**Sudan University of Science and Technology**

**College of Graduate Studies**

# Comparative Morphological, Histometric and Histochemical studies of Parotid and Mandibular Salivary Glands of Camel, Ox, Sheep and Goat

دراسات مـ قارنة مورفلوجية, نسيجية قياسية وكيميائية نسيجية عن الغدة اللعابية النكفية والفكية في الابل, الثيران, الضان و الماعز

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***DEDICATION***

***To the soul of my father Juma, mother Awatif, husband Talib, sons Hazim, Amin and Rashd, daughter Maria, Brothers and Sisters, whose love, care and encouragement had helped me to accomplish this work.***

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## Abstract

This study was performed on 100 heads of adult healthy camels, ox, sheep and goats (25 heads for each animal). Gross anatomical, histological, histometric, histochemical and ultrastructural studies were carried out on the parotid and mandibular salivary glands of the animals mentioned above. The samples were obtained from Alssalam slaughter house in Omdurman, Sudan during the period (April 2013-April 2014). The aim of this investigation was to compare the morphology and histochemistry of the parotid and mandibular salivary glands in camels, oxen, sheep and goats. The anatomical studies demonstrated that the parotid gland was partially covered by parotidoauricularis muscle in camel, completely covered in ox but only superficial in sheep and goat. It was irregularly rectanglular in camel and ox, irregularly-shaped in sheep and triangular in goat. There was a variation in the weight, length, width and thickness of the gland among these animals. The parotid duct left the gland from the medial surface and crossed the lateral surface of the masseter muscle to open at a mucosal papilla opposite to the second molar tooth in camel, sheep and goat and opposite to the fifth upper tooth in the ox. The mandibular gland was irregularly rectangular in camel, elongated in ox and irregularly-shaped in sheep and goat. The mandibular duct passed between the digastricus and ventral to the pterygoideus muscle, along the lower jaw between the mylohyoideus and geniohyoideus muscles to the external surface of the styloglosuss muscle in camel and ox. In sheep and goat the duct passed between the omohyoideus, mylohyoideus and geniohyoideus muscles beside the styloglosuss muscle. It opened in the oral cavity at a mucosal fold in camel and at the sublingual caruncle in the ox, sheep and goat.

The histological findings showed that both the parotid and mandibular glands were compoundtubulo-acinar in camel, ox and sheep and were compoundtubulo-alveolar in goat. The secretory units of parotid gland were mixed; serous and mucus in camel and purely serous in ox, sheep and goat. The mandibular

gland was seromucous in all animals used. In addition; the demilunes which capped the mucous acini were serous in camel, ox, sheep and goat. The parenchyma of the parotid and mandibular glands had three types of acini of different morpholoigal and histometric features. The duct system of parotid and mandibular glands consisted of intercalated, striated, intralobular and interlobar ducts which varied in shape and location. Myoepithelial cells were located in the angles between two cells of acini and between cells of the intercalated duct of parotid and mandibular glands.

The histometric measurements revealed three types of acini and four types of ducts. A significant difference ($P^{<}0.05$) was recorded between small, intermediate and large acini and intercalated, striated, interlobular and interlobar ducts in camel, ox, sheep and goat.

The ultrstrucural studies of parotid and mandibular glands demonstrated the presence of numerous mitochondria, secretory granules and rough endoplasmic reticulum in the cytoplasm in camel, ox, sheep and goat. In both parotid and mandibular glands the mitochondria were well developped in the gland of ox, camel, goat and sheep. The gland of sheep was characterized by abundant secretory granules. The nucleus in both parotid and mandibular glands had clear chromatin granules and the nuclear membrane was more folded in ox, goat, sheep and camel.

The histochemical observation showed a difference in the degree of PAS-positive reaction in the acini of the parotid and mandibular glands of camel, ox, sheep and goat. AB reaction used AB/PAS sequence reactions were negative in parotid gland and were positive in the mandibular gland of camel, ox, sheep and goat.

المستخلص

أجريت الدراسات التشريحية العيانية, النسيجية، النسيجية ال قياسية، البنيوية الفائ قة والنسيجية الكيميائية بالغدتين النكفية والفكية على 100 راس من الجمال، الثيران، الضان والماعز البالغة والسليمة صحيا بمعدل (25 راس لكل حيوان).

جمعت العينات من سلخانة السلام بام درمان, السودان في الفترة ما بين ابريل 2013 الي ابريل 2014. هدفت هذه الدراسة الى م قارنة التركيب التشريحي العياني, النسيجي, النسيجي ال قياسي, التركيب البنيوي الفائق والنسيجي الكيميائي لكل من الغدتين النكفية والفكية في الجمال، الثيران، الضان والماعز.

اظهرت الدراسة التشريحية العيانية اختلافا فى علا قة العضلة النكفية الصيوانية بالغدة النكفية؛ فهي مغطاة جزئياً في الجمال ، كلياً في الثيران ولكن سطحياً ف قط في الضان والماعز. الغدة مستطيلة ومنتظمة الشكل في الجمال والثيران وغير منتظمة الشكل في الضان ومثلثة في الماعز. حجم وطول وعرض وسمك الغدة كان مختلفا بين تلك الحيوانات المستخدمة. تمر قناة الغدة النكفية على السطح الوحشي للعضلة الماضغة ثم تفتح في التجويف الفموي عند الطية المخاطية الم قابلة للضرس الثاني في الابل والضان والماعز وللضرس الخامس في الثور . وتختلف طول و قطر ال قناة من حيوان لآخر . الغدة الفكية مستطيلة غير منتظمة الشكل في الجمال ومتطاولة في الثور وغير منتظمة الشكل في الضان والماعز. تمر قناة الغدة الفكية بين العضلة ذات البطنين وبطنيا للعضلة الجناحية وبطول الفك السفلي وبين العضلة الرحوية اللامية و العضلة الذ قنية اللامية للسطح الخارجي العضلة الابرية اللسانية في الجمال والثيران . في الضان والماعز تمر بين الكتفية اللامية, و الرحوية اللامية و الذ قنية اللامية بجانب العضلة الابرية اللسانية. تفتح ال قناة في التجويف الفموي عند طية مخاطية في الجمل وعند اللحيمية تحت اللسانية في الثيران والضان والماعز.

اوضحت الدراسة النسيجية ان الغدتين النكفية والفكية هما من النوع المركب النبيبي السنخي في الجمل والثور والضان اما في الماعز فهي من النوع المركب النبيبي الحويصلي. تتكون الغدة النكفية من وحدات مفرزة مصلية ومخاطية في الجمل ووحدات مفرزة مصلية ف قط في الثور والماعز والاغنام. تتكون الغدة الفكية من الوحدات المخاطية- المصلية في كل الحيوانات المستخدمة, اضافة الخلايا شبه الـ قمرية التي تغطي السنخ المخاطي تكون مصلية في الجمل, الثور, الضان و الماعز. تتكون متن الغدتين من ثلاثة انواع من الاسناخ مختلفة الملامح التركيبية والـ قياسية. النظام الـ قنوي يتكون من الـ قناة الم قحمة, المخططة, بين الفصيصية و بين الفصوص. توجد خلايا طلائية عضلية بين زوايا الخلايا السنخية و بين خلايا الـ قناة الم قحمة في الغدتين النكفية والفكية.

اظهرت الدراسة النسيجية الـ قياسية ثلاثة انواع من الاسناخ و اربعة انواع من الـ قنوات. سجل اختلاف معنوي($P<0.05$) بين الاسناخ الصغيرة, المتوسطة والكبيرة وايضا الـ قنوات بين الم قحمة, المخططة, بين الفصيصية و بين الفصوص في الجمل ،الثور، الضان والماعز.

اظهرت الدراسة البنيوية الفائ قة بالغدة النكفية والفكية وجود عدد كبير من الم قتدرات والحبيبات الافرازية والشبكة الاندوبلازمية الخشنة في هيولي الجمل والثور والضان والماعز. الم قتدرات متطورة في الثور م قارنة بالجمل, الضان و الماعز علي التوالي. اما في الضان فتتميزبكثرة الحبيبات الافرازية. النواة بالغدة النكفية والفكية لها كروماتين واضح الغشاء النووي اكثر تعرجاً في الثور, الماعز, الضان والجمل علي التوالي .

الدراسة الكيميائية النسيجية اثبتت اختلافا في تفاعل ال PAS في الاسناخ وتتفاوت درجة التفاعل في الغدة النكفية والفكية بين الجمل والثور والضان والماعز. كانت تفاعلات AB في تفاعلات تسلسل AB/PAS سالبة في النكفية وموجبة في الفكية بالجمل, الثور, الضان والماعز.

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## Introduction

Ruminants (cattle, sheep, and goat) and camel are considered as very valuable animals and in Sudan they constitute a major part of the national economy and provide the local market with meat, milk and skin. The oral cavity in ruminant and non-ruminant animals is lined by a mucous membrane and is always moistened by the saliva secreted by the associated major and minor salivary glands (Williams *et al.*, 1989; Saracco and Crabill, 1993; Amano, 2011). The major mammalian salivary glands include the parotid, mandibular, submandibular, sublingual and zygomatic glands while the minor are the buccal, labial, lingual and palatine glands (Poddar and Jacob, 1977; Dellman and Brown 1981).

The salivary glands are envaginations from buccal epithelium into the lamina propria-submucoa (Banks, 1992) which develop at different sites and they have very different architectures and produce different types of saliva (Jaskoll *et al.*, 2002). Their secretion is mostly serous containing various enzymes, water, mucopolysaccarides and glycoprotein (Adnyane *et al.*, 2010).

The relative size of the salivary glands in different species of ruminants is closely associated with their feeding habits and reflects a functional relation-ship between the mass of the glands and the composition of the diet (Kay *et al.*, 1980; Hofmann, 1989).

The salivary glands are known as multifunctional organs that perform many important digestive, protective, excretory and endocrine functions (Miletich, 2010). They collectively produce and secrete saliva, a fluid that assists in the initial activities of digestion (Micheal and Valerie 2006). This secretion has an important role in the moistening and swallowing of newly ingested food and maintenance of oral hygiene. While in ruminants the salivary secretions regulate the digestion in the forestomach (Kay and Maloiy 1989). According to Kay and Maloiy (1989) the dromedary camel salivary glands closely resemble those of typical ruminant (cattle, sheep and goat) both morphologically and physiologically.

**Objectives:**

- To investigate and to compare the gross anatomy and histology of the parotid and mandibular glands in typical ruminants such as (ox, sheep and goat) and camel.
- To give information about the histometric measurements of the acini and ducts of the parotid and mandibular glands in camel, ox, sheep and goat.
- To evaluate the constituents of the lining epithelium of the parotid and mandibular

glands and their secretions via carbohydrate tests.

# CHAPTER ONE

# LITERATURE REVIEW

- **Gross anatomy**

The gross anatomy of the salivary glands was studied in farm animals such as bovines (Shacklefort and Wilborn, 1969), buffalo (Venkata and Mariappa, 1969), sheep (May, 1970), equines (Sisson and Grossman, 1975), goat (Nawar, 1980); camel (Smuts and Beziudenhout, 1987), dogs ( Dyce *et al.*, 2010), domestic cat (MohammadPour, 2010) and pig (Zhou *et al*., 2010).

**1. 1. 1. Parotid gland**

The parotid gland was the largest of the major salivary glands in sheep (Dehghani *et al*., 2000), camel (Al-Samarrae *et al.*, 1989), horse (Dellman and Brown, 1981), dog (Mina *et al.*, 2004) and man (Amano, 2011), but it was smaller in cattle (Al-Sadi, 2013).

Sisson and Grossman (1975) stated that the parotid gland of horse was situated in the space between the ramus of the mandible and the wing of the atlas. Also Dehghani *et al.* (2005) described the parotid gland of horse and reported that the gland was located in the caudal

part of the vertical ramus of the mandible and masseter muscle, ventral to the wing of the atlas and attached to the base of the ear. In the camel, the parotid gland was situated between the vertical ramus of the mandible and the wing of the atlas (Nawar and El-Khaligi, 1975). In another report the gland was claimed to be situated around the ventral part of the auricular cartilage extending rostrally to the masseter muscle, ventrally toward the angle of the jaw and caudally to the atlantic fossa (Al-Samarrae *et al.*, 1989).

The parotid gland of bovine was situated along the caudal border of the masseter muscle extending from the zygomatic arch to the angle of the mandible (Sisson and Grossman, 1975). The gland was also located ventral to the ear along the caudal border of masseter muscle where it partially covering the parotid lymph node (Al-Sadi, 2013). In the sheep and goat the gland was situated mainly caudal to the ramus of the mandible (May, 1970; Tadjalli *et al.*, 2002), and located under the ear (Barnwal and Sinha, 1981). Dehghani *et al.* (2000) and Tadjalli *et al*. (2002) described the gland of sheep and goat, they stated that the parotid gland was in contact dorsally with the base of the ear, and extended ventrally into the neck and inter-mandibular space.

The parotid gland of carnivoroes including the dog, cat and ferret was grossly similar to the parotids in other mammalian species (Poddar and Jacob, 1977). Mina *et al.* (2004) reported that the parotid glands of dog were located ventral to the wing of atlas. Also Dyce *et al*. (2010) described the gland of dog and cat and they reported that the gland was located near the ear between the mandible and the wing of atlas.

The colour of the gland was variable among animals. In the camel it was described as dark grayish red (Van Lennep, 1957), dark brown to dark pink (Nawar and El-Khaligi, 1975). The gland of cattle was light red in colour (Al-Sadi, 2013). In the sheep it was brown when preserved, pinkish when fresh (May, 1970).

The parotid gland of camel was irregularly four-sided in shape (Khalil, 1989) or rectangular in shape (Nawar and El-Khaligi, 1975). In cattle it was elongated and thick (Sisson and Grossman, 1975). In the sheep the gland was rectangular (Dehghani *et al*., 2000). In the goat it was oval (Tadjalli *et al*., 2002).It was triangular in dog (Mina *et al.*, 2004) or irregularly triangular in dog and cat (Dyce *et al.*, 2010).

In the horse the mean wide part of the gland was 4.45±0.15 cm, mean length was 21.55±0.75 cm and mean weight was 19±3.3 g (Dehghani *et al*, 2005). The gland of camel measured 141.55 g in weight, 11-16 cm in length, 7.5-9 cm in width and 2-3 cm in thickness (Khalil, 1989). Sisson and Grossman (1975) reported that the mass of parotid gland of sheep was 11 g, in another study the

mass of the gland was reported to be 13.5±2.6 g (Dehghani *et al.*, 2000). In the goat the gland weighed 15.2±3.2 g (Tadjalli *et al.*, 2002).

According to Amano (2011) the parotid gland of man was surrounded superiorly by the zygomatic arch, anteriorly by the masseter, and posteriorly by the sternocleidomastoideus muscle. The inferior and medial poles were mostly confined to the angle of mandible and to the temporomandibular joints respectively.

Sisson and Grossman (1975) described the parotid gland of horse as having two surfaces, two borders, a base and an apex. The lateral surface was covered by the parotid fascia and the cutaneous and parotidoauricularis muscles. The medial surface contacted the guttural pouch and the great cornu of the hyoid bone and the masseter, occipitomandibularis, digasstricus and occipitohyoideus muscles. Its ventral extremity was wider, covered the parotid lymph node, and was in contact with the mandibular gland ventrally (Dehghani *et al.*, 2005).

In camel it was stated that the superficial surface of the gland was smooth and its dorsal extremity was covered by the parotid fascia, cutaneous, parotidoauricularis and zygomaticoauricularis muscles (Nawar and El-Khaligi, 1975; Khalil 1989). The risorius muscle covered the ventral extremity. The deep surface related to the parotid duct, facial vessels and nerve. The cranial border was related to the parotid lymph node and the dorsal buccal nerves, the caudal border overlapped the obliquus capitis cranialis muscle, mandibular gland and the external jugular vein. The dorsal extremity engraved the base of the external ear by a deep notch. The ventral extremity was related to the ventral buccal nerve, facial vessels and the mandibular lymph node. In cattle the gland had five processes three superficial and two deep. The dorsal extremity was wide and thick but it was not notched to fit the base of ear. The ventral extremity was small, curved rostrally and was related to the caudal border of masseter muscle and partially covered the parotid lymph node (Dehghani *et al.*, 1994 and Al-Sadi, 2013). May (1970) described the gland of sheep and reported that the gland extended from the base of the ear dorsally, to near the origin of the jugular vein caudally and the angle of the mandible rostro-ventrally. In sheep and goat the dorsal border had deep notch surrounding the external ear but the ventral border was fissured into two lobes which were directed caudally (Dehghani *et al.*, 2000 and Tadjalli *et al*., 2002). In dog and cat the dorsal extremity was wide and divided into two parts by a deep groove that received the base of the ear; the ventral extremity was small, rounded and was overlapped by the mandibular gland (Dyce *et al.*, 2010). In all species of animals the gland was surrounded by a fascial covering that sent trabeculae inward to divide the gland into lobules in camel (Nawar and El-Khaligi, 1975), horse (Dellman and

Brown, 1981), sheep (Dehghani *et al*., 2000), goat (Tadjalli *et al.*, 2002), dog (Dyce *et al.*, 2010) and cattle (Al-Sadi, 2013). The parotid duct of camel coursed along the lateral surface of the masseter muscle and it was accompanied by two nerve branches (Rami parotidi) derived from the inferior buccal nerve (Smuts and Bezuidenhout, 1987). In cattle, Al-Sadi (2013) stated that the parotid duct lay midway between the facial tubercle and corner of the mouth. It passed rostrally on the medial side of the ventral border of the mandible and ascended dorsally on the masseter muscle. Then pierced the cheek opposite the fifth upper cheek tooth where it opened in the buccal vestibule. It was accompanied by the ventral buccal branch of facial nerve, the facial artery and vein. Dehghani *et al.* (1994) claimed that it entered the oral cavity opposite the upper 2$^{nd}$ molar teeth. In the sheep the duct left the rostral border of the gland between the middle and the ventral thirds to pass rostrally over the masseter muscle. It passed medial to the vein at the point where the vein turned rostrally, then was medial to transverse facial artery and the dorsal buccal nerve. The duct turned medially and dorsally to open into the oral cavity (May, 1970). Barnwal and Sinha (1981) reported that the course of the duct of sheep and goat was variable but it usually ran across the lateral surface of the masseter muscle about 3 cm dorsal to the ventral border. The parotid duct of sheep and goat entered the oral cavity and opened opposite the upper 2$^{nd}$ molar, its mean diameter was 3.1±1.0 mm (Dehghani *et al.*, 2000 and Tadjalli *et al*., 2002). In the dog the parotid duct was formed from several small branches and emerged from the gland at the ventral and rostral border, crossing over the masseter muscle and was located between the facial vein and artery. The mean length and diameter were 17±0.4 mm and 3±0.4 mm respectively (Mina *et al.*, 2004) and opened opposite to the upper 4$^{th}$ premolar tooth.

