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On the morphology of the accessory male glands and histochemistry of the ampulla ductus deferentis of the camel (*Camelus dromedarius*)

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INTRODUCTION

Although extensive studies on the accessory male glands of reproduction of many animals are available in the literature, the camel has received little attention. The morphological studies carried out so far on the accessory glands of this animal include some general accounts of the gross anatomy of the prostate (Leese, 1927; Tayeb, 1952; El-Jack, 1970) and a brief report on the bulbo-urethral glands (Perk, 1962). The presence of urethral glands in the pelvic portion of the urethra was reported by El-Jack (1970). Recent studies by El-Wishy, Mubarak & Fouad (1972) give some account of the microscopic structure of the accessory glands.

It was therefore decided to undertake a detailed morphological study of these glands in the hope that the findings would aid in the understanding of the results of parallel histochemical and ultrastructural studies. It was felt appropriate also to investigate the morphology and histochemistry of the ampulla ductus deferentis: the histochemistry of the other glands has been reported elsewhere (Ali, Moniem & Tingari, 1976).

MATERIAL AND METHODS

Samples of accessory male glands were collected from 42 adult camels. The penis was severed at the level of the ischial arch and the entire portion of the urethra cranial to that level was transferred to formalin. Topographical observations of the glands were recorded while they were intact, and also after fixation and removal of fat and fascia.

Histological observations were made on tissue samples from the prostate, bulbourethral glands, urethra and ampulla ductus deferentis. They were fixed in Bouin's fluid or formol–Zenker and processed for paraffin sections 6–7 μm thick. Sections were stained with haematoxylin and eosin for general observation, Masson's trichrome for collagenous and muscle fibres, Gomori's aldehyde fuchsin (Brenda & Disbrey, 1970) for elastic fibres and Gordon & Sweet's method (Carleton, 1967) for reticular fibres. Fresh samples were frozen in liquid nitrogen, cut at 10 μm in a Slee cryostat at -20 °C and treated according to the method of Namba, Nakamura & Grob (1967) for the demonstration of intrinsic nerves.

Histochemical investigations were confined to paraffin, fresh frozen and fixed frozen sections of the ampulla ductus deferentis. For the demonstration of carbohydrates and nucleoproteins, tissues samples were fixed in Gendre & Lillie's alcohol

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acetic formalin (Lillie, 1954) and processed for paraffin sections. Fresh tissues frozen in liquid nitrogen were used for the demonstration of enzymes other than acid phosphatase and lipids. For the demonstration of acid phosphatase, thin slices of tissues were fixed in 2·5% glutaraldehyde in 0·1 M phosphate buffer, pH 7·4 (Sabatini, Bensch & Barrnett, 1963) at 4 °C, washed overnight in 0·2 M cacodylate buffer, pH 7·4, containing 0·2 M sucrose at 4 °C and then frozen in liquid nitrogen and cut at a thickness of 10 μm.

Carbohydrates were stained by a modified periodic acid–Schiff (PAS) technique; control sections for glycogen were treated with 0·1% malt diastase for 30 minutes at 37 °C. Mucopolysaccharides were stained by a modified alcian blue method (which was repeated after sialidase digestion) and toluidine blue at pH 3·5 (Culling, 1963). Nucleoproteins were demonstrated in sections stained by a modified methyl green–pyronin method (Culling, 1963). Control sections for RNA were treated with 0·1% ribonuclease for 1 hour at 37 °C (Carleton, 1967). Lipids were stained by a modified oil red O method (Bancroft, 1967). Acid phosphatase was stained by a modified Gomori's lead nitrate method, pH 5·2 (Culling, 1963). Alkaline phosphatase was demonstrated using a modified Gomori's calcium phosphate method at pH 9·2 (Culling, 1963). For the demonstration of both alkaline and acid phosphatases sodium β-glycerophosphate was used as substrate. Adenosine triphosphatase was stained by the method of Wachstein & Meisel (Pearse, 1968) at pH 7·2 using adenosine 5-triphosphate (disodium salt) as substrate. Adenosine 5-monophosphate was demonstrated according to the method of Barron & Bosches (Pearse, 1968) at pH 6·5. Succinic and lactic dehydrogenases (SDH and LDH) were demonstrated using the methods described by Pearse (1968). Control sections for these enzymes were incubated in media lacking the substrates. Acetylcholinesterase was demonstrated according to the method described by Gomori (1952). Acetylthiocholine iodide was used as substrate. Control sections were incubated for 30 minutes in $2{\cdot}5 \times 10^{-6}$ M eserine.

RESULTS

Prostate gland

The gland consists of a dorsal corpus prostatae and a ventral pars disseminata overlying the prostatic urethra. The corpus prostatae is entirely intrapelvic, being situated on the dorsal aspect of the urethra and overhanging the neck of the urinary bladder (Fig. 1). It is discoid in shape, soft and greyish in colour. Whereas the cranial two thirds are almost free, the caudal third is fused with the prostatic urethra.

The prostatic urethra is short (3–5 cm). The parenchyma of the corpus prostatae is observed to be gradually delineated by a thin band originating from the internal aspect of the urethral muscle, thus forming a disseminate portion confined mainly to

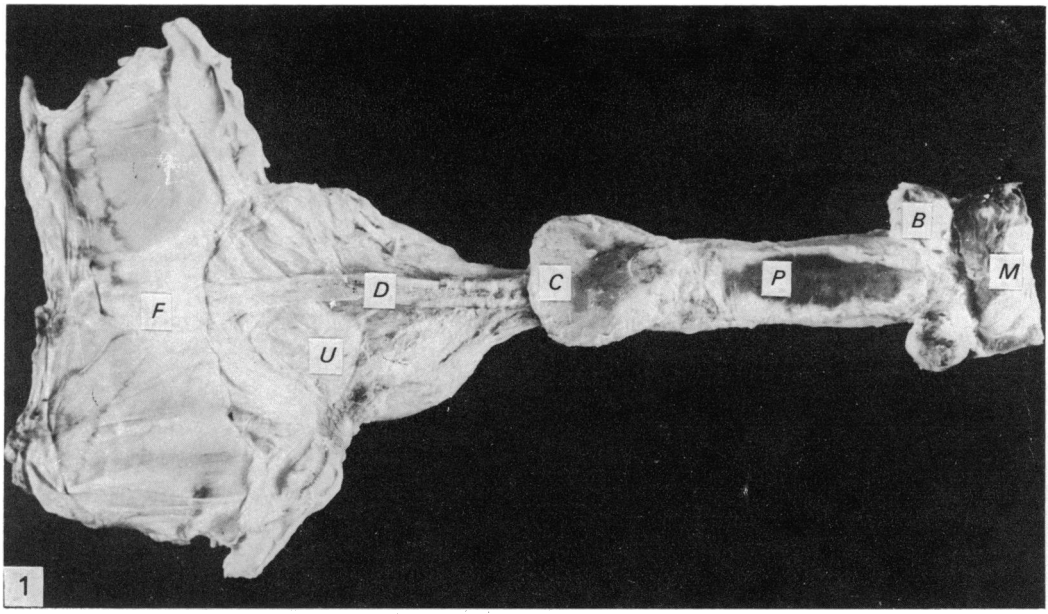
Fig. 1. Internal male genital organs showing the urogenital folds (*F*); the ductus deferens (*D*); the urinary bladder (*U*); the corpus prostatae (*C*); the pelvic urethra (*P*) and the bulbourethral glands (*B*). *M*, bulbocavernosus muscle.

