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Anatomy of the Mouth of the Giraffe (*Giraffa camelopardalis rothschildi*)

Anatomía de la Boca de la Jirafa (*Giraffa camelopardalis rothschildi*)

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SUMMARY: The giraffe (*Giraffa camelopardalis*) is both the largest extant ruminant and a strict browser. We dissect and describe the macroscopic anatomy of the mouth of the giraffe. The heads of two adult giraffes and one fetus were used in this study. The lips were well developed, the upper one was predominant and dorsally flattened near the nostrils. The tongue had a lift or lingual torus and rostrally to it a groove-shaped depression or fossa linguae. There was no adipose body of cheek (*Corpus adiposum buccae*). The hard palate in the giraffe had 18 Rugae palatinae. The final roughness reaches the caudal border of the premolar 3. Caudal ridges had no papillae. The parotid gland was small and consisted of two lobes, one rostral and one caudal to be separated dorsally to accommodate the parotid lymph node. The parotid duct followed the same way as in the cow, ended in front of the upper premolar tooth 2 in the parotid papilla, (not evident at mucosal surface). Mandibular gland was divided into two lobes, the rostral one placed in the intermandibular space and the caudal hidden by the parotid gland. Giraffes have the monostomatic and polistomatic sublingual glands. The monostomatic sublingual gland was located rostrally and joined to the monostomatic of the other side in the very narrow rostral intermandibular space. The polistomatic sublingual gland was caudally located and reached the level of the third molar and at a deeper level than the monostomatic. The studied giraffes had dorsal, ventral and intermediate bucal salivary glands. Leaving aside the differences caused by different dimensions, the mouth of the giraffe had in general a similar anatomical arrangement to the cow.

KEY WORDS: Mouth; Giraffe; Giraffa *camelopardalis rothschildi*; Macroscopic anatomy.

INTRODUCTION

The giraffe (*Giraffa camelopardalis*) is both the largest extant ruminant (Owen-Smith, 1988) and a strict browser (Leuthold & Leuthold, 1972; Pellew, 1984; Codron *et al.*, 2007). The Rothschild's giraffe is the latest charismatic African mammal to be declared "Endangered" by IUCN (the International Union for the Conservation of Nature) indicating that the Rothschild's populations are in peril. The Rothchild's now appears under the IUCN Red List *(http://www.iucnredlist.org/apps/redlist/details*/174469/0).

There are currently nine recognized giraffe subspecies and the Rothschild's is the second most imperiled, with fewer than 670 individuals remaining in the wild; it has been almost totally eliminated from most of its former range and now survives in only a few small and isolated populations in Kenya and Uganda.

The existing evidence indicates that, when compared to large grazing ruminants, the giraffe has a smaller rumen with weaker rumen pillars (Clauss *et al.*, 2003b), lower reticular crests (Hofmann, 1973), a smaller omasum (Clauss *et al.*, 2006a), less developed masseter muscles (Clauss *et al.*, 2008), average-sized parotis and larger mandibular glands (Hofmann *et al.*, 2008), a uniform rumen papillation indicative for an absence of stratification of the rumen contents (Clauss *et al.*, 2009), and a less distinct selective particle retention in the forestomach (Clauss *et al.*, 2006b). The teeth of the giraffe are different from those of grazing ruminants (Janis, 1995), which results in a reduced chewing efficiency on artificial diets in captivity (Clauss *et al.*, 2002) as compared to the natural diet (Hummel *et al.*, 2008). According to Clauss *et al.* (2007) captive giraffe do not attain the longevity possible for this species and frequently have

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problems associated with low energy intake and fat storage mobilization. Abnormal tooth wear has been among the causes suggested as an underlying problem.

The tongue was in part described in other work (Lahkar *et al*., 1989). Hall-Martin (1976) published the dental anatomy about giraffes and Clauss *et al.* (2007) studied the tooth wear in a captive giraffes. Clauss *et al.* (2007) indicates that due to the more abrasive type of food consumed by animals in captivity they are under increased teeth wear.

To our knowledge, the complete anatomy of the mouth and salivary glands of the giraffe have not been published so far, and therefore, we wanted to use the opportunity of two adult giraffe and one foetus dissections to describe these organs and we compared them with the domestic ruminants (specially with bovine species) in order to improve the existing knowledge on this species.