According to Dehghani *et al.* (2005) the parotid duct of horse composed of several small branches, it emerged from the gland rostro-ventrally, coursed along the ventral and rostral border of masseter muscle, being located between the muscle and the facial vein and artery and opened opposite to the upper 4$^{th}$ tooth. In human, the parotid duct left the cranial border, passed cranially on the masseter muscle, penetrated the buccinators muscle, and opened finally into the vestibule of the oral cavity near the second upper molar (Williams *et al.*, 1989).

### 1.1.2. Mandibular gland

Many morphological investigations were performed on the mandibular salivary gland of the one-humped camel (Nawar and El-Khaligi, 1977; Abdalla, 1979), bovine ( McLeod *et al*, 1964; Shackleford and Wilborn, 1969), buffalo (Sengar and Singh, 1970),

goat (Nawar, 1980; Islam, 1981), sheep (May, 1970), carnivores (Dyce *et al.*, 2010) and man (Williams *et al.*, 1989). In domestic animals the mandibular gland was long, bright yellow, curved and has a concave dorsal margin and it extended from the atlantal fossa to the basihyoid bone so that it was partially covered by the parotid gland (Sisson and Grossman, 1975). The colour of this gland was reported as pale yellow in camel (Nawar and El-Khaligi, 1977) and bovine (McLeod *et al*., 1964), creamy pink in sheep (May, 1970), creamy or pale yellow in goat (Rauf *et al.*, 2004; Islam, 1981). The gland was smaller than the parotid gland of sheep (May, 1970), horse (Sisson and Grossman, 1975; Dehghani *et al.*, 2005), camel (Hoppe *et al.*, 1975), goat (Rauf *et al.*, 2004) and dog (Mina *et al.*, 2004) but it was larger in cattle (Dehghani *et al.*, 1994). In the horse the gland was extended from the atlantal fossa to the basihyoid bone (Sisson and Grossman, 1975; Dhaghani *et al.*, 2005). In camel the gland was located medial to the parotid gland and covered partly by it (Smuts and Beziudenhout, 1987). In cattle the gland extended in an arch on the inner aspect of the lower jaw (Al-Sadi, 2013). It was situated on the ventral and caudal part of the angle of the mandible in sheep (Dehghani *et al.*, 2000) and (Rauf *et al.*, 2004) in goat.

The weight, length and width of the gland of horse measured 47.9±3.1 g, 19.45±0.4 cm and 2.67±0.8 cm respectively (Dehghani *et al.*, 2005). In camel the weight of the gland was 141.55 g and measured 9.60 cm in length and 2.69-4.51 cm in width (Khalil, 1989). In sheep the weight of the gland was 9.0 g (Sisson and Grossman, 1975) or 16.2±4.6 g (Dehghani *et al.*, 2000). In the goat the gland weighed 14.7±3.8 g (Tadjalli *et al.*, 2002).

In the horse the dorsal edge of the gland was concave and covered partially by the parotid gland (Dehghani *et al.*, 2005) and partially by the lower jaw. The lateral surface was covered by the parotid gland. The medial surface was related to the rectus capitis ventralis muscle, the guttural pouch, the larynx, the divisions of the common carotid artery and the tenth and eleventh cranial nerves and the sympathetic trunk (Sisson and Grossman, 1975). In the camel Nawar and El-Khaligi (1977) stated that the cranial border was related to the external carotid artery instead of the facial artery, the caudal border is related to the obliquus capitis cranialis muscle and the caudal auricular vein. The dorsal extremity was related to subcutaneous muscles and the ventral extremity was related to the facial vein (Khalil, 1989).

Sisson and Grossman (1975) in bovine and Islam (1981) in goat reported that the mandibular gland had three angles, two surfaces and three borders. The lateral surface was covered in part by the ventral portion of the

parotid gland, the sternomandibularis muscle and its tendon, the external maxillary vein and the pterygoideus medialis muscle. The medial surface was related to the retropharyngeal lymph node, the pharynx, the larynx, the lingual artery, the digastricus muscle and the stylohyoid muscle. The craniodorsal border was related to the pterygoideus medialis muscle. The caudal border was related to the retropharyngeal lymph node; the ventral border was almost straight and related to the sternothyrohyoideus muscle. In sheep the gland was related to the larynx and pharynx medially; the common carotid artery and hypoglossal nerve dorsally; the external maxillary and external jugular veins and the parotid salivary gland laterally; the mandibular lymph nodes and medial pterygoid muscle rostrally and to the skin ventrally (May, 1970).

Dehghani *et al*. (2005) stated that the mandibular duct in horse left the gland medially, passed over the cranial part of digastricus and styloglossus muscles along the genioglossus muscle and opened in the sublingual caruncle. In the camel the mandibular duct descended cranioventrally between the digastricus and medial pterygoideus muscles and coursed cranially medial to the mylohyoideus muscle (Nawar and El-khaligi, 1977).

In cattle the duct left the middle of ventral border of the gland by a ventral radicle crossing medial to the sublingual salivary gland and the compact (monostomatic) sublingual glands (Al-Sadi, 2013).

In sheep the duct left the notch above the middle of the rostral border of the gland and was formed by the union of three or four radicles. It passed rostrally between the digastricus muscle laterally and the stylohyoideus muscle medially and then passed on the medial surface of the mylohyoideus muscle, and deep to the styloglossus muscle as far forward as the sublingual salivary gland (May, 1970). The mandibular duct left the gland at the middle of the craniodorsal border as in bovine and sheep (Sisson and Grossman, 1975) and goat (Rauf *et al.*, 2004). Mina *et al*. (2004) stated that the mandibular duct of the dog left the gland from the medial surface, passed over the cranial part of digastricus and styloglossus muscle.

In horse, cattle, sheep, goat and dog the duct opened at the sublingual caruncle below apex of tongue (Sisson and Grossman, 1975). In man, the mandibular duct passed rostrally with the lingual nerve in the sublingual space to open in the sublingual caruncle with the major subligual duct (Amano, 2011).

The average length of the duct was 38.73±2.49 cm in camel (Khalil, 1989) 11 cm in goat (Rauf *et al.*, 2004) and the mean diameter was 1.4±0.3 mm

in sheep (Dehghani *et al.*, 2000) and 3.6±1.2 mm in horse (Dehghani *et al.*, 2005).

### 1.2. Histology

#### 1.2.1. Parotid gland

The histology of the parotid gland of mammals had been subjected to numerous studies (Nawar and El-Khaligi, 1975, Khalil, 1989, Stolte and Ito, 1996; Watanabe *et al.*, 1996; Tandler *et al*., 1998; Junior and Masuko, 1998; Cangussu *et al.*, 2002; Elewa *et al.*, 2010).

The gland was enclosed in a facial sheet of connective tissue; relatively dense septa passed into the gland to divide it into lobes and lobules in the horse (Dellman and Brown, 1981), camel (Nawar and El-Khaligi, 1975), bovine (Shackleford and Wilborn, 1969), sheep and goat (Elewa *et al.*, 2010) and man (Martinez-Madrigal and Micheau, 1989). The gland was classified as compound tubulo-acinar in man (Martinez- Madrigal and Micheau, 1989), camel (Khalil, 1989), horse (Dellman and Brown, 1981), bovine (Shackleford and Wilborn, 1969) and sheep (Van Lennep *et al.*, 1977). In the goat the gland was compound tubulo-alveolar (Elewa *et al.*, 2010). The parotid gland was usually serous in type in the different mammalian species (Shackleford and Wilborn, 1969; Suzuki *et al.*, 1975; Van Lennep *et al.*, 1977; Dellman and Brown, 1981; Estecondo *et al.*, 2005; El-Ramli *et al*, 2013). The gland in camel was reported to be seromucous in nature (Nawar and El-Khaligi, 1975). Furthermore, two types of secretory cells; mucous and serous cells were present in the large parotid gland of man (Micheal and Valerie, 2006). However, a few mucous cells or adenomeres were present in carnivores (Banks, 1992). Poddar and Jacob (1977) also mentioned that the parotid gland of carnivores including dog, cat and ferret was seromucous. In the domestic animals the secretory units were lined by pyramid-shaped epithelial cells with basal nuclei (Dellman and Brown, 1981). According to Nawar and El-Khaligi (1975) the secretory acini and tubules of the dromedary gland had three different phases in their secretory cycle. The parotid gland of goat, sheep and mice exhibited three different morphological phases; in the first phase, the cells showed highly condensed apical granules with basally situated spherical vesicular nuclei and the acini had relatively small lumina. In the second phase the nuclei were less vesicular and the acini had moderately sized lumina. In the third phase the acini showed disrupted and ill-defined large lumina with dark nuclei (Elewa *et al.*, 2010). Also it was reported that the acinus of the parotid gland composed of three principal cell types; light cells, dark cells and specific light cells in dog (Suzuki *et al.*, 1975), rabbits (Suzuki and Otsuka, 1977), and bovine (Suzuki *et al.*, 1981).

In hamster the

secretory units were formed of cubodial to pyramidal cells (Khojasteh and Delashoub, 2012). In domestic animals the intercalated duct which drained the secretory units joined a large striated duct lined by cuboidal or columnar epithelium (Dellman and Brown, 1981). The striated ducts extended to the edge of the lobule where they joined the interlobular ducts which were located in the connective tissue septa between the lobules. The interlobular ducts were lined by simple columnar epithelium, which changed to stratified columnar epithelium as the ducts became larger and fused with similar ducts draining other lobules. The interlobular ducts converged to form the main parotid duct which opened into the oral cavity. This duct system had also been reported in the parotid gland of horse (Dellman and Eurell, 1998), camel (Mansouri and Atri, 1994), sheep and goat (Elewa *et al.*, 2010) and man (Martinez- Madrigal and Micheau, 1989).

Dellman and Brown (1981) stated that myoepithelial cells were found in the parotid salivary glands of domestic animals. They were stellate-shaped and located between the secretory cells and the basement membrane. The myoepithelial cells were also reported in the parotid glands of man (Leeson, 1967), horse (Dellman and Eurell 1998), and goat (Suzuki *et al.*, 1975).

### 1.2.2. Mandibular gland

Histologically the mandibular salivary gland was covered by a fibrous capsule of dense connective tissue in camel (Nawar and El-Khaligi, 1977 and Khalil, 1989), horse (Dellman and Eurell, 1998), bovine (Shackleford and Wilborn, 1969), goat (Rauf *et al.*, 2004), hamster (Khojasteh and Delashoub, 2012) and African giant pouched rat (Ikpegbu *et al.*, 2014). The mandibular salivary gland of the mammals was generally a compound branched tubuloacinar gland (Dellman and Brown, 1981). In the camel the mandibular gland was described as compound tubulo-acinar (Nawar and El-Khaligi, 1977; Mansouri and Atri, 1994) but it was compound tubulo-alveolar in goat (Rauf *et al.*, 2004).

The histology of the secretory units was somewhat variable from one species to another, but it generally consisted of a tubular unit with an enlarged end-piece (Dellman and Brown, 1981). According to Banks (1992) the mandibular salivary gland was usually mucous in dogs and cats, serous in rodents, mixed in horses, humans and ruminants; the distribution of serous and mucous and mixed acini was variable. Nawar and El-Khaligi (1977) reported that the secretory cells of camel were of two types; mucous cells grouped into secretory tubules and acini and seromucus cells grouped into acini and demilunes. In bovine (Shackleford and Wilborn, 1969), goat

(Islam, 1981) and domestic animals (Dellman and Eurell, 1998) reported that the mandibular gland consisted of serous, mucus, mixed alveoli and deminules. However, in the dog and cat the mucous elements predominated with serous demilunes (Dellman and Brown, 1981). It was also claimed that in opossum, the secretory units of mandibular gland consisted of mucous and special cell types but mucous cells predominanted (Shackleford and Wilborn, 1969). Adnyane *et al*. (2010) found that in barking deer (*Muntiacus muntjak*) the mandibular gland had serous and mucous cells with the mucous type predominating.

The demilunes may be serous, seromucous, or specially serous in nature (Pinkstaff, 1980). The demilunes were seromucous in camel (Nawar and El-Khaligi, 1977), cow (Shackleford and Wilborn, 1970), sheep (Shackleford and Wiborn, 1968), squirrel monkey (Leppi and Spicer, 1966) and ferret (Jacob and Poddar, 1987).

The duct system was composed of intercalated, striated, interlobular and excretory ducts in camel (Nawar and El-Khaligi, 1977), European hedgehog (Tandler and McCallum, 1974) and calf (Shacklford and Wilborn, 1970). They reported that the intercalated duct was lined by simple cuboidal epithelium with spherical nuclei. In the horse it was lined by low cuboidal epithelium (Dellman and Eurell, 1998). The striated duct in mammals was lined by cuboidal or columnar epithelium (Dellman and Brown, 1981). It was lined by tall columnar cells in camel (Nawar and El-Khaligi, 1977).

In the horse the interlobular duct was lined by low cuboidal, simple columnar epithelium (Dellman and Eurell, 1998), whereas the interlobular duct of camel was lined by two layers of columnar cells (Khalil, 1989). The intralobular duct was lined by simple columnar cells in African giant rat (Ikpegbu *et al.*, 2014). The interlobular ducts and the excretory mandibular duct of camel contained goblet cells in their lining epithelium (Nawar and El-Khaligi, 1977). In mammals the excretory duct was lined by simple cuboidal epithelium which changed gradually to stratified squamous epithelium before it entered the oral cavity (Dellman and Brown, 1981). The excretory duct was lined by stratified cuboidal cells (Ikpegbu *et al.*, 2014).

Myoepithelial cells were identified in the human submandibular gland and the processes of myoepitheial cells were associated with the intercalated duct and often extended onto the striated duct (Riva *et al.*, 1976). Dellman and Brown (1981) studied the mandibular gland of mammals and observed that the myoepithelial cells occured between the base of the epithelial cells and the basal lamina.

**1.3. Histometry**

To our knowledge no data had been published on histometric measurements of acini and ducts of parotid and mandibular salivary glands of ruminants.

**1. 4. Ultrastructure**

**1. 4. 1. Parotid gland**

Ultrastrucural studies of the parotid gland were performed in many mammalian species including pig (Boshell and Wilborn, 1978), camel (Mansouri and Atri, 1994), mouse (Watanabe *et al.*, 1992b), sheep and goat (Elewa *et al.*, 2010) and human (Riva *et al.*, 1974). Extensive microvilli projecting into the lumen of the acini were usually seen in the salivary glands of ruminants (Shackleford and Wilborn, 1968, Van Lennep *et al.*, 1977). The presence of this type of microvilli was an indication of the production of copious amounts of saliva (Shackleford and Wilborn, 1969). In the camel numerous microvilli extended from the cell membrane into the lumina and intercellular canaliculi (Mansouri and Atri, 1994). The cells of sheep possessed numerous long microvilli extending into the lumen (Blair-West *et al.*, 1969; Van Lennep *et al.*, 1977). In the goat the acinar cells enclosed an irregular lumen with apical microvilli (Elewa *et al.*, 2010). In ferret the acinar lumen and intercellular canaliculi showed a large number of prominent microvilli (Jacob and Poddar, 1987).

In the camel, the secretory units of the parotid gland were tortuous, branched and lined with cells of different heights (Mansouri and Atri, 1994). The cells of the secretory tubules of the sheep possessed extensively folded lateral plasma membranes (Van Lennep *et al.*, 1977). The secretory acinus of both goat and sheep showed well-developed basal and lateral expansions of folds (Elewa *et al.*, 2010). In the camel the secretory cells contained abundant mitochondria, granular endoplasmic reticulum and less prominent Golgi apparatus. Two types of secretory granules of a variable size and electron density were present in the acinar cells (Mansouri and Atri, 1994). In the sheep, the cytoplasm contained a fairly large number of mitochondria (Van Lennep *et al.*, 1977). The cytoplasm of the cells of the goat possessed short segments of rough endoplasmic reticulum and free ribosomes sparsely distributed in it as well as numerous mitochondria but Golgi complexes were rarely observed (Elewa *et al.*, 2010). Jacob and Poddar (1987) reported that the acinar cells of the parotid gland of the ferret contained an abundance of rough endoplasmic reticulum, an extensive Gologi complex and electron dense granules with denser spots in each. The apices of the secretory cells in horse were filled with secretory granules (Dellman and Eurell, 1998), while Elewa *et al.* (2010) reported that the gland of goat had serous granules distributed

throughout the apical cytoplasm of the serous cells and the apical cytoplasm of the serous cells showed numerous membrane-bound secretory granules with homogenous matrices and in sheep and goat.

