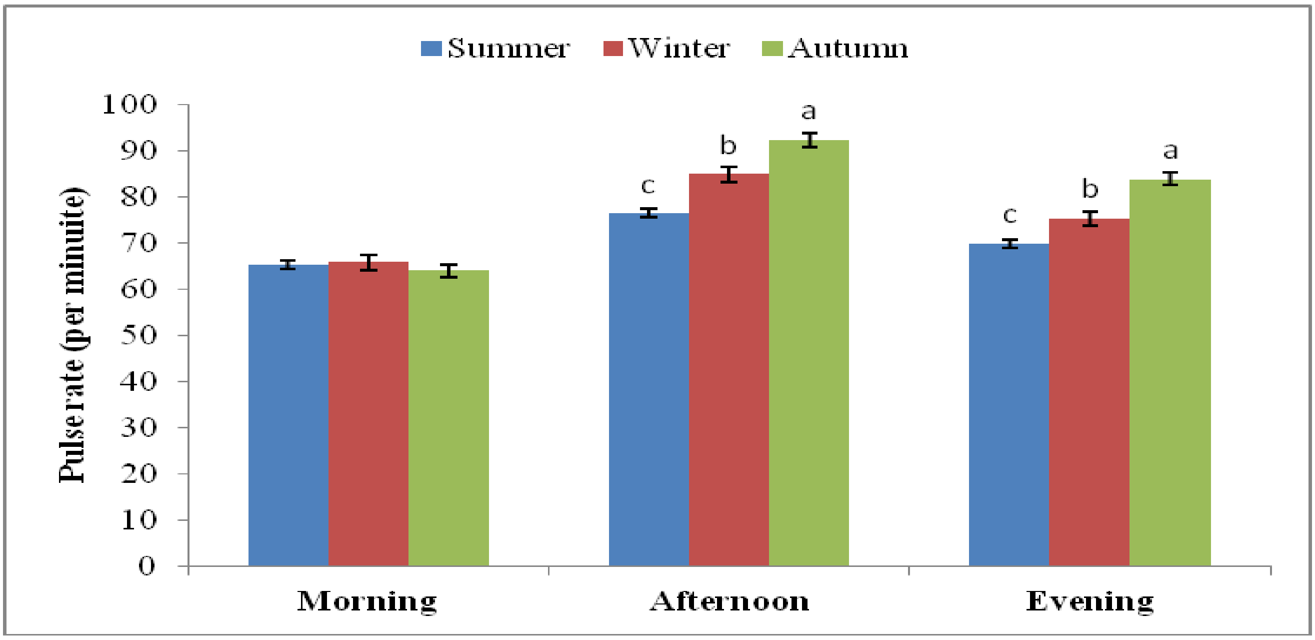
THI temperature humidity index, MinT Minimum temperature, MaxT maximum temperature, RH relative humidity, WV wind velocity. Morning reading was taken at 0800 h, and afternoon reading was taken at 1400 h.

Fig:1 Effect of season on respiration rate of ewes of farmers flock.



