Vol 18 No 1, p 145-153

SEASONAL CHANGES IN THE ANATOMY OF TESTIS OF ONE-HUMPED CAMEL (*Camelus dromedarius*)

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ABSTRACT

Present study was conducted during 4 seasons of the year, to record seasonal morphological and ultrastructural changes in the testis of one-humped camels. Studies were conducted on slaughter house material collected from 24 healthy mature camels (6 samples during each season of the year) as well as on 12 biopsy samples of testicular tissue of mature male camels (6 in each breeding and non-breeding season) kept under traditional management conditions for the study period. Tissues were processed using standard histological procedures for light and transmission electron microscopic studies using paraffin and spur embedding tissue techniques. Morphometrical studies showed that the volume, weight of the testis, average diameter of sertoli cells, volume of intertubular compartment, relative volume of leydig cells, total volume of leydig cells, numbers of leydig cells $\times 10^9$ per testis and % intertubular tissue in the parenchyma of testis, were significantly ($P<0.01$) higher during the winter and spring seasons. However, percentage area occupied by the seminiferous tubules, seminiferous tubule per cent / interstitium, the volume occupied by the seminiferous tubules and diameter of seminiferous tubules were found to be statistically significantly ($P<0.01$) higher during summer and autumn. Ultrastructural studies showed highly active leydig and sertoli cells during breeding season (cytoplasm was having abundant and well developed smooth endoplasmic reticulum (SER), more oval to elongate mitochondria and few fat droplets) and the opposite was true during non-breeding season.

Key words: Morphometry, one humped camel, seasonal, testis, ultrastructure

Reproductive activity and testicular morphology of one-humped camel appears to be influenced by the season of year (Volcani, 1957; Abdel-Raouf *et al,* 1975; Singh and Bharadwaj, 1978; Tingari *et al,* 1984; Friedlander *et al,* 1984; Tingari 1989; Zayed *et al,* 1995). These seasonal changes are further influenced by the geographical location, pasture availability and climatic conditions (Lodge and Salisbury, 1970).

The histology of testes of dromedary camel is well studied (Masood, 2007; Degen and Lee, 198; Tingari and Moniem, 1979; Bedrak *et al,* 1983; Osman and Ploen, 1986b).

Pakistan has 4 seasons: a cool, dry winter from December through February; a hot, dry spring from March through April; the summer rainy season, or southwest monsoon period, from May through September; and the retreating monsoon period of October and November. Sexual activity of male (rut) and female camel (heat) occur during the winter season (December to March) in Pakistan (Wahid and Yasin, 1957). The testicular weight and size significantly ($P<0.01$) increase during the breeding season (Masood, 2007). The diameter of seminiferous tubules to be smaller in the period of cooler months or rutting season in Suadi Arabia (Tingari *et al,* 1984). However, other authors reported increase in the diameter of seminiferous tubules during the rutting season (Abdel-Raouf *et al,* 1975). Zayed *et al* (1995) reported seasonal histological and ultrastructural changes in the interstitial connective tissue of the slaughterhouse sampled testes of camels in Egypt. However, seasonal changes in the seminiferous tubules are still dubious as reported by Abdel-Raouf *et al* (1975) and Tingari *et al* (1984). The seasonal morphological changes further influenced by the geographical location and climate of the area (Lodge and Salisbury, 1970).

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Hence, this study was designed to investigate the seasonal morphometric and ultrastructural changes in the interstitium and seminiferous tubule of testis of the indigenous camel in the natural ecology of Punjab, Pakistan.

Materials and Methods

Animals

Morphometrical studies were conducted on slaughter house material collected from 24 adult, healthy camels. Six samples were collected during each season of the year. Besides, 12 samples were collected by biopsy of testicular tissue of mature male camels kept under traditional management conditions for the study period (6 in each breeding and non-breeding season) for ultrastructural investigations.

Morophometrical evaluation collected testes were weighed with the electrical, after removal of the tunica vaginalis and epididymis. Small pieces of the tissue, approximately 5 mm thick, were taken from the middle portion of the testis and placed in Bouin's fixative solution till processed for paraffin embedding technique as described by Bancroft and Stevens (1990). Morphometric parameters were worked out using the following formulae:

Testicular volume was determined by using the formula described by Johnson and Neaves (1981):

$$\text{Testicular volume } (cm^3) = \text{Testis weight (g)} / \text{Testis density (1.052)}$$

Tissue sectioning was performed by rotary microtome; 5 µm thick sections were stained with haematoxylin and eosin for morphometric studies under light microscope.

The volume occupied by 10 seminiferous tubules cross sections was calculated by the formula described by Moura and Erickson (1997):

$$Vst = \pi \times h \times (d^2/4)$$

Where h was the section thickness (5µm) and d was the tubule diameter (µm)

The percentage of testicular volume occupied by seminiferous tubules (%ST) and interstitium was determined using Chalkley's method (1943) which was based on 600 ″hits″ taken at random within a cross section of the testes.

