MORPHOLOGICAL PARTICULARITIES OF THE TEETH CROWN IN GOLDEN JACKAL (*Canis aureus moreoticus*)

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Abstract

A thorough understanding of dental and oral anatomy is essential for a proper recognition of all members of the carnivore species and to recognize the various signs of disease. As long as the golden jackal spreading in Eastern Europe is steadily increasing, this study aims to present a detailed description of morphological features of golden jackal dental anatomy in order to be used in clinical practice and research. The anatomical crowns of the teeth from superior and inferior jaws of seven golden jackals were examined. The complete dental formula for the permanent dentition in golden jackal is I 3/3 C1/1 PM4/4 M2/3 x 2=42teeth. The inferior dental arch is anisognathic, narrower and shorter compared to the superior dental arch. The superior incisors are located slightly rostral from the inferior incisors. Their size increases from the central to the lateral incisors, each incisor crown showing a prominent cingulum and three tubercles. The canine teeth were similar in length and width, having a simple crown. The first premolar is the smallest on both dental arches, having one tubercle, while the second and third premolars have in addition a small distal tubercle. The superior forth premolar and the first inferior molar form the carnassials tooth. The superior carnassial has three distinguishing lobes: paracone, metacone and protocone. The upper molars have a short, wide and highly rough anatomical crown. The inferior carnassial is the strongest tooth with a three-lobed pattern. Inferior molars are smaller than those of the superior arch. The morphology of the crown of the golden jackal teeth is similar to that described in dogs.

Key words: teeth crown, golden jackal, dentition.

INTRODUCTION

The golden jackal is the most typical member of the genus Canis, having a medium size and no outstanding features. Despite to its phenotypic and genotypic features the golden jackal resembles the grey wolf and coyote rather than the black-backed jackal, side-striped jackal and Ethiopian wolf. Because of this, the most frequent comparisons were made with wolfs. Nevertheless, in scientific literature, there are few anatomical reports of various anatomical systems of the golden jackal, and a detailed morphological description of it has not been made. Compared to wolves, the golden jackals'projections of the skull is less developed. Even though the canine teeth are large and strong, they are thinner than wolfs' and the carnassials are weaker. Its relatively short facial region, weaker teeth row are related to the jackal's diet, composed of small birds, rodents, small vertebrates, insects and carrions. Denied carrion or prey, it feeds on fruits and seeds. This eating behaviour has imposed the occurrence of certain specific characteristics of the dentition. Every tooth, no matter its form and function has the same elements. The structures are crown, enamel, cementum, dentin, pulp, root and periodontal ligament. Anatomical crown is the part of the tooth that is occlusally located to the dentino-enamel junction, or the portion of the dentin of a tooth that is covered by enamel. The clinical crown is the portion of a tooth that is above the gingival margin or the exposed part of a tooth within the mouth. In the present study has been performed a detailed description of the clinical crown of the teeth in golden jackal in comparison with the domestic dog. Domestic dogs possess a heterodont, a diphyodont dentition with anelodont and brachyodont teeth (Evans and De Lahunta 2013). Compared to dogs, horses have hypsodont teeth (Konig et al. 2014). Rabbits have heterodont, diphyodont, with all teeth being elodont (aradicular hypsodont) (Quesenberry and Carpenter 2012, Stan 2014). Those three examples are the most representative among animals. The dental

formula for primitive carnivores consists of 44 teeth (three incisors, one canine, four premolars and three molars in each quadrant) but the evolved carnivore's dentition shows several adaptations to diet (Evans and de Lahunta, 2013). Domestic dog's teeth have short crown, covered only by a thick layer of enamel, obvious neck and long roots covered by cement (Barone 1997).

MATERIALS AND METHODS

Seven adult golden jackals (*Canis aureus moreoticus*) were examined, four male and three female. The subjects were hunting harvest, being part of an ongoing study of the anatomical description on various systems in golden jackal. The oral cavity and teeth were examined before and after exposure of the oral cavity. To expose the oral cavity, an incision was made on each side, starting from lips commissure, in horizontal line and parallel to the mandibular arch, followed by a vertical incision, along the recurved mandibular branch. The entire study was conducted in accordance with the Protocol on Medical Ethics and in compliance with the Directives 63/2010 of the European Parliament and of the Council on the Protection of Animals Used in Scientific Research.

RESULTS AND DISCUSSIONS

The particular anatomical configuration of the viscerocranium in jackal gives the oral cavity a long and narrow appearance (Figure 1). The wide oral slit, starting from the oral angles reaching close to the carnassials.

The dental formula contained 42 teeth in all subjects:

$$I : \frac{3}{3}; \quad C : \frac{1}{1}; \quad P : \frac{4}{4}; \quad M : \frac{2}{3} = 21 \times 2 = 42.$$

There were no differences in shape, number and disposition between the dentition of males and females. In dogs, Lorber et al. (1979) found differences between male and female canine crown, male having longer and wider canine crowns.

Generally, in mammals the shape, position and even number of teeth can differ according to age, breed and subject (Barone 1997). Thus, canines have 32 decidual and 42 permanent teeth. In diphyodont mammals the variations of number and shape are obvious, especially regarding the decidual and permanent dentition.
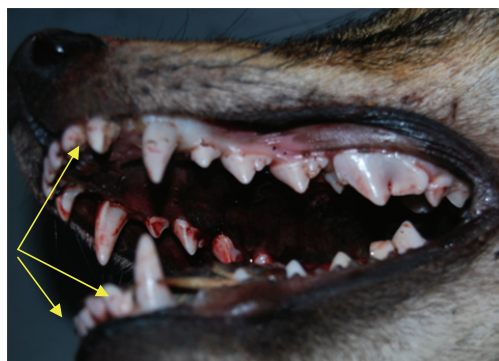

Figure 2. The short incisors crown compared with the large crowns of the majority of the teeth

Figure 1. Viscerocraniumof the golden jackal with elongated appearance of the oral cavity. Wide oral slit exceeds the carnassials plan-arrow

Figure 3. The short incisors crown with central prominent lobe, visible on the central incisors-arrows. Their size increased from central-1 to middle-2 and lateral-3 incisor teeth.

