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GROSS AND HISTOLOGICAL STUDY ON THE MINOR SALIVARY GLANDS OF CAMEL (*Camelus dromedarius*)

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ABSTRACT

Histological and histochemical investigations were carried out on the minor salivary glands of 7 adult male one–humped camels (*Camelus dromedarius*). All minor salivary glands of the camel (except the von Ebner's glands), were tubuloalveolar and mixed (predominantly mucous). The von Ebner's glands of the camel were acinar and purely serous. The labial, buccal and palatine salivary glands were compound. In the inferior portion of the cheeks, in addition to mixed glands there were also purely serous glands. The von Ebner's glands and lingual salivary glands were present at the root of the tongue. The palatine salivary glands were located in the caudal part of the hard palate and in the entire length of the soft palate. The palatine gland was most numerous at the apex of the soft palate. There was lymphatic tissue (like a tonsil) in the soft palate.

The results of histochemical studies were shown that the minor salivary glands of the camel were rich in both neutral and acidic mucopolysaccharides. The finding of the present study was compared with those reported for human and other vertebrates.

Key words: Camel, histochemistry, histology, minor salivary glands

Salivary glands are one of the most important exocrine glands that secrete saliva. The major salivary glands are the parotid, mandibular, and sublingual. The minor salivary glands are named according to their location, e.g., labial, lingual, buccal, palatine, molar (cats), and zygomatic (carnivores) (Eurell and Frappier, 2006). Although the saliva secretion from the minor salivary glands is small in quantity compared with the whole saliva secretion, the broader distributions of the minor salivary glands are advantageous for the protection of the oral cavity against pathogens (Sumi *et al,* 2007). The minor salivary glands are of great importance in the physiology and pathology of the oral cavity (Sonesson *et al,* 2003).

Much literature is available on the histological structure of the major salivary glands of one-humped camel (Nabipour *et al,* 2003), but the minor salivary glands have received little attention, especially from the histochemical point of view.

The purpose of the present study is to provide more information about the histological and histochemical features of the minor salivary glands in the one-humped camel.

Materials and Methods

The histological structure and histochemical features of the minor salivary glands including labial, buccal, lingual and palatine were studied by using routine histological techniques in 7 adult male slaughtered one-humped camels (*Camelus dromedarius*) from the industrial slaughter house of Mashhad.

Samples were taken from right and left sides and middle part of both upper and lower lips, dorsal, middle and ventral parts of the cheeks, apex, body and root of the tongue, cranial, middle and caudal parts of the hard palate and cranial and caudal parts of the soft palate. The samples were flushed with normal saline and were fixed in 10% buffered formalin for 71 hours. Tissue samples were then dehydrated and cleared by a series of graded alcohols, xylene and eventually embedded in paraffin. Sections at 5 µm thickness were stained with methods of Haematoxylin & Eosin, green Masson's Trichrome for collagen and muscle fibres, and Alcian Blue-Van Geisson and Periodic Acid Schiff (PAS) for the histochemistry of the muco-substances. Sections were examined under light microscope (Olympus CX21).

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Microphotographs were taken with an Olympus BX51 microscope.

Results

Lips

The lips of the camel were covered on the outside by skin and on the inside by a mucosa. The mucosa was nonkeratinised stratified squamous epithelium. Clusters of the labial salivary glands were embedded between the deep part of the lamina propria and the striated muscle fibres. The labial glands were of a compound branched tubuloalveolar type comprising seromucous (mainly mucous) acini (Fig 1). The amount of glands increased from the middle to the right and left parts of the lips.

In the camel, the skin contained many hair follicles and sebaceous glands but it was devoided of sweat glands (Fig 2). Anatomically, the upper lip of the camel was divided by a distinct median cleft, philtrum. Both planum nasale and planum nasolabiale were absent in camel (Fig 3).