Crude number of sertoli cells per testis was determined by the formula:

$$\text{Crude number} = (V \times \%ST \times C) / (Vst \times 10)$$

Where, V= Volume of testis, % ST= Percentage of testicular volume occupied by seminiferous tubules, Vst= volume occupied by seminiferous tubules

Actual number of sertoli cells per testis was worked out by using crude number of sertoli cells per testis by Abercrombie's formula (1946):

Actual number = Crude number × section thickness / (section thickness + average nucleolar diameter in microns)

The relative volume of leydig cells in the intertubular tissue (VLc %) was the percentage of 30 hits taken at random in each of 20 fields of view of interstitium space (600 ″hits″ per animal).

The volume of intertubular compartment was estimated by testis volume × percentage of the testis occupied by the interstitium. Total volume of leydig cells per testis was determined by multiplying VLc% times intertubular volume.

The volume of an individual leydig cell was determined by the formula:

$$Lc = (4/3) \times \pi \times D^3$$

Where D is the average diameter (µm) of leydig cells

Number of leydig cells per testis was determined by dividing TVLc by the volume of a single leydig cell. Dividing this number by testis mass (g) was given the numerical density of leydig cell population.

Ultrastructural Studies of the Testis

Freshly prepared Pipes Buffer [0.2M] (Piperzine-N, N-bis [2-ethanesulfonic acid]) was used. Glutaraldehyde 5 % solution was used for fixation of tissues. Osmium Tetroxide [0.2%] solution was used as second fixative. Uranyl Acetate 5% stain was used to enhance electron density and facilitate studying cell organelles. Standard procedure was followed for dehydration using graded ethanol, acetone and embedded in spur resin.

ERL / VCD 4206 (Vinylcyclohexene dioxide)	10 Parts
DER736 (diglycidyl ether of propylene glycol)	6
NSA (Nonyl succinic anhydride)	26
S1 (Dimethylaminoethanol)	0.4

Testicular biopsies were obtained by surgical procedure over a year during breeding and non-breeding season from adult camels after injecting epidural anesthesia (1 ml of Xylazine hydrochloride and 4 ml of Lignocaine 2%) at sacrococcygeal space using 18-G needle. Samples were fixed in the primary fixative of 5% glutaraldehyde prepared in 0.2 M pipes buffer, pH 6.8. Small blocks of tissues were

cut out and subjected to vacuum in order to remove the fixative. Rinsing of the samples to remove the fixative was performed in 0.2 M pipes buffer pH 6.8 3 times with an interval of 15 minutes each. Tissues were post fixed in 1% osmium tetroxide for 18 hrs at room temperature. The tissues were washed with autoclaved distilled water twice for 15 min and then shifted to 5% uranyl acetate solution for 16-18 hrs. The tissue were washed again with distilled water twice for 15 min and then dehydrated with graded ethanol series. Tissues were left in absolute acetone 2x15 min as transitional solvent, then infiltrated with a mixture of Spur acetone embedding media. The ratio of resin to acetone was as follows 1:3 for 18 hrs followed by 1:1 & 3:1 for 18 hrs each. A 100% spur resin mixture was added to the samples and vacuum infiltration was carried out over night. The samples were oriented in moulds and resin cured at 70°C for 48 hrs. The polymerised resin blocks were trimmed and faced with fine scalpel blade and glass knife before ultra thin serial sections of approximately 120 nm, cut with RMC MT 7000 Ultra-microtome and placed on 200 mesh nickel grid. These sections were stained with 5% uranyl acetate for 30 minutes and then washed twice with distilled water and again stained with lead citrate for 10 minutes in NaOH chamber and examined under JEOL JEM1010 Transmission Electron Microscope (National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad, Pakistan).

Statistical analysis

Data was analysed using General Linear Model (GLM) procedures. The means, standard error means (±SEM) and ranges were worked out using Microsoft Excel (Microsoft Office 2003). Means were compared by one-way analysis of variance (ANAOVA). All computations were performed by STATISICA 6.0.