Fig. 2. Tall columnar cells lining the secretory units of the corpus prostatae. H. & E. ×480.

Fig. 3. Note small basal cells (arrows) between the columnar cells and the basement membrane in the corpus prostatae. H & E. ×480.

Fig. 4. The fibromuscular capsule together with the secretory units of the pars disseminata. H & E. ×250.

Fig. 5. Some secretory units of the pars disseminata in the lamina propria of the urethra. Note that they are lined with pyramidal or columnar cells and the lumina are narrow. H & E. ×480.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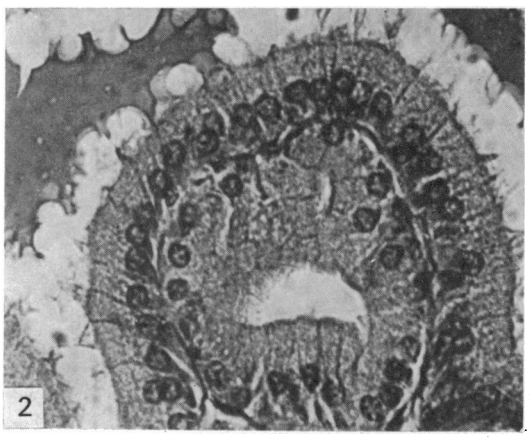
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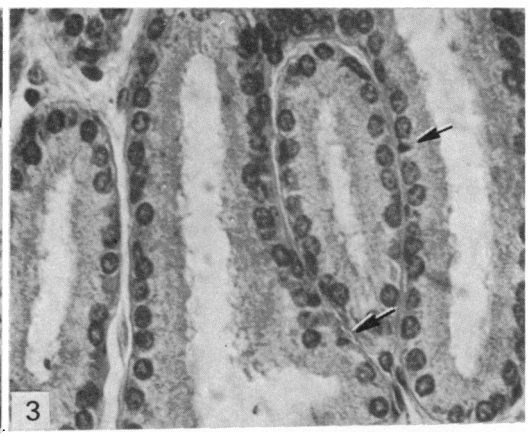
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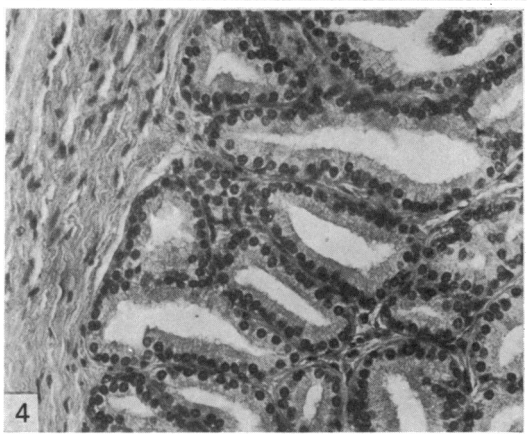
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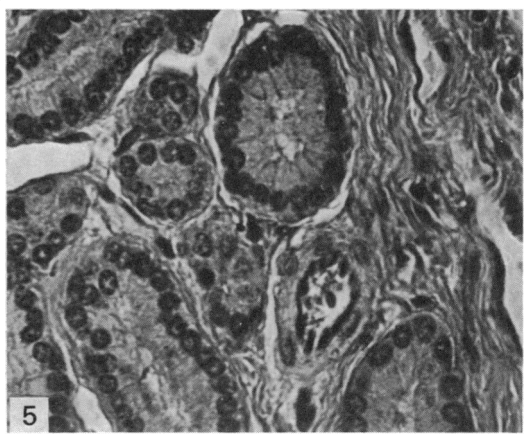
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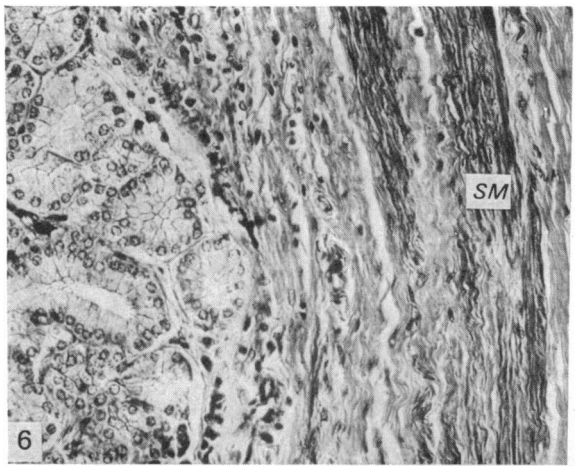
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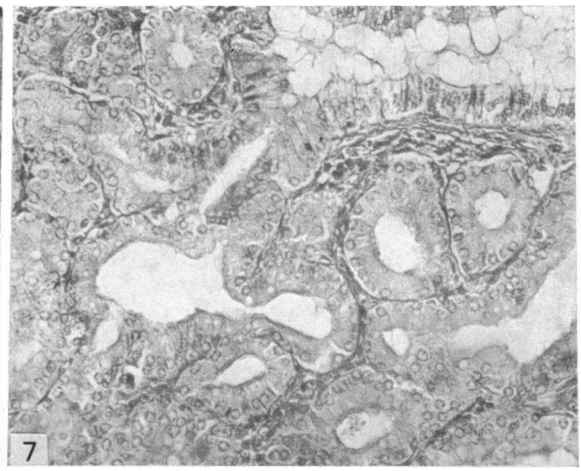
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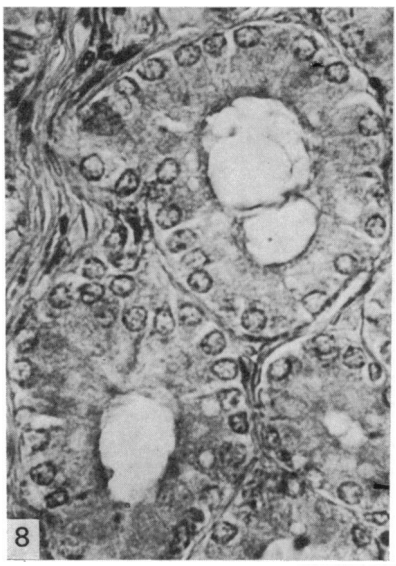
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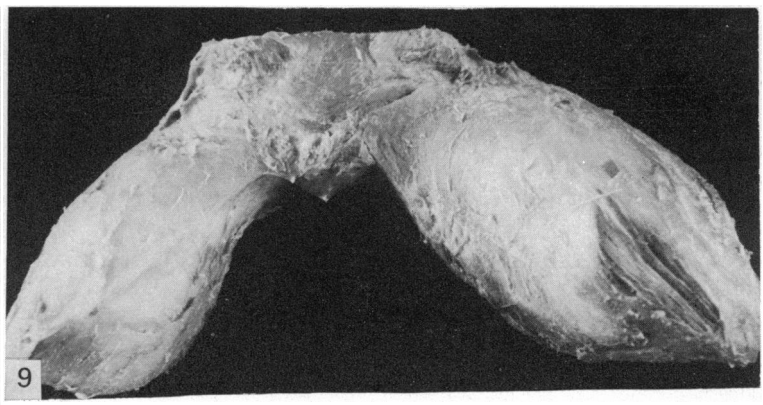
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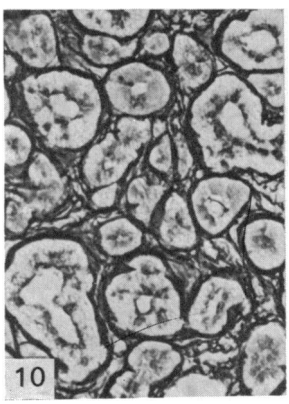
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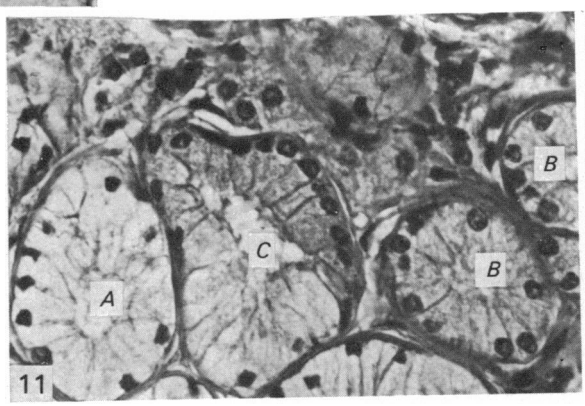
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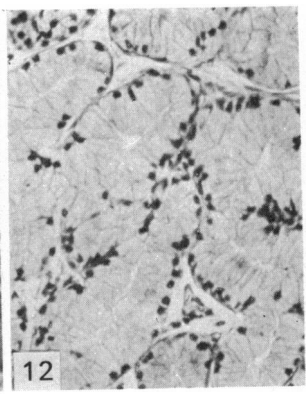
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the prostatic urethra. Caudally it becomes continuous with the glandular pelvic urethra. Close examination of the colliculus seminalis revealed about 15–20 prostatic ducts. Some of these ducts open within the colliculus seminalis, others open lateral to it.