Cheeks

The cheek of the camel was composed of an external covering of skin, a middle muscular layer (the buccinators muscle), and an internal mucosa lined by stratified squamous epithelium. The mucosa bearing large pointed conical papillae which were directed towards the pharynx and were covered with cornified epithelium (Fig 4). The skin of the cheek of the camel was devoid of sweat glands.

The buccal salivary glands of camel were compound tubuloalveolar seromucous and located in the propria submucosa (Fig 5). In the lower part of the cheek in addition to seromucous glands, there were purely serous glands (Fig 6).

Tongue

The torus linguae and transverse lingual fossa were less pronounced in the tongue of camel (Fig 7). The von Ebner's (gustatory) glands associated with the vallate papillae of the camel. They were entirely serous and their ducts were opened into the sulcus at the base of the papillae. The foliate papillae were absent in the camel. The lingual salivary glands were located in the propria submucosa and between the intrinsic muscle bundles of the tongue. They were predominantly mucous secreting glands.

Palates

The mucosa of the hard palate of the camel was covered by a keratinised stratified squamous epithelium. The propria submucosa of the middle part was composed a dense network of capillaries and veins (Fig 8). The palatine glands of the camel were located in the caudal part of the hard palate. They were consisted of branched mucous and seromucous tubuloalveolar glands (Fig 9). Also, the dental pad was present in the camel.

The soft palate of the camel consisted of a core of skeletal muscle fibres with a mucosa covering both surfaces. It was covered ventrally by a nonkeratinised stratified squamous epithelium along the oropharyngeal surface. As in the hard palate, branched tubuloalveolar mucous and seromucous palatine glands were located within the propria submucosa. The glands were increased towards the apex of the soft palate. Lymphatic tissue was occurred in the propria submucosa of the soft palate of the camel. This tissue was similar to a tonsil and was more aggregated in the middle part and apex of the soft palate. The tonsilar crypt was distinct. The epithelium was infiltrated with lymphocytes. The lymphatic nodules also possessed a germinal centre (Fig 10).

The duct system of the minor salivary glands of the camel was lined with simple cuboidal or simple columnar epithelium within the lobules and stratified cuboidal epithelium in the interlobular ducts (Figs 1, 11). The stratification of the duct epithelium increased as it reached the oral cavity, where it changed to a stratified squamous type. The intercalated duct was not existent in the minor salivary glands of the camel.

In all minor salivary glands of the camel, when treated with PAS and Alcian blue stains the mucous secretory units showed an intensely positive reaction (Figs 12, 13). By contrast, the serous units showed a poor positive reaction with PAS and Alcian blue (Figs 6, 14).

Discussion

The epithelium of the lips is keratinised in ruminants and horses but it's nonkeratinised in carnivores and pigs (Eurell and Frappier, 2006).

The finding regarding the labial glands of camel agrees with that of reported by Taib and Jarrar (1987). The parotid, mandibular and sublingual salivary glands of the one-humped camel are compound tubuloalveolar (purely serous), compound tubuloacinar (predominantly serous) and compound acinar (predominantly mucous), respectively (Nabipour *et al,* 2003). The labial gland of one-humped camel showed a considerable activity of

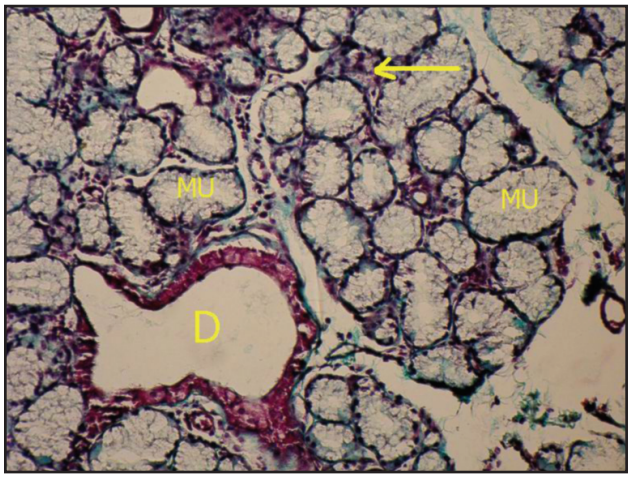

Fig 1. The labial glands of the camel. Mucous secretory units (MU), serous cells (arrow), duct (D), green Masson's trichrome X320.

