

Effect of Changes in Environmental Temperatures on Some Renal Functions in Sheep

**भेड़ के वृक्कीय कार्यों पर वातावरणीय तापमानों
में परिवर्तनों का प्रभाव**

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B. V. Sc. & A.H.

THESIS
MASTER OF VETERINARY SCIENCE
(Veterinary Physiology)



उत्तमा वतिस्तु कृषिकमैव

2002

Department of Veterinary Physiology
College of Veterinary and Animal Science
Rajasthan Agricultural University
BIKANER - 334 001

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TEMPERATURES ON SOME RENAL
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THESIS

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Faculty of Veterinary Physiology

By

RAMESH CHAND MEENA
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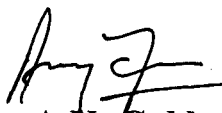
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This is to certify that **Ramesh Chand Meena** had successfully completed the **COMPREHENSIVE EXAMINATION** held on 03/05/2002 as required under the regulation for the degree of **MASTER OF VETERINARY SCIENCE**.


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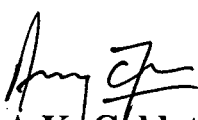
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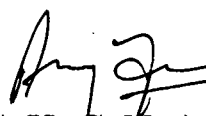

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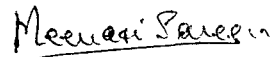
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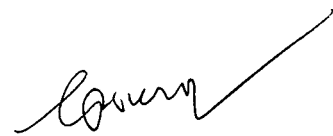
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This is to certify that the thesis entitled "**EFFECT OF CHANGES IN ENVIRONMENTAL TEMPERATURES ON SOME RENAL FUNCTIONS IN SHEEP**" submitted by Mr. Ramesh Chand Meena to the Rajasthan Agricultural University, Bikaner, in partial fulfillment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** in the subject of **VETERINARY PHYSIOLOGY** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory, we therefore, recommend that the thesis be approved.


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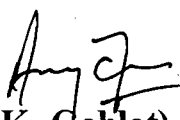
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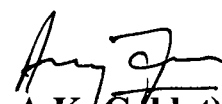
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This is to certify that **Mr. Ramesh Chand Meena** of the Department of Veterinary Physiology, College of Veterinary and Animal Science, Bikaner has made all corrections/modifications in the thesis entitled "**EFFECT OF CHANGES IN ENVIRONMENTAL TEMPERATURES ON SOME RENAL FUNCTIONS IN SHEEP**", which were suggested by the external examiner and the advisory committee in the oral examination held on 29 / 10 / 2002. The final copies of the thesis duly bound and corrected were submitted on 30 / 10 / 2002 are enclosed herewith for approval.


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Enclosed one original and two hard bound copies of the thesis. Forwarded to the Dean, Post Graduate Studies, RAU, Bikaner, through the Dean of college.


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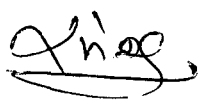
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Introduction

INTRODUCTION

India has a large population of sheep and it is the most wide spread domesticated animal. It is the backbone of landless and small farmers, particularly in areas where agriculture production is low and the farmers have to depend upon livestock for their livelihood. These have been raised for food, meat, milk, pelts and hide and thus sheep industry have become an alternate enterprise to agriculture in arid region. The sheep has a tremendous potential to keep its productive ability next to camel in utilising waste and low quality fodder into animal produce *viz.* wool, mutton and manure. With the immense significance of sheep in enhancing the economy of farmers, very little work has been done to assess its adaptability in special reference to renal function tests.

In veterinary medicine, the question of whether renal function is normal or abnormal is of frequent concern. Further, it is required that renal function test should be carried out reasonably quickly at the least cost of the owner of the animal. For this purpose the evaluations should be simple and quick. Many renal function tests like for azotaemia and endogenous clearance come into this category. Various clearance techniques can be employed to estimate the glomerular filtration rate (GFR) and endogenous true creatinine clearance (ETC) is one of them.

The rate of formation of creatinine and its concentration in plasma remain relatively constant. Determination of endogenous creatinine clearance appears to provide a reliable estimate of GFR

in animals with early stage of renal disease. It is a satisfactory and convenient measure of GFR because it can be determined without employing a continuous intravenous infusion technique. Single sample fractional excretion determination can also be used in clinical veterinary practice. However, scanty data are available on this aspect in sheep.

Urinary diagnostic indices calculated for healthy sheep may be used as reference values for early recognition of renal damage or renal failure. Urinalysis usually is performed as screening method for acquiring a large amount of information about several body systems, with minimal expenditure of resources. It is also performed specifically for evaluation of diseases of the kidneys in animals. Extensive systems of management, problems of distance and transport and difficulties in maintaining adequate veterinary services have been major factors contributing to this situation. The normal values of renal functions will be helpful for potential health management of sheep raised under different climatic conditions in arid and semi-arid regions.

The use of haematological norms is one of the easy means to evaluate the adaptability and productive efficiency of the animals. In veterinary clinical medicine it helps to assess the health status of the animals. Certain haematological parameters *viz.* specific gravity, viscosity etc. are very less studied in this species and they can provide picture of the health status of the animal particularly in the diseases leading to dehydration i.e. diarrhoea, vomiting etc. In addition certain inorganic and organic constituents of extracellular fluid give fairly good index of the disease conditions and adaptability to different climatic conditions.

The normal blood profile in animals are essential to determine the course and outcome of many viral, bacterial, parasitic, anaemic condition, metabolic disorders and adaptability of domestic animals. Therefore, normal values of blood indices and biochemical constituents of serum in animals are of academic as well as of clinical importance. Research conducted in India revealed that these values vary from region to region (Pandiya *et al.*, 1977). It is therefore, necessary to establish the normal levels of biochemical constituents of blood and serum in animals of particular region. Many factors affect the blood biochemistry in animals (Kaneko, 1980 and Blood *et al.*, 1983). The haematological picture get altered during growth and development stages at different age groups and also different climatic temperatures. The present study will be helpful in understanding the effect of varying environmental temperature on levels of haematological and serum biochemical constituents in sheep of western region of Rajasthan.

Maintenance of normal level of serum electrolyte are essential for normal growth, reproduction and health of animals. The electrolytes play a great role in the maintenance of fluid balance in different physiological states of the animals. Their status varies with different physiological and climatic conditions. (Hidiroglou, 1979). Although, several studies have been conducted on serum electrolyte concentration in blood of sheep, research pertaining to their levels in blood during different physiological and climatic condition is meagerly carried out.

The changes in the environmental temperature bring about changes in the values of different blood constituents, which are necessary for physiological adjustments (McDonald, 1980) during changing environments. Higher environmental temperature brings about alternation in water and electrolyte balance in animals and depending on the temperature load derangements in the physiological mechanism involved in the homeostasis of the body may take place (Dale *et al.*, 1956b). The available literature (Harvey, 1963 and Mullick, 1964) did not reveal enough pertinent information about the influence of changing climatic variable on water and electrolyte status of sheep.

Control of turnover of water and electrolyte is important in the survival of mammals in arid areas particularly in different climatic conditions. However, there is paucity of work on this aspect in marwari sheep of western part of Rajasthan. Therefore, study of renal functions in sheep will be helpful in assessing the productive potential during changes in environmental temperatures. In view of this an endeavour has been made to study the effect of changes in environment temperatures on some renal functions in sheep with following objectives :

1. To determine different renal functions in normal healthy sheep during moderate environmental temperature.
2. To determine haematological parameters, serum metabolites and electrolytes in normal healthy sheep during moderate environmental temperature.
3. To study the changes in renal functions, haematological parameters, serum metabolites and electrolytes during extremely cold and hot environmental temperatures.

*Review
Of
Literature*

REVIEW OF LITERATURE

Changes in environmental temperatures greatly alter the renal functions thereby affecting productive potential of the animals. Studies on this aspect in sheep are meagre, therefore pertinent review of other closely associated species have also been included. The review is presented in the following sequence.

1. RENAL FUNCTIONS :

- (a) Endogenous creatinine clearance.
- (b) Urea clearance
- (c) Electrolyte clearances (Sodium, potassium, chloride, phosphorus and magnesium)
- (d) Transfer function of kidney (TFK)
- (e) Urine concentration test (Urine colour, pH and Specific gravity)
- (f) Filtered and excreted loads of some serum constituents (Creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium)

2. HAEMATOLOGICAL PARAMETERS AND PLASMA OSMOLARITY (Posm)

(Haematological parameters included haemoglobin (Hb), packed cell volume (PCV), erythrocyte sedimentation rate (ESR), specific gravity (Sp.Gr.), relative viscosity and mean corpuscular haemoglobin concentration (MCHC))

3. SERUM METABOLITES AND ELECTROLYTES

(Creatinine, urea, total proteins, glucose, sodium, potassium, chloride, calcium, phosphorus and magnesium)

1. RENAL FUNCTION TESTS :

(i) Endogenous Creatinine Clearance :

Gribetz *et al.* (1955) compared the renal endogenous creatinine and inulin clearance in the rats. They suggested that endogenous creatinine clearance was a useful index of GFR. The ratio of Ccr/Cin was 0.90.

Macfarlane *et al.* (1958) observed the relation between environment and the water intake and output of young merino sheep in the hot dry tropics. Evaporative cooling by panting increased water demand and in summer merinos drank on the average 4 times as much water as in winter. Urine output was lower in summer than in winter.

Schmidt Nielsen *et al.* (1957b) used the endogenous true creatinine clearance as a measurement of glomerular filtration rate in camels. The average ratio of endogenous true creatinine clearance and inulin clearance was 1.01 ± 0.03 .

Knudsen (1959) measured endogenous creatinine clearance and inulin clearance in mare and reported that creatinine clearance was equal to endogenous inulin clearance.

Groot and Aafjes (1960) demonstrated that cow excreted creatinine at a constant rate and it was a better measure of the concentration of urine.

Lewis (1961) measured creatinine clearance and inulin clearance in rats and concluded that creatinine clearance could be used as an estimate of GFR.

Kaneko and Cornelius (1971) reported that the renal clearance of endogenous creatinine was 20.4% lower in summer than in winter season.

Rawlings and Bisgard (1975) used the endogenous creatinine clearance for clinical measurement of renal function in ponny and stated that creatinine was mostly eliminated by the glomerular filtration, therefore, used to measure glomerular filtration rate.

Nawaz and Shah (1984) simultaneously measured the renal clearance of endogenous creatinine and exogenous inulin in sheep and observed similar mean $\pm$ S.D. values of 13.8 ± 1.3 and 13.2 ± 2.0 ml/min./kg body weight, respectively. The renal clearance of endogenous creatinine was 11.0 ± 1.0 ml min⁻¹ in summer which was significantly lower than the clearance value 14.2 ± 3.0 ml min⁻¹ (10 kg)⁻¹ in winter.

Yagil (1985) compared the creatinine clearance and inulin clearance ratios in watered and water deprived camels. Water deprivation in winter season led to a decline in creatinine clearance of 23% and inulin clearance of 21%. In summer season declines were 72% and 74%, respectively.

Farningham (1986) compared the renal clearance of endogenous creatinine and inulin in sheep and reported that the creatinine clearance was a useful indication of glomerular filtration rate.

Bickhardt and Dangelhoff (1994) found that creatinine clearance in sheep ranged from 1.1 to 2.3 ml/min/kg b.wt. They suggested creatinine clearance as a useful measure of GFR.

Akhtar *et al.* (1997) determined renal clearance of endogenous creatinine in goats during summer and winter seasons and suggested it as a satisfactory measure of GFR. They recorded a highly significant ($P < 0.01$) seasonal difference in renal clearance of endogenous creatinine values. The mean $\pm$ S.D. values of renal clearance of endogenous creatinine during summer and winter seasons were 252 ± 52 and 181 ± 84 ml/min/kg b.wt., respectively.

Nafeesa *et al.* (1999) determined renal clearance of endogenous creatinine in female goats. They found that the renal clearance of endogenous creatinine was 1.28 ± 0.40 ml/min/kg b.wt.

Kataria (2000) found endogenous true creatinine as a good measure of GFR in dromedary camels and observed a good correlation between inulin and creatinine clearances.

Puri (2001) observed that in marwari goat endogenous true creatinine clearance could be effectively used as a measure of GFR.

(ii) Urea Clearance :

Laurence and Wesson Jr. (1954) studied urea excretion by the mammalian kidney and reported that urea clearance was always less than the rate of GFR. Urea clearance increased with increasing urine flow.

Meyer *et al.* (1955) observed a low total urine nitrogen values when the sheep were deprived of water and feed for limited periods .

Parry and Taylor (1955b) observed that in toxaemic sheep there was a considerable impairment of renal function and this caused a rise of blood urea.

Schmidt Nielsen *et al.* (1957b) determined urea excretion in camel and suggested that on low nitrogen intake the amount of nitrogen excreted in the form of urea, NH_3 and creatinine decreased to 2.3 g/day and this decrease was caused by a drop in urea excretion from 13g to 0.2-0.5 g/day.

Schmidt Nielsen *et al.* (1958) studied renal regulation of urea excretion in sheep in order to elucidate the renal mechanism for the regulation of urea excretion. Differences in the effect of osmotic and water diuresis and the effects of abrupt changes in rate of urine flow were also studied. In sheep on normal protein intake the urea/inulin clearance ratio was constant in the range of urine flows corresponding to inulin u/p ratios from 10 to 500. On low protein intake the urea/inulin clearance ratio decreased markedly with decreasing urine flow.

Schmidt-Nielsen and Osaki (1958) reported that sheep was able to regulate the renal excretion of urea. During low protein intake urea clearance fell to very low values and maximum urea concentration in urine was only about 5 to 7 times the plasma concentration at low urine flows.

Weeth and Haverland (1961) reported that water intake and urine flow rate associated with sodium chloride solution ingestion caused increased urinary urea excretion and low blood urea concentration in cattle.

Vercoe (1967) reported significant negative correlation between plasma urea and both water intake and urine in steers fed a low nitrogen diet. The urinary urea excretion was positively correlated with urine volume.

Labouche (1970) reported that in cattle when blood urea increased, renal reabsorption of urea and water decreased; but when concentration of blood urea exceeded 500 mg/l, the phenomenon was reversed.

Thornton (1970) studied factors affecting urinary excretion of urea nitrogen in cattle and found that plasma urea concentration was linearly related to urinary urea excretion. Urea clearance and the fraction of filtered urea excreted were both related to urine flow rate and not to urinary urea output.

Ide (1971) studied plasma urea turnover and renal urea excretion in goats and reported that the rate of urea turnover was always higher than that of renal urea excretion and increased with the increase in dietary protein intake. Low protein intake caused a decrease of about 3% of the rate of renal urea excretion to that of urea turnover.

Osbaldiston and Moore (1971) conducted renal function tests in cattle and value of urea clearance was 1.23 for calf and 0.84 ml/min/kg for adult cow.

Rabinowitz and Gunther (1972a) while studying the urea diuretics in sheep reported that animal did not respond to acute elevations of plasma urea concentration or urinary urea excretion with an enhanced ability to osmotically concentrate the urine.

Ergene and Pickering (1978) found a fall in urea excretion and in plasma urea concentration along with reduction in GFR in sheep fed with low nitrogen.

Jorna (1978) observed that a fall in effective renal blood flow in sheep was associated with increase in urea levels as 217 mg/100 ml in sheep.

Sykes and Russel (1979) observed a seasonal variation in concentration of urea nitrogen in sheep being 100-300 mg/l in summer and 23-61 mg/l during winter.

Nawaz and Shah (1984) reported that renal clearance of urea was 10.2 ± 3.6 and 9.58 ± 2.94 ml min $(10 \text{ kg})^{-1}$ during summer and winter, respectively in goat.

Benlamlih *et al.* (1985) reported an increased urea plasma level in late pregnancy in ewes and a decreased urea clearance during pregnancy and lactation.

Choshniak and Arnon (1985) studied nitrogen economy of Nubian ibex goats and found that recycling of urea and reabsorption of urea increased to 48% and 78% and GFR decreased upto 28.97 ml/min. in order to maintain nitrogen metabolism.

Leng and Szanyiova (1987) observed that in merino sheep after 3 days of water deprivation, GFR decreased from 77.6 to 6.37 ml/min.; plasma concentration of urea decreased from 7.98 to 6.37 mmol/l and urea excretion decreased by 41% from 354 to 208.5 μ mol/min.

Rodriguez *et al.* (1996) evaluated renal urea conservation in corriedale ewes during late pregnancy and lactation. Glomerular filtration, renal plasma flow and urea clearance were significantly reduced during both states compared with control sheep. Filtered load of urea and urine urea elimination were significantly reduced only during lactation (-46% and -45% respectively, Vs. Controls). No changes were noted in fractional excretion of urea. Therefore corriedale ewes restricted urine urea losses during lactation by reducing glomerular filtration.

Ndibualonji *et al.* (1998) investigated the changes in renal function in late pregnancy and early lactation in corriedale ewes and compared with the non-productive state. Plasma urea concentration was increased by 67% during pregnancy and decreased by 36% during lactation. Urine flow, urea clearance, renal plasma flow and glomerular filtration rate were significantly reduced during both late pregnancy and early lactation.

Kataria (2000) estimated urea clearance in dromedary camels during water restriction and rehydration in winter and summer.

Kachhwaha (2001) determined urea clearance in marwari female goats during dehydration and rehydration. During control phase the mean value of urea clearance was 22.85 ± 2.74 ml / min.

(iii) **Electrolyte Clearances :**

Hernandez and Coulson (1957) observed that cold increased the concentration of the urinary sodium, chloride, calcium, magnesium while it decreased the excretion of phosphate in alligators.

Gans and Mercer (1962) demonstrated that when sheep were maintained on high protein diet, the urine volume decreased and excretion of sodium and potassium decreased but administration of vasopressin was followed by an increase in rate of secretion of sodium into urine.

Potter (1963) studied the effect of saline water on kidney tubular function and electrolyte excretion in sheep. Prolonged ingestion of sodium chloride did not induce any increase in the number of active tubules in kidneys. The urinary excretion of sodium and chloride was greatly increased and potassium to lesser extent. Reabsorption of electrolytes was found to be reduced during transit through the renal tubules. The urinary pH was increased and osmolarity reduced.

English (1966) studied water and electrolyte metabolism in sheep and reported that during dehydration there was a positive balance of sodium, potassium and chloride and on rehydration sodium chloride

balance was negative but potassium remained positive. Mean urinary potassium/sodium ratios were 9.0, 4.5 and 4.0 during before dehydration, rehydration and after rehydration, respectively.

English (1967) carried out an investigation in which water and electrolyte metabolism in sheep was studied after producing osmotic diuresis and studied of water and electrolyte metabolism in sheep and reported that external balances of sodium, potassium and chloride were negative to the extent of 340, 87 and 353 meq./lit., respectively.

Pandey and Roy (1969) recorded seasonal changes in the water and electrolytes status of buffalo cow. They reported that total molecular concentration of urine remained low during winter and increased during summer. The concentration of sodium and chloride was maintained fairly constant both through the winter and summer season. Excretion of potassium was found lowest with the onset of summer and progressively increased throughout the summer. Excretion of sodium and chloride with the onset of summer had a similar pattern but their excretion remained lower throughout the summer.

Schmidt Nielsen and Pfeiffer (1970) reported that urine urea concentrations varied inversely with urine sodium concentration. Low sodium intake was accompanied by decreased urine sodium and increased urine urea concentration in mountain beaver.

Johnson (1971) found that in British and zebu cows during normal hydration and mild dehydration urinary sodium increased

from 21.4 to 107.6 (British) and 12 to 91.9 (Zebu); Potassium increased from 124 to 266 (British) and 144 to 249 (Zebu); Plasma sodium increased from 143 to 153.2 and potassium from 3.7 to 3.9 (British) and sodium 142.4 to 149.2 and Potassium 3.9 to 3.8 mmol/l (zebu) during the 2 phases, respectively.

Ghosh *et al.* (1976) studied the effect of short term water deprivation in summer on marwari sheep and reported that urinary potassium concentration remained unaffected while urinary sodium was increased from 21 ± 9.0 (meq/day) to 50 ± 9.9 on 48 hr. of dehydration.

Yagil and Berlyne (1976a) studied effect on sodium and potassium metabolism during dehydration and rehydration in Bedouin camel. During dehydration potassium metabolism was more affected and concentration of potassium in urine declined while that of sodium increased. Following rehydration, significant changes in cation metabolism were reported within 15 to 45 minutes.

More and Sahni (1979) evaluated water, sodium and potassium balances in Chokla sheep intermittently watered. A large balance for potassium especially in sheep given water every 12 hrs. suggested that this unusually high balance of potassium was an adaptation for hot climate.

Rabinowitz *et al.* (1979) reported that administration of amiloride increased the sodium excretion from 6 to 180 fold and potassium excretion decreased to one-third of base-line values in cattle.

Yesberg *et al.* (1979) found that when arginine vasopressin was infused in sheep there was an increase in water and electrolyte output along with solute clearance, solute free water reabsorption and tubular sodium reabsorption.

Williams and Pickering (1980) infused hydrochloric acid in sheep to assess renal functions. The urinary excretion of inorganic phosphate was slightly increased after infusion. The quantities of inorganic phosphate ions filtered and reabsorbed decreased whereas the proportion of the filtrate reabsorbed remained unaltered.

Elnoughty and Hassan (1983) observed that serum and urinary concentration of sodium and potassium decreased on heat exposure in Hereford cows. Dehydration increased plasma sodium concentration.

McKinley *et al.* (1983) studied the effect of water deprivation on sodium balance in sheep and reported that dehydration induced a considerable increase in daily output of sodium in urine causing animals to be water and sodium depleted. Mean sodium in urine excreted was 224 ± 45 mmol/lit. in first 24 hrs and 365 ± 23 mmol/lit during second 24 hr. of water deprivation. A small but significant increase in potassium was seen.

Nicpon (1983c) found an increase in sodium concentration in serum and urine and a slight increase in serum chloride level following 6 days of dehydration in sheep and these values returned to normal 3 days after rehydration.

More and Rawat (1984) during their study of intermittent watering in Chokla sheep reported that differential alternations in plasma sodium and potassium levels in these groups were not observed and chloride level was regulated secondarily to that of sodium.

Michell *et al.* (1988) studied sodium, potassium and water balance in pregnant ewes and observed that greater water turnover was seen in sheep excreting majority of sodium in urine than in faeces and therefore sodium loss was greater at the end of pregnancy in sheep with low sodium diet.

Itoh (1989) reported that fractional electrolyte excretion in cows which indicated electrolyte clearance per nephron ranged from 1.30 ± 0.13 % in summer to 0.33 ± 0.06 % in spring for sodium; 55.16 ± 4.12 in summer to 21.65 ± 3.41 % in spring for potassium, 2.25 ± 0.12 % in autumn to 0.68 ± 0.12 % in spring for chloride.

Meintjes and Engelbrecht (1994) observed that following dehydration for 2 days in sheep sodium was lost and electrolyte free water was retained by the kidney. Later in dehydration and early rehydration, sodium retention increased along with increased water reabsorption to maintain total body water.

Bickhardt *et al.* (1995) observed that in sheep with renal failure, fractional renal water excretion and fractional excretion of sodium and phosphate were elevated.

Akhtar *et al.* (1997) found that sodium clearance was 0.063 and 0.093, potassium clearance was 0.44 and 0.70 and chloride clearance was 0.029 and 0.046 ml/min during summer and winter, respectively in goats.

Kataria(2000) reported the mean values of sodium, potassium and chloride in urine of camels as 172.0 ± 5.3 and 177.0 ± 4.5 mmol/lit; 314.437 ± 7.06 and 311.08 ± 7.5 mmol/lit; and 469.75 ± 44.6 and 501.75 ± 47.28 mmol/lit, respectively during winter and summer.

Kachhwaha (2001) determined the mean values of sodium, potassium and chloride clearances in female marwari goat in ml/min. as 0.402 ± 0.029 , 3.77 ± 0.22 and 0.071 ± 0.009 , respectively.

(iv) Transfer Function of Kidney :

Purohit (1972) gave a formula for the determination of transfer function of kidney in sheep. It is the ratio of urine volume and water intake.

Kataria (2000) determined transfer function of kidney in camels and observed the effect of dehydration (24 days in winter and 11 days in summer) on the mean values of transfer function of kidney during rehydration.

Kachhwaha(2001) reported the mean value of TFK in female marwari goat as 0.49 ± 0.025 . She further observed the effect of dehydration on TFK.

(v) Urine Concentration Test :

Macfarlane *et al.* (1956) studied water economy of tropical Merino sheep. The urine output in winter was 1.34 ± 0.65 l/24 hrs. and in summer was 0.73 ± 0.39 l/24 hrs.

Kalra and Arya (1958) conducted preliminary studies of camel's urine. Colour varied from pale yellow to dark yellow, specific gravity was 1.010 to 1.065 and reaction was highly alkaline.

Macfarlane *et al.* (1958) derived a relation between environment and water intake and output of Merino sheep living in hot dry tropics. In summer one-fifth to one-quarter of water consumed appeared in urine whereas in winter six times as much water was passed in urine as consumed.

Kamal *et al.* (1962) stated that urea is the main component contributing to specific gravity of urine of ruminants.

Potter (1963) observed that when sheep were confined to rain water pH was 8.0, specific gravity was 1.043 and daily urinary flow rate was 0.54 ml/min while in sheep which drank 1.3% sodium chloride, pH was 8.4, specific gravity was 1.025 and rate of urine formation was 2.28 ml/min.

Bianca (1970) reported that dehydration caused an increase in the specific gravity of urine and this rise was greatest during the first two days of water deprivation in ox. Following rehydration, rapid restoration of urine specific gravity was there to normal or below to normal.

Maloiy and Taylor (1971) found that under desertic condition in African goats and haired sheep, evaporation was the major avenue of water loss and was reduced during water restriction. Urinary water loss accounted for a very small fraction 10-15% and under water restriction, urine volume reduced to 50% in both species.

Ghosh *et al.* (1976) reported that the urine volume progressively decreased with body water deficit. The mean excretion of urine after 48 hr. water deprivation was less than half the normal volume of urine excreted by the animals due to decline in GFR.

Guerrini *et al.* (1980) studied effect of ambient temperature and humidity on urine output in sheep. Urine output increased during hot humid, hot dry and cool humid exposure but was 70% greater during hot humid environment than during hot dry exposure.

Elnoughty and Hassan (1983) studied the effect of high ambient temperature and water deprivation on Hereford cows and found no change in urine volume.

Olsson and Dahlborn (1989) reported that goats increased the water turnover during heat stress if allowed to drink *ad libitum*, but when they were deprived of water lactating goats reduced water loss in urine, milk and by evaporation.

Fleming *et al.* (1991) determined total 24 hour urine production for 7 cows which ranged from 4515-7130 ml/day or 0.02-0.04 mg/kg b. wt/day.

Schlerka *et al.* (1996) observed that urinary pH was 6.7 in 60 healthy calves aged 2-28 days and pH reduced to 5.7 in calves with diarrhoea accompanied with metabolic acidosis.

Kataria (2000) conducted a study in dromedary camels and observed that with the advancement of dehydration the pH and specific gravity of urine increased. The colour of urine became dark.

Rajkhowa and Hazarika (2000) observed decreased urine output in goats deprived of water for 96 hour under hot climatic conditions.

Kachhwaha (2001) gave the mean values of total urine output (l/ day), urine pH and specific gravity in female marwari goat as 0.671 ± 0.056 , 7.75 ± 0.111 and 1.017 ± 0.001 , respectively. The colour of urine varied from pale yellow to yellow.

(vii) Filtered and excreted loads of serum constituents :

There is paucity of literature on this aspect in animals.

Schmidt Nielsen *et al.* (1957b) studied urea excretion in camel. They observed that during normal nitrogen intake about 40% of the urea filtered in the glomeruli were excreted in the urine while during low nitrogen intake only 1-2% were excreted.

Thornton (1969) determined the factor affecting the urinary excretion of urea nitrogen in cattle. It was observed that urea supplementation increased the plasma urea concentration, excretion of faecal nitrogen urinary urea and non-urea nitrogen.

Yagil and Berlyne (1976a) studied sodium and potassium metabolism in the dehydrated and rehydrated camels. Further they calculated the filtered and excreted loads of sodium and potassium.