MATERIAL AND METHOD

The heads of two adult giraffes and one fetus were used in this study. The animals proceeded from a Zoological Garden of Uruguay. The animals were dissected at the Veterinary Faculty of the University of Montevideo. After removal of the heads, the skin was removed and the muscles were identified and dissected. Subsequently the salivary glands and their conducts were dissected. After this the floor and roof of the oral cavity were dissected and the remnant structures were removed and cleaned the head by ebullition in caustic solution. The head was radiographed and the teeth removed for posterior studies. The weight and dimensions listed in the text were taken in the organs of one of the giraffes. The dissections were documented by digital photography (Nikon D90). Additionally we observed two living giraffes eating in order to study the activity of visible and superficial structures. Data from the domestic cattle was taken from Barone (1997) in order to compare. Terms are used in agreement with the Nomina Anatómica Veterinaria.

RESULTS

The muscles that form the cheek and act over the lips were identified and dissected: masseter, buccinator, zygomatic, canine, lifting the upper lip, lower lip depressor depressor upper lip. There was no parotid-auricular muscle. The cutaneous muscle of the face was poorly developed. Observing living giraffes while feeding you can see the prominences of the above mentioned muscles, especially of the zygomatic and buccinators ones. The lips and tongue of the giraffe are the main elements used in the obtaining of food. The lips were well developed, the upper one was dominant and flattened dorsally near the nostril. The tongue had a lift or lingual Torus (Fig. 1) and rostrally to it a groove-shaped depression or fossa linguae. The rostral part of the tongue was pigmented, black, mostly in its ventral side. The lingual papillae were circumvallate, lenticular, fungiform and conical. They were a few and short, which gave the tongue a smooth appearance. The extrinsic muscles of the tongue were styloglossus, hyoglossus and genioglossus muscles, which were highly developed.

Fig. 1. Palatum and tongue of the giraffe. 1: Apex linguae; 2: Fossa linguae; 3: Torus lingual; 4: Palatum durum, caudal part; 5: Rugae palatinae; 6: Papillae buccales, 7: Pulvinus dentalis.

The inside of the cheek (Bucca) (Figs. 1 and 2) presented abundant oral papillae of 2.0 cm in length and 3 mm in diameter at its base. Between the skin and mucosa the buccinators and depressor muscles of the lower lip and buccal salivary glands were located. The cheek had no body fat (*Corpus adiposum buccae*). We found 18 Rugae palatinae on the hard palate of the giraffe (Fig. 1). The final roughness going to the edge of premolar 3. There were no papillae at the caudal ridges. The width in the most rostral incisive foramen level was 5.5 cm, 4.0 cm in the middle and 8.0 cm in the most caudal. The hard palate in the more caudal side showed a depression, and in the remainder was flat. The soft palate was slightly concave and relatively short. The parotid gland (Fig. 3 and 4) was small and consisted of two lobes, one rostral and one caudal which were separated dorsally to accommodate the parotid lymph node. The rostral lobe measuring 6 x 3 cm and 8 x 4 cm. The caudal lobe was thicker. The left weighed 90 g and 88 g right one. The parotid lymph node measured 6 x 3 cm and weighed 10.5 g, the left one 8.7 g left right.

The parotid duct passed through the mandibular fissure accompanying the facial artery and vein. Ended in front of the upper premolar tooth 2 in the parotid papilla (not evident at mucosal surface). The mandibular gland (Figs. 4 and 5) was divided into two lobes, one rostral placed in the intermandibular space and the caudal was hidden by the parotid gland. The rostral lobe was subdivided into small lobes and the caudal lobe was smaller. Rostral lobe was 2.5 cm thick the caudal was 1.5 cm. It weighed

Fig. 3. Left side view of the caudal part of the head. 1: Left Parotid gland; 2: Left parotid lymph node. This photo is schematized in the right side (caudal part of the head) of the figure 4.

Fig. 2. Rostral part of the floor of the mouth. CS: *Caruncula sublingualis*.

170 g. The animals studied presented the monostomatic and polistomatic sublingual glands (Fig. 5). The monostomatic sublingual gland was located rostrally and joined the monostomatic of the other side in a very narrow rostral intermandibular space.

The polistomatic sublingual gland was located caudally and reached the level of the third molar and at a deeper level than the monostomatic. The giraffes studied had buccal glands distributed in dorsal, ventral and intermediate (Fig. 4).