### 1. 4. 2. Mandibular gland

Ultrastructural observations were reported in the comparative studies of mandibular gland of different mammalian species (Tamarin and Sreebny, 1965; Tandler and Erlandsen, 1976; Brocco and Tamarin, 1979; Pinkstaff, 1980; Espinal *et al.*, 1983; Watanabe *et al.*, 1992). These studies revealed that in many species the secretory acini contained cells of either the serous type or mucous type or a combination of both. Tightly packed small granules of moderate electron density were seen in the cat, dog and rabbit (Dorey and Bhoola, 1972). The morphology of the mitochondria in the rat was clearly noted in three-dimensional images and shown to possess a compact network of tubular and tubulo-vesicular cristae (Watanabe *et al.*, 1996).

## 1. 5. Histochemistry

### 1. 5. 1. Parotid gland

The available literature revealed that little is known about the carbohydrate histochemistry of salivary glands in ruminants. In mammals mucosal units of parotid gland reacted strongly with periodic acid Schiffs reagent (PAS) (Shackleford and Schneyer, 1964). The parotid saliva of camel like that of bovine was strongly buffered with bicarbonate and phosphate and was approximately iso-osmotic with plasma (Kay and Maloiy, 1989). Khalil (1989) detected some amyloytic activity in the dromedary parotid gland and also in mixed saliva. According to Elewa *et al.* (2010) PAS-positive reactions in the parotid glands of goat and sheep was moderate. Jacob and Poddar (1987) reported the presence of neutral mucosubstances in the parotid gland of ferret.

### 1. 5. 2. Mandibular gland

The mucous and demilune cells in camel contained an appreciable amount of acid and sulphate mucopolysaccharides (Abdalla, 1979), ruminants (Shackleford and Wilborn, 1968), human (Munger, 1964), and rabbits (Al-Saffar, 2014). The mucosal units of mandibular gland of rodents reacted strongly with the staining techniques; Alcian Blue (AB) and PAS (Shackleford and Schneyer, 1964).

# CHAPTER TWO

# MATERIAL AND METHODS

A total number of 100 heads of adult camel, ox, sheep and goat (twenty five heads of each animal) were used in this study. Heads of apparently healthy adult animals were collected from Alssalam slaughter house, Omdurman, Sudan, during the period of (April 2013-April 2014). Forty heads (ten heads of each animal) were used for studying the gross anatomy of parotid and mandibular salivary glands. Sixty heads (fifteen heads of each animal) were used for histological, histometric, ultrastrucural and histochemical studies.

Morphological and histochemical studies were done in the Sudan University of Science and Technology, Collage of Veterinary Medicine. The ultrastructural studies were done in Cairo University, Agriculture Park.

## 2. 1. Gross Anatomy

Fixed and unfixed heads were used in this study. The heads were injected by 10% formalin through the external jugular vein and common carotid artery. They were then immersed in containers filled with 5% formalin. After fixation the heads were carefully dissected to determine the position of the parotid and mandibular glands. The skin over each gland was incised; the fascia was removed from each gland and the glands were carefully freed from the surrounding tissue and the ducts were followed along the entire length until they reached the oral cavity. The weights of fresh specimens were taken by using a sensitive electronic balance and ruler (cm) for length, width and thickness of the gland, length and diameter of the duct. The average means were recorded and analyzed.

## 2. 2. Histology

Samples of tissue of parotid and mandibular glands (3-5 mm) thick were immediately removed after slaughter and were fixed in 10% buffered formalin. They

were then dehydrated in ascending concentrations of ethanol (70%, 90% and 100%), cleared in xylene or chloroform and impregnated with paraffin wax (Drury and Wallington, 1980). Sections (5-7 µ) thick were cut in a rotary microtome and mounted on glass slides. For general histological observations, the sections were stained with haematoxylin and eosin (H&E).

Special stains were also applied according to Carleton (1967) which included:

1. Verhoeff's haematoxylin elastic tissue stain. 2. Silver stain haematoxylin reticular tissue stain. 3. Masson's Trichrome stain for muscles fibers. The slides were examined and micrographs were taken with a camera (Mottican U.K) attached to the Olympus microscope.

**2. 3. Histometry**

Histomertic measurements were recorded for the parotid and mandibular glands of camel, ox, sheep and goat. The luminal diameter of the acini and ducts of the glands mentioned above were measured randomly from lobules of eight slides of each animal, under micrometer lens X40. The objective lens X40 was used for determining the measurements after calibrating the ocular scale of the microscope (Thienpont *et al*., 1986). Then the data were analyzed by the Statistical Tool for Agricultural Research (R-Star, 2013).

**2. 4. Ultrastructure**

For ultrastructural studies, small pieces of tissue were taken from parotid and mandibular salivary glands and fixed rapidly in 2.5% glutaraldehyde in 0.1 M sodium cacodylate buffer pH 7.2 containing sucrose (30 g/L), then washed 3 times every 10 minutes for 30 minutes in phosphate buffer. The material was then post-fixed in 1% osmium tetroxide for 2 hours. This was followed by washing the tissue 3 times in phosphate buffer every 10 minutes for 30 minutes. Dehydration was carried out in ascending grades of ethanol 30%, 50% and 70% alcohol overnight, 80%, 90% alcohol for 30 minute and twice in 100% alcohol for 30 minute. The blocks were then immersed in a solution composed of acetone: resin mixture 2:1, 1:1, 2:1 to 100% resin gradually using a rotator machine. They were then embedded in epoxy resin. Dimethyl aminomethyl phenol (DMP30 1.5%) was added to the mixture as a hardner. The blocks were kept in an oven at 70 C˚ for 24-48 hours. Semi thin sections (0.5 -1.5 nm) were cut using glass knives, stained with toluidine blue and examined with the light microscope.

The desired regions for electron microscopy were then selected and ultrathin sections (pale gold to silver), were prepared at approximately 75-90 nm thickness with a Leica Ultracut ultramicrotome (Japan) and were stained with uranyl acetate and lead citrate for 5 minutes, washed in distilled water and placed in citrate for 30-40 seconds, then washed dried and examined by transmission electron microscope JEOL (JEM-1400 TEM) (Japan) at the candidate magnification (Bancroft and Stevens 1990). Images were captured by CCD camera model AMT(Japan).

**2. 5. Histochemistry**

The histochemical investigations were made on paraffin sections. Samples (3-5 mm) thick were fixed in 10% buffered formalin for neutral and acid polysaccharides. They were then processed for paraffin sections, cut at thickness of (5-7 µm) on a rotary microtome and the following stains were used:

1. Periodic Acid Schiff (PAS) technique control sections for glycogen were treated with (0.1%) amylase for 30 minutes at 37 C˚ for neutral polysaccharides (Carleton, 1967).

2. Alcain Blue (AB) technique for acid polysaccharides (Carleton, 1967). The slides were examined and photomicrographs were taken with a camera attached to the Olympus microscope (Mottican U.K).

# CHAPTER THREE

# RESULTS

## 3. 1. Gross Anatomy

### 3. 1. 1. Parotid gland

#### 3. 1. 1. 1. Camel

The gland was large, located under the ear ventral to auricular cartilage and extended between the caudal part of vertical ramus of the mandible and masseter muscle. It was dark brown to red in colour, irregularly rectangular in shape and had five extensions directed ventrally (Fig. 1). It was lobulated and was covered partially by parotidoauricularis muscle, thick connective tissue and skin (Fig. 1). The gland measured 129.5±4.075 g in weight; 11.3±0.6 cm in length; 6.56±0.361 cm in width and 0.78±0.228 cm in thickness (Table 1). The gland had two extremities, two surfaces and two borders; the cranial extremity was wide and related to the parotid lymph node and the dorsal buccal nerve. The caudal extremity was divided into two processes and related to the jugular vein, masseter muscle and mandiblular ramus (Fig. 2). The lateral surface of the gland was related to partidoauricularis, great auricular nerve, cervical fascia, subcutaneous muscle and skin. The medial surface was related to masseter muscle, the mandibular gland, dorsal buccal nerve and parotid duct (Fig. 3). The dorsal border was related to the base of ear, zygomaticoauricularis, partidoauriculari muscles and caudal auricular nerve. The ventral border was related to the ventral buccal nerve, facial vessels and external jugular vein (Fig. 2).

The parotid duct emerged from the ventral surface and coursed along the rostral border of masseter muscle (Fig. 2) with some branches of dorsal buccal nerve crossing the zygomaticus muscle and opened in the oral cavity at a mucosal papilla opposite the second molar tooth (Fig. 2). The average measurements of parotid duct were 21.36±1.09 cm in length and 0.22±0.45 cm in diameter (Table 1).

#### 3.1.1.2. Ox

The gland was small in

size, dark red in colour and rectangular in shape and lobulated (Fig. 4). It was located along the ventral part of the auricular cartilage under the base of ear caudal to the vertical mandibular ramus and covered completelly by the parotidoauricularis muscle (Fig. 4, 5). The gland measured 11.62±0.601 g in weight, 5.95±0.273 cm in length, 3.78±0.655 cm in width and 0.4±0.070 cm in thickness (Table 1).

The gland had two extremities, two surfaces and two borders; the cranial extremity was wide and related to the stylohyoideum, parotid lymph node, base of the ear and caudal auricular artery. The caudal extremity was thin related to maxillary vein and mandibular gland. The lateral surface was related to parotidoauricular muscle, cervical fascia, auricular nerve, cutaneous muscle and skin. Medially the gland was related to the masseter muscle, fascial vein, ventral buccal nerve, mandibular gland and the parotid duct. The dorsal border was related to the base of ear, caudal auricular nerve, partidoauricularis and zygomaticoauricularis muscles. The ventral border was related to maxillary vein, partidoauricularis muscle and mandibular gland (Fig. 4, 5).

The parotid duct was run parallel to the ventral buccal nerve, facial artery and facial vein and passed the masseter muscle laterally (Fig. 6), then turned medially and opened in the oral vestibule opposite the fifth upper cheek tooth (Fig. 6). The mean length and diameter of the duct were 28.6±1.194 cm and 0.24±0.548 cm respectively (Table 1).

**3.1.1.3. Sheep**

The parotid gland was large, lobulated, irregular in shape and brown in colour. It was situated posterior to the mandibular ramus and ventral part of the auricular cartilage under the ear (Fig. 7). The parotidoauricularis muscle passed superficially above the gland. By palpation the gland was present between the mastoid process of temporal bone cranially and the coronoid caudally. The measurements of the gland were 5.9±0.374 g in weight, 6.04±0.48 cm in length, 2.74±0.152 cm in width and 0.3±0.070 cm in thickness (Table 1). The cranial extremity was wide and related to the base of the ear, dorsal buccal nerve and zygomaticauricularis muscle. The caudal extremity was divided into two processes which were directed caudally and cranially and they were related to linguofacial vein, ventral buccal nerve and the angle of the mandible. The lateral surface was related to superfascial fascia, cutaneous muscle and skin. The medial surface was related to parotid duct, facial vein, ventral buccal nerve, mandibular gland and masseter muscle (Fig. 7). The dorsal border was related to caudal auricular vein and zygomaticoauricularis muscle. The ventral border was related to mandibular ramus, facial vessels, ventral buccal nerve. The parotid duct left the deep surface of the gland together with the ventral buccal nerve, facial artery and

facial vein, passed along the lateral surface of the masseter muscle (Fig. 7) and opened in the mucosa of the vestibule in a papilla opposite the second molar tooth of the upper jaw. The duct measured 10.6±0.866 cm in length and 0.18±0.447 cm in diameter (Table 1).

**3.1.1.4. Goat**

The parotid gland was larger than mandibular gland, triangular in shape (Fig. 8) and situated under the ear, ventral to the auricular cartilage. The parotidoauricularis muscle crossed the gland superficially. The gland was brown in colour. It weighed 7.18±0.574 g and measured 6.56±0.361 cm in length, 3.06±0.364 cm in width and 0.27±0.044 cm in thickness (Table 1).The cranial extremity was wide and related to dorsal buccal nerve the base of the ear and zygomaticoauricularis muscle. The caudal extremity was thin and related to the sternomandibularis muscle, lingofacial vein and ventral buccal nerve. The lateral surface was related to parotidoauricularis muscle, superficial fascia and skin. It was related craniomedially to the mandibular ramus, masseter muscle, branches of the facial vein and ventral buccal nerve, mandibular gland and parotid duct. The dorsal border was related to the great auricular nerve, caudal auricular vein and zygomaticoauricularis muscle. The ventral border was related to the mandibular ramus, facial vessels, ventral buccal nerve.

The parotid duct left the gland together with the ventral buccal nerve (Fig. 8) facial artery and facial vein and passed on the lateral surface of the masseter muscle and opened into the oral vestibule opposite the second upper molar. The duct measured 11.5±1.118 cm in length and 0.18±0.447 cm in diameter (Table 1).

**Table 1**: Mean and standard deviation of weight (gm), length (cm), width (cm) and thickness (cm) of parotid gland and length (cm) and diameter (cm) of duct of camel, ox, sheep and goat.

| Parameters/ Animals | Camel | Ox | Sheep | Goat |
|---|---|---|---|---|
| **Weight** | 129.5±4.075 | 11.62±0.601 | 5.9±0.374 | 7.18±0.574 |
| **Length** | 11.3±0.6 | 5.94±0.273 | 6.04±0.48 | 6.56±0.361 |
| **Width** | 6.56±0.361 | 3.78±0.655 | 2.74±0.152 | 3.06±0.364 |
| **Thickness** | 0.78±0.228 | 0.4±0.070 | 0.3±0.070 | 0.27±0.044 |
| **Length of duct** | 21.36±0.089 | 28.6±1.194 | 10.6±0.866 | 11.5±1.118 |
| **Diameter of duct** | 0.22±0.447 | 0.24±0.548 | 0.18±0.447 | 0.18±0.447 |

M±SD

### 3. 1. 2. Mandibular Gland

#### 3. 1. 2. 1. Camel

The mandibular gland was situated obliquely under the parotid gland. The gland was generally oval in shape, lobulated and pale yellow in colour. It was more compact in texture and smaller in size than parotid gland. It was located between the wing of atlas and the digastricus muscle. The gland was covered partially by the parotid gland which divided it into two lobes superficial and deep lobes. It was covered by a capsule and connected to the parotid gland by thick connective tissue (Fig. 9). The means of weight, length, width and thickness were 30.56±0.56 g, 9.26±0.441 cm, 4.72±0.387 cm and 1.08±0.164 cm respectively (Table 2). The cranial extremity was round-shaped and related to the occipitohyoideus muscle and great cornu of hyoid bone. The caudal extremity was round and related to ventral buccal nerve, auricular vein, mandibular lymph node and sternohyoideus, sternomandibularis and omohyoideus muscles (Fig. 9). The lateral surface was related to parotid gland, the mandible angle, facia and skin. The medial surface of the gland was related to the lateral retropharyngeal lymph node, linguofacial vein and sternohyoideus and sternomandibularis muscles. The dorsal border of the gland was round in shape and related to the lateral retropharyngeal lymph node, stylohyoideus muscle, occiptal vein and subcutaneous muscle. The ventral border was round and related to the facial vein and auricular nerve.

The mandibular duct passed between the digastricus and ventral pterygoideus muscles (Fig. 9) and along the lower jaw between the mylohyoideus and geniohyoideus muscles to the external surface of the styloglosuss muscle together with the ventral buccal nerve of the facial nerve and opened at a mucosal fold ventral to apex of tongue. The duct measured 32.2±2.280 cm in length and 0.22±0.447 cm in diameter (Table 2).

#### 3. 1. 2. 2. Ox

The gland was elongated in shape and distinctly lobulated (Fig. 10). It was larger than the parotid gland, dark yellow in colour and less compact in texture. It was located under the parotid gland; curved along the medial side of the angle of the mandible and extended from the wing of the atlas into the inter-mandibular space. Caudally the gland was covered by the parotid gland, adipose tissue and loose connective tissue separated the mandibular gland from parotid gland (Fig. 10). The gland weighed 72.6±0.811 g and measured 10.66±0.393 cm in length, 3.94±0.463 cm in width and 0.74±0.114 in thickness (Table 2). The cranial extremity was related to the great cornu of the hyoid bone and the occipitohyoideus muscle. The caudal extremity was thin and

related to ventral buccal nerve, lingofacial vein, mandibular lymph node and sternomandibularis, omohyodeus and sternohyodeus muscles. The lateral surface was related to the parotid gland, facial and maxillary veins (Fig. 10). The medial surface was related to the mandibular duct, lateral retropharyngeal and thyroid lymph nodes. The dorsal border was related to the lateral retropharyngeal lymph node and the internal jugular vein. The ventral border was related to the sternothyroideus muscle, thyroid gland and common carotid artery.

The mandibular duct passed above the rostral belly of digastricus muscle with the lingual nerve between the geniohyoideus and mylohyoideus muscles, beside the styloglosuss muscle (Fig. 10) and mandible and opened into the oral vestibule ventral to apex of tongue at the sublingual caruncle. It measured 40.2±1.924 cm in length and 0.22±0.447 cm in diameter (Table 2).

