A Histological, Histochemical and Morphometric Study
On the Postnatal Development of the
Intratesticular Tubular System of
Nubian Goat Kids

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Dedication
To my Mother, Father,
Brothers and Sisters
To my Husband
And my Daughter
Yathrib
With great love
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INTRODUCTION

Sudan is considered as one of the richest African and Arabian countries in livestock population which constitutes an important source of income.

Goats are important component of this livestock population and participate particularly in the national economy and provide meat, milk and skin in the local markets. The estimated livestock population in the Sudan is as follows: 44.8 million sheep, 37.3 million goats, 35.8 million cattle and 3 million camels (AOAD, 2001).

Nubian goats are distributed mainly in Aljazeera, Khartoum, Northern, White Nile, River Nile, Blue Nile and Kassala states (Mustafa, 2006). They are considered as a good source of meat and the best known diary breed in the Sudan and the whole of Africa.

To the author's knowledge, there is only one report about the development of the seminiferous tubules of goats (Nishimura, Okano, Yasukouchi, Gotoh, Tabata and Iwamoto, 2000), and a few investigations on the intratesticular excurrent ducts in sexually mature goats (Hemeida, Sack and Kenneth, 1978; Osman and Plöen, 1978a, 1979; Ezeasor 1986; Goyal and Williams, 1987).
The male Tokara goat reaches puberty at about 4 months of age and usually a large number of spermatozoa are always present in their seminiferous tubules (Nishimura et al., 2000).

The intratesticular excurrent ducts of goats are divided into terminal segment which is usually lined with modified Sertoli cells, the tubuli recti which are subdivided into two regions, and the rete testis consisting of septulae, mediastinal and extratesticular parts. The extratesticular part is usually located outside the testis in the rat (Roosen-Runge, 1961), man (Roosen-Runge and Holstein, 1978) and goat (Goyal and Williams, 1987).

Some studies were conducted on the histochemistry of the seminiferous tubules and the intratesticular excurrent ducts in different sexually mature mammals such as the camel (Osman, 1975), buffalo (Goyal and Dhingra, 1973; Dhingra, 1980), ram (Osman, 1984), and bull (Yasein, 2005).

Some morphometric studies were performed in the seminiferous tubules of the cat (Franca and Godinho, 2003), ram (Wrobel, Reichold and Schimmel, 1995), rat (Wing and Christensen, 1982), hamster (Lue, Sinha, Wang, Bonavera, Baravarian, Leung and Swerdloff, 1997).

Morphometric evaluation on the intratesticular excurrent ducts in sexually mature bulls was carried out by Yasein (2005).
To the author’s knowledge, there is no information about the development of the intratesticular tubular ducts of goats. It is therefore to conduct this investigation with the following objectives in mind.

1- To study the histology of the seminiferous tubules and the intratesticular excurrent ducts of goats from birth to sexual maturity.

2- To measure the diameter of the developing seminiferous tubules and their intratesticular ducts from birth to sexual maturity.

3- To conduct some histochemical tests to evaluate the effect of development on some enzymes and histochemical substances which are located in the intratesticular tubules of goats.

4- To perform morphometric measurements on the different parts of the intratesticular tubular system to study the effect of development on the different components of the goat testis
CHAPTER ONE

LITERATURE REVIEW

I. 1. The seminiferous cords and tubules:-

A few reports have dealt with the histological development of the seminiferous tubules in the rat (Vitale, Fawcett and Dym, 1973; Osman, Plöen and Hagenäs, 1979), bull (Wrobel, Schilling and Zwack, 1986), and some mammalian species (Johnson, Gomes and Vandemark, 1970).

At birth, the seminiferous cords of the bull calf had 30-40 peripheral cells with 8-12 central cells known as gonocytes which were formed by inward movement of the peripheral cells (Johnson et al., 1970). However, Vitale et al. (1973) reported that, during postnatal development of the seminiferous cords, the gonocytes move from the centre to the periphery where they undergo a number of divisions and differentiate into typical type A and type B spermatogonia. The term gonocytes is used to designate the germ cells up to their differentiation into spermatogonia when spermatogenic activity starts. Osman et al. (1979) observed a few gonocytes in the terminal segment of 5 days old rats. At 6 weeks postnatal development of the ram testis, the seminiferous cord is about 115 µm in diameter and there are numerous gonocytes in it and these gonocytes are situated at the basal lamina like proper
spermatogonia (Nilnophakoon, 1978). Gonocytes are rather large rounded cells mostly situated toward the centre of the sex cords and much more numerous at birth than at one to four months postnatal development of the bull calf testis (Nicander, Abdel-Raouf and Crabo, 1961). Wrobel et al. (1986) reported that the nongermin al supporting cells of the bull calf possess spherical nuclei with basal location at 4th and 8th weeks postnatal development. The meiotic changes begin in the peripheral layer at about 6 months of age in the bull and 7 months in the dog (Johnson et al., 1970).

During 14 days of development of the rat testis, the germinal components of the seminiferous epithelium consist only of spermatogonia and early spermatocytes forming a single layer of cells on the basal lamina (Vitale et al., 1973). During early development of the testis of mammals, the seminiferous tubules don’t possess a lumen (Dym, 1976). Nilnophakoon (1978) also observed that no lumen had been formed in the seminiferous cords after 6 weeks of postnatal development in the ram testis. The formation of a lumen had been observed between 20 and 25 weeks old bull calf (Wrobel et al., 1986), 12 weeks of age in the ram (Nilnophkoon, 1978); starts at the age of 15 days and is completed in all seminiferous tubules at 25 days old rats (Osman et al., 1979), toward the end of the third week in the hamster (Fouquet and Guha, 1969), and at approximately 6 years of age in primates (Johnson et al., 1970)
With the formation of a lumen, the seminiferous cords are transformed into seminiferous tubules in the ram (Nilnophakoon, 1978), and some mammalian species (Johnson et al., 1970).

At 13 weeks postnatal development in the ram testis, the seminiferous tubules measure about 170 µm in diameter and mostly possess two generations of germ cells in addition to spermatogonia, and the round spermatids are the most differentiated cell type observed; the elongated spermatids or testicular spermatozoa are not formed up to 15 weeks of age. In the ram testis, the seminiferous tubules measure about 190 µm in diameter and all stages of spermatogenesis are found and the appearance of the testis approaches that in mature animal at 18 weeks of age (Nilnophakoon, 1978). However, the male tokara goat reaches puberty at around 4 months of age but testis development continues up to 12 months of age (Nishimura et al., 2000).

The basal lamina of the mature bovine seminiferous tubules is multiple layered where as the elongated peritubular cells are arranged in 3–5 concentric layers around the seminiferous tubules (Wrobel, Mademann, and Sinowatz, 1979).

There have been no developmental investigations of the histochemistry of the seminiferous tubules. However, the histochemistry of the seminiferous tubules of mature animals has been studied in the camel (Osman, 1975) and bull (Yasein, 2005).
PAS-reactive substances resistant to diastase digestion are present in the wall of the blood vessels and in the boundary tissue of the seminiferous tubules of the camel (Osman, 1975). Osman, Moneim and Tingari (1976) also observed that PAS-reactive substance removable with diastase enzyme (glycogen) is present in the germinal epithelium of the seminiferous tubules of the camel.

No acid phosphatase reactivity was seen in the seminiferous tubules of the camel (Osman, 1975).

The basement membrane of the seminiferous tubules of the bull reacts strongly for the enzyme alkaline phosphatase (Yasein, 2005). A clear reaction is demonstrable in the boundary tissue of the seminiferous tubules and in the germinal epithelium near the lumen in the camel (Osman, 1975). The interstitial cells react strongly for alkaline phosphatase, while the peritubular connective tissue reacts very weakly in the bull (Yasein, 2005).

I. 2. The terminal segment of the seminiferous tubules:-

The terminal segment of the seminiferous tubule is that short narrow portion of the seminiferous tubules which connects the seminiferous tubules with the tubuli recti. A few reports have dealt with the histological development of the terminal segment in the rat (Osman et al., 1979), bull (Wrobel et al., 1986), and some mammalian species (Johnson et al., 1970; Osman and Plöen, 1979).
The terminal segment of the seminiferous tubules develops between 20 and 25 weeks of postnatal development in the calf (Wrobel et al., 1986). However, the plug-like structure of the terminal segment was observed before the formation of a lumen in the seminiferous tubules of juvenile goat testis (Osman and Plöen, 1979).

In 5 to 15 days old rats, the terminal segment is possible to identify only when its connection to the tubulus rectus or the rete channels is established, because the presence of a patent lumen in the later structures. Clear distinction of the terminal segment from the seminiferous tubules proper is possible at 20 days of age and onwards in the rat (Osman et al., 1979), and at 30 weeks in the bull due to the formation of primary spermatocytes and spermatids in the seminiferous tubules (Wrobel et al., 1986).

Between 40 and 52 weeks of age of the bovine calf, the terminal segment of the seminiferous tubules is tripartite consisting of a transitional region, intermediate portion and a terminal plug (Wrobel et al., 1986).

The histology of terminal segment of the seminiferous tubules in sexually mature animals has been extensively studied but with different names in different animals: transitional zone, in the rat (Roosen-Runge, 1961; Nykänen, 1979, 1980), stallion (Amann, Johnson and Pickett, 1977), monkey (Dym, 1974), transitional stage in the fowl (Lake, 1957),

The terminal segment width varies between 0.091 and 0.126 mm with an average of 0.110 mm in the bull (Yasein, 2005).

At the junction between the seminiferous tubule and the terminal segment of the camel, the epithelium changes gradually by losing their germ cells and replaced by simple tall columnar cells resembling Sertoli cells of the seminiferous tubule proper but with some modifications, hence the name modified Sertoli cells (Osman, 1978).

The modified Sertoli cells of the terminal segment of the seminiferous tubules are characterized by having columnar shape, vaculated cytoplasm and long cytoplasmic processes which occlude the lumen and project into the dilated proximal part of the tubulus rectus, the receptacle, to form a plug-like structure, inside the receptacle. This plug–like structure is found in the boar (Osman, 1978), buffalo (Dhingra, 1980), man (Marin-Padilla, 1964), camel (Singh and Bharadwaj, 1980; Osman, 1986), rat (Osman
and Plöen, 1978), mouse (Barack, 1968), monkey (Dym, 1974), bull, ram and goat (Osman and Plöen, 1979). However, Osman (1979) reported that, in most cases, the cells of the terminal segment in the rabbit do not project into the dilated proximal part of the tubulus rectus, to form the plug–like structure. This is also true for the guinea pig (Calpe and Aoki, 1969; Fawcett and Dym, 1974).

The modified Sertoli cells are characterized by indented nuclei with prominent nucleoli, and peripheral heterochromatin encrustations attached to the inner nuclear membrane and are mostly situated close to the basal lamina, with highly irregular outline or lobulated. These features characterize the modified sertoli cells nuclei in the rat (Osman and Plöen, 1978; Nykänen, 1979), bull (Wrobel et al., 1982), monkey (Dym, 1974), guinea pig (Calpe and Aoki, 1969), rabbit and fowl (Osman, 1979, 1980). However, Osman (1978) observed that, in the boar these nuclei are mostly situated in the portion which forms the plug. Furthermore, Osman (1986) added that, in most cases, the nucleoli are not attached to the inner membrane of the nuclear envelop in the camel.

Degenerated spermatozoa were seen within the apical part of the modified Sertoli cells cytoplasm in the rat (Nykänen, 1980), bull (Wrobel et al., 1982), monkey (Dym, 1974), boar, rabbit and camel (Osman, 1978, 1979, 1986).
The terminal segments of the seminiferous tubules possess very narrow lumen which is difficult to see under normal conditions in the hamster (Cavicchia and Burgos, 1977), rat (Osman and Plöen, 1978), and bull (Osman, 1979; Wrobel et al., 1982). A central lumen was evident only when the efferent ductules were ligated in the rat and rabbit (Osman and Plöen, 1978; Osman 1979). However, a central lumen was seen in most cases in the terminal segment of the camel (Osman, 1986). A few spermatogonia and degenerated spermatocytes were observed inside the lumen of the terminal segment.

Lymphocytes are distributed among the modified Sertoli cells of the terminal segment inside dilated intercellular spaces. These lymphocytes are small rounded cells, characterized by irregular shape, few organelles mainly mitochondria, pale staining cytoplasm and they are usually found near the basal lamina and separated from it by a narrow cytoplasmic process of the lining epithelium in the monkey (Dym, 1974), rat and rhesus monkey (Dym and Romrell, 1975), rabbit and fowl (Osman, 1979, 1980). The cells of the terminal segment rest upon a thick basal lamina which is bounded by a layer of collagenous fibres in the rat (Osman and Plöen, 1978). Degen and Lee (1982) reported that the cells of the boundary tissue in the camel are mostly arranged in a single layer, whereas in the boar (Osman, 1978; Bloom and Fawcett, 1986), rabbit (Osman, 1979), bull (Wrobel et al., 1979; Yasein, 2005), monkey (Dym, 1974),
and ram (Bloom and Fawcett, 1986), these cells are arranged in more than one overlapping layer, and two types of cells could be identified. The cell of the first type is found near the basal lamina, and has filamentous cytoplasm and elongated nucleus similar to that of contractile cells which surround the seminiferous tubules. The second type of cells has few microfilaments but abundant rough endoplasmic reticulum, and resembles fibroblasts. Light cells are present in the boundary tissue of the rat testis (Nykänen, 1979).

The bull terminal segment is surrounded by a vascular plexus in a cuff – like or in a sleeve like manner (Wrobel et al., 1979), and is divided into three subsequent regions: transitional region, middle portion and terminal plug (Wrobel et al., 1978).

The histology of the terminal segment of the seminiferous tubules of sexually mature goats was studied by Osman and Plöen (1978,1979) and Ezeasor (1986). These authors subdivided the terminal segment, according to the gradual depletion of the germ cells, into proximal part with a large number of spermatogonia and a few primary spermatocytes together with the modified Sertoli cells, middle region which contains only a few spermatogonia and modified Sertoli cells and distal part or terminal plug.

Two types of modified Sertoli cells are found in the goat: type I are inclined, columnar cells which contain profuse arrays of a granular
endoplasmic reticulum in their apical cytoplasm and type II are smaller cells located at the apex of the plug, and each possesses cytoplasmic processes which surround the apex of type I cells (Ezeasor, 1986). Phagocytic activity of the goat modified Sertoli cells has also been observed in the goat (Ezeasor, 1986).

To the author’s knowledge, there are no available histochemical investigations about the developing terminal segment of the seminiferous tubules, but some studies have been conducted in sexually mature animals, like the buffalo (Dhingra, 1980), rat (Nykänen, 1980), ram (Osman, 1984) and bull (Yasein, 2005).

PAS – positive substances resistant to diastase digestion were detected in the basal lamina of modified Sertoli cells and the epithelial lining of the plug in the buffalo (Dhingra, 1980) and ram (Osman, 1984).

Yasein (2005) detected strong PAS - positive reaction in the terminal segment of the bull and this reaction was more intense in the basement membrane of both the transitional and middle regions than that of the terminal plug. Nykänen (1980) also noticed PAS-positive reaction surrounding the nuclei in the distal aspect of the terminal segment of the rat. Osman (1984) reported that PAS- reactive substance resistant to diastase digestion is detected in the boundary tissue of the terminal segment of the ram. PAS- positive material removed with diastase enzyme (glycogen) was detected by Dhingra (1980) in the basement
membrane of the epithelial lining of the terminal segment of the buffalo. Fabbrini and Conti (1969) reported that a progressive decrease in tubular glycogen was found, corresponding to an increase in tubular diameter in human testis. No PAS-positive element was found in the interstitial area in human testis (Fabbrini and Conti, 1969). However, a faint cytoplasmic reaction for PAS-positive material was noted in the interstitial cells of the ram testis (Cavazos and Melampy, 1954).

The lining epithelium of the terminal segment of the seminiferous tubules of the ram shows intense reaction for the enzyme alkaline phosphatase which marked the limit of the terminal segments from the seminiferous tubules proper (Osman, 1984). The basement membrane of the terminal segments of the bull reacts strongly for alkaline phosphatase, while the reaction is fairly strong in the terminal segments than that of the seminiferous tubules proper (Yasein, 2005). The interstitial cells react strongly for alkaline phosphatase, while the peritubular connective tissue reacts weakly in the bull (Yasein, 2005).

In the available literature, there is no morphometrical analysis on the development of the intratesticular tubular ducts of mammals and birds. However, morphometrical analysis on the intratesticular excurrent ducts of the adult bull was conducted by Yasein (2005).
1.3. The Tubulus Rectus

The tubulus rectus is that part of the intratesticular excurrent duct which connects the terminal segment of the seminiferous tubule to the rete channels.

Some information about the development of the tubulus rectus was reported by Wrobel et al. (1986) in the bull calf.

During the 4th and 8th weeks of age of bovine calf, the straight tubules have narrow lumina and stratified epithelium. Starting from the 16th week and proceeding through the 30th week and onward, the epithelium of the tubulus rectus, close to the connection with the seminiferous tubule, becomes monolayered. Then the straight testicular tubules adjacent to the terminal segment are modified into a cup region encompassing the terminal plug of the terminal segment followed by a narrow stalk which is lined by simple columnar epithelium at 40-52 weeks of age (Wrobel et al., 1986).

