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Gular Gland of the Indian Sheath-tailed Bat

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Pandey S. D. & Dominic C. J., 1987: Gular gland of the Indian sheat-tailed bat. Acta theriol., 32, 6: 83—93 [With 1 Table, 2 Figs. & Plates I—II].

The morphology, histology and histochemistry of the gular gland of the Indian sheath-tailed bat, *Taphozous longimanus* Hardwicke, 1823, are described. The gular gland which is present only in the male is a flattened, pear-shaped structure lying below the skin on the ventral side of the neck. The most striking histological feature of the gular gland is the segregation of the sebaceous and sudoriferous units into distinct lobes. The gular gland is composed of seven lobes, viz. the caudo-median sudoriferous lobe, paired inner sebaceous lobes, paired outer sebaceous lobes and paired cephalo-lateral sudoriferous lobes. Each sebaceous lobe is composed of a large number of acini, the cells of which exhibit typical holocrine secretory activity. The sudoriferous cells show typical apocrine secretion. During the breeding season, hypertrophy and hyperplasia are noticed in both the sebaceous and sudoriferous cells. The secretion of the sebaceous glands is lipoidal and that of the sudoriferous glands proteinaceous in nature. The secretory products of both the sebaceous and sudoriferous glands are discharged into the vestibule which serves as a reservoir. The hypertrophy of the gland during the breeding season suggests that its secretion plays some role in reproductive activities.

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1. INTRODUCTION

Cutaneous scent glands exhibiting great diversity in location, structure and function have been reported in 15 of the 18 extant mammalian orders (Müller-Schwarze, 1971). Schaffer (1940) has systematically reviewed the various skin glands and their distribution and morphology. The secretion of these glands have come to be recognised as playing a very important role in the regulation of behaviour in many species. Recent reviews pertaining to the structure, hormonal control, chemistry of secretions and communicatory role of the cutaneous glands in mammals are provided by a number of investigators (*cf.* Strauss & Ebling, 1970; Mykytowycz & Goodrich, 1974; Ralls, 1971; Eisenberg & Kleiman, 1972; Adams, 1980).

Bats possess well developed skin glands the secretions of which are

used in olfactory communication (Quay, 1970). They are best developed in molossids and least in vespertilionids. Glandular pouches located on the throat or neck, which are termed as gular or chest glands, are of widespread occurrence in *Molossidae* and *Emballonuridae* (Starck, 1958; Goodwin & Greenhall, 1961; Werner & Lay, 1963; Valdivieso & Tamsitt, 1964; Horst, 1966; Gutierrez & Aoki, 1973; Dapson *et al.*, 1977). The genus *Taphozous* (family *Emballonuridae*) shows most interesting diversity of the gular glands. According to Dobson (1873) the gular gland in *Taphozous* is species characteristic.

The present report deals with the histology and histochemistry of the gular gland of *Taphozous longimanus* which is present only in the male.

2. MATERIALS AND METHODS

Twenty adult males of *T. longimanus* collected from Varanasi during different months of the year were used in this study. After sacrifice, the gular gland with its duct and adjoining skin was carefully dissected out and fixed in appropriate fluids (*vide infra*). Care was taken to maintain the normal anatomical relationship of the gland orifice with the adjacent skin. Of the 14 glands employed for histological study, 6 were from nonbreeding and 8 from breeding males. Glands from 6 males in the nonbreeding period were used for histochemical investigations. Materials meant for routine histological study were fixed in aqueous Bouin's fluid, embedded in paraffin and serially sectioned at 6 μ in the transverse, sagittal or frontal planes; the sections were stained with Mayer's haemulun and eosin and mounted in DPX. For the demonstration of polysaccharides and total proteins, paraffin sections of materials fixed in Bouin's fluid were stained with Periodic acid-Schiff's reagent (PAS) and mercury bromphenol blue methods, respectively. Materials fixed in Baker's formal-calcium or 10 per cent neutral formalin were sectioned on a cryostat and stained with oil red O and Nile blue sulphate for detection of total lipids and neutral lipids, respectively. The indices of histochemical reactions in the various components of the gular gland were visually determined on an arbitrary scale as follows, none (−), light (+), moderate (++) and intense (+++).