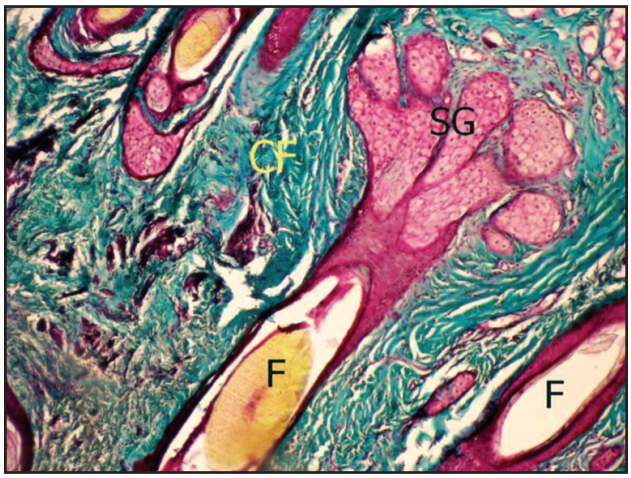

Fig 2. The hypodermis of the skin of the camel. Sebaceous glands (SG), collagen fibres (CF), hair follicle (F), green Masson's trichrome X160.

alkaline phosphatase, acid phosphatase, non-specific esterase, carbonic anhydrase and amylase. The strong reactivity of the phosphatases detected in the glands is agreement with the buffered composition of the camel's saliva which is an essential medium for food fermentation in the forestomach of the camel. Such reactivity of the phosphatases in the labial salivary glands of the camel might be an indication of the involvement of these enzymes in the release of secretory products by the glandular cells (Taib and Jarrar, 1987). Amylase was also detected from the parotid and mandibular glands of the camel (Osman and Uro, 1982). The labial glands are branched, tubuloalveolar types that are mucous in small ruminants and carnivores but mixed in other species. They are serous glands in the bovine planum nasale (Banks, 1986). The labial glands are most numerous

Fig 3. Showing the upper lip (UL), philtrum, nostril (NO) and conical papillae (CP) of the camel.

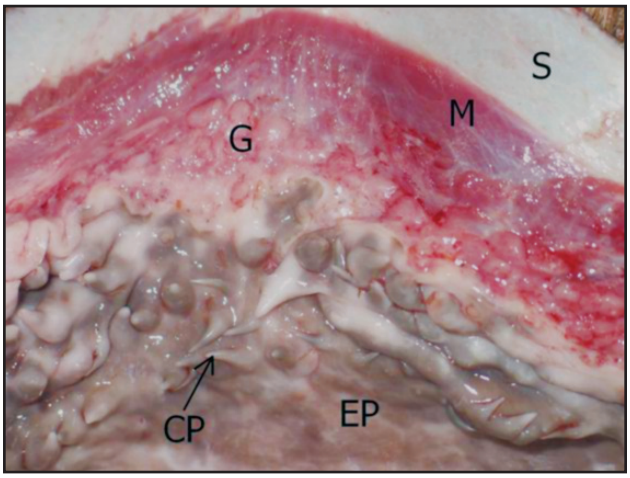

Fig 4. Showing the cheek of the camel. Skin (S), buccinator muscle (M), buccal glands (G), epithelium (EP), conical papillae (CP).

in the horse, and decrease in the following sequence: horse, ox, goat, sheep, pig, dog, cat (Nickel *et al,* 1979). In human, the gland areas in the lower lips are greater than those in the upper lips. The labial gland areas are smaller in the patients with Sjögren syndrome which is a chronic autoimmune disease affecting salivary and lacrimal glands (Sumi *et al,* 2007).