The tubulus rectus has been investigated extensively in sexually mature animals, like the camel (Singh and Bharadwaj, 1980; Osman, 1986), bull (Osman, 1978; Osman and Plöen, 1978; Wrobel et al., 1986; Yasein, 2005), buffalo (Dhingra, 1980), stallion (Amann et al., 1977), fowl (Gray, 1937), bird (Aire, 1982), rat (Roosen-Runge, 1961; Perey, Clermont and Leblond, 1961; Osman and Plöen, 1978; Nykänen, 1980),
mouse (Barack, 1968), man (Marin-Padilla, 1964), guinea fowl (Aire, Ayeni and Olowo-Okorun, 1979), hamster (Cavicchia and Burgos, 1977), guinea pig (Calpe and Aoki, 1969), ram, goat and rabbit (Osman and Plöen, 1978) and marsupials (Rodger, 1982).

Osman (1980) reported that the seminiferous tubules in the fowl are linked to the rete channels in three different ways; in two of these ways there is no obvious tubulus rectus joining the terminal segments or seminiferous tubules to the rete channels; the seminiferous tubules open directly into the rete. The seminiferous tubules open into the rete testis directly or into the straight tubules in birds (Aire, 1982). Nykänen (1980) also observed that, in one third of the cases there is a true tubule or classic tubulus rectus in the rat.

The tubulus rectus consists of three regions, proximal, middle and distal in the camel (Singh and Bharadwaj, 1980; Osman, 1986), bull (Osman and Plöen, 1978; Yasein, 2005) and hamster (Cavicchia and Burgos, 1977). There are two regions (proximal and middle) in the ram, boar and goad, and only one region (middle) in the rabbit and rat (Osman, 1978). The proximal region is the dilated proximal part of the tubulus rectus which accommodates the plug-like structure of the terminal segment, the receptacle. The epithelial cells change abruptly from tall columnar cells of the terminal segment to short cells of the receptacle. The epithelium is simple cuboidal in the stallion (Amann et al., 1977),
guinea pig (Fawcett and Dym, 1974), guinea fowl (Aire et al., 1979) and simple squamous to low cuboidal in the buffalo (Dhingra, 1980), camel (Singh and Bharadwaj, 1980; Osman, 1986), Japanese quail (Aire, 1979), bull, boar, ram and goat (Osman and Plöen, 1978). The epithelial cells of the receptacle have oval nuclei with their long axis parallel to the basal lamina.

Marin-Padilla (1964) mentioned that in man, horse, mule, dog, cat and hamster, the communication between the seminiferous tubules and the tubuli recti are only found during the reproductive age when mature spermatozoa become ready for discharge, so that there is no receptacle in presexual maturity period.

The main part is the middle region of the tubulus rectus, and it had a narrow lumen and mostly lined by a single layer of cuboidal cells in the guinea pig (Calpe and Aoki, 1969), fowl (Gray, 1937), hamster (Cavicchia and Burgos, 1977), rat (Nykänen, 1980), bull, ram and goat (Osman and Plöen, 1978), but patches of columnar cells were also seen in the camel (Singh and Bharadwaj, 1980; Osman, 1986), and man (Marin-Padilla, 1964). Cavicchia and Burgos (1977) reported that, occasionally the main part of the tubuli recti was absent in the hamster and the proximal part was immediately followed by the distal one.
The distal part of the tubulus rectus is wide and has a festooned appearance, and is characterized by a high epithelium which is thrown into folds in the bull (Osman and Plöen, 1978; Yassein, 2005).

The tubuli recti are usually situated in the septulae testis toward the mediastinum. The cells lining the tubuli recti contain an ovoid nucleus in the stallion (Amann et al., 1977) and roughly ovoid with peripheral chromatin clumps in the guinea pig (Calpe and Aoki, 1969). These nuclei possess heterochromatin attached to the inner nuclear membrane and their nucleoli are either centrally or eccentrically situated in the camel (Osman, 1986).

Intraepithelial lymphocytes were also seen within the epithelium of the tubuli recti of mammals including the camel. In between the simple cuboidal epithelium of the tubuli recti, lymphocytes are relatively inconspicuous, but could be found in small numbers in the rat and rhesus monkey (Dym and Romrell, 1975).

No histochemical study of the development of the tubulus rectus has as yet been reported, but a few investigations have been conducted in sexually mature animals, such as the camel (Osman, 1975; Singh and Bharadwaj, 1980), buffalo (Dhingra, 1980) and bull (Yasein, 2005).

The epithelial cells of the tubuli recti of the camel revealed positive-PAS reaction supported by an intensely PAS-positive basement membrane (Singh and Bharadwaj, 1980). Yasein (2005) added that the
basement membrane of the tubulus rectus of the bull is PAS-positive and the intensity of the reaction varies markedly in the three different parts of the tubule. Dhingra (1980) stated that the epithelium of the receptacle rests on a PAS-positive basement membrane and also shows positive reaction in its luminal border in the buffalo. Osman (1975) detected intense reaction for PAS in the boundary tissue of the tubuli recti of the camel.

A moderate number of glycogen particles are distributed throughout the cytoplasm of the tubuli recti of the guinea pig (Fawcett and Dym, 1974; Bloom and Fawcett, 1986). Osman (1975) detected PAS-positive substance removable with diastase enzyme (glycogen) in the lining epithelium of the tubuli recti, and the wall of blood vessels of the camel. Osman (1975) noticed that, the tubuli recti of the camel give negative reaction for the enzyme acid phosphatase.

Alkaline phosphatase –positive reaction was seen in the boundary tissue of the tubuli recti of the camel (Osman, 1975). The tubuli recti in the bull reacted positively for alkaline phosphatase but this reaction showed marked differences in its three parts (yasein, 2005).

I.4. The rete testis

The rete testis consists of channels into which the seminiferous tubules or tubuli recti open and its enclosed in the fibrous tissue of the mediastinum testis.
The histological development of the rete testis in the buffalo is provided by Goyal and Dhingra (1973) and Dhingra (1980). More information is reported by Dym (1976) in some mammals. The epithelium lining the different parts of the rete varies from simple cuboidal to pseudostratified columnar up to 30 weeks of postnatal life in the buffalo, and it becomes stratified in most of the regions of the rete channels at 52 weeks (Goyal and Dhingra, 1973). Moreover, Dhingra (1980) added that there are patches of pseudostratified columnar epithelium in prepubertal buffalo and is transformed to simple cuboidal in the adult animal. During early development of the mammalian testis in prepupertal animals, the rete lacks a lumen (Dym, 1976). Fibroblasts and undifferentiated mesenchymal cells are randomly scattered in the mediastinum testis around the rete from birth to 15 weeks of age. Leydig cells with characteristic rounded nuclei were observed in the peripheral region at 30 - 52 weeks of age in the buffalo (Goyal and Dhingra, 1973). The arrangement of the rete and its mediastinum of adult animals could be classified into two types: 1- The superficial rete lying at the surface of the testis immediately beneath the tunica albuginea and this type is characteristic of the rat, mouse and hamster (Dym, 1976). 2- The second type is the axial rete coursing longitudinally through the long axis of the testis. The axial position of the rete and mediastinum shows great variation between the different species:
In the Australian marsupial, the rete is horse shoe-shaped extending down both the epididymal and free margins of the testis underneath the blood vessels, about half way along the testis (Johnson et al., 1970; Rodger, 1982). In the camel (Osman, 1975, 1980), bull (Sinowatz, Wrobel, Sinowatz and Kugler, 1979; Hees, Wrobel, Kohler, Leiser and Rothbacher, 1987; Yasein, 2005), ram (Johnson et al., 1970; Dym, 1976), boar, monkey, cat, dog, guinea pig, rabbit and baboon (Dym, 1976), the mediastinum and rete testis are placed centrally in the testis, and extend approximately along two-thirds of the length of the testis.

In man, the rete is enclosed in a well developed mediastinum which is formed as an inturning of the fibrous tissue of the tunica albuginea into the testis, and it extends caudally to lie along most of the epididymal edge (Johnson et al., 1970). In general, the rete channels run parallel to the long axis of the testis and open into the efferent ducts (Bustos-Obregón and Holstein, 1976). The laterally placed rete and fibrous mediastinum as seen in man is also found in the monkey (Burgos, Cavicchia and Jensen, 1979).

In the stallion, the rete tubules are located around the central vein in a tortuous or anastomosing pattern, (Amann et al., 1977)
In the buffalo, the mediastinum extends as a median core from the proximal extremity to approximately two-third or three-fourth of the distance to the distal extremity (Goyal and Dhingra, 1973).

In the rat, there is very little mediastinum and the rete is an irregular, flat, cavernous sac about 1cm long and 0.2 - 0.3cm wide, closely applied to the inner surface of the tunica albuginea on the lateral edge, and the face toward the parenchyma is the side of the opening of the tubuli recti (Johnson et al., 1970).

The width of rete channels varies among the different animals. In the stallion, bull, boar and ram, the width is 4-11mm, 2-3mm, 1-2mm and 4mm, respectively (Hemeida et al., 1978). In the rat it is 3.00mm (Roosen-Runge, 1961), in the guinea fowl it is 51.1um (Aire et al., 1979), in the monkey it is 1-3mm (Burgos et al., 1979), and in the bull it is 4.3 - 7.7mm with an average of 5.9mm (Yasein, 2005).

The rete is divided into three parts intratesticular, intratunical and extratesticular rete (Roosen-Runge, 1961). Viotto, Orsi, Dias and Neumann, (1991) and Viotto, Orsi, Vicentini, Dias and Gregorio (1993), divided the rete testis of the cat into septal, mediastinal and tunical part. In man, the rete is divided into septal, mediastinal and extratesticular (Roosen-Runge and Holstein, 1978).
The mediastinal rete is formed of long straight channels which increase in size and become more irregular and anastomotic at the cranial extremity of the testis. In most animals, the rete is lined by simple epithelium which varies in height in the camel, bull, man and rat; the cells vary between squamous, cuboidal and columnar (Leeson, 1962; Bustos-Obregón and Holstein, 1976; Osman, 1978\textsuperscript{b}; Nykänen, 1980; Osman, 1986). In the domestic fowl, quail and mouse, the cells lining the rete are low cuboidal (Barack, 1968; Tingari, 1972; Aire, 1979). The cells lining the rete of birds are simple squamous to cuboidal (Aire, 1982) while cuboidal to low columnar in man and cat (Marin-Padilla, 1964; Viotto et al., 1991,1993) and Simple squamous epithelium in guinea fowl and rabbit (Aire et al., 1979; Lohiya and Mathur, 1983). In the camel, the mediastinum testis and its radiating septulae into the parenchyma consist mainly of collagenous and a few elastic fibers surrounding the rete (Osman, 1975; Singh and Bharadwaj, 1978). However, Goyal and Dhingra (1973) reported that the mediastinal connective tissue consists of collagenous fibers with a few reticular fibers, and the elastic and muscle fibers are associated with the blood vessels in the buffalo. The connective tissue of the rete is remarkably rich in blood vessels in birds (Aire, 1982). Occasionally, interstitial cells in small groups were observed in the mediastinum testis of the camel (Osman, 1975; Singh and Bharadwaj, 1978). In the bull, ram, goat, boar, rabbit, cat and rat, the nuclei of the
rete epithelium vary in shape: round, oval or indented and possessed one or two prominent nucleoli (Osman, 1978). Lymphocytes are commonly seen inside the rete testis epithelium and they are usually found near the basal lamina. Different stages of degraded spermatozoa were frequently observed in many of the epithelial cells in the bull (Sinowatz et al., 1979; Goyal, 1982), man and rhesus monkey (Holstein, 1978).

The histology of the rete testis of the goat was studied by Hemeida et al. (1978), Osman (1978) and Goyal and Williams (1987). The latter authors divided the rete testis of the goat into three parts; septal, mediastinal and extratesticular parts. The mediastinal rete is a labyrinth of intercommunicating channels that occupy about two-thirds of the central axis of the testis, while the extratesticular rete is located outside the testis. The width of the rete testis of the goat measures between 3 and 5 mm (Hemeida et al., 1978).

The cells lining the rete are cuboidal or squamous, with a few lymphocytes. There were no phagocytized sperms in the rete epithelium, but luminal macrophages containing sperm fragments were occasionally encountered (Goyal and Williams, 1987).

A few accounts on the histochemical development of the rete testis were given in the buffalo (Goyal and Dhingra, 1973) and hamster (Fouquet and Guha, 1969). Reports on the histochemistry of the rete testis
of sexually mature buffalos (Dhingra, 1980), human (Bustos-obregón and Holstein, 1976), camel (Osman, 1975) and bull (Yasein, 2005) were found in the literature.

No glycogen was detected from birth to maturity in the epithelium of intratesticular and extratesticular portions of the rete testis of the hamster (Fouquet and Guha, 1969). The rete epithelium of buffalo calves is supported by a delicate PAS-positive basement membrane between 3 and 16 weeks of age, and becomes more positive and distinct between 30 and 52 weeks of postnatal development (Goyal and Dhingra, 1973). Bustos-obregón and Holstein (1976) reported that, particles of glycogen were distributed throughout the cytoplasm of the cells lining the rete testis of man.

A PAS-positive substance removable with diastase digestion was detected in the epithelium lining the rete testis of the camel and the reaction was more intense in the boundary tissue than elsewhere (Osman, 1975). The presence of glycogen in the rete testis of the buffalo was detected between 30–52 weeks of postnatal development (Goyal and Dhingra, 1973). An intense PAS activity was shown as an apical granulation in the rete testis epithelium in the vampire bat (Orsi, Vicentini, Dias, Michelin and Viotto, 1990).
The rete testis of the camel reacted negatively for the enzyme acid phosphatase (Osman, 1975).

Moderate to intense alkaline phosphatase activity was detected in the luminal border of the rete testis of the buffalo, whereas the cell cytoplasm, basement membrane and nuclei were mildly reactive (Goyal and Dhingra, 1973; Dhingra, 1980). It has also been noticed that the fibrous connective tissue of the mediastinum reacted negatively for alkaline phosphatase, while the tunica intima of the mediastinum blood vessels reacted positively.
CHAPTER TWO
MATERIAL AND METHODS

The tissue samples used in this study were taken from testes of 5 groups of kids with the following ages:-

Group 1: 5-6 weeks of age.
Group 2: 8-10 weeks of age.
Group 3: 12-15 weeks of age.
Group 4: 17-18 weeks of age.
Group 5: 21 weeks of age and onwards (sexually mature animals)

These groups of animals were obtained from Abozeid and hellat koko Animal markets and Elsalam slaughter house. The testes were removed from the kids immediately after they were slaughtered in the premices of the department of anatomy. Slaughter house material was taken from the kids a few minutes after death.

II. 1. Histological techniques

For the preparation of histological sections, 25 animals were used. After slaughter, the testes were removed from the animal and the epididymis was dissected out. Then the testis was divided longitudinally into two halves and small blocks of tissue (about 1cm thick) were cut out, including the mediastinum.
10% formalin, Bouin’s fluid, formal saline or Zinker’s formol were used for the fixation of the blocks of tissue. It has been found that Bouin’s fluid was the best fixative for the tissue blocks from the testis and the ideal time of fixation was 16 hours. The samples were dehydrated through ascending grades of ethanol (70% - 90% - 100%), and cleared in chloroform. Then, the tissue samples were impregnated in three changes of molten paraffin wax with melting point of 55°-60° C (one hour for each change), and blocked in paraffin wax (Drury and Wallington, 1980).

By using a rotary microtome, sections (about 5–8 µm thick) were cut and picked up on clean slides. The sections were stained by using the following techniques:-

1. Haematoxylene and Eosin (H & E) for general histological structures (Drury and Wallington, 1980).
3. Orcine and aldehyde fuchsin for elastic fibers (Drury and Wallington 1980).
4. Gomori’s reticulin methods for reticular fibers (type III collagen fibers) (Culling, 1974).

Histometrical measurements were carried out in tubules transversely cut to determine the tubular diameter in the different age groups. Olympus microscope (CH20-Japan) was used in this measurement and
using ocular micrometer lens X6. The objective lenses X10, X40 and X100 were used for determining the measurements after calibrating the ocular scale of the microscope (Thienpont, Rochette and Vanparijs, 1986). Ten measurements were counted for the diameter of the tubules from each animal and the average was calculated. The tubules measured were the seminiferous tubules, the terminal segments, the tubuli recti (receptacle and main part) and the rete testis.

II.2. Histochemistry:

The material used for histochemical investigation was collected from 10 kids (two animals from each age group).

II.2.1. Polysaccharides

The specimens for the investigation of carbohydrates were fixed in Bouin’s solution and Ginder’s solution and processed for the paraffin wax sections and then stained with periodic acid Schiff (PAS) technique (Culling, 1974). Control sections for glycogen were treated with 0.1% malt diastase or saliva for 30 minutes at room temperature.