3. RESULTS

1. Gross Anatomy of the Gular Gland

The gular gland is unpaired and lies in the mid-ventral region of the neck (Fig. 1A). The gland area is covered by the hairy skin and hence the gland is not visible from the exterior. However, when the skin on the mid-ventral region of the neck is slightly stretched, the orifice of the gland is seen.

The gular gland can be easily exposed by flaying the overlying skin (Fig. 1A). It is pear-shaped, dorsoventrally flattened and reddish to yellowish in colour in the fresh state (Fig. 1B and C). The largest gland

measured 11×10 mm. The gland is composed of seven major lobes, viz. the unpaired caudo-median sudoriferous lobe, paired inner sebaceous lobes, paired outer sebaceous lobes and the paired cephalo-lateral sudoriferous lobes (Figs. 1B, C and 2). The boundaries of these lobes are demarcated by furrows which do not correspond with each other on the dorsal and ventral surfaces of the gular gland. Each sebaceous lobe is subdivided into a number of lobules whose boundaries appear as shallow furrows on the gland surface. The sudoriferous lobes can be easily distinguished from the sebaceous lobes due to their paler coloration.

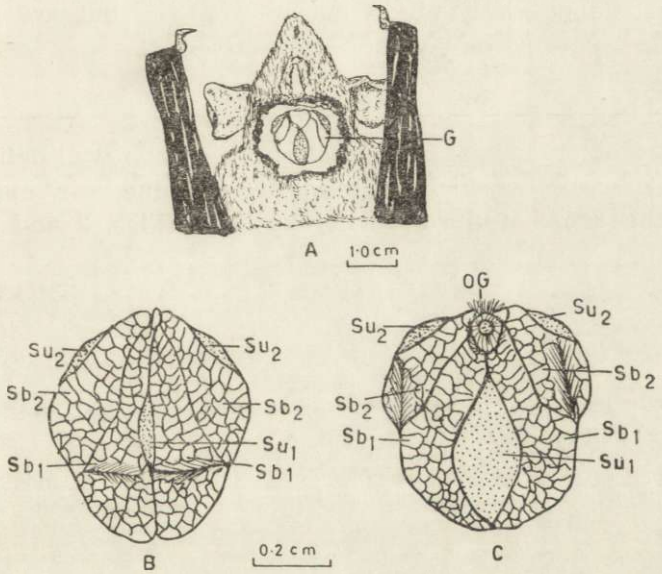

Fig. 1. Topography of the gular gland. A. Ventral view of the neck region of a male. The skin is flayed to show the gular gland in situ. B. Gular gland (dorsal view). Note the transverse blood vessel on the dorsal side of the inner sebaceous lobes. C. Gular gland (ventral view). G=gular gland; OG=orifice of the gular gland; Sb_1=inner sebaceous lobe; Sb_2=outer sebaceous lobe; Su_1=caudo-median sudoriferous lobe; Su_2=cephalo-lateral sudoriferous lobe.

The caudo-median sudoriferous lobe extends from the anterior one third of the gular gland to its posterior extremity (Figs. 1C, 2 and 3) and is partly covered laterally, posteriorly and dorsally by the paired inner sebaceous lobes (Figs. 1B, C and 4). Hence this lobe is not visible on the dorsal side of the gland. The paired inner sebaceous lobes are very conspicuous and extend from the anterior to the posterior extremity of the gular gland (Fig. 1B). A prominent blood vessel which runs transversely is present on the dorsal side of each inner sebaceous lobe (Fig. 1B). Flanking the anterior two-third of the paired inner sebaceous

lobes are the paired outer sebaceous lobes which are readily recognisable (Fig. 1B, C). The outer sebaceous lobes extend from the transverse blood vessel present on the dorsal surface of the inner sebaceous lobes to the anterior extremity of the gular gland. The paired cephalo-lateral sudoriferous lobes flank the cephalo-lateral border of the outer sebaceous lobes and often extend up to the orifice of the gular gland.

2. Histology of the Gular Gland

The tubulo-alveolar holocrine sebaceous and the ecrine sudoriferous elements in the gular gland do not intermingle, but are confined to distinct lobes separated by layers of connective issue.