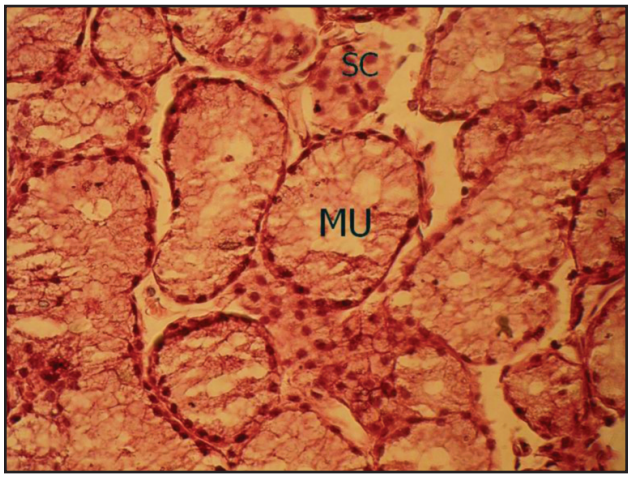

Fig 5. The buccal glands of the camel. Mucous secretory units (MU), serous cells (SC), Hematoxylin & Eosin X640.

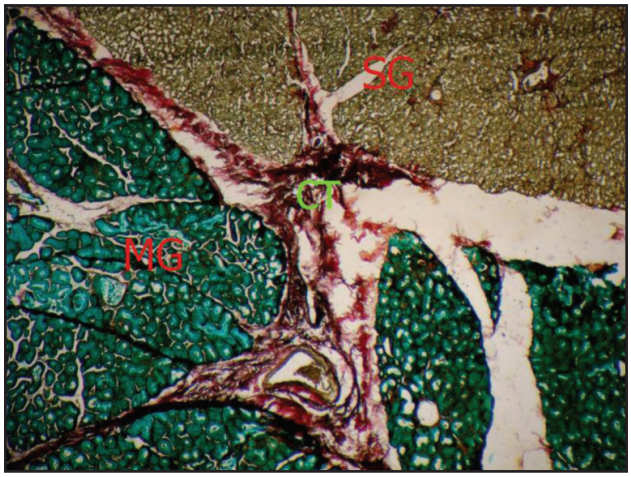

Fig 6. The mixed (MG) and purely serous (SG) buccal glands of the camel. Connective tissue (CT), Alcian blue-van Geisson X64.

Deep philtrum of camel is similar to that of carnivores and small ruminants. Philtrum is shallow or absent in the other species. In ox, a linear arrangement of the grooves on the midline of the upper lips gives a superficial indication of a philtrum. In horse, the upper lip has a shallow philtrum (Getty, 1975a). In the ox and pig, the middle of the upper lip and the surface between the nostrils is bare and is termed the planum nasolabiale. It is smooth and (in health) is kept cool and moist by a clear fluid secreted by the nasolabial glands. In sheep and goat, the bare planum nasale is restricted to the area between the nostrils (Getty, 1975a and Nickel *et al,* 1979).

The anatomical features of the cheek of the camel are similar to that of other ruminants (Getty, 1975a; Eurell and Frappier, 2006). The conical papillae facilitate the prehension and mastication of food (Eurell and Frappier, 2006).