II.2.2. Enzymes

Preparation of frozen sections

The specimens used for the frozen sections were cut into small slices about (5mm thick) as soon as possible after the kids were slaughtered and quickly frozen in liquid nitrogen (-196°c) without any fixation. The
frozen sections were cut into 10-12µm thick with Slee cryostat, picked up on clean cover slips and stored in Columbia jar at -20°C for later use. The stored sections were allowed to dry for 1 minute before staining them. Fresh medium was used for each patch of sections.

II.2.2.1. Acid phosphatase

Fresh frozen sections were fixed in acetone at 4°C and stained according to the method of Gomori as described by Drury and Wallington (1980). The sections were incubated at pH 5.0 for two hours at 37°C using the substrate lead nitrate.

II.2.2.2. Alkaline phosphatase

Fresh frozen sections were fixed in acetone at 4°C and stained according to the methods of Gomori and Lillie as described by Drury and Wallington (1980). The sections were incubated at pH 9.2 for 30 minutes at 37°C using the substrate calcium phosphate.

II.3 Morphometry

The specimens used for the morphometric analysis were prepared from three groups of animals (3 animals in each group) with the following ages:

1. 5 – 10 weeks of age referred to as group A.
2. 12 – 18 weeks of age referred to as group B.
3. 21 weeks of age and onwards referred to as group C.
In all the three groups, the volume of the testis was measured first by using water displacement method (Aherne and Dunnil, 1982), after dissecting the epididymis and removing. The testis of each animal was transversely cut into two halves. Then one block, about 1cm in length, was randomly cut out from each half. The number of the blocks which were randomly cut out varied among the different groups (A, B and C).

In group A, the testis was cut transversely into two halves and then one block was randomly selected and cut out from each half.

In group B, the testis was cut transversely into four segments and then one block was randomly selected from each segment and cut out.

In group C, which was quite different in size from group A and B, the testis was cut transversely into six segments and then one block was randomly selected from each segment and cut out. The increase in the number of the blocks (2 blocks from each kid in group (A), 4 blocks in group (B) and 6 blocks in group (C)) is due to the increase in the size of the testis with advancing age. All blocks were processed for routine histological sections. One section from each block was completely analyzed field by field, using the point counting technique of Weibel (1963) and Hally (1964) so that the data were obtained from 6 sections in group (A), 12 sections in group (B) and 18 sections in group (C), and consequently a total of 36 sections were counted in this study.
The results were expressed as a percentage of the testis components volume (Vv %). These components included the seminiferous tubules, the interstitial connective tissue (Leydig cells, blood vessels and fibres), the terminal segments, the tubuli recti, the rete testis and the mediastinal connective tissue.

The absolute volume of each of the testis components was then obtained by multiplying Vv by fresh testis volume (i.e. Absolute volume = Vv × V).

The statistical analysis of the data obtained by point-counting was restricted to the determination of the means and standard deviation as suggested by Weibel (1963).
CHAPTER THREE
RESULTS

III.1. Histology:

The intratesticular tubules were classified in this study according to their characteristic features into the seminiferous tubules and their tubular ducts. The seminiferous tubules were lined by stratified germinal epithelium and sertoli cells, while the duct system generally lacked the spermatogenic cells and was lined with monolayered epithelium (Fig. 1).

The intratesticular tubular ducts were classified also according to their proximity to the seminiferous tubules into: the terminal segment of the seminiferous tubules, the tubulus rectus and the rete testis (Figs. 1,2). The seminiferous tubules occupied the testicular lobules forming the testicular parenchyma, while the tubular ducts were situated around and within the central axial mediastinal testis (Fig. 3). Some segments were seen extending inside the testicular trabeculae or adjacent to them

III.1.1. The seminiferous cords and tubules:-

At 5-6 weeks of age, the seminiferous cords varied between 39.0 µm and 48.0 µm with an average of 42.3 µm in diameter (table 1) and were lined by one layer of epithelium surrounded with a boundary of connective tissue (Fig. 4). At this age the seminiferous cords possessed a few gonocytes,
mostly 1-3 in number in each cross section (Fig. 4). The gonocytes were large round cells. The cytoplasm of gonocytes was faintly stained and their nuclei were large and spherical and possessed euchromatin (Fig. 5). These cells first formed a peripheral layer and divided to give rise to spermatogonia and then moved toward the centre of the seminiferous cords and disappeared with the starting of the spermatogenic cycle (Fig. 4). The epithelium of the seminiferous cords was composed of two major categories of cells: supporting cells and spermatogonia. Supporting cells (Sertoli cells) had oval or spherical nuclei. The nuclei of the Sertoli cells were mostly situated close to the basal lamina, and only rarely situated some distance from the basal lamina. The nuclei usually possessed prominent nucleoli and fine chromatin material (Fig. 6). The cytoplasm of sertoli cells was arranged in long cytoplasmic processes which extended toward the interior of the seminiferous cords. Spermatogonia were the only germ cells which raised from the gonocytes. Their nuclei were round or oval in shape and situated close to the basal lamina. Two types of spermatogonium were observed: Type A spermatogonia, had spherical or ovoid nucleus and the nucleoplasm was dark and had fine chromatin granules or dustlike with one or two eccentrically located nucleoli. Type B spermatogonia had small nuclei and the nucleoplasm had chromatin granules of varying sizes and one centrally located nucleolus. The seminiferous cords had no lumen. The lining epithelium of the seminiferous cords rested on a thin basal lamina. The
connective tissue surrounding the seminiferous cords consisted of two layers, internal zone of fibrous tissue, supported with an external zone of small, dark and flat or spindle shaped cells (Fig. 6). The fibrous connective tissue which was situated subjacent to the basal lamina consisted mainly of collagenous fibres (Fig. 7). The small dark flat or spindle shaped cells were myoid-like cells which were arranged in a single layer around the seminiferous cord and separated it from the interstitial connective tissue (Fig. 6).

The intertubular tissue constituted the framework of the testis and consisted of loose fibrous connective tissue that supported the Leydig cells, blood vessels, lymphatics and nerves (Fig. 8). The connective tissue cells were fibroblasts, macrophages, plasma cells and lymphocytes. The distinctive components of the interstitial tissue were epithelioid cells or glandular interstitial cells (Leydig cells). These cells were grouped in variable numbers or often in clusters of cells (Fig. 4). The process of spermatogenesis was not yet started.

At 8–10 weeks of age, the seminiferous cords increased slightly in diameter which varied between 40.0 µm and 54.0 µm with an average of 48.8 µm (Table 2). The spermatogenic cycle was just started so that primary spermatocytes were present as a result of meiotic division of type B spermatogonia (Fig. 9). The number of primary spermatocytes was 1 to 5 cells with an average of 3 cells per cross section. Primary spermatocytes were situated away from the basal lamina and accumulated more cytoplasm
so that they became distinctly larger than the spermatogonia. The seminiferous cords were still without a lumen. The gonocytes were rarely seen, only one cell per cross section.

At 12–15 weeks of age, the seminiferous cords were increased in diameter at the expense of the interstitial tissue and varied between 61.0 µm and 87.0 µm with an average of 73.7µm (Table 3). The spermatogenic cycle increased in activity so that the seminiferous cords became crowded with primary spermatocytes (2 to 9 cells, with an average of 7 cells per cross section) (Fig. 10). The gonocytes disappeared completely. The seminiferous cords were transformed into seminiferous tubules by acquiring a lumen (Fig.10). The lumina of the seminiferous tubules were narrow and inconspicuous. At this stage the seminiferous tubules developed a terminal segment (Fig. 11).

At 17- 18 weeks of age, the diameter of the seminiferous tubules varied between 140.8 µm and 205.8 µm, with an average of 173.3 µm (Table 4). Round and elongated spermatids were present within and on top of the stratified epithelium of the seminiferous tubules. The seminiferous tubules had a patent lumen and the terminal segment could easily be distinguished from the seminiferous tubules proper due to the presence of spermatids in the latter (Fig. 12).

At 21 weeks of age and onward, the seminiferous tubules were enlarged, 162.5 µm to 205.8 µm with an average of 187.4 µm in diameter
(table 5), and they had a wide central lumen (Fig. 13). The last products of spermatogenesis, spermatozoa, were formed and clearly seen inside the lumen of the seminiferous tubules. The fibres of the interstitial tissue were numerous and formed the major intertubular component.

**III.2. The terminal segment of the seminiferous tubules:-**

The term terminal segment has been used by several authors to designate a short portion of the seminiferous tubule which joined it to the tubulus rectus.

The terminal segment of the seminiferous tubules could not be identified between the age of 5 and 10 weeks.

At 12-15 weeks of age, the terminal segment of the seminiferous tubules measured between 45.0 µm and 52.0 µm with an average of 49.7 µm in diameter (Table 3); and could be distinguished only when their connection with the tubulus rectus was established due to the presence of a wide lumen of the proximal part of the tubulus rectus (Fig. 11). The terminal segments had no lumen. The terminal segments were lined by tall cells with apically vaculated cytoplasm and these cells were usually known as modified Sertoli cells. The modified Sertoli cells possessed long cytoplasmic processes which projected from the sides of the tubules and then protruded for a short distance into the cup shaped modification of adjacent tubuli recti forming a terminal plug of the terminal segment of the seminiferous tubules (Fig. 11). The nuclei of modified Sertoli cells were large and spherical in shape; some
of them were oval, and these nuclei usually possessed prominent nucleoli and fine chromatin granules distributed mainly in the periphery. Most of the nuclei of modified Sertoli cells were localized close to the basal lamina, while a few of them were seen some distance from it.

At 17–18 weeks of age, the terminal segment of the seminiferous tubule varied between 75.81 µm and 140.8 µm with an average of 102.0 µm in diameter (Table 4) and had acquired a small central lumen. The epithelium lining the terminal segment contained tall columnar cells (modified Sertoli cells), with often basally situated nuclei. The nuclei were spherical or irregular in shape and possessed prominent nucleoli.

At 21 weeks of age and onward, the terminal segment of the seminiferous tubules measured 97.47 µm to 173.3 µm in diameter with an average of 125.6 µm (Table 5). The terminal segment could be subdivided into three regions, according to the gradual depletion of their germ cells; transitional region, middle portion and terminal plug (Figs. 14, 15, 16).

In the transitional region of the terminal segment of the seminiferous tubules, the spermatogonia were constantly found along the basal lamina together with the modified Sertoli cells, while the spermatocytes were few in number and the spermatids and spermatozoa were completely absent (Fig. 15).

In the middle region of the terminal segment, the main lining cells were modified Sertoli cells with long vaculated cytoplasm, while the
spermatogonia were few in number and spermatocytes were rarely encountered (Figs. 15, 16, 17, 18).

The terminal plug contained only the cytoplasm processes of modified Sertoli cells. The modified Sertoli cells had indent nuclei and some of them were situated basally in the cells and others were situated some distance from the basal lamina (Fig. 19). The nuclei were spherical, or irregular in shape. The nucleoli were often dark, small and prominent (Figs. 17, 19). The cytoplasm of modified Sertoli cells was lightly stained.

Spermatozoa were seen within the apical parts of the modified Sertoli cell cytoplasm (Fig. 19). The absence of spermatogonia and the increased number of phagocytized spermatozoa strongly marks the beginning of the plug cells from the other parts of the terminal segment. All the three parts of the terminal segment had a lumen (Fig. 20, 33). Spermatozoa and desquamated spermatogenic cells were frequently found within the lumen of the terminal segment of the seminiferous tubules.

A few intraepithelial lymphocytes were seen in between the modified Sertoli cells. These lymphocytes were small and irregular and their cytoplasm was lightly stained.

The modified Sertoli cells rested on a delicate basal lamina which was the continuation of that of the seminiferous tubules proper. The connective tissue layer was relatively thin and consisted of collagenous fibers and a few
reticular fibres (Fig. 22). Small flat or spindle shaped cells surrounded the fibrous layer.

**III. 3. The tubulus rectus**

The terminal segments of the seminiferous tubules were linked to the rete channels by a portion of the intratesticular excurrent ducts known as tubuli recti.

At 5-6 weeks of age, the tubuli recti were small tubules and had a narrow lumen; their diameter varied between 8.0 µm and 12.0 µm with an average of 10.0 µm (Table 1). The tubuli recti were lined with a single layer of low cuboidal epithelium.

At 8-10 weeks of age, the tubuli recti increased slightly in their diameter; they varied between 8.01 µm and 21.36 µm with an average of 14.41 µm (Table 2), and were lined with low cuboidal cells.

At 12-15 weeks of age, the tubuli recti were modified into a dilated proximal cup shaped part followed by a narrow stalk region (Fig. 11). The dilated proximal part of the tubuli recti usually encompassed the protruded vaculated cytoplasm of the plug of the terminal segment of the seminiferous tubules. The tubuli recti were subdivided into two regions, the first one is the dilated proximal part which accommodated the plug of the terminal segment and known as the receptacle, The diameter of this region varied between 30 µm and 40 µm with an average of 34 µm (Table 3). The tubuli recti, when seen in cross section near the junction between the terminal segments and the
receptacle, contained a central accumulation of the apical portions of the cells of the terminal segments separated by a narrow space from the lining epithelium of the tubuli recti. At the junction between the terminal segment of the seminiferous tubule and the tubulus rectus, the epithelium changed abruptly from tall cells of the terminal segment to low cells of the receptacle. The epithelium lining the receptacle varied between simple squamous and low cuboidal cells.

The second part of the tubuli recti was a narrow stalk region which joined the receptacle, and known as the main narrow part. The diameter varied between 25 µm and 28 µm with an average of 26 µm (Table 3). The epithelium lining the main part was simple low cuboidal cells.

At 17-18 weeks of age, the diameter of the receptacle varied between 86.64 µm and 97.47 µm with an average of 93.86 µm (Table 4) and was lined with simple flattened and low cuboidal cells (Fig. 23). The main part reached 43.32 µm to 64.98 µm in diameter with an average of 48.74 µm (Table 4). The epithelium lining the main part was low cuboidal.

At 21 weeks of age and onwards, the diameter of the receptacle reached 86.64 µm to 129.96 µm with an average of 102.89 µm (table 5). The main part reached 54.15 µm to 64.98 µm with an average of 59.57 µm (table 5). The tubuli recti were distributed in the testicular parenchyma mainly in the connective tissue which extended radially from the mediastinum to the septulae testis.
The receptacle was usually lined with low cells that varied between simple squamous and low cuboidal cells (Fig. 24). The nuclei of the cells lining the receptacle were either ovoid with their long axis parallel to the basal lamina or round and often situated in the bases of the cells. The epithelium lining the main part was simple low cuboidal with rounded nuclei mostly situated in the centre of the cells (Fig. 25).

Intraepithelial lymphocytes were less conspicuous within the epithelium lining the tubuli recti, specially the receptacles, while a few intraepithelial lymphocytes were seen within the main parts and located into dilated intercellular spaces.

The tubular lumen of the main part was usually empty but some times spermatozoa or degenerated spermatogenic cells were seen.

The tubuli recti, like the terminal segment, rested on a delicate basal lamina which consisted of collagenous fibers and a network of reticular fibers and surrounded by small flat or spindle shaped dark cells.

III.1.4. The rete testis

The rete testis was in the form of a group of channels occupying an axial and centrally located fibrous mediastinum testis (Fig. 3). The rete testis and its mediastinum coursed through about two-thirds of the length of the central longitudinal axis of the testis. Some of the channels extended from the mediastinum to the, septulae testis where the fibrous connective tissue of the mediastinum into the testicular parenchyma. The extended fibrous
connective tissue of the mediastinum extended into the septulae testis divided the testicular parenchyma into lobules occupied by the seminiferous tubules.

At 5-6 weeks of age, the rete testis was in the form of small channels, less intercommunicating, and their width varied between 13.35 µm and 38.0 µm with an average of 31.0 µm (table 1). Some of the channels coursed parallel to each other (Fig. 26). The rete channels were lined mainly with pseudostratified columnar epithelium (Fig. 26). Patches of low cuboidal cells were observed lining some areas of the rete (Figs. 26, 28). The rete channels possessed conspicuous lumina (Fig. 27). Fibroblast and undifferentiated mesenchymal cells were distributed throughout the mediastinum around the rete channels (Fig. 27). Groups of Leydig cells were seen near the rete channels in the mediastinum connective tissue (Fig. 29).

The epithelium lining the rete testis rested upon a conspicuous basal lamina. The connective tissue of the mediastinum was abundant and consisted of bundles of collagen fibres and reticular fibres (Fig. 32).

Blood and lymphatic vessels were seen coursing throughout the mediastinal connective tissue but mainly in the periphery of the mediastinum.

At 8-10 weeks of age, the width of the rete channels varied between 22.0 µm and 45.39 µm with an average of 31.27 µm (Table 2). The rete channels were still parallel to each other (Fig. 30). Many types of epithelial
cells lined the rete testis such as simple squamous, simple low cuboidal and pseudostratified columnar epithelium. Fibroblasts and undifferentiated mesenchymal cells were found. Leydig cells were also observed.

At 12-15 weeks of age, the rete width varied between 25.0 µm and 62.0 µm with an average of 37.9 µm (Table 3). The main epithelium lining the rete was pseudostratified columnar epithelium; some of the channels were lined with simple cuboidal epithelium.

At 17-18 weeks of age, the rete width varied between 32.49 µm and 119.1 µm with an average of 68.23 µm (Table 4). The epithelial lining of the rete channels was simple squamous or low cuboidal (Fig. 31). The rete channels were still less intercommunicating.