Results

Morphometric Studies

Morphometric measurements are documented in 3 tables 1, 2 and 3. The light microscopic seasonal changes in the testicular tissue of the camel in Punjab-Pakistan are captured in (Figs 1 and 2). The weight and volume of the testis were significantly higher ($P<0.01$) during winter season, declined in spring and summer and lowest during autumn. The volume occupied by seminiferous tubules and the diameter of the seminiferous tubules were recorded as significantly higher during the autumn season, lower in summer and lowest during winter and spring. Average diameter of sertoli cells was highly significant ($P<0.01$) more during winter, unchanged during summer and autumn and lowest during spring season. Statistically, highly significant ($P<0.01$) correlation of more volume of intertubular compartment was recorded during winter season as compared to other seasons of year. The relative volume of leydig cells (VLc%) was significantly higher during winter, relatively low but same during spring and summer while lowest during autumn. Total volume of leydig cells per testis and % intertubular tissue was significantly higher ($P<0.01$) during winter, low in spring and lowest during autumn season. Statistically non-significant change was observed in the number of sertoli cells during different seasons of the year. The number of leydig cells per testis were significantly more during winter season as compared to other seasons of the year. Numerical density of leydig cell population×10^7 per gram of testicular parenchyma was not significantly different among different seasons of the year. Per cent area occupied by seminiferous tubules and seminiferous tubule per cent / interstitium was significantly ($P<0.01$) more during autumn and summer while less during winter and spring seasons.

Ultrastructural studies

Breeding season

During breeding season the leydig cells were large in size and closely packed having very scanty intercellular spaces (Fig 3a). The leydig cells of camels were polygonal in shape, having round to oval central nucleus. The nucleus was with small heterochromatin evenly granular areas and prominent nucleolus (Fig 3c). The cytoplasm were having abundant and highly developed smooth endoplasmic reticulum (SER) in the circular cisternal structure and randomly oriented tubular form. High to moderate mitochondria, spherical or oval to elongate in shape having tubular cristae, few lipid droplets and aggregates of free ribosomes were obvious in the cytoplasm. The rough endoplasmic reticulum (RER) was poorly developed having petite tubular form. The lysosomal bodies were poorly developed. The rough endoplasmic reticulum and lysosomal bodies started to increase in number towards the end of spring season or the beginning of non-breeding season of the camel.

The seminiferous tubule comprised of basal layer of tall columnar sertoli cells extending from the basal membrane to the lumen of the tubule, and many layers of spermatogenic cells in different stages of cell division including spermatogonia,

Table 1. Morphometric parameters of one-humped camel testis and seminiferous tubules during different seasons of the year.

Parameters	Seasons			
	Winter	Spring	Summer	Autumn
RTV (cm^3)	135.48±1.48^a	116.15±0.82^b	87.91±1.14^c	77.52±0.55^d
LTV (cm^3)	137.00±1.28^a	117.37±1.01^b	88.60±1.26^c	81.50±1.06^d
RTW (g)	142.53±1.56^a	122.19±0.87^b	92.48±1.20^c	81.55±0.58^d
LTW (g)	144.13±1.35^a	123.47±1.07^b	93.21±1.33^c	85.73±1.12^d
VST (cm^3)	1307.5±12.45^b	1221.2±12.25^c	1336.9±22.82^b	1428.7±17.47^a
STD (μm)	166.50±1.59^b	155.17±1.62^c	169.83±2.88^b	181.50±2.26^a

Means with different letters in a column are statistically significant ($P<0.05$)
RTV=Right testis volume, LTV= Left testis volume, RTW= Right testis weight, LTW= Left testis weight,
VST= Volume of seminiferous tubules, STD= Seminiferous tubules diameter

Table 2. Morphometric parameters of intertubular compartment of the testis of one-humped camel during different seasons of the year.

Parameters	Seasons			
	Winter	Spring	Summer	Autumn
VIC (cm^3)	71.37±2.37^a	56.53±1.94^b	30.32±0.70^c	24.18±1.09^d
RVLCIT (VLc %)	24.67±0.49^a	19.83±0.60^b	21.50±0.43^b	7.33±1.05^c
TVLCPT × 10^{12} μm^3	13.20±1.00^{ab}	9.71±0.68^b	15.69±3.29^a	2.21±0.57^c
VILC (μm^3)	1696.8±334.1	901.4±204.8	1358.0±228.4	1011.7±270.6
NLC×10^9 per testis	9.84±2.23^a	5.53±1.52^b	4.68±0.63^b	1.73±0.68^c
NDLCP×10^7 per gram of testicular parenchyma	6.88±1.59	5.73±1.11	5.03±0.72	5.25±0.98

Means with different letters in a column are statistically significant ($P<0.05$)
VIC= Volume of intertubular compartment, RVLCIT= Relative volume of leydig cell in interstitial tissue,
TVLCPT= Total volume of leydig cells per testis, VILC= Volume of individual leydig cell,
NLC= Number of leydig cells, NDLCP= Numerical density of leydig cells per testis

Table 3. Morphometric parameters of the sertoli cells and percentage values of testicular compartments of one-humped camel testis during different seasons of the year.