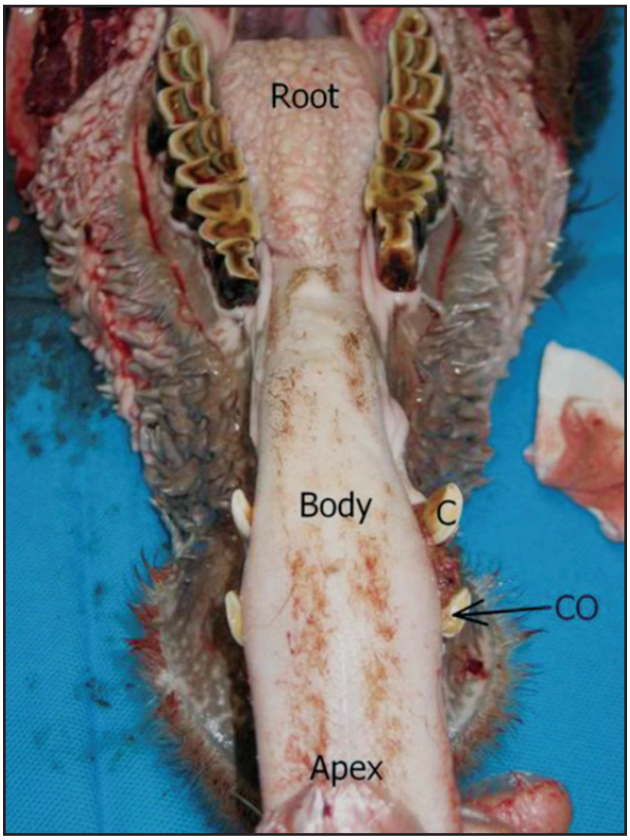

Fig 7. Showing the tongue (root, body and apex), corner (CO) and canine (C) teeth of the camel.

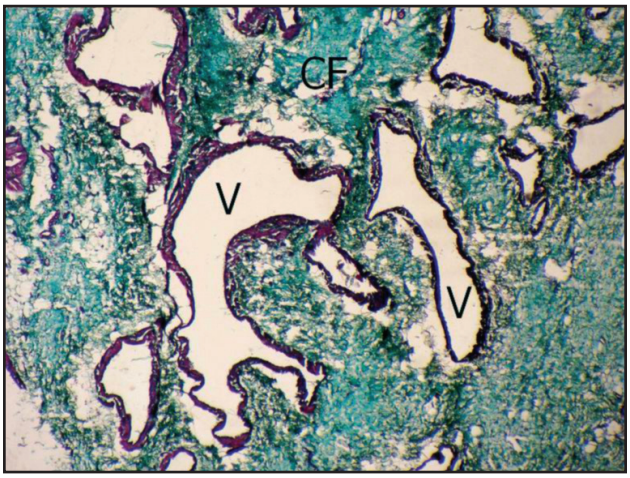

Fig 8. The propria submucosa of the middle part of the hard palate of the camel. Veins (V), collagen fibres (CF), green Masson's trichrome, X64.

The histological structure of the buccal salivary glands of the camel is similar to that of the buccal salivary gland of Arabian camel (Taib and Jarrar, 1989). The histoenzymological tests employed have detected alkaline phosphatase, adenosine triphosphatase, succinic dehydrogenase, non-specific esterases and α-amylase in the buccal salivary gland of Arabian camel but no activities for aminopeptidase,

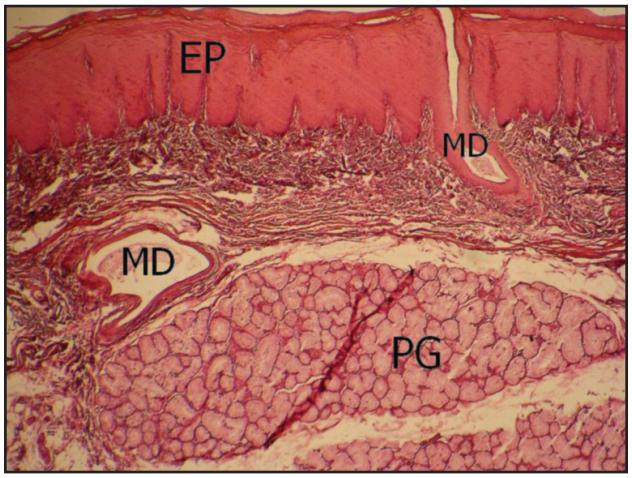

Fig 9. The caudal part of the hard palate of the camel. Epithelium (EP), palatine glands (PG), main excretory duct (MD). Haematoxylin & Eosin X64.