Yagil and Berlyne (1978) reported extensive decline in urea excretion by dehydrated camel and an increase in tubular reabsorption of urea as a percentage of filtered load.

Rodriguez (1996) determined renal functions and urea handling in pregnant and lactating corriedale ewes. They observed that filtered load of urea was significantly reduced (-46%) during lactation. No change was noted in fractional excretion of urea. Therefore, corriedale ewes restricted urine urea losses during lactation by reducing glomerular filtration.

Ndibualonji *et al.* (1998) observed that filtered load of urea and the amount of urea eliminated were significantly reduced only in lactating ewes. No change was noted in the fractional excretion of urea during both the pregnancy and early lactation.

Kataria (2001b) determined filtered and excreted loads of urea in different climatic conditions and hydration states in dromedary camels. The excreted load of urea decreased significantly in hot condition.

2. HAEMATOLOGICAL PARAMETERS AND PLASMA OSMOLARITY :

Ham and Castle (1940) gave the first data correlating the shape of RBC with the viscosity of whole blood in human being.

Grunsell (1955) studied seasonal variation in haematological correlates in animals. The possibility of variation of PCV and Hb could be due to multifarious factors including environmental stress, availability and quality of feed and fodder, reproductive stress etc.

Edwards (1956) demonstrated in animals that specific gravity of whole blood varied with the red cells concentration while the specific gravity of plasma depended largely on the plasma protein concentration.

Spipple (1958) observed that specific gravity of whole blood and plasma was increased in animals during dehydration caused by diarrhoea, vomiting, burns, severe affections of kidney etc.

Mehrotra and Mullick (1959) bled 12 healthy sheep at monthly interval to record the composition of blood as affected by the changes in the air temperature from 65°F to 105°F in January to June, respectively and they concluded that the values of Hb and PCV in whole blood declined from 8.63 gm% to 6.99 gm% and 38.0 to 34.47%, respectively.

Stufflebeam *et al.* (1964) reported that Hb and haematocrit values in cattle increased with changes in environmental

temperature. The mean values of Hb and PCV were higher during summer i.e. 13.5 gm% and 33.9%, respectively and lower in moderate month i.e. 13.1 gm% and 31.6%, respectively.

Schalm (1965) reported that moving of sheep from companionship of the flock increased the PCV and Hb values significantly until the adjustment to the new environment occurred. The PCV was observed to vary as much as 25% under conditions of excitement or emotional stress.

Warner and Stacy(1965) studied solutes in the rumen of sheep and recorded the Posm in sheep which had not been given food or water for 18 hrs.

Stone *et al.* (1968) studied the influence of erythrocyte on blood viscosity and stated that viscosity of whole blood increased with decreased cell size. The deformity of erythrocyte and charge density of erythrocyte also affected the blood viscosity.

English *et al.* (1969) recorded the mean value of plasma osmolality in sheep as 293.1 ± 5.3 m osm/ kg. They stated that sex difference for Posm as applies to man may not be applicable to sheep.

Usami *et al.* (1969) studied the viscometric characteristics of blood of sheep and goat and reported that sheep and goat erythrocyte did not form significant aggregation even in the presence of proteins. The addition of serum proteins and fibrinogen did not increase the shear dependence of suspension viscosity.

Vaidya *et al.* (1970) studied haematological constituents of blood of various categories of Gujarat goats during different seasons of the year and observed no changes in Hb concentration.

Purohit *et al.* (1972) observed the effects of various degrees of water restriction in marwari sheep and reported that PCV was increased from 25.42 to 33.61% during complete water restriction of 3 days.

Sharma *et al.* (1973) studied the age wise and species wise haematological profile in farm animals and reported that there was no sedimentation of erythrocyte in sheep during the first one Hour. ESR and PCV tended to rise with age as in other species. Hb concentration was highest in young sheep and lowest in lamb. The mean values of MCHC were 26.53 ± 2.9 and $28.83 \pm 1.31\%$, respectively in adult and young sheep.

Chyla *et al.* (1975) observed that haematocrit and Hb values decreased with age in sheep. They also noticed the seasonal variation among these correlates.

Kaushish *et al.* (1976) conducted a study on adaptability of nail sheep and reported a variation in haemoglobin concentration and PCV in different seasons of the year. They further reported that Hb and PCV% decreased significantly in summer. Diurnal variation in these correlates was also noticed. The evening values were higher in all seasons than the morning values.

Singh and Taneja (1978) observed comparatively increased PCV in water deprived marwari ewes. Purohit (1979) found PCV (%) of marwari sheep as 25.70 during winter season.

More and Sahni (1979) studied haematological changes in three months old Chokla lambs under semi-arid conditions and reported that PCV and haemoglobin concentration declined 40th to 60th day post-natal growth and thereafter a rise was noted in there components. The Hb concentration in lambs was lower than in adult sheep.

More *et al.* (1980) conducted a study in sheep exposed to thermal stress and reported that there was no change in the haematocrit values due to the thermal exposure.

Chahal and Rattan (1981) studied seasonal variations in the contents of Hb (gm%) and PCV (%) in the blood of corriedale rams and the values for different seasons were 10.67, 11.70, 12.97, 12.20 g% during winter, spring, summer and rains, respectively.

Udalove *et al.* (1981) reported that blood values of karakul sheep changed with the different seasons of the year. Erythrocytic count and Hb contents increased significantly in summer and fell sharply in spring.

Mazumder *et al.* (1982) studied normal values of some blood parameters in Indian pashmina goats and the effect of age, sex and season was not observed on the Hb contents.

Somvanshi *et al.* (1987) studied haematology of healthy Chegu breed of goats and observed the values of Hb (g/dl), PCV (%) and ESR (mm/hour) as 7.46, 31.0 and 0.0, respectively.

Igbokwe and Abodunrin (1990) studied daily variation in haematological parameters of hydrated and dehydrated sheep in hot and dry environments and found that the PCV tended to be lower and total WBC higher in the water deprived sheep.

Kataria *et al.* (1992) reported an increase in PCV (%) from 28.49 ± 0.23 to 32.95 ± 0.25 , respectively from winter to summer in marwari goats. A significant increase in RBC and PCV content during summer was related to heat stress. A non significant increases in Hb content was also observed during summer (11.76 ± 0.13 to 12.35 ± 0.13).

Dutta *et al.* (1996) studied haematological parameters in sheep of Assam and the values of Hb and PCV were 11.02 ± 0.64 gm% and $35.81 \pm 1.97\%$, respectively. The mean value of MCHC was $30.86 \pm 1.31\%$.

Alonso *et al.* (1997) reported the average values of Hb (gm/l) 101.74 ± 11.63 , 101.86 ± 18.15 , 102.16 ± 19.5 , 103.25 ± 21.81 , 106.34 ± 19.90 in lambs, yearlings, twinters, thrinters and mature ewes, respectively.

Dalvi *et al.* (1998) determined haematological values in camel under hot humid climate of Konkan region and reported the mean values of ESR (mm/hour), PCV (%), Hb (g/dl) 1.58, 22.74, 6.38, respectively. They also suggested that lowered

concentration of Hb due to increase in temperature and humidity reduced feed consumption in animals.

Kalleswarappa and Jayaprakash (1999) studied haematological profile of UAS strain of sheep and found PCV (%) and Hb (gm%) as 42.76 ± 3.12 , 10.80 ± 0.92 , respectively. They further reported that no sedimentation was noticed even after 24 hrs. in any of the animals due to absence of rouleaux formation. The mean value of MCHC was 25.14 ± 3.36 %.

Ram Prabhu and Dhanapalan (1999) studied comparative blood profile of sheep in the hilly tract. They determined Hb, PCV, glucose, cholesterol, Ca, P in the two breeds of sheep and demonstrated the necessity to consider the influence of breed and season upon haematological and serum parameters in the evaluation of laboratory finding.

Shrikhande and Sarode (1999) studied haemoglobin levels in cows of different age groups and reported non-significant effect of age on haemoglobin.

Kataria(2000)reported the mean values of haemoglobin , ESR, PCV, MCHC, relative viscosity and plasma osmolarity in dromedary camel during winter and summer seasons and studied the effect of dehydration and rehydration on the mean values.

Shaikh (2000) demonstrated that sex wise comparison in Hb and PCV showed significant lower value in male goats than in female goats.

Charan *et al.* (2002) studied blood indices in marwari goats and reported the range of specific gravity, viscosity and PCV (%) from 1.01 to 1.08, 2.34 to 5.65 and 25 to 36%, respectively.

Meena *et al.* (2002) conducted a study on the normal blood indices in 50 Marwari sheep and determined the range of PCV (%), relative viscosity, specific gravity and plasma osmolarity from 12.5 to 46%; 4.07 to 7.28; 1.048 to 1.063; and 280 to 312 m osm/l respectively.

3. SERUM METABOLITES AND ELECTROLYTES

Clark (1959) determined plasma sodium and potassium concentration in normal merino sheep and reported that 90% of the values were ranged from 138 to 150 meq/l for sodium and 4.1 to 5.5 meq/l for potassium.

Ayoub *et al.* (1960) determined calcium levels in farm animals and reported higher levels in young males which decreased gradually to a mean values of 10.0 ± 0.05 mg/100 cc serum at maturity. They also reported that female animals had a lower level than males which might be attributed to the great losses in milk secretion.

Kamal *et al.* (1962) found no change in plasma sodium and potassium contents with increasing temperature in temperate cattle but Goverdhan (1955) observed an increase in sodium and potassium contents of serum upto 21.1°C but when the

temperature was raised to 26.7°C these changes became inconsistent in temperate cattle.

Lazer *et al.* (1967) carried out a study on 15 Sloval merino sheep between 2 to 6 years of age and reported that the range of potassium values was from 27.0 to 70.0 mg % and sodium from 380.0 to 388.0 mg %.

Lane *et al.* (1968) studied the blood mineral composition in sheep and found a significant effect of age on electrolytes values.

Idris *et al.* (1976) determined range of sodium and potassium in 500 healthy adult sheep of Gesire province of Sudan as from 130.0 to 150.0 meq/l and from 3.0 to 6.0 meq/l for sodium and potassium, respectively.

Moldoven *et al.* (1979) observed that magnesium, copper, glucose were higher during summer than winter in cow.

More and Sahni (1979) found that serum biochemicals changed during three months after birth in Chokla lambs under semi-arid conditions and observed that sodium and potassium (146.17 ± 1.881 , 6.82 ± 0.673) were higher at 40 days of age in comparison of 60 and 90 days of age. Serum urea nitrogen (mg/100m) was highest at 60 days of age in comparison of 40 and 90 days of age.

Singh *et al.* (1979) reported that average blood potassium concentration in the HK and LK karakul sheep was 38.01 ± 0.649 and 7.50 ± 0.428 meq/l, respectively, whereas Na concentration was 122.64 ± 0.886 and 135.39 ± 1.739 meq/lit., respectively. They

also observed that females had higher values of sodium and potassium than male.

Sykes and Russel (1979) reported seasonal variation in plasma protein in sheep. They observed low concentration of albumin during the summer which was associated with hyperglobulinaemia.

More *et al.* (1980) studied effect of exposure to temperature of 42.5°C for 5 Hrs. in sheep and goat and observed that plasma inorganic phosphorus value was significantly increased in goats but not in sheep.

✓ Shaffer *et al.* (1981) reported that glucose concentration in blood decreased with influence of hot summer months due to increase in respiration rate where caused a rapid utilisation of blood glucose by the respiratory muscles. They further observed a slight increase in total protein from 6.48 (winter) to 6.83 (summer). A:G ratio was lower during intermediate temperature than cool and hot temperature. No significant changes in Ca and phosphorus concentration were noted due to temperature in cattle.

✓ Chahal and Rattan (1982) reported the average blood glucose level during different seasons as 69.96, 73.55, 81.10 and 76.86 mg/ 100 ml during winter, spring, summer and rains respectively in the rams of the corriedale breed of sheep.

Pyne *et al.* (1982) observed the values of serum protein, calcium, inorganic phosphorus and magnesium as 5.85 ± 0.16 ,

9.05±0.12, 4.53±0.18 and 2.13±0.06 mg/100 ml, respectively of goat.

Mousa *et al.* (1983) reported normal serum urea concentration(mg/dl) in sheep (11.3±1.5), goat (15.3±1.5) and camel (13.3±1.5).

Nawaz and Shah (1984) found that plasma concentration of endogenous creatinine and urea were significantly higher because of haemoconcentration during summer.

Nigam *et al.* (1990) studied the levels of serum Ca and P during oestrus cycles in Surti and marwari goats and reported the mean serum Ca values as 11.56±1.42, 10.53±0.80 mg/100 ml and mean serum P value as 8.71, 7.33 mg/100 ml in surti and marwari goats, respectively.

Rastogi and Singh (1990) estimated mean values of total plasma protein, blood glucose, total plasma Ca, P, Mg and P in Gaddi goats as 9.41±0.22, 27.43±1.47, 9.46±0.48, 6.83±0.44 (mg/dl), 161.29±3.95 (meq/l) 6.07±0.24 (meq/l), respectively.

Sharma *et al.* (1990) conducted a study on some biochemical parameters in serum of Chegu goats and reported that the Inorganic phosphorus and glucose concentration showed insignificant variation due to age and sex. Protein and creatinine values of both sexes increased significantly with age but there was no change due to sex.

Gaikwad *et al.* (1992) carried out an investigation on blood biochemical constituents in cattle and reported no effect of sex on

serum calcium and potassium concentration. The serum sodium concentration was higher in males calves than in any other groups. The levels of serum chloride was significantly higher in female calve (107.4 ± 1.33 meq/l) than male calves (100 ± 5.68 meq/l) of the same age group indicating the effect of sex.

Kataria *et al.* (1993) gave the mean values of calcium, phosphorus, chloride, proteins in serum and urea, glucose in blood of marwari goats which were 9.84 ± 0.05 mg%, 5.83 ± 0.03 mg%, 110.05 ± 0.62 meq/l, 7.07 ± 0.26 mg%, 14.99 ± 0.22 mg% and 44.51 ± 0.88 mg%, respectively and found season wise non significant variation in the mean values. It indicated better adaptability of the animals to the desert environments particularly the summer season.

Bhattacharyya *et al.* (1995) determined macro minerals in the serum of goat under different seasons and recorded the calcium, inorganic, phosphorus, magnesium (mg/100 m) sodium, potassium (meq/l) values as 10.53 ± 0.28 , 6.02 ± 0.23 , 2.72 ± 0.10 , 148.44 ± 2.33 , 5.52 ± 0.13 during summer and 10.17 ± 0.25 , 5.70 ± 0.22 , 2.51 ± 0.07 , 140.32 ± 2.88 , 5.06 ± 0.14 during winter, respectively.

✓ Dutta (1996) determined biochemical parameters in sheep of Assam and observed that protein (gm/dl) and glucose (mg/dl) concentrations were 5.72 ± 0.07 and 61.97 ± 0.02 , respectively.

✓ Sudhan *et al.* (1996) evaluated blood profile of exotic sheep in Kashmir and estimated mean blood glucose, serum calcium, serum phosphorus, magnesium (mg/dl), protein (gm/dl)

as 42.60 ± 1.83 , 10.24 ± 0.25 , 5.70 ± 0.24 , 2.88 ± 0.11 , 7.63 ± 0.23 in Corriedale and 65.60 ± 1.91 , 9.62 ± 0.63 , 5.9 ± 0.36 , 2.86 ± 0.11 , 9.68 ± 0.56 in polled desert breed, respectively.

Das *et al.* (1997) reported that the mean values of total serum protein, albumin, globulin, A/G ratio of crossbreed cattle differed among physiological stages and agro-climatic zones.

Kumar *et al.* (1997) studied variation in plasma biochemical constituents due to age and sex in Gaddi goats.

Latif *et al.* (1997) reported the total protein, albumin globulin (gm/100 ml) and A/G ratio as 7.36 ± 0.8 , 3.59 ± 0.23 , 3.78 ± 0.23 , 0.95 ± 0.06 , respectively during winter and 7.29 ± 0.24 , 4.26 ± 0.13 , 3.03 ± 0.34 , 1.41 ± 0.12 , respectively during summer in sheep. They also noted creatinine (mg/l) and urea N (mg/100 ml) concentrations as 7.26 ± 0.12 , 57.76 ± 18.6 , respectively during winter and 10.33 ± 0.12 and 59.25 ± 1.51 , respectively during summer in sheep.

Kalita and Mahapatra (1999) determined mineral profile of Black bengal kids and reported that calcium, sodium and potassium concentration were not significantly altered between the 3 months to 6.5 months of age.

Kalleswarappa and Jayaprakash (1999) studied blood biochemical constituents of sheep. The mean value of serum calcium (mg%), serum inorganic phosphorus (mg%), serum magnesium (mg%), serum sodium (meq/l) and serum potassium

(meq/l) were 11.47 ± 1.23 , 5.59 ± 0.59 , 2.95 ± 0.38 , 175.32 ± 13.72 , 5.19 ± 0.65 , respectively.

Ram Prabhu and Dhanapalan (1999) reported the comparative blood profile of sheep. They determined glucose (mg%), Total proteins (g%), albumin (g%), calcium (mg%), phosphorus (mg%), sodium (mmol/l) and potassium (mmol/l) during different seasons.

Takarkhede *et al.* (1999) estimated biochemical profile during different phases of reproduction in ewes in comparison to rams and reported significant changes in the values. The mean values of glucose, total protein, calcium and phosphorus were 49.702 ± 1.42 (mg/dl), 6.08 ± 0.16 (g/dl), 10.90 ± 0.23 (mg/dl), 6.35 ± 0.23 (mg/dl), respectively in rams and 48.83 ± 1.63 , 6.74 ± 0.21 , 11.56 ± 0.24 , 6.03 ± 0.23 , respectively in pregnant ewes.

Kumar and Pachauri (2001) reported that physiological status as well as season influenced the creatinine levels in crossbred dairy cattle at medium elevation in central Himalayas.

Kataria *et al* (2002a) found higher values of serum sodium, chloride, Na/ K ratio, phosphorus, calcium, total protein, urea and creatinine during hot condition in comparison to cold condition while that of potassium and glucose were higher during cold than hot in camels.

*Materials
And
Methods*

MATERIALS AND METHODS

Experimental animals :

155 apparently healthy marwari sheep of both sex ageing 0 to 3 years (Fig.1) belonging to farmers' stock were used in the present investigation. The animals were kept in well ventilated area. Animals were fed with sole roughage diet of dry *pala* (*Ziziphus nummularia*) leaves and watered *ad libitum*.

Category wise breakup of the animals to study the effects of changes in environmental temperatures on renal functions during moderate and extreme environmental temperatures in goats were as follows :

Main effects	Renal functions	Haematological Parameters and plasma osmolarity	Serum metabolites & electrolytes
1. Environmental Conditions			
Overall	90	155	155
(a) Moderate	30	40	40
(b) Cold	30	75	75
(c) Hot	30	40	40
2. Sex			
(a) Male	90	100	81
(b) Female	-	55	74
3.Age groups			
(a) Below 1 year	45	91	79
(b) 1 to 3 years	45	64	76

2. Experimental design :

The experiment was designed to determine the renal functions in sheep during moderate, extreme cold and extreme hot environmental temperatures. The total experiment was divided into 3 phases.

1. Phase-I (Control period)

The duration of this phase was comprised of the months (August to October) when environmental temperature remained moderate. This also served as control phase.

2. Phase-II (Extreme cold temperature)

This phase comprised of the months (December to January) when the ambient temperature was extremely low. The results of this phase were compared with that of control phase (moderate).

3. Phase-III (Extreme hot temperature)

This phase was comprised of the months (mid of April to May) when the environmental temperature was extremely high. The results were compared with that of control phase.

The following parameters were determined to achieve the objectives of present study in all the phases.

1. RENAL FUNCTION TESTS.

- (i) Endogenous creatinine clearance(C_{cr})
- (ii) Urea clearance (C_{urea})
- (iii) Electrolyte clearance(C_e)
 - (a) Sodium (C_{Na})



Fig. 1 : EXPERIMENTAL ANIMALS

- (b) Potassium (C_K)
- (c) Chloride (C_{Cl})
- (d) Phosphorus (C_P)
- (e) Magnesium (C_{Mg})
- (iv) Transfer function of kidney (TFK), water intake and urine volume.
- (v) Urine concentration (Colour, pH and specific gravity)
- (vi) Filtered and excreted loads of serum constituents (FL and EL)
 - (a) Creatinine (FL_{cr} and EL_{cr})
 - (b) Urea (FL_{urea} and EL_{urea})
 - (c) Sodium (FL_{Na} and EL_{Na})
 - (d) Potassium (FL_K and EL_K)
 - (f) Chloride (FL_{Cl} and EL_{Cl})
 - (g) Phosphorus (FL_P and EL_P)
 - (h) Magnesium (FL_{Mg} and EL_{Mg})

2. HAEMATOLOGICAL PARAMETERS AND PLASMA OSMOLARITY (Posm).

Haematological parameters included:

- (i) Haemoglobin (Hb)
- (ii) Packed cell volume (PCV)
- (iii) Erythrocyte sedimentation rate (ESR)
- (iv) Specific gravity(Sp.Gr.)
- (v) Relative viscosity
- (vi) Mean corpuscular haemoglobin concentration (MCHC)
- (vii) Plasma osmolarity(Posm)

3. SERUM METABOLITES AND ELECTROLYTES

- (i) Total proteins, albumin and globulins
- (ii) Glucose
- (iii) Creatinine
- (iv) Urea
- (v) Sodium, potassium and chloride
- (vi) Phosphorus and magnesium

4. STATISTICAL ANALYSIS.

1. Renal function tests :

Renal function tests were carried out in 90 male sheep of below 1 year and 1 to 3 years age groups during moderate, cold and hot environmental temperatures. For the collection of urine samples during the experiment, the specially designed urine bags (Fig. 2) were used so that possible least amount of the urine could be collected.

(a) Endogenous creatinine clearance (C_{cr}) :

It is observed that creatinine is freely filtered through the glomeruli and is handled by the kidney in a manner similar to its handling of inulin in most of the mammalian species. The C_{cr} provides an estimate of GFR. It is easy to determine endogenous creatinine clearance in clinical cases than exogenous creatinine clearance. Moreover, levels of creatinine in the blood remain relatively constant over short intervals of time.



SHEEP WITH FILLED URINE BAG



SHEEP WITH EMPTIED URINE BAGS

Fig. 2 : SHEEP WITH URINE BAGS

Endogenous creatinine clearance was determined as per the method described by Coles (1986). 24 hour C_{cr} values were obtained.

Technique :

The volume of urine produced over 24 hrs. was recorded and the creatinine concentration was measured. Specially designed urine bags were used to collect the urine samples. The bags were emptied after every 8 hrs. into a separate flask and in this manner 24 hour urine samples were collected. At the end of 24 hour simultaneous blood samples were taken to determine serum creatinine values. For every C_{cr} measurement the same procedure was repeated. For each clearance determination, 3 observations were taken on consecutive days. The creatinine concentrations in serum and urine were determined by Alkaline picrate method as described by Varley (1988).

Calculation :

$$C_{cr} \text{ ml/min} = \frac{U_{cr} V_u}{S_{cr}}$$

U_{cr} = concentration of creatinine in urine (mg/dl)

V_u = Rate of urine formation (ml/min)

S_{cr} = Concentration of creatinine in serum (mg/dl)

(b) Urea Clearance (C_{urea}) :

In mammals urea is formed from ammonia in the liver. Urea is a small, nonionic substance. Therefore glomerular membranes offer no barrier to it and it readily diffuses into the

capsular fluid. Urea is reabsorbed by the tubules and the fate of urea in the more distal nephrons segments depends on the rate of urine flow. When a filtered substance is reabsorbed by the tubules its clearance is less than the inulin clearance. Therefore, the urea clearance represents between 70 and 75 per cent of GFR.

Urea clearance was determined as per the formula given by Swenson and Reece (1996). The serum and urine urea concentrations were determined by diacetylene monoxime method (Varley, 1988). The urine and blood samples were collected in the same manner as described in endogenous creatinine clearance.

Calculation :

Urea clearance was determined using following formula :

$$C_{\text{urea}}, \text{ ml/min} = \frac{U_{\text{urea}} \times V_u}{S_{\text{urea}}}$$

S_{urea} and U_{urea} = Serum and urine urea concentrations (mg/dl), respectively.

V_u = Rate of urine formation, ml/min

(c) Electrolyte clearance (C_E) :

Electrolyte clearances were determined by the methods described by Rawlings and Bisgard (1975) and Yagil and Berlyne (1976a). Simultaneous urine and blood samples were collected as described in endogenous creatinine clearance.

(i) Sodium and potassium clearances (C_{Na} and C_K):

Sodium is the main extracellular fluid cation and potassium is major cation of intracellular fluid. The most important route for their excretion is the kidney. The aldosterone hormone facilitates excretion of potassium and reabsorption of sodium. Most potassium is excreted through glomerular filtration and tubular secretion. During abnormalities in their metabolism renal compensatory mechanisms operate. Therefore, these indices are of value in early identification of renal irregularities with GFR.

Determination of sodium and potassium in serum and urine was carried out by the method of Oser (1976) using flame photometer (Systronics). Serum was diluted 100 times for the determination of both sodium and potassium. The dilution of urine was 1:100 for sodium and 1:1000 for potassium determination. Double glass distilled water was used for the dilution.

(ii) Chloride clearance (C_{Cl}) :

It is one of the primary anions in extracellular fluid. A close relationship exists between chloride and sodium ions. It is involved in the regulation of extracellular osmotic pressure and is important in acid-base balance.

Serum chloride was determined by the method of Schales and Schales and urine chloride by the method of Van Slyke as described by Varley (1988).

(iii) Phosphorus clearance (C_P):

Phosphorus is present in every cell of the body and plays an important part in metabolic processes. The amount of phosphorus excreted in the urine naturally depends mainly on the amount of phosphorus in the diet. Phosphorus in the urine is almost entirely inorganic phosphorus. Determination of phosphorus clearance is important in certain endocrinological disorders like hyperparathyroidism or hypoparathyroidism.

Determination of phosphorus in serum and urine was carried out by the method of Fiske and SubbaRow as described by Varley (1988).

(v) Magnesium clearance (C_{Mg}):

Magnesium is an active component of several enzyme systems. It is an essential activator for the phosphate-transferring enzymes. Renal clearance of magnesium and its components are determined to assess the renal efficiency. Variation in serum magnesium levels and renal clearance occur in both acute and chronic renal diseases.

Determination of magnesium in serum and urine was done by the titan yellow method as described by Varley (1988).

Calculation for electrolyte clearances :

$$C_E \text{ ml/min} = \frac{U_E \times V_u}{S_E}$$

U_E and S_E = Urine and serum electrolyte concentrations, respectively.

V_u = Rate of urine formation (ml/min)

U_E and S_E are in mmol/l for sodium, potassium and chloride and in mg / dl. for phosphorus and magnesium.

(d) Transfer function of kidney :

TFK was determined as described by Purohit (1972) and Kataria (2000).

(e) Urine concentration test :

Urine concentration test was carried out as described by Coles (1986). Colour of the urine was observed visually. The specific gravity was determined by using urinometer. pH of the urine was determined by using a pH meter (Systronics).

(f) Filtered and excreted loads :

Plasma and filtered loads of any substance are the kidney solute loads. The amount of any substance contained in plasma that is presented to the kidneys each minute is known as the plasma load for that substance. The filtered load of a plasma substance is the part of the plasma load that filters into Bowman's capsule. It is the amount presented to the tubules regardless of whether or not it is reabsorbed. The role of the tubules in body homeostasis can be evaluated by the determination of fractional excretion. It is the fraction of filtered substance that is excreted in the urine. The fractional excretion of a substance can be calculated from the values for its filtered load and its urinary excretion.

Filtered and excreted loads were determined for creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium as

per the method described by Kataria (2000). GFR was determined by measuring endogenous creatinine clearance as described by Coles(1986). Serum and urine electrolytes were determined as described by Oser (1976) and Varley (1988).