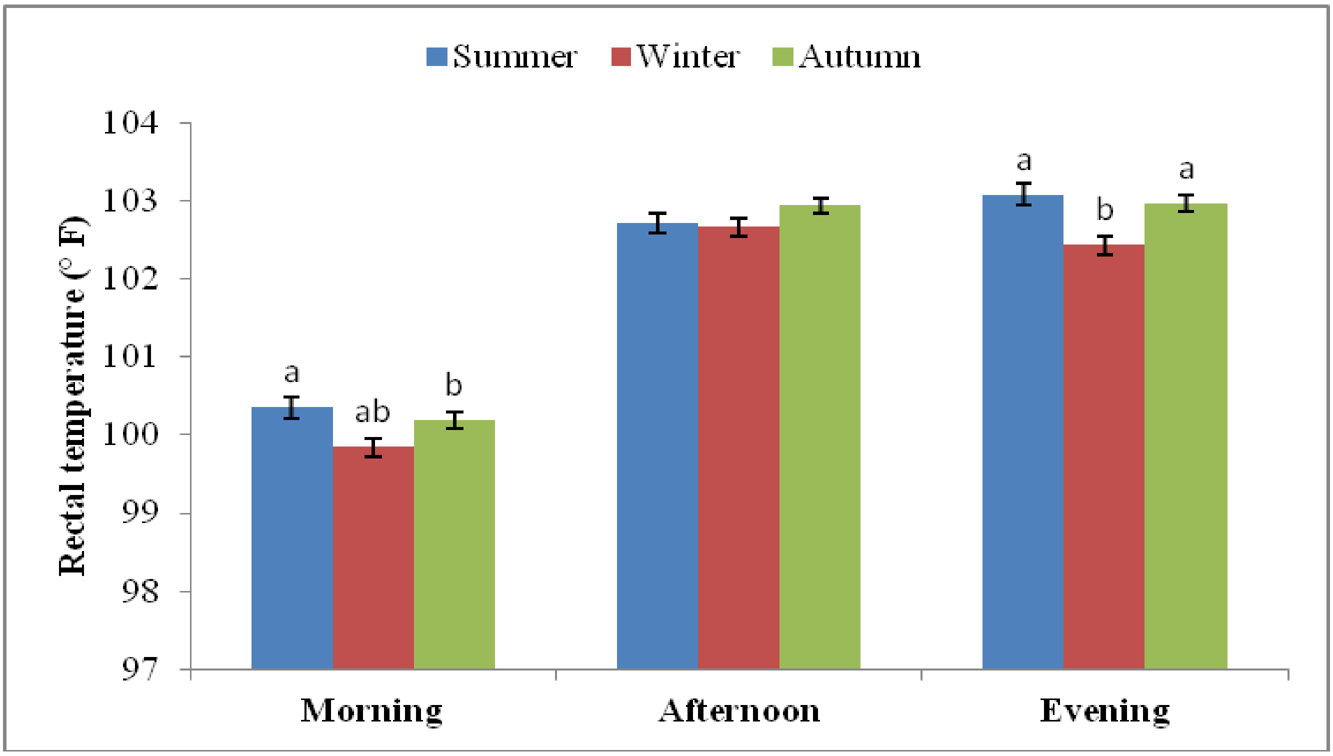
Respiration rate in experimental animals were taken in morning (0800h), afternoon (1400 h) and evening (1900 h) for 15 days interval during summer (May-June), Autumn (September-October) and winter (December-January). Respiration rate of ewes varied significantly (P<0.01) between the season. Similar superscripts bearing column with in a group did not differ significantly (P<0.05).

Fig:2 Effect of season on pulse rate of ewes of farmers flock.



Pulse rate in experimental animals were taken in morning (0800h), afternoon (1400 h) and evening (1900 h) for 15 days interval during summer (May-June), Autumn (September-October) and winter (December-January). Pulse rate of ewes varied significantly (P<0.01) between the season. Similar superscripts bearing column with in a group did not differ significantly (P<0.05).

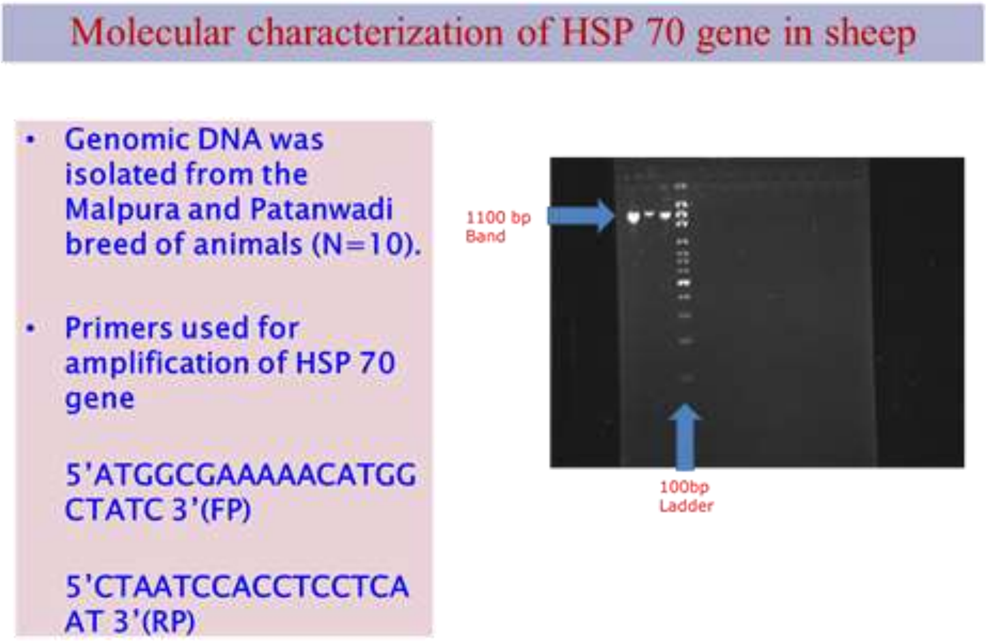
Fig 3:- Effect of season on rectal temperature of ewes of farmers flock.