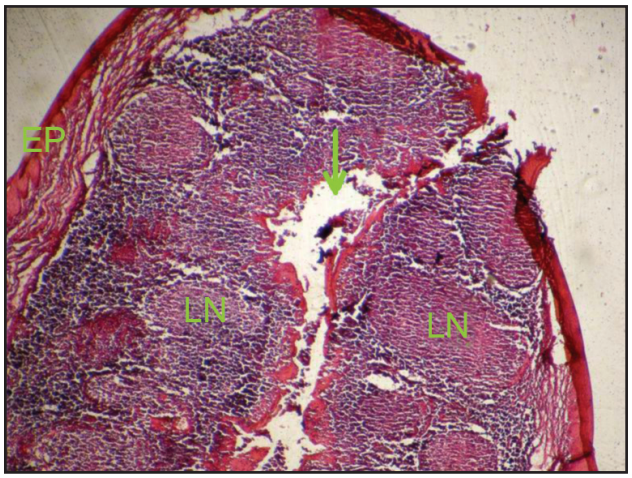

Fig 10. The tonsil located at the apex of the soft palate of the camel. Epithelium (EP), lymphatic nodules (LN), tonsilar crypt (arrow). Haematoxylin & Eosin X64.

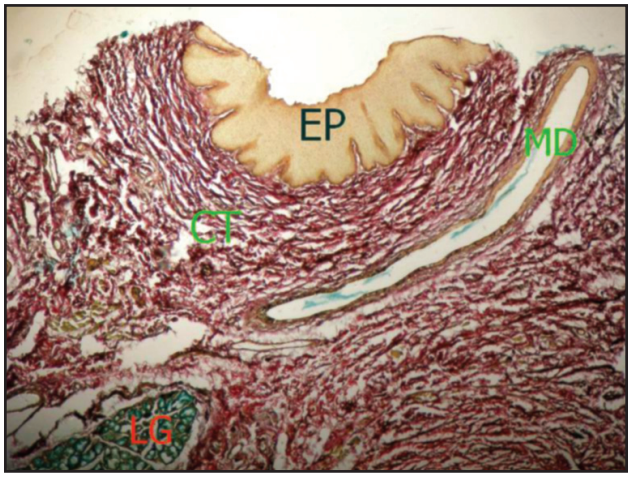

Fig 11. Showing epithelium (EP), connective tissue (CT), a part of lingual glands (LG), main excretory duct (MD) of the camel. Alcian blue-Van Geisson X64.

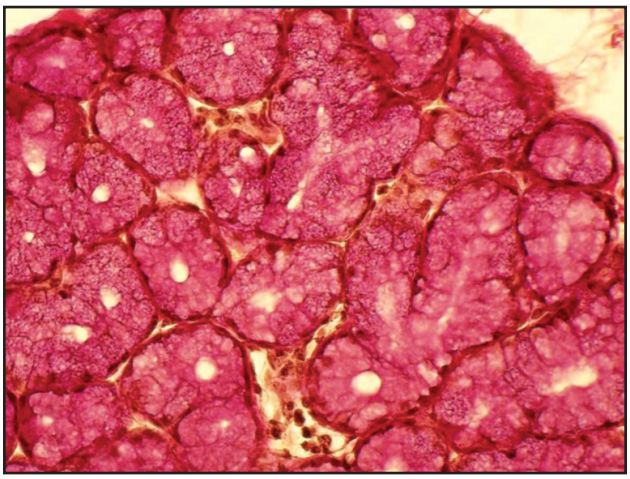

Fig 12. High intensity positive reaction of the labial glands secretions in camel. PAS X640.