Parameters	Seasons			
	Winter	Spring	Summer	Autumn
CNSCPT	449.37±27.08	454.70±25.16	431.39±19.23	439.90±18.15
ANSC	460.87±26.99	461.36±24.84	441.06±18.90	448.40±18.38
ADSCN(μm)	11.17±0.48^a	6.67±0.61^c	9.67±0.42^{ab}	8.50±0.56^b
% IT	52.67±1.58^a	48.67±1.63^b	34.50±0.76^c	31.17±1.25^c
% AST	47.33±1.58^c	51.33±1.63^b	65.50±0.76^a	68.83±1.25^a
% ST/I	0.88±0.056^c	1.07±0.070^c	1.90±0.065^b	2.23±0.131^a

Means with differntletters in a column are statistically significant ($P<0.05$)
CNSCPT= Crude number of sertoli cells per testis, ANSC= Actual number of sertoli cells,
ADSCN=Average diameter of sertoli cell nuclei, %IT= Percentage of Intertubular tissue,
% AST= Percentage area occupied by Seminiferous tubules, %ST/I= Percentage Seminiferous tubules / Interstitium

primary and secondary spermatocytes and spermatids near the lumen (Fig 4a). The nuclei of sertoli cells were irregular in shape, located in the basal part of the cells having deep indentations and prominent nucleolus (Fig 4b). During breeding season, the diameter or size of sertoli cell nuclei was larger, with comparatively less deep indentations. The smooth endoplasmic reticulum (SER) and ovoid or elongated mitochondrion were highly developed and abundant in the cytoplasm which indicate cellular activities (Fig 4c). Smooth endoplasmic reticulum appeared as numerous cisternae; these were greatly developed and arranged in concentric vortex form. There were many scattered free ribosomes in the cytoplasm. Lipid droplets were very less during this season. The intermediate filaments were distributed around the