**3. 1. 2. 3. Sheep**

The gland was irregular in shape, lobulated and less compact in appearance, yellow in colour and smaller than parotid gland. The gland was located obliquely caudal to the parotid gland which divided the mandibular gland into deep and superficial parts. The gland rested on the angle of the mandible (Fig. 11). It weighed 2.14±0.476 g and measured 5.14±0.206 cm in length, 2.92 ±0.376 cm in width and 0.34±0.114 cm in thickness (Table 2).

The cranial extremity was related to great auricular nerve and caudal auricular vein and retropharyngeal lymph node. The caudal extremity was fissured and related to mandibular lymph node, omohyoideus and sternohyoideus muscles, fascia, cutaneous muscle and the skin. The lateral surface was related to the parotid gland, adipose tissue, maxillary and lingual veins. The medial surface was related to the external carotid artery, thyroid gland and thyrohyoideus and stylohyoideus muscles. The dorsal border was related to the lateral retropharyngeal lymph node. The ventral border was related to the jugular vein and omohyoideus muscle.

The mandibular duct passed above the belly of digastriceus muscle together with the lingual nerve (Fig. 11). The duct passed between the geniohyoideus and mylohyoideus muscles, beside the styloglosuss muscle and opened into the ventral surface of oral vestibule ventral to apex of tongue at sublingual caruncle. It measured 18.4±2.419 cm in length and 0.18±0.447 cm in diameter (Table 2).

**3.1.2.4. Goat**

The gland was located obliquely caudal to the parotid gland. It was irregularly triangular in shape, less compact in texture and yellow in color, lobulated and small in size than parotid gland. The parotid gland divided the mandibular gland into superficial and deep lobes (Fig. 12). The gland

weighed 2.86±0.595 g and measured 4.9±0.363 cm in length, 2.88±0.214 cm in width and 0.29±0.074 cm (Table 2).

The cranial extremity was related to caudal auricular vein, great auricular nerve and retropharyngeal lymph node. The caudal extremity was related to mandibular lymph node and omohyoideus and sternohyoideus muscles, adipose tissue, cutaneous muscle and skin. The lateral surface was related to the parotid gland, maxillary and linguofacial veins and sternomandibularis muscle (Fig. 12). The medial surface was related to thyrohyideud and cleidomastoideus muscles and ventral buccal branch of facial nerve. The dorsal border was related to cleidooccipitalis muscle and caudal auricular vein. The ventral border was related to the jugular vein and cleidomastoideus muscle.

The mandibular duct passed above the digastricus muscle together with the lingual nerve between the geniohyoideus and mylohyoideus muscles under the styloglosuss muscle and mandible and opened into oral vestibule below apex of tongue at the sublingual caruncle (Fig. 12). The means of length and diameter were 16.8±1.483 cm and 1.8±0.447 cm respectively (Table 2).

**Table 2**: Mean and standard deviation of weight (gm), length (cm), width (cm) and thickness (cm) of mandibular gland and length (cm) and diameter (cm) of duct.

| Parameters/Animals | Camel | Ox | Sheep | Goat |
|---|---|---|---|---|
| **Weight** | 30.56±0.554 | 72.6±0.811 | 2.14±0.476 | 2.86±0.595 |
| **Length** | 9.26±0.441 | 10.66±0.393 | 5.14±0.206 | 4.9±0.363 |
| **Width** | 4.72±0.387 | 3.94±0.463 | 2.92±0.376 | 2.88±0.214 |
| **Thickness** | 1.08±0.164 | 0.74±0.114 | 0.34±0.114 | 0.29±0.074 |
| **Length of duct** | 32.2±2.280 | 40.2±1.924 | 18.4±2.419 | 16.8±1.483 |
| **diameter of duct** | 0.22±0.447 | 0.22±0.447 | 0.18±0.447 | 0.18±0.447 |

M±SD

### 3. 2. Histology

#### 3. 2. 1. Parotid gland

##### 3. 2. 1. 1. Camel

The parotid gland was surrounded by a connective tissue septa consisting of collagenous fibers and a few irregularly arranged elastic fibers which divided the gland into several lobes and lobules of different sizes and contained blood

vessels and nerves (Fig. 13, 14). The gland was compound tubuloacinar in type. The parenchyma was composed of acini and ducts. The acini were located close to each other and separated by thin reticular fibers. Two types of acini were present; mucous and serous acini. The mucous acini were lighter lined by flattened nuclei. The serous acini were distributed between the mucus acini and lined by pyramidal or cuboidal epithelium with round nuclei (Fig. 15). The acini were divided, according to the luminal diameter, into three types; small, intermediate and large acini. In the small acini the lumen was small in diameter. The lumen of the intermediate acini was intermediate in diameter. The large acini had large luminal diameter (Fig. 15). The number of cells lining the acinus was 5 in the small, 8 in the intermediate and 12 in the large acini. Four types of ducts were seen. The intercalated duct had a small sized luminal diameter. It was lined by cuboidal epithelium with round nuclei located apically (Fig. 15). The striated duct was a large intralobular duct. It had a large irregular luminal diameter. It was lined by tall columnar cells, with oval nuclei bulging into the lumen (Fig. 15). The cells had basal striations extending from the base of the cells to the level of the nuclei. Both intercalated and striated ducts were situated within the lobules at different locations and varied in number. The interlobular and had a large diameter (Fig. 16). It was located in the connective tissue between the lobules and lined by low columnar epithelium. The interlobar duct was found in the connective tissue septa between the lobes. It was lined by stratified cuboidal to stratified columnar epithelium with goblet cells (Fig. 17). Myoepithelial cells were observed around the acini and intercalated ducts such as red spots.

**3. 2. 1. 2. Ox**

The gland was surrounded by a connective tissue capsule from which septa extended into the stroma dividing it into numerous lobes and lobules. The septa consisted mainly of collagenous, elastic fibers and thin reticular fibers passed between the acini. The gland was compound tubuloacinar in type, consisting of clusters of serous acini (Fig, 18).

Three types of acini were observed (Fig. 19). The small acini were pink in colour, had small luminal diameters and round in shape and lined by pyramidal cells. The intermediate acini had intermediate luminal diameters and lined by cuboidal cells with round nuclei. The large acini had large luminal diameters and were lined by simple cuboidal cells (Fig. 19). The average number of lining cells was 6 in the small, 8 in the intermediate and 11-12 in the large acini. Intercalated, striated, interlobular and interlobar ducts were observed. The intercalated duct was a small round intralobular duct, regular in shape and lined by cuboidal cells with round nuclei. The

striated duct had an irregular large-sized lumen, basal striations and lined by two layers of simple cuboidal cells with oval nuclei (Fig. 19).The interlobular duct was located in the connective tissue septa between the lobules and was lined by two layers of simple columnar epithelium with oval nuclei. The interlobar duct was observed in the connective tissue septa between the lobes and was lined by stratified cuboidal epithelium. Myoepithelial cells were seen in the basal lamina of acini and intercalated ducts liked red spots (Fig. 20).

**3. 2. 1. 3. Sheep**

The gland was surrounded by a connective tissue capsule which gave off septa that divided the gland into lobules. The connective tissue septa composed of collagenous, elastic and reticular fibers (Fig. 21). The parenchyma consisted of compound tubuloacinar units which were purely serous in type. The acini were associated with intercalated and striated ducts (Fig. 21). The lobules were composed of three types of secretory acini (Fig. 22). The small acini had small lumina and lined by pyramidal cells with round nuclei. The intermediate acini had intermediate lumina and lined by simple cuboidal cells. The large acini had large lumina lined by simple cuboidal cells with oval nuclei. The average number of lining cell in each type was 5 in the small, 8 in the intermediate and 11 in the large acini.

Four types of ducts were seen; intercalated, striated, interlobular and interlobar ducts (Fig. 22). The intercalated duct had a small regular lumen lined by cuboidal cells. The striated duct had a large irregular lumen, basal striations and lined by simple columnar epithelium. The interlobular duct was located in the connective tissue between the lobules. It had a large irregular lumen lined by simple columnar cells. The lumina showed secretory products. The interlobar duct was situated in the connective tissue between the lobes and lined by stratified cuboidal to stratified columnar epithelium (Fig. 23). Myoepithelial cells were observed around the acini and intercalated ducts (Fig. 24).

**3. 2. 1. 4. Goat**

The gland was covered with a capsule consisting of dense fibrous connective tissue containing collagenous, elastic and reticular fibers. The acini were located close to each other and separated by a thin layer of connective tissue (Fig. 25). The parenchyma consisted of serous compound tubulo-alveolar secretory units (Fig. 26).

Three types of serous acini were present; small, intermediate and large acini. In the small acini the cells showed highly condensed apical granules with basally situated spherical vesicular nuclei and had

relatively small lumina (Fig. 26). The intermediate acini were vesicular, with oval nuclei and intermediate lumina. The large acini also showed oval but dark nuclei and large lumina. The average number of cells in the first, second and third acini were 5, 7 and 9 cells respectively. Two types of intralobular ducts were observed; the intercalated ducts were lined by cuboidal epithelium and the striated duct was a large duct, lined by simple columnar epithelium with basal striations (Fig. 26). The interlobular duct was located in the connective tissue around the lobules being lined by simple cuboidal epithelium (Fig. 27). The interlobar duct had a large lumen and was lined by simple columnar epithelium. Myoepithelial cells were observed scattered around the acini and the intercalated duct (Fig. 27).

**3. 2. 2. Mandibular gland**

**3. 2. 2. 1. Camel**

The mandibular gland was surrounded by connective tissue septa which divided the gland into lobes and lobules (Fig. 28). The connective tissue septa composed of collagenous and few elastic fibers a thin layer of reticular fibers surrounding the acini. The gland was compound tubuloacinar. Two types of acini and demilunes were observed in its pranchyma, these were serous and mucous acini (Fig. 29). The serous acini had pyramidal cells, pink in colour with round and centrally located nuclei. The mucus acini were light in colour, had cuboidal cells, oval nuclei were basally located. The demilunes were seen at the ends of mucous cells as a few serous cells arranged in a crescent (Fig. 29). According to size of lumen, there were three types of acini. The small had a small lumen and an intermediate lumen was seen in the intermediate acini. The large type had a large lumen. The average number of lining cells was 5, 8 and 11 cells for the small, intermediate and large acini respectively.

The duct system was composed of intercalated, striated, interlobar and interlobar ducts. The intercalated duct was lined by cuboidal epithelium with spherical nuclei (Fig. 29). The striated ducts were lined by columnar epithelium with tall cells and basal striations (Fig. 30). The interlobular ducts were lined by simple columnar cells (Fig. 31). The interlobar duct was lined by stratified columnar epithelium with goblet cells (Fig. 32). Myoepthial cells were observed around the acini and intercalated ducts.

**3. 2. 2. 2. Ox**

The gland was externally covered by a layer of connective tissue septa which divided the gland parenchyma into lobes and lobules. The connective tissue septa consisted of collagenous, elastic and reticular fibers. The gland was made up of compound tubuloacini. The secretory acini were mucous and serous acini and demilunes (Fig. 33). The serous acini were dark red in color, and lined

by pyramidal cells with round nuclei. The mucus acini were light in appearance and had cuboidal cells with flattened nuclei. At the ends of mucus acini, the serous and mucous cells were arranged in a crescent forming serous demilunes (Fig. 33). Three types of acini were seen in the lobules. The small were dark red in colour and had small lumina. The intermediate one had an intermediate lumen and the large one had a large lumen. The average number of lining cells in each acinus was 5, 7 and 11 cells for the small, intermediate and large acini respectively. The duct system was composed of intercalated, striated, interlobular and interlobar ducts. The intercalated duct was present within the lobules and was lined by cuboidal epithelium (Fig. 33). The striated duct was also present in the lobules and lined by columnar epithelium (Fig. 33). The interlobular duct was seen in the connective tissue septa between the lobules and was lined by simple columnar cells. The interlobar duct was found in the connective tissue septa and was lined by stratified cuboidal epithelium (Fig. 34). Myoepithelial cells were seen around the acini and intercalated ducts (Fig. 35).

**3. 2. 2. 3. Sheep**

The mandibular glands were enclosed by connective tissue septa which gave off septa that divided the glands into lobules (Fig. 36). The septa were composed of collagenus, elastic and reticular fibers. The parenchyma consisted of tubuloacinar secretory units resting on a basement membrane. Three types of acini were observed; mucus and seruos acini (Fig. 37). The serous acini were dark red in colour. They had pyramidal cells with round nuclei. The mucus acini were light in appearance, lined by cuboidal epithelium with flattened oval nuclei and capped by groups of serous cells. According to luminal diameter three types of acini were present in the lobules. The small acini had a small luminal diameter. The intermediate acini had an intermediate luminal diameter. The large acini had a large luminal diameter. The average number of lining cells in each acinus was 5, 8, and 11 cells in the small, intermediate and large acinus respectively.

The duct system was composed of intercalated, striated, interlobular and, interlobar ducts. The intercalated duct had a small lumen and connected to the acini and lined by cuboidal epithelium (Fig. 37). The striated duct had a large irregular lumen and was placed between the acini and lined by columnar epithelium (Fig. 37). The interlobular and the interlobar ducts were located in the connective tissue septa between lobules and lobes and had irregular lumina. The interlobular duct was lined by simple columnar cells (Fig. 38) and the interlobar duct was lined by stratified columnar epithelium (Fig. 39). There was a great variation in the size and shape of these ducts. The myoepithelial cells were presented in red colour.

**3. 2. 2. 4. Goat**

The gland was covered externally by connective tissue septa which gave off septa of collagnuos, few elastic fibers and thin reticular fibers between the acini (Fig. 40). The connective tissue septa contained ducts, blood and lymphatic vessels and nerves. The parenchyma consisted of compound tubuloalveolar units and ducts, containing serous and mucous and serous demilunes (Fig. 41). The mucous alveoli were larger and lighter coloured. The epithelial cells were wedge-shaped with flattened nuclei. The serous alveoli were smaller than the mucous alveoli and had a narrow lumen lined by cuboidal cells with oval basal nuclei and capped by groups of serous cells (Fig. 41).

Within the lobules there were three types of acini; the small acini were dense had small lumina, the intermediate had intermediate lumina and the large had large lumina. The average number of lining cells was 5, 8 and 11 cells in the small, intermediate and large alveolar respectively.

The intercalated ducts were lined by cuboidal epithelium (Fig. 41). The striated ducts were numerous and lined by columnar epithelium with basal striations (Fig. 41). The interlobular duct was lined by simple columnar epithelium (Fig. 42). The interlobar duct was lined by stratified columnar epithelium (Fig. 43). The myoepithelial cells were seen at the base of alveoli and intercalated ducts. They were red and spindle-shaped cells (Fig. 44).

**3. 3. Histometry**

**3. 3. 1. Parotid gland**

The diameters of the small, intermediate and large acini of parotid gland were shown in (Table 3).

According to the statistical analysis of the diameter of small acini (Table 3 and 4) there was a significant difference (P0.05) between the camel and ox, high significant difference (P) between camel and sheep; ox and sheep; sheep and goat. There was no significant difference (P between camel and goat; ox and goat. Diameters of the intermediate acini, showed a significant difference (P0.05) between camel and ox; camel and sheep; ox and goat while a high significant difference (P was present between ox and sheep, but no significant difference (Pwas observed between camel and goat; sheep and goat. The diameters of large acini of the gland showed a significant difference (P0.05) between camel and ox; ox and sheep. There was no significant difference (Pbetween camel and sheep; camel and goat; ox and goat; sheep and goat. The diameters of the intercalated, striated, interlobular and interlobar ducts were shown in (table 5).

The statistical analysis

of the diameters of ducts in camel, ox, sheep and goat (Table 6) revealed that there was no significant difference (P) in the diameter of the intercalated duct in camel, ox and goat; whereas there was a significant difference (P0.05) bet,ween ox and goat and a high significant difference (P) between camel and sheep; sheep and goat. In the striated duct, there was no significant difference (Pbetween ox and sheep and goat; while there was a significant difference (P0.05) between camel and ox, and highly significant difference (P) between camel and sheep; camel and goat; sheep and goat. In the interlobular duct; there was no significant difference (Pbetween camel and ox; camel and sheep; sheep and goat. A significant difference (P0.05) was shown between camel and goat; ox and sheep; while a high significant difference (P) occurred between ox and goat. In the interlobar duct, there was no significant difference (Pbetween ox, sheep and goat; sheep and goat. However there was a significant difference (P0.05) between camel and ox; camel and sheep and a highly significant difference (P) between camel and goat.