Histologically the glandular parenchyma is lobulated and covered by a thin fibromuscular capsule. The interstitial connective tissue is abundant and rich in smooth muscle which often encircled the lobules. Each lobule consists of tubulo-alveolar secretory units resting on a distinct basement membrane and presenting a wide variation in size and diameter. The secretory units are lined with one layer of columnar cells averaging 17 μm in height. The nuclei are spherical and basal (Fig. 2). In some units, small cells wedged between the columnar cells and the basement membrane are observed (Fig. 3). Granules are numerous in the supranuclear cytoplasm; only a few granules are present elsewhere. Units lined with cuboidal epithelium are devoid of granules and are possibly inactive. The main ducts are lined with transitional epithelium.

The glandular parenchyma of the pars disseminata is surrounded by a striated muscle layer on all sides except dorsally where there is a dense fibromuscular band (Fig. 4). Thin fibromuscular trabeculae extend into the parenchyma, which consists of a few lobules. The secretory units are similar to those of the corpus prostatae, particularly under the fibromuscular band (Fig. 4). A few lobules are observed in the lamina propria of the urethra. Most of its units have narrow lumina and are lined with columnar or pyramidal cells (Fig. 5).

Pelvic urethra

The pelvic urethra is thick and flattened dorsoventrally, averaging 13 cm in length (Fig. 1). It is entirely glandular: urethral glands (glandulae urethrales) extend a short distance from the caudal end of the corpus prostatae to the level of the urethral bulb. The glands are continuous with the pars disseminata cranially. In transverse macroscopic sections the parenchyma is thick dorsally, comparatively thin laterally and indiscernible ventrally. Numerous ducts open irregularly caudal to the colliculus seminalis. The urethral glands, the urethra and its corpus cavernosum are surrounded by thick striated muscle laterally and ventrally, and by a dense fibromuscular layer dorsally (Fig. 6). The glandular parenchyma is lobulated. The secretory units are tubular and densely crowded (Fig. 7). Each unit is lined with a single layer of tall pyramidal cells (13 μm) with spherical nuclei in the basal cytoplasm, which is basophilic (Fig. 8). Supranuclear vacuoles are always present. These are probably the

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Fig. 6. Loosely disposed smooth muscle fibres (*SM*) in the capsule of the urethral glands. Masson's trichrome. × 250.

Fig. 7. Note that the urethral glands are tubular and densely crowded. H & E. × 250.

Fig. 8. Secretory units of urethral glands showing tall pyramidal cells with spherical nuclei and cytoplasmic vacuoles in apical cytoplasm, H & E. × 480.

Fig. 9. Bulbourethral glands lying close together with a thick interglandular septum in between.

Fig. 10. Secretory units of the bulbourethral glands together with abundant reticular fibres. Gordon & Sweet's method. × 250.

Fig. 11. Three types of secretory units (*A*, *B*, *C*) of the bulbourethral glands found together. H & E. × 480.

Fig. 12. Type A units of the bulbourethral glands. The epithelium is pyramidal or columnar and the nuclei are dark, flattened and basally located. H & E. × 250.

sites where lipids were extracted during the histological processing. The main ducts are lined with transitional epithelium. A few tubules and ducts are always seen beneath the mucosa of the urethra.

Bulbourethral glands

The bulbourethral glands are situated on the dorsolateral aspect of the pelvic urethra, above the ischial arch and partly covered by the bulbocavernosus muscle (Fig. 1). The two glands lies close together with a thick interglandular septum between them (Fig. 9). The glands are found about 10 cm caudal to the corpus prostatae. Each gland opens by one duct into the urethra, in a U-shaped fossa flanked on each side by a fold of mucous membrane.

The glands are covered externally by striated muscle and internally by a thick, mostly fibrous, capsule as reported by Perk (1962). The parenchyma is lobulated and consists of compound tubulo-alveolar secretory end-pieces supported by abundant reticular fibres (Fig. 10). Three types of secretory units, designated A, B and C, are always seen (Fig. 11). Type A is lined with one layer of tall pyramidal or columnar cells; the nuclei are flattened and basal with the chromatin material markedly condensed, and the cytoplasm is basophilic (Fig. 12). The height of the epithelium is inconstant, but averages 21 μm. Type B units are either in isolated lobules, or they are irregularly scattered among Type A units (Fig. 11). The units are comparatively small in size and densely crowded. They are lined with one layer of cuboidal cells. The nuclei are spherical and basal and the cytoplasm is pale reddish. A composite picture in which both types of cells are present in the same secretory unit is represented by Type C units (Fig. 11).

The secretory end-pieces are continuous with the primary ducts whose lining epithelium is similar to that of Type A units. The lumina are wide and branching. The main duct is lined with transitional epithelium, measuring 35 μm in height. A small amount of parenchyma accompanies the duct along its extraglandular portion in the wall of the pelvic urethra.