Calculation :

1. For sodium, potassium and chloride.

$$(i) \quad \text{Filtered load (mmol /min)} = \frac{\text{GFR} \times S_E}{1000}$$

GFR = Glomerular filtration rate

S_E = Serum electrolytes mmol/l

$$(ii) \quad \text{Excreted loads (mmol/min)} = \frac{V_u \times U_E}{1000}$$

V_u = Rate of urine formation, ml/min

(V_u = Total urine output in 24 hours in ml / 1440)

U_E = Concentration of electrolyte in urine mmol/l

(iii) Reabsorbed electrolytes (R_E), mmol/min

$$R_E = F_L - E_L$$

F_L = Filtered load (mmol/min)

E_L = Excreted load (mmol/min)

(iv) OTR (%) = Overall tubular reabsorption

$$= \frac{R_E}{F_L} \times 100$$

(iv) Fractional excretion (F_E), %

$$F_E = \frac{C_E}{C_{cr}} \times 100$$

2. For urea, creatinine, magnesium and phosphorus :

(i) Filtered load (mg /min) $= \frac{\text{GFR} \times S_s}{100}$

S_s = Serum concentration of substance , mg/dl

(ii) Excreted loads (mg/min) $= \frac{V_u \times U_s}{100}$

U_s = Concentration of substance in urine mg/dl

(iii) Reabsorbed substance , R_s (mg/min)

$$R_s = F_L - E_L$$

(iv) OTR (%) = Overall tubular reabsorption

$$= \frac{R_s}{F_L} \times 100$$

(v) Fractional excretion (F_E)

$$F_E = \frac{C_s}{C_{cr}} \times 100$$

C_s = Clearance of substance (ml/min)

2. Haematological parameters and plasma osmolarity :

(a) **Hb :**

Hb was determined in g/dl by Sahli's method as described by Schalm *et al.* (1975).

(b) **PCV :**

PCV (%) was determined by Wintrobe method (Schalm *et al.*, 1975).

(c) **ESR :**

ESR (mm/3hrs. and mm / 24 hrs.) was determined by Westergren's method as described by Schalm *et al.*, 1975 .

(d) Sp. Gr. :

It was determined by falling drop method using copper sulphate as described by Ranade *et al.* (1975).

(e) Relative Viscosity :

Relative Viscosity was determined by using Ostwald's viscometer as described by Oser (1976).

(f) MCHC:

It was calculated as per the formula given by Swenson (1996).

(g) Posm :

It was determined as per described by Guyton and Hall (1996).

3. Serum metabolites and electrolytes :

(a) Total Serum Proteins :

Total serum proteins were determined by Reinhold's method as described by Oser (1976).

(b) Glucose :

Glucose was determined by Folin and Wu method as described by Oser (1976).

(c) Creatinine :

Creatinine was determined by alkaline picrate method as described by Varley (1988).

(d) Urea :

Urea was determined by diacetylene monoxime method as described by Varley (1988).

(e) Sodium and potassium :

Sodium and potassium were determined by the method of Oser (1976) using a flame photometer (Systronics).

(f) Chloride :

Chloride concentration in serum was determined by the method of Schales and Schales as described by Varley (1988).

(g) Calcium :

Calcium concentration in serum was determined by the method of Clark and Collip as described by Oser (1976).

(h) Phosphorus :

Phosphorus concentration in serum was determined by the method of Fiske and SubbaRow as described by Oser (1976).

(i) Magnesium :

Magnesium concentration was determined by Titan yellow method as described by Varley (1988).

4. Statistical analysis

The main parameters of the present investigation were renal functions, haematological parameters and plasma osmolarity, serum metabolites and electrolytes. The main effects were classified as environmental temperatures, age groups and sex. The subsets of environmental temperatures were moderate, cold and hot conditions; of age groups were below 1 year and 1 to 3 years and of sex were male and female. For each subset data were expressed as mean $\pm$ SE of means.

The changes in the means were measured as the difference between the control mean i.e. moderate in environmental temperature or below 1 year mean in age groups or male mean in sex group and the respective values at a particular subset whether each mean change was significantly different from control was assessed by paired 't' test (Snedecor and Cochran, 1967; Steel

and Torrie, 1980). For renal functions *viz.* endogenous creatinine clearance, urea clearance, electrolyte clearance, TFK, urine concentration test and filtered and excreted loads of serum constituents, the effects of different environmental temperatures and age were studied while for other parameters *viz.* haematological parameters and plasma osmolarity, serum metabolites and electrolytes, the other additional effect *i.e.* sex was also studied.

Mixed model least square and maximum likelihood computer programme PC-I (Copyright, 1987, Walter R. Harvey) were used to determine analyses of variance, to test the significance of the effects of environmental temperatures, age groups and sex.

*Results
And
Discussion*

RESULTS AND DISCUSSION

The investigation was carried out on 155 apparently healthy marwari sheep of both sex ageing 0 to 3 years to determine the renal functions during moderate, cold and hot environmental temperatures when the environmental temperature and relative humidity were as follows :

S. No.	Environmental Conditions	Environmental Temperatures °C		Relative Humidity %	
		Minimum	Maximum	8.30 AM	5.30 PM
1.	Moderate	21.56±	36.38±	59.30±	34.66±
	Mean±SEM	0.44	0.28	1.61	1.48
2.	Cold	7.38±	25.22±	65.54±	31.85±
	Mean±SEM	0.37	0.38	2.24	0.92
3.	Hot	25.22±	41.66±	32.25±	16.32±
	Mean±SEM	0.45	0.42	1.90	1.0

The results are presented in following order :

1. RENAL FUNCTION TESTS

- (i) Endogenous creatinine clearance
- (ii) Urea clearance
- (iii) Electrolyte clearance
- (iv) Transfer function of kidney
- (v) Urine concentration
- (vi) Filtered and excreted loads of serum constituents

2. HAEMATOLOGICAL PARAMETERS AND PLASMA OSMOLARITY

3. SERUM METABOLITES AND ELECTROLYTES

1. RENAL FUNCTION TESTS

(i) Endogenous creatinine clearance (Ccr)

Mean $\pm$ SEM values of creatinine clearance during different environmental temperatures and age groups are presented in table 1 and analysis of variance in table 3.

The overall mean value of Ccr in present study was 28.157 ± 1.262 ml/min which was in accordance to that reported by Nawaz and Shah (1984) and Farningham (1986) in sheep; Puri (2001) in goats. However, the overall mean value was lower than that observed by Parry and Taylor (1955a), Kaufman and Bergman (1978) and Rodriguez *et al.* (1996) in sheep.

In the present study Ccr was used as a measure of GFR. Various earlier workers like Bovee and Joyce (1979) in dogs; Zatzman *et al.* (1982) in pony and horse; Bickhardt and Dunglehoff (1994) in ewes and Kataria (2000) in camels had compared the endogenous creatinine clearance with inulin clearance and observed that former was a good indicator of GFR. The overall mean value of Ccr in present study was in accordance with the values of inulin clearance as given by Farningham (1986) in sheep and Khan *et al.* (1979) in goats. This substantiated the use of Ccr as a measure of GFR in the present study in sheep. This corroborated the findings of Puri (2001) in goats and Kataria (2000) in camels who also advocated the Ccr as a good index of GFR.

The mean values of Ccr during cold and hot environmental temperatures were compared with the control mean value during

Table 1 : Mean±SEM values of renal clearance of creatinine in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _{Cr} (mg/dl)	S _{Cr} (mg/dl)	C _{Cr} (ml/min.)
1.	Overall (90)	0.572±0.014	55.178±4.402	1.115±0.015	28.157±1.262
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	54.520±3.001	1.106±0.017	29.286±2.439
	Cold (30)	0.674 ^b ±0.028	49.689 ^a ±2.935	1.080 ^a ±0.019	31.522 ^a ±2.604
	Hot (30)	0.449 ^b ±0.017	61.356 ^b ±3.010	1.150 ^b ±0.030	23.665 ^b ±1.268
3.	Age groups				
	Below 1 year (45)	0.459±0.014	53.154±2.999	1.107±0.020	21.899±1.152
	1 to 3 years (45)	0.684 ^b ±0.022	57.149 ^a ±3.021	1.120 ^a ±0.023	34.415 ^b ±1.921

Contd. ...

Table-1 Contd...

4.	Environmental temperatures and age groups					
	Moderate					
	Below 1 year (15)	0.461±0.017	53.291±4.111	1.108±0.035		22.566±2.622
	1 to 3 years (15)	0.733 ^b ±0.026	55.753 ^a ±4.671	1.133 ^b ±0.043		36.006 ^b ±3.365
	Cold					
	Below 1 year (15)	0.549±0.017	46.666±3.862	1.073±0.026		23.620±1.784
	1 to 3 years (15)	0.799 ^b ±0.028	52.666 ^a ±4.414	1.086 ^a ±0.029		39.424 ^b ±3.999
	Hot					
	Below 1 year (15)	0.368±0.0137	60.768±5.201	1.148±0.042		19.513±1.346
	1 to 3 years (15)	0.521 ^b ±0.014	61.344 ^a ±5.315	1.148 ^a ±0.046		27.816 ^b ±1.547

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).
(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.
(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

C_{Cr} = Creatinine clearance
U_{Cr} = Concentration of creatinine in urine
S_{Cr} = Concentration of creatinine in serum

moderate temperature. The mean value of Ccr decreased significantly ($P \leq 0.05$) during hot environmental temperature, however, during cold temperature the mean value differed nonsignificantly ($P > 0.05$) from moderate mean value. Rate of urine formation also showed the similar pattern. In comparison to control mean values during moderate temperature, the mean values of serum and urine creatinine were found higher during hot environment.

Low GFR (Ccr), low urine flow rate with higher serum and urine creatinine concentrations were indicative of water conservation during hot environmental temperatures. Nawaz and Shah (1984) in sheep and Akhtar *et al.* (1997) in goats also found a decline in GFR during summer season. Decreased GFR (Ccr) in present study during hot environmental temperature suggested that marwari sheep being a desert adapted animal reduced the GFR as one of the principal adaptational strategies to meet the threat of body desiccation particularly during periods of water insufficiency (Khan *et al.*, 1979). Reduction in GFR during hot environment was also correlated with significantly increased blood viscosity (table 26) which was a good indicator of water conservation (Kataria, 2000). Nawaz *et al.* (1988) suggested that GFR was lower in subtropical environments in indigenous goats, cows, sheep and buffaloes. Significant rise in serum creatinine in present investigation was indication of haemoconcentration (Kataria, 2000). Increased concentration of urine creatinine was obtained due to decrease in urine formation. Nawaz and Shah

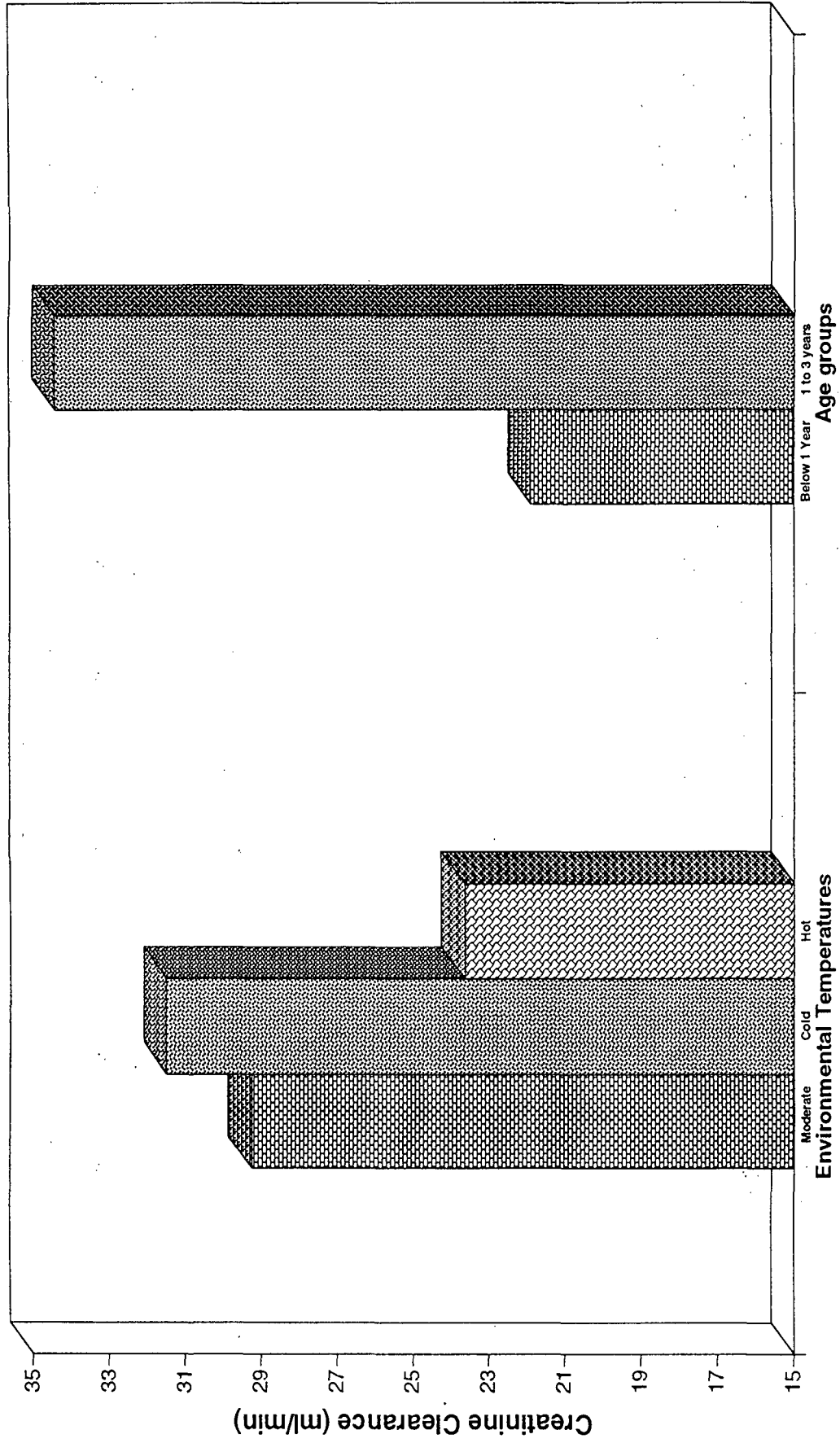
(1984) observed that higher plasma concentration of creatinine during summer resulted in lower GFR in sheep than in winter.

During cold environment the Ccr was nonsignificantly ($P>0.05$) higher than the control mean value during moderate environment. This was followed by significantly ($P\leq 0.05$) higher rate of urine formation during cold temperature than moderate. Similar observations were recorded by Kataria (2000) in camels during winter season. Serum and urine creatinine concentrations during cold were found non significantly ($P>0.05$) lower from the respective control mean values during moderate environment. The possible reason of lower urine creatinine concentration was increased rate of urine formation (Kataria, 2000).

The results of Ccr in present investigation indicated that it could be used effectively as a measure of GFR in sheep in varying conditions of environments.

Results of present investigation reflected the effect of age on the Ccr and rate of urine flow. The mean values were significantly ($P\leq 0.05$) higher during the 1 to 3 years age group. When the animals were classified according to age groups in different environments, it was found that similar trend was maintained. In all the environmental temperatures, the mean values of Ccr and Vu were found higher in 1 to 3 years age group. Analysis of variance also reflected a significant ($P<0.05$) effect of environmental temperatures and age on the creatinine clearance.

Fig. 3 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF CREATININE IN SHEEP DURING DIFFERENT ENVIRONMENTAL TEMPERATURES AND AGE GROUPS



(ii) Urea Clearance (C_{urea}) :

Mean $\pm$ SEM values of urea clearance during different environmental temperatures and age groups are presented in table 2 and analysis of variance in table 3.

In the present study the overall mean value of C_{urea} was 11.387 ± 0.496 ml/min. which was in agreement to that reported by Nawaz and Shah (1984) in sheep and lower than that observed by Rodriguez *et al.* (1996) in ewes and Kachhwaha (2001) in goats. It was observed that differences in C_{urea} were due to difference in urine flow rate (V_u), serum (S_{urea}) and urine concentrations (U_{urea}) of urea. The overall mean values of urine flow rate and urine urea concentration in present study were found similar to that reported by Kachhwaha (2001) in goats, however, serum urea concentration of present investigation was higher than these reports. The overall mean value of C_{urea} was lower than C_{cr} . Guyton and Hall (1996) stated that one half of the filtered urea is passively reabsorbed from the renal tubules therefore its clearance is lower than GFR.

The mean values of C_{urea} during cold and hot environmental temperatures were compared with the control mean value during moderate period. The mean value of C_{urea} decreased significantly ($P\leq0.05$) during hot and increased significantly ($P\leq0.05$) during cold period. Nawaz and Shah (1984) in sheep, Akhtar *et al.* (1997) in goats and Kataria (2000) in camels also found that urea clearance was decreased during summer and increased during winter.

It was probably due to water conservation process taken by the animals as an adaptive measure during hot period. Reece (1996) opined that during water deprivation urea is excreted at a slower rate. In the present study urine flow rate was decreased significantly ($P \leq 0.05$) during hot period and increased significantly ($P \leq 0.05$) during cold period. As per Smith (1951) urea clearance was influenced by the rate of urine production. In present study urine urea concentration was also found decreased, although nonsignificantly ($P > 0.05$). But this certainly indicated towards decrease in total excretion of urea in urine. On the other hand, urine urea concentration increased, although again nonsignificantly ($P > 0.05$) but in terms of increase in urine output, the total urea excretion rate was increased. This was in accordance with the Akhtar *et al.* (1997) in goat and Kataria (2000) in camels, who also observed a positive correlation between the rate of urine flow and urea clearance. Schwartz (1967) opined that serum and urine urea concentration can be used as an index of water reabsorption from urine, however, in the present study a nonsignificant ($P > 0.05$) difference was observed between the mean values of serum urea (S_{urea}) during moderate and hot periods. However, S_{urea} value decreased significantly ($P \leq 0.05$) during cold period.

The data of urea clearance and its components were also compared as per age. The mean values of C_{urea} and V_u were found significantly ($P \leq 0.05$) higher in the higher age group i.e. 1 to 3 years. This was due to the effect of age on GFR which was also found increased in higher age group. Probably the younger

Table 2 : Mean±SEM values of renal clearance of urea in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _{urea} (mg/dl)	S _{urea} (mg/dl)	C _{urea} (ml/min.)
1.	Overall (90)	0.572±0.014	767.333±17.887	41.577±0.926	11.387±0.496
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	762.666±37.956	45.366±1.461	10.245±0.798
	Cold (30)	0.674 ^b ±0.028	805.333 ^a ±25.114	36.266 ^b ±1.432	15.882 ^b ±1.139
	Hot (30)	0.449 ^b ±0.017	734.000 ^a ±26.989	43.100 ^a ±1.881	8.188 ^b ±0.735
3.	Age groups				
	Below 1 year (45)	0.459±0.014	760.444±24.482	41.488±1.206	8.888±0.582
	1 to 3 years (45)	0.684 ^b ±0.022	774.222 ^a ±25.840	41.666 ^a ±1.618	13.989 ^b ±0.966

Contd...

Table 2 Contd...

4.	Environmental temperatures and age groups					
	Moderate					
	Below 1 year (15)	0.461±0.017	753.333±51.811	45.066±1.544		7.690±0.623
	1 to 3 years (15)	0.733 ^b ±0.026	772.000 ^a ±57.198	45.666 ^a ±2.540		12.800 ^b ±1.149
	Cold					
	Below 1 year (15)	0.549±0.017	785.333±34.000	38.266±2.279		11.806±0.996
	1 to 3 years (15)	0.799 ^b ±0.028	825.333 ^a ±37.414	34.266 ^a ±1.654		19.958 ^b ±1.420
	Hot					
	Below 1 year (15)	0.368±0.0137	742.666±41.718	41.133±2.117		7.168±0.948
	1 to 3 years (15)	0.521 ^b ±0.014	725.333 ^a ±35.588	45.066 ^a ±3.102		9.208 ^b ±1.092

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).
(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

S_{urea} = Concentration of urea in serum

U_{urea} = Concentration of urea in urine
C_{urea} = Urea clearance

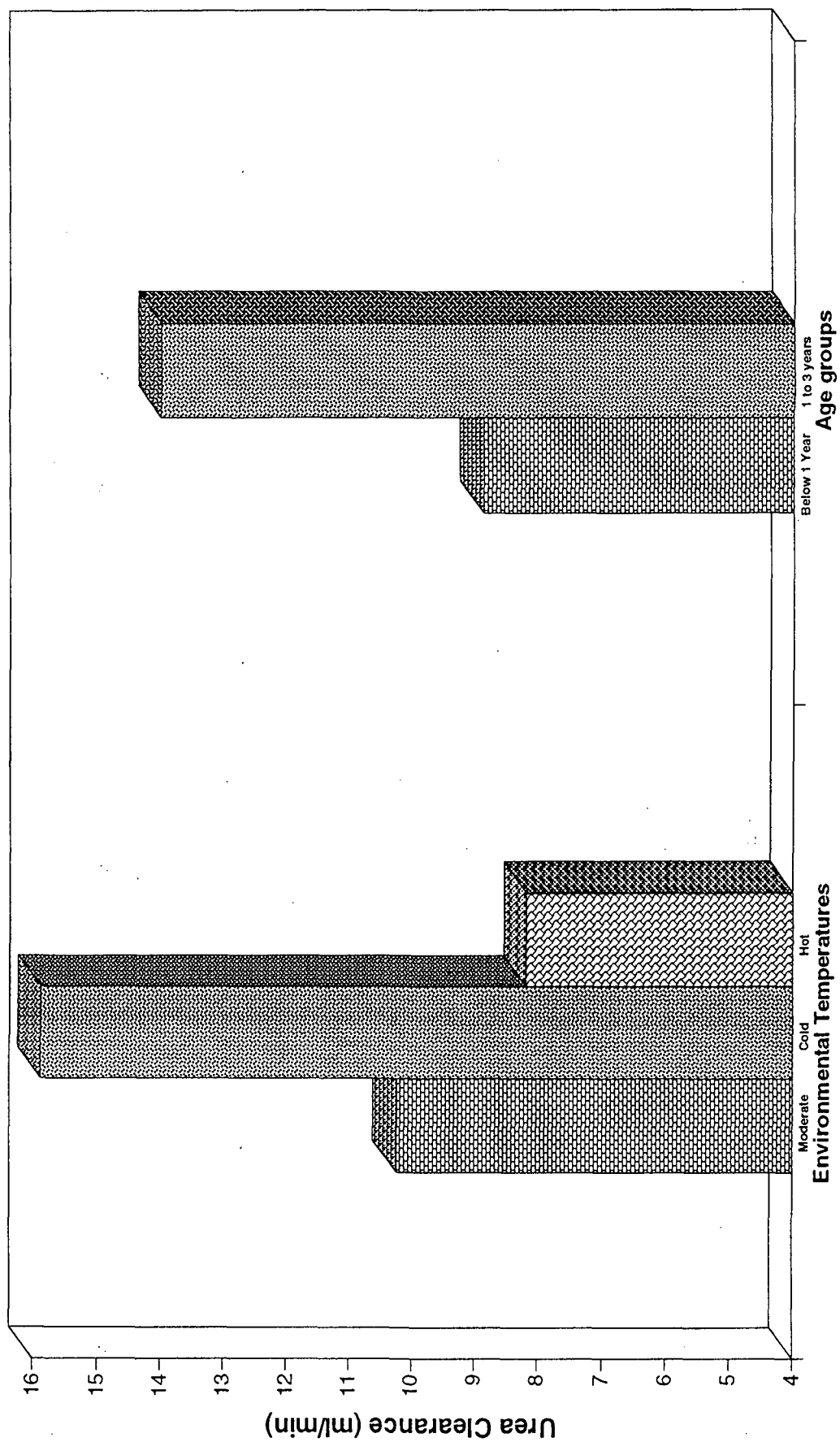
Table 3 : ANOVA of urea and creatinine clearances in sheep during different environmental temperatures and age groups.

			Urea	Creatinine
SOURCE OF VARIATIONS	Between environmental temperatures	DF	2	2
		MSS	474.887**	491.650*
	Within environmental temperatures	DF	87	87
		MSS	22.149	143.450
	Between age groups	DF	1	1
		MSS	563.150**	3524.630**
	Within age groups	DF	88	88
		MSS	26.291	112.941
	Between environmental temperatures and age groups	DF	2	2
		MSS	59.479*	110.296*
	Within environmental temperatures and age groups	DF	84	84
		MSS	14.820	103.988

** = Highly significant ($P \leq 0.01$)

* = Significant ($P \leq 0.05$)

Fig. 4 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF UREA IN SHEEP DURING DIFFERENT ENVIRONMENTAL TEMPERATURES AND AGE GROUPS



animals were able to consume more water due to high metabolic activity. Similar pattern was observed when animals were classified according to age during different periods. However, in all cases the mean values of U_{urea} and S_{urea} differed nonsignificantly ($P>0.05$).

A highly significant ($P\leq 0.01$) effect of environment and age groups was observed on the urea clearance as exhibited by analysis of variance.

(iii) Electrolyte Clearance (C_E) :

The mean $\pm$ SEM values of sodium (C_{Na}), potassium (C_K), Chloride (C_{Cl}), phosphorus (C_P) and magnesium (C_{Mg}) during different environmental temperatures and age groups are presented in tables 4, 5, 6, 8 and 9, respectively. Analysis of variance for sodium, potassium and chloride clearance is presented in table 7 and for phosphorus and magnesium in table 10.

The overall mean values of clearances of sodium, potassium, chloride, phosphorus and magnesium in ml/min. were 0.668 ± 0.027 , 14.29 ± 0.849 , 1.112 ± 0.021 , 13.022 ± 0.488 and 1.852 ± 0.051 , respectively. The results showed that mean values of C_K and C_P were higher than other electrolyte clearances. This was probably due to higher fractional excretion of potassium and phosphorus in the present study, the values were 50.180 ± 3.293 and 49.454 ± 2.871 per cent, respectively.

The overall mean values of C_{Na} , C_K and C_{Cl} were higher than that reported by Akhtar *et al.* (1997) in goats. The mean

values of C_{Na} and C_{Cl} were in partial agreement and of C_K was found higher than the respective values recorded by Kachhwaha (2001) in goats. In the present study higher concentrations of urine sodium, potassium and chloride (U_{Na} , U_K and U_{Cl}) were recorded than in the above mentioned reports.

In the present study the overall mean value of C_{Na} was similar to that observed by Rawlings and Bisgard (1975) in pony, while that of C_K was found higher than that reported by Rawlings and Bisgard (1975) in pony and Kohn and Strasser (1986) in mare.

The results of present study indicated that the mean values of all the electrolyte clearances decreased significantly ($P \leq 0.05$) during hot environment. This was in line with decreased GFR during this period when compared to control mean value during moderate period. Akhtar *et al.* (1997) in goats also observed a decrease in sodium, potassium and chloride clearances. The decline in electrolyte clearances during hot environment could be attributed to stress where GFR also decreased. Kataria (2000) suggested an increase in ADH and aldosterone levels during hot environment. In present study a significant ($P \leq 0.05$) rise was observed in the mean value of S_{Na} while the U_{Na} concentration showed a nonsignificant ($P > 0.05$) decrease during hot environmental temperature when compared with moderate period.

Urine concentrations of all the electrolytes during hot period differed nonsignificantly ($P > 0.05$) from the respective control mean values. This suggested a decline in total excretion

Table 4 : Mean±SEM values of renal clearance of sodium in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _{Na} (mmol/l)	S _{Na} (mmol/l)	C _{Na} (ml/min)
1.	Overall (90)	0.572±0.014	164.000±2.592	144.877±1.120	0.668±0.027
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	161.500±5.267	139.866±1.977	0.708±0.056
	Cold (30)	0.674 ^b ±0.028	173.0 ^b ±5.252	147.466 ^b ±1.699	0.806 ^b ±0.049
	Hot (30)	0.449 ^b ±0.017	157.0 ^a ±4.922	147.300 ^b ±2.223	0.490 ^b ±0.032
3.	Age groups				
	Below 1 year (45)	0.459±0.014	149.711±3.053	145.355±1.715	0.470±0.019
	1 to 3 years (45)	0.684 ^b ±0.022	178.288 ^b ±4.280	144.400 ^a ±1.666	0.866 ^b ±0.039

Contd...

Table 4 Contd...