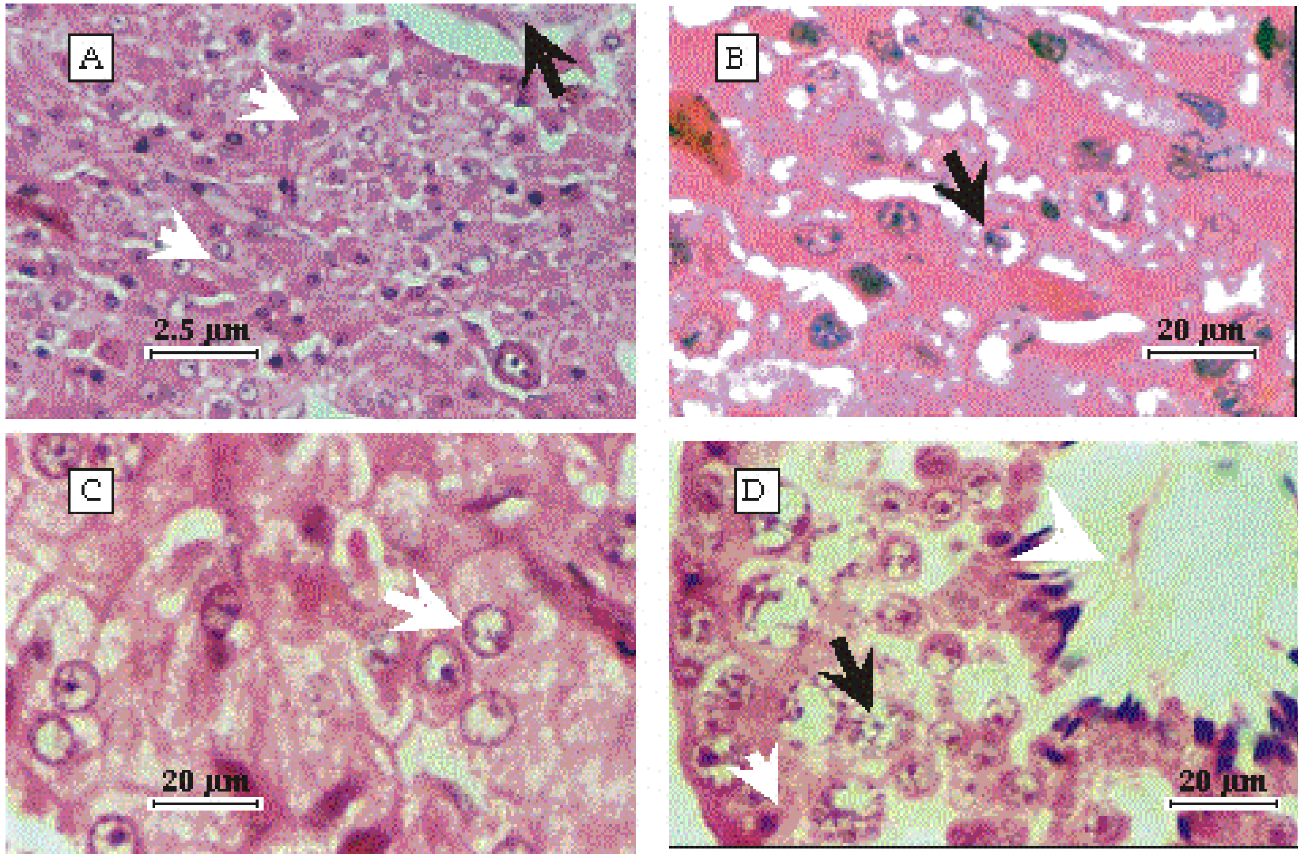

Fig 1. Photomicrographs of interstitium and seminiferous tubules of testis of one-humped camel during winter and spring seasons; **A)** Interstitium (Note increased number of leydig cells-white arrows); (blood vessel-black arrow) (winter season) X 400. **B)** Interstitium during winter (Leydig cells-black arrow) (winter) X 1000. **C)** Interstitium (Leydig cells-white arrows) (spring) X 1000. **D)** Seminiferous tubule (Sertoli cell -white arrow; primary spermatocyte -black arrows; spermatids- white arrow head) (winter) X 1000 (H & E).

nucleus while the less abundant lysosomal bodies were found mainly in the basal region of the cell.

Non-breeding season

The volume, size and numbers of the leydig cells decreased and cells were arranged in clusters. The nucleus of the cells was oval in shape with less heterochromatin chromatin material (Fig 3b). The quantity of smooth endoplasmic reticulum (SER) decreased while lipid droplets, rough endoplasmic reticulum (RER) and electron dense bodies increased in the cytoplasm. The smooth endoplasmic reticulum was observed as meandering tubules and narrow cisternae, instead of parallel or concentric form as recorded during breeding season. Free ribosomes, lysosomal bodies and vacuoles also increased during inactive phase of the cell. Lipid droplets were observed as medium sized to large in the cytoplasm, sometimes the droplets were surrounded by tubules of smooth endoplasmic reticulum. While few number of mitochondria were randomly scattered in the cytoplasm showing wide discrepancy in size. Dense bodies either homogenous electron dense or heterogenous shaded in appearance were scattered in the cytoplasm.

Sertoli cells nuclei were reduced in size having deep indentations (Fig 3b). The cytoplasmic organelles including cisternae of smooth endoplasmic reticulum, mitochondria and free ribosomes were less developed and less abundant during the non-breeding season, showing inactivity of the cell. The oval to elongated mitochondria was found within the cell cytoplasm. Dense bodies and rough endoplasmic reticulum (RER) were observed. The golgi apparatus appeared in the apical region of the cell and microfilaments were dispersed near the nuclear region. Dense accumulations of pigments and lipid droplets were common feature of the basal portion of the cytoplasm during inactive phase of the cell. Lysosomes were present mainly in the basal portion of the cell, which increased during this season.