At 21 weeks of age and onward, the rete width varied between 97.47 µm and 270.8 µm with an average of 162.4 µm (Table 5). The rete testis could be subdivided into septulae, mediastinal and extratesticular portions. The extratesticular rete is usually located outside the testis.

The mediastinum rete channels tended to anastamose and intercommunicate and then became large and more intercommunicating and anastomosing cavities. The main epithelium lining the rete cavities was simple squamous, but also low cuboidal epithelial cells were observed lining some areas of the re
The diameters of the developing seminiferous tubules and their intratesticular excurrent ducts in the different age groups were documented in the following tables.

Table (1): 5 to 6 weeks of age.

<table>
<thead>
<tr>
<th>Tubule Segment</th>
<th>Diameter (µm)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
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<tr>
<td>Seminiferous cords</td>
<td>39.0</td>
<td>48.0</td>
<td>42.3</td>
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<tr>
<td>Tubuli recti</td>
<td>8.0</td>
<td>12.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Rete testis</td>
<td>13.35</td>
<td>38.0</td>
<td>31.0</td>
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Table (2): 8 to 10 weeks of age.

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<th>Maximum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminiferous Cords</td>
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<td>54.0</td>
<td>48.8</td>
<td></td>
</tr>
<tr>
<td>Tubuli recti</td>
<td>8.01</td>
<td>21.36</td>
<td>14.41</td>
<td></td>
</tr>
<tr>
<td>Rete testis</td>
<td>22.0</td>
<td>45.39</td>
<td>31.27</td>
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</tbody>
</table>

Table (3): 12 to 15 weeks of age.

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<th>Diameter (µm)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminiferous tubules</td>
<td>61.0</td>
<td>87.0</td>
<td>73.7</td>
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<tr>
<td>Terminal segments</td>
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<td>52.0</td>
<td>49.7</td>
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<td>Receptacle of TR</td>
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<td>34.0</td>
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</tr>
<tr>
<td>Main part of TR</td>
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<td>28.0</td>
<td>25.0</td>
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Table (4): 17 to 18 weeks of age.

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<td>Minimum</td>
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Table (5): 21 weeks of age and onwards.

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TR: Tubuli recti.
III.2. Histohemistry:

III.2.1. Polysaccharides

A varying degree of positive reaction for PAS diastase resistant material and diastase digested material was seen. The boundary tissue of the intratesticular tubules showed a positive reaction for PAS distase resistant material in all groups of kids studied (Figs. 35, 40). The reaction was strong in the basement membrane of the seminiferous cords whereas the strongest reaction was seen in the boundary tissue of the rete testis. The epithelium lining the seminiferous cords gave a negative reaction (Fig. 37). The epithelium of the seminiferous tubules of sexually mature group showed a moderate reaction.

The presence of PAS diastase digested material (glycogen) varied between the seminiferous cords (Figs. 34, 35). A large number of fine glycogen granules were seen within the cytoplasm of the epithelium of some of the seminiferous cords, while some other cords showed moderate number and still some other seminiferous cords contained a few number of scattered glycogen granules or none at all (Figs. 36, 37).

A large number of PAS positive granules resistant to diastase digestion were seen within the cytoplasm of the rete testis (Fig. 40). The
number of the granules gradually decreased with advancing age until became a few in the mature kids.

The seminiferous tubules, after their transformation from the seminiferous cords, contained a few number of fine glycogen granules, less than that of the seminiferous cords. The basement membrane of the terminal segment of the seminiferous tubules showed a strong reaction for PAS, that markedly demarcated the terminal segment from the seminiferous tubule proper (Fig. 41). The epithelium lining the terminal segment contained a few fine glycogen particles.

The receptacle and the main part of the tubulus rectus showed also a strong reaction (Fig. 41). Blood vessels and the interstitial connective tissue around them gave a weak reaction in the young groups and a moderate reaction in the sexually mature group.

The basement membrane of the rete testis of sexually mature group of kids and the rete contents also gave a strong reaction (Figs. 42, 43).

III. 2.2. Enzymes

III.2.2.1. Acid phosphatase

A positive reaction for the enzyme acid phosphatase was seen in all the intraresticular tubules. The reaction was detected in the cytoplasm of the lining epithelium, while the basement membrane showed a weak reaction (Fig. 44).
The epithelium lining the seminiferous cords showed positive reaction which increased slightly with advancing age until it became very strong in the sexually mature kids (Figs. 45, 46, 47). The reaction was more intense at the basal layers of the seminiferous tubules epithelium than that of the luminal layer (Fig. 47). Blood vessels and interstitial connective tissue revealed a negative reaction in all age groups of kids, while the interstitial cells reacted very strongly (Fig. 44).

The epithelium lining the terminal segment of the seminiferous tubule demonstrated a positive reaction for acid phosphatase and the intensity of the reaction increased steadily with advancing age (Fig. 47). The tubulus rectus and the rete testis also gave a strong reaction.

III.2.2.2. Alkaline phosphatase

The basement membrane of all intratesticular tubules reacted positively for the enzyme alkaline phosphatase in all groups of kids. The cytoplasm of the lining epithelium gave a positive reaction but the intensity and localization of the reaction varied. The reaction was strong in the basement membrane of the seminiferous cords, and very strong reaction was seen in the cytoplasm of the epithelium lining the seminiferous cords (Fig. 48). The reaction of the enzyme alkaline phosphatase was very week in the peritubular connective tissue (Fig. 49). Blood vessels showed negative reaction while the interstitial cells reacted strongly (Fig. 50).
The basement membrane and the epithelium which lined the seminiferous tubules of kids at the age of 12-15 weeks also gave a strong reaction but less than that of the seminiferous cords and the reaction in the lining epithelium was in the form of small areas of dense reaction (Fig. 51).

The terminal segment of the seminiferous tubule, when developed, showed a strong reaction in the basement membrane, more than that of the seminiferous tubule proper. The epithelium lining the terminal segment also gave a reaction stronger than that of the seminiferous tubule epithelium.

The receptacle and the main part of the tubulus rectus gave a strong reaction for alkaline phosphatase in their basement membrane. The reaction in the interstitial tissue was weak and similar to that of the tissue surrounding the seminiferous tubules.

The rete testis basement membrane revealed a strong alkaline phosphatase reaction in all groups of kids studied. The luminal border of the lining epithelium and the mediastinal aconnetive tissue demonstrated negative reaction for the enzyme alkaline phosphatase.
III.3. Morphometry

The morphometric analysis of the testis of the three groups of kids was illustrated in the tables 6-25.

The absolute volume of the fresh testis in group (A) varied between $2\text{cm}^3$ and $3\text{cm}^3$ with an average of $2.333\text{cm}^3 \pm 0.577$. While the volume was increased in group (B) in which it varied between $10\text{cm}^3$ and $33\text{cm}^3$ with an average of $21\text{cm}^3 \pm 11.53$ and further increased in sexually mature kids (group C) and varied between $50\text{cm}^3$ and $70\text{cm}^3$ with an average of $61.66\text{cm}^3 \pm 10.41$.

The morphometric analysis of the data revealed that the seminiferous cords gave a value which varied between $36.95\%$ ($1.108\text{cm}^3$) and $40.99\%$ ($0.820\text{cm}^3$) with an average of $38.60\%$ ($0.895\text{cm}^3 \pm 0.187$) of the testicular volume; but when the cords were transformed into seminiferous tubules in group (B) the value varied between $50.89\%$ ($16.79\text{cm}^3$) and $62.36\%$ ($6.236\text{cm}^3$) with an average of $55.40\%$ ($11.21\text{cm}^3 \pm 5.303$) of the volume of the testis and reached a value varied between $66.04\%$ ($45.23\text{cm}^3$) and $76.87\%$ ($49.96\text{cm}^3$) with an average of $70.93\%$ ($43.70\text{cm}^3 \pm 7.809$) of the volume in group (C).

The interstitial connective tissue constituted about a value which varied between $39.50\%$ ($0.790\text{cm}^3$) and $49.89\%$ ($1.497\text{cm}^3$) with an average of $46.30\%$ ($1.092\text{cm}^3 \pm 0.364$) of the testicular volume in group
(A) and varied between 25.09% (8.280 cm³) and 37.41% (7.482 cm³) with an average of 32.19% (6.390 cm³ ± 2.614) of the volume in group (B), while this value reached a value varied between 17.09% (11.11 cm³) and 24.50% (17.15 cm³) with an average of 21.66% (13.32 cm³ ± 3.329) of the volume in group (C).

The terminal segment of the seminiferous tubules, when developed in group (B) gave a value which varied between 0.017% (0.002 cm³) and 0.087% (0.017 cm³) with an average of 0.046% (0.010 cm³ ± 0.007) of the testicular volume and reached a value that varied between 0.054% (0.035 cm³) and 0.279% (0.140 cm³) with an average of 0.137% (0.077 cm³ ± 0.055) of the volume in group (C).

The tubulus rectus represented a value which varied between 0.047% (0.001 cm³) and 0.091% (0.003 cm³) with an average of 0.067% (0.002 cm³ ± 0.001) of the testicular volume in group (A). The value varied between 0.070% (0.007 cm³) and 0.241% (0.048 cm³) with an average of 0.129% (0.027 cm³ ± 0.020) of the testicular volume in group (B) and varied between 0.142% (0.099 cm³) and 0.256% (0.128 cm³) with an average of 0.200% (0.120 cm³ ± 0.018) of the testicular volume in group (C).

The mediastinal connective tissue gave a value which varied between 9.710% (0.291 cm³) and 16.02% (0.320 cm³) with an average of 11.89% (0.270 cm³ ± 0.063) of the volume of the testis in group (A); varied
between 2.184% (0.218cm³) and 14.27% (4.709cm³) with an average of 7.900% (2.125cm³± 2.320) of the volume in group (B), while the value varied between 2.949% (1.917cm³) and 6.270% (4.389cm³) with an average of 4.753% (2.942cm³±1.288) of the testicular volume in group (C).

The rete testis constituted a value that varied between 2.631% (0.053cm³) and 3.426% (0.069cm³) with an average of 3.138% (0.074cm³±0.024) of the volume of the testis in group (A), and varied between 1.310% (0.131cm³) and 9.631% (3.178cm³) with an average of 4.324% (1.238cm³±1.685) of the testicular volume in group (B), and between 1.093% (0.547cm³) and 2.966% (2.076cm³) with an average of 2.297% (1.488cm³±0.823) of the testicular volume in group (C).
Table (6): The data obtained by points counting fields of sample section of the testis of animal No.1 in group (A).

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SC  Seminiferous Cords.
ICT Interstitial connective tissue.
TS  Terminal segment of the seminiferous tubule.
TR  Tubulus rectus
MCT Mediastinal connective tissue.
RT  Rete testis channels.
Table (7): The data obtained by points counting fields of sample section of the testis of animal No.3 in group (B).

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ST  Seminiferous tubule.
ICT Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
MCT Mediastinal connective tissue.
RT  Rete testis channels.
Table (8): The data obtained by points counting fields of sample section of the testis of animal No.1 in group (C).

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ST  Seminiferous tubule.
ICT  Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
MCT  Mediastinal connective tissue.
RT  Rete testis channels.
Table (9): Animal No.1 (group A): The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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SC  Seminiferous cords.
ICT  Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
MCT  Mediastinal connective tissue.
RT  Rete testis channels.
V.v  Volume fraction.
Abs.v  Absolute volume.

Table (10): Animal No.2 (group A): The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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Table (11): Animal No.3 (group A) : The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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SC     Seminiferous cord.
ICT    Interstitial connective tissue.
TS     Terminal segment.
TR     Tubulus rectus.
MCT    Mediastinal connective tissue.
RT     Rete testis channels.
V.v    Volume fraction.
Abs.v  Absolute volume.
Table (12): Animal No.1 (group B): The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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Table (13): Animal No.2 (group B): The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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ST    Seminiferous tubules  
ICT   Interstitial connective tissue  
TS    Terminal segment  
TR    Tubulus rectus  
MCT   Mediastinal connective tissue  
RT    Rete testis channels  
Vv.   Volume fraction  
Abs.v Absolute volume
Table (14): Animal No.3 (group B): The total points counted, the volume fraction and the absolute volume of each component of goat testis.

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<td>8.280 cm³</td>
<td>0.011 cm³</td>
<td>0.025 cm³</td>
<td>4.709 cm³</td>
<td>3.178 cm³</td>
<td>33 cm³</td>
</tr>
</tbody>
</table>

ST  Seminiferous tubules.
ICT  Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
MCT  Mediastinal connective tissue.
RT  Rete testis channels.
V.v  Volume fraction.
Abs.v  Absolute volume.
Table (15): Animal No.1 (group C): The total points counted, the volume fraction and the absolute volume of each component of the testis of goat.

<table>
<thead>
<tr>
<th>Section No.</th>
<th>ST</th>
<th>ICT</th>
<th>TS</th>
<th>TR</th>
<th>MCT</th>
<th>RT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2873</td>
<td>400</td>
<td>6</td>
<td>14</td>
<td>100</td>
<td>7</td>
<td>3400</td>
</tr>
<tr>
<td>2</td>
<td>3950</td>
<td>250</td>
<td>2</td>
<td>10</td>
<td>25</td>
<td>7</td>
<td>4237</td>
</tr>
<tr>
<td>3</td>
<td>6212</td>
<td>1780</td>
<td>6</td>
<td>20</td>
<td>233</td>
<td>78</td>
<td>8329</td>
</tr>
<tr>
<td>4</td>
<td>4790</td>
<td>1300</td>
<td>--</td>
<td>7</td>
<td>300</td>
<td>90</td>
<td>6487</td>
</tr>
<tr>
<td>5</td>
<td>3987</td>
<td>1162</td>
<td>1</td>
<td>16</td>
<td>131</td>
<td>85</td>
<td>5677</td>
</tr>
<tr>
<td>6</td>
<td>3970</td>
<td>838</td>
<td>3</td>
<td>1</td>
<td>200</td>
<td>395</td>
<td>5407</td>
</tr>
<tr>
<td>Total</td>
<td>25782</td>
<td>5730</td>
<td>18</td>
<td>68</td>
<td>989</td>
<td>950</td>
<td>33537</td>
</tr>
</tbody>
</table>

V.v           | 76.87%| 17.09%| 0.054%| 0.203%| 2.949%| 2.833%| 100%  |
Abs.v         | 49.96 cm³| 11.11 cm³| 0.035 cm³| 0.132 cm³| 1.917 cm³| 1.841 cm³| 65 cm³ |

Table (16): Animal No.2 (group C): The total points counted, the volume fraction and the absolute volume of each component of the testis of goat.

<table>
<thead>
<tr>
<th>Section No.</th>
<th>ST</th>
<th>ICT</th>
<th>TS</th>
<th>TR</th>
<th>MCT</th>
<th>RT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3800</td>
<td>1750</td>
<td>3</td>
<td>10</td>
<td>500</td>
<td>212</td>
<td>6275</td>
</tr>
<tr>
<td>2</td>
<td>3038</td>
<td>1150</td>
<td>1</td>
<td>3</td>
<td>306</td>
<td>100</td>
<td>4598</td>
</tr>
<tr>
<td>3</td>
<td>4200</td>
<td>1516</td>
<td>8</td>
<td>18</td>
<td>237</td>
<td>116</td>
<td>6095</td>
</tr>
<tr>
<td>4</td>
<td>3000</td>
<td>2000</td>
<td>6</td>
<td>4</td>
<td>341</td>
<td>200</td>
<td>5551</td>
</tr>
<tr>
<td>5</td>
<td>4650</td>
<td>1200</td>
<td>9</td>
<td>12</td>
<td>400</td>
<td>201</td>
<td>6472</td>
</tr>
<tr>
<td>6</td>
<td>4002</td>
<td>800</td>
<td>--</td>
<td>2</td>
<td>370</td>
<td>190</td>
<td>5364</td>
</tr>
<tr>
<td>Total</td>
<td>22690</td>
<td>8416</td>
<td>27</td>
<td>49</td>
<td>2154</td>
<td>1019</td>
<td>34355</td>
</tr>
</tbody>
</table>

V.v           | 66.04%| 24.50%| 0.079%| 0.142%| 6.270%| 2.966%| 100%  |
Abs.v         | 46.23 cm³| 17.15 cm³| 0.055 cm³| 0.099 cm³| 4.389 cm³| 2.076 cm³| 70 cm³ |

ST     Seminiferous tubule.
ICT    Interstitial connective tissue.
TS     Terminal segment.
TR     Tubulus rectus.
MCT    Mediastinal connective tissue.
RT     Rete testis channels.
V.v    Volume fraction.
Abs.v  Absolute volume.
Table (17): Animal No. 3 (group C): The total points counted, the volume fraction and the absolute volume of each component of the testis of goat.