Rectal temperature in experimental animals were taken in morning (0800h), afternoon (1400 h) and evening (1900 h) for 15 days interval during summer (May-June), Autumn (September-October) and winter (December-January). Rectal temperature of ewes did not differ significantly (P<0.01) between the season. Similar superscripts bearing column with in a group did not differ significantly (P<0.05).

Experiment 3: ***Differential expression of genes in sheep under nutritional and climatic stress conditions***

Amplification of HSP 70 gene of sheep was established (Fig) which will be helpful for deriving phylogenic relationship among different species and for determining expression and identifying new functions considering its importance in conferring thermotolerance.



Objective 3

Experiment 1: ***Establishment of cactus field to provide biomass during hot summer***

A cactus field was developed in an area of 0.8 ha and four different types of cactus (*Opuntia ficus-indica (L.) Mill.*) propagated successfully to provide feed biomass during summer scarcity.

Experiment 2: ***Amelioration of water deprivation stress vide feeding of prickly-pear cactus [Opuntia ficus indica (L.) Mill.] and its nutritional evaluation in the feeding of sheep during summer***

The results of the experiment are presented in tables 14 to 17. In both G2 and G3 Opuntia feeding provided 0.88 L of water. There was reduced DM intake from cenchrus due to Opuntia feeding and thus the effect on total feed intake was non-significant (P>0.05). However, the digestibility was similar between G1 and G2, but reduced in G3 that exposed to water restriction by 2L.

Table 14. Feed and nutrient intake in different treatment groups

Parameters	T1	T2	T3	Significant
Cenchrus DMI (g/d)	744b	606a	618a	*
Opuntia DMI (g/d)	0b	118a	118a	**
Concentrate DMI (g/d)	380	380	380	NS
Total DMI (g/d)	1124	1104	1116	NS
Dry matter intake (g/kgW$^{0.75}$)	72.0	72.0	74.6	NS
Crude protein intake (g/d)	111	109	110	NS
Crude protein intake (g/kgW$^{0.75}$)	7.13	7.11	7.37	NS
Digestible CPI (g/d)	84.5	89.3	82.5	NS
Digestible CPI (g/kgW$^{0.75}$)	5.40	5.82	5.52	NS
Digestible OMI (g/d)	593	577	537	NS
Digestible OMI (g/kgW$^{0.75}$)	37.9	37.7	35.9	NS
ME intake (MJ/d)	8.84	8.91	8.16	NS
ME intake (MJ/kgW$^{0.75}$)	0.566	0.582	0.546	NS
% DCP of ration	7.52	8.09	7.40	**
% TDN of ration	52.2	54.3	48.6	NS

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Non Significant

Table 15. Nutrient digestibility in different treatment groups

Parameters	T1	T2	T3	Significance
Dry matter	57.1b	56.4b	52.1a	*
Organic matter	59.0	59.5	54.5	NS
Crude protein	75.8ab	78.8b	74.9a	*
Crude fat	70.2	69.1	68.5	NS
Total carbohydrate	55.7	54.1	53.4	*
Neutral detergent fibre	48.2	48.8	42.1	NS
Acid detergent fibre	36.6	32.8	23.4	NS
Cellulose	47.5	45.4	36.9	NS