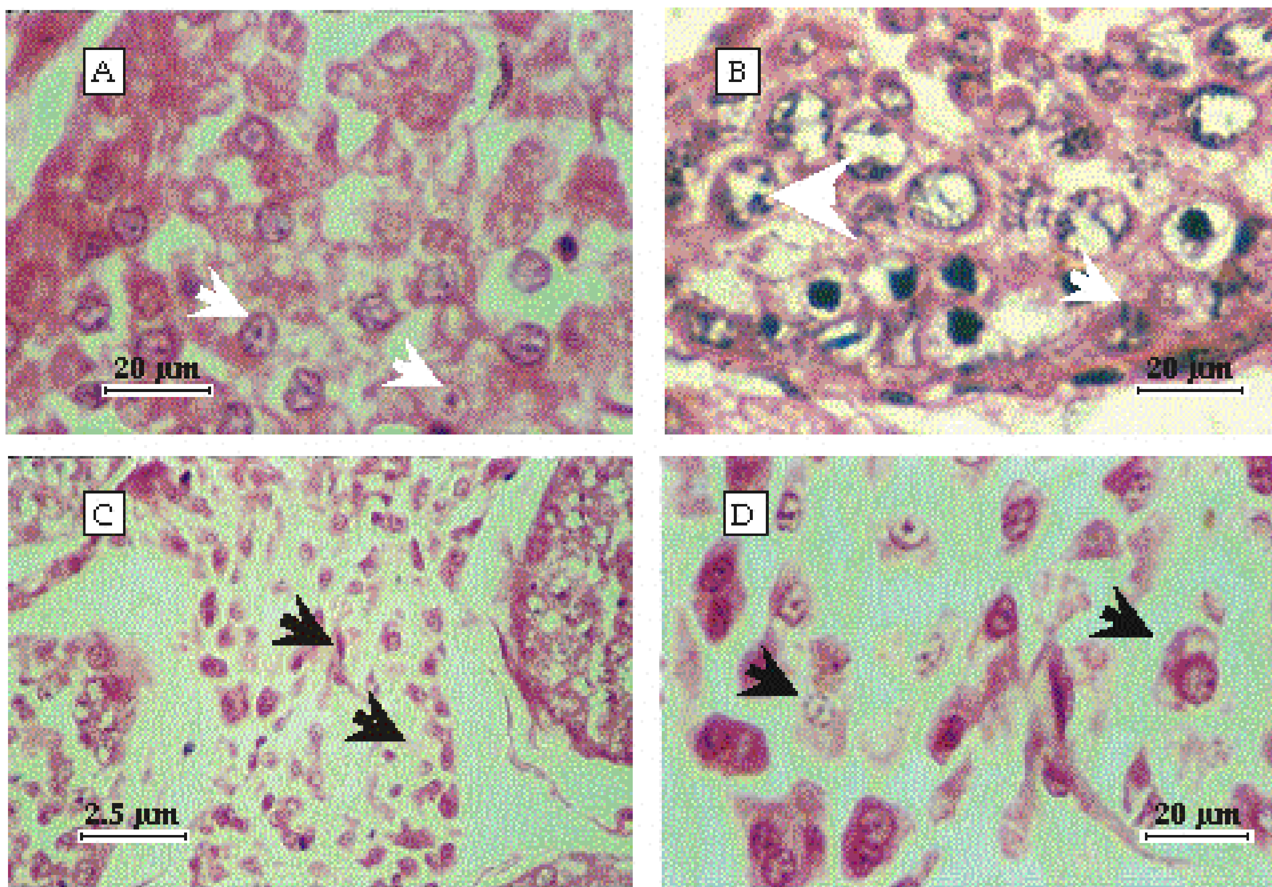

Fig 2. Photomicrographs of interstitium and seminiferous tubules of testis of one-humped camel during summer and autumn seasons; **A)** Interstitium (Leydig cells-white arrows) (summer) X 1000 **B)** Seminiferous tubule (Sertoli cell-white arrow; primary spermatocyte-white arrow head) (summer) X 1000 **C)** Interstitium (Note minimum scattered and small size of leydig cells-black arrows) (autumn) X 400 **D)** Interstitium (Leydig cells-black arrows) (autumn) X 1000 (H & E).

Discussion

Morphometric studies of the testis

Present investigation revealed that the volume and weight of the testis were significantly (P<0.01) higher during winter and spring seasons as compared to summer and autumn. Similar seasonal changes were previously reported in other climatic regions by Wilson (1984); Tingari *et al* (1984); Arthur *et al* (1985), Zayed *et al* (1995) and Masood (2007). The overall diameter of seminiferous tubules was reported earlier in the range 131-250 (Volcani, 1957), 180-215 µm (Abdel-Raouf *et al,* 1975), 113-250 µm (Singh and Bharadwaj, 1978), while present study revealed diameter 155.17-181.50 µm which is in range of earlier reports. Present study exposed that the diameter of seminiferous tubules was maximum during the summer and autumn seasons and reduced during the winter which confirmed the results of Tingari *et al* (1984) who reported maximum diameter during the cooler months (December, January and February) and minimum during the hot months (June, July and August) in Suadi Arabia camel. The divergence noted above from the values reported by other researchers could be attributed to the geographic, and climatic variations. The average diameter of sertoli cells was found to be significantly (P<0.01) higher during winter season (11.17±0.48 µm) followed by summer and autumn while it was minimum in the spring season (6.67±0.61 µm). This shows that maximum activity of the cells were during winter season. No report is available in the literature to compare this parameter in the camel. However, these results are in accordance with Elsayed (2000), who correlated the size of sertoli cell nuclei with the activity of the cell, and reported that the size of nuclei increased during the breeding season of the bucks. The volume of intertubular compartment was measured as significantly (P<0.01) maximum during the winter (71.37±2.37 cm^3) and spring (56.53±1.94 cm^3) when compared to summer (30.32±0.70 cm^3) and autumn (24.18±1.09 cm^3). These results are in accord with the Singh and Bharadwaj

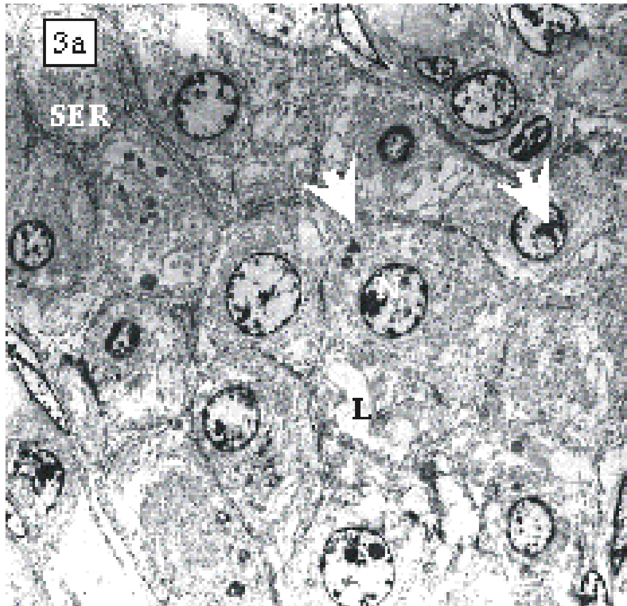

Fig 3a. Ultrastructure of Interstitium of the camel testis during breeding season. Cells are closely packed and larger in size, showing nucleus (N), nucleoli (arrow), highly developed smooth endoplasmic reticulum (SER), small lipid droplets (L) in the cytoplasm, and developing leydig cells in the peritubular position (stub by arrow). X2500.