**Table 3**: Diameter of parotid acini (µm) of camel, ox, sheep and goat.

| Animals/parameters | Small acini | Intermediate acini | Large acini |
|---|---|---|---|
| **Camel** | 17.18±0.3 | 25.61±0.3 | 37.35±0.7 |
| **Ox** | 17.48±0.5 | 23.9±0.6 | 33.61±1.32 |
| **Sheep** | 18.99±0.3 | 27.31±0.4 | 38.26±0.64 |
| **Goat** | 17.39±0.4 | 26.78±0.6 | 37.03±0.9 |

M±SE

**Table 4**: Comparison between mean diameters (µm) of parotid acini of camel, ox, sheep and goat.

| Animals/parameters | Small acini | Intermediate acini | Large acini |
|---|---|---|---|
| **Camel-Ox** | 0.0013±0.3956* | 1.7000±0.7390* | 3.730±1.540* |
| **Camel-Sheep** | 1.82±0.2995** | 1. ±0.5820* | 0.85±0.99 NS |
| **Camel-Goat** | 0.216±0.449 NS | 1.180±0.684 NS | 0.32±1.46 NS |
| **Ox-Sheep** | 1.82±0.449** | 3.41±0.5820** | 4.59±1.36* |
| **Ox-Goat** | 0.216±0.449 NS | 2.88±0.897* | 3.41±1.91 NS |
| **Sheep-Goat** | 1.6±0.496** | 0.3110±0.534 NS | 1.17±1.12 NS |

M±SE. ** P highly significant. * P0.05 Significant. P

**Table 5:** Diameter of parotid ducts (µm) of camel, ox, sheep and goat.

| Animals/parameters | Intercalated duct | Straiated duct | Interlobular duct | Interlobar duct |
|---|---|---|---|---|
| **Camel** | 47.27±2.13 | 95.07±6.6 | 87.5±3.4 | 123.72±5.48 |
| **Ox** | 39.27±2.47 | 70.32±6.3 | 77.8±2.9 | 106.07±3.03 |
| **Sheep** | 32.86±2.18 | 53.67±3.2 | 90.17±4.7 | 104.74±3.52 |
| **Goat** | 55.16±3.62 | 71.32±5.5 | 101.86±2.6 | 109.43±3.82 |

M±SE

**Table 6:** Comparison between mean diameters (µm) of parotid duct of camel, ox, sheep and goat.

| Animals/parameters | Intercalated duct | Striated duct | Interlobular duct | Interlobar duct |
|---|---|---|---|---|
| **Camel-Ox** | 8.00±4.20 NS | 24.75±9.6* | 9.70±4.94 NS | 17.65±4.33* |
| **Camel-Sheep** | 14.41±2.61** | 41.39±7.8** | 2.64±5.48 NS | 18.98±5.48* |
| **Camel-Goat** | 7.89±4.55 NS | 23.74±5.09** | 14.33±5.29* | 14.29±7.00 NS |
| **Ox-Sheep** | 6.40±2.60* | 16.65±7.55 NS | 12.34±5.34* | 1.33±5.00 NS |
| **Ox-Goat** | 15.89±4.94* | 1.00±8.68 NS | 24.03±3.99** | 3.36±5.12 NS |
| **Sheep-Goat** | 22.29±4.9** | 17.65±4.77** | 11.69±6.30 NS | 4.69±4.63 NS |

M±SE. ** P highly significant. * P0.05 Significant. P

### 3. 3. 2. Mandibular gland

The diameters of the small, intermediate and large acini in camel, ox, sheep and goat were shown in (Table 7). A comparison between the diameter of small, intermediate and large acini of the gland was shown in (Table 8). The small acini showed no significant difference (Pin the diameter in camel and goat; ox and sheep; goat and sheep, a significant difference (P0.05) appeared between camel and ox; a high significant difference (P was observed between camel and sheep. In the intermediate acini, there was no significant difference between camel and goat; ox and goat; sheep and goat, whereas there was a significant difference (P0.05) between camel and ox and a high significant difference (P between camel and sheep; ox and sheep. In the large acini, there was no significant difference (Pbetween camel and ox, camel and sheep and camel and goat but there was a high significant difference (P0.05) between camel and sheep; ox and sheep; ox and goat; sheep and goat.

The diameters of intercalated, striated, interlobular and interlobar ducts in camel, ox, sheep and goat were shown in (Table 9). Statistical analysis of the diameters of ducts in camel, ox, sheep and goat (Table 10) revealed that there was no significant difference (Pbetween ox and goat; sheep and goat in the diameter of the intercalated duct, whereas there was significant differences (P0.05) between camel and ox; camel and goat; ox and sheep and a high significant difference (P between camel and sheep. In the striated duct, no significant difference (Poccurred between camel and ox; camel and sheep; ox and sheep. A high significant difference (P) between camel and goat was recorded. There was a high significant difference (P between ox and goat; sheep and goat. The interlobular duct showed no significant difference (Pbetween camel and ox; camel and sheep; camel and goat; ox and sheep; ox and goat; sheep and goat. No significant difference (Pwas recorded between camel and ox; camel and sheep; camel and goat; ox and sheep; ox and goat in the interlobar duct. A high significant difference (P between sheep and goat was shown (Table 10).

**Table 7**: Diameters of mandibular acini (µm) of camel, ox, sheep and goat.

| Animals/parameters | Small acini | Intermediate acini | Large acini |
|---|---|---|---|
| **Camel** | 18.57±0.42 | 26.48±0.60 | 38.52±0.57 |
| **Ox** | 20.38±0.25 | 28.28±0.25 | 39.7±0.43 |
| **Sheep** | 20.70±0.42 | 30.52±0.31 | 36.92±0.39 |
| **Goat** | 18.89±1.26 | 27.96±1.17 | 33.08±0.73 |
| | | | |
| | | | |

M±ES

**Table 8**: Comparison between mean diameter of mandibular acini of camel, ox, sheep and goat (µm).

| Animals/parameters | Small acini | Intermediate acini | Large acini |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Camel-Ox** | 1.81±0.634* | 1.79±0.528* | 1.17±0.756 NS |
| **Camel-Sheep** | 2.13±0.427** | 4.03±0.547** | 1.600±0.764 NS |
| **Camel-Goat** | 0.3195±1.51 NS | 1.47±1.51 NS | 0.319±1.50 NS |
| **Ox-Sheep** | 0.319±0.557 NS | 2.24±0.425** | 2.77±0.553** |
| **Ox-Goat** | 1.49±1.23 NS | 0.319±1.15 NS | 6.62±0.801** |
| **Sheep-Goat** | 1.81±1.49 NS | 2.56±1.42 NS | 3.84+0.644** |

M±SE. ** P high significant. * P0.05 Significant. P

**Table 9**: Diameter of mandibular ducts of camel, ox, sheep and goat (µm).

| **Animal/parameters** | **Intercalated duct** | **Striated duct** | **Interlobular duct** | **Interlobar duct** |
|---|---|---|---|---|
| **Camel** | 34.14±2.44 | 57.73±4.98 | 89.63±5.63 | 103.72±8.16 |
| **Ox** | 38.41±2.53 | 55.7±3.34 | 87.12±5.10 | 104.24±7.30 |
| **Sheep** | 45.38±2.09 | 54±3.11 | 89.63±2.85 | 99.66±4.92 |
| **Goat** | 45.24±2.24 | 59.98±4.65 | 93.53±4.36 | 102.50±5.48 |

M±ES

**Table 10**: Comparison between diameters of parotid ducts of camel, ox, sheep and goat (µm).

| Animals/parameters | Intercalated duct | Striated duct | Interlobular duct | Interlobar duct |
|---|---|---|---|---|
| **Camel-ox** | 4.270±1.53* | 2.03±5.66 NS | 2.50±6.29 NS | 0.517±13.69 NS |
| **Camel-sheep** | 11.23±2.48** | 3.73±6.32 NS | 0.0041±5.76 NS | 4.06±7.12 NS |
| **Camel-goat** | 11.10±4.35* | 23±8.35* | 3.91±5.40 NS | 17.78±10.55 NS |
| **Ox-sheep** | 6.83±2.64* | 3.73±6.32 NS | 2.50±5.60 NS | 4.58±9.48 NS |
| **Ox-goat** | 6.83±4.54 NS | 25.28±5.63** | 6.41±7.78 NS | 17.27±9.48 NS |
| **Sheep-goat** | 0.132±4.01 NS | 26.98±5.32** | 3.9±4.94 NS | 21.85±5.18** |

M±SE. ** P high significant.* P0.05 Significant. P.

**3. 4. Ultrastructure**

**3. 4. 1. Parotid gland**

**3.**

**4. 1. 1. Camel**

Two types of acini which possessed serous and mucous cells were observed. The serous cell was pyramidal in shape (Fig. 45). The luminal surface had dense microvilli-like cytoplasmic projections; secretory products were seen in the lumen. The nucleus of the serous cell was round and centrally located. The chromatin granules were dense along the inner nuclear membrane with some clumps randomly scattered in the nucleoplasm (Fig. 46). Well-developped spherical or oval mitochondria, rough endoplasmic reticulum and free ribosomes were observed around nucleus. A small Golgi complex was observed mainly in the supranuclear cytoplasm. Round and dark large secretory granules were seen in the cytoplasm and lumen (Fig. 46).

The cell of the mucus acinus was cuboidal, and had an oval, flattened basal nucleus. The basal lamina was markedly irregular in outline. The chromatin was scattered along the inner nuclear membrane and was clumped randomly in the nucleoplasm. The nuclei showed remarkable variations in size. The cytoplasm contained numerous mitochondria,

which were basally and apically aggregated, elongated and intermediate in size (Fig. 47). A well- developped Golgi apparatus was situated in the supranuclear region and coated vesicles were commonly associated with it. Rough endoplasmic reticulum with free ribosome was observed. The basal parts of cells were tightly joined by extensive cytoplasmic interdigitation. Dense-cored vesicles were closely applied to the basal lamina. The lateral plasma membranes were linked together by junctional complexes, tight junctions, intermediate junction and desmosomes. Small, spindle-shaped myoepithelial cells were observed (Fig. 48).

Necrotic nuclei and necrotic cells were seen in some acini (Fig. 49). **3. 4. 1. 2. Ox**

The serous cells were pyramidal in shape and their apices were directed towards the lumen. Microvilli-like cytoplasmic projections were shown on the apical surface (Fig. 50). A large number of round granules and electron dense bodies of various sizes were seen (Fig. 50). The lateral plasma membrane was held together by junctional complexes. The nucleus was irregular and folded occupying the basal cytoplasm. The chromatin content was heavily concentrated along the inner nuclear membrane (Fig. 51). The cell contained well developped perinuclear mitochondria. Rich rough endoplasmic reticulum and free ribosomes and numerous secretory granules were seen (Fig. 51). Golgi apparatus was seen in the supranuclear region. Necrotic nuclei and necrotic cells were observed in some acini (Fig. 52). Myoepithelial cells were observed, basally and outside the basal membrane (Fig. 52).

**3. 4. 1. 3. Sheep**

The serous cell was pyramidal with the apical surface projecting into the lumen (Fig. 53). The lumen contained secretory granules. Microvillus-like cytoplasmic projections were seen. The basal and the lateral portions of the cytoplasm were closely linked together by cytoplasmic interdigitations (Fig. 54). The lateral plasma membrane of the acinus cells was connected together by junctional complexes. The nucleus was located in the basal cytoplasm. It was oval in shape and had a folded nuclear membrane (Fig. 55). Chromatin granules were concentrated heavily along the inner nuclear membrane and some clumps were scattered randomly in the nucleoplasm (Fig. 55). The nucleuolus was observed in the nucleoplasm. The cytoplasm was rich in organelles including many mitochondria, well-developped Golgi complex and rough endoplasmic

reticulum. Mitochondria were small, elongated, electron dense and located beside to the nucleus (Fig. 55). Secretory products appeared as massive accumulations of round, oval and dark granules.

### 3. 4. 1. 4. Goat

The serous cell had numerous apical long microvilli. The cell was cuboidal in shape and directed towards lumen. The apical cytoplasm and the lumen contained numerous secretory granules (Fig. 56). A well-developped plasma membrane was seen; forming numerous basal infolddings and cytoplasmic complexes between the acinus cells. The nucleus was oval in shape and centrally located (Fig. 56).

The nuclear membrane had chromatin granules scattered within the nucleoplasm and along the nuclear membrane (Fig. 57). Rough endoplasmic reticulum and free ribosomes as well as mitochondria were distributed in the basal part of the acinus cell (Fig. 58). Golgi apparatus was rarely observed.

The myoepithelial cell was seen outside the basal lamina and between two acinus cells. It had a dark cytoplasm and large spindle shaped nucleus. The nucleus occupied the bottom of the cell. Dense chromatin granules were scattered along the folded nuclear membrane and projected into the nucleoplasm (Fig. 56).

### 3. 4. 2. Mandibular gland

**3.**

### 4. 2. 1. Camel

The secretory units showed two types of cells; serous and mucus cells. They had short microvilli which were directed towards the lumen and contained round secretory granules (Fig. 59). Adjacent acinar cells were joined together with junctional complexes. The mucous cell had an oval nucleus located at the basal part. The cytoplasm contained well-developped round and elongated mitochondria around the nucleus. Well-developped Golgi apparatus and rough endoplasmic reticulum were observed (Fig. 60). Dense granules were seen in the cytoplasm. The basal parts were connected by junctional complexes. The serous cell had a round nucleus located centrally. Chromatin granules were clumped along the nuclear memmbrane and some in nucleoplasm. Numerous mitochondria were distributed around the nucleus. They were elongated in shape and varying in size. Rough endoplasmic reticulum and Golgi complex were observed. Necrotic nuclei and necrotic cells were seen in some acini. The myoepithelial cells were

seen basally between some cells.

### 3. 4. 2. 2. Ox

Two types of cells were identified; mucous and serous. The apices of cells were directed toward the lumen and had nuclei of different sizes (Fig. 61). The apical surface of acinar cells possessed long and dense microvilli, cytoplasmic projections, vacuoles and dense granules close to the lumen (Fig. 61). The acinar cells were joined together by junctional complexes. The mucous cell had a flattened nucleus resting basally. It had a folded plasma membrane. Chromatin granules were present along the nuclear membrane and in the nucleoplasm. Mitochondria were scattered in the lateral and apical cytoplasm. Rough endoplasmic reticulum and Glogi complex were observed (Fig. 62).

The serous cell possessed round nuclei situated in the basal cytoplasm. Chromatin granules were scattered in the nucleoplasm and along the folded nuclear membrane and one or two nucleoli were present. The cell contained abundant round and elongated mitochondria which were aggregated in the apical part of the cell. Golgi apparatus was seen in the lateral nuclear region and rough endoplasmic reticulum (RER) and free ribosomes were attached to the nuclear membrane.

The spindle myoepithelial cell was located basally at the junction of two cells. The nucleus was spindle-shaped and had more chromatin scattered along the folded nuclear membrane (Fig. 61).

**3.**

### 4. 2. 3. Sheep

There were two types of secretory cells; serous and mucus with variable electron density. The serous cell was small had a dark cytoplasm. The mucous cell was lighter and was larger. Both serous and mucous cells were directed toward the lumen. The apical surface showed bleb-like cytoplasmic luminal projections, packed with round granules of different sizes.

The nucleus of serous cell was round and basally situated. It contained cloudy chromatin granules along the nuclear envelope and nucleoplasm. A large amount of secretory material was seen in the cytoplasm in the form of granules of various sizes. Well developped mitochondria were present around the nucleus and were accumulated in the apical cytoplasm.

The nucleus of mucous cell was basally located, large, flattened and characterized

by a folded membrane. The chromatin granules were scattered along the inner nuclear membrane and nucleoplasm (Fig. 63). The cytoplasm possessed a well-developed Golgi apparatus. Numerous well-developped round and elongated mitochondria form apical aggregations towards the lumen. Long cisternae of rough endoplasmic reticulum were shown. Abundant secretory material occupied the apical cytoplasm (Fig. 63).

The spindle myoepithelial cell was located basally at the junction of two cells. The cytoplasm was dark when compared to that of the acinar cells. The nucleus was spindle-shaped and had more chromatin scattered along the folded nuclear membrane (Fig. 64).

**3. 4. 2. 4. Goat**

Two types of cells were identified in the gland; serous and mucus in both cells a remarkable number of lucent and dense electron bodies were accumulated in the apical cytoplasm. The mucous cell was light in appearance. The apical surface was tortuous, projecting into the lumen. Dense microvilli were seen in the luminal surfaces of the cells. The nucleus of mucous cell was large in size, oval and situated in the basal cytoplasm. The nuclear membrane was folded having chromatin granules. Chromatin granules were also present in the nucleoplasm. The cytoplasm contained rough endoplasmic reticulum and free ribosomes together with numerous round granules of different electron density, well-developped mitochondria and light and electron dense vesicles with or without dense granules were observed in the apical cytoplasm (Fig. 65). A well-developped Golgi apparatus was present mainly in the supranuclear cytoplasm.

The serous cell was pyramidal in shape and dark in colour and directed towards the lumen. The nucleous was round in shape and located centrally. The nucleoplasm possessed abundant chromatin material and some was attached to the nucleolemma. The secretory granules were small dark, round and occupied the apical cytoplasm and lumen (Fig. 66). The lateral and basal membranes were joined together by junctional complexes. The cytoplasm contained elongated mitochondria scattered around the nucleus and accumulated in the apical cytoplasm. Rough endoplasmic reticulum and free ribosomes were seen. Golgi apparatus was observed in the supranucler region.

The myoepitheial cell was small, spindle-shaped and located at the junction between the bases of the acinar cells and directly between two acini. The cytoplasm was somewhat darker than that of the acinar cells. The nucleus was spindle shaped having a large amount of chromatin material (Fig. 65).

**3. 5. Histochemistry**

### 3. 5. 1. Parotid gland

#### 3. 5. 1. 1. Periodic Acid Schiff (PAS)

**3.**

**5. 1. 1. 1. Camel**

A varying degree of PAS-positive reaction, resistant to diastase digestion was observed (Fig. 67). The reaction was strong in the lining epithelium of mucus and serous acini. It was also strong in the epithelial lining of intercalated, striated, interlobular and interlobar ducts. The connective tissue revealed a weak reaction.

**3. 5. 1. 1. 2. Ox**

PAS positive reaction resistant to diastase digestion was seen (Fig. 68). Strong reactions were seen in the epithelial lining of serous acini, intercalated, striated, interlobular and interlobar duct and very strong reaction as red spots were scattered randomly in the parenchyma. A negative reaction was observed in the connective tissue and capsule. The associated blood vessels showed very strong reaction.

**3. 5. 1. 1. 3. Sheep**

A strong PAS activity, resistant to diastase digestion, was shown in the lining epithelium of acini and moderate in intercalated, striated, interlobular and interlobar duct (Fig. 69). A weak or negative PAS reaction was shown in the connective tissue septa.