4.	Environmental temperatures and age groups			
	Moderate			
	Below 1 year (15)	0.461±0.017	147.000±5.273	137.1332±2.343
	1 to 3 years (15)	0.733 ^b ±0.026	176.00 ^b ±7.558	142.600 ^b ±3.105
	Cold			
	Below 1 year (15)	0.549±0.017	159.666±3.233	147.533±2.128
	1 to 3 years (15)	0.799 ^b ±0.028	186.333 ^b ±8.856	147.400 ^a ±2.725
	Hot			
	Below 1 year (15)	0.368±0.0137	142.466±6.186	151.400±3.155
	1 to 3 years (15)	0.521 ^b ±0.014	172.533 ^b ±5.459	143.200 ^b ±2.850

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

C_{Na} = Sodium clearance

U_{Na} = Concentration of sodium in urine

S_{Na} = Concentration of sodium in serum

Table 5 : Mean±SEM values of renal clearance of potassium in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _K (mmol/l)	S _K (mmol/l)	C _K (ml/min)
1.	Overall (90)	0.572±0.014	123.833±3.720	5.437±0.131	14.290±0.849
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	120.533±9.432	5.576±0.231	13.560±1.510
	Cold (30)	0.674 ^b ±0.028	132.533 ^a ±8.107	5.313 ^a ±0.215	19.273 ^b ±2.146
	Hot (30)	0.449 ^b ±0.017	118.433 ^a ±8.885	5.423 ^a ±0.268	10.036 ^b ±0.715
3.	Age groups				
	Below 1 year (45)	0.459±0.014	130.822±6.804	5.631±0.187	11.167±0.902
	1 to 3 years (45)	0.684 ^b ±0.022	116.844 ^b ±7.047	5.244 ^b ±0.199	17.412 ^b ±1.695

Contd...

Table 5 Contd...

4.	Environmental temperatures and age groups					
	Moderate					
	Below 1 year (15)	0.461±0.017	128.533±12.233	5.580±0.292		11.384±1.967
	1 to 3 years (15)	0.733 ^b ±0.026	112.533 ^a ±12.456	5.573 ^a ±0.370		15.733 ^b ±2.342
	Cold					
	Below 1 year (15)	0.549±0.017	135.733±11.838	6.226±0.354		12.341±1.597
	1 to 3 years (15)	0.799 ^b ±0.028	129.333 ^a ±11.023	4.400 ^b ±0.240		26.208 ^b ±3.409
	Hot					
	Below 1 year (15)	0.368±0.0137	128.200±11.853	5.173±0.304		9.776±0.579
	1 to 3 years (15)	0.521 ^b ±0.014	108.666 ^a ±12.937	5.673 ^a ±0.354		10.297 ^a ±1.315

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

Ck = Potassium clearance

U_k

= Concentration of potassium in urine

S_k

= Concentration of potassium in serum

Table 6 : Mean±SEM values of renal clearance of chloride in sheep during different environmental temperatures and age groups.

S. No.	Classification	V _u (ml/min)	U _{Cl} (mmol/l)	S _{Cl} (mmol/l)	C _{Cl} (ml/min)
1.	Overall (90)	0.572±0.014	200.748±2.305	103.245±0.619	1.112±0.021
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	199.104±4.424	103.074±1.142	1.137±0.059
	Cold (30)	0.674 ^b ±0.028	204.412 ^a ±4.219	102.305 ^a ±1.285	1.336 ^b ±0.058
	Hot (30)	0.449 ^b ±0.017	198.729 ^a ±3.273	104.356 ^a ±0.953	0.844 ^b ±0.035
3.	Age groups				
	Below 1 year (45)	0.459±0.014	202.058±3.533	101.193±0.976	0.910±0.033
	1 to 3 years (45)	0.684 ^b ±0.022	199.439 ^a ±2.979	105.297 ^b ±0.766	1.301 ^b ±0.050

Contd.....

Table 6 Contd.....

4.	Environmental temperatures and age groups					
	Moderate					
	Below 1 year (15)	0.461±0.017	204.983±6.221	102.049±1.755		0.917±0.059
	1 to 3 years (15)	0.733 ^b ±0.026	193.224 ^a ±6.121	104.100 ^a ±1.0476		1.357 ^b ±0.065
	Cold					
	Below 1 year (15)	0.549±0.017	200.359±7.614	98.970±1.656		1.093±0.029
	1 to 3 years (15)	0.799 ^b ±0.028	208.466 ^a ±3.666	106.152 ^b ±0.822		1.578 ^b ±0.068
	Hot					
	Below 1 year (15)	0.368±0.0137	200.832±4.485	102.561±1.622		0.721±0.035
	1 to 3 years (15)	0.521 ^b ±0.014	196.626 ^a ±4.861	105.639 ^b ±1.586		0.968 ^b ±0.04

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

C_{Cl} = Chloride clearance

U_{Cl} = Concentration of chloride in urine

S_{Cl} = Concentration of chloride in serum

Table 7 : ANOVA of sodium, potassium and chloride clearances in sheep during different environmental temperatures and age groups.

SOURCE OF VARIATIONS				Sodium	Potassium	Chloride
	DF					
Between environmental temperatures	DF	2		2		2
	MSS	0.847**		651.910**		1.859**
Within environmental temperatures	DF	87		87		87
	MSS	0.066		64.711		0.083
Between age groups	DF	1		1		1
	MSS	3.465**		877.406**		3.461**
Within age groups	DF	88		88		88
	MSS	0.045		68.821		0.085
Between environmental temperatures and age groups	DF	2		2		2
	MSS	0.093*		354.030**		0.122 ^{NS}
Within environmental temperatures and age groups	DF	84		84		84
	MSS	0.025		48.147		0.042

** = Highly significant ($P \leq 0.01$)

* = Significant ($P \leq 0.05$)

NS = Non-significant ($P > 0.05$)

Table 8 : Mean±SEM values of renal clearance of phosphorus in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _P (mg/dl)	S _P (mg/dl)	C _P (ml/min)
1.	Overall (90)	0.572±0.014	102.198±1.493	4.856±0.128	13.022±0.488
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	104.483±2.782	4.110±0.220	16.646±1.390
	Cold (30)	0.674 ^b ±0.028	98.180 ^a ±2.855	5.747 ^b ±0.183	11.687 ^b ±0.579
	Hot (30)	0.449 ^b ±0.017	103.932 ^a ±2.788	4.712 ^b ±0.256	10.732 ^b ±0.763
3.	Age groups				
	Below 1 year (45)	0.459±0.014	108.086±2.146	4.779±0.218	11.066±0.530
	1 to 3 years (45)	0.684 ^b ±0.022	96.310 ^b ±2.142	4.934 ^a ±0.194	14.978 ^b ±1.050

Contd...

Table 8 Contd...

4.	Environmental temperatures and age groups					
	Moderate					
	Below 1 year (15)	0.461±0.017	108.228±4.106	4.419±0.292		12.021±0.908
	1 to 3 years (15)	0.733 ^b ±0.026	100.738 ^a ±3.636	3.801 ^b ±0.337		21.271 ^b ±2.030
	Cold					
	Below 1 year (15)	0.549±0.017	107.766±3.837	5.759±0.268		10.693±0.785
	1 to 3 years (15)	0.799 ^b ±0.028	88.593 ^b ±2.433	5.735 ^a ±0.261		12.682 ^b ±0.792
	Hot					
	Below 1 year (15)	0.368±0.0137	108.264±3.439	4.351±0.433		10.484±1.055
	1 to 3 years (15)	0.521 ^b ±0.014	99.600 ^b ±4.208	5.074 ^a ±0.256		10.984 ^a ±1.135

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

C_P = Phosphorus clearance

U_P = Concentration of phosphorus in urine

S_P = Concentration of phosphorus in serum

Table 9 : Mean±SEM values of renal clearance of magnesium in sheep during different environmental temperatures and age groups.

S. No.	Classification	Vu (ml/min)	U _{Mg} (mg/dl)	S _{Mg} (mg/dl)	C _{Mg} (ml/min)
1.	Overall (90)	0.572±0.014	8.168±0.203	2.487±0.033	1.852±0.051
2.	Environmental temperatures				
	Moderate (30)	0.597±0.029	8.713±0.510	2.500±0.085	1.986±0.098
	Cold (30)	0.674 ^b ±0.028	7.599 ^a ±0.314	2.383 ^a ±0.036	2.114 ^a ±0.087
	Hot (30)	0.449 ^b ±0.017	8.192 ^a ±0.436	2.580 ^a ±0.065	1.395 ^b ±0.073
3.	Age groups				
	Below 1 year (45)	0.459±0.014	9.478±0.379	2.486±0.057	1.755±0.071
	1 to 3 years (45)	0.684 ^b ±0.022	6.858 ^b ±0.170	2.489 ^a ±0.052	1.908 ^b ±0.064

Contd..

Table 9 Contd..

4.	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	0.461 $\pm$ 0.017	10.501 $\pm$ 0.740	2.332 $\pm$ 0.120	1.954 $\pm$ 0.165
	1 to 3 years (15)	0.733 ^b $\pm$ 0.026	6.925 ^b $\pm$ 0.271	2.668 ^b $\pm$ 0.107	2.018 ^a $\pm$ 0.113
	Cold				
	Below 1 year (15)	0.549 $\pm$ 0.017	8.684 $\pm$ 0.469	2.308 $\pm$ 0.049	2.105 $\pm$ 0.152
	1 to 3 years (15)	0.799 ^b $\pm$ 0.028	6.513 ^b $\pm$ 0.144	2.457 ^b $\pm$ 0.048	2.123 ^a $\pm$ 0.093
	Hot				
	Below 1 year (15)	0.368 $\pm$ 0.0137	9.248 $\pm$ 0.682	2.818 $\pm$ 0.043	1.206 $\pm$ 0.102
	1 to 3 years (15)	0.521 ^b $\pm$ 0.014	7.136 ^b $\pm$ 0.405	2.342 ^b $\pm$ 0.089	1.584 ^b $\pm$ 0.080

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P > 0.05$) and letter "b" differ significantly ($P \leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Vu = Rate of urine formation

C_{Mg} = Magnesium clearance

U_{Mg} = Concentration of magnesium in urine

S_{Mg} = Concentration of magnesium in serum

Table 10 : ANOVA of phosphorus and magnesium clearances in sheep during different environmental temperatures and age groups.

			Phosphorus	Magnesium
SOURCE OF VARIATIONS	Between environmental temperatures	DF	2	2
		MSS	302.359**	4.445**
	Within environmental temperatures	DF	84	84
		MSS	28.515	0.243
	Between age groups	DF	1	1
		MSS	344.256**	0.373 ^{NS}
	Within age groups	DF	88	88
		MSS	31.150	0.337
	Between environmental temperatures and age groups	DF	2	2
		MSS	164.484**	0.321 ^{NS}
	Within environmental temperatures and age groups	DF	84	84
		MSS	21.518	0.239

** = Highly significant ($P \leq 0.01$)

* = Significant ($P \leq 0.05$)

NS = Non-significant ($P > 0.05$)

Fig. 5 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF SODIUM IN SHEEP DURING DIFFERENT ENVIRONMENTAL TEMPERATURES AND AGE GROUPS

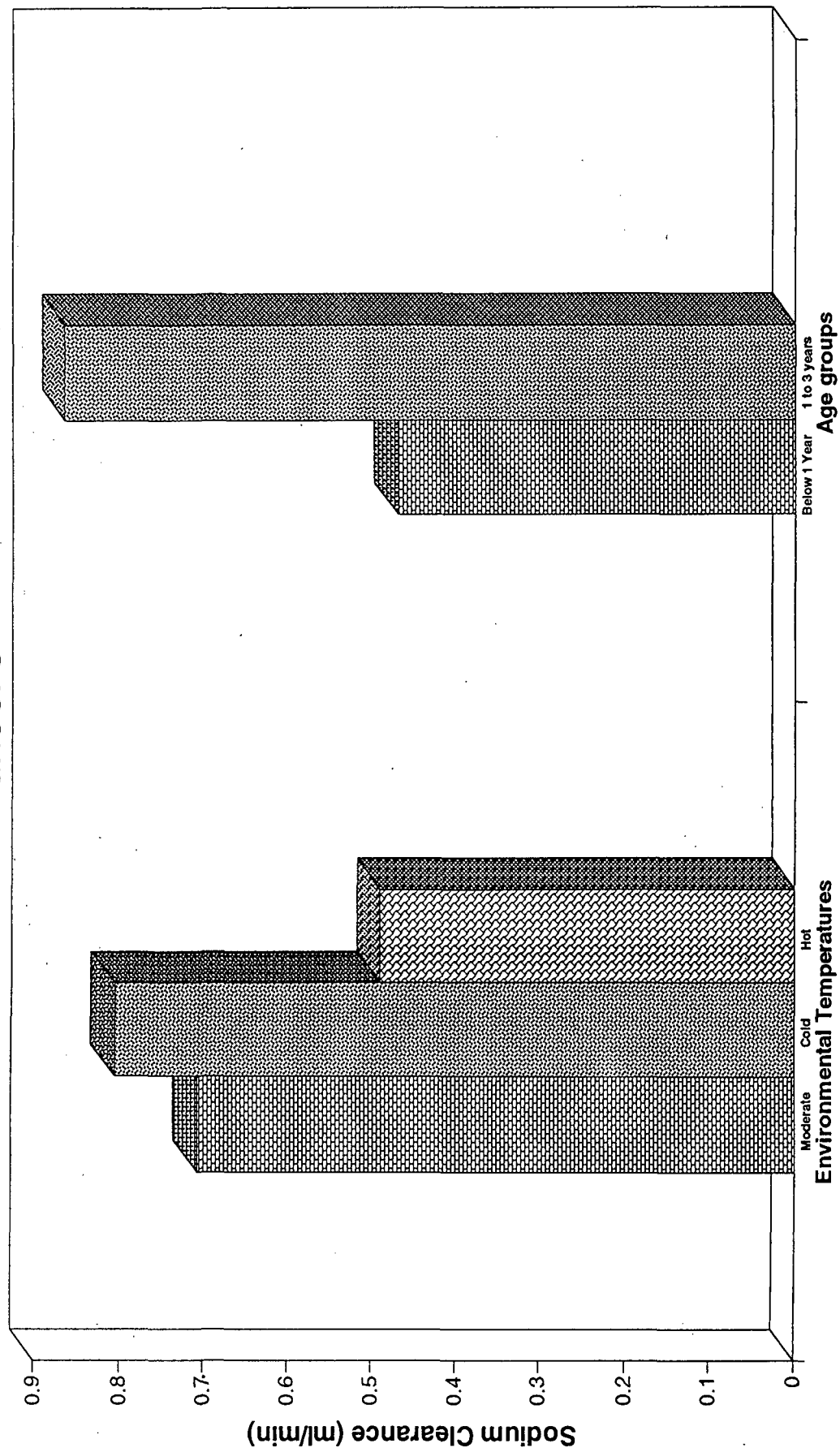


Fig. 6 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF POTASSIUM IN SHEEP DURING DIFFERENT ENVIRONMENTAL TEMPERATURES AND AGE GROUPS

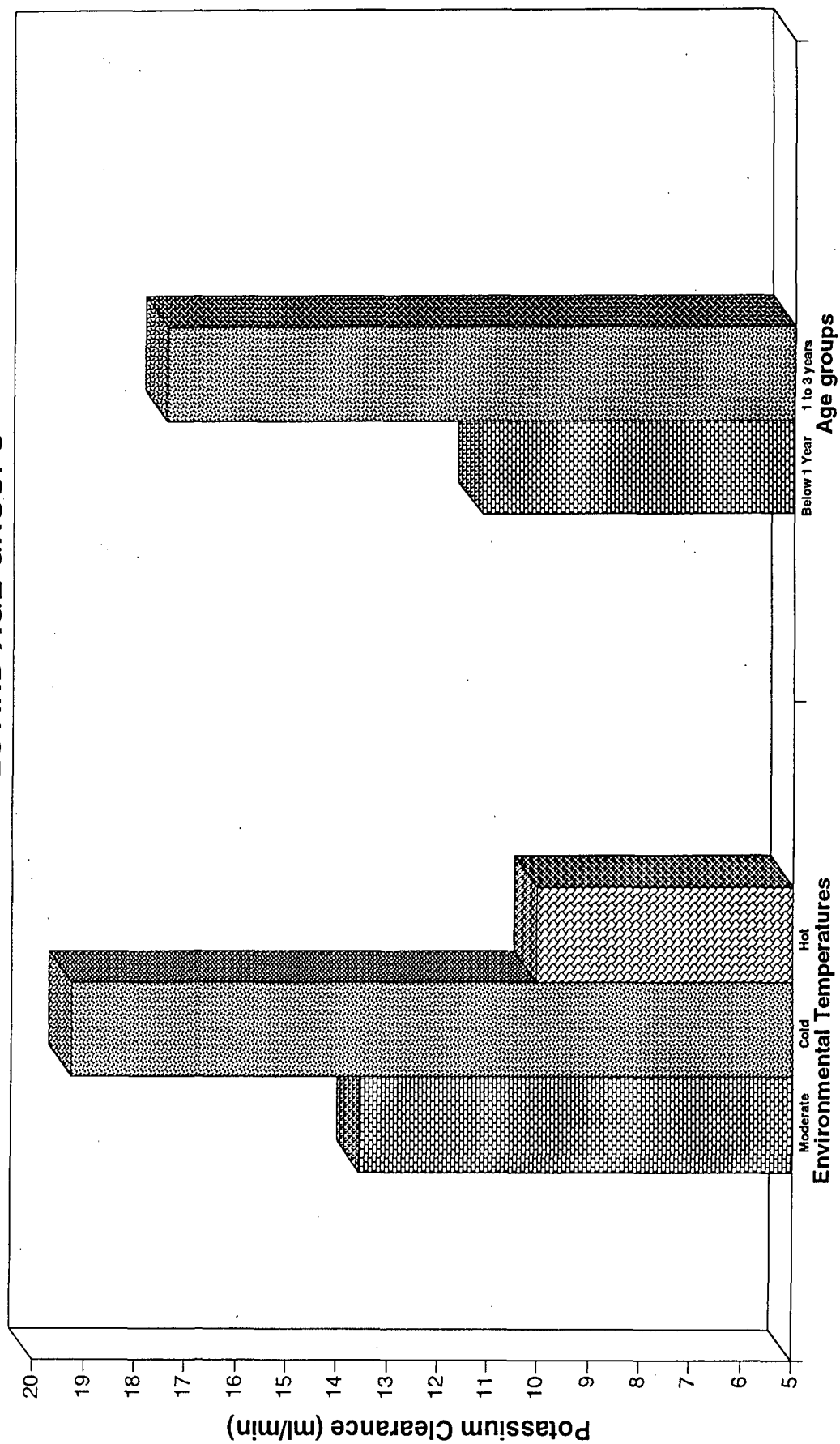


**Fig. 7 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF CHLORIDE
IN SHEEP DURING DIFFERENT ENVIRONMENTAL TEMPERATURES AND
AGE GROUPS**

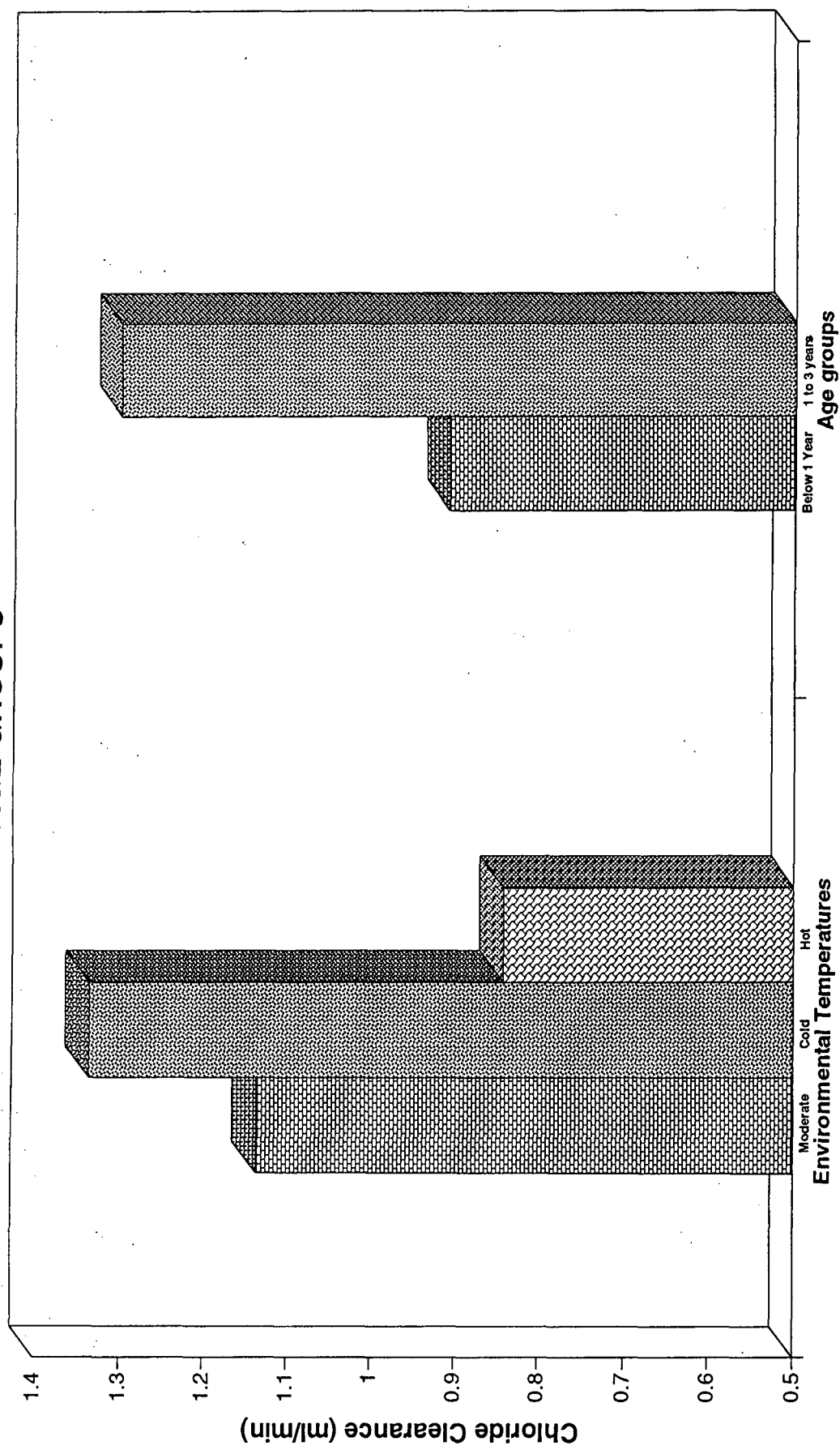


**Fig. 8 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF
PHOSPHORUS IN SHEEP DURING DIFFERENT ENVIRONMENTAL
TEMPERATURES AND AGE GROUPS**

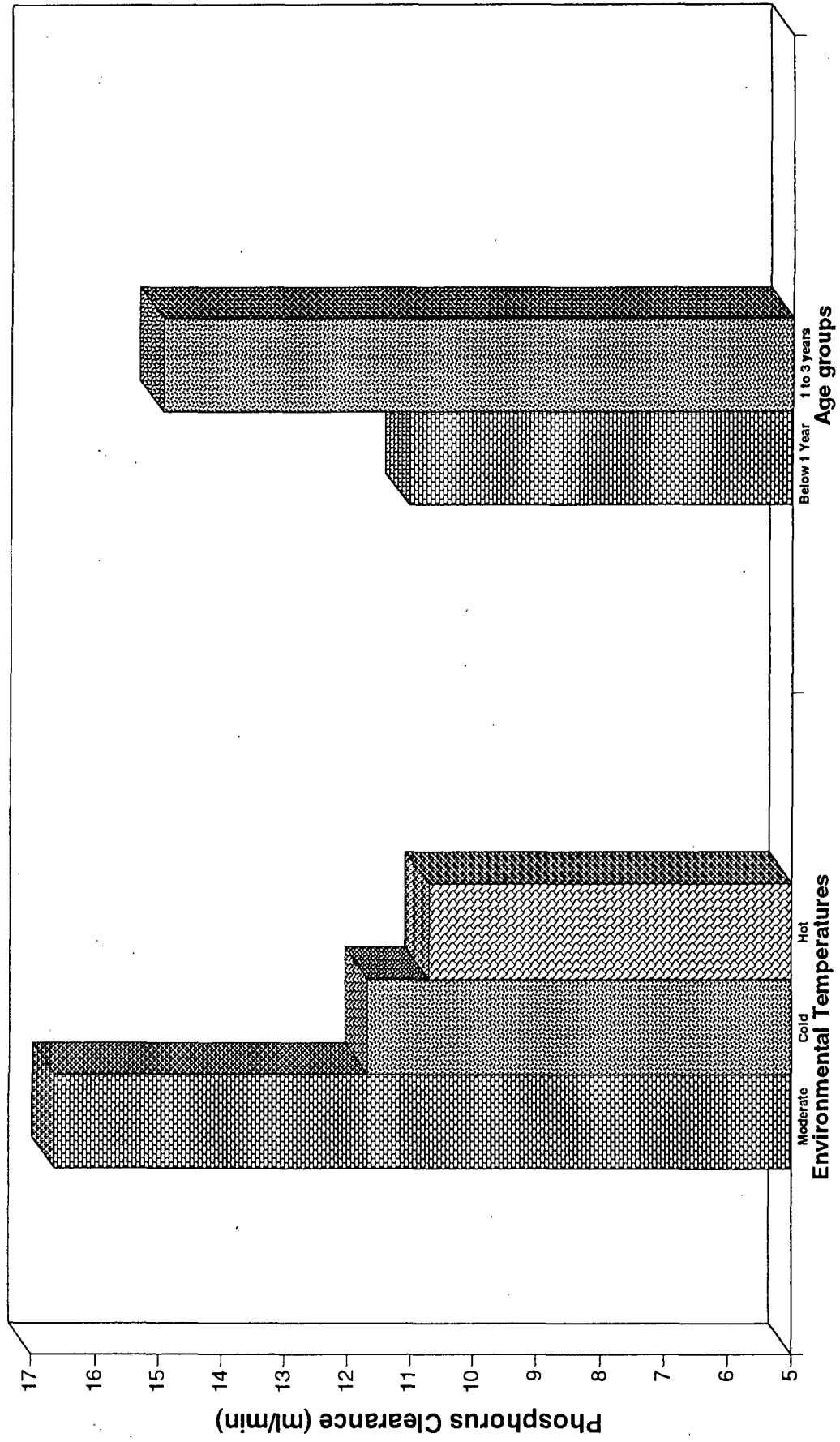
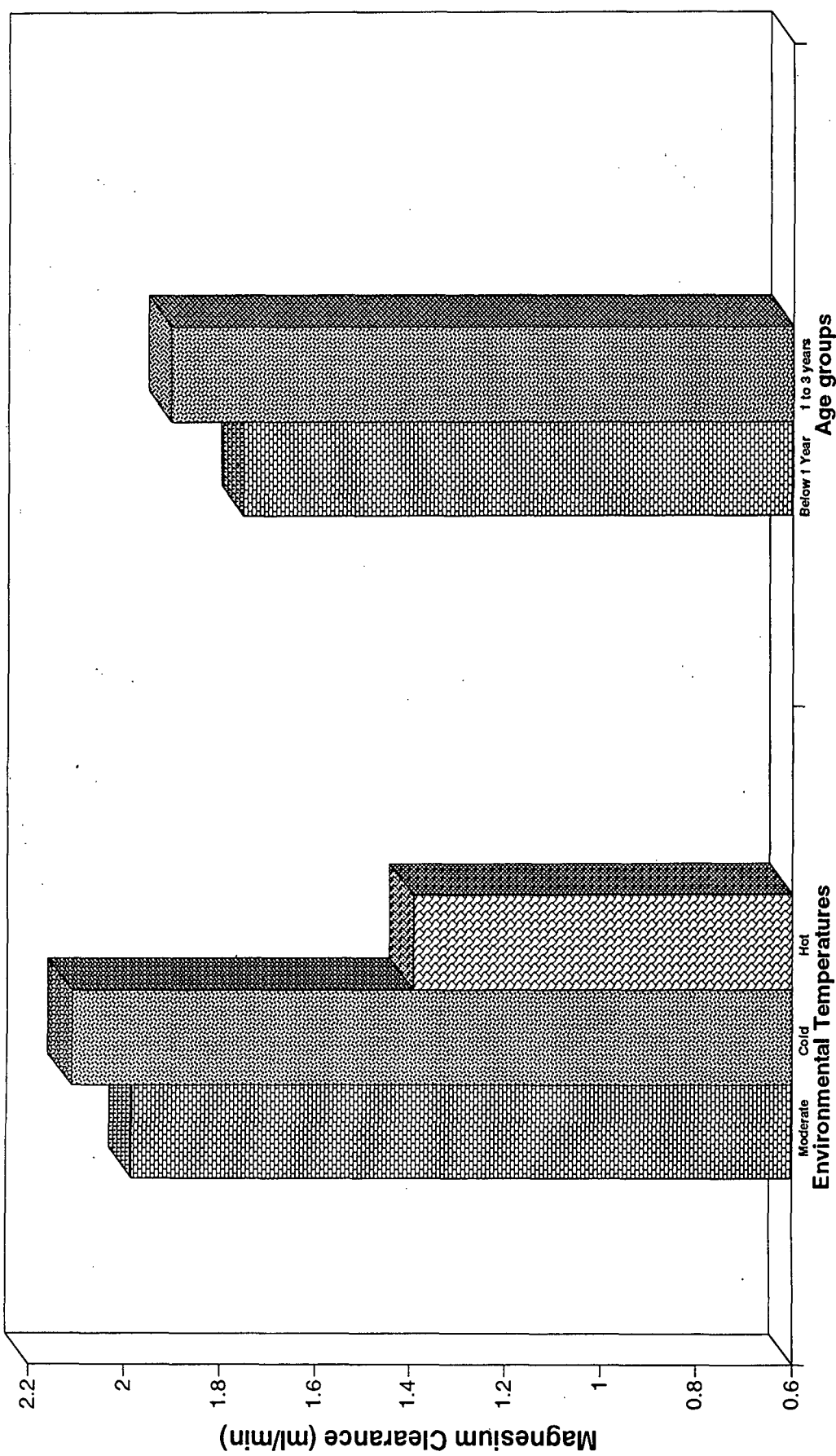


Fig. 9 : MEAN CHANGES IN VALUES OF RENAL CLEARANCE OF
MAGNESIUM IN SHEEP DURING DIFFERENT ENVIRONMENTAL
TEMPERATURES AND AGE GROUPS



of electrolytes, as rate of urine formation decreased significantly ($P \leq 0.05$).