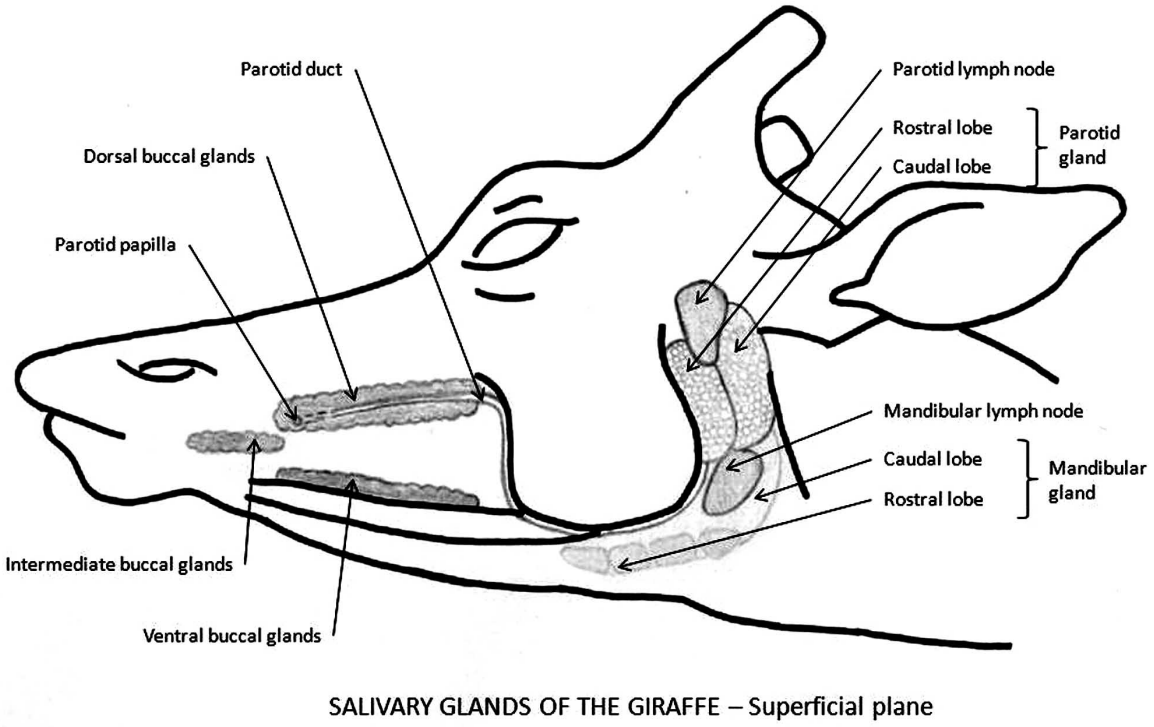

Fig. 4. Schematic drawing of the salivary glands of the giraffe, superficial plane, left side.

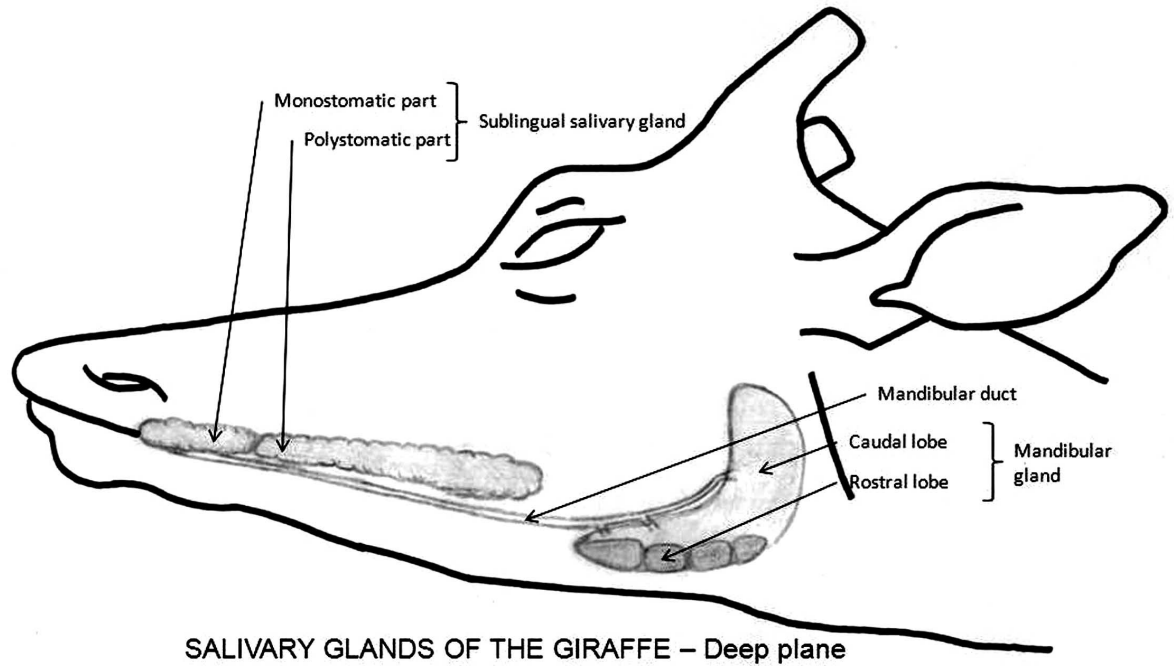

Fig. 5. Schematic drawing of the salivary glands of the giraffe, deep plane, left side.