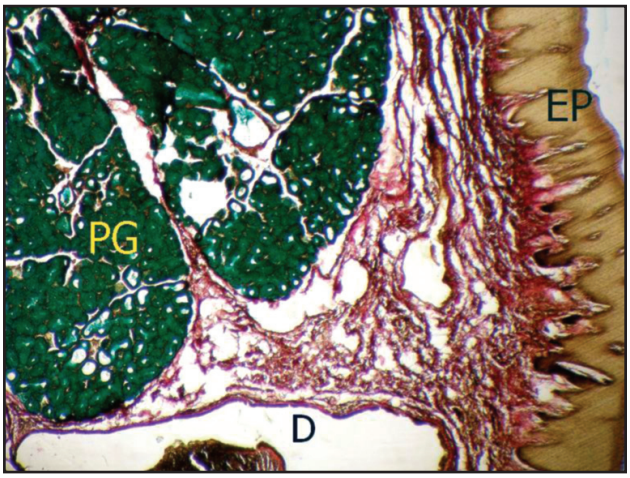

Fig 13. High intensity positive reaction of the soft palate glands secretions in camel. Palatine glands (PG), epithelium (EP), duct (D). Alcian blue-van Geisson X160.

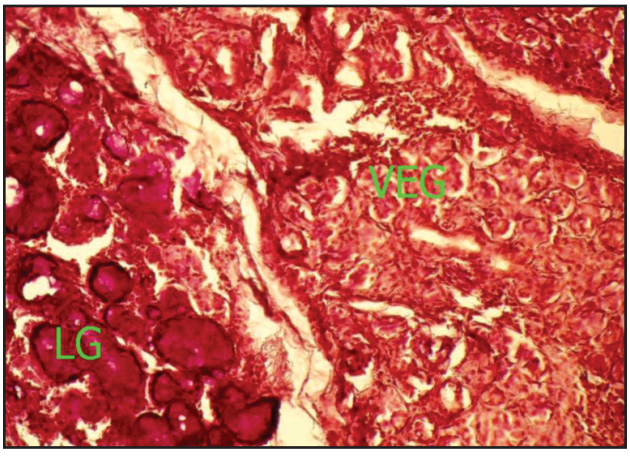

Fig 14. Showing the lingual glands (LG) and von Ebner's glands (VEG) of the camel. PAS X320. Note the high intensity positive reaction of lingual glands secretions and poor intensity positive reaction of the von Ebner's glands secretions.

lipase, cholinesterases and β-glucuronidase (Taib and Jarrar, 1989).

The buccal salivary glands are compound tubuloacinar glands in domestic animals and may be serous, mucous, or seromucous, depending on the location and the species (Eurell and Frappier, 2006). In ruminants, the buccal glands are well developed and are arranged in three groups. The dorsal buccal glands are yellow and covered by the superficial layer of the buccinator muscle, and by the masseter. The ventral buccal gland forms a compact brownish mass which reaches from the angle of the mouth caudal to a point a short distance under the masseter muscle. The middle buccal glands are loosely arranged yellow lobules in the buccinator muscle and deep to it. In horse, the buccal glands are arranged in two rows. The dorsal buccal glands lie on the outer surface of the buccinator muscle, near its upper border. The ventral buccal glands, less voluminous than the dorsal, are situated in the submucous tissue at the lower border of the buccinator muscle (Getty, 1975a).

In carnivores, the zygomatic gland may be regarded as the homologue of the dorsal buccal glands of the other animals. The ventral buccal glands are opposite the cheek teeth and in series with the ventral labial glands (Getty, 1975b). The parenchyma of the zygomatic salivary gland is composed of long, branched tubuloacinar secretory units that are predominantly mucous-secreting (Eurell and Frappier, 2006).

In ruminants, the caudal part of the body of the tongue forms an elliptical dorsal prominence, the torus linguae, defined rostrally by the transverse lingual fossa. In horse, the dorsal surface of the tongue is free throughout (Getty, 1975a). In horses, a cord of hyaline cartilage and fibroelastic tissue, the dorsal lingual cartilage, lies mid-dorsally within skeletal muscle and provides additional support to the tongue (Samuelson, 2006). In the dog, the dorsum of the tongue is divided by a median groove into two equal halves; the apex contains the characteristic lyssa, a median filiform structure embedded in the musculature along the ventral surface of the apex (Nickel *et al,* 1979).