**3. 5. 1. 1. 4. Goat**

A very strong PAS-positive reaction resistant to diastase digestion was shown in the gland (Fig. 70). The reaction was strong in the lining epithelium of acini, intercalated, striated, interlobular, interlobar duct and connective tissue. A very strong reaction was seen in the blood vessels.

**3. 5. 1. 2. Alcian Blue (AB)/ Periodic Acid Schiff (PAS) sequence**

**A** negative reaction to AB and AB/PAS were shown in the epithelial lining of serous and mucuos acini, intercalated, striated, interlobular and interlobar ducts of gland of camel. The capsule and connective tissue also showed a negative reaction (Fig. 71). AB reaction was also negative in the serous acini, lining epithelium of intercalated, striated, interlobular and interlobar duct and capsule and connective tissue of gland of ox and goat (Fig. 72, 73). In the sheep it was negative in the acini and ducts but the blue

spots were randomly present in the parenchyma (Fig. 74).

**Table 11:** Summary of carbohydrates reactions of parotid glands of camel, ox, sheep and goat.

| Reactions | Camel | Ox | Sheep | Goat |
|---|---|---|---|---|
| **PAS** | ++ | ++ | ++ | ++ |
| **PAS/diastase** | - | + | + | + |
| **AB** | - | - | - | - |
| **AB/PAS** | - | - | - | - |

**3. 5. 2. Mandibular gland** **3. 5. 2. 1.**

**Perodic Acid Schiff (PAS)** **3. 5. 2. 1.**

**1. Camel**

The gland showed PAS-positive reaction, non-resistant to diastase digestion (Fig. 75). A strong PAS-reaction was seen in the lining epithelium and lumen of serous acini and only in the epithelial lining of mucus acini. Intercalated, striated, interlobular and interlobar showed a moderate reaction for PAS. Week or negative reaction was seen in the

connective tissue septa.

**3. 5. 2. 1. 2. Ox**

A strong PAS positive reaction resistant to diastase digestion was seen (Fig. 76). The lining epithelium of mucus acini, serous acini and ducts were strongly positive. Connective tissue around the interlobular ducts and blood vessels also showed a strong reaction. A weak reaction was observed in the connective tissue septa.

**3. 5. 2. 1. 3. Sheep**

PAS-positive reaction resistant to diastase digestion was observed (Fig. 77). The lining epithelium of mucus acini, serous acini and ducts were strongly positive. Connective tissue around the interlobular ducts and blood vessels also showed a strong reaction.

**3. 5. 2. 1. 4. Goat**

A strong PAS activity, resistant to diastase digestion was seen in the gland (Fig. 78). The reaction clearly appeared in the epithelial lining of mucus and serous acini. It was more intense in the serous acini. A moderate reaction was shown in the epithelial lining of the intercalated, striated, interlobular and interlobar ducts. A weak or negative reaction was seen in the capsule and connective tissue.

**3. 5. 2. 2. Alcian Blue (AB)/ Perodic Acid Schiff (PAS) sequence**

**3. 5. 2. 2. 1. Camel**

Three regions were identified in the gland; red, bule and gray. The red region was PAS-positive, the blue was AB-positive and the gray was AB/PAS positive (Fig. 79). In the red region, the strong PAS-reaction was clearly seen in the epithelial lining and lumen of serous acini. The mucuos acini showed positive reaction in the epithelial lining and weak or negative reaction in the lumen. In the blue region, the moderate AB-reaction was seen in the epithelial lining and lumen of the mucus acini and strong PAS reaction in the serous acini (Fig. 80). In the gray region, the AB/PAS reaction was positive in the mucus acini and positive PAS reaction in the serous acini. The intercalated, striated, interlobular and interlobar ducts showed strong PAS-positive reaction in the epithelial lining. A weak or negative PAS, AB and AB/PAS reaction was seen in the connective tissue septa. The blood vessels were positive for PAS and negative for AB and AB/PAS reactions.

**3. 5. 2. 2. 2. Ox**

The reaction varied markedly in its colours; red was PAS-reaction and gray was AB/PAS reaction (Fig. 81). Strong PAS-reaction was detected in the epithelial lining and lumen of serous acini

and epithelial lining of mucus acini and ducts. AB/PAS reaction was present in the lumen of mucus acini. Connective tissue septa revealed week or negative reaction for PAS, AB and AB/PAS reaction and blood vessels were positive for PAS reaction.

#### 3. 5. 2. 2. 3. Sheep

PAS reaction was seen in the epithelial lining of serous acini, mucus acini and ducts and strong AB/PAS reaction in the lumen of mucus acini (Fig. 82). Connective tissue showed weak reaction for PAS and AB/PAS reaction and blood vessels were moderately PAS positive.

#### 3. 5. 2. 2. 4. Goat

A very strong PAS activity was observed in the epithelial lining and lumen of serous acini and epithelial lining of mucus acini (Fig. 83). Ducts and blood vessels showed a moderate reaction. Connective tissue fibers were weakly positive to AB/PAS reaction.

**Table 12**: Summary of carbohydrate reactions of mandibular glands of camel, ox, sheep and goat

| **Substences** | **Camel** | **Ox** | **Sheep** | **Goat** |
|---|---|---|---|---|
| **PAS** | + | +++ | ++ | ++++ |
| **PAS/diastase** | + | - | - | - |
| **AB** | ++ | +++ | + | + |
| **AB/PAS** | ++ | ++ | +++ | +++ |

# CHAPTER FOUR
# DISCUSSION

## 4.1. Parotid gland

The present study shown that the parotid glands of camel, ox, sheep and goat were located under the ear ventral to auricular cartilage. The parotid gland was larger than the mandibular salivary gland but it was smaller in ox. A similar observation was reported in camel (Abdalla, 1979 and Al-Samarrae *et al.*, 1989), sheep (May, 1970), goat (Nawar, 1980) and ox (Sisson and Grossman, 1975; Al-Sadi, 2013).

In current investigation the parotid gland was covered by paratidoauriculari muscle partially, completely and superficially in camel, ox and sheep and goat respectivelly. The gland was irregular rectangular in camel, rectangular-shaped in ox, irregular in sheep and triangular-shaped in goat. This is in agreement with Khalil (1989) in camel; Nawar (1980), Nickel *et al*. (1976) in sheep and goat. However, the shape of parotid gland of cattle was club-shaped (Al-Sadi, 2013) or irregularly triangular (Sission and Grossman, 1975); elongated and triangular and roughly quadrilateral in camel (Smuts

and Bezuidenhout, 1987) and irregularly four-sided in horse (Sisson and Grossman, 1975).

This investigation described the colour of the glands as dark brown to red in camel, dark red in ox, brown in sheep and goat. Similar observations have been reported in camel (Khalil, 1989) and cattle (Al-Sadi, 2013) and different reports given by (Van Lennep, 1957) who described it as dark greyish red colour. It was light red in colour in cattle (Dehghani *et al.*, 1994). Kay (1987) suggested that the colour of the gland depends on the type of feed. In this study the gland was lobulated in camel, ox, sheep and goat. This is in agreement with Nawar and El-Khaligi (1975) in camel, Dehghani *et al.* (1994) in ox, Dehghani *et al.* (2000) in sheep, Islam (1981) in goat, Mina *et al.* (2004) in dog and is in disagreement with Khalil (1989) who reported that the gland of camel was smooth. Currently the mean weight of the glands of camel, ox, sheep and goat were 129.5±4.075 g, 11.62±0.601 g, 5.9±0.374 g and 7.18±0.574 g respectively. Khalil, (1989) reported that, the average weight of the gland of camel was 141.55 g, but Hoppe et al (1975), Nawar and El-Khaligi (1975) and Abdalla (1979) claimed that the weight of gland of camel is in the range of 117-200 g. Kay *et al.* (1980) reported that the parotid glands of the dromedary weighed about 0.5 g/kg body weight as in other ruminants adapted to feeding on coarse roughages. In sheep, it has been reported to weigh 11 g (Sisson and Grossman, 1975) and 16.2±4.6 g (Dehaghani *et al.*, 2000). In the goat the parotid gland weighed 15.2±3.2 g (Tadjalli *et al.*, 2002). In dog the parotid gland weighed 6.93±0.14 g (Mina *et al.*, 2004).

The present study revealed that the mean length of the gland of camel was 11.3±0.6 cm. This is in agreement with Khalil (1989) who reported that the gland of camel measured 11-16 cm in length. Obviously the gland is longer than that of ox 5.94±0.273 cm, sheep 6.04±0.48 cm and goat 6.56±0.361 cm. However according to Dehghani *et al.* (2000) the length of the gland of sheep was 20-25 cm. In dog the length is 3.96±0.26 cm (Mina *et al.*, 2004).

In all farm animals the gland is enclosed within a fascial covering that sends trabeculae inward to divide the gland into visible lobules (Dyce *et al.*, 2010). Similarly in this study the gland of camel, ox, sheep and goat was enclosed by a fascial capsule dividing the gland into lobules. It was also observed that the cranial extremity of the gland of camel, ox, sheep and goat was wide and covered the regional lymph node, the caudal end of the gland of camel and ox and goat was thin except in sheep which it was divided into two processes as in camel (Khalil, 1989), cattle (Al-Sadi, 2013), sheep and goat (Dhghani *et al.*, 2000 and Tadjalli *et al.*, 2002) and dog (Mina *et al.*, 2004). In this investigation

the cranial extremity of gland of camel was related to the parotid lymph node and the dorsal buccal nerve, while in the ox it was related to the stylohoideum, base of ear, caudal auricular artery, parotid lymph node and dorsal buccal nerve. In sheep and goat it was related to the base of ear, zygomaticauricular muscle and dorsal buccal nerve (Sisson and Grossman, 1975). The caudal extremity of gland of camel was related to the jugular vein, masseter muscle and mandibular ramus, whereas in the ox it was related to maxillary vein and mandibular gland; lingofacial vein and the angle of mandible in sheep and goat it was related to sternomandibularis muscle, lingofacial vein and ventral buccal nerve. The topography of the gland of camel as currently described is in agreement with the description of Nawar and El-Khaligi (1975) in the same animal. In bovines the caudal border was also related to the masseter muscle and parotid lymph node (Al-Sadi, 2013).

In this study the lateral surface of the gland of camel and ox was related to the skin, fascia, cervical fascia and great auricular nerve, parotidoauricularis muscle. In the sheep and goat it was related to cutaneous muscle, superficial connective tissue and skin. The medial surface of the gland of camel, ox, sheep and goat was related to masseter muscle, mandibular gland dorsal buccal nerve and parotid duct. The connective tissue was thick in the camel and loose in the ox, sheep and goat. In the horse (Sisson and Grossman, 1975) the lateral surface was related to parotid fasia, cutaneous and parotidauricularis muscle and the medial surface is related to guttural pouch, the great cornu of the hyoid bone, masseter, occiptomandibularis, digastricus and occipitohyoideus muscle.

In this investigation the dorsal border of the gland of camel and ox was related to the base of ear, zygomaticoauricularis and partido-auicularis muscles and caudal auricular nerve. This relationship was similar to that observed in the camel (Khalil, 1989) and cattle (Al-Sadi, 2013). In the sheep and goat however, the dorsal border was related to zygomaticoauricularis muscle and caudal auricular vein. In the present study the ventral border in camel was related to the ventral buccal nerve, facial vessels and mandibular ramus but in the ox it was related to partidoauricularis muscle, maxillary vein and mandibular gland while in sheep and goat it was related to maxillary and lingofacial vein and submandibular gland. In this study the parotid duct of camel, sheep and goat left the deep surface of the gland and passed along the rostral border of masseter muscle and opened in the oral vestibule at a mucosal papilla opposite to the second molar tooth in camel, sheep and goat. This was in agreement with Nawar and El-Khaligi (1975) and Khalil (1989) in camel and Nickel *et al.* (1976), Nawar (1980) in sheep and goat.

In the current investigation the parotid duct of ox was parallel to the ventral buccal nerve, facial artery and facial vein and passed lateral to the masseter muscle. It opened opposite

the fifth upper cheek tooth. This is in agreement with Al-Sadi, (2013). Measurements of the duct were done for the first time in this study. The length of duct was 21.36±0.089 cm, 28.6±1.194 cm, 10.6±0.866 cm and 11.5±1.118 cm in camel, ox, sheep and goat respectively and the diameter was large in camel 0.22±0.447 cm, ox 0.24±0.548 cm, but small in sheep 0.18±0.447 cm and goat 0.18±0.447 cm.

Histologically, the present study showed that the parotid gland of camel, ox, sheep and goat was surrounded by a connective tissue septa consisting of collagenous fibers with few irregularly arranged elastic fibers, dividing the gland into several lobules of different sizes. The acini were separated by thin reticular fibers. This is in agreement with Nawar and El-Khaligi (1975) in camel, Shackleford and Wilborn (1969) in bovine and Elewa *et al.* (2010) in goat and sheep.

In this study the parenchyma of the gland of camel, ox, sheep and goat consisted of secretory acinar cells and ducts. They were compound tubuloacinar secretory units in camel, ox, and sheep but compound tubuloalveolar secretory units in goat. A similar observation was reported in camel (Nawar and El-Khaligi, 1975), bovine (Shacklford and Wilborn, 1969), sheep and goat (Elewa *et al.*, 2010).

The parotid gland of camel as observed at present was seromucous but composed of only serous acini in ox, sheep and goat. The presence of seromucus acini had been reported by Leeson (1967) in man, Nawar and El-Khaligi (1975) in camel, Podder and Jacob (1977) in carnivores, Raubenheimer *et al.* (1988) in African elephant. However serous acini were reported by Shackleford and Wilborn (1969) in bovine, Elewa *et al.* (2010) in goat and sheep and El-Ramli *et al.* (2013) in rabbits. It appears that the presence of a well developped serous cells may be an adaptation for increased digestion of carbohydrates by amylase in the oral cavity. In this study and according to diameter the acini were divided into three types; small, intermediate and large acini in the gland of camel, ox, sheep and goat. A similar observation was given by Nawar and El-Khaligi (1975) in camel and Elewa *et al*. (2010) in sheep and goat who reported that the presence of the three different morphological types of acini might be an indication of different phases of activity.

In the current investigation there was a large difference in diameter of small acini in sheep but obviously it was almost identical in camel, ox and goat. However, there was a remarkable difference (P0.05) between the camel, ox and goat in the diameters of intermediate and large acini. Moreover, Elewa *et al.* (2010) reported that the diameters of acini in sheep were larger than that in goat. According to Dellman and Brown (1981) four types of ducts were observed in the gland of camel, ox,

sheep and goat. They differed in structure, location and size. Intercalated and striated ducts were located within lobules and interlobular and interlobar ducts located between lobules or lobes. In this investigation the intercalated duct was lined by simple cuboidal cells with round nuclei. This was in agreement with Khalil (1989) in camel, Tandler and Erlandson, (1976) in baboon. In the fish rat the intercalated duct was lined by simple squamous to cuboidal cells with elongated or oval nuclei (Jezek *et al.*, 1999). The striated duct of camel, sheep and goat was lined by simple columnar cells while in ox it was lined by two layers of cells and was characterized by the presence of basal striations in all animals used. This is in agreement with Khalil (1989) in camel, Van lennep *et al.* (1977), and Khojasteh and Delashoub (2012) in European hamster.

In the present study the interlobular duct was lined by low columnar cells as in camel, ox, sheep and goat and the interlobar duct was lined by two layers of columnar epithelium with goblet cells in camel and simple columnar epithelium in ox, sheep and goat. This is in disagreement with Khalil (1989) who reported goblet cells in the interlobular ducts. In this study a variation in the diameter of ducts of camel, ox, sheep and goat was observed. The intercalated ducts showed a slight difference (Pbetween of camel, ox and sheep while a remarkable difference (P0.05) was recorded in goat. The striated ducts showed clear difference (P0.05)between in camel, ox, goat and sheep. A large difference (P between camel and ox; sheep and goat and a remarkable difference (P0.05) between ox and goat recorded. The interlobular ducts showed a large difference (P in diameter between camel and goat; ox and goat and a big difference (P between camel, ox, and sheep. There was a large difference (P in diameters of interlobar ducts between camel and ox; sheep and goat and slight difference (P between ox, sheep and goat.

In the present study the myoepithelial cells appeared as red spots surrounding the acini and intercalated ducts in the camel, ox, sheep and goat. This was similar to that reported by Leeson (1967) in man, Dellman and Brown (1981) in domestic animals and Suzuki *et al.* (1975) in goat. According to Redman (1994) and Amano *et al.* (2011) the myoepithelial cells surounding the secretory acinar cells and intercalated ducts in rodents provided contractile force to help expel the secretion from the acini cells through the intercalated ducts. This contraction of the myoepithelial cells is under the control of autonomic nervous stimulation (Ogawa, 2003). It had also been suggested that they gave support to the underlying acinar tissues and prevent over-distension by the secretory products (Emmelin and Gjorstrup, 1973).

The ultrastrucural examination of sections of parotid gland revealed the presence of mucous and serous cells in camel and

only serous cell in ox, sheep and goat. This confirmed the present histological observations. In the present study the gland revealed the presence of extensive microvilli-like cytoplasmic projections in the acini of camel (Mansouri and Atri, 1994), ruminants (Shackleford and Wilborn, 1968; Van Lennep *et al.*, 1977; Kayanja and Sholtz, 1974), sheep (Blair-West *et al.*, 1969) and goat (Elewa *et al.*, 2010) and ferret (Jacob and Poddar, 1987). The present study demonstrated extensive rough endoplasmic reticulum, prominent Golgi complex and electron dense granules in the gland of camel, ox, sheep and goat. Protein secreting serous cells possessed extensive rough endoplasmic reticulum, prominent Golgi complex and electron dense granules (Jacob and Poddar, 1987). The presence of well developped mitochondria, Golgi complex, numerous cisternae of rough endoplasmic reticulum and free ribosomes and secretory granules clearly indicate that the acinar cells were active.