During cold environmental temperature period the mean values of all electrolyte clearances increased significantly ($P \leq 0.05$) than respective control mean value during moderate period. However, phosphorus clearance decreased significantly ($P \leq 0.05$) during cold environment while magnesium clearance during this period showed a nonsignificant ($P > 0.05$) increase. This corroborated the earlier findings of Akhtar *et al.* (1997) for C_{Na} , C_K and C_{Cl} during winter season in goats. Changes in phosphorus and magnesium clearance could be correlated with the changes in tubular reabsorption related with the concentration of phosphorus in the diet (Guyton and Hall, 1996).

Results of present investigation suggested that electrolyte clearances could be effectively used in sheep to assess the renal efficiency. The pattern of changes in C_E during different environmental temperature was suggestive of adaptive measures taken by the animals to fight with the environmental stress, particularly conservation of water during hot environments. According to Kataria (2000), total excretion of electrolytes was decreased in animals to prevent negative salt balance during heat stress. During cold environment the picture was reversed when ample water was available. Further the results indicated that V_u should also be considered while interpreting the results of electrolyte clearances.

A significant ($P \leq 0.05$) effect of age was observed on the mean values of C_E and V_u , being higher in higher age group i.e. 1 to 3 years. The effect was similar as described for GFR, although electrolyte concentrations in serum and urine showed a different pattern among electrolytes. When the animals were classified age wise in different environmental temperatures, the similar trend was observed. However, in higher age group the mean values of C_K and C_P during hot period differed nonsignificantly ($P > 0.05$) from respective mean values in lower age group while mean values of C_{Mg} of higher age group differed nonsignificantly ($P > 0.05$) from respective lower age group values in moderate and cold environmental temperatures.

Analysis of variance revealed a highly significant ($P \leq 0.01$) effect on environmental temperature and age groups on C_E except C_{Mg} where the effect of age was nonsignificant ($P > 0.05$). The combined effect of environmental temperature and age was variable.

(iv) Transfer function of kidney (TFK) :

The mean $\pm$ SEM values of TFK and its components according to environmental temperatures and age groups are presented in table 11 and analysis of variance in table 12.

The overall mean value of TFK in the present study was 0.41 ± 0.003 which was nearly equal to that reported by Kachhwaha (2001) in goats and higher than that reported by Purohit (1972) in sheep and Kataria (2000) in camels. The results of present study indicated that about 41 % of total water intake

Table 11 : Mean±SEM values of transfer function of kidney (TFK).

S. No.	Classification	Water intake (ml/24 hrs)	Urine volume (ml/24 hrs)	TFK
1.	Overall (90)	2078.444 ±41.201	823.866 ±21.465	0.410 ±0.003
2.	Environmental temperatures			
	Moderate (30)	2077.833 ±72.750	860.233 ±42.917	0.408 ±0.003
	Cold (30)	1723.833 ^b ±66.404	970.700 ^b ±41.106	0.561 ^b ±0.008
	Hot (30)	2433.666 ^b ±74.670	640.666 ^b ±24.803	0.261 ^b ±0.002
3.	Age groups			
	Below 1 year (45)	1740.222 ±46.565	661.577 ±20.854	0.398 ±0.0019
	1 to 3 years (45)	2416.666 ^b ±56.232	986.155 ^b ±32.330	0.423 ^b ±0.0032
4.	Environmental temperatures and age groups			
	Moderate			
	Below 1 year (15)	1725.333 ±38.660	664.000 ±24.997	0.383 ±0.0018
	1 to 3 years (15)	2430.333 ^b ±51.776	1056.466 ^b ±38.805	0.433 ^b ±0.003
	Cold			
	Below 1 year (15)	1426.666 ±48.542	790.733 ±25.629	0.555 ±0.0081
	1 to 3 years (15)	2021.000 ^b ±57.412	1150.666 ^b ±41.432	0.567 ^a ±0.0078
	Hot			
	Below 1 year (15)	2068.666 ±47.092	530.000 ±19.784	0.255 ±0.0071
	1 to 3 years (15)	2798.666 ^b ±47.092	751.333 ^b ±20.192	0.268 ^a ±0.0068

- (i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).
- (ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).
- (iii) In interactions means comparison has been made within a class of parameters only.
- (iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.
- (v) Figure in the parenthesis indicate number of animals.

Table 12 : ANOVA of Transfer Function of Kidney (TFK) in sheep during different environmental temperatures and age groups.

SOURCE OF VARIATIONS			Water intake	Urine Volume	TFK
Between environmental temperatures	DF	2		2	2
	MSS	3778983.611**		846672.033**	0.674**
Within environmental temperatures	DF	87		87	87
	MSS	152777.183		41468.831	0.009
Between age groups	DF	1		1	1
	MSS	10295484.444*		2370391.511**	0.014**
Within age groups	DF	88		88	88
	MSS	119932.929		33303.873	0.016
Between environmental temperatures and age groups	DF	2		2	2
	MSS	39096.944*		61943.744*	0.003**
Within environmental temperatures and age groups	DF	84		84	84
	MSS	34737.341		13256.063	0.0007

** = Highly significant ($P \leq 0.01$)

* = Significant ($P \leq 0.05$)

was voided out as urine which was lower than that observed by Kachhwaha (2001) in goats and higher than that reported by Kataria (2000) in dromedary camels. This exhibited a higher TFK in sheep than camel and lower than goat.

The mean value of urine volume in present study was lower than that reported by Macfarlane *et al.* (1956) in sheep and higher than that observed by Kachhwaha (2001) in goats. The overall mean value of water intake was higher than that reported by Kachhwaha (2001) in goats.

During hot environmental temperature TFK decreased significantly ($P \leq 0.05$) than moderate mean value. Similar observations were recorded by Kataria (2000) in dromedary camel. This decrease was attributed to lowered urine volume and increased water intake. Total urine volume decreased by 25.58 % while water intake increased by 17.14 % when compared to respective moderate mean values. This suggested that kidney function was depressed during hot environment in order to conserve water (Kataria, 2000).

In the cold environmental temperature TFK increased significantly ($P \leq 0.05$) than the mean value during moderate temperature. The percent increase was 37.5. This was due to significant ($P \leq 0.05$) decrease in water intake and significant ($P \leq 0.05$) increase in urine volume.

The results indicated that calculation of TFK could serve to assess the water retention ability of the sheep as in goats (Kachhwaha, 2001) and camels (Kataria, 2000) as a part of

adaptive measures in the arid desert regions where the water scarcity is a frequent feature.

Effect of age was also evident on TFK. In higher age group TFK was significantly ($P \leq 0.05$) increased indicating towards higher clearance and urine volume. Similar trend was noticed when the animals were classified according to age in different environmental temperatures, although this was non significant ($P > 0.05$) in cold and hot periods.

Analysis of variance also reflected highly significant ($P \leq 0.01$) effect of environmental temperatures and age groups on TFK.

(v) Urine concentration test :

Mean $\pm$ SEM values of urine specific gravity and pH during different environmental temperatures and age groups are presented in table 13 and analysis of variance in table 14.

In the present study the colour of urine ranged from pale yellow to yellow. During hot environmental temperature condition, it was yellow while in moderate and cold conditions, it was pale yellow. Similar observations were recorded by Kataria (2000) in camels. The dark colour of urine is due to concentration of urochromes per unit volume (Coles, 1986). In the present study dark colour of the urine was followed by decreased volume of urine (Kachhwaha, 2001).

The overall mean value of specific gravity was lower and of pH was found similar to the respective values reported by Potter (1963) in sheep. Both the mean values of present study were

Table-13 : Mean±SEM values of specific gravity and pH in sheep during different environmental temperatures and age groups :

S.No.	Classification	Specific gravity	pH
1.	Overall (90)	1.038±0.0016	8.469±0.019
2	Environmental temperatures		
	Moderate (30)	1.038±0.0035	8.531±0.025
	Cold (30)	1.033 ^a ±0.0021	8.342 ^b ±0.037
	Hot (30)	1.042 ^a ±0.0026	8.535 ^a ±0.038
3.	Age groups		
	Below 1 year (45)	1.039±0.0026	8.509±0.033
	1 to 3 years (45)	1.037 ^a ±0.002	8.429 ^b ±0.027
4.	Environmental temperatures and age groups		
	Moderate		
	Below 1 year (15)	1.044±0.0059	8.616±0.036
	1 to 3 years (15)	1.032 ^a ±0.0037	8.446 ^b ±0.020
	Cold		
	Below 1 year (15)	1.032±0.003	8.336±0.065
	1 to 3 years (15)	1.034 ^a ±0.0032	8.348 ^a ±0.040
	Hot		
	Below 1 year (15)	1.040±0.0043	8.576±0.042
	1 to 3 years (15)	1.044 ^a ±0.0033	8.493 ^a ±0.064

- (i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).
- (ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).
- (iii) In interactions means comparison has been made within a class of parameters only.
- (iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.
- (v) Figure in the parenthesis indicate number of animals.

Table 14 : ANOVA of urine specific gravity and pH in sheep during different environmental temperatures and age groups.

			Specific gravity	pH
SOURCE OF VARIATIONS	Between environmental temperatures	DF	2	2
		MSS	0.00056 ^{NS}	0.364**
	Within environmental temperatures	DF	87	87
		MSS	0.00024	0.035
	Between age groups	DF	1	1
		MSS	0.0009 ^{NS}	0.144 ^{NS}
	Within age groups	DF	88	88
		MSS	0.00025	0.042
	Between environmental temperatures and age groups	DF	2	2
		MSS	0.0049 ^{NS}	0.062 ^{NS}
	Within environmental temperatures and age groups	DF	84	84
		MSS	0.00024	0.0339

** = Highly significant ($P \leq 0.01$)

NS = Non-significant ($P > 0.05$)

higher than those reported by Kachhwaha (2001) in goats. The mean value of specific gravity was in partial agreement to that reported by Akhtar *et al.* (1997) in goats and Amer and Alhendi (1996) in camels.

In hot environmental temperature the specific gravity of urine increased while reaction became alkaline. Similar trend was noticed by Kataria (2000) in dromedary camels. During cold environmental temperature the mean values for both the parameters decreased than respective moderate mean values.

A significant ($P \leq 0.05$) effect of age was observed on the mean values of urine pH. The mean value was lower in higher age group. This was probably due to increased volume of urine. Specific gravity was also lower in this age group, although nonsignificantly ($P > 0.05$). This trend was maintained during moderate environmental temperature but afterwards no effect of age was seen during different environmental temperatures. Analysis of variance also confirmed the effects of environmental temperatures and age groups on the specific gravity and pH of urine.

(vi) Filtered (FL) and excreted loads (EL) of serum constituents :

Mean $\pm$ SEM values of filtered and excreted loads of creatinine (FL_{Cr} and EL_{Cr}), urea (FL_{urea} and EL_{urea}), Sodium (FL_{Na} and EL_{Na}), potassium (FL_K and EL_K), chloride (FL_{Cl} and EL_{Cl}), phosphorus (FL_P and EL_P) and magnesium (FL_{Mg} and EL_{Mg}) during different environmental temperatures and age groups are presented in tables 15, 16, 18, 19, 21, 23 and 24, respectively.

Analysis of variance are presented in table 17, for creatinine and urea, 20 for sodium and potassium, 22 for chloride and 25 for phosphorus and magnesium.

During hot environmental temperature period, the FL and EL of all the constituents decreased while during cold environmental temperature the mean values increased. In age wise classification the mean values of all the FL and EL were found to be increased in 1 to 3 years age group animals. The similar pattern was maintained when the animals were classified as per different environments according to age.

(a) Creatinine :

The overall mean values of FL_{Cr} and EL_{Cr} in the present study were 0.308 ± 0.012 and 0.307 ± 0.013 mg/min., respectively. Filtered load indicated the part of plasma load that filtered into the Bowman's capsule. The overall mean value of FL_{Cr} was less than that reported by earlier workers (Guyton and Hall (1996) in human being, Kataria (2000) in camels and Puri (2001) in goats).

In hot environment the FL_{Cr} and EL_{Cr} decreased significantly ($P \leq 0.05$) from respective control (moderate) mean values. The percent decrease in FL_{Cr} was 16.51 and in EL_{Cr} 16.87. This showed a slight increase in overall tubular reabsorption (OTR) which became 0.742 during hot from 0.31 during moderate period. The decrease in C_{Cr} could be the possible cause for it as a decrease was observed in fractional excretion (FE) per cent.

Table 15 : Mean±SEM values of filtered and excreted loads of creatinine in sheep during different environmental temperatures and age groups.

S. No.	Classification	FL (mg/min)	EL (mg/min)	R _{Cr} (mg/min)	OTR %	FE %
1	Overall (90)	0.308±0.012	0.307±0.013	0.0015±0.0001	0.487±0.026	99.520±0.115
2	Environmental temperatures					
	Moderate (30)	0.321±0.025	0.320±0.025	0.001±0.0002	0.310±0.021	99.70±0.161
	Cold (30)	0.337 ^a ±0.026	0.336 ^a ±0.026	0.001 ^a ±0.0001	0.320 ^a ±0.092	99.67 ^a ±0.287
	Hot (30)	0.268 ^b ±0.014	0.266 ^b ±0.014	0.002 ^b ±0.0002	0.742 ^b ±0.031	99.32 ^b ±0.144
3	Age groups					
	Below 1 year (45)	0.239±0.011	0.238±0.011	0.001±0.0001	0.418±0.0110	99.70±0.332
	1-3 years (45)	0.378 ^b ±0.018	0.376 ^b ±0.018	0.002 ^b ±0.0001	0.529 ^b ±0.071	99.65 ^a ±0.196

Contd.....

Table 15 Contd.....

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	0.243±0.025	0.242±0.025	0.001±0.00012	0.401±0.001
	1 to 3 years (15)	0.398 ^b ±0.033	0.397 ^b ±0.033	0.001 ^a ±0.00012	0.251 ^b ±0.005
	Cold				
	Below 1 year (15)	0.254±0.019	0.253±0.018	0.001±0.0001	0.392±0.014
	1 to 3 years (15)	0.420 ^b ±0.038	0.419 ^b ±0.035	0.001 ^a ±0.0001	0.24 ^b ±0.017
	Hot				
	Below 1 year (15)	0.220±0.013	0.219±0.012	0.001±0.00010	0.450±0.022
	1 to 3 years (15)	0.316 ^b ±0.017	0.315 ^b ±0.017	0.001 ^a ±0.0001	0.316 ^b ±0.012

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_{Cr} = Reabsorbed Creatinine

OTR = Overall Tubular Reabsorption

FE = Fractional Excretion

During cold environment the mean values of FL_{Cr} and EL_{Cr} increased nonsignificantly ($P>0.05$) from respective control mean values during moderate environment. OTR% and FE% were similar to that during moderate environment.

Analysis of variance revealed significant ($P\leq 0.05$) effect of environmental temperature on FL_{Cr} and EL_{Cr} only.

The results of FL and EL loads in present investigation suggested that they could help to assess the extent of tubular reabsorption and tubular secretion in sheep. EL is the product of rate of urine formation and concentration of creatinine in the urine. In the present study nonsignificant ($P>0.05$) difference was there between the mean values of FL and EL during all the effects viz. environmental temperatures and age groups. As per Guyton and Hall (1996) the amount of creatinine reabsorbed by tubules was zero and FL and EL were equal. As creatinine is a waste product and is a larger molecule, tubular membrane is essentially impermeable to it therefore, almost none of the creatinine that is filtered is reabsorbed, so that virtually all the creatinine filtered by the glomeruli is excreted in urine.

The results of present study revealed that creatinine was not secreted by the tubules as mean value of EL was found equal to that of FL at all the levels of effects studied. Further according to Guyton and Hall (1996) the amount of creatinine excreted in urine represents the sum of tubular reabsorption and secretion minus glomerular filtration. The findings regarding excretion of creatinine was similar to that reported by Puri (2001) in goats.

Robinson *et al.* (1974) suggested that excretion of creatinine was dependent almost entirely on the process of glomerular filtration and tubular secretion contributed very slightly.

A significant ($P \leq 0.05$) age effect was observed on the mean values of FL_{Cr} and EL_{Cr} , being higher in 1 to 3 years age group. This was probably due to higher transfer function of kidney in this age group. Similar trend was maintained when the animals were classified according to age and environmental temperatures. Analysis of variance revealed the same pattern.

(b) Urea :

Overall mean $\pm$ SEM values of FL_{urea} and EL_{urea} in present study were 11.767 ± 0.63 and 4.434 ± 0.164 mg/min, respectively. These were more or less similar when compared to calculated values as reported by Kachhwaha (2001) in goats and Kataria (2001b) in camels.

In hot environment the mean values of FL_{urea} and EL_{urea} decreased significantly ($P \leq 0.05$) from respective control (moderate) mean values. This was due to decrease in urea clearance in this period. Percent of FE was also found decreased in hot environment. In cold environment, although FL_{urea} decreased nonsignificantly ($P > 0.05$) from the control mean value but EL_{urea} increased significantly ($P \leq 0.05$). Per cent of FE increased probably because of an increase in urea clearance. The other reason was decreased OTR% in cold environment.

Kataria (2000) in camels observed a nonsignificant ($P > 0.05$) difference between the mean values of FL during

Table 16 : Mean±SEM values of filtered and excreted loads of urea in sheep during different environmental temperatures and age groups.

S. No.	Classification	FL (mg/min)	EL (mg/min)	R _U (mg/min)	OTR %	FE %
1	Overall (90)	11.767±0.630	4.434±0.164	7.356±0.559	56.567±2.015	43.902±2.143
2	Environmental temperatures					
	Moderate (30)	13.476±1.324	4.569±0.337	8.929±1.170	59.792±3.838	40.566±4.025
	Cold (30)	11.422 ^a ±1.045	5.470 ^b ±0.314	5.998 ^b ±0.862	46.260 ^b ±3.680	54.794 ^b ±4.106
	Hot (30)	10.404 ^b ±0.853	3.262 ^b ±0.173	7.141 ^a ±0.836	63.650 ^a ±2.878	36.347 ^a ±2.880
3	Age groups					
	Below 1 year (45)	9.068±0.566	3.508±0.167	5.564±0.532	56.564±2.779	43.532±2.822
	1-3 years (45)	14.467 ^b ±0.996	5.359 ^b ±0.277	9.147 ^b ±0.932	56.571 ^a ±3.296	44.272 ^a ±3.609

Contd....

Table 16 Contd....

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	10.076±1.232	3.475±0.289	6.601±1.104	60.004±4.762
	1 to 3 years (15)	16.876 ^b ±2.024	5.663 ^b ±0.467	11.257 ^b ±1.919	59.579 ^a ±6.193
	Cold				
	Below 1 year (15)	9.000±0.862	4.303±0.220	4.712±0.845	47.502±5.000
	1 to 3 years (15)	13.844 ^b ±1.715	6.637 ^b ±0.406	7.284 ^b ±1.458	45.018 ^a ±5.557
	Hot				
	Below 1 year (15)	8.128±0.794	2.474±0.213	5.381±0.781	62.184±4.025
	1 to 3 years (15)	12.680 ^b ±1.282	3.778 ^b ±0.202	8.901 ^b ±1.357	65.116 ^a ±4.221

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_u = Reabsorbed Urea

OTR = Overall Tubular Reabsorption

FE = Fractional Excretion

Table 17 : ANOVA of FL and EL of creatinine and urea in sheep during different environmental temperatures and age groups.

SOURCE OF VARIATIONS		CREATININE						UREA			
		FL	EL	R _{Cr}	OTR%	FE%	FL	EL	R _U	OTR%	FE%
		DF	2	2	2	2	2	2	2	2	2
Between environmental temperatures	MSS	0.038*	0.037*	0.000 ^{NS}	0.337 ^{NS}	491.650 ^{NS}	13.475 ^{NS}	36.952**	65.476 ^{NS}	2501.991**	2802.781**
Within environmental temperatures	DF	87	87	87	87	87	87	87	87	87	87
Between age groups	MSS	0.015	0.015	0.000	0.521	143.450	35.744	2.428	28.128	365.656	413.558
Within age groups	DF	1	1	1	1	1	1	1	1	1	1
	MSS	0.435**	0.438**	0.000*	9.318**	3524.630**	655.722**	77.111**	288.816**	0.001 ^{NS}	12.335 ^{NS}
Between environmental temperatures and age groups	DF	88	88	88	88	88	88	88	88	88	88
Within environmental temperatures and age groups	MSS	0.108	0.10	0.000	0.416	112.941	29.557	2.364	26.014	418.365	472.418
	DF	2	2	2	2	2	2	2	2	2	2
	MSS	0.010*	0.011*	0.0000 ^{NS}	0.200 ^{NS}	110.296 ^{NS}	11.210 ^{NS}	3.818 ^{NS}	8.163 ^{NS}	56.053 ^{NS}	91.568 ^{NS}
	DF	84	84	84	84	84	84	84	84	84	84
	MSS	0.010	0.010	0.0000	0.423	103.988	28.948	1.506	25.500	377.381	426.001

** Highly significant (P<0.01)

* Significant (P<0.05)

NS Non Significant (P>0.05)

summer and winter seasons. Akhtar *et al.* (1997) found a lower FE in goats during summer than winter.

In the present study about 46.26 per cent and 63.65 per cent of filtered urea was reabsorbed back during cold and hot environments, respectively. This was in agreement with the variation of OTR% in sheep on different rations (Choshniak and Arnon, 1985). Decrease in OTR% during cold environment was probably due to reduced ADH (Reece, 1996) resulting in poor reabsorption of water and urea. Akhtar *et al.* (1997) reported 38 and 32 per cent of filtered urea reabsorption during summer and winter, respectively in goats. However, Thornton (1970) observed 70 per cent back diffusion of urea in sheep. During hot environment the per cent FE of urea decreased in comparison to both moderate and cold environments. The reduction in FE was directly related with the reduction in GFR.

Analysis of variance reflected the effect of different environments on the FL_{urea} and EL_{urea} and their components.

The effect of age was well evident on FL_{urea} and EL_{urea} . The mean values of both FL_{urea} and EL_{urea} increased significantly ($P \leq 0.05$) in higher age group. However, in both the age groups, OTR% and FE% were similar. The possible cause was that in higher age group, EL_{urea} increased but simultaneously FL_{urea} was also increased, about 1.6 times of lower age group. Due to that OTR% remained similar. This trend was maintained when the animals were classified as per age groups and different environments. Analysis of variance also reflected the effect of age in FL_{urea} and EL_{urea} with some variation.

The results of present study indicated that renal excretion of urea in sheep was nicely regulated. It was associated with changes in GFR due to different environments and age groups.

(c) Electrolytes :

The overall mean values of FL_{Na} and EL_{Na} ; FL_K and EL_K ; FL_{Cl} and EL_{Cl} ; FL_P and EL_P and FL_{Mg} and EL_{Mg} were 4.055 ± 0.177 and 0.095 ± 0.003 ; 0.152 ± 0.0076 and 0.071 ± 0.002 ; 2.898 ± 0.129 and 0.114 ± 0.0032 mmol/min; 1.39 ± 0.078 and 0.575 ± 0.014 and 0.695 ± 0.028 and 0.044 ± 0.0009 mg/min, respectively.

The results showed that although the FL_{Na} was 26.67 times higher than FL_K but the EL_{Na} and EL_K were nearly equal. This difference was due to higher clearance of potassium. Similarly FL_{Na} was 2.91 times higher than FL_P but EL_P was 6.05 times higher than EL_{Na} . The reason was higher phosphorus renal clearance.

FL_{Na} differed nonsignificantly ($P > 0.05$) during cold and hot environments when compared to moderate environment. However, EL_{Na} in both the periods showed significant ($P \leq 0.05$) differences than moderate period. A higher FL_{Na} during cold environment indicated that a higher concentration of sodium was presented to tubules. FL_{Na} was dependent upon GFR which was increased during cold environment. Similar observations were recorded by Yagil and Berlyne (1976a) in camels.

A decrease in FL_{Na} during hot than cold environment exhibited that animals adapted themselves to high environmental temperature to conserve water by sodium retention. OTR% was higher in hot environment with decreased FE%. C_{Na} was also

Table 18 : Mean±SEM values of filtered and excreted loads of sodium in sheep during different environmental temperatures and age groups.

S. No.	Classification	FL (mmol/min)	EL (mmol/min)	RE (mmol/min)	OTR %	FE %
1	Overall (90)	4.055±0.177	0.095±0.003	3.959±0.175	97.444±0.102	2.555±0.102
2	Environmental temperatures					
	Moderate (30)	4.111±0.350	0.098±0.007	4.012±0.347	97.281±0.210	2.717±0.211
	Cold (30)	4.578 ^a ±0.356	0.117 ^b ±0.006	4.460 ^a ±0.353	97.165 ^a ±0.186	2.835 ^a ±0.186
	Hot (30)	3.476 ^a ±0.178	0.071 ^b ±0.004	3.405 ^a ±0.176	97.886 ^b ±0.120	2.115 ^b ±0.121
3	Age groups					
	Below 1 year (45)	3.210±0.166	0.069±0.003	3.141±0.165	97.662±0.122	2.339±0.122
	1-3 years (45)	4.900 ^b ±0.270	0.122 ^b ±0.005	4.777 ^b ±0.269	97.227 ^b ±0.169	2.772 ^b ±0.169

Contd...

Table 18 Contd...