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Non Significant

Table 16. Nitrogen balance in different treatment groups

Parameters	T1	T2	T3	Significance
N intake (g/d)	17.83	17.45	17.63	NS
N outgo in faeces (g/d)	4.34	3.17a	4.42b	*
N outgo in urine (g/d)	5.65	5.8b	4.44a	*
N retention(g/d)	7.84	8.48	8.76	NS
NB/NI (%)	43.97	48.38	49.64	NS
NB/NA(%)	58.16a	59.32a	66.28b	*

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Noon Significant

Table 17. Water balance in different treatment groups

Parameters	T1	T2	T3	Significant
Water intake (mL/d)				
Free water	5056c	4032b	3000a	**
Preformed water				
Water through conc	19.8	19.8	19.8	ND
Water through Cenchrus	55.8	45.5a	46.2	NS
Water through opuntia	0.0b	851.0a	851.7a	**
Metabolic water	337	317	315	NS
Total (TWI)	5469b	5265b	3918a	**
Excretion (mL/d)				
outgo in faeces	988	1435	1247	NS
outgo in urine	555b	483ab	411a	*
Total	1543	1918	1657	NS
Balance (mL/d)	3926c	3347b	2576a	*
Balance/TWI(%)	71.8	63.6	60.9	*
Balance/DMI	3.49	3.03	2.31	*
Balance/MEI	1.06	0.90	0.75	*

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* ($P<0.05$), ** ($P<0.01$) and NS= Noon Significant

Conclusion:

Feeding of Opuntia compensated mild water restriction up to 1 L without any significant effect on feed intake. Thus, Opuntia can be successfully fed to sheep during feed scarcity meeting water and nutrient requirement. The native sheep Malpura exhibited adaptability to conserve water in the face of deprivation/scarcity.

Objective 4

Experiment 1. ***Development of shelter to combat heat and cold stress***

<u>Shelters to protect from cold</u>

Dome-type easy to carry shed made of bamboo **House with thermocol-insulated roof**

Shelters to protect from summer

Yagya-type shed to protection against summer

Integrated farming with tree-shade for protection against summer

Experiment 2: ***Effect of micro environment manipulation on growth performance, physiological response, blood metabolites and endocrine profile of Malpura lambs in semi-arid region during winter***

The experiment on micro-environment impact on animal performance was studied during winter months. The meterological data is presented in table 18. The observations on physiological responses, blood metabolic and endocrine profile are depicted in tables 19, 20 and 21. Micro environment manipulation had no significant (P<0.05) effect on physiological response and skin temperature except morning respiration rate. The present study reveals that, Hb, PCV, total protein, albumin, T3 and cortisole level were significantly (P<0.050 influenced by microenvironment manipulation. Further, the study signifies the importance of micro environment manipulation for lambs during winter in hot semi-arid tropical region to improve their average daily gain.

Table 18. Meteorological data during the study period in different shed.

	Maximum temperature (°C)	Minimum temperature (°C)	RH(%)	THI	Wind velocity (m/s)	Day length (h)
Environmental	24.13 ± 0.44	8.76 ± 0.87	77.78 ±2.43	10.21±0.98		
GI	25.07±0.30	8.59±0.71	59.28 ±4.50	12.51±0.91	2.68 ± 0.32	8.11 ± 0.52
GII	23.91±0.41	14.59±0.54	66.44±2.02	16.12±0.62		
GIII	22.61±0.46	11.84±0.64	56.67±3.73	13.80±1.06		

GI, Control; GII, Dome; GIII, Thermocol insulated.
RH, Relative humidity, THI, Temperature humidity Index The meteorological data were recorded at morning 0700h and afternoon 1400 h. Temperature humidity index were calculated with the formula of, THI = db ◦C − {(0.31 − 0.31 RH)(db ◦C − 14.4)} given by Marai *et al*. (2007).

Table 19. Effect of micro environment manipulation on physiological response in Malpura lambs.