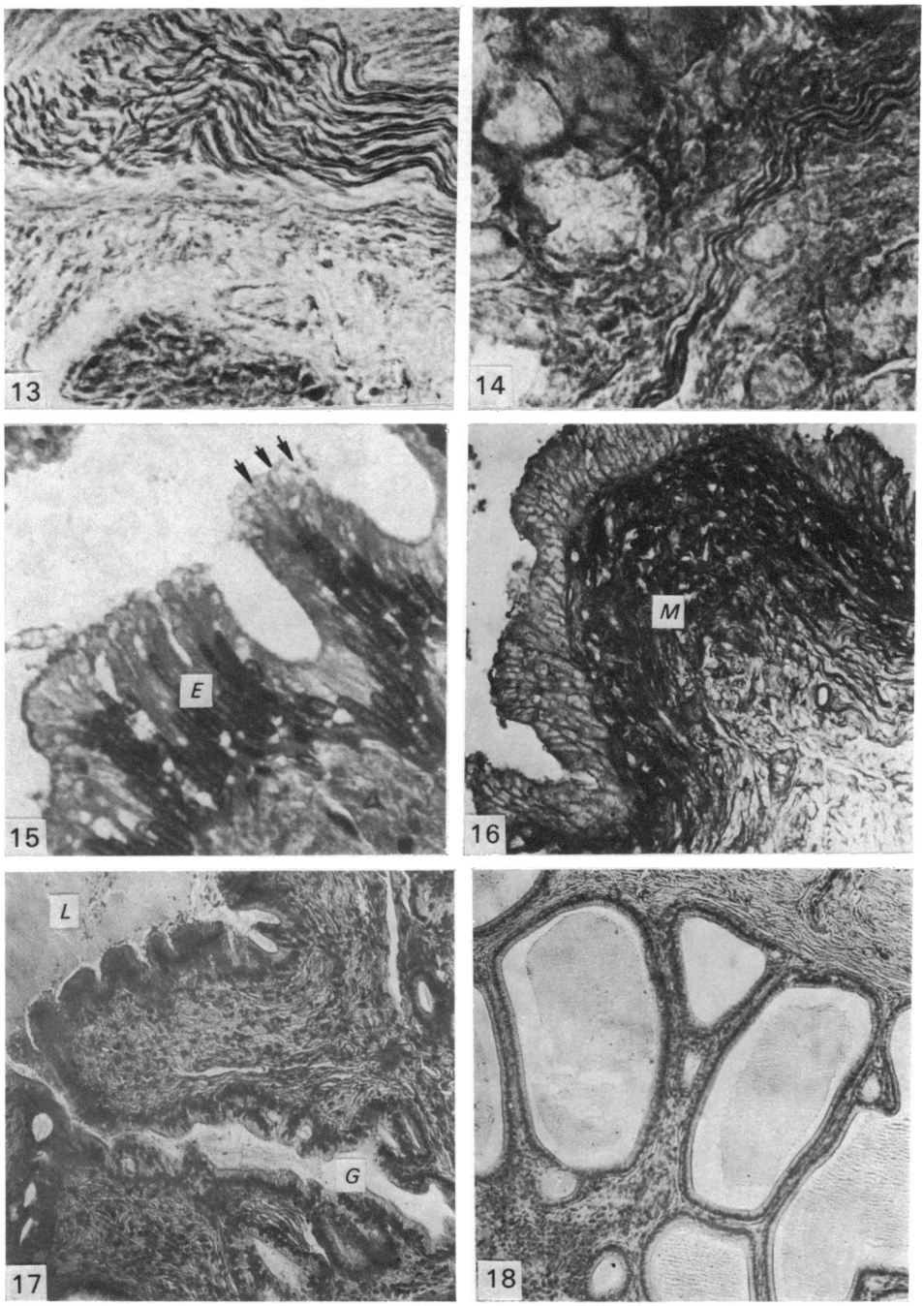
Intrinsic innervation

Large and small nerve trunks are observed in the capsule and interstitial tissue of all glands (Figs. 13, 14). Fine ramifications are seen along the course of capsular and interstitial smooth muscle fibres, and in the vicinity of blood vessels.

Ampulla ductus deferentis

Macroscopic observations. The intrapelvic portion of the ductus deferens emerges from the internal inguinal orifice under cover of the superficial layer of the urogenital fold. It runs between the superficial and deep layers of the fold dorsal to the urinary bladder and medial to the ureters (Fig. 1). The initial part of the ductus deferens is slender and highly tortuous. The subterminal end, which averages 18 cm in length, is slightly winding and markedly thickened to form an ampulla (ampulla ductus deferentis). The subterminal end of the ductus deferens pursues a short course in a deep groove on the ventral surface of the corpus prostatae, narrows gradually, pierces the dorsal wall of the prostatic urethra, and opens internally on the colliculus seminalis.

Histology. The mucosa of the ductus deferens is folded and lined with a pseudostratified columnar epithelium (Fig. 15). Its height appears inconstant, averaging 36 μm. The luminal contents consist of spermatozoa, degenerating cells and a



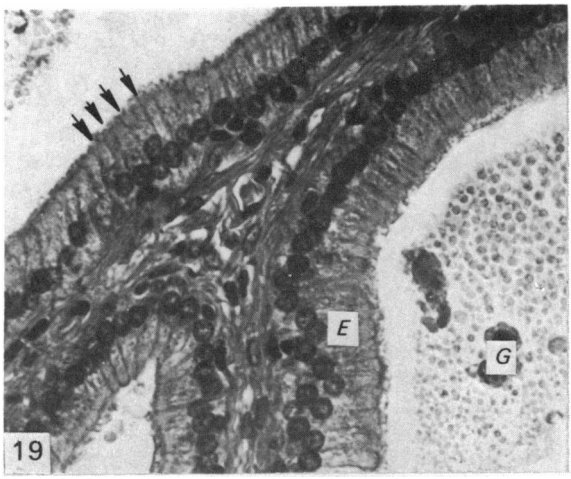
Figs. 13, 14. Nerve trunks coursing in the capsule (Fig. 13) and interstitial tissue (Fig. 14) of the bulbourethral gland. Namba *et al.* ×480.

Fig. 15. Ductus deferens lined by pseudostratified columnar epithelium (*E*). Note the apical protrusions (arrows). Masson's trichrome. ×480.

Fig. 16. Abundant elastic fibres underlying the mucosa (*M*) of the ductus deferens. Gomori's aldehyde fuchsin. ×480.

Fig. 17. Ampullary gland (*G*) opening into the lumen (*L*) of the ductus deferens. H & E. ×130.