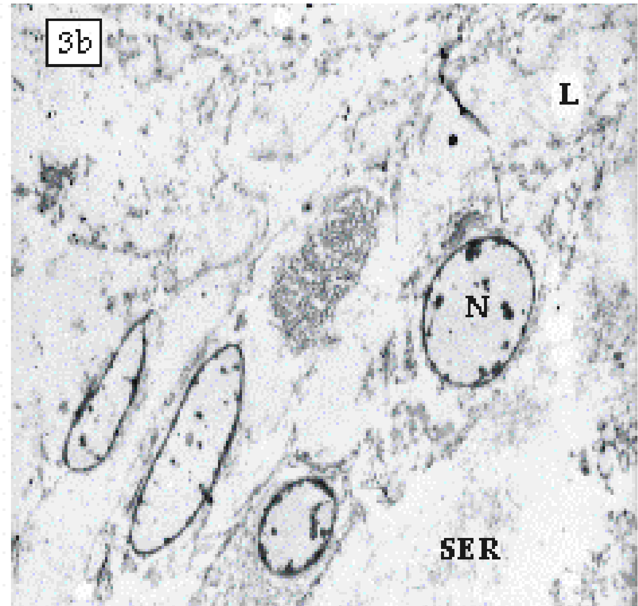

Fig 3b. Ultrastructure of interstitium of the camel testis during non-breeding season. Reduced number of leydig cells, loosely arranged and smaller in size, showing nucleus (N), reduced smooth endoplasmic reticulum (SER), increased lipid droplets (L) in the cytoplasm X3000.

(1978) and Zayed *et al* (1995) who reported higher volume in spring and winter while lower in autumn season. However, Volcani (1957) documented the distorted and reduced amount of interstitial tissue in the testis of camel in Israel during the cooler months of the year (December to March).

The relative volume of leydig cells (VLc%) was found to be significantly higher (P<0.01) during winter (24.67±0.49), low during spring (19.83±0.60) and summer (21.50±0.43) and minimum in autumn (7.33±1.05). The total volume of leydig cells (TVLc × $10^{12}\mu m^3$) was recorded as maximum during winter and summer seasons (13.20±1.00) and (15.69±3.29) while declined in spring (9.71±0.68) and minimum in autumn season (2.21±0.57). These findings are in agreement with the Zayed *et al* (1995) in Egypt who reported same trend of the seasonal changes in the volume of leydig cells per testis in camels. The numbers of leydig cells ×10^9 per testis were found to be significantly (P<0.01) more during the winter (9.84±2.23) as compared to spring (5.53±1.52) and summer (4.68±0.63) while lowest during the autumn season (1.73±0.68). These findings are aligned with the Zayed *et al* (1995), who reported maximum numbers of leydig cells per testis during winter (6.28×10^9), followed by spring (5.80×10^9) and summer (5.72×10^9) while lowest during autumn (3.68×10^9).

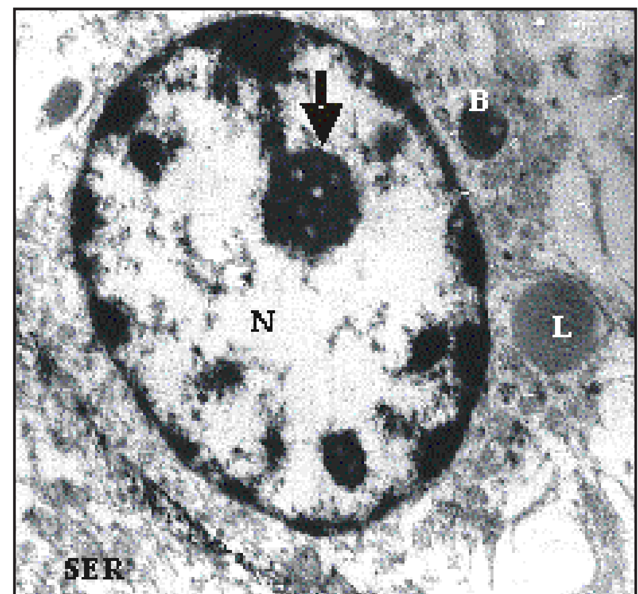

Fig 3c. Ultrastructure of leydig cell of one-humped camel during breeding season showing large nucleus (N) having heterochromatin with nucleoli (arrow), while lysosomal body (B), lipid droplet (L) and smooth endoplasmic reticulum (SER) are obvious in the cytoplasm X8000.