<table>
<thead>
<tr>
<th>Section No.</th>
<th>ST</th>
<th>ICT</th>
<th>TS</th>
<th>TR</th>
<th>MCT</th>
<th>RT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4206</td>
<td>1100</td>
<td>22</td>
<td>9</td>
<td>337</td>
<td>100</td>
<td>5774</td>
</tr>
<tr>
<td>2</td>
<td>3204</td>
<td>900</td>
<td>10</td>
<td>4</td>
<td>100</td>
<td>42</td>
<td>4260</td>
</tr>
<tr>
<td>3</td>
<td>4000</td>
<td>1750</td>
<td>17</td>
<td>19</td>
<td>300</td>
<td>37</td>
<td>6123</td>
</tr>
<tr>
<td>4</td>
<td>3885</td>
<td>1250</td>
<td>15</td>
<td>10</td>
<td>132</td>
<td>4</td>
<td>5296</td>
</tr>
<tr>
<td>5</td>
<td>3000</td>
<td>1128</td>
<td>15</td>
<td>32</td>
<td>500</td>
<td>42</td>
<td>4717</td>
</tr>
<tr>
<td>6</td>
<td>3000</td>
<td>1000</td>
<td>6</td>
<td>4</td>
<td>167</td>
<td>108</td>
<td>4285</td>
</tr>
<tr>
<td>Total</td>
<td>21295</td>
<td>7128</td>
<td>85</td>
<td>78</td>
<td>1536</td>
<td>333</td>
<td>30455</td>
</tr>
<tr>
<td>V.v</td>
<td>69.92%</td>
<td>23.40%</td>
<td>0.279%</td>
<td>0.256%</td>
<td>5.044%</td>
<td>1.093%</td>
<td>100%</td>
</tr>
<tr>
<td>Abs.v</td>
<td>34.96 cm³</td>
<td>11.70 cm³</td>
<td>0.140 cm³</td>
<td>0.128 cm³</td>
<td>2.522 cm³</td>
<td>0.547 cm³</td>
<td>50 cm³</td>
</tr>
</tbody>
</table>

ST: Seminiferous tubule.
ICT: Interstitial connective tissue.
TS: Terminal segment.
TR: Tubulus rectus.
MCT: Mediastinal connective tissue.
RT: Rete testis channels.
Vv: Volume fraction.
Abs.v: Absolute volume.
Table (18): The volume fraction and standard deviation of each component of the testis in group (A) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>SC (Vv)%</th>
<th>ICT (Vv)%</th>
<th>TR (Vv)%</th>
<th>MCT (Vv.)%</th>
<th>RT (Vv.)%</th>
<th>Total (Vv.)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37.89</td>
<td>49.50</td>
<td>0.047</td>
<td>9.933</td>
<td>2.631</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>40.99</td>
<td>39.50</td>
<td>0.062</td>
<td>16.02</td>
<td>3.426</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>36.95</td>
<td>49.89</td>
<td>0.091</td>
<td>9.710</td>
<td>3.357</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>115.8</td>
<td>138.9</td>
<td>0.200</td>
<td>35.66</td>
<td>9.414</td>
<td>300</td>
</tr>
<tr>
<td>Mean</td>
<td>38.60</td>
<td>46.30</td>
<td>0.067</td>
<td>11.89</td>
<td>3.138</td>
<td>100</td>
</tr>
<tr>
<td>S.D</td>
<td>2.114</td>
<td>5.889</td>
<td>0.022</td>
<td>3.58</td>
<td>0.44</td>
<td></td>
</tr>
</tbody>
</table>

SC  Seminiferous cord.
ICT Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
MCT Mediastinal connective tissue.
RT  Rete testis channels.
Vv  volume fraction.
SD  Standard deviation.
Table (19): The volume fraction and standard deviation of each component of the testes in group (B) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>ST (Vv.)%</th>
<th>ICT (Vv.)%</th>
<th>TS (Vv.)%</th>
<th>TR (Vv.)%</th>
<th>MCT (Vv.)%</th>
<th>RT (Vv.)%</th>
<th>Total (Vv.)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52.98</td>
<td>37.41</td>
<td>0.087</td>
<td>0.241</td>
<td>7.250</td>
<td>2.032</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>62.36</td>
<td>34.06</td>
<td>0.017</td>
<td>0.070</td>
<td>2.184</td>
<td>1.310</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>50.89</td>
<td>25.09</td>
<td>0.034</td>
<td>0.077</td>
<td>14.27</td>
<td>9.631</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>166.2</td>
<td>96.56</td>
<td>0.138</td>
<td>0.388</td>
<td>23.70</td>
<td>12.97</td>
<td>300</td>
</tr>
<tr>
<td>Mean</td>
<td>55.40</td>
<td>32.19</td>
<td>0.046</td>
<td>0.129</td>
<td>7.900</td>
<td>4.324</td>
<td>100</td>
</tr>
<tr>
<td>SD</td>
<td>6.108</td>
<td>6.37</td>
<td>0.036</td>
<td>0.096</td>
<td>6.069</td>
<td>4.609</td>
<td></td>
</tr>
</tbody>
</table>

Table (20): The volume fraction and standard deviation of each component of the testes in group (C) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>ST (Vv.)%</th>
<th>ICT (Vv.)%</th>
<th>TS (Vv.)%</th>
<th>TR (Vv.)%</th>
<th>MCT (Vv.)%</th>
<th>RT (Vv.)%</th>
<th>Total (Vv.)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>76.87</td>
<td>17.09</td>
<td>0.054</td>
<td>0.203</td>
<td>2.949</td>
<td>2.833</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>66.04</td>
<td>24.50</td>
<td>0.079</td>
<td>0.142</td>
<td>6.270</td>
<td>2.966</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>69.92</td>
<td>23.40</td>
<td>0.279</td>
<td>0.256</td>
<td>5.044</td>
<td>1.093</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>212.8</td>
<td>64.99</td>
<td>0.412</td>
<td>0.601</td>
<td>14.26</td>
<td>6.892</td>
<td>300</td>
</tr>
<tr>
<td>Mean</td>
<td>70.93</td>
<td>21.66</td>
<td>0.137</td>
<td>0.200</td>
<td>4.753</td>
<td>2.297</td>
<td>100</td>
</tr>
<tr>
<td>SD</td>
<td>5.487</td>
<td>3.998</td>
<td>0.123</td>
<td>0.057</td>
<td>1.679</td>
<td>1.045</td>
<td></td>
</tr>
</tbody>
</table>

ST         Seminiferous tubule.  
ICT        Interstitial connective tissue.  
TS         Terminal segment.  
TR         Tubulus rectus.  
MCT        Mediastinal connective tissue.  
RT         Rete testis channels.  
Vv.        Volume fraction.  
SD         Standard deviation.
Table (21): The absolute volume and standard deviation of each component of the testes in group (A) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>SC Abs.V. cm³</th>
<th>ICT Abs.V. cm³</th>
<th>TR Abs.v. cm³</th>
<th>MCT Abs.v. cm³</th>
<th>RT Abs.v cm³</th>
<th>Total Abs.v. cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.758</td>
<td>0.990</td>
<td>0.001</td>
<td>0.199</td>
<td>0.053</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>0.820</td>
<td>0.790</td>
<td>0.001</td>
<td>0.320</td>
<td>0.069</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.108</td>
<td>1.497</td>
<td>0.003</td>
<td>0.291</td>
<td>0.101</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>2.686</td>
<td>3.277</td>
<td>0.005</td>
<td>0.810</td>
<td>0.223</td>
<td>7</td>
</tr>
<tr>
<td>Mean</td>
<td>0.895</td>
<td>1.092</td>
<td>0.002</td>
<td>0.270</td>
<td>0.074</td>
<td>2.333</td>
</tr>
<tr>
<td>S.D</td>
<td>0.187</td>
<td>0.364</td>
<td>0.001</td>
<td>0.063</td>
<td>0.024</td>
<td>0.577</td>
</tr>
</tbody>
</table>

SC  Seminiferous cord.
ICT  Interstitial connective tissue.
TS  Terminal segment.
TR  Tubulus rectus.
M  Mediastinal connective tissue.
RT  Rete testis channels.
Abs.v  Absolute volume.
SD  Standard deviation.
Table (22): The absolute volume and standard deviation of each component of the testis in group (B) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>ST Abs.v. cm³</th>
<th>ICT Abs.v. cm³</th>
<th>TS Abs.v. cm³</th>
<th>TR Abs.v. cm³</th>
<th>MCT Abs.v. cm³</th>
<th>RT Abs.v. cm³</th>
<th>Total Abs.v. cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.59</td>
<td>7.482</td>
<td>0.017</td>
<td>0.048</td>
<td>1.450</td>
<td>0.406</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>6.236</td>
<td>3.406</td>
<td>0.002</td>
<td>0.007</td>
<td>0.218</td>
<td>0.131</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>16.79</td>
<td>8.280</td>
<td>0.011</td>
<td>0.025</td>
<td>4.709</td>
<td>3.178</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>33.62</td>
<td>19.17</td>
<td>0.030</td>
<td>0.08</td>
<td>6.377</td>
<td>3.715</td>
<td>63</td>
</tr>
<tr>
<td>Mean</td>
<td>11.21</td>
<td>6.390</td>
<td>0.010</td>
<td>0.027</td>
<td>2.125</td>
<td>1.238</td>
<td>21</td>
</tr>
<tr>
<td>SD</td>
<td>5.303</td>
<td>2.614</td>
<td>0.007</td>
<td>0.020</td>
<td>2.320</td>
<td>1.685</td>
<td>11.53</td>
</tr>
</tbody>
</table>

Table (23): The absolute volume and standard deviation of each component of the testis in group (C) and their mean values.

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>ST Abs.v. cm³</th>
<th>ICT Abs.v. cm³</th>
<th>TS Abs.v. cm³</th>
<th>TR Abs.v. cm³</th>
<th>MCT Abs.v. cm³</th>
<th>RT Abs.v. cm³</th>
<th>Total Abs.v. cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49.96</td>
<td>11.11</td>
<td>0.035</td>
<td>0.132</td>
<td>1.917</td>
<td>1.841</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>46.23</td>
<td>17.15</td>
<td>0.055</td>
<td>0.099</td>
<td>4.389</td>
<td>2.076</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>34.96</td>
<td>11.70</td>
<td>0.140</td>
<td>0.128</td>
<td>2.522</td>
<td>0.547</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>131.2</td>
<td>39.96</td>
<td>0.230</td>
<td>0.359</td>
<td>8.828</td>
<td>4.464</td>
<td>185</td>
</tr>
<tr>
<td>Mean</td>
<td>43.70</td>
<td>13.32</td>
<td>0.077</td>
<td>0.120</td>
<td>2.942</td>
<td>1.488</td>
<td>61.66</td>
</tr>
<tr>
<td>SD</td>
<td>7.809</td>
<td>3.329</td>
<td>0.055</td>
<td>0.018</td>
<td>1.288</td>
<td>0.823</td>
<td>10.41</td>
</tr>
</tbody>
</table>

ST    Seminiferous tubule.
ICT   Interstitial connective tissue.
TS    Terminal segment.
TR    Tubulus rectus.
MCT   Mediastinal connective tissue.
RT    Rete testis channels.
Abs.v Absolute volume.
SD    Standard deviation
Table (24): A summary of the result shown in table 16 & 17.

<table>
<thead>
<tr>
<th>Animal group</th>
<th>SC %</th>
<th>Cm³</th>
<th>ICT %</th>
<th>Cm³</th>
<th>TR %</th>
<th>Cm³</th>
<th>MCT %</th>
<th>Cm³</th>
<th>RT %</th>
<th>Cm³</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38.60 ± 2.114</td>
<td>0.895 ± 0.187</td>
<td>46.30 ± 5.889</td>
<td>1.092 ± 0.364</td>
<td>0.067 ± 0.022</td>
<td>0.002 ± 0.001</td>
<td>11.89 ± 3.58</td>
<td>0.270 ± 0.063</td>
<td>3.138 ± 0.44</td>
<td>0.074 ± 0.024</td>
<td>2.333</td>
</tr>
</tbody>
</table>
Table (25): A summary of the results shown in tables 17, 18, 20 & 21.

<table>
<thead>
<tr>
<th>Animal groups</th>
<th>ST</th>
<th>ICT</th>
<th>TS</th>
<th>TR</th>
<th>MCT</th>
<th>RT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Cm³</td>
<td>%</td>
<td>Cm³</td>
<td>%</td>
<td>Cm³</td>
<td>%</td>
</tr>
<tr>
<td>B\</td>
<td>55.40</td>
<td>11.21</td>
<td>32.19</td>
<td>6.390</td>
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CHAPTER FOUR
DISCUSSION

IV.1. Histology

Dellmann and Wrobel (1981) and Bloom and Fawcett (1986) classified the intratesticular tubules into the seminiferous tubules and their excurrent ducts. Osman (1978) classified the intratesticular excurrent ducts of the goat into: the terminal segment of the seminiferous tubule, the tubulus rectus and the rete testis. This classification is adopted in the present study.

IV.1.1. The seminiferous cords and tubules:

The term seminiferous cords was used by several authors to designate the seminiferous tubules before acquiring lumina in many mammals such as the bull calf (Johnson et al., 1970), rat (Vitale et al., 1973) and ram (Nilnophakoon, 1978). However, some authors used the term sex cords in the bull calf (Nicander et al., 1961) and hamster (Fouquet and Guha, 1969). In the present study the term seminiferous cords was used.

The mean diameter of the developing seminiferous cords and tubules increased with advancing age (from 42.3 µm, 48.8 µm, 73.7 µm, 173.3 µm to 187.4 µm). The seminiferous cords were lined with
peripheral cells and central cells known as gonocytes. These gonocytes were formed by inward movement of the peripheral cells in the bull calf (Johnson et al., 1970). However, in the rat, these gonocytes move from the centre to the periphery where they differentiate into type A and type B spermatogonia. Nilnophakoon (1978) reported that, the seminiferous cords of 6 weeks postnatal development of the ram testis contained numerous gonocytes situated at the basal lamina. In the present study, the gonocytes first formed the peripheral layer of the seminiferous cords where they divided into typical spermatogonia, type A and type B and then some of them moved toward the centre of the cords and disappeared. The peripheral layer of the seminiferous cord, in addition to spermatogonia, contains nongerminal supporting cells or Sertoli cells. The spermatogenic activity begins in the spermatogenic cells of the seminiferous cords at about 6 months of age in the bull and 7 months in the dog (Johnson et al., 1970), and after 14 days of age in the rat (Vitale et al., 1973). In the present study, the primary spermatocytes were present at 8-10 weeks of age. No lumen had been formed in the seminiferous cords at 5 and 10 weeks of age in the present study. These result are in agreement with those reported by Nilnophakoon (1978) in the ram, and Dym (1976) in some mammals.

The formation of a lumen and the transformation of the seminiferous cords into the seminiferous tubules start toward the end of
the third week in the hamster (Fouquet and Guha, 1969), at 15 days of age and completed in all the seminiferous tubules at 25 days old rats (Osman et al., 1979), between 20 and 25 weeks in the bull (Wrobel et al., 1986), and approximately at 6 years of age in the primate (Johnson et al., 1970). In the present study, the lumen was formed between 12 and 15 weeks of age and this is similar to the result reported in the ram by Nilnophakoon (1978). The seminiferous tubules have two generations of spermatogenic cells, spermatogonia and primary spermatocytes, at 12-15 weeks of age in the present study. This result is not in agreement with that given by Nilnophakoon (1978) in the ram. All stages of spermatogenesis were found and the appearance of the testis approaches that of mature animals at 18 weeks of age in the ram. In the present investigation, however, the formation of the testicular spermatozoa and the histological appearance of the sexually mature testis were reached at the age of 21 weeks. This supports the finding of Nishimura et al. (2000) who claim that the male tokara goat reaches sexual maturity at 4 months of age.

The epithelium of the seminiferous tubules of the testis of sexually mature bovine rested on a basal lamina of multiple layers and the elongated peritubular cells were arranged in 3-5 concentric layers around the seminiferous tubules (Wrobel et al., 1979). In the present investigation the epithelium of the developing seminiferous tubules rested
on a conspicuous basal lamina consisting of an internal layer of collagenous and reticular fibers and an external layer of small dark spindle shape cells.

**IV.1.2. The terminal segment:**

The terminal segment is the part of the seminiferous tubules which terminates the seminiferous tubules toward the mediastinum and joins it to the tubuli recti. Many authors used different terms to describe this segment such as: transitional zone in the rat (Roosen-Runge, 1961; Nykänen, 1979, 1980), stallion (Amann *et al.*, 1977) and monkey (Dym, 1974), transitional stage in the fowl (Lake, 1957), intermediate region in the guinea pig (Calpe and Aoki, 1969), terminal segment in the bull (Wrobel *et al.*, 1978; Wrobel *et al.*, 1982), hamster (Cavicchia and Burgos, 1977), ram (Osman and Plöen, 1979), goat (Osman and Plöen, 1979; Ezeasor, 1986), boar and rabbit (Osman, 1978a, 1979). In the present study, the term terminal segment is used.