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	3.190±0.381	0.067±0.003	3.122±0.379	97.516±0.254
	1 to 3 years (15)	5.033 ^b ±0.493	0.129 ^b ±0.008	4.903 ^b ±0.493	2.947 ^a ±0.334
	Cold				
	Below 1 year (15)	3.562±0.241	0.088±0.004	3.474±0.241	2.608±0.182
	1 to 3 years (15)	5.594 ^b ±0.565	0.147 ^b ±0.006	5.446 ^b ±0.566	3.062 ^b ±0.320
	Hot				
	Below 1 year (15)	2.880±0.202	0.052±0.002	2.828±0.200	1.924±0.158
	1 to 3 years (15)	4.072 ^b ±0.202	0.090 ^b ±0.004	3.982 ^b ±0.202	2.306 ^b ±0.176

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_{Na} = Reabsorbed Sodium

OTR = Overall Tubular Reabsorption

FE = Fractional Excretion

Table 19 : Mean±SEM values of filtered and excreted loads of potassium in sheep during different environmental temperatures and age groups.

S.No.	Classification	FL (mmol/min)	EL (mmol/min)	R _K (mmol/min)	OTR %	FE %
1	Overall (90)	0.152±0.0076	0.071±0.002	0.085±0.006	51.349±2.102	50.180±3.293
2	Environmental temperatures					
	Moderate (30)	0.161±0.014	0.0716±0.006	0.091±0.012	51.159±3.571	49.469±4.737
	Cold (30)	0.166 ^a ±0.045	0.090 ^b ±0.006	0.088 ^a ±0.013	47.302 ^a ±3.853	54.007 ^a ±7.495
	Hot (30)	0.129 ^b ±0.009	0.0522 ^b ±0.003	0.077 ^a ±0.008	55.586 ^a ±3.488	46.458 ^a ±4.358
3	Age groups					
	Below 1 year (45)	0.124±0.008	0.060±0.003	0.065±0.007	47.110±2.919	53.340±3.683
	1-3 years (45)	0.180 ^b ±0.011	0.081 ^b ±0.005	0.106 ^b ±0.010	55.588 ^b ±2.941	45.036 ^b ±5.747

Contd...

Table 19 Contd...

4	Environmental temperatures and age groups						
	Moderate						
	Below 1 year (15)	0.122±0.014	0.059±0.004	0.064±0.013	45.743±4.889	55.970±6.163	
	1 to 3 years (15)	0.200 ^b ±0.021	0.083 ^b ±0.009	0.119 ^b ±0.019	56.574 ^b ±4.975	46.969 ^a ±7.217	
	Cold						
	Below 1 year (15)	0.149±0.014	0.074±0.005	0.075±0.016	44.816±5.706	56.888±6.560	
	1 to 3 years (15)	0.183 ^b ±0.026	0.105 ^b ±0.009	0.101 ^b ±0.022	49.789 ^a ±5.298	51.386 ^a ±10.162	
	Hot						
	Below 1 year (15)	0.101±0.010	0.047±0.003	0.055±0.008	50.772±4.701	50.001±6.811	
	1 to 3 years (15)	0.156 ^b ±0.011	0.056 ^b ±0.005	0.099 ^b ±0.013	60.401 ^b ±4.964	39.754 ^a ±5.086	

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P > 0.05$) and letter "b" differ significantly ($P \leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load
EL = Excreted Load
R_K = Reabsorbed Potassium

OTR = Overall Tubular Reabsorption
FE = Fractional Excretion

Table 20 : ANOVA of FL and EL of sodium and potassium in sheep during different environmental temperatures and age groups.

SOURCE OF VARIATIONS			SODIUM					POTASSIUM				
			FL	EL	R _{Nb}	OTR%	FE%	FL	EL	R _K	OTR%	FE%
Between environmental temperatures	DF		2	2	2	2	2	2	2	2	2	2
	MSS		9.179*	0.016**	8.416 ^{NS}	4.499*	4.464*	0.012 ^{NS}	0.010**	0.0016 ^{NS}	515.500 ^{NS}	3675.409*
Within environmental temperatures	DF		87	87	87	87	87	87	87	87	87	87
	MSS		2.821	0.001	2.771	0.936	0.940	0.005	0.0008	0.004	397.229	976.212
Between age groups	DF		1	1	1	1	1	1	1	1	1	1
	MSS		64.194**	0.063**	60.222**	4.255*	4.203*	0.070**	0.010**	0.038**	1617.220*	2.070 ^{NS}
Within age groups	DF		88	88	88	88	88	88	88	88	88	88
	MSS		2.268	0.0007	2.246	0.980	0.983	0.004	0.0009	0.003	386.548	1048.627
Between environmental temperatures and age groups	DF		2	2	2	2	2	2	2	2	2	2
	MSS		1.452 ^{NS}	0.0012 ^{NS}	1.372 ^{NS}	0.016 ^{NS}	0.014 ^{NS}	0.003 ^{NS}	0.0008 ^{NS}	0.0016 ^{NS}	71.799 ^{NS}	2709.962 ^{NS}
Within environmental temperatures and age groups	DF		84	84	84	84	84	84	84	84	84	84
	MSS		2.122	0.0004	2.120	0.919	0.923	0.004	0.0006	0.003	390.971	946.529

** Highly significant ($P \leq 0.01$)

* Significant ($P \leq 0.05$)

NS Non Significant ($P > 0.05$)

Table 21 : Mean±SEM values of filtered and excreted loads of chloride in sheep during different environmental temperatures and age groups.

S.No.	Classification	FL (mmol/min)	EL (mmol/min)	R _{Cl} (mmol/min)	OTR %	FE %
1	Overall (90)	2.898±0.129	0.114±0.0032	2.783±0.127	95.666±0.151	4.331±0.151
2	Environmental temperatures					
	Moderate (30)	2.999±0.247	0.118±0.0059	2.881±0.244	95.546±0.288	4.453±0.288
	Cold (30)	3.221 ^a ±0.265	0.137 ^b ±0.006	3.083 ^a ±0.261	95.215 ^a ±0.292	4.780 ^a ±0.291
	Hot (30)	2.474 ^b ±0.136	0.088 ^b ±0.0037	2.385 ^a ±0.133	96.236 ^b ±0.194	3.760 ^b ±0.194
3	Age groups					
	Below 1 year (45)	2.205±0.108	0.092±0.0031	2.112±0.106	95.474±0.224	4.521±0.224
	1-3 years (45)	3.591 ^b ±0.192	0.137 ^b ±0.0052	3.454 ^b ±0.189	95.858 ^a ±0.216	4.142 ^a ±0.216

Contd....

Table 21 Contd.....

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	2.286±0.241	0.094±0.005	2.191±0.237	95.391±0.391
	1 to 3 years (15)	3.712 ^b ±0.352	0.141 ^b ±0.006	3.571 ^b ±0.354	95.702 ^a ±0.433
	Cold				
	Below 1 year (15)	2.329±0.170	0.108±0.003	2.220±0.171	94.962±0.405
	1 to 3 years (15)	4.113 ^b ±0.384	0.166 ^b ±0.007	3.946 ^b ±0.382	95.469 ^a ±0.425
	Hot				
	Below 1 year (15)	1.999±0.135	0.073±0.003	1.925±0.133	96.070±0.339
	1 to 3 years (15)	2.948 ^b ±0.162	0.102 ^b ±0.004	2.845 ^b ±0.160	96.402 ^a ±0.192

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition.

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group.

(iii) In interactions means comparison has been made within a class of parameters only.

- Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from control mean (moderate).

- Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_{Cl} = Reabsorbed Chloride

OTR = Overall Tubular Reabsorption

FE = Fractional Excretion

Table 22 : ANOVA of FL and EL of chloride in sheep during different environmental temperatures and age groups.

		CHLORIDE				
		FL	EL	R _{Cl}	OTR%	FE%
Between environmental temperatures	DF	2	2	2	2	2
	MSS	4.419 ^{NS}	0.018**	3.869 ^{NS}	8.134*	8.143*
Within environmental temperatures	DF	87	87	87	87	87
	MSS	1.502	1.0009	1.456	2.064	2.062
Between age groups	DF	1	1	1	1	1
	MSS	43.250**	0.044**	40.519**	3.310 ^{NS}	3.233 ^{NS}
Within age groups	DF	88	88	88	88	88
	MSS	1.094	0.0008	1.067	2.188	2.187
Between environmental temperatures and age groups	DF	2	2	2	2	2
	MSS	1.315 ^{NS}	0.0015*	1.225 ^{NS}	0.087 ^{NS}	0.084 ^{NS}
Within environmental temperatures and age groups	DF	84	84	84	84	84
	MSS	1.010	0.0004	0.996	2.096	2.095

** Highly significant ($P \leq 0.01$)

* Significant ($P \leq 0.05$)

NS Non Significant ($P > 0.05$)

SOURCE OF VARIATIONS

Table 23 : Mean±SEM values of filtered and excreted loads of phosphorus in sheep during different environmental temperatures and age groups.

S.No.	Classification	FL (mg/min)	EL (mg/min)	R _P (mg/min)	OTR %	FE %
1	Overall (90)	1.390±0.078	0.575±0.014	0.833±0.0729	51.873±2.077	49.454±2.871
2	Environmental temperatures					
	Moderate (30)	1.225±0.131	0.613±0.026	0.668±0.115	45.792±4.107	56.154±4.012
	Cold (30)	1.835 ^b ±0.176	0.653 ^a ±0.026	1.181 ^b ±0.168	57.454 ^b ±3.141	42.548 ^b ±3.145
	Hot (30)	1.111 ^a ±0.082	0.460 ^b ±0.020	0.651 ^a ±0.077	52.374 ^a ±3.482	47.660 ^b ±3.474
3	Age groups					
	Below 1 year (45)	1.072±0.075	0.497±0.019	0.588±0.063	48.014±2.900	52.069±4.116
	1-3 years (45)	1.708 ^b ±0.136	0.653 ^b ±0.021	1.079 ^b ±0.130	55.732 ^b ±3.004	46.121 ^a ±5.747

Contd....

Table 23 Contd....

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	1.043±0.155	0.497±0.024	0.585±0.130	46.944±5.576
	1 to 3 years (15)	1.407 ^b ±0.205	0.728 ^b ±0.018	0.751 ^a ±0.194	58.036 ^a ±9.639
	Cold				
	Below 1 year (15)	1.346±0.102	0.598±0.035	0.474±0.097	47.456±4.022
	1 to 3 years (15)	2.324 ^b ±0.290	0.709 ^b ±0.033	1.614 ^b ±0.286	37.640 ^b ±4.620
	Hot				
	Below 1 year (15)	0.829±0.093	0.398±0.019	0.430±0.089	55.478±5.434
	1 to 3 years (15)	1.394 ^b ±0.091	0.522 ^b ±0.029	0.871 ^b ±0.098	39.842 ^b ±3.429

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_P = Reabsorbed Phosphorus

OTR = Overall Tubular Reabsorption

FE = Fractional Excretion

Table 24 : Mean±SEM values of filtered and excreted loads of magnesium in sheep during different environmental temperatures and age groups.

S, No.	Classification	FL (mg/min)	EL (mg/min)	R _{Mg} (mg/min)	OTR %	FE %
1	Overall (90)	0.695±0.028	0.044±0.0009	0.650±0.033	92.438±0.390	7.551±0.389
2	Environmental temperatures					
	Moderate (30)	0.725±0.067	0.0489±0.0015	0.676±0.066	91.578±0.802	8.402±0.800
	Cold (30)	0.758 ^a ±0.068	0.0498 ^a ±0.0017	0.708 ^a ±0.067	92.255 ^a ±0.600	7.758 ^a ±0.600
	Hot (30)	0.602 ^a ±0.031	0.0357 ^b ±0.0017	0.566 ^a ±0.031	93.480 ^b ±0.607	6.493 ^b ±0.602
3	Age groups					
	Below 1 year (45)	0.540±0.024	0.043±0.0019	0.496±0.024	91.133±0.627	8.840±0.626
	1-3 years (45)	0.851 ^b ±0.054	0.046 ^a ±0.0013	0.804 ^b ±0.053	93.742 ^b ±0.400	6.261 ^b ±0.400

Contd...

Table 24 Contd...

4	Environmental temperatures and age groups				
	Moderate				
	Below 1 year (15)	0.530±0.049	0.047±0.003	0.482±0.049	89.762±1.195
	1 to 3 years (15)	0.920 ^b ±0.103	0.050 ^a ±0.001	0.870 ^b ±0.103	93.395 ^b ±0.877
	Cold				
	Below 1 year (15)	0.537±0.037	0.047±0.003	0.489±0.037	90.542±0.858
	1 to 3 years (15)	0.980 ^b ±0.103	0.051 ^a ±0.001	0.928 ^b ±0.102	93.968 ^b ±0.579
	Hot				
	Below 1 year (15)	0.552±0.041	0.034±0.003	0.518±0.040	93.096±1.056
	1 to 3 years (15)	0.652 ^b ±0.044	0.036 ^a ±0.002	0.615 ^b ±0.045	93.864 ^a ±0.626

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In interactions means comparison has been made within a class of parameters only.

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

FL = Filtered Load

EL = Excreted Load

R_{Mg} = Reabsorbed Magnesium

OTR = Overall Tubular Reabsorption
FE = Fractional Excretion

Table 25 : ANOVA of FL and EL of phosphorus and magnesium in sheep during different environmental temperatures and age groups.

SOURCE OF VARIATIONS		PHOSPHORUS					MAGNESIUM				
		FL	EL	R _P	OTR%	FE%	FL	EL	R _{Mg}	OTR%	FE%
		DF	2	2	2	2	2	2	2	2	2
Between environmental temperatures	MSS	4.539**	0.312**	2.718**	1025.712 ^{NS}	5057.725 ^{NS}	0.202 ^{NS}	0.001**	0.165 ^{NS}	27.884 ^{NS}	28.313 ^{NS}
Within environmental temperatures	DF	87	87	87	87	87	87	87	87	87	87
Between age groups	MSS	0.552	0.018	0.479	388.625	741.893	0.101	0.00008	0.099	13.740	13.650
Within age groups	DF	1	1	1	1	1	1	1	1	1	1
Between environmental temperatures and age groups	MSS	9.083**	0.544**	5.423**	1340.346 ^{NS}	1175.923 ^{NS}	2.174**	0.0001 ^{NS}	2.135**	153.141**	149.640**
Within environmental temperatures and age groups	DF	88	88	88	88	88	88	88	88	88	88
Between environmental temperatures and age groups	MSS	0.546	0.018	0.475	392.290	835.048	0.079	0.0001	0.078	12.477	12.438
Within environmental temperatures and age groups	DF	2	2	2	2	2	2	2	2	2	2
Between environmental temperatures and age groups	MSS	0.735 ^{NS}	0.0329 ^{NS}	0.936 ^{NS}	628.690 ^{NS}	743.311 ^{NS}	0.255*	0.000 ^{NS}	0.254*	19.143 ^{NS}	19.663 ^{NS}
Within environmental temperatures and age groups	DF	84	84	84	84	84	84	84	84	84	84
Between environmental temperatures and age groups	MSS	0.446	0.011	0.409	371.580	736.692	0.072	0.0008	0.071	11.951	11.883

** Highly significant (P≤0.01)

* Significant (P≤0.05)

NS Non Significant (P>0.05)

found decreased during hot period. Kohn and Strasser (1986) opined that FE_{Na} reflected variable intake.

In higher age group FL_{Na} and EL_{Na} were significantly ($P \leq 0.05$) higher than lower age group. OTR% was lower in higher age group with higher FE%. This was due to increased GFR in higher (1 to 3 years) age group. This effect of age was maintained in all the periods *viz.* moderate, hot and cold.

The effect of environmental temperature on FL_K and EL_K was similar to that for sodium, however, FE % was higher in potassium. According to Kohn and Strasser (1986) the kidneys provided the main avenue for excretion of potassium, since this ion is presented in abundance in most forages. OTR% of potassium in present study was lower than that of sodium. This was due to effect of aldosterone hormone (Kataria, 2000) which caused sodium retention and potassium excretion.

The effect of age on FL_K and EL_K was similar to that on sodium but the mean value of FE % showed deviation. FL_K and EL_K mean values were significantly ($P \leq 0.05$) higher in 1 to 3 years age group but FE % decreased. This was due to increased OTR%. This trend was remained similar throughout all the environments *viz.* moderate, cold and hot.

The chloride excretion and reabsorption was consistent with sodium excretion and reabsorption. In the effect of age, in higher age group OTR% was found slightly higher so that FE% found decreased otherwise the trend was similar to that for sodium.

The pattern of FL_P and EL_P was comparable to that of potassium. OTR% and FE% of phosphorus were similar to that of potassium. The reason was higher phosphorus clearance.

In the present study the FE% of phosphorus was higher than the reported values by Kohn and Strasser (1986) in horses. According to Guyton and Hall (1996) phosphorus is poorly reabsorbed and therefore, concentrated in tubules. It is excreted in urine in order to maintain the pH of tubular fluid as a part of phosphate buffer system.

The filtering and excretion pattern of magnesium was similar to that of phosphorus but the mean values differed. The overall OTR% was 92.438 ± 0.390 which was in accordance with that suggested by Guyton and Hall (1996). They explained that the regulation of magnesium excretion is achieved by changing tubular reabsorption which occurs at different levels in tubules. Renal excretion of magnesium can increase markedly during magnesium excess or decrease to almost nil during magnesium depletion.

2. HAEMATOLOGICAL PARAMETERS AND PLASMA OSMOLARITY :

Mean $\pm$ SEM values of haemoglobin (Hb), erythrocyte sedimentation rate (ESR) mm/3 hrs. and mm/24 hrs., packed cell volume (PCV), relative viscosity, specific gravity (Sp. Gr.), mean corpuscular haemoglobin concentration (MCHC) and plasma osmolality (P_{osm}) are presented in table 26 and analysis of variance in table 27 according to different environmental temperatures, sex and age groups.

The overall mean values of Hb, ESR, PCV, Sp.Gr., MCHC and P_{osm} in the present study were more or less similar to that reported by earlier workers (Mehrotra *et al.*, 1959; Schalm, 1965; English, 1969; Purohit *et al.*, 1972; Singh and Taneja, 1978; Chahal and Rattan, 1981; Dutta *et al.*, 1996; Kalleswarappa and Jayaprakash, 1999 and Meena *et al.*, 2002) in sheep. The differences in the mean values could be attributed to environmental stress (Dutta *et al.*, 1996) which had been found to evoke specific regulatory mechanisms thereby affecting haematological parameters or the different type of management of the animals (Gahlot, 1987).

The overall mean values of present study were compared with more related species. The mean values of Hb, PCV, Sp. gr. and relative viscosity were found in agreement to those reported by Pareek (2001) and Charan *et al.* (2002) in marwari goats. The mean values of MCHC and P_{osm} were in accordance with that reported by Kataria (2000) in camels.

The mean changes in haematological parameters during hot and cold environmental temperatures were compared with the mean values during moderate environmental temperature. During hot environment, the mean values of all the parameters differed significantly ($P \leq 0.05$) from the respective mean values during moderate period except sp. gr. which showed a nonsignificant ($P > 0.05$) change. Rise in Hb, PCV, relative viscosity and P_{osm} during hot environment with a decrease in ESR was suggestive of haemoconcentration (Kataria, 2000). Kataria *et al.* (1992) also reported an increase in PCV from winter to summer in marwari

goats. Probably it was related to heat stress. However, Kaushish *et al.* (1976) reported a decrease in the mean values of Hb and PCV during summer in sheep. Kataria *et al.* (2002b) reported higher values of Hb, PCV and MCHC during summer than winter while lower value of ESR during summer in camels. Kataria *et al.* (2001a) reported higher values of sp. gr. and relative viscosity during summer in camels. Increase in P_{osm} during hot environment in present study was suggestive of water loss from plasma (Kataria, 2000).

During cold environment the mean values of ESR, PCV and P_{osm} differed significantly ($P < 0.05$) from that in moderate environment. Increase was observed in the mean values of PCV and P_{osm} , however they were still lower than those reported in hot environment. The mean value of ESR was found decreased, however, it was higher than that reported in hot environment. These findings were in line with that reported by Kataria (2000) in camels.

Effect of sex was observed on the mean values of ESR, PCV, sp. gr. and MCHC, the values being lower in female animals except for PCV which was higher in females. No effect of sex was observed on mean values of P_{osm} . English (1969) suggested no effect of sex on P_{osm} value in sheep. According to Grunsell (1955) the variation in haematological factors apart from sex, could be due to reproductive stress, availability of fodder and environmental stress. Mazumder *et al.* (1982) did not observe any effect of sex, age and season on haemoglobin content in goats.

Significant ($P \leq 0.05$) effect of age was observed on ESR and PCV only, the values being higher in 1 to 3 years age group. This

Table 26 : Mean±SEM values of haematological parameters and plasma osmolarity in sheep during different environmental temperatures, sex and age groups.

S. No.	Classification	Hb (g/dl)	ESR (mm/3 hrs.)	ESR (mm/24 hrs.)	PCV (%)	Relative Viscosity	Specific gravity	MCHC (g/dl)	Plasma Osmolarity (mosm/l)
1.	Overall (155)	11.709±0.169	1.358±0.068	13.531±0.447	30.758±0.527	4.488±0.059	1.056±0.005	39.679±0.569	311.176±2.093
2	Environmental temperatures								
	Moderate (40)	10.723±0.313	1.556±0.127	19.550±0.827	27.523±0.979	4.292±0.109	1.059±0.006	41.704±1.076	299.600±3.946
	Cold (75)	11.270 ^a ±0.324	1.672 ^a ±0.132	13.447 ^b ±0.857	30.040 ^b ±1.014	4.209 ^a ±0.113	1.058 ^a ±0.006	39.583 ^a ±1.076	310.559 ^b ±3.946
	Hot (40)	13.135 ^b ±0.227	0.847 ^b ±0.092	7.59 ^b ±0.599	34.710 ^b ±0.710	4.957 ^b ±0.079	1.055 ^a ±0.004	38.055 ^b ±0.786	317.376 ^b ±2.881
3	Sex								
	Male (100)	11.530±0.195	1.450±0.079	13.778±0.514	29.316±0.609	4.434±0.067	1.060±0.003	40.097±0.688	312.017±2.893
	Female (55)	11.889 ^a ±0.280	1.267 ^b ±0.113	13.284 ^a ±0.739	32.199 ^b ±0.875	4.541 ^a ±0.097	1.052 ^a ±0.005	38.107 ^b ±0.928	313.191 ^a ±3.026
4.	Age groups								
	Below 1 year (91)	11.784±0.210	1.170±0.085	13.369±0.555	30.028±0.657	4.518±0.073	1.060±0.004	39.789±0.727	312.250±2.929
	1-3 years (64)	11.635 ^a ±0.266	1.547 ^b ±0.108	13.693 ^a ±0.703	31.487 ^b ±0.833	4.458 ^a ±0.092	1.052 ^a ±0.005	38.825 ^a ±0.867	312.918 ^a ±2.987

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In sex wise classification mean values of all parameters of female animals have been compared with respective mean values of male animals (control).

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Hb = Haemoglobin

PCV = Packed Cell Volume

ESR = Erythrocyte Sedimentation Rate

MCHC = Mean Corpuscular Haemoglobin Concentration

Table 27 : ANOVA of haematological parameters and plasma osmolarity in sheep during different environmental temperatures, sex and age groups.

SOURCE OF VARIATIONS		Hb (g/dl)	ESR (mm/3 hrs)	ESR (mm/24 hrs)	PCV (%)	Relative Viscosity	Specific Gravity	MCHC (g/dl)	Plasma Osmolarity
Between environmental temperatures	DF	2	2	2	2	2	2	2	2
	MSS	90.237**	9.482**	1809.610**	970.812**	10.320**	0.0012 ^{NS}	174.627**	4548.992**
Within environmental temperatures	DF	152	152	152	152	152	152	152	152
	MSS	3.331	622.907	0.606	23.473	34.598	0.415	0.0014	622.907
Between sex	DF	1	1	1	1	1	1	1	1
	MSS	4.872 ^{NS}	3.310*	7.762 ^{NS}	104.731*	0.447 ^{NS}	0.0007*	140.565*	53.354 ^{NS}
Within sex	DF	153	153	153	153	153	153	153	153
	MSS	4.457	0.705	46.923	46.377	0.544	0.0014	47.427	677.951
Between age groups	DF	1	1	1	1	1	1	1	1
	MSS	1.716 ^{NS}	3.160*	1.070 ^{NS}	0.0055*	1.135 ^{NS}	0.0011 ^{NS}	34.966 ^{NS}	17.300 ^{NS}
Within age groups	DF	153	153	153	153	153	153	153	153
	MSS	4.478	0.706	46.967	47.062	0.540	0.0014	48.117	678.187

** Highly significant ($P \leq 0.01$)

* Significant ($P \leq 0.05$)

NS Non Significant ($P > 0.05$)

was in accordance with that reported by Meena *et al.* (2002) and Sharma *et al.* (1973) in sheep.

Analysis of variance also exhibited similar results as discussed for haematological parameters according to different environmental temperatures, sex and age groups.

3. SERUM METABOLITES AND ELECTROLYTES :

Mean $\pm$ SEM values of different serum metabolites *viz.* glucose, total proteins, albumin, globulin, A/G ratio, urea and creatinine are presented in table 28 and analysis of variance in table 29 and of different serum electrolytes *viz.* sodium (Na), potassium (K), Na/K ratio, chloride (Cl), calcium (Ca), phosphorus (P) and magnesium (Mg) are presented in table 30 and analysis of variance in table 31 according to different environmental temperatures, sex and age groups.

The overall mean values of serum metabolites and electrolytes in present study corroborated the earlier findings by various workers in sheep (Clark (1959); Lazer *et al.* (1967); Idris *et al.* (1976); Singh *et al.* (1979); Pyne *et al.* (1982); Chahal and Rattan (1982); Dutta (1996); Sudhan *et al.* (1996); Latif *et al.* (1997) and Kalleswarappa and Jayaprakash (1999)).

During hot environmental temperature period the mean values of all the metabolites differed nonsignificantly ($P>0.05$) from respective control mean values during moderate period. Similar observations were recorded by Kataria *et al.* (1993) in goats and they attributed it towards better adaptability of animals. During cold period the mean values of glucose, total proteins,

albumin, globulin were observed significantly ($P \leq 0.05$) increased while that of urea and creatinine were observed significantly ($P \leq 0.05$) decreased from the respective control mean values during moderate period. Latif *et al.* (1997) also observed lowered values of urea nitrogen and creatinine in sheep during winter season. However, Nawaz and Shah (1984) in sheep reported higher values of both the parameters during summer.

Chahal and Rattan (1982) found lower value of glucose during winter than summer in sheep. Shaffer *et al.* (1981) attributed decreased blood glucose during hot summer to increase in respiration rate which caused a rapid utilisation of blood glucose by the respiratory muscles. In present study when the mean values of serum glucose were compared during hot and cold period, it was found lowered during hot. In present study the albumin concentration was low during hot than cold. Sykes and Russel (1979) also observed low plasma albumin during summer in sheep.

Kataria (2002a) observed that serum proteins, urea and creatinine were higher during hot than cold condition while serum glucose was higher during cold than hot in dromedary camels.

Analysis of variance reflected highly significant ($P \leq 0.01$) and significant ($P \leq 0.05$) effects of environmental temperatures on glucose, total serum proteins, globulin, A:G ratio and urea and on albumin and creatinine, respectively.

When the mean values of serum electrolytes were assessed on the basis of environmental temperatures, it was found that mean values of sodium and chloride were found increased significantly ($P \leq 0.05$) during hot environment when compared to

Table 28 : Mean±SEM values of serum metabolites in sheep during different environmental temperatures, sex and age groups.

S. No.	Classification	Glucose (mg/dl)	Total Proteins (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G Ratio	Urea (mg/dl)	Creatinine (mg/dl)
1.	Overall (155)	70.411±0.817	6.508±0.076	3.189±0.0402	3.340±0.042	0.955±0.00014	42.379±0.859	1.122±0.120
2.	Environmental temperatures							
	Moderate (40)	69.681±1.563	6.347±0.146	3.048±0.075	3.208±0.079	0.953±0.0028	45.658±1.640	1.137±0.022
	Cold (75)	74.201 ^b ±1.131	6.899 ^b ±0.105	3.396 ^b ±0.055	3.579 ^b ±0.058	0.947 ^b ±0.0002	38.563 ^b ±1.186	1.082 ^b ±0.166
	Hot (40)	67.350 ^a ±1.61	6.277 ^a ±0.151	3.102 ^a ±0.078	3.201 ^a ±0.081	0.964 ^b ±0.0003	42.916 ^a ±1.693	1.146 ^a ±0.201
3.	Sex							
	Male (81)	71.186±1.127	6.740±0.105	3.299±0.054	3.450±0.058	0.950±0.0008	42.651±1.182	1.119±0.016
	Female (74)	69.635 ^a ±1.341	6.276 ^b ±0.125	3.072 ^b ±0.056	3.225 ^b ±0.060	0.955 ^b ±0.0008	42.107 ^a ±1.407	1.122 ^a ±0.071
4.	Age groups							
	Below 1 year (79)	71.424±1.156	6.418±0.108	3.124±0.067	3.269±0.080	0.955±0.002	43.292±1.212	1.105±0.016
	1-3 years (76)	69.397 ^a ±1.278	6.597 ^a ±0.119	3.252 ^a ±0.053	3.409 ^a ±0.055	0.953 ^a ±0.002	41.466 ^a ±1.341	1.140 ^b ±0.016

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In sex wise classification mean values of all parameters of female animals have been compared with respective mean values of male animals (control).