In the current study the gland had revealed extensive cytoplasmic interdigitations and junctional complexes in the folded basal lamina and luminal part as an interlocking cellular membrane. Similar observations were reported in the parotid gland of goat and sheep (Elewa *et al.*, 2010) and brown bat (Tandler and Cohan, 1984).

The present study had shown an accumulation of mitochondria in the basal and lateral cytoplasm. It was well developped in ox than in camel, sheep and goat. Shackleford and Wilborn (1969) and Van Lnnep *et al.* (1977) reported that the gland of sheep contained numerous mitochondria and small granular endoplasmic reticulum. The variation in the number of mitochondria may be related to activity of feeding and growth. In this study the presence of extensive rough endoplasmic reticulum, free ribosomes and Golgi complexes as reported before in the gland of goat (Elewa *et al.*, 2010), camel (Mansouri and Atri, 1994), sheep (Van Lennep *et al.*, 1977), bovine (Shackleford and Wilborn, 1969) and rat (Watanabe *et al.*, 1996) might indicate active synthesis of secretory material as suggested by Jacob and Poddar (1987).

In this study, secretory granules, electron-dense bodies and vacuoles were observed in the gland of camel, ox, sheep and goat. Similar finding were reported in the parotid gland of the squirrel monkey (Cowley and Shackleford, 1970), pig (Boshell and Wilborn, 1978) and goat and sheep (Elewa *et al.*, 2010). The number of the secretory granules and vacuoles was variable among the glands of animals currently investigated. However; they were few in camel, moderate in ox and goat and abundant in sheep.

The ultrastructural studies of myoepithelial cells of the gland revealed that the cells were spindle-shaped and located basally at the

junction of two acinar cells. The cytoplasm was dark and contained numerous electron-lucent granules when compared to that of the acinar cells. This was similar to the fine structrue of the myoepithelial cell in the European hedgehag reported by Tandler *et al.* (1998). The present study demonstrated the presence of PAS positive reaction resistant to diastase digestion in gland of camel, ox, sheep and goat. The reaction had different degrees in the gland parenchyma. This is in agreement with Khalil (1989) in camel, Elewa *et al.* (2010) in sheep and goat. Al-Saffar (2014) reported that the parotid gland of rabbits showed different PAS reactions. In this study the gland had shown a negative reaction to (AB) in all animals used. A similar observation was reported by Khalil (1989) in camel, Elewa *et al*. (2010) in goat and sheep and Al-Saffar (2014) in rabbits. This finding suggests that the parotid glands secrete neutral mucopolysacharides.

**4.2. Mandibular gland**

Most of the earlier studies on the salivary glands were concerned with the position of the mandibular gland which was described as superficial in the neck region. In the present study the mandibular gland of camel, ox, sheep and goat was obliquely superficial and was situated caudal to the parotid gland which divided the gland into deep and superficial parts. This is in agreement with the reports given in camel (Nawar and El-Khaligi, 1977) and other domestic animals (Sisson and Grosman, 1975).

In the present investigation, the shape of the gland was irregularly oval in camel, an elongated in ox, irregularly shaped in sheep and irregularly triangular in goat. Similar observations were reported in camel (Nawar and El-Khaligi, 1977; Khalil, 1989), cattle (Al-Sadi, 2013), sheep and goat (Nawar, 1980; Nickel *et al*., 1976) and irregularly triangular in dog (Mina *et al.*, 2002).

In the present study the colour of the gland was pale yellow in camel, dark yellow in ox and yellow in the sheep and goat. In domestic animals it has been generally described as bright yellow (Dyce *et al.*, 2010).

In this study the gland of camel, ox, sheep and goat was lobulated as reported by Kay *et al*. (1980) in camel, Al-Sadi (2013) in cattle and Nawar (1980) in goat and Nickel *et al.* (1976) in sheep.

In the present study the gland was covered by thick connective tissue in camel and loose connective tissue in ox, sheep and goat. This result confirmed that the gland was covered by connective tissue in ox and goat as described by (Sisson and Grossman, 1975) and sheep (May, 1970). In the current study the gland in camel was located between the atlas and digastricus muscle, but in ox it was

situated on the medial side of the mandible extending from the wing of atlas into the intermandibular space. However, the glands were lying at the angle of mandible, in camel (Khalil, 1989), cattle (Al-Sadi, 2013) and sheep and goat (Nickel *et al.*, 1976; Rauf, *et al.*, 2004). In this study the mandibular gland of camel, sheep and goat was small and the gland of ox was large when compared with the parotid gland. This was previously reported by Nawar and El-Khaligi (1977) in camel, Dehghani *et al.* (1994) in cattle, Rauf *et al*. (2004) in goat and Nickel *et al.* (1976) in sheep. In the present study the weight of gland in camel was 30.56±3.554 g, 72.6±0.811 g in ox, 2.14±0.476 g in sheep and 2.86±0.595 g in goat. In contrast, the weight of mandibular gland in camel was 52-70 g (Khalil, 1989); 47.9±9.1 g in cow (Dehghani *et al.*, 1994); 9.05 g in sheep (Sisson and Grossman, 1975) and 13.5±2.6 g in goat (Tadjalla *et al.*, 2002). This variation in weight is probably due to age or nutritional status. The mean length of the gland in camel, ox, sheep and goat was 9.26±0.441 cm, 10.7±0.393 cm, 5.14±0.206 cm and 4.9±0.363 cm respectively. This is in agreement with Khalil (1989) who reported a length of 9.5 cm in camel but in disagreement with Van Lennep (1957) who reported 11-12 cm in camel and 20-25 cm in sheep Dehghani *et al.* (2000). According to Khalil, (1989) the width of gland of camel was 2.69-4.51 cm but Van Lennep (1957) reported 7-9 cm. Presently the width of gland of camel was 4.72±0.387 cm which was almost identical to that reported by Khalil (1989).

In this study the cranial extremity of the gland of camel and ox was related to great cornu of hyoid bone and occipitohyoideus muscle. The caudal extremity was related to the ventral buccal nerve, sternohyoideus, omohyodideus and sternomandibularis muscles and mandibular lymph node. This is in agreement with Khalil (1989) in camel and Al-Sadi (2013) in cattle. In the sheep and goat the cranial extremity was related to caudal auricular vein, great auricular nerve and retropharyngeal lymph node. The caudal extremity was related to mandibular lymph node, omohyoideus and sternohyoideus muscles, adipose tissue, cutaneous muscle and skin (May, 1970) in sheep and (Rauf *et al*., 2004) in goat. In this investigation the lateral surface of the gland in camel was related to thick connective tissue, parotid gland, and caudal auricular vein and the medial surface was related to lateral retropharengeal lymph node, occipital vein and stylohyoideus muscle. Nawar and El-Khaligi (1977) had described the lateral surface of the gland of camel as being traversed by the maxillary and caudal auricular veins and that the deep surface was related to the lateral retropharyngeal lymph node, occiptal vein and the stylohyoideus muscle.

In the present work and according to Al-Sadi (2013) in cattle the lateral surface of the gland of cattle was related to parotid gland, facial and maxillary veins. The medial

surface was related to the mandibular duct, lateral retropharyngeal and thyroid lymph nodes. In sheep however, the lateral surface was related to the parotid gland, adipose tissue, maxillary and linguofacial veins. The medial surface was related to external carotid artery, thyroid gland and thyroidhyodeus and stylohyoideus muscles. In goat the lateral surface was related to parotid gland, maxillary vein, linguofacial vein and sternomandibularis muscle. The medial surface was related to thyroid gland, cleidomastoideus and thyroidhyoideus muscles and ventral buccal branch of facial nerve.

In this study the mandibular duct left the gland and passed along the lower jaw between the mylohyoideus and geniohyoideus muscles toward the external surface of the styloglosuss muscle together with the ventral buccal and lingual nerves. A similar course was given by Khalil (1989) in camel, Al-Sadi (2013) in cattle, Dehghani *et al.* (2000) in sheep and Rauf *et al.* (2004) in goat.

In the present study the mandibular duct opened in the oral vestibule at the sublingual caruncle in ox, sheep and goat and at a mucosal fold in the sublingual region in camel. This is in agreement with Nawar and Elkhaligi (1977) in camel, Al-Sadi (2013) in cattle, Dehghani *et al.* (2000) in sheep and Tadjalli *et al.* (2002) in goat.

In the present study the mandibular duct was variable in length and diameter. The length was 32.2±2.28 cm in camel, 40.2±0.924 cm in ox, 18.4±0.419 in sheep and 16.8±0.483 cm in goat. The diameter of the mandibular duct was 0.22±0.447 cm in camel, 0.22±0.447 cm in ox, 0.18±0.447 cm in sheep and 0.18±0.447 mm in goat. It was similar in diameter in ox and camel and also in sheep and goat. Histologically, the present investigation showed that the gland was covered by dense connective tissue septa which consisted of collagenous, elastic and reticular fibres. The pranchyma of gland of camel, ox and sheep consisted of was compound tubuloacini, but it consisted of tubuloalveolar acini in the gland of goat. In all animals it was composed of serous, mucous, demilunes and ducts. This was in agreement with (Khalil, 1989) in camel, (Rauf *et al.*, 2004) in goat, (Khojasteh and Delashoub, 2012) in European hamster.

The presence of both serous and mucus acini indicated a mixed secretion. This had been reported in camel (Khalil, 1989), bovine (Shackleford and Wilborn, 1968), goat (Rauf *et al.*, 2004) and dog and cat (Mina *et al.*, 2004). In this study the gland of camel, ox, sheep and goat had serous and mucous acini. An entirly mucus gland had been reported in ferrets (Poddar and Jacob, 1977). It is therefore suggested that the gland secretes digestive enzymes and mucus for lubrication of oral cavity.

The present study had shown differences in diameters of acini in the gland of camel, ox, sheep and goat. The small acini revealed a

slight difference (Pin diameter between camel and sheep but a similar diameter in goat and camel, ox and sheep and goat and sheep. The intermediate acini showed a slight difference (Pbetween camel and ox, ox and sheep and sheep and goat. The large acini showed clearly a small difference (P0.05) in diameter among these animals. In the current study the demilunes were serous in camel, ox, sheep and goat. Similarly Rauf *et al*. (2004) reported that the demilunes were serous cells in goat. However Nawar and El-Khaligi (1977) in camel, Shackleford and Wilborn (1968) in sheep and cow described the demilunes as seromucous cells. In this study the mandibular gland had four classes of ducts which included; intercalated, striated, interlobular and interlobar duct. Islam (1981) reported that the mandibular gland of goat had an intercalated, striated and excretory duct. In this study the intercalated duct was lined by simple cuboidal cells with spherical nuclei. The presence of spherical nuclei in the eptheilial lining of intercalated duct is also reported by Nawar and El-Khaligi (1977) and Khalil (1989) in camel, Shackleford and WiIborn (1970) in calf and Tandler and MacCallum (1974) in European hedgehog. The striated duct was lined by simple columnar cells with basal striations. The simple columnar and the basal striations observed in this study were similar to that observed in goat (Rauf *et al*., 2004) and camel (Khalil, 1989). The interlobular duct was lined by simple columnar cells and the interlobar duct was lined by stratified columnar cell as in camel (Nawar and EL-Khaligi, 1977), bovine (Shackleford and Wilborn, 1969) and goat (Rauf *et al.*, 2004). It was claimed that the presence of stratified epithelium in the interlobular duct may reflect the need for protection of underlying basement membrane for occasional action of activated serous fluid enzymes (Ikpegbu *et al.*, 2014). In present study the mandibular ducts were variable in diameters. This was confirmed by histometry. The diameters of the intercalated duct revealed a slight difference (Pbetween camel and ox and almost identical in sheep and goat. The diameters of striated duct of camel revealed a big variation in diameter between the goat and other animals but the diameter was almost similar in camel, ox and sheep. The diameters of interlobular duct were similar in camel, ox and sheep and a big difference (P was shown between goat and the rest of animals. The diameters of interlobar duct revealed greatest diameter in the goat but were similar in camel, ox and sheep. The present study had demonstrated myoepihelial cells around the acini and intercalated ducts. A similar observation was reported by Tamarin (1966) and Ikpegbu *et al.* (2014) in rat. Martinez-Madrigal and Micheau (1989) and Redman (1994) reported that the myoepithelial cells which surrounded the secretory acinar cells and intercalated ducts provided contractile force to help expel the secretion from the acinar cells into the

intercalated duct. In the current investigation, the ultrastructure of the gland showed the presence of two types of cells; serous and mucus in camel, ox, sheep and goat which revealed the presence of numerous vesicles with or without dense granules. Mansouri and Atri (1994) reported that the gland of camel contained heterogeneous secretory granules.

The sections of the gland had shown serous and mucous cells. This was also true in camel (Mansouri and Atri, 1994), man (Pinkstaff, 1980) and dog and cat (Dorey and Bhoola, 1972). In this study the serous cell was characterized by the presence of numerous mitochondria and secretory granules, Golgi complex, rough endoplasmic reticulum with free ribosomes. A similar report was given by (Jaccob and Poddar, 1987) in ferret. The serous cell had a round nucleus located centrally. Chromatin granules were scattered in the nucleoplasm and along the folded nuclear membrane. The mitochondria were located around the nucleus in the camel and sheep but they were apical in ox and goat. The mucous cell had an oval, flattened nucleus located at the basal part of gland. The mitochondria were located around the nucleus in the camel, laterally and apically in ox, and formed apical aggregations towards the lumen in the sheep and goat. A well developed Golgi complex and Rough endoplasmic reticulum in camel, ox, sheep and goat were present in the cytoplasm.

In the present study the myoepithelial cells were dark with spindle-shaped nucleus and scanty cytoplasm containing cytplasmic organelles. This was similar to the observation reported by Tamarin (1966) in rat.

In the present study the gland of camel showed a PAS-positive reaction, non-resistant to diastase digestion which probably indicated the presence of glycogen in the gland while in the ox, sheep and goat the positive reaction was resistant to diastase. This was in agreement with Nawar and El-Khaligi (1977) in camel, Shackleford and Wilborn (1968) in mammals. They reported that the mandibular mucus cell contained neutral mucopolysccharides. But there was a weak reaction in the lining epithelium in the ducts of camel, while the reaction was strong in the epithelial lining of intercalated, striated, interlobular and interlobar in the gland of ox, sheep and goat. Van Lennep (1957) claimed that glycogen was often found in the cells of the intercalated and striated ducts in camel. In this study the reaction was moderate in the lining epithelium of mucous acini and strong in the lining epithelium of serous acini and weak in the connective tissue in the gland of ox, sheep and goat.

Acid mucopolysccharides (AB) reaction was positive in the camel, ox, sheep and goat. A strong reaction was seen in the mucous cell and a negative reaction in the serous acini in all animals. The intercalated, striated, interlobular and interlobar ducts

reacted weakly in camel and sheep, but the reaction was weak or negative in ox and goat. The reaction was negative in the connective tissue in gland of camel, ox, sheep and goat. The presence of acid mucopolysccharides in acini and deminules of mandibular gland was observed in camel (Abdalla, 1979), ruminants (Shackleford and Wilborn, 1968), human (Munger, 1964) and in rabbits (Al-Saffar, 2014).

## CONCLUSION AND RECOMMENDATIONS

### Conclusion

Grossly minor differences were observed in the location, topography, shape and linear measurements of the parotid and mandibular salivary glands of the camel, ox, sheep and goat.

Histologically the parenchyma of the parotid gland was made up of tubuloacinar units in camel, ox and sheep and tubuloalveolar in the goat. In camel parotid gland the acini were

entirely mucous but serous in other animals. The demilunes of mandibular gland of camel, ox and sheep consisted of serous and mucous cells but in the goat the demilunes were made up of serous cells. Histometrically there were high significant differences between the diameters of acini and ducts among these animals.

Ultrastructurally there were accumulations of cell components which were variable among the animals used.

Histochemically the glands were positive to periodic Acid Schiff (PAS) but the parotid gland was negative to Alcian Blue (AB) which indicates that the gland secreted neutral mucopolysccharides. In contrast the mandibular gland was positive to Alcian Blue stain, an indication of the presence of acid mucopolysaccharides.

**Recommendations**

Future immunohistochemical studies are needed to characterize the secretions of the parotid and mandibular glands in these animals.

**References**

**Abdalla**, **A. B**. **(1979).** Structure of the secretory cells of the salivary glands of the dromedary camel, *Sudan Journal of Veterinary Science and Animal Husbandry*, **20**: 65-76.

**Adnyane, I. K. M, Zuki, A. B. Noordin, M. M. and Agungpriyono, S. (2010).** Histological study of the parotid and mandibular glands of Barking Deer (*Muntiacus muntjak*) with special reference to the distribution of carbohydrate content. *Anatomy Histology Embryology*, **39 (6)**: 516-520. **Al-Saffar, F. J. (2014).** Histomorphological and Histochemical study of the major salivary glands of adult local rabbits. *International Journal of Advanced Research*, **2**: 278-402.

**Al-Sadi, S. (2013).** Gross and Radiological studies of the salivary glands in cattle. *Basic Journal of Veterinary Research*, **12**: 65-76.