In the present study the terminal segment was seen to develop after the age of 10 weeks. Wrobel *et al.* (1986) however, observed that the terminal segments of the seminiferous tubules of the bull calf were developed between 20 and 25 weeks of age of the postnatal life. Osman and plöen (1979) stated that the plug-like structure of the terminal segment was seen before the formation of a lumen in the seminiferous
tubules of juvenile goat testis. In the present investigation, the presence of
the terminal segment was observed at the same time of the formation of a
lumen at 12-15 weeks of age. It was possible to identify the terminal
segment only when their connection to the tubuli recti was established
due to presence of a patent lumen in the latter, while the clear distinction
between the terminal segment and the seminiferous tubule proper was
noticed between 17 and 18 weeks of age due to formation of spermatids
in the tubules. This result is in agreement with the result in the rat
(Osman et al., 1979) and bull (Wrobel et al., 1986).
Wrobel et al. (1986) stated that the terminal segment of the seminiferous
tubules of the bull could be subdivided into three parts between 40 and 52
weeks of age: transitional region, intermediate portion and terminal plug.
Yasein (2005) also subdivided the terminal segment of sexually mature
bulls into similar three parts. Dym (1974) mentioned that the erroneous
impression of a plug occluding the lumen of the transitional zone is due
to oblique or tangential sectioning, and that there was no real plug in the
monkey. The three subdivisions mentioned above, are distinguished in
this investigation starting at 21 weeks of age and the plug-like
appearance that is formed by modified Sertoli cells is quite
distinguishable in the goat terminal segment whether the segment is cut
in longitudinal, cross, or oblique sections. This result is inagreement with
the investigations in the goat (Ezeasor, 1987), bull (Wrobel et al., 1982; Yasein, 2005) and camel (Osman, 1986)

The terminal segment is usually lined with modified Sertoli cells which are tall cells with long cytoplasmic processes and vaculated cytoplasm. Calpe and Aoki (1969), Fawcett and Dym (1974) in the guinea pig and Osman (1979) in the rabbit stated that, in most cases the cells of the terminal segment do not project into the dilated proximal part of the tubulus rectus to form the plug-like structure. In the present study, the characteristic features of the modified Sertoli cells are similar to those reported in the boar (Osman, 1978), buffalo (Dhingra, 1980), man (Marin-padilla, 1964), camel (Singh and Bharadwaj, 1980; Osman, 1986), rat (Osman and Plöen, 1978), mouse (Barack, 1968), monkey (Dym, 1974), bull (Osman and Plöen, 1979; Wrobel et al., 1982; Yasein, 2005), ram and goat (Osman and Plöen, 1979). In this investigation, the terminal segment acquired a small central lumen between 17 and 18 weeks of age and this may be due the increased amount of the testicular fluid. The lumen of the terminal segment usually appeared empty and free from cells. The presence of degenerated spermatogenic cells and spermatozoa in the apical vaculated cytoplasm of the modified Sertoli cells was observed in this investigation. A similar observation was mentioned in the rat (Nykänen, 1980), bull (Wrobel et al., 1982), monkey (Dym, 1974), boar, rabbit and camel (Osman, 1978b, 1979,1980). The presence and
distribution of the intraepithelial lymphocytes that is reported in the monkey (Dym, 1974), rat and rhesus monkey (Dym and Romrell, 1975), rabbit and fowl (Osman, 1979, 1980) were also noticed in the present study.

Nykänen (1980), Osman (1986) and Hermo and Dworkin (1988) stated that the terminal segment of the seminiferous tubules possesses a tubular lumen in the rat and camel respectively. However, in the hamster (Cavicchia and Burgos, 1977), boar and rat (Osman, 1978a), buffalo (Dhingra, 1980) and cat (Murakami, Yokoyama, Nishida, Shiromoto and Sato, 1988) the tubular lumen is very narrow and is difficult to see under normal conditions. Moreover, Osman (1978b) and Osman and Plöen (1979) added that the lumen of the terminal segment of the rat and rabbit respectively becomes quite evident only under increased intratesticular pressure caused by efferent ductule ligation.

In the present investigation, the tubular lumen of the goat terminal segment is easily identified at 21 weeks of age and onward.

The modified Sertoli cells rested on a delicate basal lamina which is continuous with that of the seminiferous tubule proper. The arrangement of the cells of the boundary tissue in the present study is similar to that of the camel (Degen and Lee, 1982). The presence of a vascular plexus surrounding the bull terminal segment of the seminiferous tubule in a cuff-like or sleeve-like manner has been reported by Wrobel et al. (1978).
and Wrobel et al. (1982) respectively. Such an observation was not found in the goat terminal segment because the capillary network was evenly distributed in the testicular parenchyma.

**IV.1.3. The tubulus rectus:**

This part is the site of connection between the terminal segment of the seminiferous tubule and the rete channels. Wrobel et al. (1986) observed that the straight tubules have a narrow lumen lined by a stratified epithelium between 4 and 8 weeks of age in bovine calf. In the present investigation, the tubuli recti are small tubules, with narrow lumina and are lined by simple cuboidal epithelium between 5 and 10 weeks of age.

Wrobel et al. (1986) observed that the epithelium of the tubulus rectus close to the connection with the terminal segment of the seminiferous tubule of bull calf becomes monolayered starting from 16th weeks and proceeding through the 30 weeks of age and onward. The straight tubules adjacent to the terminal segments are modified into a cup-like region encompassing the terminal plug of the terminal segment followed by a narrow stalk lined with simple columnar epithelium at 40-52 weeks of age. In the present investigation, a similar modification of
the tubuli recti was seen at 12-15 weeks of age. And it also confirms the result given by Osman (1978) in the goat that the tubuli recti of goats consist of two regions: receptacle and main part.

In the fowl, the connection of the seminiferous tubules to the rete testis is established either through tubuli recti or direct i.e. without tubuli recti (Osman, 1980). Nykänen (1980) observed that in only one third of the cases, the seminiferous tubules of the rat are linked to the rete via the tubuli recti. Moreover, Marin-Padilla (1964) mentioned that, the connection between the seminiferous tubules and the tubuli recti are only found during the reproductive age. In the present study, the tubuli recti are found in all age groups, but the true communication between the seminiferous tubule and the tubulus rectus is established at the age of 12-15 weeks. The modified dilated proximal part of the tubuli recti (the receptacle) and the main narrow region are found in the camel (Singh and Bharadwaj, 1980; Osman, 1986), bull (Osman, 1978; Osman and Ploen, 1978; Wrobel et al.,1986; Yasein, 2005), buffalo (Dhingra, 1980), stallion (Amann et al.,1977), fowl (Gray, 1937), bird (Aire, 1982), rat (Roosen-Runge, 1961; Osman and Plöen, 1978; Nykänen, 1980), mouse (Barack, 1968), man (Marin-Padilla, 1964), guinea fowl (Aire et al., 1979), hamster (Cavicchia and Burgos, 1977), guinea pig (Calpe and Aoki, 1969), ram, goat and rabbit (Osman and Plöen, 1978), marsupial (Rodger, 1982), as well as in the present study.
In the present investigation the receptacle is lined by simple squamous to low cuboidal epithelium similar to that in the buffalo (Dhingra, 1980), camel (Singh and Bharadwaj, 1980; Osman, 1986), Japanese quil (Aire, 1979a) and bull, boar, ram and goat (Osman and Plöen, 1978).

The main part of the tubulus rectus is lined by low cuboidal epithelium in the guinea pig (Calpe and Aoki, 1969), fowl (Gray, 1937), bull, ram and goat (Osman and Plöen, 1978) and also in the goat as revealed in the present study.

The presence of the intraepithelial lymphocytes was inconspicuous in the tubuli recti, and only very few of them were seen in the main part of the tubuli recti.

**IV.1.4. The rete testis:**

The rete is the labyrinth or cavity which occupies mainly the axial mediastinum testis. In some mammals like the rat (Roosen-Runge, 1961), man (Roosen-Runge and Holstein, 1978) and goat (Goyal and Williams, 1987), there is an extratesticular rete located outside the testis. In the present investigation, only the mediastinal rete was studied and the arrangement of the mediastinum and its rete is in agreement with that observed in the camel (Osman, 1975, 1986), bull (Sinowatz et al., 1979; Hees et al., 1987; Yasein, 2005), ram (Johnson et al., 1970; Dym, 1976) and boar, monkey, cat, dog, guinea pig, rabbit and baboon (Dym, 1976). Some of the mediastinal rete channels extend into the septulæ
testis and are called the septulae rete testis. Goyal and Dhingra (1973) observed that the rete of the buffalo is lined with simple cuboidal and pseudostratified columnar epithelium up to 30 weeks of postnatal life, and it becomes stratified in most of the regions of the canal at 52 weeks. Dhingra (1980) mentioned that the rete of the buffalo is lined with pseudostratified columnar cells in prepubertal buffalo and it is transformed to simple cuboidal in the adult animal. Moreover, Hees, Wrobel, Kohler, Abou Elmagd and Hees (1989) reported that the bovine rete is lined with cuboidal or columnar cells. In the present investigation, the epithelium lining the rete varies in height, but in general the epithelium is either pseudostratified columnar or simple cuboidal up to 15 weeks of age and transformed into low cuboidal or simple squamous at 17 weeks of age and onwards.

The epithelial cells of the goat rete testis (Osman, 1978), like those of the rat (Leeson, 1962), man (Bustos-Obregón and Holstein, 1976), ram, rabbit and cat (Osman, 1978) rest upon a typical basal lamina, whereas the basal lamina of the fowl (Gray, 1937) and camel (Osman 1986) is indistinct. In the present observation in the goat the basal lamina of the rete testis is similar to the one reported by Osman (1978a) also in the goat.

The connective tissue which surrounds the rete testis is composed of irregularly arranged bundles of collagen fibers and fibroblasts in the
buffalo (Goyal and Dhingra, 1973). However, Osman (1978) is of the opinion that the fibers are regularly arranged in one direction in the goat, ram, cat and rabbit. In the present investigation the result is similar to the observation of Osman (1978) in the goat.

IV.2. Histochemistry:

IV.2.1. Polysaccharides

There are very few reports in the available literature about the histochemical development of most parts of the intratesticular tubules for polysaccharides. The histochemical development of the rete testis for polysaccharides is mentioned by Fouquet and Guha (1969) in the hamster and Goyal and Dhingra (1973) in the buffalo. More information was reported about the different parts of the intratesticular tubules of sexually mature animals such as the camel (Osman, 1975), buffalo (Dhingra, 1980), rat (Nykanen, 1980), man (Fabbrini and Conti, 1969; Bustos Obreógn and Holstein, 1976), ram (Cavazos and Melampy, 1954; Osman, 1984; Alamin, 2000) and bull (Yasein, 2005).

The boundary tissue of the seminiferous tubules of the camel showed a positive reaction for PAS material resistant to diastase enzyme (Osman, 1975). In the present study, the boundary tissue of the seminiferous cords and tubules gives positive reaction for PAS material
resistant to diastase digestion and this reaction increase with advancing age.

The epithelium lining the seminiferous cords gives a negative reaction at the age of 5 and 10 weeks, and it becomes positive progressively with advancing age.

In the present study, the basement membrane and the epithelium lining the terminal segment showed positive PAS material resistant to digestion with diastase and this supports the observation in the buffalo and ram given by Dhingra (1980) and Osman (1984) respectively. Osman (1984) in the ram and Yasein (2005) in the bull observed that the reaction in the basement membrane of the terminal segment for PAS diastase resistant material is more intense than that of the basement membrane of the seminiferous tubule to the extent that they are clearly demarkated from each other. A similar observation is seen in the basement membrane of the terminal segment of the goat in the present investigation.

Yasein (2005) reported that the basement membrane of the tubuli recti of the bull is PAS positive and the reaction varied markedly in its three parts. Dhingra (1980) stated that the epithelium of the receptacle rested on a PAS-positive basement membrane and also at its luminal border. Moreover, Osman (1975) detected intense reaction for PAS in the
boundary tissue of the tubuli recti of the camel. The present investigation supports the findings mentioned above.

Goyal and Dhingra (1973) reported that a delicate PAS-positive basement membrane supports the rete testis of the buffalo between 3 and 16 weeks of age, and becomes more positive and distinct between 30 and 52 weeks of postnatal development. In the present study, an intense reaction for PAS–positive material resistant to diastase digestion is found in the basement membrane of the goat rete testis from 5 weeks of age to sexual maturity.

Osman (1984) assumed that the intense reaction of the terminal segment basement membrane to PAS stain in the ram is an indication that this segment is more permeable than the seminiferous tubule. This assumption may also be true for the tubulus rectus and rete testis in this study, since they gave a reaction similar to that of the terminal segment in the ram.

A granular reaction of PAS–positive material resistant to diastase digestion is seen in the cytoplasm of the epithelium lining the rete testis in the present investigation and this reaction is more intense in the young groups and gradually decreased with advancing age. PAS–reactive substance resistant to diastase digestion is present in the wall of the blood vessels, in the present study, and in the camel as observed by Osman (1975). PAS–reactive substance removable with
diastase enzyme (glycogen) is present in the germinal epithelium of the seminiferous tubules of the camel (Osman, 1975). In the present investigation, the presence of fine glycogen particles in the cytoplasm of the cells which line the seminiferous cords showed cyclical changes and this supports the findings of Osman et al. (1976) in the camel and Osman (1984) and Alamin (2000) in the ram. In the present study the seminiferous tubules of the kids showed gradual decrease in the amount of the fine glycogen particles with advancing age and this supports the findings given by Fabbrini and Conti (1969) in human testis.

Dhingra (1980) noticed that the epithelium lining the terminal segment in the buffalo rested on a basement membrane with PAS-positive material removable with diastase enzyme. In the present investigation, a few number of fine glycogen particles is found in the cytoplasm of the lining epithelium of the terminal segment. Fabbrini and Conti (1969) observed that no PAS-positive element was found in the interstitial area of the human testis. However, a faint cytoplasmic reaction for PAS material was noted in the interstitial cells of the ram testis (Cavazos and Melampy, 1954). The present investigation, at the age of 5 and 10 weeks, supports the findings of Fabbrini and Conti (1969) in the human testis but it differs at the age of 12 weeks and onward because the interstitial connective tissue gives PAS-positive reaction.
Osman (1975) and Bustos-obregón and Holstein (1976) reported that PAS-positive substance removable with diastase digestion was found in the epithelium lining the rete testis of the camel and human respectively. Goyal and Dhingra (1973) mentioned that the presence of glycogen in the rete testis of the buffalo was detected between 30 and 52 weeks of postnatal development. However, Fouquet and Guha (1969) reported that the hamster rete epithelium lacks glycogen until puberty. The present study supports the findings of Fouquet and Guha (1969) in the hamster.

IV.2.2. Enzymes

IV.2.2.1. Acid phosphatase

The testis of the man (Montagona, 1952) and the camel (Osman, 1975) are negative for acid phosphatase reaction. However, Koudstaal, Frensdorf, Kremer, Mudde and Hardonk (1967) demonstrated this enzyme in the periphery of the seminiferous tubules and in interstitial cells of the human testis. Singh and Mathur (1968), in the Indian gerbil and house shrew, and Singh, Kaul and Mathur (1974) in Indian langur, reported that acid phosphatase reaction is seen in the basement membrane and all the germinal epithelium of the seminiferous tubules. Moreover, Kugler (1975) observed high activity for the enzyme acid phosphatase in the testis of juvenile rooster. In the present investigation, all the intratesticular tubules give positive reaction for acid phosphatase but the intensity of the reaction varied among the different age groups. The
reaction was detected in the lining epithelium while the basement membrane showed weak reaction. The intensity of the reaction in the lining epithelium is increased with advancing age. The interstitial cells also give a strong reaction. Osman (1975) mentioned that the presence of acid phosphatase is an indication to lysosomal activity.

IV.2.2.2. Alkaline phosphatase

Histochemical investigations of the enzyme alkaline phosphatase in the different parts of the intratesticular tubules are reported in the bull (Rollinson, 1955; Yasein, 2005), camel (Osman, 1975; Osman et al., 1976), ram (Osman, 1984; Alamin, 2000), buffalo (Goyal and Dhingra, 1973) and rooster (Kugler, 1975). The germinal epithelium of the testis of the bull (Rollinson, 1955) and camel (Osman, 1975; Osman et al., 1976) gives a positive reaction. A strong reaction was seen in the basement membrane of the seminiferous tubules of the bull (Yasein, 2005) and boundary tissue of the camel (Osman, 1975). The present study supports the findings mentioned above. The reaction of the epithelium of the seminiferous cords is more intense than that of the germinal epithelium of old age groups because the reaction is decreased gradually with advancing age.

In the present investigation, the activity of the enzyme alkaline phosphatase in the basement membrane and the epithelium lining the
terminal segment is similar to that mentioned in the ram (Osman, 1984) and bull (Yasein, 2005). Yasein (2005) observed that the interstitial cells reacted strongly for alkaline phosphatase while the peritubular connective tissue reacted very weakly in the bull. Similar observations were seen in the kids in all age groups in the present study.

Osman, (1975) detected positive reaction for alkaline phosphatase in the boundary tissue of the tubuli recti of the camel. In the bull (Yasein, 2005) stated that the reaction showed marked differences among the three parts of the tubuli recti. The receptacles and the main parts of the tubuli recti of the kids of this investigation showed a strong reaction for alkaline phosphatase.

The basement membrane and the cell cytoplasm of the rete testis of the buffalo showed moderate reaction for alkaline phosphatase (Goyal and Dhingra, 1973). In the present investigation, the basement membrane of the rete testis gives a strong reaction for alkaline phosphatase and this is similar to the result given by Yasein (2005) in the bull.