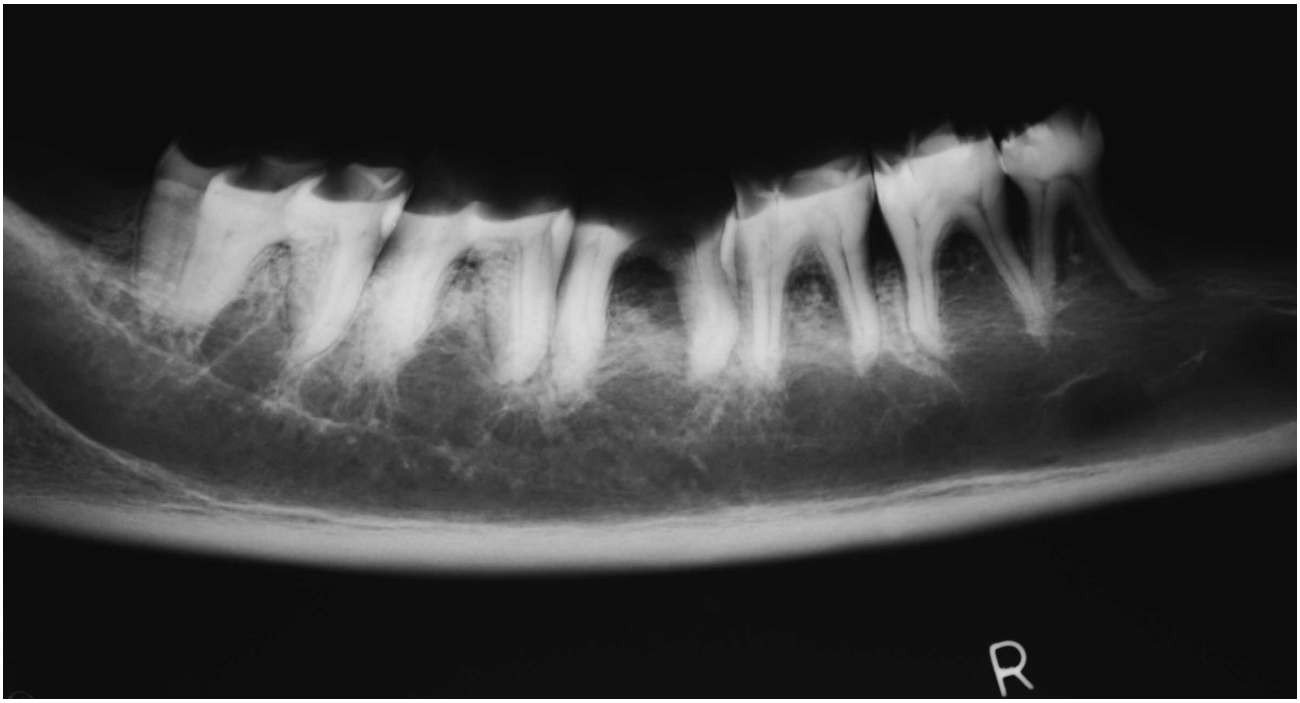

Fig. 6. Radiography of the right mandible of a giraffe to see the location of the roots of the teeth.

Fig. 7. Incisors and canines of the Giraffe (top) and their comparison with the cow (bottom).

Dorsal buccal glands were located in the dorsal part of the buccinator muscle and formed a long, triangular mass of 16 cm long and 2.5 cm wide at the most caudal part. Rostral width became smaller. Ventral buccal glands were a little lower distributed along the ventral border of the buccinators and together were16cm long and1.3cm wide at the caudal part, the width in the rostral part was1.0 cm.

The giraffe dentition had a dental formula (I 0/3 C 0/1 P 3/3 M 3/3)2. Teeth (Figs. 6, 7, 8, 9) were short crown and belonged to the braquidonte type. The incisors and canines were long and their neck slightly marked. The free end of canine tooth was crushed in the vestibular-lingual direction. Premolars and molars were reduced in size, especially the upper and lower molar 1.

Fig. 8. Vestibular surface of inferior premolars and molars of the giraffe (bottom) in comparison with the cow (top).

Fig. 9. Vestibular surface of superior premolars and molars of the giraffe (bottom) in comparison with the cow (top).

Lower premolars and molars have two roots. Superiors had three roots. The temporomandibular joint cavity had its split into two independent parts, dorsal and ventral by a powerful articular disk.