Sebaceous Glands

The paired outer and inner sebaceous lobes have well-defined lumina with irregular outlines which communicate with the vestibule into which also open the ducts of the sudoriferous lobes (Figs. 2 and 6, Plate I).

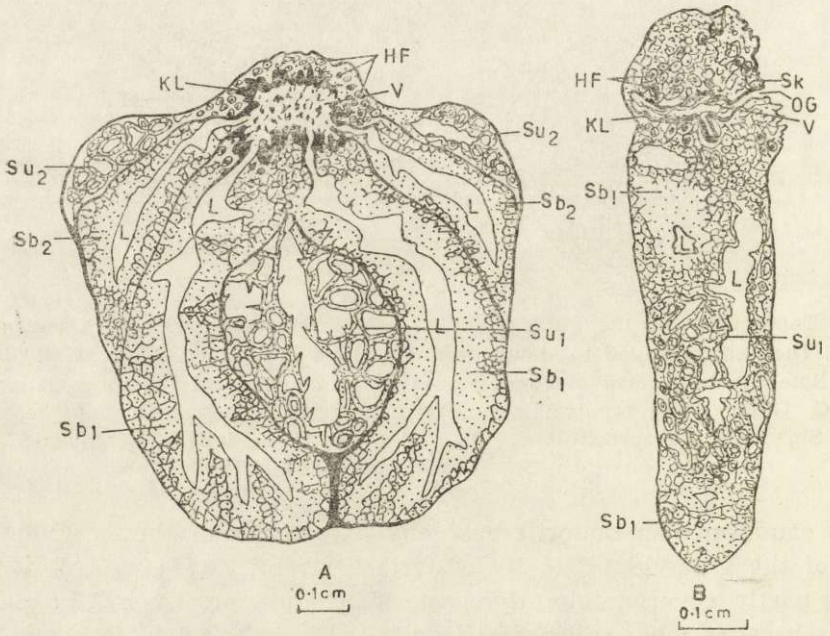

Fig. 2. Semidiagrammatic drawings of the sections of the gular gland. A. Frontal section showing the sebaceous and sudoriferous lobes and the vestibule. B. Sagittal section. Note the opening of the caudo-median sudoriferous lobe into the vestibule. HF=hair follicles; KL=keratinized layer; L=lumen; OG=orifice of gular gland; Sb_1=inner sebaceous lobe; Sb_2=outer sebaceous lobe; SK=skin; Su_1=caudo-median sudoriferous lobe; Su_2=cephalo-lateral sudoriferous lobe; V=vestibule.

Each sebaceous lobe is composed of several acini which are separated by connective tissue trabeculae (Figs. 3, 4 and 6, Plates I—II). The boundaries of the more centrally located acinar cells are not clearly demarcated and the central portion of each sebaceous lobe appears as a continuous mass of cells without being grouped into acini (Fig. 6). Each acinus is densely packed with sebaceous cells exhibiting different stages of secretory activity (Fig. 7). The sebaceous cells in an acinus exhibit progressive increase in size and secretory activity from the periphery to the lumen. A single layer of undifferentiated squamous cells is seen at the periphery lying on the basement membrane. The basal cells have distinct boundaries and contain very little secretion. Mitotic divisions are also seen in some of the cells. The more apical cells contain more of the secretory material and discharge their contents into the central lumen by holocrine secretion. The lumina are often filled with secretory products and cell debris. Secretion-loaded cells are also found among the luminal contents.

Sudoriferous Glands

The unpaired caudo-median and paired cephalo-lateral lobes are composed exclusively of sudoriferous glands (Figs. 1B, C and 2). The sudoriferous cells have the characteristic appearance of similar cells present elsewhere on the skin and possess highly chromophilic basally located nuclei (Fig. 8, Pl. II). Mitotic figures and binucleated cells are occasionally seen in the sudoriferous glands. The lumina of the sudoriferous tubules are wide and contain a weak eosinophilic secretion (Fig. 8). The sudoriferous tubules of each lobe open into a central lumen which opens anteriorly into the vestibule of the gular gland (Fig. 2A, B). In contrast to the sudoriferous glands on the skin, the sudoriferous glands in the gular gland discharge their secretions into the vestibule which opens to the exterior.