Item	RR morning	RR afternoon	PR morning	PR afternoon	RT morning (°F)	RT afternoon (°F)	ST (°F)
μ ± SE	42.45 ± 0.87	63.11 ± 2.48	93.57 ± 1.56	104.85 ± 1.20	102.86 ±0.09	103.31 ±0.09	95.95 ±0.57
Group effect	*	NS	NS	NS	NS	NS	NS
GI	40.33[a]	58.17	96.21	102.58	102.77	103.50	94.86
GII	46.58[b]	68.38	93.88	107.08	103.01	103.28	95.97
GIII	40.45[a]	62.17	90.63	104.88	102.79	103.15	97.00
Pooled SE	1.50	4.31	2.70	2.08	0.16	0.15	0.95
Week effect	**	**	**	**	NS	*	**
1st week	27.72[a]	41.88[c]	94.61[a]	110.83[a]	102.74	103.22[bc]	92.00[b]
2nd week	47.330[b]	60.55[bc]	88.00[b]	107.22[a]	102.66	102.63[c]	95.46[b]
3rd week	46.00[b]	70.67[ab]	101.78[ab]	107.56[a]	102.77	103.37[ab]	95.66[b]
4th week	48.77[b]	79.33[a]	89.89[b]	93.78[b]	103.26	104.03[a]	100.68[a]
Pooled SE	1.73	4.94	3.11	2.40	0.19	0.18	0.99
Group×week	NS	NS	*	NS	NS	NS	*

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature. [a,b] Values within a column with different superscripts differ significantly at *P*<0.05.

Table 20. Effect of micro environment manipulation on blood metabolites in Malpura lambs**.**

Item	Hb (g/dL)	PCV (%)	Glucose (mg/dL)	Total Protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)	Cholesterol (mg/dL)	Urea (mg/dL)
μ ± SE	12.50 ± 0.26	48.67 ± 1.28	103.05 ± 2.20	6.90 ± 0.15	5.50 ± 0.06	2.49 ± 0.12	116.91 ± 3.81	36.01 ± 1.68
Group effect	*	*	NS	*	*	NS	NS	NS
GI	11.52[a]	44.24[a]	100.78	6.49[a]	4.27[a]	2.22	109.82	38.68
GII	12.96[ab]	51.42[b]	101.51	6.76[ab]	4.43[a]	2.59	128.60	30.61
GIII	13.03[b]	50.36[ab]	106.85	7.46[b]	4.79[b]	2.66	112.32	38.76
Pooled SE	0.44	2.21	3.81	0.26	0.10	0.20	6.61	2.90

Week effect	**	**	**	NS	*	NS	NS	**
1st week	19.28c	59.17c	121.41b	6.73	4.27a	2.46	107.39	40.02b
2nd week	10.29ab	50.87b	93.10a	6.55	4.52ab	2.37	114.47	41.48b
3rd week	11.25b	47.68b	112.08b	7.36	4.79b	2.57	124.75	39.86b
4th week	9.19a	36.96a	85.60a	6.96	4.41ab	2.55	121.05	22.71a
Pooled SE	0.51	2.05	4.40	0.30	0.12	0.23	7.63	3.35
Group*week	NS	NS	NS	NS	NS	NS	NS	NS

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature.
[a,b] Values within a column with different superscripts differ significantly at $P<0.05$.

Table 21. Effect of microenvironment manipulation on endocrine parameters in Malpura lambs

Item	GH (mlU/L)	IGF-1 (ng/mL)	T4 (nmol/l)	T3 (nmol/l)	Cortisol (nmol/l)
μ ± SE	**0.070±0.006**	**353.26±16.00**	**175.42±8.81**	**5.83±2.82**	**30.03±2.81**
Group effect	**NS**	**NS**	**NS**	*	*
GI	0.071	335.08	183.00	6.11ab	29.85ab
GII	0.067	344.77	173.52	6.62b	35.64b
GIII	0.072	379.94	169.77	4.78a	22.78a
Pooled SE	0.010	27.72	15.25	0.49	4.76
Week effect	**NS**	**NS**	**NS**	**NS**	*
1st week	0.079	348.31	176.87	6.46	16.90
2nd week	0.065	383.03	184.34	6.31	44.39
3rd week	0.082	340.26	189.75	5.34	31.49
4th week	0.054	341.46	150.76	5.24	25.98
Pooled SE	**0.01**	**32.00**	**17.31**	**0.56**	**5.89**
Group×week	**NS**	**NS**	**NS**	**NS**	*

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature.
[a,b] Values within a column with different superscripts differ significantly at $P<0.05$