The von Ebner's glands secrete digestive enzymes and proteins with possible taste perception function (Hand *et al,* 1999). The von Ebner's glands of sheep are tubuloalveolar type. They show moderate intensity of PAS reaction with no effect after diastase digestion. It has intense and weak reaction for sulphated and acid mucopolysaccharides respectively. Whereas in goat, the von Ebner's glands are mucous type and have strong PAS reaction. Sulphated acid mucopolysaccharides are negative (Biradar and Ramkrishna, 2000). The bovine von Ebner's glands secrete glycoproteins with 1, 2-glycol containing hexoses and carboxyl-rich glycoconjugates and that galactosyl (beta-->3) Nacetylgalactosamine is the most frequent sugar residue present in these glycoproteins (Pedini *et al,* 1997).

The foliate papillae are absent in other ruminants (Eurell and Frappier, 2006). In domestic animals, the leaflike type foliate papillae are arranged in parallel folds located posterolaterally along the dorsoventral margin of the tongue. Taste buds are located in the epithelium on the sides of the folds (Samuelson, 2006; Eurell and Frappier, 2006). In cats taste buds partially develop within foliate papillae, but are rudimentary and without sensory function (Samuelson, 2006).

The location and histological structure of the lingual salivary glands of camel is similar to that of other domestic animals (Eurell and Frappier, 2006). The human anterior lingual salivary glands are composed predominantly of mucous tubules (which come in two distinct sizes: large and small), seromucous demilunes, and rare seromucous acini (Tandler *et al,* 1994). The lingual glands are seromucous in sheep and goat (Biradar and Ramkrishna, 2000). The lingual salivary glands of the little Egret are composed of two posterior entities at the base of the tongue and one anterior entity on the dorsal surface of the free lingual part. These glands are made of mucoserous cells that elaborate sialomucins, sulfomucins and proteins, but they are devoid of glycogen and neutral mucosubstances (Almansour and Jarrar, 2007). The Weber's glands in the rat (a collection of salivary glands in the root of the tongue) are mixed glands, consisting of long mucous tubules that often are capped by serous demilunes. The mucus elaborated by Weber's glands undoubtedly aids in swallowing dry food. The serous cells in these glands, as in the more anterior Von Ebner's glands, might play a role in the mechanism of taste (Nagato *et al,* 1997).

The mucosa of the hard palate is especially developed in ruminant species (Samuelson, 2006). Presence a dense network of capillaries and veins in the middle part of the hard palate of the camel is similar to that of other domestic animals, except it especially well developed in horses (Eurell and Frappier, 2006). The location of the palatine glands of the hard palate of the camel is similar to other domestic mammals. The palatine salivary glands of

domestic animals consisting of branched mucous and seromucous glands (Samuelson, 2006).

The rostral part of the mucosa of the hard palate is especially thick in ruminants and forms the dental pad. It consists of a heavily keratinised stratified squamous epithelium overlying a thick layer of dense irregular connective tissue (Eurell and Frappier, 2006).

The palatine glands of other domestic animals are branched tubuloacinar serous or seromucous (Eurell and Frappier, 2006). The salivary glands of the human soft palate are interwoven and bound firmly together by a connective tissue stroma rich in elastic fibres. The secretory units consist of elangated, branched, and sometimes convoluted tubules lined by a single layer of pyramidal mucous cells (Black, 1977).

In pigs and horses, a macroscopically visible tonsil is present on the oropharyngeal surface (Eurell and Frappier, 2006).

The duct system of the minor salivary glands of other domestic animals is lined with simple cuboidal epithelium within the lobules and two-layered cuboidal epithelium in the larger interlobular ducts (Eurell and Frappier, 2006). The duct system of the mandibular salivary gland of the camel is shown to contain goblet cells (Nabipour *et al*, 2003). The intercalated duct is not prominent in the sublingual salivary gland of camel (Nabipour *et al*, 2003). Positive reaction of mucous secretory units with PAS and Alcian blue stains indicating that the secretions are contained much acidic and neutral muco-substance. Whereas, poor positive reaction of serous units with PAS and Alcian blue indicating the amount of acidic and neutral muco-substances is less in the secretions of serous units.

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