The vestibule is the terminal duct of the gular gland into which open the lumina of the four sebaceous and the three sudoriferous lobes (Figs. 2 and 6). It is obvious that the gular gland secretion is a mixture of sebaceous and sudoriferous elements.

3. Changes in the Histology of the Gular Gland during the Breeding Season

In *T. longimanus* the peak spermatogenic activity occurs in October, January and from April to May (Krishna & Dominic, 1982). During these periods the gular glands exhibited signs of increased activity; the glands increased in size accompanied by distinct hypertrophy and hyper-

plasia of both the sebaceous and sudoriferous gland cells (Figs. 9—12). The acinar cells in all sebaceous lobes exhibited active proliferation and hypertrophy resulting in the enlargement of cells and cell nuclei (Figs. 9—11, Pl. II). Some acinar cells appeared vacuolated (Fig. 10). Mitotic figures were often noticed in the basal cells of the acini. The apical cells were much enlarged and exhibited a notable increase in secretory activity (Fig. 11) as compared to those of the glands of animals in the nonbreeding season. In the sudoriferous glands the cells were much enlarged suggestive of increased secretory activity (Fig. 12). The lumina of the sudoriferous glands contained greater amount of secretory material as compared to those of non-breeding animals.

4. Histochemical Observations

Summary of the histochemical tests is shown in Table 1.

The sebaceous tissue was almost totally devoid of polysaccharides and proteins. By contrast, polysaccharides were detected in moderate quanti-

Table 1
Summary of the histochemical tests.

Nature of secretion & technique employed	Sebaceous lobes		Sudoriferous	Luminal secretion	
	Basal cells	Apical cells	lobes	Sebaceous lobes	Sudoriferous lobes
Polysaccharides (PAS)	—	—	++	—	++
Proteins (Mercury bromphenol)	±	—	++	—	++
Lipids (Oil red O)	+	+++	—	+++	—
Neutral lipids (Nile blue sulphate)	—	+	—	+	—

ties in the sudoriferous glands. Proteinaceous materials were demonstrated in sudoriferous cells and in the luminal contents of sudoriferous glands. Lipoidal substances (oil red O) were abundantly present in the secretory material in the lumina of the sebaceous glands and in the cytoplasm of the apical cells. Lipids were not detected in the sudoriferous glands. Neutral fats were seen in moderate quantities in the luminall secretion and in the more apical cells of the sebaceous acini. By contrast, the basal cells of the sebaceous acini contained only negligible amount of neutral fats. Neutral fats were not detected in the sudoriferous cells and in the secretory material in the lumina of the sudoriferous glands.

4. DISCUSSION

The members of the families *Emballonuridae* and *Molossidae* possess specialised neck (gular) glands (*cf.* Schaffer, 1940). The gular gland of *T. longimanus* resembles that of *Molossus rufus nigricans* (Horst, 1966) and *Phyllostomus discolor* (Valdivieso & Tamsitt, 1965) in being present only in the male.

The most striking feature of the gular gland of *T. longimanus* is the segregation of sebaceous and sudoriferous units into distinct lobes. Such topographical separation of the sebaceous and sudoriferous elements is rarely encountered in the cutaneous glands of mammals. In *Phyllostoma discolor* (Valdivieso & Tamsitt, 1965) and *Tadarida brasiliensis* (Gutierrez & Aoki, 1973; Dapson *et al.*, 1977) the gular gland is composed exclusively of sebaceous cells. This is also true of the cutaneous glands in most mammalian species (*cf.* Schaffer, 1940). However, in certain bat species the sudoriferous glands form a major component of the cutaneous glands (Stark, 1958). In *Molossus bondae,* the gular gland has conspicuous apocrine tubules above the sebaceous cells (Dapson *et al.*, 1977). The chin gland of the Australian wild rabbit (Lyne *et al.*, 1964) and the cutaneous glands of some species of *Macropodidae* (Mykytowycz & Nay, 1964) are composed exclusively of sudoriferous gland cells. The inguinal gland of the rabbit (Mykytowycz, 1966) resembles the gular gland of *T. longimanus* in being composed of two easily distinguishable glands, a superficial white-coloured sebaceous gland and an adjacent deeper seated brownish sudoriferous gland. The metatarsal gland of the black-tailed deer consists of extremely well developed sudoriferous glands and moderately developed sebaceous glands (Quay & Müller-Schwarze, 1970).