Moog and Wenger (1952) mentioned that the enzyme alkaline phosphatase occurs at the sites where PAS-positive diastase resistant material is demonstrated. This correlation is found to be true in the present investigation since both PAS-positive diastase resistant material and alkaline phosphatase are detected in the boundary tissue of the
seminiferous cords and tubules, terminal segment, tubulus rectus and rete testis.

Kugler (1975) suggested that the deposition of the enzyme alkaline phosphatase in the boundary tissue of the bull may play a role in the energy production needed for contraction of the tubules. On the other hand, Osman (1975) is of the opinion that this enzyme may play a role in the transportation of material between the blood vessels of the interstitium and the cellular elements of these tubules. In the present study, the mediastinal connective tissue gives a negative reaction for alkaline phosphatase and this is in agreement with the results observed in the buffalo (Goyal and Dhingra, 1973) and the bull (Yasein, 2005).
IV.3. Morphometry

Morphometric information about the development of the intratesticular tubular ducts of the goat is not found in the available literature.

Some morphometric investigations were conducted on the seminiferous tubules and other testicular components in different sexually mature animals like the camel (Tingari, Ramos, Gaili, Rahma and Saad, 1984), ram (Alamin, 2000), rat (Wing and Christensen, 1982), Fowl (Elbagory, 1990), hamster (Lue et al., 1997), bull (Lennox and Logue, 1979; Yasein, 2005) and domestic cat (Franca and Godinho, 2003).

A comparative study between vasectomized and non vasectomized ram testis revealed that the vasectomized testis showed remarkable decrease in the ram testicular tubules (Alamin, 2000). Elbagory (1990) reported that there are slight differences between the volume components of the right and left testes of the fowl.
A comparative study on the seasonal effect on the camel testis showed that the mean testicular weight of the camel is about 164.3g at the summer season while the mean weight reached 180.2g at the winter. The mean diameter of the seminiferous tubules is 176.4 µm at the summer and decreased to 162.6 µm at the winter (Tingari et al., 1984)

Lennox and Logue (1979) observed that the seminiferous tubules represented about 77% (229cm³ ± 11.7) of the testicular volume, while the populations of the Leydig cells represented only about 4.6% (12.1cm³ ±1.3) of the volume of the bull testis. Moreover, they mentioned that the average length of the bull seminiferous tubule is about 5.2 km. Yasein (2005) found that the testicular parenchyma constitutes about 92.73% (123.65cm³ ± 6.61) of the testicular volume in the young bull, while this value reaches 94.78% (168.78cm³ ± 41.0693) of the volume of the testis in the adult one. Lennox and Logue (1979) reported that the absolute volume of the mature bull testis is 280 ml; While Yasein (2005) estimated that the mean absolute volume of sexually mature bull is 178cm³ ± 44.8144.

In the present investigation, a clear relationship is noticed between the testicular volume and the ages of the kids. The testicular volume in kids of group C (61.66cm³ ± 10.41) is higher than that in group B (21cm³± 11.53) and it is lowest in group (A) (2.333cm³ ± 0.577).
The seminiferous tubules are the dominant component of the testis in the kids of group C (70.93% 43.70cm$^3$ ± 7.809) and group B (55.40% 11.21cm$^3$ ±5.303) although it is higher in group (C) than in group (B). However, this component is low and not the highest one in group A (38.60% 0.895cm$^3$ ± 0.187).

The interstitial connective tissue constituted the greatest component of the testis of the kids in group A (46.30% 1.092cm$^3$ ± 0.364); however this value is decreased in group B (32.19% 6.390cm$^3$ ± 2.614) and further decreased in group C (21.66% 13.32cm$^3$ ± 3.329). The increase of the value of the seminiferous tubules and the decrease of the interstitial connective tissue with the advancing age is due to the increased diameter of the seminiferous tubules at the expense of the interstitial connective tissue. The increase of the diameter of the seminiferous tubules with the advancing age may be due to the ability of the testis of mature kids to produce spermatozoa and testicular fluid.

Yasein (2005) reported that, on the contrary to the testicular parenchyma, the mediastinal connective tissue of young bulls (4.68%, 6.25cm$^3$ ± 2.2193) is much more than that of old bulls (2.84%, 5.34cm$^3$ ± 3.4872). The present investigation supports the finding mentioned above because there is a gradual decrease in the mediastinal connective tissue with the advancing age 11.89% (0.270cm$^3$ ± 0.063) in group (A), 7.900% (2.125cm$^3$ ±2.320) in group (B) and 4.753% (2.942cm$^3$ ± 1.288) in group
The decrease in the amount of the mediastinal connective tissue with advancing age may be due to the increase in the value of the testicular parenchyma at the expense of the mediastinal connective tissue.

The terminal segment of the seminiferous tubules represents only a very small portion of the testicular parenchyma in groups (B) and (C), although this value is greater in group (C) (0.137%, 0.077cm$^3$ ± 0.055) than that of group (B) (0.046%, 0.010cm$^3$ ±0.007) (The terminal segments were not developed in group A). This result contradicts the result given by Yasein (2005) who stated that the terminal segment of the seminiferous tubule represents equal value of the testicular volume in both young and old bulls. The increased value of the terminal segments of the sexually mature groups, than that of the younger one, may be due to the increased diameter of these tubules and the ability of the kids at this age to produce the semen and sperms and pass them into the intratesticular excurrent ducts.

The tubuli recti also occupy small portion of the testicular volume and showed increased value with advancing age. Initially, the value is very small in group A (0.067%, 0.002cm$^3$ ± 0.001), then the tubulus rectus are modified in group B and this value is duplicated and constitutes about 0.129% (0.027cm$^3$ ± 0.020) and is slightly increased and reaches 0.20% (0.120cm$^3$ ± 0.018) in the mature kids (group C).
The rete testis channels constitute about 3.138% (0.074cm$^3$ ± 0.024) of the testis volume in group A; this value is slightly increased and constitutes 4.324% (1.238cm$^3$ ± 1.686) in group B. However, the value is decreased in group (C) in which the rete channels represent 2.297% (1.488cm$^3$ ± 0.823) with a constant or small increase in the mean volume. The reduction in the percentage of the volume of the rete channels or the slight increase of the absolute volume may be due to the limitation of the rete development at the specific age and the continuous development of the other testicular components.
CONCLUSIONS

1- The intratesticular tubules were divided into the seminiferous tubules and their excurrent ducts that are divided into: the terminal segments of the seminiferous tubules, the tubuli recti and the rete testis.

2- The spermatocytes appeared at the age of 8 to 10 weeks, while spermatids appeared at the age of 17 to 18 weeks and spermatozoa appeared at the age of 21 weeks and onward.

3- The seminiferous cords are transformed into seminiferous tubules at the age of 12 to 15 weeks.

4- The terminal segment and the receptacle of the tubulus rectus were developed at 12-15 weeks of age.

5- The histochemical findings revealed that the activity of some substances and enzymes of the intratesticular tubules (glycogen and alkaline phosphatase) is decreased with advancing age, while others are increased (acid phosphatase).

6- The morphometric results indicate a significant variation in the volume of the testis and percentage of the testicular parenchyma and mediastinal connective tissue in the three groups of kids studied.
7- Age is a major factor in determining the volume of the different components of the testis when studied morphometrically.

8- For future work:

More histochemical tests and immunohistochemical investigations are needed to evaluate the functions of the lining epithelium of the intratesticular tubular system in the different age groups.
SUMMARY

1. A histological, histochemical and morphometric study has been conducted on the intratesticular tubules in 35 nobian kids of different age. The age varied from 5 to 21 weeks and onward (sexually mature kids).

2. The intratesticular tubules are classified into seminiferous cords and seminiferous tubules and their excurrent ducts.

3. The intratesticular excurrent ducts consisted of the terminal segments of the seminiferous tubules, the tubuli recti and the rete testis.

4. The seminiferous tubules occupy the lobules forming the testicular parenchyma.

5. The intratesticular excurrent ducts are localized within and around the central axial mediastinum testis.

6. Age is a major factor in the increase of the diameter of the developing seminiferous tubules and their excurrent ducts.

7. The developing seminiferous tubules lack lumina and are lined by one layer of spermatogonia and Sertoli cells. They are known as the seminiferous cords during 5 to 10 weeks of age.
8. One to three large gonocytes are found toward the centre of the seminiferous cords at 5-6 weeks of age and disappeared at 12-15 weeks of age.

9. The primary spermatocytes are present within the seminiferous cords at 8-10 weeks of age.

10. The seminiferous cords were transformed into seminiferous tubules by acquiring a lumen at 12-15 weeks of age.

11. Round and elongated spermatids are present at 17-18 weeks of age.

12. Spermatozoa appear at 21 weeks of age and onward.

13. The terminal segments are differentiated at 12-15 weeks and are lined with modified Sertoli cells.

14. The terminal segments of the seminiferous tubules acquire lumina at 17-18 weeks of age.

15. The terminal segment of the seminiferous tubules is subdivided into: transitional region, middle region and terminal plug according to the depletion of the germinal epithelium and its replacement by the modified Sertoli cells at 21 weeks of age and onward.

16. The tubuli recti appear as small tubules between 5 and 10 weeks of age, and are modified into: proximal dilated parts, the receptacles and main narrow parts at 12-15 weeks of age.

17. The receptacles are lined with squamous or cuboidal cells and the main parts are lined with cuboidal cells.
18. The rete testis consists of a group of channels which occupy an axial mediastinum testis, and becomes cavernous and intercommunicated at 21 weeks of age and onward.

19. A few intraepithelial lymphocytes are present in the terminal segments and mains parts of the tubuli recti.

20. PAS-positive diastase resistant material is detected in the boundary tissue of all segments of the intratesticular tubules, specially in the terminal segments and rete testis.

21. Glycogen particles show cyclic changes in the lining epithelium of the developing seminiferous tubules and their number decrease with advancing age.

22. The epithelium of the intratesticular tubules show positive reaction for acid phosphatase enzyme and the reaction is detected in the lining epithelium and the reaction increased with advancing age.

23. Strong activity for alkaline phosphatase is demonstrated in the basement membrane and the cytoplasm of the epithelium lining of the intratesticular tubules. The reaction in the lining epithelium decreases with advancing age.

24. The terminal segments show positive reaction for alkaline phosphatase in both the basement membrane and the lining epithelium and the reaction is stronger than that of the seminiferous tubules.
25. The morphometry of the intratesticular tubules has been studied in nine kids (three kids from each age group referred to as group A, group B and group C).

26. The mean absolute volume of the testis of group (A) is about $2.333\text{cm}^3 \pm 0.577$, and increased in group (B) to $21\text{cm}^3 \pm 11.53$ and further increased in sexually mature kids (group C) to $61.66\text{cm}^3 \pm 10.41$.

27. The seminiferous cords gave mean value about $38.60\%$ ($0.895\text{cm}^3 \pm 0.187$) in group (A) and transformed into seminiferous tubules in group (B) and group (C) which constituted the largest components of the testicular volume ($55.40\% 11.21\text{cm}^3 \pm 5.303$) in group B and ($70.93\% 43.70\text{cm}^3 \pm 7.809$) in group C.

28. The interstitial connective tissue constituted the largest components of the testicular volume in group (A) $46.30\% (1.092\text{cm}^3 \pm 0.364)$ and decreased in group (B) to $32.19\% (6.390\text{cm}^3 \pm 2.280)$ and further decreased in group (C) to $21.66\% (13.32\text{cm}^3 \pm 3.329)$.

29. The terminal segments of the seminiferous tubules were not developed in group (A) and occupy a very small portion in group (B) $0.046\% (0.010\text{cm}^3 \pm 0.007)$ and group (C) $0.137\% (0.077\text{cm}^3 \pm 0.055)$.

30. The tubuli recti represent a mean value of $0.067\% (0.002\text{cm}^3 \pm 0.001)$ in group (A) and increased slightly in group (B) to $0.129\%$
(0.027cm³ ±0.020) and further increased in group (C) to 0.200% (0.120cm³ ±0.018).

31. The mediastinal connective tissue represents a mean value of 11.89% (0.270cm³ ±0.063) in group (A) and decreased to 7.900% (2.125cm³ ±2.320) in group (B) and further decreased to 4.753% (2.942cm³ ±1.288) in group (C).

32. The percentage of the rete testis volume was 3.138% (0.074cm³ ±0.024) in group (A) and slightly increased in group (B) to 4.324% (1.238cm³ ±1.685) and then decreased in group (C) to 2.297% (1.488cm³ ±0.823).
ملخص الطرحه

1- اجريت هذه الدراسة للتعرف على البنية النسيجية والكيمياء النسيجية والقياس الشكلي للنباتات الخصوية الداخلية لخمسة وثلاثين من ذكور الماعز النمو بأعمار مختلفة تتراوح من خمسة أسابيع إلى وعشرين أسبوع فأكثر (أى بالغة جنسيا).

2- تم تقسيم النبباتات الخصوية الداخلية إلى النباتات الناقلة للمنى و القنوات الناقلة الخصوية الداخلية.

3- تحتوى القنوات الناقلة الخصوية الداخلية على الجزء الانتهائي للأنابيب الناقلة للمنى، الأنابيب المستقيمة والشبكة الخصوية.

4- تحتل النباتات الناقلة للمنى القصيصات مكونة بذلك متن الخصية.

5- تتركز القنوات الناقلة الخصوية الداخلية في داخل وحول المنصف الخصوى المركزى.

6- يمثل العمر عامل كبير في زيادة أقطار النباتات الناقلة للمنى في طور النمو وقرونها الناقلة الخصوية الداخلية.

7- النباتات الناقلة للمنى في طور النمو خالية من التجاويف و مبطنة بطبقة واحدة من أميئات الخلايا المنوية وخلايا سيرتولى وتعتبر بالجبال الناقلة للمنى خلال خمسة إلى عشرة أسابيع من العمر.

8- توجد واحده إلى ثلاث خلايا جرثومية أولية كبيرة في ناحية منتصف الجبال الناقلة للمنى خلال خمسة إلى ستة أسابيع من العمر وتخفي خلال أثنا عشر إلى خمسة عشر أسبوع من العمر.

9- تظهر الخلايا المنوية الأولية في داخل الجبال الناقلة للمنى خلال ثمانية إلى عشرة أسابيع من العمر.

10- تتحول الجبال الناقلة للمنى إلى النباتات الناقلة للمنى باكتسابها التجاويف خلال أثنا عشر إلى خمسة عشر أسبوعا من العمر.
11- تظهر أرومات النافط الدائرية والمتوازنة خلال سبعة عشر إلى ثمانية عشر أسبوعا من العمر.

12- تظهر الحيوانات المنوية في عمر واحد وعشرين أسبوعا فأكثر.

13- تنمو الأجزاء الانتهائية للنباتات الناقلة للمنى خلال اثنا عشر إلى خمسة عشره أسبوعا من العمر وتبطن بخلايا سيرتوئي المتحورة.

14- تكتمل الأجزاء الانتهائية للنباتات الناقلة للمنى التجاويف خلال سبعة عشر إلى ثمانية عشر أسبوعا من العمر.

15- تم تقسيم الجزء الانتهائي للنبيب الناقل للمهى إلى: المنطقة الانتقالية، المنطقة الوسطى والسدادة الانتهائية وذلك بناءً على تناظر الخلايا الجنسية واستبدالها بخلايا سيرتوئي المتحورة خلال واحد وعشرون أسبوعا من العمر فأكثر.

16- تظهر النباتات المستقيمة في شكل نبوب صغيرة خلال خمسة إلى عشره أسابيع من العمر ثم تطور إلى جزء متسع داكن يسمى بالمستقبل وجزء ضيق رئيسي خلال اثنا عشر إلى خمسة عشرة أسبوعا من العمر.

17- تبطن المستقبلات بخلايا قصيرة مسطحة أو مكعبة بينما تبطن الأجزاء الضيقة الرئيسية بخلايا مكعبة.

18- الشبكة الخلوية تتكون من مجموعة من الفنوات وتحت المنتصف الخصوي المحوري، ثم تصبح محاكات كهفية متصلة خلال واحد وعشرون أسبوعاً من العمر فأكثر.

19- تظهر قليل من الخلايا الليمفاوية داخل النسيج الظهاري في الأجزاء الانتهائية للنباتات الناقلة للمنى والأجزاء الضيقة الرئيسية للنباتات المستقيمة.

20- وجدت مادة عديد السكرى المخاطي المقاومة لحميرة الدياستاز في الغشاء القاعدى للنسيج الظهارى لكل أجزاء النباتات داخل الخصية، خاصة في الأجزاء الانتهائية والشبكة الخلوية.
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21- تظهر جزيئات الجليكوژين في النسيج الظهاري للنبيبات الناقلة للمنى في طور النمو بصورة دورية ويتناقص عددها بزيادة العمر.

22- النسيج الظهاري للنبيبات الخصوية الداخلية أظهر تفاعلاً "موجبا" لانزيم الفوسفاتيز الحمضي ويزداد التفاعل قوة بزيادة العمر.

23- وجد تفاعلاً "قويا" لانزيم الفوسفاتاز القلوي في الأغشية القاعدية وسيتو بلازم النسيج الظهاري للنبيبات الخصوية الداخلية، والتفاعل في النسيج الظهاري يقل بزيادة العمر.