**Al-Samarrae, N. S., Rabie, F. O**. **and Abbas**. **(1989).** Topography and histology of parotid gland of one humed camel. *Iraqian Journal of Veterinary Medicine*, **13** (1): 42-49.

**Amano**, **O**. **(2011).** The salivary gland: anatomy for surgeons and researchers. *Japanese Journal of Oral maxillafac of surgery*, **57**: 384- 393.

**Banks, W**. **J**. **(1992).** *Applied Veterinary Histology*. 3rd Ed. Mosby year book. United

State of America. **Bancroft**, **J**. **D**. **and Stevens**, **A**. **(1990).** *Theory and Practice of Histology Techniques*. 3th Ed New York USA. Edinburgh. **Barnwal**, **A. K., Sinha, R. D. (1981).** Macromorphological of the mandibular salivary gland of buffalo (*Bubalus bubalis*). *Indian Journal of Animal Science*, **51**: 931-935.

**Blair-West, J. R., Coghlan, J. P., Denton, D. A., Nelson, J., Wright, R. D. and Yamanchi**, **A. (1969).** Ionic, histological and vascular factors in the reaction of the sheep's parotid gland. *Journal of Physiology* (London), **205**: 563- 579. **Boshell, J. L. and Wilborn, W.H. (1978).** Histology and ultrastructure of pig parotid gland. *American journal of anatomy*, **152**: 447-465. **Brocco, S. L. and Tamarin, A. (1979).** The topography of the rat submandibular gland parenchyma as observed with SEM *Anatomical record* (*New York*),**194**: 445-459.

**Cangussu, S. D., Vieira, F. G. and Rossoni, R. B. (2002).** Sexual dimorphism and seasonal variation in submandibular gland histology of Bolomys lasiurus (Rodentia, Muridae). *Journal of Morphology*, **254**: 320-327. **Carleton**, **H. M. (1967).** *Histological Technique*. 4th Ed. New York London and Toronto. Oxford University Press.

**Cowley, L. H. and Shackleford, J. M. (1970).** Electron microscopy of squirrel monkey parotid glands. *Alabama Journal of Medical Sciences*, **7**: 273-282. **Dehghani, S. N., Lischer, C. J., Iselin, U., Kaserhotz, B. and Auer, J. A. (1994).** Sialography in cattle: Technique and Normal Appearance. *Veterinary Radiology and Ultra Sound*, **35** (6): 433-439. **Dehghani, S. N., Tadjalli, M. and Masoumzadeh, M. H. (2000).** Sialography of sheep parotid and mandibular salivary glands. *Research of Veterinary Sciences*, **68**: 3-7.

**Dehghani, S. N., Tadjalli, M and Seifali, A. (2005).** Sialography in horse: technique and normal appearance. *Veterinarski Arhiv*, **75**: 531-540. **Dellman, H. D. and Brown, E. M. (1981).** *Text Book of Veterinary Histology*. 2ed Ed. Lea and Febiger. Philadelphia.

**Dellman, H. D. and Eurell, J. (1998).** *Textbook of veterinary histology*. 5th Ed. Lea and Febiger. Philadelphia.

**Dorey, G. and Bhoola, K. D. (1972).** Ultrastructure of duct cell granules in mammalian submaxillary glands. *Zeitschrift fur Zellforschung und Mikroskopische Anatomie*, **126**: 335-347. **Drury, R. A. B. and Wallington, E. A. (1980).** *Carleton's Histological Technique*. 5th Ed. New York. Toronto. Oxford University Press. **Dyce**, K. **M., Sack, W. O., Wensing, C. J. G. (2010).** *Textbook of Veterinary Anatomy*. Published in China library

of Congress Catalouging in WB Saunders Comp.

**Elewa, Y. H., Bareedy, M.H., Abuel-Atta, A. A., Ichii, O., Otsuka, S., Kanazawa, T., Lee, S., Hashimoto, Y and Kon, Y. (2010).** Strucural characteristics of goat (*Capra hircus*) parotid salivary glands. *Japanese Journal of Veterinary Research*, **58** (2):121-135. **El-Ramli, A., Yasear, A. Y and Sultan, A. (2013).** Structural Histological changes in the parotid salivary gland of rabbit treated with neostigmine. *Journal of Basic medical allied sciences*, 1: 1-15. **Emmelin, N. and Gjorstrup, P. (1973).** On the function of myoepithelial cells in salivary gland. *Journal of physiology*, **230**: 185-198. **Espinal, E. G., Ubios, A. M. and Cabrini, R. L. (1983).** Freeze-fracture surface of salivary glands of rat observed by scanning electron microscopy. *Acta Anatomica*, **117**: 15-20.

**Estecondo, S., Codon, S.M and Casanave, E.B. (2005).** Histological Study of the Salivary Glands in *Zaedyus Pichiy* (Mammalia, Xenarthra Dasypodidae) *International Journal of Morphology*, **23** (1): 19-24.

**Hofmann**, **R. R. (1989**). Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia*, **78**: 443-457.

**Hoppe, P., Kay R. N. B. and Maloiy G. M. O. (1975).** Salivary secretion in the camel. *Journal of Physiology*, **244**: 32-33.

**Ikpegbu, E., Nlebedum, U. C., Nnadozie, O. and Agbakwuru, I. O. (2014).** The mandibular salivary gland of the adult African giant pouched rat (*Cricetomy gambianus, waterhouse 1840*) microscopic morphology. *Eurpean Journal of Anatomy*, **18**: 26-31.

**Islam, M**. **N. (1981).** Gross anatomy of the salivary gland of the Black Bengal goat. *Bangladesh Veterinary Journal*, **15**: 17-21. **Jacob, S. and Poddar, S. (1987).** Ultrastructure of the ferret submandibular gland. *Journal of Anatomy*, **154**: 39-46. **Jaskoll, T., Zhou, Y. M., Chai, Y., Makarenkova, H. P., Collinson, J. M., West, J.D. and Carvalho, A. D. (2002).** Embryonic submandibular gland morphogenesis; stage-specific protein localization of FGFs, BMPs, Pax6 and Pax9 in normal mice and abnormal phenotypes in FgFR2-111 c (+/Delta), BMP7 (-/-) and Pax6 mice. *Cells, Tissues and Organs*, **170**; 83-90. **Jezek, D., Banek, L. J., pezerovic Panijan, R and Pezerovic, D.Z (1999).** Quantitative study on the rat parotid gland after orchiectomy. *Veterinarski Arhiv*; **69**: 49-59.

**Junior, B. K. and Masuko, T. S. (1998).** Ultrastructure of the

parotid and submandiular gland of the old world marten (*Carnivora mustelidae*). *Annals of Anatomy*, **180**: 31-36.

**Kay, R. N., Engelhardt, W. V. and White, R. G. (1980).** The Digestive Physiology in wild ruminants. In: *Digestive Physiology and Metabolism in Ruminants*. (eds. Y. Ruckwbusch and P. Thivend). MTP press, Lancaster.

**Kay**, **R**. **N. B**. **(1987).** Weights of Salivary glands in some ruminant animals. *Journal of Zoology London*, **211**: 431- 436. **Kay, R. N. B. and Maloiy, G. M**. **O. (1989).** *Digestive secretions in camels*. Options mèditerreane-series seminaries-n. 2º. **Kayanja, F. I. B. and Sholtz, P. (1974).** The ultrastructure of the parotid gland of some East African Wild Ungulates. *Anatomischer Anzeiger*, **134**: 339-350. **Khalil**, **M. M. K**. **(1989).** *Morphological studies on the salivary glands of the one humped camel* (*Camelus dromedarius*). MVSC thesis. Faculty of Veterinary Science. U.K.

**Khojasteh, S. M. B. and Delashoub, M. (2012).** Microscopic anatomy of the parotid and submandibular salivary glands in European hamster (*Cricetus cricetus*). *International Research Journal of Applied Basic Sciences*, **3** (7): 1544-1548.

**Leppi, T. J. and Spicer, S. S. (1966).** The histochemistry of mucins in certain primate salivary glands. *American Journal of Anatomy*, **118**: 833-860. **Leeson**, **C. R. (1967).** Structure of salivary glands. In Handbook of physiology (ed. C.F. code), Sect. *American Physiological Society*, Washington, D. C, **6** (11): 463-495.

**Mansouri**, **S. H. and Atri**, **A.** (**1994**). Ultrastructure of parotid and mandibular glands of camel (*camelus dromedarius*). *Journal of Applied Animal Research*, **6** (2):131-141. **Martinez-Madrigal, F. and Micheau, C. (1989).** Histology of the major salivary glands. *American Journal of Surgery and Pathology*, **13**: 879-899. **May**, **N. D. S. (1970).** *The Anatomy of the sheep*. 3rd Ed. University of Queensland Press.

**McLeod, W. M., Trotter, D. M. and Lumb, J. W. (1964).** *Bovine Anatomy*. 2ed Ed. Burgess publishing CO., USA. **Michael**, **M**. **and Valerie, D. O.** (**2006**). *Human anatomy*. 4th Ed. McGraw Hill; America, New York.

**Miletich**, **I**. (**2010**). Introduction to salivary glands: structure, function and embryonic development. *Front Oral Biology*, **14**: 1-20.

**Mina, T., Seifollah, N. D. and Mehrdad, B. (2004).** Sialography in dog: normalappearance. *Veterinarski Arhiv*, **47**: 225-233.

**Mohammadpour**, **A**. **A**. **(2010).** Anatomical and histological study of molar salivary gland in domestic cat. *Iranian Journal of Veterinary Researches*, **11**: 164-167.

**Munger, B. L. (1964).** Histochemical studies on seromucous and mucous secreting cells of human salivary glands. *American Journal of anatomy*, **115**: 411-429.

**Nawar, S. M. A. (1980).** Micromorphological study of the salivary gland of goat. *Journal of Veterinary Medicine*, **28**: 329-339.

**Nawar, S. M. and El-Khaligi, G. E. (1975).** Morphological, micromorphological and histochemical studies on the parotid Salivary gland of one-humped camel (*Camelus dromedarius*). *Gegenbaurs morphologisches Jahrbuch, Leipzig*, **4**: 430-449.

**Nawar, S. M. and El-Khaligi, G. E. (1977).** Morphological and Histochemical Studies of the mandibular salivary glands of one-humped camel (*Camelus dromedarius*). *Anatomischer Anzeiger,* **142** (4): 346-362.

**Nickel, R., Schummer, A. and Seiferle, E. (1976).** *The viscera of the domestic animals*. 2ed Ed. Verlag Paul Parery. Berlin. Hamburg.

**Ogawa, Y.** (**2003**). Immunocytochemistry of myoepithelial cells in the salivary glands. *Histochemstry and Cytochemistry*, **38** (4): 343-426.

**PinkStaff**, **C. A.** (**1980**). The cytology of salivary glands. *International Review of Cytology*, **63**: 141-261.

**Poddar**, **S. and Jacob**, **S.** (**1977**). Gross and microscopic anatomy of the major salivary glands of the ferret. *Acta Anatomia*, **98**: 434-443.

**Raubenheimer, E. J., Dauth, J., Dreyer, M. J. and De Vos, J. (1988).** Parotid salivary gland of the African Elephant (*Loxodonta African*) structure and composition of saliva. *Journal of the South African Veterinary Association*, **59** (4): 184-187.

**Rauf, S. M. A., Islam, M. R. and Anam, M. K. (2004).** Macroscopic and microscopic study of the mandibular salivary gland of Black Bengal goats. *Bangladesh Journal of Veterinary Medicine*, **2**: 137-142.

**Redman, R**. **S. (1994).** Myoepithelium of salivary glands. *Microscopic Research Technique*, **27**: 25-45.

**Riva, A., Motta, M. P. and Riva-Testa, F. (1974).** Ultrastructural diversity in secretory granules of human major salivary glands. *American Journal of Anatomy*, **139**:293-298.

**Riva, A., Testa-Riva., F., DelFiacco, M. and Lantini, M. S. (1976).** Fine structure and cytochemistry of the interlobular ducts of the human parotid gland. *Journal of Anatomy*, **122**: 627-640.

**R-Star, (2013**).

*Statistical Tools for Agriculture Research*. Version 1.1, international rice research institute (IRRI) Los banos, Phillippines. **Saracco**, **C.G and Crabill, E.V. (1993).** *Anatomy of the human salivary glands*. In: Biology of the salivary glands., ed. by K. Dobrosielski-Vergona, CRC Press; Boca Raton.

**Sengar**, **O**. **P**. **S and Singh**, **S**. **N**. **(1970).** Studies of the digestive system of ruminants 3-strucure of the foregut in buffalo (*Bos bubalis).Agra University Journal of researches Science*, **19**: 43-*64.*

**Shackleford, J. M. and Schneyer, C. A. (1964).** Structural and functional aspects of rodent salivary glands including two desert species. *Amrican Journal of Anatomy*, **115**: 279-307.

**Shackleford, J. M. and Wilborn, W. H. (1968).** Structural and histochemical diversity in mammalian salivary gland. *Alabama Journal of medicalsciences*, **5**: 180-203.

**Shackleford**, **J. M. and Wilborn**, **W**. **H**. **(1969).** Ultrastructue of bovine parotid glands. *Journal of Morphology*, **127**: 453-473. **Shackleford, J. M. and Wilborn, W. H. (1970).** Ultrastructural aspects of calfsubmandibular glands. *American Journal of Anatomy*, **127**: 259-279. **Sisson**, **S**. **and Grossman**, **J. D**. **(1975).** *The anatomy of the Domestic Animals*. 5th Ed. Philadelphia, London, W. B. Saunders Co.

**Smuts, M. M. S and Bezuidenhout, A. J. (1987).** *Anatomy of the Dromedary*. Oxford: Clarendon Press.

**Stolte, M. and Ito, S**. **(1996).** A comparative ultrastructural study of parotid gland acinar cells of nine wild ruminant species (Mammalia artiodactyla). *European Journal of Morphology*, **34**: 79-85. **Suzuki, S., Kamei, K. and Otsuka, J. (1975).** On the fine structure of salivary gland of goat and dog. I. parotid gland. *Bulletin of the Faculty of Agriculture*, **25**: 25-41.

**Suzuki**, **S. and Otsuka**, **J**. **(1977).** On the fine structure of salivary gland of rabbit: I. parotid gland. *Bulletin of the Faculty of Agriculture*, **27**: 95-104. **Suzuki, S., Nishinakagawa, H. and Otsuka, J. (1981).** Fine structure of the bovine parotid gland. *Japanese Journal of Veterinary Sciences*, **43**: 169-179. **Tadjalli, M., Dehghani, S. N. and Ghadiri, M. (2002).** Sialography of the goat parotid, mandibular and sublingual salivary glands. *Small Ruminant Researches*, **44**:179-185.

**Tandler, B. and MacCallum, D. N. (1974).** Ultrastructure and histochemistry ofthe submandibular gland of the European hedgehog (*Erinaceus europaeus*). *Journal of Anatomy*, **117**: 177-131. **Tandler, B. and Erlandsen, R. A. (1976).** Ultrastructure of baboon parotid gland. *The Anatomical*

*Record*, **184**: 115-132. **Tandler, B. and Cohan, R. P. (1984).** Structure of the parotid gland in the little brown bat. *Anatomical Record*, **210**: 491-502. **Tandler, B., Nagato, T. and Carleton**, **J. P. (1998).** Ultrastructure of the binary parotid glands in the free-tailed bat, Tadarida thersites. II, Accessory parotid gland. *The Anatomical Record*, **252**: 122-135. **Tamarin, A. and Sreebny, L. M. (1965).** The rat submaxillary salivary gland: a correlative study by light and electron microscopy. *Journal of Morphology*, **117**: 295- 352.

**Tamarin**, **A**. **(1966).** Myoepithelial of the rat submaxillary gland. *Journal of Ultrastrucural Researches*, **16**: 320-338.

**Thienpont, D., Rochette, F. and Vanparijs, O. F. J. (1986).** *Diagnosing Helminthiasis by Coprological Examination*, 2ed Ed. Janssen Research foundation. Beers, Belgium.

**Van Lennep, E. W. (1957).** The glands of the digestive system in the one humped camel, (*Camelus dromedarius*). 1. The salivary glands. *Acta Morphologica Neerlando Scandinavica*, **1**: 286-292.

**Van Lennep, E. W., Kennerson, A. R. and Compton, J. S. (1977).** The ultrastructure of the sheep parotid gland. *Cells and Tissues Researches*, **179**: 377-392. **Venkata, K**, **A. and Mariappa, D**. **(1969).** Studies on the structure of salivary glands of Indian buffaloes (*Bos bubalis*). *Indian Veterinary Journal*, **46**: 768-773.

**Watanabe**, **I., Koriyama,Y. and Yamada, E. (1992).** High resolution scanning electron microscopic study of the mouse submandibular salivary gland. *Acta Anatomica*, **143**: 59-66.

**Watanabe, I., Seguchi, H., Okada, T., Kobayashi, T., Jin, Q. S. and Jiang, X. D. (1996).** Fine structure of the acinar and duct cell components in the parotid and submandibular salivary glands of the rat: a TEM, SEM, and HRSEM study. *Histology and Histopathology*, **11**: 103-110.

**Williams, P. L., Warwick, R., Dyson, M. and Bannister, L. H. (1989).** *Gray's Anatomy*. 37th Ed. Churchill Livingstone. Edinburgh.

**Zhou**, **J**., **Wang**, **H**., **Xang, G., Wang, X., Sun, Y., Song, T., Zhang, C. and Wang**, **S. (2010).** Histological and ultrastructural characterization of developing miniature pig salivary gland. *Anatomical Records*, **293**: 1227 1239.