The structure and holocrine secretory activity of the sebaceous cells in the gular gland of *T. longimanus* are comparable to those reported in the sebaceous glands on the skin in other mammals (*cf.* Strauss & Ebling, 1970). The sebaceous acini in the gular gland of *T. longimanus* develop by the characteristic centripetal enlargement of cells. Those in the centre are much enlarged, irregular in shape and loaded with secretion and manifest varying stages of disintegration releasing the secretion into the lumen; those at the periphery are undifferentiated and contain minimal amount of secretion.

Histochemical studies indicate that lipoidal substances which originate in the sebaceous lobes, and proteins which originate mainly in the sudoriferous lobes, form the bulk of the gular gland secretion of *T. longimanus.* Polysaccharides which originate mainly in the sudoriferous glands form only a minor fraction of the gular gland secretion. In the gular gland of *Molossus rufus nigricans* also proteinaceous acrine and lipoid holocrine

materials form the major constituents in the secretion (Horst, 1966). Although Dapson *et al.* (1977) did not detect carbohydrates, proteins or phospholipids in the sebaceous secretions in the gular glands of *Tadarida brasiliensis* and *Molossus bondae*, Horst (1966) found PAS-positive material in similar secretions of *Molossus rufus*. The products of sebaceous and sudoriferous units in the gular gland of *T. longimanus* are discharged into the vestibule where they accumulate to form the secretion which is a melange of lipids, proteins, cellular detritus, flakes of keratinized cells and micro-organisms. The vestibule is enclosed by a fold of skin leaving behind only a slit-like opening which probably regulates the release of the secretion. When needed, copious quantities of the secretion may be voided by pressure exerted on the vestibule. The erection of the hairs around the vestibular opening may enable the quick diffusion of the odorous materials present in the secretion.

It is possible that the microbial breakdown of proteins, carbohydrates and lipids secreted by the gular gland may yield volatile fatty acids. Microbial involvement in scent production has been suggested in noctilonid bats (Studier & Lavoie, 1984), red fox (Albone *et al.*, 1974) and humans (Shelly, 1956). Sexual, protective, warning and identification functions have been attributed to the cutaneous gland secretions of bats (Dobson, 1873; Valdivieso & Tamsitt, 1965; Horst 1966). In certain bat species the skin glands show seasonal variations in secretory activity (Horst, 1966; Gutierrez & Aoki, 1973) which are related to the secondary sex characters or the sexual activity (Monticelli, 1894). Since the gular gland of *T. longimanus* is present only in the male and since it shows increased secretory activity during the breeding season, it is likely that its secretion plays some role in reproductive activities. It should be noted that sex dimorphic skin glands in several mammalian species exhibit hyperactivity during the breeding season and are regulated by gonadal hormones, and their secretions play an important role in olfactory communication (*cf.* Strauss & Ebling, 1970).

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GRUCZOŁ SZYJNY U NIETOPERZA *TAPHOZOUS LONGIMANUS*

Streszczenie

Opisano morfologię i histologię gruczołu szyjnego u nietoperza, *Taphozous longimanus* Hardwicke, 1823. Gruczoł ten występuje jedynie u samców, ma spłaszczony, gruszkowaty kształt, leży pod skórą szyi na brzusznej stronie ciała (Ryc. 1). Najbardziej uderzającą cechą tego gruczołu jest oddzielne występowanie płatów łojowych i potowych. Cały gruczoł zbudowany jest z siedmiu płatów (Ryc. 2—12). Każdy płat łojowy tworzony jest z dużej liczby gron, których komórki wykazują typową aktywność holokrynową, podczas gdy komórki płatów potowych przejawiają aktywność apokrynową. W sezonie rozrodczym komórki gruczołu ulegają przerostowi, a ich wydzielina przedostaje się do przedsionka gruczołu. Fakt ten sugeruje, że opisywany gruczoł odgrywa pewną rolę w aktywności rozrodczej *Taphozous longimanus*.