Fig. 18. Peripheral ampullary glands. H & E. ×130.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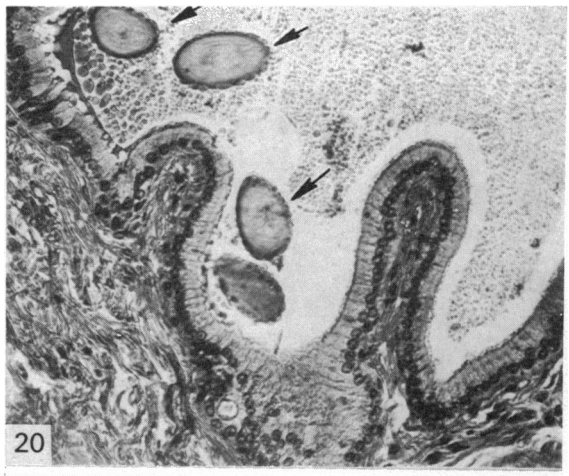
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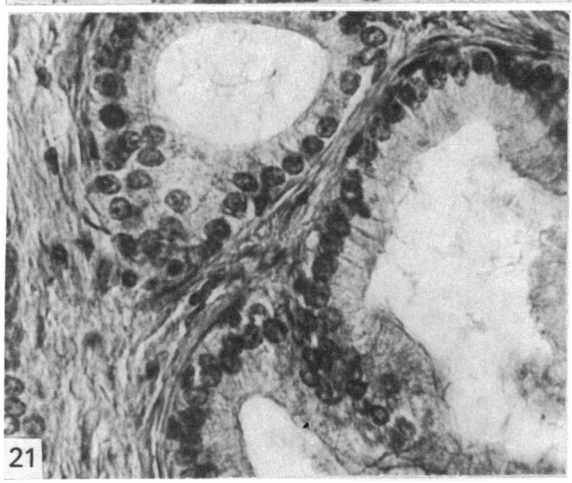
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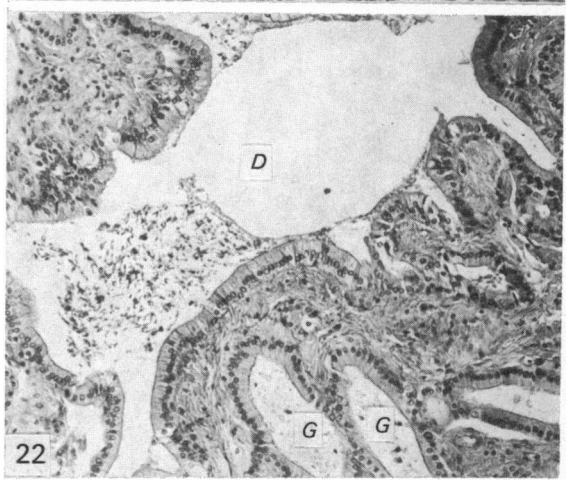
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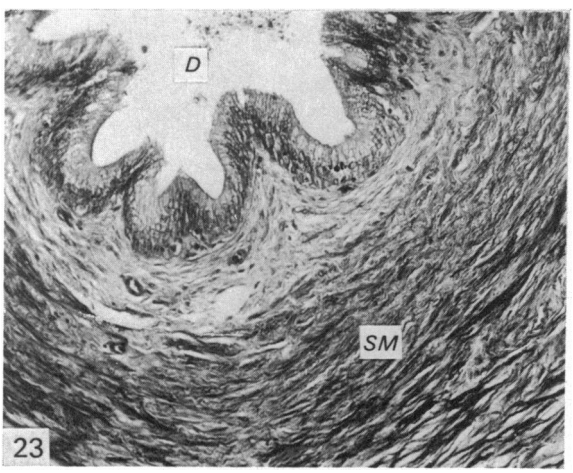
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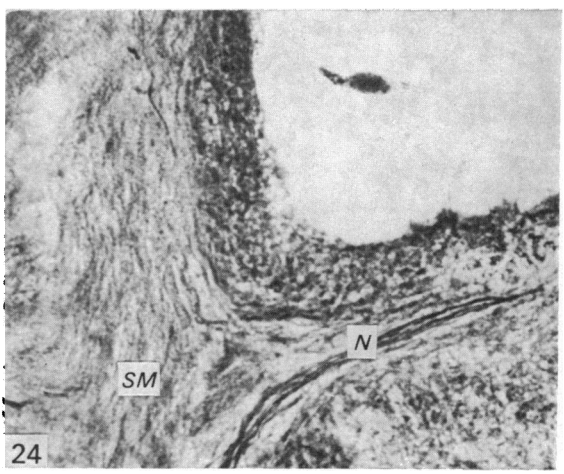
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homogeneous eosinophilic material. The mucosa is supported by abundant elastic fibres (Fig. 16).

The submucosa is glandular, consisting of peripheral, central and submucosal tubular glands which open directly into the lumen of the ductus deferens (Fig. 17). The interstitial tissue is mainly fibroelastic, but a few smooth muscle fibres are also present.

The peripheral glands are large and their lumina are generally wide (Fig. 18). They are lined with tall slender columnar cells and a few basal cells (Fig. 19). The columnar cells appear to have a brush border. The lining epithelium rests on a distinct basement membrane and averages 15 μm in height. The nuclei are spherical and occupy the basal cytoplasm. Nucleoli are frequently seen. The cytoplasm is acidophilic, with small acidophilic granules in the supranuclear region; a few granules are present elsewhere in the cytoplasm. The luminal contents are mainly composed of globular bodies, but spermatozoa and oval concretions are also frequently seen (Fig. 20).

The central and submucosal glands are comparatively small and possess narrow lumina (Fig. 21). They are lined with low columnar epithelium (10 μm). The cytoplasm occasionally contains acidophilic granules.

The ampullary glands decrease in thickness in that part of the ductus deferens underlying the corpus prostatae (Fig. 22), and particularly in the lamina propria of the urethra; in this region the lining epithelium of the ductus deferens becomes simple columnar.

The tunica muscularis is thick in the non-glandular portion of the ductus deferens, where it consists of a thick circular smooth muscle layer together with longitudinal smooth muscle bundles disposed peripherally (Fig. 23). In the glandular portion, the tunica muscularis is comparatively thin and irregularly arranged into an inner circular layer of smooth fibres which are loosely disposed and an outer layer with the fibres being irregularly disposed.

Large nerve bundles are numerous in the adventitia. Fine nerve fibres are seen in the interstitial connective tissue of the ampullary glands (Fig. 24) and in the submucosa of the ductus deferens. Fine ramifications are observed in the circular smooth muscle layer. Sympathetic ganglia and isolated nerve cell bodies are numerous in the adventitia of the non-glandular portion of the ductus deferens (Fig. 25), but extremely rare in the glandular portion.

Fig. 19. Tall slender columnar epithelium (*E*) lining the peripheral ampullary glands. Note the brush border (arrows) and globular bodies (*G*) in the lumen. Masson's trichrome. × 480.

Fig. 20. Peripheral ampullary gland showing oval concretions (arrows) in the lumen. Masson's trichrome. × 250.

Fig. 21. Central and submucosal ampullary glands. Note that they are small in size and their lumina are narrow in comparison to the peripheral glands illustrated in Fig. 18. Masson's trichrome. × 480.

Fig. 22. Ampullary glands in that portion of the ductus deferens underlying the corpus prostatae. Note the reduction in number and size of the glands (*G*) and the simple columnar epithelial lining of the ductus deferens (*D*). H & E. × 250.

Fig. 23. Showing the tunica muscularis (*SM*) in the non-glandular portion of the ductus deferens (*D*). Masson's trichrome. × 130.