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Table 29 : ANOVA of serum metabolites in sheep during different environmental temperatures, sex and age groups.

SOURCE OF VARIATIONS		Glucose (mg/dl)	Total proteins (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A:G Ratio	Urea (mg/dl)	Creatinine (mg/dl)
Between environmental temperatures	DF	2	2	2	2	2	2	2
	MSS	451.463**	9.224**	1.966*	2.683**	0.0039**	681.163**	1.826*
Within environmental temperatures	DF	152	152	152	152	152	152	152
	MSS	85.447	0.964	0.229	0.250	0.0009	93.897	0.406
Between sex	DF	1	1	1	1	1	1	1
	MSS	30.006 ^{NS}	7.570**	1.890**	1.894**	0.0003**	2.303 ^{NS}	0.536 ^{NS}
Within sex	DF	153	153	153	153	153	153	153
	MSS	90.594	1.029	0.241	0.273	0.0005	102.172	0.424
Between age groups	DF	1	1	1	1	1	1	1
	MSS	142.294 ^{NS}	3.191 ^{NS}	0.750 ^{NS}	0.846 ^{NS}	0.0003 ^{NS}	2.070 ^{NS}	0.611*
Within age groups	DF	153	153	153	153	153	153	153
	MSS	89.860	1.057	0.249	0.280	0.0000	102.174	0.424

** Highly significant ($P \leq 0.01$)

* Significant ($P \leq 0.05$)

NS Non Significant ($P > 0.05$)

Table 30 : Mean±SEM values of serum electrolytes in sheep during different environmental temperatures, sex and age groups.

S. No.	Classification	Sodium (mmol/l)	Potassium (mmol/l)	Na/K ratio	Chloride (mmol/l)	Calcium (mg/dl)	Phosphorus (mg/dl)	Magnesium (mg/dl)
1.	Overall Means (155)	145.780±1.026	5.680±0.124	25.696±0.646	103.244±0.570	10.653±0.533	4.505±0.109	2.442±0.027
2.	Environmental temperatures							
	Moderate (40)	140.628±1.963	5.733±0.238	24.541±1.220	103.160±1.091	10.754±0.438	4.066±0.209	2.526±0.0521
	Cold (75)	148.042 ^b ±1.421	5.562 ^a ±0.172	26.615 ^a ±1.405	100.984 ^a ±0.790	9.830 ^b ±0.317	5.533 ^b ±0.151	2.290 ^b ±0.037
	Hot (40)	148.669 ^b ±2.028	5.745 ^a ±0.246	25.890 ^a ±1.205	105.587 ^b ±1.127	10.249 ^a ±0.453	3.916 ^a ±0.216	2.511 ^a ±0.053
3.	Sex							
	Male (81)	143.442±1.416	5.654±0.171	25.384±2.002	102.944±0.787	10.468±0.316	4.780±0.151	2.487±0.037
	Female (74)	148.117 ^b ±1.685	5.706 ^a ±0.204	25.967 ^a ±2.121	103.543 ^a ±0.937	10.087 ^a ±0.376	4.230 ^b ±0.179	2.398 ^b ±0.044
4.	Age groups							
	Below 1 year (79)	144.022±1.452	5.688±0.176	25.330±2.000	101.657±0.807	10.361±0.324	4.549±0.155	2.408±0.044
	1 to 3 years (76)	147.538 ^b ±1.605	5.673 ^a ±0.194	26.017 ^a ±1.615	104.830 ^b ±0.892	10.194 ^a ±0.358	4.461 ^a ±0.171	2.477 ^a ±0.042

(i) Mean values during cold and hot environmental temperatures of all the parameters have been compared from respective means during moderate condition (control).

(ii) In age wise classification mean values of all parameters of the animals of 1 to 3 years age group have been compared with respective mean values of animals of below 1 year age group (control).

(iii) In sex wise classification mean values of all parameters of female animals have been compared with respective mean values of male animals (control).

(iv) Means superscribed by letter "a" do not differ significantly ($P>0.05$) and letter "b" differ significantly ($P\leq 0.05$) from respective control means.

(v) Figure in the parenthesis indicate number of animals.

Table 31 : ANOVA of serum electrolytes in sheep during different environmental temperatures, sex and age groups.

SOURCE OF VARIATIONS		Sodium (mmol/l)	Potassium (mmol/l)	Na/K ratio	Chloride (mmol/l)	Calcium (mg/dl)	Magnesium (mg/dl)	Phosphorus (mg/dl)
Between environmental temperatures	DF	2	2	2	2	2	2	2
	MSS	993.316**	0.137 ^{NS}	62.955 ^{NS}	191.274*	15.635 ^{NS}	0.705**	24.530**
Within environmental temperatures	DF	152	152	152	152	152	152	152
	MSS	0.115	1.766	78.237	44.044	136.017	1.989	6.762
Between sex	DF	1	1	1	1	1	1	1
	MSS	11.650**	0.0349 ^{NS}	55.001 ^{NS}	3.667 ^{NS}	29.898 ^{NS}	0.936**	5.322**
Within sex	DF	153	153	153	153	153	153	153
	MSS	148.037	1.978	78.190	46.233	6.727	0.117	2.040
Between age groups	DF	1	1	1	1	1	1	1
	MSS	3.777*	0.0067 ^{NS}	9.250 ^{NS}	390.652**	9.703 ^{NS}	0.604 ^{NS}	1.323 ^{NS}
Within age groups	DF	153	153	153	153	153	153	153
	MSS	148.088	1.978	78.485	43.703	6.859	0.123	2.067

** Highly significant ($P \leq 0.01$)

* Significant ($P \leq 0.05$)

NS Non Significant ($P > 0.05$)

moderate. The mean values of potassium and Na/K ratio were non-significantly ($P>0.05$) higher and that of calcium, phosphorus and magnesium were nonsignificantly ($P>0.05$) lower than respective moderate mean values.

Various workers (Kamal *et al.*, 1962 and Goverdhan, 1965 in cattle; More *et al.*, 1980 in sheep; Kataria *et al.*, 1993 and Bhattacharyya, 1995 in goats; Kataria, 2002 in camels) have reported the effect of environmental temperatures on the serum electrolytes.

The results of present study showed that mean values of all the electrolytes except phosphorus were found higher during hot environment than, cold environment, mean value of phosphorus was lower during hot than cold environment. This was in agreement to the reports of Bhattacharyya *et al.* (1995) in goats and in partial agreement to that reported by Kataria (2002a) in camels.

In present study a significant ($P\leq 0.05$) increase in serum sodium during hot could be suggestive of adaptive hypernatraemia so that animals can hold more water (Yagil and Berlyne, 1976a). Hypernatraemia in dehydrated animals is a well established fact (Macfarlane, 1968; Carlson, 1979 and Dahlborn, 1997). However, in the present study the mean value of sodium was also found similar to that of hot environment and was significantly ($P\leq 0.05$) higher than moderate environment.

A significant ($P\leq 0.05$) effect of sex was observed in the mean values of total proteins, albumin and globulin, the values being higher in male animals. Mean values of glucose and urea were nonsignificantly ($P>0.05$) higher in male animals and that of

creatinine in female animals. In serum electrolytes the mean value of sodium was significantly ($P \leq 0.05$) higher in female animals while that of phosphorus and magnesium were lower in female animals in comparison to male animals. The mean values of potassium, Na/K ratio and chloride were nonsignificantly ($P > 0.05$) higher and that of calcium was nonsignificantly ($P > 0.05$) lower in female animals than male animals. However the mean value of phosphorus was significantly ($P \leq 0.05$) lower in female animals than males. Various workers (Ayoub *et al.*, 1960 in farm animals; Singh *et al.*, 1979 in sheep; Sharma *et al.*, 1990 in goats; Gaikwad *et al.*, 1992 in cattle and Kumar *et al.*, 1997 in goats) have studied the effect of sex on blood metabolites and electrolytes. The main reason of discrepancies could be different managemental aspects and physiological states of the animals (Gahlot, 1987). Analysis of variance also revealed a highly significant ($P \leq 0.01$) effect of sex on the mean values of total serum protein, albumin, globulin and A/G ratio, sodium, phosphorus and magnesium.

Effect of age was found significant ($P \leq 0.05$) for serum creatinine, sodium and chloride, the values being higher in 1 to 3 years age group. Various workers (Ayoub *et al.*, 1960 in farm animals; Lane *et al.*, 1968 in sheep; Sharma *et al.*, 1990 in goats and Gaikwad *et al.*, 1992 in cattle) have recorded the effect of age on serum metabolites and electrolytes. The differences in results were due to different time periods taken for the study and feeding regimen which affected the serum metabolites and electrolytes. Analysis of variance of metabolites and electrolytes exhibited the significant ($P \leq 0.05$) effect of age on serum creatinine, sodium and chloride.

Summary

SUMMARY

The investigation was carried out on 155 apparently healthy marwari sheep of both sex ageing 0 to 3 years to determine the renal functions during moderate, cold and hot environmental temperatures. The renal function tests were carried out in 90 male animals and included creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium clearances; transfer function of kidney; urine concentration and filtered and excreted loads of creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium. The haematological parameters (haemoglobin, erythrocyte sedimentation rate, packed cell volume, specific gravity, relative viscosity, mean corpuscular haemoglobin concentration and plasma osmolarity); serum metabolites (glucose, total protein, albumin globulin, creatinine and urea) and serum electrolytes (sodium, potassium, chloride, calcium, phosphorus and magnesium) were also determined.

The overall mean values of creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium clearances (ml/min) were 28.157 ± 1.262 , 11.387 ± 0.496 , 0.668 ± 0.027 , 14.290 ± 0.849 , 1.116 ± 0.021 , 13.022 ± 0.488 , 1.852 ± 0.051 , respectively. The mean values of all the clearances decreased during hot environment and increased during cold environment in comparison to moderate environment. Phosphorus clearance showed little variation. The mean value during cold environment did not increase than moderate mean value. The effect of age was observed on the mean values of all the clearances, values being higher in 1 to 3 years age group animals than that in below 1 year age group. Similar trend was observed when the

animals were classified age wise in different environments i.e. moderate, cold and hot.

The overall mean value of transfer function of kidney (TFK) was 0.410 ± 0.003 . The mean value decreased significantly ($P \leq 0.05$) during hot and increased significantly ($P \leq 0.05$) during cold environments when compared to moderate environmental condition. A significant ($P \leq 0.05$) age effect was found on the mean value of TFK. It was significantly ($P \leq 0.05$) higher in 1 to 3 years age group than 0-1 year age group animals. This effect of age was seen in all the environmental conditions.

The overall mean values of urine specific gravity and pH were 1.038 ± 0.0016 and 8.469 ± 0.019 , respectively. During hot environmental temperature the urine specific gravity and pH increased nonsignificantly ($P > 0.05$). During cold environmental temperature the mean values for both the parameters decreased than respective moderate mean values. The mean value of urine pH was lower in higher age group. Specific gravity was also lower in this age group, although non significantly ($P > 0.05$). This trend was maintained during moderate environmental temperature but afterwards no effect of age was seen during different environmental temperatures.

The overall mean values of filtered and excreted loads of creatinine (mg/min), urea (mg/min), sodium (mmol/min), potassium (mmol/min) chloride (mmol/min), phosphorus (mg/min) and magnesium (mg/min) were 0.308 ± 0.012 and 0.307 ± 0.0013 ; 11.767 ± 0.630 and 4.434 ± 0.164 ; 4.055 ± 0.177 and 0.095 ± 0.003 ; 0.152 ± 0.0076 and 0.071 ± 0.002 ; 2.898 ± 0.129 and 0.114 ± 0.0032 ;

1.390±0.078 and 0.575±0.014; and 0.695±0.028 and 0.044±0.0009, respectively.

During hot environmental temperature period, the filtered load and excreted load of all the constituents decreased while during cold environmental temperature the mean values increased. In age wise classification the mean values of all the filtered and excreted load were found to be increased in 1 to 3 yearss age group animals. The similar pattern was maintained when the animals were classified as per different environments according to age.

The overall mean values of various haematological parameters viz. haemoglobin (g/dl), erythrocyte sedimentation rate (mm/3 hrs. and mm/24 hrs.), packed cell volume (%), relative viscosity, specific gravity, mean corpuscular haemoglobin concentration (g/dl), plasma osmolarity (mosm/l) were 11.709±0.169, 1.358±0.068, 13.531±0.447, 30.758±0.527, 4.488±0.059, 1.056±0.005, 39.679±0.569 and 311.176±2.093, respectively.

The mean changes in haematological parameters during hot and cold environmental temperatures were compared with the mean values during moderate environmental temperature. During hot environment the mean values of all the parameters differed significantly ($P \leq 0.05$) from the respective mean values during moderate period except specific gravity which showed a non significant ($P > 0.05$) change.

Effect of sex was observed on the mean values of erythrocyte sedimentation rate, packed cell volume, specific gravity and mean corpuscular haemoglobin concentration, the values being lower in female animals except for packed cell volume which was higher in

females. No effect of sex was observed on mean value of plasma osmolarity.

Significant ($P \leq 0.05$) effect of age was observed on erythrocyte sedimentation rate and packed cell volume only, the values being higher in 1 to 3 years age group.

The overall mean values of various serum metabolites viz. glucose (mg/dl), total proteins (g/dl), albumin (g/dl), globulin (g/dl), A/G ratio, urea (mg/dl) and creatinine (mg/dl) were 70.411 ± 0.817 , 6.508 ± 0.076 , 3.189 ± 0.0402 , 3.340 ± 0.042 , 0.955 ± 0.00014 , 42.379 ± 0.859 and 1.122 ± 0.120 , respectively and of different serum electrolyte viz. sodium (mmol/l), potassium (mmol/l), Na/K ratio, chloride (mmol/l), calcium (mg/dl), phosphorus (mg/dl) and magnesium (mg/dl) were 145.780 ± 1.026 , 5.680 ± 0.124 , 25.696 ± 0.646 , 103.244 ± 0.570 , 10.653 ± 0.533 , 4.505 ± 0.109 and 2.442 ± 0.027 , respectively.

During hot environmental temperature period the mean values of all the metabolites differed non significantly ($P > 0.05$) from respective control mean values during moderate period. During cold period the mean values of glucose, total proteins, albumin, globulin were observed significantly ($P \leq 0.05$) increased while that of urea and creatinine were observed significantly ($P \leq 0.05$) decreased from the respective control mean values during moderate period.

When the mean values of serum electrolyte were assessed on the basis of environmental temperature, it was found that mean values of sodium and chloride were increased significantly ($P \leq 0.05$) during hot environment when compared to moderate. The mean values of potassium and Na/K ratio were non significantly ($P > 0.05$) higher and

that of calcium, phosphorus and magnesium were non significantly ($P>0.05$) lower than respective moderate mean values

A significant ($P\leq 0.05$) effect of sex was observed in the mean values of total proteins, albumin and globulin, the values being higher in male animals. Mean values of glucose and urea were non significantly ($P>0.05$) higher in male animals and that of creatinine in female animals. In serum electrolyte the mean value of sodium was significantly ($P\leq 0.05$) higher in female animals while that of phosphorus and magnesium were lower in female animals in comparison to male animals. The mean values of potassium, Na/K ratio and chloride were nonsignificantly ($P>0.05$) higher and that of calcium was nonsignificantly ($P>0.05$) lower in female animals than male animals. However the mean value of phosphorus was significantly ($P\leq 0.05$) lower in female animals than males. Effect of age was found significant ($P\leq 0.05$) for serum creatinine, sodium and chloride, the values being higher in 1 to 3 years age group.

Literature Cited

LITERATURE CITED

- Akhtar, P.; Nawaz, M.; Iqbal, T. and Nawaz, R. (1997). Renal clearance of creatinine, urea, para amino hippuric acid, sodium, potassium and chloride during summer and winter seasons in goats. *Vet. Archiv.* **67** : 267-275.
- Alonso, A.J.; Teresa, R.D.; Garcia, M.; Gonzalez, J.R. and Vallejo, M. (1997). The effects of age and reproductive status on serum and blood parameters in Merino breed sheep. *J. Vet. Med. A.* **44** : 223-231.
- Amer, H.A. and Alhendi, A.B. (1996). Physical, biochemical and microscopical analysis of camel urine. *J. Camel Prac. Res.* **1** : 17-21.
- Ayoub, M.H.; Awad, Y.L. and Bayyazeed, L.A. (1960). Calcium level in Egyptian farm animals. *Indian J. Vet. Sci.* **30** (1) : 43-49.
- Benlamlih, S.; Bourkaik, A. and Abouhala, A. (1985). Fluid balance in pregnant and lactating Dman ewes. Effects of litter size, protein intake and inhibition of prostaglandin synthesis. *Comp. Biochem. Physiol.* **80** : 591-597.
- Bhattacharyya, B.N.; Talukdar, S.C.; Baruah, R.N.; Baruah, K.K. (Sr.); Baruah, K.K. (Jr.) and Anubha Baruah (1995). Concentration of certain macrominerals in the serum of goat under different seasons. *Indian Vet. J.* **72** : 1222-1223.

- Bianca, W. (1970). Effect of dehydration, rehydration and over hydration on the blood and urine of oxen. *Br. Vet. J.* **126** : 121-131.
- Bianca, W.; Findlay, J.D. and McLean, J.A. (1965). Responses of steers to water restriction. *Res. Vet. Sci.* **6** : 38-55.
- Bickhardt, K. and Dungelhoff, R. (1994). Clinical examination of renal function in sheep. I. Methods and reference values of healthy animals. *Deutsche Tierärztliche Wochenschrift*. **101** : 463-466. (Vet. Bull., **66** : 279, Abst., 1936).
- Bickhardt, K.; Ganter, M. and Chavez, C.S. (1995). Clinical examination of renal function in sheep. III. Pathological changes of function in nephropathies of sheep and in urolithiosis of rams and male goats. *Deutsche Tierärztliche Wochenschrift*, **102** : 59-64. (cited from Vet. Bull. **65** (7) abst. 4695).
- Blood, D.C.; Radostits, O.M. and Henderson, J.A. (1983). *Veterinary Medicine* 6th ed. ELBS Bailliere Tindal, London.
- Bovee, K.C. and Joyce, T. (1979). Clinical evaluation of glomerular function : 24 hour creatinine clearance in dogs. *J. Amer. Vet. Med. Assoc.* **174** : 488-491.
- Carlson, G.P.; Rumbaugh, G.E. and Harrold, D. (1979). Physiologic alterations in the horse produced by food and water deprivation during periods of high environmental temperatures. *Amer. J. Vet. Res.* **40** : 982-985.

- Chahal, A.S. and Rattan, P.J.S. (1981). Seasonal variations in the contents of haemoglobin and the packed cell volume in the blood of Corriedole rams. J. Res. Punjab Agric. Univ. India, **18** : 341-344.
- Chahal, A.S. and Rattan, P.J.S. (1982). Studies on the seasonal variations of some biochemical constituents of blood in Corriedale rams. Indian Vet. J. **59** : 931-936.
- Charan, R.S.; Kataria, N. and Dhuria, D. (2002). A note on blood indices in Marwari goats. Abstract cited from souvenir and compendium of National symposium and XX ISVM convention. 249 abst. 7.18.
- Choshniak, I. and Arnon, H. (1985). Nitrogen metabolism and kidney function in the Nubian ibex (*Capra ibex nubiana*). Comp. Biochem. Physiol. **82** : 137-139.
- Chyla, M.; Vragula, L.; Miklusicak, R. and Skalka, J. (1975). A two year haematological study of young sheep. Folia Veterinaria, **19** : 379-391.
- Clark, R. (1959). A study of the plasma sodium and potassium levels of normal Merino sheep. Onderstepoort J. Vet. Res. **28** : 229-235.
- Coles, E.H. (1986). In : Veterinary Clinical Pathology. 4th ed. W.B. Saunders Company, Philadelphia.
- Dahlborn, K.; Hossaini-Hilali, J. and Benlamlih, S. (1997). Changes in fluid balance, milk osmolality and water content during

- dehydration and rehydration in two lactating camels (*Camelus dromedarius*). J. Camel Prac. Res. 4 : 207-211.
- Dale, H.E.; Burge, G.J. and Brody, S. (1956b). Environmental temperature and blood volume. Mo. Agr. Exp. Sta. Res. Bul., 608.
- Dalvi, S.H.; Mantri, A.M.; Talvelkar, B.A.; Bharucha, S.V.; Gadhave, L.R. and Ingole, S.D. (1998). Haematological studies on Indian camel (*Camelus dromedarius*) under hot humid climate of Konkan region. Indian Vet. J. 75 : 117-119.
- Das, U.; Roy, S.; Roy, B.N.; Ghosh, S.P. and Desarkar, M.K. (1997). Some blood constituents of crossbred cattle in two agro-climatic zones of West Bengal. Indian J. Anim. Hlth. 36 (1) : 11-13.
- Dutta, A.; Sarmah, S. and Raj khowa, N.K. (1996). Haemtological and biochemical studies in sheep of Assam. Indian Vet. J. 73 : 402-405.
- Edwards, B.L. (1956). A simple method for the examination of blood samples by the estimation of specific gravity. Vet. Record. 48 : 842-843.
- Elnoughty, F.D. and Hassan, G.A. (1983). Thyroid hormone status and water metabolism in Hereford cows exposed to high ambient temperature and water deprivation. Indian J. Anim. Sci. 53 : 807-812.

- English, P.B. (1966). A study of water and electrolyte balance in sheep. I. External balances of water, sodium, potassium and chloride. Res. Vet. Sci. 7 : 233-257.
- English, P.B. (1967). A study of water and electrolyte metabolism in sheep : IV. osmotic diuresis. Br. Vet. J. 123 : 123-131.
- English, P.B.; Hardy, L.N. and Holmes, E.M. (1969). Values for plasma electrolyte, osmolality and creatinine and venous P_{CO_2} in normal sheep. Amer. J. Vet. Res. 30 (11) : 1967-1973.
- Ergene, N. and Pickering, E.C. (1978). The effects of reducing dietary nitrogen and of increasing sodium chloride intake on urea excretion and reabsorption and on urine osmolality in sheep. Quart. J. Exp. Physiol. 63 : 67-76.
- Farningham, D.A.H. (1986). Comparison between the renal clearance of endogenous creatinine and inulin in sheep. Res. Vet. Sci. 41 (3) : 410-411.
- Fleming, S.A.; Hunt, E.L.; Riviere, J.E. and Anderson, K.L. (1991). Renal clearance and fractional excretion of electrolytes over four 6 hour periods in cattle. Amer. J. Vet. Res. 52 : 5-8.
- Gahlot, N. (1987). Studies on some serum enzymes in camel (*Camelus dromedarius*). M.V.Sc. thesis presented to Sukhadia University, Udaipur, Rajasthan.

- Gaikwad, N.Z.; Deshpande, S.D.; Bapat, S.T. and Deshpande, B.B. (1992). Certain blood biochemical constituents in Jersey x Red Kandhari cattle with reference to sex. *Indian J. Dairy Sci.* **45** (11) : 626-627.
- Gans, J.H. and Mercer, P.F. (1962). Effect of osmotic diuretics and vasopressin on renal function in the sheep. *Amer. J. Vet. Res.* **23** : 230-235.
- Ghosh, P.K.; Khan, M.S. and Abichandani, R.K. (1976). Effect of short term water deprivation in summer on Marwari sheep. *J. Agric. Sci. Camb.* **87** : 221-223.
- Goverdhan, C.K. (1955). (Cited by Bianca, W. 1965. *J. Dairy Res.* **32** : 291-300).
- Gribetz, D.; Loon, K.V. and Crawford, J.D. (1955). Comparison of renal endogenous creatinine and inulin clearances in rat. *Amer. J. Physiol.* **183** (3) : 401-405.
- Groot, T.D. and Aafjes, J.H. (1960). On the constancy of creatinine excretion in the urine of the dairy cow. *British Vet. J.* **CXVI**, II, 409-418.
- Grunsell, C.S. (1955). Seasonal variation in the blood and bone marrow of Scottish hill sheep. *J. Comp. Path.* **65** : 93-107.
- Guerrini, V.H.; Koster, N. and Bertchinger, H. (1980). Effect of ambient temperature and humidity on urine output in sheep. *Amer. J. Vet. Res.* **40** : 1851-1853.

- Guyton, A.C. and Hall, J.E. (1996). In "Text book of medical physiology" 9th edn. published by W.B. Saunders Comp. Philadelphia.
- Ham, T.H. and Castle, W.B. (1940). Relation of increased hypotonic fragility and of erythrostasis to the mechanisms of hemolysis in certain anaemias. Trans. Assoc. Am. Physicians **50** : 127-132.
- Harvey, D. (1963). Some aspects of the importance of buffalo as farm stock. Nutr. abst. Rev. **33** : 931.
- Harvey, W.R. (1989). User's guide on LSMLMW and MIXMDL PL2 version mixed model least squares and maximum likelihood computer programme, 4255, Mumford Drive, Columbus, Ohio, 43220, USA.
- Hernandez, T. and Coulson, R.A. (1957). Inhibition of renal tubular function by cold. Amer. J. Physiol. **188** (3) : 485-489.
- Hidiroglou, M. (1979). Trace elements deficiencies and fertility in ruminants. A review J. Dairy Sci. **62** : 1195.
- Ide, Y. (1971). Observations on plasma urea turnover and renal urea excretion in goats. Jap. J. Vet. Sci. **33** : 179-185.
- Idris, O.P.; Tartour, G. and Babiker, S.A. (1976). Blood mineral status and haematological values in sheep in the Gezire Province of Sudan. Tropical Animal Health and Production. **8** : 13.
- Igbokwe, I.O. and Abodunrin, F.O. (1990). Variations within the day in the haematological parameters of normal and water

- deprived Yankasa sheep in a hot, dry weather. *Tropical veterinarian*, 8 : 123-127.
- Itoh, N. (1989). Fractional electrolyte excretion in adult cows, establishment of references ranges and evaluation of seasonal variation. *Vet. Clin. Path.* 18 : 86-87.
- Johnson, K.G. (1971). Renal function in *Bos taurus* and *Bos indicus* – Crossbred cows under conditions of normal hydration and mild dehydration. *Res. Vet. Sci.* 12 : 438-447.
- Jorna, T. (1978). The renal blood flow in ruminants with pyloric stenosis. *Utrecht Netherlands; Fa culteit der Diergeneeskunde; Rijsuniver siteit*. 169 pp. (cited from *Vet. Bull.* 49 (4) abst. 2090).
- Kachhwaha, S. (2001). Effect of dehydration and rehydration on some renal function in goat. M.V.Sc. thesis submitted to Rajasthan Agricultural University, Bikaner Rajasthan.
- Kalita, D.J. and Mahapatra, M. (1999). Mineral profile of Black Bengal kids. *Indian Vet. J.* 76 : 1065-1066.
- Kalleswarappa and Jayaprakash (1999). Haematological profile of UAS strain of sheep. *Indian Vet. J.* 76 : 673-675.
- Kalra, D.B. and Arya, P.L. (1958). A preliminary study of the camel's urine. *Indian Vet. J.* 36 : 24-26.
- Kamal, T.H.; Johnson, H.D. and Ragsdale, A.C. (1962). *Res. Bull. Mo. Agric. Exp. Sta. No. 785*. (cited from Bianca *et al.*, 1965).