DISCUSSION

Leaving aside the differences caused by different dimensions (different length and proportions), the giraffe's mouth had in general a similar anatomical arrangement to the cow. The data from the cow, which are well known, are published in the veterinary anatomy literature (Barone).

There was nonasolabial plane in the giraffe and the lips were more mobile than those of the bovine. The papillae on the inside of the cheek were long and somewere compound, similar to the ones in the cow. There were three groups of oral glands like in the last mentioned. The hard palate was narrower than in the cow and much longer.

Like in the domestic cattle it was rostrally wide and rounded, and rostrally narrow to the premolars and widened between the molars. The dental pad (*Pulvinus dentalis*) was similar to that of the cow but less developed. There oral orifices of the incisive ducts were the same as in cattle. The number of palatal shelves were similar to the ones in bovine but longer occupying two thirds of the hard palate in the giraffe. The tongue was longer and more mobile than in bovine and pigmented in part of its extension. Genioglossus muscle, which had a larger caudal insertion on the body of the tongue enable a greater mobility and protraction to the outside of the tongue.

The four findings on the tongue coincide with those reported (Lahkar *et al*.). The mandibular gland was slightly larger than the parotid gland similar to bovine. But shape of the latter was very different from the bovine. The parotid gland in the cow was dorsoventrally elongated and did not cover completely the caudal part of the the mandibular gland (Barone), in the giraffe, the parotid had two lobes ventrally joined that were separated like a V dorsally to accommodate the parotid lymph node. The parotid duct of the giraffe had a path similar to that described for the cow (Barone) and opened into the oral cavity itself more rostrally than in the cow the height of the II upper premolar tooth in the parotid papilla. In the cow such duct opens opposite to the upper molar II to the surface of mucosa, with no parotid papillae (Barone). The other salivary glands and their ducts path were similar to those described for bovine (Barone). The dental formula and tooth roots coincide with those of bovine (Barone) and previous reports (Hall-Martin). According to Clauss *et al.* (2007) the dental wear pattern of the free-ranging population is dominated by attrition in a browser herbivore but the wear pattern of the captive population is dominated by abrasion typical of grazing herbivores. A potential explanation for this difference in tooth wear is likely related to the content of abrasive elements in zoo diets: grass hay and the majority of pelleted compound feeds contain higher amounts of silica that caused abnormal wear pattern in captivity giraffes (Clauss *et al*, 2007). Studies on the irrigation and innervation of the mouth of the giraffe are needed and it is also important to study wild animals for its comparison with the zoo animals which have differences as the ones already studied on tooth wear.

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RESUMEN: La jirafa (*Giraffa camelopardalis*) es a la vez el rumiante más grande que existe y un ramoneador estricto. Nosotros disecamos y describimos la anatomía macroscópica de la boca de la jirafa. En este estudio se utilizaron las cabezas de dos jirafas adultas y de un feto. Los labios estaban bien desarrollados, el superior era el predominante y estaba aplastado dorsalmente cerca de las narinas. La lengua tenía una protuberancia o Torus lingual y rostralmente a él una depresión en forma de surco o Fossa linguae. No había cuerpo adiposo de la mejilla (*Corpus adiposum buccae*). El paladar duro en la jirafa tenía 18 rugae palatinae. Las rugosidades finales alcanzaban el borde caudal del premolar 3. Las crestas caudales no tenían papilas. La glándula parótida era pequeña y consistía de dos lóbulos, uno rostral y otro caudal que se separaban dorsalmente para acomodar al nódulo linfático parotídeo. El conducto parotídeo seguía el mismo trayecto que en la vaca, terminando frente al segundo diente premolar superior en la papila parotídea (no evidente en la superficie de la mucosa). La glándula mandibular estaba dividida en dos lóbulos, el rostral se colocaba en el espacio intermandibular y el caudal estaba oculto por la glándula parótida. Las jirafas tenían glándulas sublinguales monostomática y polistomática. La glándula sublingual monostomática estaba localizada rostralmente y se unía a la monostomática del otro lado en el muy estrecho espacio intermandibular. La glándula sublingual polistomática estaba localizada caudalmente y alcanzaba el nivel del tercer molar en un plano más profundo que la monostomática. Las jirafas estudiadas tenían glándulas salivares bucales dorsales, ventrales e intermedias. Dejando de lado las diferencias causadas por las diferentes dimensiones, la boca de la jirafa tenía en general una disposición anatómica similar a la de la vaca.

PALABRAS CLAVE: Boca; Jirafa; *Giraffa camelopardalis rothschildi*; Anatomía macroscópica.

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