24- أظهرت الأجزاء الأنتهائية للنبيبات الناقلة للمنى تفاعلاً "موجبا" في الغشاء القاعدى أقوى من ذلك الذي في النبيبات الناقلة للمنى.

25- تم دراسة القياس الشكلي للنبيبات الخصوية الداخلية في تسعة من ذكور الحيوانات النوبي، ثلاثة حيوانات لكل فئة عمرية سجلت كالمجموعة (أ)، المجموعة (ب) والمجموعة (ج).

26- بلغ متوسط حجم الخصية حوالي 2.333 cm³ ± 0.577 في المجموعة (أ) وازداد في المجموعة (ب) إلى 11.53 ± 6.11 cm³ وازداد أكثر في الذكور البالغة جنسيا" (المجموعة ج) إلى 61.66 cm³ ± 10.41 cm³.

27- بلغ متوسط حجم الحبال الناقلة للمنى حوالي 0.187 ± 0.895 cm³ (0.860%) - في المجموعة (أ) ثم تتحول إلى النبيبات الناقلة للمنى في المجموعة (ب) والمجموعة (ج) حيث تعتبر أكبر مكونات الخصية "حجمًا"، حوالي (5.303 ± 11.21 cm³) في المجموعة (ج) و (7.809 ± 43.70 cm³) في المجموعة (ب) و (70.93% في المجموعة (ج).

28- يمثل النسيج الظهاري الخلايلي أكبر مكونات حجم الخصية في المجموعة (أ) حوالي 32.19% ويتناقص في المجموعة (ب) إلى 6.390 (46.30% (1.092 cm³ ± 0.364 cm³ ) ويتناقص في المجموعة (ج) إلى 21.66% (13.32 cm³ ± 3.329 cm³).
29- الأجزاء الأنتهائية للنبيبات الناقلة للمنى لم تنمو في المجموعة (أ) وتحتل جزء صغير جداً من حجم الخصية في المجموعة (ب) (0.077 cm³ ± 0.0010 cm³ درجة حرارة حمضية 0.046% والمجموعة (ج) 0.137% (0.120 cm³ ± 0.018 cm³ درجة حرارة حمضية 0.200%)

30- بلغ متوسط حجم النبيبات المستقيمة حوالي (0.027 cm³ ± 0.010 cm³ درجة حرارة حمضية 0.067%) في المجموعة (أ) وازداد قليلاً في المجموعة (ب) إلى (20.027 cm³ ± 0.020 cm³ درجة حرارة حمضية 0.129%) وازداد أكثر في المجموعة (ج) إلى (0.200 cm³ ± 0.018 cm³ درجة حرارة حمضية 0.200%).

11.89% (0.27 cm³ ± 0.063 cm³ درجة حرارة حمضية 0.002 cm³ درجة حرارة حمضية 0.002) في المجموعة (أ) وتناقص إلى (2.125 cm³ ± 7.900 cm³ درجة حرارة حمضية 0.020% في المجموعة (ب) وتناقص أكثر إلى (2.320 cm³ ± 2.312 cm³ درجة حرارة حمضية 4.753% في المجموعة (ج)).

31- بلغ النسيج الضام لمنصف الخصية متوسط حجم حوالي (7.900 cm³ درجة حرارة حمضية 2.125 cm³ درجة حرارة حمضية 0.020% في المجموعة (ب) وتناقص إلى (2.320 cm³ ± 2.312 cm³ درجة حرارة حمضية 4.753% في المجموعة (ج)).

32- النسبة المئوية لحجم الشبكة الخصوية حوالى (0.074 cm³ ± 0.024 cm³ درجة حرارة حمضية 3.138%) في المجموعة (أ) وازدادت قليلاً في المجموعة (ب) إلى (1.238 cm³ ± 1.685 cm³ درجة حرارة حمضية 4.324%) ثم تناقصت في المجموعة (ج) إلى (0.488 cm³ ± 0.823 cm³ درجة حرارة حمضية 2.297%).
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FIGURES
Figure 1: A schematic diagram illustrating the different parts of the intratesticular tubular ducts of a sexually mature kid.

ST: Seminiferous tubule.

TS: Terminal segment of seminiferous tubule.

R: Receptacle of the tubulus rectus.

M: Main narrow segment of the tubulus rectus.

RT: Rete testis channel.
Figure 2: A photomicrograph of the testis of sexually mature kid to show the seminiferous tubule (ST), terminal segment (TS), tubulus rectus (TR) and part of the rete testis (RT).
H&E stain. X250.

Figure 3: A photomicrograph of a goat testis cut longitudinally into two halves to demonstrate the longitudinal axial mediastinum testis (M).
Figure 4: A photomicrograph of the testis of kid at 5 to 6 weeks of age showing the seminiferous cords (SC) lined by one layer of epithelium and surrounded with a boundary tissue of flat cells. The large gonocytes (G) are situated at the basal lamina and at the centre of the seminiferous cords and a group of Leydig cells (L) are found in between the cords.

H & E stain. X250.

Figure 5: A photomicrograph of the seminiferous cords of kid at 5 to 6 weeks of age, showing large gonocytes (arrows) with faint cytoplasm and nuclei situated toward the centre of the seminiferous cords. The seminiferous cords are surrounded with spindle shaped cells with dark and flat nuclei.

H & E stain. X 1000.
Figure 6: A photomicrograph of a longitudinal section of the seminiferous cord of kid at 5 to 6 weeks of age showing the spherical nuclei of the Sertoli cells (arrows) with prominent nucleoli and fine chromatin material. The gonocytes have large nuclei with euchromatin. Note the peritubular dark spindle shaped cells. H & E stain. X 1000.

Figure 7: A photomicrograph of the testis of kid at 5-6 weeks of age, illustrating the seminiferous cords (SC), and part of the rete testis (RT). The seminiferous cords and rete channels are surrounded by collagen fibres. Masson’s trichrome stain. X40
Figure 8: A photomicrograph of the testis of kid at 5 to 6 weeks of age illustrating the seminiferous cords (SC), and the interstitial connective tissue which contain many blood vessels.

H&E stain. X400.

Figure 9: A photomicrograph of the seminiferous cords of kid at 8 to 10 weeks of age showing the presence of primary spermatocytes (P). Note the presence of many mitotic figures in the spermatogonia.

H & E stain. X 100.
Figure 10: A photomicrograph of the seminiferous tubules of kid at 12 to 15 weeks of age illustrating the increased number of primary spermatocytes and some of them show mitotic figures. Small Lumina (L) appear at the centre of some seminiferous cords to transform them into seminiferous tubules.

H & E stain. X 250.

Figure 11: A photomicrograph of the testis of kid at 12-15 weeks of age. The parenchyma contains the seminiferous tubules (ST), the developing terminal segment (TS) protruding into a cup shaped region of the tubulus rectus (TR).

H & E stain. X100.
Figure 12: A photomicrograph of the testis of kid at 17 to 18 weeks of age, showing the mediastinum (below) and the testicular parenchyma (above).

Note the presence of the terminal segment (TS), the receptacle (R) and the rete testis (RT).

The mediastinal rete (MR) is less intercommunicating.

TR: Tubulus Rectus.

H & E stain. X 100.

Figure 13: A photomicrograph of the sexually mature kid showing a part of the seminiferous tubule (ST) and a cross section of the middle portion (MP) of the terminal segment.

Note the large lumen of the seminiferous tubule.

Masson’s trichrome stain. X400.
Figure 14: A photomicrograph of a longitudinal section of the terminal segment with its three parts: transitional region (TR), middle portion (MP) and terminal plug (TP) protruded into the receptacle (R) in sexually mature kid. The terminal segment is surrounded by a large amount of collagen fibres

Masson’s trichrome stain. X400.

Figure 15: A photomicrograph of the testis of sexually mature kid illustrating the seminiferous tubules (ST), transitional region (TR) and middle portion (MP) of the terminal segment.

H&E stain. X100.
Figure 16: A photomicrograph of the testis of sexually mature kid showing the seminiferous tubules (ST), the transitional region (TR) and middle portion (MP) of the terminal segment (TS) and the receptacle (R) of the tubulus rectus.

A large muscular artery is present.

H&E stain. X100.

Figure 17: A high magnification of the seminiferous tubule (ST) and a cross section of the middle portion of the terminal segment of sexually mature kid lined by modified Sertoli cells (MSC) with long cytoplasmic processes. The large nuclei (arrow) of modified Sertoli cells possess prominent nuclei. The interstitial space become distinctly fibrous

H&E stain. X 400.
Figure 18: A photomicrograph of the seminiferous tubules (ST) and middle portion of the terminal segment of sexually mature kid showing the vaculated cytoplasmic processes of the modified Sertoli cells (arrows).

H&E stain. X400.

Figure 19: A high magnification of the plug of the terminal segment in sexually mature kid showing the large nuclei of modified Sertoli cells and most of them situated near the basal lamina.

The nuclei possess prominent nucleoli.

Some phagocytized spermatozoa are found within the apical cytoplasm of modified Sertoli cells.

H&E stain. X1000.
Figure 20: A photomicrograph of the testis of sexually mature kid showing the seminiferous tubules (ST) and a cross section of middle portion of the terminal segment (MP) with a narrow lumen (L). The modified Sertoli cells have long and vacuolated cytoplasmic processes and their nuclei are situated near the basal lamina.

H&E stain. X400.

Figure 21: A photomicrograph of the testis of sexually mature kid illustrating the seminiferous tubules (ST), transitional region (Tr) and middle portion (MP) of the terminal segment and the receptacle (R) of the tubulus rectus and the rete testis (RT).

TR: tubulus rectus.

H&E stain. X100.
Figure 22: A photomicrograph of the transitional regions of sexually mature kid demonstrating a few reticular fibers surrounding the terminal segments.

The terminal segment has a relatively wide lumen.

Gomori’s silver stain. X400.

Figure 23: A photomicrograph representing the seminiferous tubules (ST), the terminal segments (TS), the receptacles (R) and mediastinal rete testis (MR) in kid at 17-18 weeks of age.

Note the presence of round and elongated spermatid within the seminiferous tubules and the less intercommunicating rete testis.

H&E stain. X100.
Figure 24: A photomicrograph of a longitudinal cut terminal segment (TS) with a plug protruded into the receptacle of the tubulus rectus (TR) of sexually mature kid. The tubulus rectus is lined with a single layer of low cuboidal cells.

H&E stain. X400.

Figure 25: A high magnification of the testis of sexually mature kid showing the seminiferous tubules (ST) and a cross section of the main part (MP) of the tubulus rectus lined by a single layer of cuboidal cells and surrounded by fibrous tissue.

Note a few intraepithelial lymphocytes between the bases of the epithelium (arrow).

H&E stain. X250.
Figure 26: A photomicrograph demonstrating the seminiferous cords (SC) (right) and mediastinl rete testis (MR) (left) of kid at 5-6 weeks of age.

Note the parallel arrangement of the rete channels at this age.

The rete channels lined by pseudostratified columnar epithelium.

Masson’s trichrome stain. X400.

Figure 27: A high magnification of the mediastinum testis of kid at 5-6 weeks of age, demonstrating the simple cuboidal cells (arrow) lining the mediastinal rete channels.

The mediastinal connective tissue contains mainly collagen fibres and fibroblasts.

Note The conspicuous lumen of the rete channels.

Masson’s trichrome stain. X1000.
Figure 28: A photomicrograph of the seminiferous cords (right below) and mediastinal rete channels (left) of goat at 5-6 weeks of age the rete channels are lined mainly by simple cuboidal epithelium (arrow). The seminiferous cords are separated from the rete channels by a large area of collagen fibres. Masson’s trichrome stain. X400.

Figure 29: A photomicrograph of the mediastinum testis of goat at 5-6 weeks of age showing the Leydig cells (arrow) at the mediastinal connective tissue in between the rete testis (RT). H&E stain. X 1000.
Figure 30: A photomicrograph of the rete testis and part of a seminiferous cord (below) of goat at 8-10 weeks of age. The channels of the rete are still parallel to each other at this age. The pseudo stratified columnar epithelium lined the rete channels.
H&E stain. X 400.

Figure 31: A photomicrograph of the rete testis (RT) and part of seminiferous tubules (above) of kid at 17-18 weeks of age, demonstrating the simple squamous cells (white arrow) and low cuboidal cells (black arrow) which line the rete testis.
H&E stain. X 250.
Figure 32: A photomicrograph of the testis of kid at 5-6 weeks of age illustrating the reticular fibers in the mediastinal connective tissue and surround the rete testis and seminiferous cords

Gomori’s silver stain. X100.

Figure 33: A photomicrograph of the receptacle (R) containing the plug of the terminal segment of sexually mature kid.

ST: seminiferous tubules.

Note the presence of a lumen in the terminal plug.

H&E stain. X 400.
Figure 34: A photomicrograph of the seminiferous cords of kid at 5-6 week of age, showing the presence of glycogen granules within the cytoplasm of the cells lining the cords.

PAS stain without diastase. X 400.

Figure 35: A photomicrograph of the seminiferous cords of kid at 5-6 weeks of age showing the positive reaction of boundary tissue of the seminiferous cords to PAS diastase resistant material.

PAS stain with diastase. X 400.
Figure 36: A photomicrograph of the testis of kid at 5-6 weeks of age showing the varying number of glycogen granules in the different seminiferous cords.

PAS stain without diastase. X 100.

Figure 37: A photomicrograph of seminiferous cords of kid at 5-6 weeks of age showing strong PAS positive reaction in the boundary tissue and varying number of glycogen granules within the seminiferous cords. The epithelium lining the cords and the interstitial tissue gives a negative reaction for PAS.

PAS stain without diastase. X 1000.
Figure 38: A photomicrograph showing PAS positive basement membrane of the seminiferous tubules (ST) and terminal segment (TS) of kid at 12-15 weeks of age. The lining epithelium and the interstitial connective tissue gives a moderate reaction.

PAS technique. X 100.

Figure 39: A photomicrograph of the testis of sexually mature kid demonstrating PAS-positive basement membrane of the seminiferous tubules (ST), terminal segments (TS) and receptacle (R) of the tubulus rectus.

PAS technique. X 100.
Figure 40: A photomicrograph of the rete testis of kid at 5-6 weeks of age showing PAS positive boundary tissue and PAS positive granules resistant to diastase digestion within the cytoplasm of the rete epithelium.

PAS stain with diastase. X1000.

Figure 41: A photomicrograph showing PAS –positive basement membrane of the seminiferous tubules (ST), terminal segments (TS) and receptacle (R) of the tubulus rectus. The reaction is stronger at the terminal segment and receptacle than the seminiferous tubule.

PAS technique .X 400.
Figure 42: A photomicrograph of the rete testis and part of the seminiferous tubule (ST) of kid at 21 weeks of age and onward illustrating the positive reaction of basement membrane and rete content for PAS material. 
Note: The reaction in the basement membrane of the seminiferous tubule is less than that of the rete testis. 
PAS technique. X 100.

Figure 43: A photomicrograph of the rete testis of kid at 21 week of age and onward, showed the strong reaction for PAS resistant to diastase digested material in the basement membrane, rete contents and mediastinal connective tissue.
PAS technique. X400.
Figure 44: A photomicrograph of kid at 12-15 weeks of age showing strong reaction of the epithelium lining the seminiferous tubules while the basement membrane showed a weak reaction to acid phosphatase. The interstitial connective tissue reacted strongly (arrows).

Gomori’s technique. X 400.

Figure 45: A photomicrograph of the testis of kid at 5-6 weeks of age, showed the positive reaction of the seminiferous cords for acid phosphatase.

Gomori’s technique. X100.
Figure 46: A photomicrograph of the testis of kid at 12-15 weeks of age showed positive reaction of the seminiferous tubules for acid phosphatase.

Note: The reaction is stronger than at 5-6 weeks of age.

Gomori’s technique. X100.

Figure 47: A photomicrograph of the testis of kid at 21 weeks of age and onward, showed the strong reaction of acid phosphate in the epithelium lining the seminiferous tubules and terminal segments.

Note: The reaction is more intense at the basal layers of the seminiferous tubules.

The basement membrane and the interstitial connective tissue showed negative reaction.

Gomori’s technique. X 100.
Figure 48: A photomicrograph of the seminiferous cords at 5-6 weeks of age demonstrating a strong reaction of the basement membrane and the epithelium lining the seminiferous cords to alkaline phosphatase.

Gomori and Lillie technique. X 100.

Figure 49: A photomicrograph showing the strong reaction of the lining epithelium of the seminiferous cords of kid at 5-6 weeks of age to alkaline phosphatase while the peritubular connective tissue reacted very weak.

Gomori and Lillie technique. X 400.
Figure 50: A photomicrograph of the testis of kid at 5-6 weeks of age showing the weak reaction of the interstitial connective tissue while the interstitial cells reacted strongly to alkaline phosphatase (arrows).

Gomori and Lillie technique. X 400.

Figure 51: A photomicrograph of the testis of kid at 12-15 weeks of age. The cytoplasm of the cells of the seminiferous tubules showed a positive reaction to alkaline phosphates.

Gomori and Lillie technique. X100.