EXPLANATION OF PLATES I—II

Plate I

Fig. 3. Horizontal section of the gular gland passing through the caudo-median sudoriferous lobe (Su_1) and the inner sebaceous lobes (Sb_1). ×31.

Fig. 4. Transverse section of the gular gland showing the caudo-median sudoriferous lobe (Su_1) and the inner sebaceous lobes (Sb_1). ×29.

Fig. 5. Frontal section of the gular gland showing the cephalo-lateral sudoriferous lobe (Su_2) and the outer sebaceous lobe (Sb_2). ×31.

Fig. 6. Frontal section of the gular gland passing through the vestibule. Note the openings (arrows) of the inner sebaceous lobes (Sb_1) into the vestibule (V) and the keratinized inner lining of the vestibule and the hair follicles on the surrounding skin. L=lumen of the inner sebaceous lobe. ×28.

Plate II

Fig. 7. Sebaceous acini of the inner sebaceous lobe. ×296.

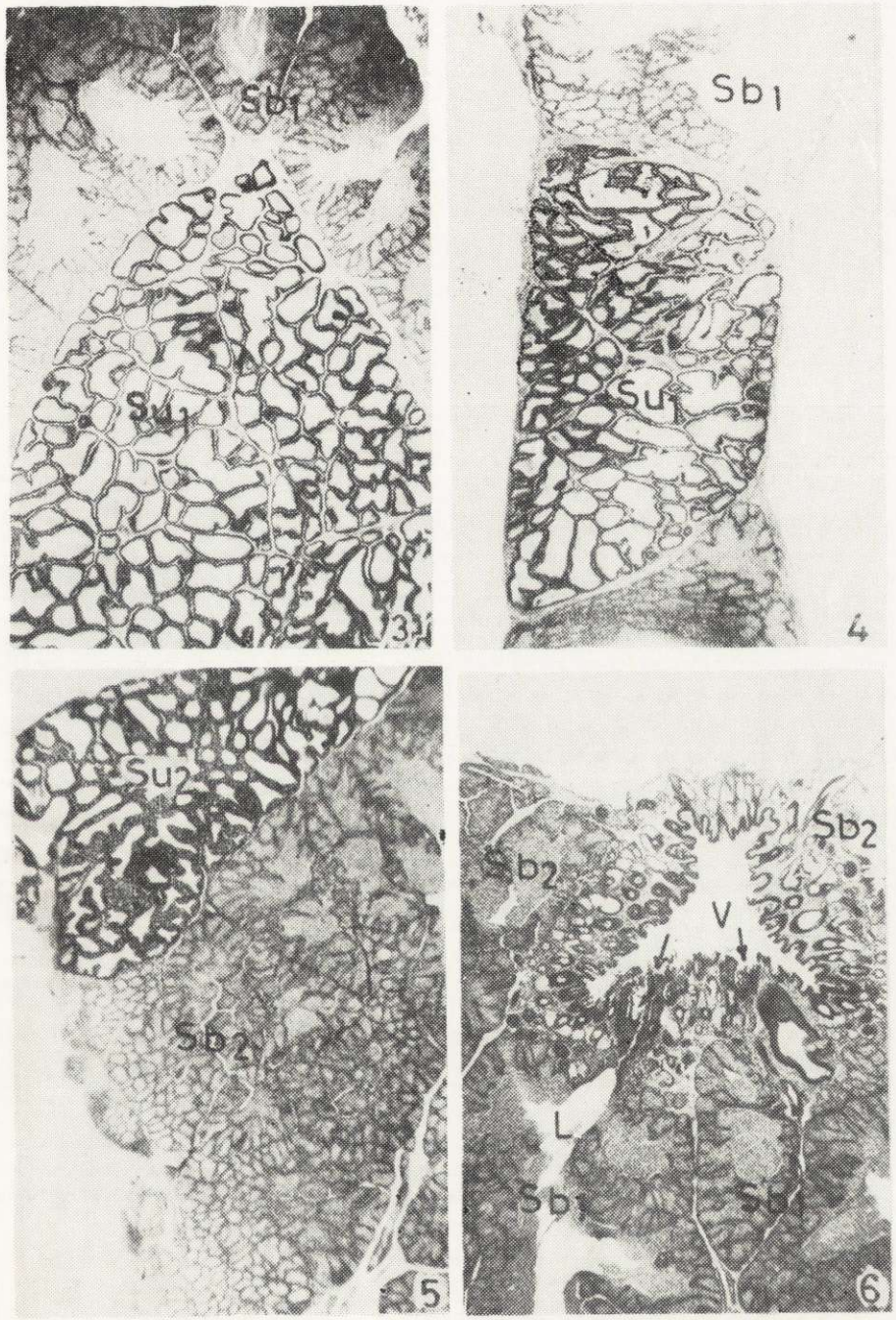
Fig. 8. Portion of the caudo-median sudoriferous lobe showing the structural details of the sudoriferous tubules. Note the darkly stained basally located nuclei in the cells and the secretory material in the lumen (L). ×43.5.