Fig. 24. Fine nerve fibres (*N*) are depicted in the intertubular connective tissue. *SM*, smooth muscle. Silver stain. × 480.

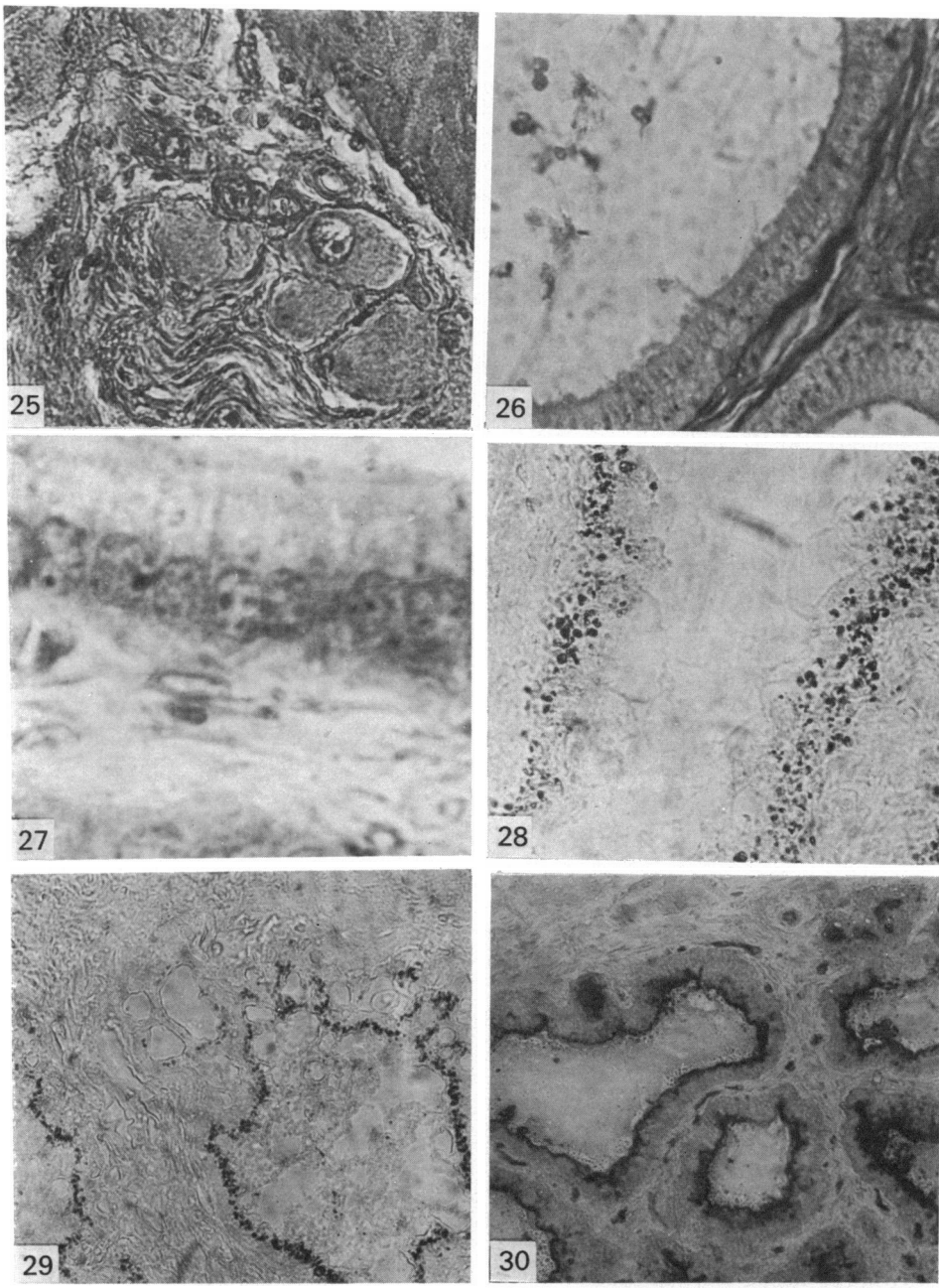


Fig. 25. Sympathetic ganglion in the adventitia of the non-glandular portion of the ductus deferens. Masson's trichrome. ×480.

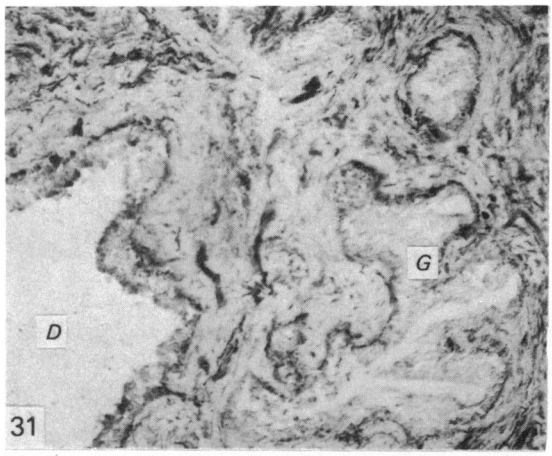
Fig. 26. PAS-positive granules are seen in the supranuclear cytoplasm of ampullary glands. ×480.

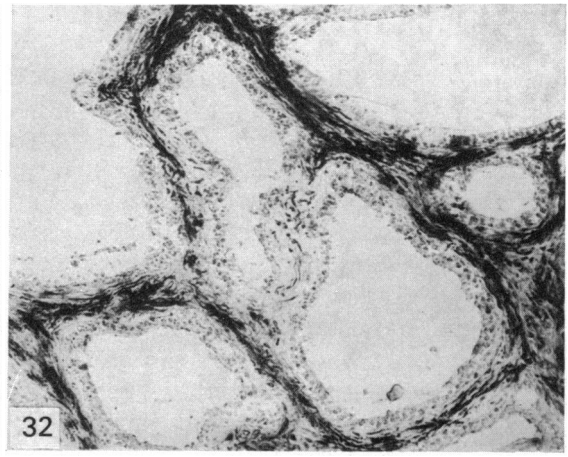
Fig. 27. RNA in the infranuclear cytoplasm and nucleoli of cells of ampullary glands. Methyl green pyronin. ×1100.

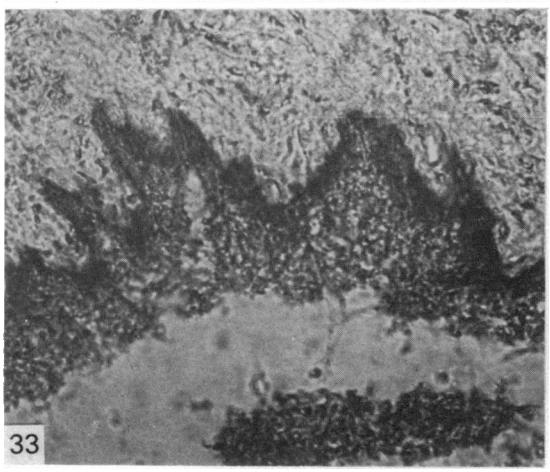
Fig. 28. Abundant lipid droplets are scattered in the basal cytoplasm of cells of ampullary glands. Oil red O. ×480.