Table 22. Effect of microenvironment manipulation on body weight gain in different type of housing

	Initial weight (kg)	Final body weight (kg)	Weekly body weight gain (kg)
Control	9.97	13.17	1.072
Dome	9.97	13.9	1.294
Thermocol insulated	9.88	13.97	1.339
SE	0.55	0.60	0.135

Conclusion:

Bamboo-make dome-type shed and thermocol-insulated shed provided warmth by raising the minimum temperature by 6.0 and 3.3 °C compared to conventional asbestos roof shed. This provided comfort to young lambs by minimizing cold stress which was reflected with relatively lower stress (lower cortisol) in animals kept in thermocol-insulated shelter. The animals kept inside bamboo-dome structure showed more stress as against better thermo-insulation, probably due to restricted floor space.

9. Results of Significant value

- The water samples from different sources available for livestock were analyzed from five districts (water dark zone) of Rajasthan and found that specific conductivity, chloride magnesium, sodium, silica and total solids were above the range of maximum permissible limits, while calcium was lower
- Despite significant effects of water restriction on physiological response, blood biochemical, endocrine profile and feed intake, Malpura ewes showed capability to adapt and tolerate up to 40% water restriction during summer season under semi-arid tropical environmental conditions, but comparatively less to alternate day water restriction. A reduction in feed and nutrient intake may have more detrimental effect, if water scarcity prolonged
- Feeding of prickly pear cactus [*Opuntia ficus indica* (L.) Mill.] could be a very good strategy to compensate water and feed scarcity in arid and semi-arid regions. Feeding of only 1.0 kg fresh Opuntia provides 0.9 L and water thereby compensating mild water restriction (nearly 1 L) without any significant effect on feed intake and digestibility besides providing feed and nutrients.
- Sheep under field conditions of semi-arid region try to tolerate high temperature and solar radiation by increasing physiological responses and by hiding under trees near the source of water during peak hours (44.3 ºC during 13.00 h to 14.00 h) of summer season.
- The indigenously developed bamboo dome structure could able to provide better protection from cold stress (inside temp. 19.33°C vs outside: 9.25°C; a difference of 10.08°C) to lambs but relatively more stress due to restricted floor space. Thermocol-insulated shelter was found to be the best to protect lambs against extreme winter and would be useful for commercial sheep farmers.

10. Procurement of Equipments

Name of the Equipment	Status of Procurement	Estimated Cost/ Budget allocated (Rs. in lakhs)	Actual Cost
1. ELISA Reader	Installed	7,00,000/-	6,47,806/-
2. Water Purification System*	Installed	6,00,000/-	6,00,000/-
3. Hematology Analyzer	Installed	6,00,000/-	6,42,750/-
4. Milk Analyzer	Not Purchased	6,00,000/-	-
5. Deep -Freezer	Not Purchased	1,90,000/-	-
Total=		**26,10,000/-**	**18,72,556/-**
Note: *Rs.17,487/- has been returned from water purification system.			

11. Status of works, if any:

Name of the Work	Actual expenditure incurred
1. Construction a Green House for Azolla Production	29599/-
2. Cactus farm	49525/-
3. House with thermocol-insulated roof for cold protection for Lambs	143500/-
4. Integrated farming with tree-shade to withstand summer	28050/-
Total	**250674/-**

12. Budget details:

Head	2012-13			Cumulative		
	Release	Exp.	%	Release	Exp.	%
I. RC	**7,35,679**			**16,64,321/-**	**19,74,663/-**	**82.28**
i.	4,66,687			17,33,313/-	19,34,977/-	87.95
ii.	2,68,992			(-)68,992/-	39,686/-	19.84
iii.	-	-	-	-	-	-
II. NRC	**26,07,600/-**			**(-)76,00/-**	**18,72,556/-**	
i.	24,07,850			2150	18,72,556/-	77.7
ii.	1,90,000				-	-
iii.	9,750			**(-)**9,750	-	-
III. Inst Charges						
IV. Total	**33,43,279/-**			**48,00,130/-**	**69,90,628/-**	**85.84**