Fig. 9. Portion of the inner sebaceous lobe of the gular gland of a male in the breeding condition. Note the hypertrophy of the sebaceous acinar cells. ×43.5.

Fig. 10. Portion of Fig. 9 enlarged to show the hyperactive sebaceous acini. ×209.

Fig. 11. Luminal portion of the inner sebaceous lobe of the gular gland of a male in the breeding condition. Note the hyperactive sebaceous cells and the holocrine secretory activity. L=lumen. ×209.

Fig. 12. Portion of the caudo-median sudoriferous lobe of the gular gland of a male in the breeding condition. Note the abundance of secretory material in the lumen (L). ×209.



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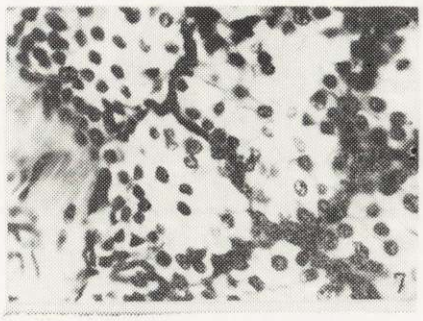

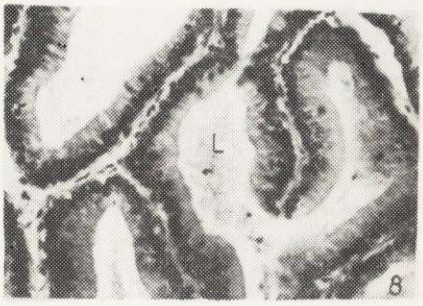

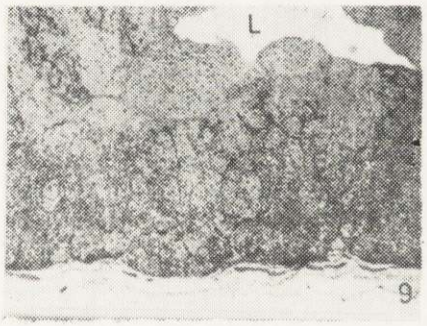

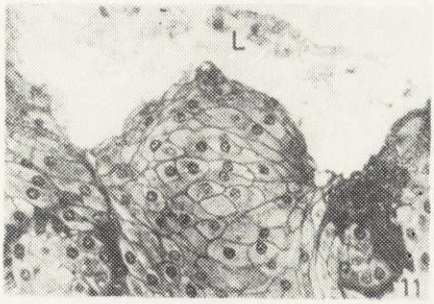

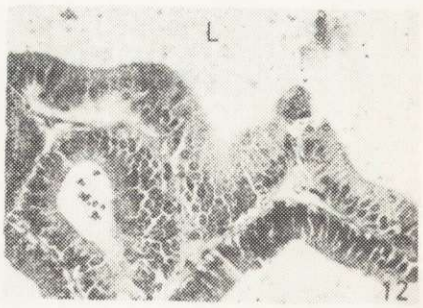

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