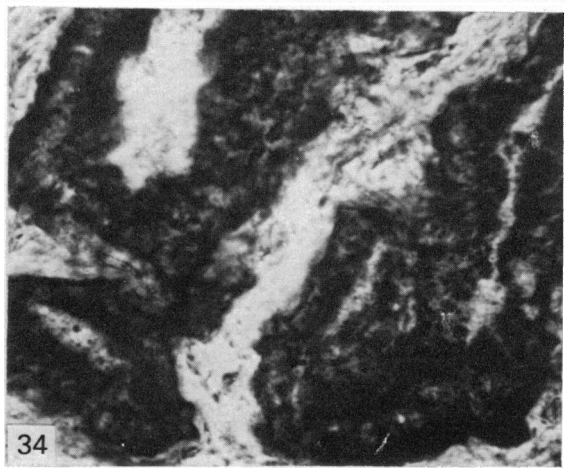
Fig. 29. Abundant acid phosphatase granules in the supranuclear cytoplasm of ampullary glands. 10 minutes lead nitrate method. ×250.

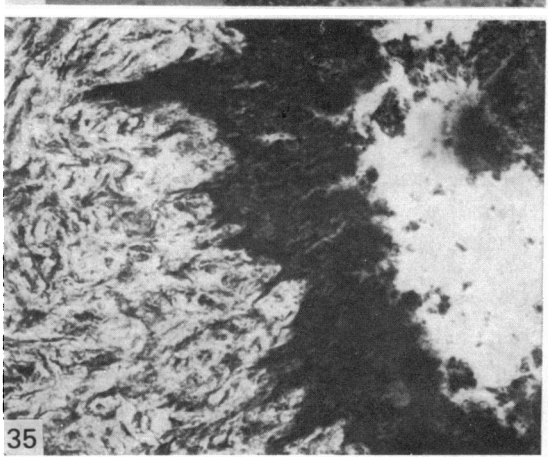
Fig. 30. Showing alkaline phosphatase activity in apical cytoplasm of ampullary glands. 10 minutes calcium phosphate method. ×130.











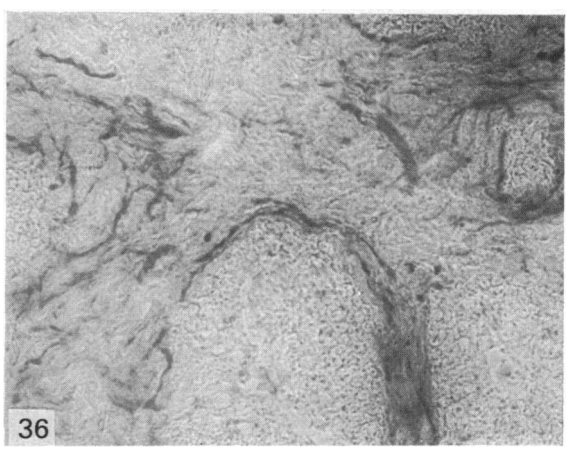


Fig. 31. Adenosine triphosphatase activity in the basal laminae and interstitial tissue of the ampullary glands (*G*) and the ductus deferens (*D*). 15 minutes. ×130.

Fig. 32. Strong adenosine 5-monophosphatase activity in the basal laminae and interstitial tissue of the ampullary glands. 10 minutes. ×130.

Fig. 33. Note strong SDH activity in the ductus deferens. 45 minutes. ×480.

Figs. 34, 35. Strong LDH activity in the cytoplasm of the ampullary glands (Fig. 34) and the ductus deferens (Fig. 35). 15 minutes. ×480.

Fig. 36. Acetylcholinesterase activity appears to be confined to neural elements. 90 minutes. Gomori's method. ×480.

Histochemistical observations

Carbohydrates. In the peripheral ampullary glands there is invariably a granular PAS-positive reaction in the supranuclear region, with scattered granules elsewhere in the cytoplasm (Fig. 26). The central and submucosal tubules exhibit a weak granular reaction. The luminal contents, the cytoplasm of the ductus deferens and the basal laminae are also positive. The PAS-positive material is diastase-resistant, shows weak alcianophilia (inhibited by sialidase) and is orthochromatic with toluidine blue.

RNA. RNA was seen in the infranuclear cytoplasm and the nucleoli of the peripheral ampullary glands (Fig. 27). It was less abundant in the central and submucosal glands.

Lipids. Large and small oil red O-positive droplets were abundant in the basal cytoplasm of the ampullary glands (Fig. 28).

Acid phosphatase. Strong enzyme activity was seen in the ampullary glands and the ductus deferens. The reaction was mainly localized in granules just above the nucleus although some granules were seen in other parts of the cytoplasm (Fig. 29).

Alkaline phosphatase. Strong enzyme activity was present in the apical cytoplasm of the lining epithelium of the ampullary glands (Fig. 30). Some positive reaction was detected in the subepithelial connective tissue of the ductus deferens.

Adenosine triphosphatase and adenosine 5-monophosphatase. Activity of these enzymes was strong in the interstitial connective tissue and muscle fibres (Figs. 31, 32). Some reaction was detectable also in the subepithelial connective tissue of the ductus deferens.

SDH and LDH. Strong enzyme activity of both was observed in the basal laminae and cytoplasm of the ampullary glands and ductus deferens (Figs. 33–35).

Acetylcholinesterase. Enzymic activity was confined to neural elements in the adventitia and interstitial connective tissue of the ampullary glands (Fig. 36) and in the adventitia of blood vessels.

DISCUSSION

The morphological findings in this study are largely in agreement with those of El-Wishy *et al.* (1972) who described a corpus prostatae and a pars disseminata. However, the pars disseminata indicated in their study seems to extend over a considerable length of the urethra, and corresponds to what we consider two distinct regions. According to this study, and in agreement with El-Jack (1970), the glandular zone occupying the prostatic urethra (cranial zone) is histologically similar to the corpus prostatae and is therefore considered to be pars disseminata. The large remaining part of the glandular zone (caudal zone) is histologically different from the above, and is therefore considered to constitute the zone of urethral glands.

The camel pars disseminate seems to be small, confined to the prostatic urethra and to contain only a few mucous units. In this respect it differs from its homologue in the bull (Kainer, Faulkner & Abdel-Raouf, 1969), ram (Aitken, 1959) and boar (Aitken, 1960) where it extends along the entire length of the pelvic urethra and contains abundant mucous units (Bharadwaj & Calhoun, 1959; Atiken, 1960; Kainer *et al.* 1969).

There are numerous reports on urethral glands in the pelvic portion of the urethra in many domestic animals (Hirsch, 1927; Ellenberger & Baum, 1943; Bharadwaj &

Calhoun, 1959). In the bull, ram and goat the glands are represented by the pars disseminata, whereas in the stallion and dog only a few scattered mucous glands (glands of Littré) have been observed. In the camel, however, the caudal gandular zone is quite extensive.