- Kaneko, J.J. (1980). Clinical Biochemistry of domestic animals. 3rd ed. Academic Press, INC London.
- Kaneko, J.J. and Cornelius, C.E. (1971). Clinical biochemistry of domestic animals. 2nd edn., Vol. II., Academic Press, New York.
- Kataria, A.K.; Kataria, N. and Ghosal, A.K. (1992). Haematological changes associated with season in Marwari goats. Indian Vet. J. 69 : 552-554.
- Kataria, A.K.; Kataria, N.; Bhatia, J.S. and Ghosal, A.K. (1993). Blood metabolic profile of Marwari goats in relation to seasons. Indian Vet. J. 70 : 761-762.
- Kataria, N. (2000). Hormonal and renal regulation of fluid retention in dromedary camel. A Ph. D. Thesis submitted to C.C.S., Haryana Agricultural University, Hissar.
- Kataria, N.; Kataria, A.K.; Agarwal, V.K.; Garg, S.L. and Sahni, M.S. (2001a). Changes in certain blood indices due to long term seasonal water deprivation and rehydration in dromedary camel. Inter. J. Anim. Sci. 16 (2) : 269-275.
- Kataria, N.; Kataria, A.K.; Agarwal, V.K.; Garg, S.L. and Sahni, M.S. (2001b). Filtered and excreted loads of urea in different climatic conditions and hydration states in dromedary. J. Camel Prac. Res. 8 (2) : 203-207.
- Kataria, N.; Kataria, A.K.; Agarwal, V.K.; Garg, S.L. and Sahni, M.S. (2002a). Effect of long term dehydration on serum

- constituents in extreme climatic conditions in camel (*Camelus dromedarius*). Indian J. Physiol. Pharmacol. 46 (2) : 218-222.
- Kataria, N.; Kataria, A.K.; Agarwal, V.K.; Garg, S.L. and Sahni, M.S. (2002b). Effect of seasonal water restriction on erythrocytic and leucocytic indices in camel. Indian J. Anim. Hlth. 41 (1) : 24-28.
- Kaufman, C.F. and Bergman, E.N. (1978). Renal function studies in normal and toxæmic pregnant sheep. Cornell Vet., 68 : 124-137.
- Kaushish, S.K.; Bhatia, D.C. and Arora, K.L. (1976). Studies on adaptability of sheep to sub-tropical climate and seasonal changes in rectal temperature, cardiorespiratory and haematological attributes of Nali sheep. Indian Vet. J. 53 : 760-765.
- Khan, M.S.; Sasidharan, T.O. and Ghosh, P.K. (1979). Glomerular filtration rate and blood and urinary urea concentrations in Barmer goats of Rajasthan desert. J. Agri. Sci. Camb. 93 : 247-248.
- Knudsen, E. (1959). Renal clearance studies on the horse. I. Inulin, endogenous creatinine and urea. Acta. Vet. Scand. 1 : 52-66.
- Kohn, C.W. and Strasser, S.L. (1986). 24 hours renal clearance and excretion of endogenous substances in the mare.

- Kumar, B. and Pachauri, S.P. (2001). A note on plasma creatinine in crossbred dairy cattle at medium elevation of Central Himalayas. *Indian Vet. J.* **78** : 253-254.
- Kumar, N.; Rastogi, S.K.; Singh, S.P. and Tyagi, S.K. (1997). Variations in leucocytic count and some plasma biochemical constituents due to age and sex in Gaddi goats. *Indian J. Anim. Sci.* **67** (4) : 312-313.
- Labouche, C. (1970). Renal excretion of urea by tropical domestic animals. Relationship between uraemia and renal excretion of urea in cattle. *Annls. Biol. Anim. Biochem. Biophys.* **10** : 143-150. (cited from *Vet. Bull.* **40** (6) abst 5380).
- Lane, A.G.; Campbell, J.R. and Krause, G.F. (1968). Blood mineral composition in ruminants. *J. Anim. Sci.* **27** (3) : 766-770.
- Latif, H.A.E.; Ismail, E.; Salem, M.H. and Hassan, G.A. (1997). Effect of dehydration on some biochemical constituents of blood in Barki, Suffolk and their crossbred sheep. *Indian J. Anim. Sci.* **67** : 786-791.
- Laurence G. and Wesson, Jr. (1954). A Theoretical analysis of urea excretion by the mammalian kidney. *Amer. J. Physiol.* **179** : 364-371.
- Lazer, J.; Rushik, V.; Machyick, V. and Jeneik, F. (1967). Effect of diet on some minerals in serum of sheep. *Folia Vet. Kosice* **11** : 19-29.

- Leng, L. and Szanyiova, M. (1987). Renal retention of urea in sheep. *Veterinarni Medicina*, **32** : 201-208. (cited from Vet. Bull. **57** (12) abst. 8088).
- Lewis, G. (1961). Renal excretion of creatinine in the rat. *Amer. J. Physiol.* **200** (1) : 167-169.
- Livingston, H.G.; Payne, W.J.A. and Friend, M.T. (1962). Urea excretion in ruminants. *Nature Lond.* **194** : 1057.
- Macfarlane, W.V.; Morris, R.J.H. and Howard, B. (1956). The water economy of tropical Merino. *Nature*, **178** : 304-305.
- Macfarlane, W.V.; Morris, R.J.H. and Howard, B. (1958). Heat and water in tropical Merino sheep. *Aust. J. Agri. Res.* **9** : 217-228.
- Macfarlane, W.V. (1968). Comparative functions of ruminants in hot environments. In : Hafez, Adaptation of domestic animals. Lea and Febiger, Philadelphia.
- Maloiy, G.M.O. and Taylor, C.R. (1971). Water requirements of African goats and haired sheep. *J. Agric. Sci. Camb.* **77** : 203-208.
- Mazumder, N.K.; Lal, M.; Mazumder, A. and Goswami, K.K. (1982). Studies on normal values of some blood parameters and factors influencing them in Indian Pashmina goats. *Indian J. Anim. Sci.* **52** (11) : 1052-1055.
- McDonald, L.e. (1980). In : Veterinary Endocrinology and Reproduction. 3rd ed. Lea and Febiger, Philadelphia.

- McKinley, M.J.; Denton, D.A.; Nelson, J.F. and Weisinger, R.S. (1983). Dehydration induces sodium depletion in rat, rabbits and sheep. *Amer. J. Physiol.* **245** : 287-292.
- Meena, R.; Kataria, N. and Dhuria, D. (2002). A study on normal blood indices in sheep. Abstract cited from souvenir and compendium of National symposium and XX ISVM convention : 248 Abst. 7.17.
- Mehrotra, P.N. and Mullick, D.N. (1959). Studies on physiological ractions of sheep. II. Seasonal variation in the blood composition. *Indian J. Vet. Sci.* **29** : 62.
- Meintjes, R.A. and Engelbrecht, H. (1994). The effect of short term dehydration on kidney function, plasma renin concentration, faecal water loss and total body water in sheep. *South Afri. J. Sci.* **90** : 27-32.
- Meyer, J.H.; Weir, W.C. and Smith, J.D. (1955). *J. Anim. Sci.* **14** : 160. (cited from Livingston *et al.*, 1962).
- Michell, A.R.; Moss, P.; Hill, R.; Vincent, I.C. and Noakes, D.E. (1988). The effect of pregnancy and sodium intake on water and electrolyte balance in sheep. *Br. Vet. J.* **144** : 151-157.
- Moldoven, N.A.; Pop, A.; Danieleescu, N. and Ghergariu, S. (1979). Metabolic profile of the cow. III. Seasonal effects on some values. *Revista. de Cresterea Animalelor.* **29** : 51-56.

More, T. and Rawat, J.S. (1984). Plasma electrolytes of HK and LK sheep given long term intermittent watering under semi arid conditions. *Indian Vet. J.* **61** : 837-841.

More, T. and Sahni, K.L. (1979). Effect of long-term intermittent watering on some blood and urine attributes of pregnant sheep under semi-arid conditions. *Indian J. Anim. Sci.* **49** (7) : 549-553.

More, T. and Sahni, K.L. (1979). Some haematological changes during three months after birth of Chokla lambs under semi-arid conditions. *Indian Vet. J.* **56** : 646-649.

More, T.; Rai, A.K. and Singh, M. (1980). Note on certain biochemical responses of sheep and goats exposed to thermal stress. *Indian J. Anim. Sci.* **50** : 1012-1014.

Mousa, H.M.; Ali, K.E. and Hume, I.D. (1983). Effects of water deprivation on urea metabolism in camels, desert sheep and desert goats fed dry desert grass. *Comp. Biochem. Physiol.* **74a** : 715-720.

Mullick, D.N. (1964). Review of investigations on the physiology of Indian buffaloes. *Indian J. Dairy Sci.*, **17** : 45.

Nafeesa, A.; Rashid, A.; Iqbal, T.; Munir, A.S. and Nawaz, M. (1999). Disposition kinetics, renal clearance and urinary excretion of kanamycin in goats. *Veterinoasrski Archiv.* **69** (5) : 251-260.

- Nawaz, M. and Shah, B.H. (1984). Renal clearance of endogenous creatinine and urea in sheep during summer and winter. *Res. Vet. Sci.* **36** : 220-224.
- Nawaz, M.; Iqbal, T. and Nawaz, R. (1988). Geonetical considerations in disposition kinetics evaluation of chemotherapeutic agents. *Vet. Pharmacol Toxicol. and Therapy of food producing Animals. Vol. 2, Proc. 4th Cong. Europ Assoc. Vet. Pharm. Therap. Budapest.* p. 260.
- Ndibualonji, B.B.; Rodriguez, M.N.; Dehareng, D.; Cirio, A. and Godeau, J.M. (1998). Effects of late pregnancy and early lactation on renal urea handling in Corriedale ewes. *J. Agric. Sci.* **130** : 213-216.
- Nicpon, J. (1983c). Pathogenesis and diagnosis of dehydration and rehydration status in sheep. *Deutsche Tierarztliche Wochenschrift.* **90** : 13-20. (cited from *Vet. Bull.* **53** (6) abst. 5990).
- Nigam, R.; Patel, A.V.; Sureshkumar, P.K.; Patel, D.M. and Mehta, V.M. (1990). A study on the levels of serum calcium and phosphorus during oestrous cycle in Surti and Marwari goats (1990). *Indian J. Anim. Res.* **24** (1) : 52-54.
- Olsson, K. and Dahlborn, K. (1989). Fluid balance during heat stress in lactating goats. *Quart. J. Exp. Physiol.* **74** : 645-659.
- Osbaldiston, G.W. and Moore, W.E. (1971). Renal function tests in cattle. *J. Amer. Vet. Med. Assoc.* **159** : 292-301.

- Oser, B.L. (1976). In : Hawk's physiological chemistry. 14th ed. Tata McGraw-Hill Publishing Co. Ltd., NewDelhi.
- Pandey, M.D. and Roy, A. (1969). Studies on the adaptability of buffaloes to tropical climate. I. Seasonal changes in the water and electrolyte status of buffalo-cows. Indian J. Anim. Sci. 39 : 367-377.
- Pandiya, S.C.; Dwarkanath, P.K. and Rathore, S.S. (1977). Ibid., 54 : 130. (cited by Shrikhande and Sarode, 1999).
- Pareek, S. (2001). Effect of water restriction on body fluids and blood indices in goat. M.V.Sc. thesis presented to Rajasthan Agricultural University, Bikaner, Rajasthan.
- Parry, H.B. and Taylor, W.H. (1955a). Renal clearances of creatinine and p-amino-hippuric in normal pregnancy and toxemia of pregnancy. Proc. Physiol. Soc. 54-55.
- Parry, H.B. and Taylor, W.H. (1955b). Renal function in sheep during normal and toxemic pregnancies. J. Physiol. 131 : 383-392.
- Potter, B.J. (1963). The effect of saline water on kidney tubular function and electrolyte excretion in sheep. Aust. J. Agric. Res. 14 : 518-528.
- Puri, G. (2001). Assessment of renal efficiency during water deprivation and rehydration in goat. M.V.Sc. thesis presented to Rajasthan Agricultural University, Bikaner, Rajasthan.

- Purohit, G.R. (1972). Effects of various degrees of water restriction on physiological functioning of desert sheep breeds. Ph.D. Thesis submitted to Univ. of Jodhpur, Rajasthan, India.
- Purohit, G.R. (1979). Water metabolism in desert sheep breed some physiological responses of dehydration and rehydration in pure and cross bred desert sheep. *Trans. Isdt. and Ucdr.* 4 : 34-36.
- Purohit, G.R.; Ghosh, P.K. and Taneja, G.C. (1972). Water metabolism in desert sheep. *Aust. J. Agric. Res.* 23 : 685-691.
- Pyne, A.K.; Duttagupta, R. and Maitra, D.N. (1982). Physiological studies on blood of goats. *Indian Vet. J.* 59 : 597-599.
- Rabinowitz, L. and Gunther, R.A. (1972a). Renal concentrating ability in sheep during urea, mannitol and methylurea diuresis. *Amer. J. Physiol.* 222 (4) : 801-806.
- Rabinowitz, L.; Gunther, R.A. and Sarason, R.L. (1979). Renal sodium and potassium excretion in sheep given amiloride. *Amer. J. Vet. Res.* 40 (5) : 688-691.
- Rajkhowa, S. and Hazarika, G.C. (2000). Clinico-biochemical studies on the effect of water deprivation on goats under hot climatic conditions. *Indian Vet. J.* 77 : 856-858.
- Ram Prabhu, R. and Dhanapalan, P. (1999). Comparative blood profile of sheep in the hilly tract of TamilNadu. *Inter. J. Anim. Sci.* 14 (2) : 255-257.

- Ranade, V.G.; Joshi, N.P. and Pradhan, S. (1975). In : A text book of practical physiology. P.V.G. Prakashan, Poona.
- Rastogi, S.K. and Singh, S.P. (1990). Normal hemogram and blood analytes of mountain Gaddi goats. Indian J. Anim. Sci. 60 (11) : 1338-1339.
- Rawlings, C.A. and Bisgard, G.E. (1975). Renal clearance and excretion of endogenous substance in the small pony. Amer. J. Vet. Res. 36: 45-48.
- Reece, W.O. (1996). The kidneys (Cited from Swenson and Reece, 1996).
- Robinson, T.; Harbison, M. and Bovee, K.C. (1974). Influence of reduced renal mass on tubular secretion of creatinine in the dog. Amer. J. Vet. Res. 35 : 487-491.
- Rodriguez, M.N.; Tebot, I.; Le Bas, A.; Nievas, C.; Leng, L. and Cirio, A. (1996). Renal functions and urea handling in pregnant and lactating Corriedale ewes. Can. J. Anim. Sci. 76 : 469-472.
- Schalm, O.W. (1965). Veterinary Haematology, 2nd edition Lea and Febiger, Philadelphia.
- Schalm, O.W.; Jain, N.C. and Carroll, E.J. (1975). In : Veterinary Haematology. 3rd edn.; Lea and Febiger, Philadelphia.
- Schlerka, G.; Baumgartner, W. and Wehrle, A. (1996). Value of urinary pH for interpreting acidaemia in unweaned calves

- with diarrhoea. *Tierarztliche umschau*. **51** : 96-99. (cited from Vet. Bull. **66** (6) abst. 3917).
- Schmidt-Nielsen, B. and Osaki, H. (1958). Renal response to changes in nitrogen metabolism in sheep. *Amer. J. Physiol.* **193** : 657-661.
- Schmidt-Nielsen, B. and Pfeiffer, E.W. (1970). Urea and urinary concentrating ability in the mountain beaver *Aplodontia rufa*. *Amer. J. Physiol.* **218** (5) : 1370-1375.
- Schmidt-Nielsen, B.; Osaki, H.; Murdaugh, H.V. and O'dell, R. (1958). Renal regulation of urea excretion in sheep. *Amer. J. Physiol.* **194** : 221-228.
- Schmidt-Nielsen, B.; Schmidt-Nielsen, K.; Houpt, T.R. and Jarnum, S.A. (1957b). Urea excretion in camel. *Amer. J. Physiol.* **188** (3) : 477-484.
- Schwartz, H.M. (1967). The rumen metabolism of non-protein nitrogen. In urea as a protein supplement, Briggs, M.H., editor, Pergamon Press Inc., London, 95-109.
- Shaffer, L.; Roussel, J.D. and Koonce, K.L. (1981). Effects of age, temperature-season and breed on blood characteristics of dairy cattle. *J. Dairy Sci.* **64** : 62-70.
- Shaikh, I.D. (2000). Effect of age and sex on haematological parameters in Beetal x Osmanabadi crossbred goats. *Indian Vet. J.* **77** : 389-392.

- Sharma, B.; Biswas, J.C. and Lal, M. (1990). Some biochemical parameters in serum of Cheghu goats. *Indian J. Anim. Sci.* **60** (11) : 1340-1341.
- Sharma, D.P.; Malik, P.D. and Sapra, K.L. (1973). Age-wise and species-wise haematological studies in farm animals. *Indian J. Anim. Sci.* **43** (4) : 289-95.
- Shrikhande, G.B. and Sarode, D.B. (1999). Haemato-biochemical level in cows of Different age groups. *Indian Vet. J.*, **76** : 26-28.
- Singh, L.B.; Dwarkanath, P.K.; Rakhimov, A. and Prasad, S.P. (1979). Blood electrolytes (K and Na) and Hb. variants in Karakul sheep. *Indian Vet. J.* **56** : 554-556.
- Singh, N. and Taneja, G.C. (1978). Studies on the effect of prolonged water deprivation on Marwari sheep under arid condition. *Haryana Agric. Univ. J. Res.* **8** : 136-142.
- Smith, H.W. (1951). In : The kidney. Structure and function in health and disease. Oxford University Press, New York.
- Snedecor, G.W. and Cochran, W.G. (1967). In : statistical methods 6th ed. Oxford and IBH Pub. Co., New Delhi.
- Somvanshi, R.; Biswas, J.C.; Sharma, B. and Koul, G.L. (1987). Haematological studies in Indian Pashmina goats. *Res. vet. Sci.* **42** (1) : 124-126.
- Spipple, W.L. (1958). Specific gravity of blood and plasma. *Vet. Med.* **53** : 514-518.

- Steel, R.G.R. and Torrie, J.H. (1980). In : Principles and procedures of statisticals, A biometrical approach, 2nd edn. McGraw Hill, Inc. Kogakusha Ltd., New Delhi.
- Stone, H.O.; Thompson, H.K. and Schmidt-Nielsen, K. (1968). Influence of erythrocytes on blood viscosity. Amer. J. Physiol. **214** (4) : 913-918.
- Stufflebeam, C.E.; Wilson, L.L.; Mayer, D.T.; Day, B.N.; Comfort, J.E. and Lasley, J.E. (1964). Seasonal variations in levels of some chemical and haematological componants in the blood of Hereford cows. Mo. Agric. Exp. Sta. Res. Bull. 859.
- Sudhan, N.A.; Risam, K.S.; Bucho, B.A. and Azmi, S. (1996). Blood profile of exotic sheep in Kashmir. Indian Vet. J. **73** : 1039-1041.
- Swenson, M.J. and Reece, W.O. (1996). In : Duke's Physiology of Domestic Animals. 11th edn., Panima Publishing Corp., New Delhi.
- Sykes, A.R. and Russel, A.J.F. (1979). Seasonal variation in plasma protein and urea nitrogen concentrations in hill sheep. Res. Vet. Sci. **27** : 223-229.
- Takarkhede, R.C.; Gondane, V.S.; Kolte, A.Y. and Rekhate, D.H. (1999). Biochemical profile during different phases of reproduction in ewes in comparison to rams. Indian Vet. J. **76** : 205-207.

- Thornton, R.F. (1970). Factors affecting the urinary excretion of urea nitrogen in cattle. I. sodium chloride and water loads. Aust. J. Agric. Res. **21** : 131-144.
- Thornton, R.F. and Yates, N.G. (1969). Some effects of water restriction on nitrogen metabolism of cattle. Aust. J. Agric. Res. **20** : 185-190.
- Udalove, M.N.; Naisebekov, N. and Pak, T.A. (1981). Blood values of Karakul sheep in relation to seasons of the year. Referativnyi zhurnal. **58** : 172.
- Usami, S.; Chien, S. and Gregersen, M.I. (1969). Viscometric characteristics of blood of the elephant, man, dog, sheep and goat. Amer. J. Physiol. **217** : 884-890.
- Vaidya, M.B.; Vaghari, P.M. and Patel, B.M. (1970). Haematological constituents of blood of goats. Indian Vet. J. **47** : 642-647.
- Varley, H. (1988). In : Practical clinical Biochemistry, 4th edn. (Indian) CBS, Publishers.
- Vercoe, J.E. (1967). Breed and nutritional effects on the composition of faeces, urine and plasma from Hereford and Brahman x Hereford steers fed on high and low quality diets. Aust. J. Agric. Res. **18** : 1003-1013.
- Warner, A.C.I. and Stacy, B.D. (1965). Solutes in the rumen of sheep. Quart. J. Exptl. Physiol. **50** : 169-184.

- Weeth, H.J. and Haverland, L.H. (1961). Tolerance of growing cattle for drinking water containing sodium chloride. *J. Anim. Sci.* **20** : 518-521.
- Williams, J.H. and Pickering, E.C. (1980). Effects of an intravenous infusion of hydrochloric acid on renal function in sheep. *Res. Vet. Sci.* **28** : 347-350.
- Yagil, R. (1985). In : The desert camel. Comparative physiological adaptation. Karger, Brasil, Paris, London, New York.
- Yagil, R. and Berlyne, G.M. (1976a). Sodium and potassium metabolism in the dehydrated and rehydrated Bedouin camel. *J. Appl. Physiol.* **41** : 457-461.
- Yagil, R. and Berlyne, G.M. (1978). Glomerular filtration rate and urine concentration in camel in dehydration. *Renal Physiol.* **1** : 104-112.
- Yesberg, N.E.; Henderson, M. and Budtz-Olsen, O.E. (1979). Inhibition of angiotensin II of some vasopressin effects of renal function in sheep. *Quart. J. Exp. Physiol. and Cognate Med. Sci.* **64** : 161-168.
- Zatzman, M.L.; Clarke, L.; Ray, W.J.; Garner, H.E. and Traver, D. (1982). Renal function of the poney and the horse. *Amer. J. Vet. Res.* **43** : 608-612.

Abstract

EFFECT OF CHANGES IN ENVIRONMENTAL TEMPERATURES ON SOME RENAL FUNCTIONS IN SHEEP

M.V.Sc. Thesis

**DEPARTMENT OF VETERINARY PHYSIOLOGY
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ABSTRACT

The present investigation was carried out in 155 apparently healthy marwari sheep of both sex ageing 0 to 3 years to determine the renal functions during moderate, cold and hot environmental temperatures. The renal function tests were carried out in male animals by using specially designed urine bags to collect the urine.

The renal function tests included renal clearances *viz.* creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium; transfer function of kidney (TFK), urine concentration test and filtered and excreted loads of some serum constituents *viz.* creatinine, urea, sodium, potassium, chloride, phosphorus and magnesium. Some haematological parameters *viz.* haemoglobin, erythrocyte sedimentation rate, packed cell volume, relative viscosity, mean corpuscular haemoglobin concentration and plasma osmolarity, serum metabolites *viz.* glucose, protein, creatinine and urea and serum electrolytes *viz.* sodium, potassium, chloride, phosphorus, calcium and magnesium were also determined. The effect of age was also studied on all the above mentioned parameters while the effect of sex was recorded only for haematological parameters, serum metabolites and electrolytes.

The effect of changes in environmental temperature was observed on renal function tests. The mean values of all the clearances, transfer function of kidney, urine volume and filtered and excreted loads were found to be decreased.

during hot environmental temperature in comparison to moderate environment. During cold environment the mean values increased. Effect of age was also observed on the mean values of various renal function tests, the mean values being higher in 1 to 3 years age group.

During hot environment a rise was observed in the mean values of haemoglobin, packed cell volume, relative viscosity and plasma osmolarity. The mean value of erythrocyte sedimentation rate decreased. Effect of sex was observed on the mean values of erythrocyte sedimentation rate, packed cell volume, specific gravity and mean corpuscular haemoglobin concentration, the values being lower in female animals except packed cell volume which was higher in females. During hot environmental temperature the mean values of sodium and chloride were found increased significantly ($P \leq 0.05$). The effect of sex was observed on the mean values of some of electrolytes and metabolites.

भेड़ के वृक्कीय कार्यों पर वातावरणीय तापमानों में परिवर्तनों का प्रभाव

स्नातकोत्तर शोध ग्रंथ
पशु शरीर क्रिया विज्ञान विभाग,
पशु चिकित्सा एवं पशु विज्ञान महाविद्यालय,
बीकानेर

प्रस्तुतकर्ता :

रमेश चन्द मीना

उपादेष्टा :

डॉ. नलिनी कटारिया

अनुक्षेपण

मध्यम, शीत एवं गर्म वातावरणीय तापमानों के दौरान वृक्कीय कार्यों का अन्वेषण 155 स्वस्थ, दोनों लिंग एवं 0 से 3 वर्ष उम्र की मारवाडी भेड़ों में किया गया। मूत्र संग्रहण के लिए विशेषतौर से तैयार मूत्र थैली का उपयोग करते हुए वृक्कीय कार्यों का अन्वेषण नव जानवरों में किया गया।

वृक्कीय कार्य परीक्षणों में वृक्कीय शुद्धीकरण जैसे कि क्रिएटीनीन, यूरिया, सोडियम, पोटेशियम, क्लोराइड, फास्फोरस और मैग्नीशियम, वृक्कों का स्थानान्तरण कार्य, मूत्र सान्द्रता परीक्षण एवं कुछ रक्तोद घटकों जैसे क्रिएटीनीन, यूरिया, सोडियम, पोटेशियम, क्लोराइड, फास्फोरस और मैग्नीशियम का छनित एवं उत्सर्जित भारों को शामिल किया गया। कुछ रक्त राशियाँ जैसे कि हीमोग्लोबीन, लाल रक्त कणिका जमाव दर, कोशिकीय जमाव आयतन, आपेक्षिक ह्यान्ता, मीन कार्पस्कूलर हीमोग्लोबीन कन्सन्ट्रेशन एवं प्लाज्मा ओस्मोलैरिटी, रक्तोद चयापचय के घटकों जैसे कि शर्करा, प्रोटीन, क्रिएटीनीन एवं यूरिया और रक्तोद लवणों जैसे कि सोडियम, पोटेशियम, क्लोराइड, फास्फोरस, कैल्शियम एवं मैग्नीशियम का भी आकलन किया गया।

वृक्कीय कार्यों पर वातावरणीय तापमानों में परिवर्तनों के प्रभाव का पता लगाया गया। वृक्कीय शुद्धीकरण, स्थानान्तरण कार्य, मूत्र आयतन और छनित एवं उत्सर्जित भारों की औसत मात्राएँ मध्यम तापमान की तुलना में गर्म तापमान में घटी। ठण्डे वातावरणीय तापमान के दौरान औसत मात्राएँ बढ़ी हुई पायी गई। विभिन्न वृक्कीय कार्यों की औसत मात्राओं पर उम्र के प्रभाव का भी अध्ययन किया गया। 1 से 3 वर्ष के उम्र समूह में उपरोक्त की औसत मात्राएँ अधिक थी।

गर्म तापमान के दौरान हीमोग्लोबीन, कोशिकीय जमाव आयतन, आपेक्षिक श्यानता एवं प्लाज्मा ओस्मोलैरिटी बढ़ी हुई पायी गयी। लाल रक्त कणिका जमाव दर की औसत मात्रा घटी। लाल रक्त कणिका जमाव दर, कोशिकीय जमाव आयतन, विशिष्ट गुरुत्व और मीन कार्पस्कूलर हीमोग्लोबीन कन्सन्ट्रेशन की औसत मात्राओं पर लिंग का प्रभाव देखा गया, कोशिकीय जमाव आयतन के अलावा सभी मात्राएँ मादा जानवरों में कम थी।

गर्म तापमान के दौरान सोडियम एवं क्लोराइड की औसत मात्राएँ महत्वपूर्ण ढंग से बढ़ी हुई पायी गयी। कुछ रक्तोद लवणों एवं चयापचय घटकों की औसत मात्राओं पर लिंग का प्रभाव देखा गया।