13. HRD Program conducted, if any:

- Farmers under training programme at CSWRI, Avikanagar were exposed to different shelter management strategies under NICRA.
- Visit of farmers under training programme at CSWRI to Cactus field area and exposure to its importance during summer food and water scarcity
- Exposure of resource persons and dignitaries to different shelter and nutritional management activities carried out under NICRA project at CSWRI, Avikanagar

14. Publication/ patents

A. Research papers

1. Sejian, V, Naqvi, S.M.K., Sahoo, A. 2012. Effect of mineral mixture and antioxidant supplementation on growth, reproductive performance and adaptive capability of Malpura ewes subjected to heat stress. *Journal of Animal Nutrition and Animal Physiology [*DOI: 10.1111/jpn.12037].

B. Book Chapters

1. Sahoo A. 2012. Feeding and nutrition of animals at high altitude. In: Animal Nutrition-Advances and Developments, U.R. Mehra, P.Singh and A.K. Verma (eds). Satish Serial Publishing House, Delhi. pp 329-350.

C. Scientific/Teaching Reviews/Lead Paper

1. Sahoo, A. 2013. Nutritional issues in grazing and migratory sheep and goats. Centre of Advanced Faculty Training in Animal Nutrition is organizing an advanced Short Course on "Clinical Nutrition Approaches for Health and Productivity of Farm Animals", February 06-26, 2013, IVRI, Izatnagar. pp 174-181.
2. Naqvi S.M.K., Davendra Kumar and Sahoo A. 2013. Strategies for sustainable small ruminant production in arid regions under changing climate. In: Proc. Workshop on "Strategies for sustainable small ruminant production in arid regions under changing climate", 14-15, March, 2013, CAZRI, Jodhpur.
3. Naqvi, S.M.K. and Kumar, D. 2012. Environmental stresses and sheep production under changing climatic scenario. In: National Symposium on "Physiological research in changing environmental scenario for sustainable livestock and poultry production'', Navsari, 6-8 November, Invited paper, pp 15

D. Folders:

1. Chaturvedi, O. H., Sahoo, A., Bhatt, R. S., Sankhyan, S. K., Shinde A. K. and Meena, M. C. 2013. Akal Men Pashudhan Ka Bharan poshan. Published By CSWRI, Avikanagar.

E. Abstract papers

1. Chaturvedi, O. H. and Sahoo, A. 2012. Intake and utilization of nutrients in grazing ewes supplemented with complete feed block during scarcity in semi-arid region. In Souvenir cum Abstracts of National Seminar on Future Challenges and Opportunities to Improve Health and Production of Small Ruminants. December 22-23, Makhdoom, Farah (Mathura), India. Pp.95.
2. Singh, A.K., Kumar, D., and Naqvi, S.M.K. 2012. Physiological adaptability of sheep in farmer's flock during peak summer season in semi-arid region of Rajasthan. In: XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012, pp 47.
3. Kumar, K., Singh, A.K., Kumar, D., and Naqvi, S.M.K. 2012. Effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment. In: XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research

in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012, pp 48.

4. Singh, A.K., Kumar, K., Kumar, D., Naqvi, S.M.K. 2012. Effect of water restriction on the endocrine response of Malpura ewes under semi-arid tropical environment In: Souvenir cum abstracts, National Seminar on Future Challenges and Opportunities to Improve Health and Production of Small Ruminants and Annual Conference of ISSGPU organized by Indian Society for Sheep and Goat Production and Utilization, Avikanagar (ISSGPU) in association with Central Institute for Research on Gotas, Makhdoom at CIRG Makhdoom, - 281122 (Mathura, U.P) pp 148.

15. Any other information:

1. Dr A. Sahoo attended workshop on "Strategies for sustainable small ruminant production in arid regions under changing climate", 14-15, March, 2013, at CAZRI, Jodhpur.
2. Dr Davendra Kumar attended XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012
3. A total of four abstract papers were presented, two at CIRG, Makhdoom and two at NAU, Navsari
4. Dr A. Sahoo chaired a technical session in the Workshop at CAZRI, Jodhpur
5. Dr A. Sahoo presented an invited paper on "Environmental Stresses and Sheep Production under Changing Climatic Scenario" in the Workshop at CAZRI, Jodhpur.