It has been claimed by Perk (1962) that there are marked seasonal variations in the bulbourethral glands of the camel. Abundant active units have been described in the rutting season (March); in the inactive period (July) the parenchyma is said to be made up of small inactive tubules. In the present investigation three types of secretory units designated as A, B and C were observed throughout the year. Type A units, which are particularly abundant in the period between December and June, are identical with those described by Perk (1962) in the rutting season. Type B and C are similar to the tubules seen in the inactive period (Perk, 1962). The slight fluctuations in the proportions of the various secretory units and in the amount of interstitial tissue observed here, seem to be a normal functional response to changing environmental conditions, as reported in other domestic animals (Julian & Tyler, 1959). Complete inactivity, however, was not observed in the glands of the camel. Trotter (1959) reported an active and inactive state in the glands of the bull.

The units described in the rutting season (Perk, 1962), designated here as Type A, are highly active mucous units. Secretion of mucus occurs in the glands of the bull (Trotter, 1959; Bharadwaj & Calhoun, 1962; Kainer *et al.* 1969), ram (Aitken, 1959) and boar (Aitken, 1960). Type B and C units seem to be inactive, but when adequately stimulated they probably develop into Type A. The cytoplasmic vacuolation reported by Perk (1962) and observed here may be lipid material lost during paraffin processing.

The ampulla ductus deferentis is essentially similar to that of the bull and stallion. Peripheral ampullary glands are wider than the central and submucosal glands. PAS-positive material is always contained in the lumen. It is possible that these glands serve as a temporary reservoir for secretion prior to its ejaculation.

The pelvic urethra and the bulbourethral glands are shown to be richly innervated. Ganglia were not seen. Capsular sympathetic nerves and autonomic ganglia have been observed in the prostatae gland of the bull (Kainer *et al.* 1969) and man (Charles & Madge, 1963). Nerves seen ramifying on muscle fibres in the camel glands probably cause muscle contraction and effect expulsion of glandular secretion.

No glycogen was detected in the ampulla ductus deferentis. The PAS-positive, diastase-resistant material observed in the ampullary glands and the ductus deferens possibly contains carbohydrate–protein complexes. The weak alcianophilia seen here in the ampullary glands of the camel, and inhibited by sialidase digestion, is suggestive of a very small amount of sialic acid. This is unlike the case in the stallion and jackass, where most of the sialic acid in the seminal plasma is derived from the ampulla and epididymis (Mann, 1964).

In the present study RNA was seen in the cytoplasm and nucleoli of the ampullary glands. RNA is known to be involved in the synthesis of proteins, which may be either utilized intracellularly or secreted. The presence of abundant RNA in the camel ampulla suggests that it may be involved in the secretion of carbohydrate–protein complexes.

In the bull, numerous lipid-laden cells have been described in the epithelium of the seminal vesicle (Mann, Davies & Humphrey, 1949). It is known that the lipids in the seminal plasma of man, dog, cat and rabbit are derived from the prostate gland (Mann, 1964). In the case of the camel, abundant lipid droplets were observed in the

ampullary glands and the ductus deferens. It is therefore possible that lipids in the seminal plasma of camel may originate from the ampulla.

As in the bull (Rollinson, 1954; Stallcup & Griffon, 1969), abundant acid phosphatase granules are seen in the cytoplasm of the ampullary glands and ductus deferens. The granules seem to correspond to the subcellular fractions, the lysosomes, in which the enzyme is detected (de Duve, Wattiaux & Baudhuin, 1962). These lysosomes contain numerous enzymes which hydrolyse proteins, carbohydrates, glycoproteins, glycolipids and phosphates (Barrett, 1969; Tappel, 1969). The exact function of acid phosphatase is not known, but a role in intracellular digestion has been postulated (de Duve & Wattiaux, 1966; Gahan, 1967). It has been reported that the prostatic secretion and the seminal plasma in man (Mann, 1964) are rich in acid phosphatase. The relative abundance of the enzyme in the camel ampulla suggests that acid phosphatase is probably secreted into the seminal plasma.

Also, in the camel as in the bull (Rollinson, 1954; Stallcup & Griffon, 1969) alkaline phosphatase is uniformly distributed in the apical cytoplasm of the ampullary glands. Adenosine triphosphatase and adenosine 5-monophosphatase are abundant in the basal laminae and interstitial tissue. This pattern of distribution suggests that these hydrolytic enzymes may be involved in active transport. A functional correlation between these hydrolytic enzymes and the passage of metabolites across cell membranes has been indicated by Novikoff *et al.* (1962). Adenosine triphosphatase has been also associated with the hydrolysis of high energy bonds and the contraction of smooth muscle (Hoffman, 1960; Bonting, Simon & Hawkins, 1961). The abundance of the enzyme in the circular smooth muscle layer in the camel ampulla suggests that this muscle is involved in the expulsion of secretory material.

SDH is concerned with tissue respiration, and forms a link in the tricarboxylic acid cycle; LDH is involved in glycolysis. As in the bull (Stallcup & Griffon, 1969), SDH and LDH activities in the camel ampullary glands and ductus deferens are high.

In the camel, ampulla acetylcholinesterase (AChE) activity is confined to neural elements. AChE is known to regulate the level of acetylcholine released by cholinergic fibres. Cholinergic fibres have been observed in the prostate gland of man and dog (Sasaki, 1971): they are presumably involved in the emptying mechanism.

As reported by Leese (1927), Tayeb (1952) and El-Jack (1970), the camel has no seminal vesicle. It is well known that fructose, which is metabolized by spermatozoa, is mainly secreted by the seminal vesicles in other animals but small amounts are also produced in the ampulla and prostate (Mann, 1964). According to Sulman (1953) and White & White (1965) fructose may be absent, or only present in traces, in canine seminal plasma. Sulman (1953) states that some animals can manage without fructose. This is supported by the fact that the semen of the stallion contains glucose, but is remarkably poor in fructose (Mann, 1964). In the camel, either fructose is secreted by the ampullary and/or prostate glands, or it is not present: this point needs to be investigated.

SUMMARY

A morphological study of the prostate, and the urethral and bulbourethral glands of the camel was carried out. The ampulla ductus deferentis was also studied and its histochemistry investigated.

The prostate gland consists of a massive corpus prostatae and a small pars disseminata. The parenchyma is arranged in lobules made up of irregular units lined with one layer of simple columnar secretory epithelium with sporadic basal cells.

The pelvic urethra is entirely glandular; its cells are of the mucous type. The bulbourethral glands are large and exhibit three types of secretory units, designated A, B and C. Type A units are considered as highly active mucous, whereas B and C are inactive. Seminal vesicles are not present in the camel.

The terminal end of the ductus deferens is grossly enlarged to form an ampulla. Peripheral, central and submucosal glands open directly into the lumen of the ductus deferens. Ampullary glands probably secrete carbohydrate–protein complexes. RNA is demonstrable in the basal cytoplasm. Acid phosphatase granules are present in abundance in the glands and ductus deferens. Alkaline phosphatase is uniformly distributed in the apical cytoplasm of the glands. Adenosine triphosphatase and adenosine 5-monophosphatase are seen in the basal laminae and interstitial tissue. There is strong succinic and lactic dehydrogenase activity in the cytoplasm of the ampullary glands and ductus deferens. Acetylcholinesterase activity is confined to neural elements. The significance of the histochemical findings is discussed.

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