The % intertubular tissue in the parenchyma of testis was found to be significantly (P<0.01) higher during winter season (52.67±1.58), followed by spring (48.67±1.63) and minimum during summer (34.50±0.76) and autumn (31.17±1.25). Tingari *et al* (1984) reported 42% intertubular tissue in summer

season and 56% in the winter, showing same trend like the present findings. However Zayed *et al* (1995) documented slightly lower values (per cent) of intertubular tissue, 24% in autumn (minimum), and maximum during spring (39%). The discrepancy between these results and our findings may be attributed to the climatic and environmental temperature during different seasons. The per cent area occupied by the seminiferous tubules was measured as significantly ($P<0.01$) high during summer (65.50±0.76) and autumn (68.83±1.25) while low during winter (47.33±1.58) and spring (51.33±1.63). The per cent seminiferous tubule / interstitium was also recorded as significantly ($P<0.01$) more during summer (1.90±0.065) and autumn (2.23±0.131) while less during winter (0.88±0.056) and spring seasons (1.07±0.070). It is obvious from these findings that interstitial tissue occupies larger area as compared to seminiferous tubules especially during the winter season. This ratio decreased during the hot months or non-breeding season. Same trend is evident in the testicular volume and weight during different seasons of the year. These results confirm the findings of Tingari *et al* (1984) who reported same trend in these parameters in the epididymis of one humped camel during different seasons of year.

Ultrastructural studies of the testis

The ultrastructure of camel leydig cells and sertoli cells was earlier described in different environmental regions by Zayed *et al* (1995), Friedlander *et al* (1984), Singh and Bharadwaj (1978), Tingari *et al* (1984) and Osman and Ploen (1986a), respectively. Present study revealed that during breeding season of camel, the interstitial connective tissue was mainly comprised of large, polygonal, closely packed leydig cells corroborated the findings of Friedlander *et al* (1984) and Zayed *et al* (1995). The cytoplasm of leydig cells was having abundant and developed smooth endoplasmic reticulum (SER) in the circular cisternae and tubular form. Large amount of smooth endoplasmic reticulum (SER) in the interstitial cells also reported earlier during breeding season of camel (Singh and Bharadwaj, 1978; Friedlander *et al,* 1984; Tingari *et al,* 1984 and Zayed *et al,* 1995). The presence of smooth endoplasmic reticulum and mitochondria is closely associated with the steroid hormonal biosynthesis. The smooth endoplasmic reticulum provides binding sites on the surface for enzymes which are necessary for steroidogenic activity (Christensen, 1975). The cytoplasmic lipid droplets were reduced during the breeding season, which indicate leydig cells activity in utilizing the lipid for steroid hormonal synthesis (Christensen, 1975). During non-breeding season the size, volume and numbers of leydig cells decreased, nucleus was observed as oval in shape having less chromatin material. The amount of smooth endoplasmic reticulum (SER) and mitochondria became less abundant as compared to breeding season while rough endoplasmic reticulum (RER), lysosomal bodies, lipid droplets and dense bodies increased in the cell cytoplasm, which indicates the lower activity of the cell. These changes might be related to the serum testosterone concentration.

The present study elucidated the enhanced activity of the sertoli cells during breeding season of camel. Ultrastructural features changed during increased activity of the cell. During breeding season, the size of the nucleus increased with less deep indentations located on the basal portion of the cell. Abundant smooth endoplasmic reticulum, free ribosomes, increased number and size of mitochondria was obvious in the cytoplasm of active cell. No report is available to compare these changes in the camel, however, almost same changes were reported during the breeding season of buck (Jurado *et al,* 1994). During non-breeding season the smooth endoplasmic reticulum, mitochondria and free ribosomes declined and lipid droplets increased in the cell cytoplasm. Accumulation of the lipid cells might be related and contributed to the degeneration process of germ cells during non-breeding season (Zamboni *et al,* 1974). These ultrastructural changes might be also related to the hormonal profile of the camel especially FSH and testosterone as these cells are under the effect of FSH and secrete different factors and hormones (Androgen binding proteins, Inhibin) (Hafez and Hafez, 2008).

In conclusion, these changes within the seminiferous tubules could be used as a guide to determine the best time for mating in one humped camel in Punjab region of Pakistan. It could also lay the ground for further studies to improve redproductive activity of the one humped camel.

Acknowledgements

We sincerely thank Dr. Sohail Hamid and Mr. Javed Iqbal (NIBGE), for technical support related to electron microscopy. We gratefully acknowledge the financial support of Higher Education of Pakistan (HEC) and PARC-ALP Agriculture Linkage Program, during the period of this study.

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