In canines, when the first premolar is considered deciduous, the dental formula is as follows:

$$i:\frac{3}{3}; \quad c:\frac{1}{1}; \quad m:\frac{4}{4}=16\times2=32,$$

In studied subjects, the incisor teeth (*Dentes incisivi*) had a short crown (*Corona dentis*) compared to the large crown of the premolar and molar teeth (Figure 2 and 3). More developed on the superior arch, their size increased from the central to lateral incisor, being rostral slightly arched (Figure 4). Their crowns were flattened and laterally compressed, heavilyfixed. The oclusal border (*Margo occlusalis*) of the crown has shown three salient cusps (lobes), the middle one being more prominent (Figure 4). The smooth vestibular surface (*Facies vestibuaris*), convex in all directions was slightly narrowed towards the neck of the teeth (Figure 4).The lingual surface (*Facies lingualis*), slightly swollen near the neck (*Cervix dentis*) showed a strong girdle (*Cingulum*) in all subjects. Its extremities from the base of the cuting edge were more obvious and formed on each side a small tubercle. The cingulum concavity delimited a small recess which subdivided the large prominent central tubercle. This tubercule was disposed along the cutting edge.The large contact surfaces (*Facies contactus*) from the incisor neck show a sharp reduction before their ending on the cingulum extremities. The oclusal border, like a delicate pointed arch (ogive), was surrounded at its base

Figure 5. The tooth wear starting from the central lobe of incisors leave the occlusal surface, thick and straight. Note the obvious reduction of the crowns starting from the middle incisors and stump appearance of teeth

by the two tubercles that marked the end of the cingulum (Figure 4). These tubercles were separated from the central cusps by a small notch.Therefore, this three-lobed appearence, with a prominent central lobe like a „clover" shape or like a „lily flower" is similar with the pattern described in canines (Evans and de Lahunta 2013). This disposition announces the three tubercules pattern of the premolars and molars. The incisors neck was well marked in all subjects.

In older subjects (2 subjects) it was noticed a conspicuous wear of the teeth (Figure 5). The wearing was started primarily on the cutting edge of the central lobe (on the ogiva), which was shortened up to the two tubers on the edges (Figure 5). In this way, the occlusal edge
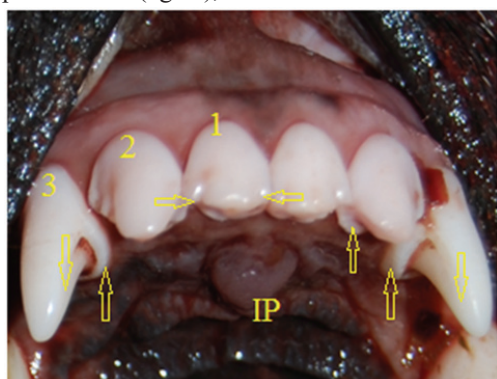

Figure 4. Superior incisors (1,2,3) with smooth, convex appearance of vestibular face. Strong cingulum on the lingual side-up arrows delineated two tubercles on its extremities-horizontal arrows, and a long, narrow central lobe of the lateral incisors-down arrows. IP-incisive papilla

Figure 6. Superior incisors (1,2,3) are located rostral to the inferior incisors (1', 2', 3'). The superior canine tooth (4) is separated by lateral superior incisor by an interdental space, matching the inferior canine tooth (4'), in scissor like appearance

became straight and thick, the "lily flower" disappeared and the levelling appeared. The crown was strongly reduced, taking the form of a stub, the incisors distancing themselves from one another. Gums also suffered a marked process of retraction, emphasizing the appearance of stump incisors. The wear was most evident on the central incisors, progressing towards the middle and the lateral incisors (Figure 5). The wear process described here is similar to that of carnivores (Evans and de Lahunta 2013). There were few differences of size, pattern and disposition between the superior and inferior incisors. Regarding the incisors dimensions, the central were smaller than the middle, which in turn were smaller than the lateral. The obvious difference was shown on the upper jaw. Upper incisors were almost two times stronger than those of the same rank from the lower arch (Figure 4, 5 and 6). Prominent cingulum and stronger central lobe, well separated from the marginal lobes, were well defined characteristics, especially at the central incisors. The lateral incisors showed a long and sharp central lobe in absence of the distal lobe; resembling somewhat and in a small way, the canine pattern. In the occlusion of the arch the lower canine is positioned slightly distal and opposite from the superior lateral incisor.

The upper incisors exceeded rostrally to the lowers, so that, during occlusion, the sharp edges of their lingual surfaces are positioned over the vestibular surface of the lower incisors (Figure 6 and 7). Also, from the superior lateral incisor to the superior last premolar, the upper and lower teeth alternate in their disposition in the dental arch. This type of dentition is called "scissor" dentition and is described especially in dogs (Evans and de Lahunta 2013). Moreover, the central incisors only partially cover their counterparts and the adjacent parts of the inferior middle incisors. In turn, the middle superior incisors cover the occlusal edge of the two inferior lateral incisors. The superior lateral incisors were placed between the inferior lateral incisors and inferior canine teeth, a small diastema separating them from the upper canines. The dolichocephalics canine breeds retain this disposition, while brachiocephalic breeds have a marked inferior prognathism, in which the superior incisors and canines are placed more at varied distances behind their counterparts, reducing their effectiveness of cutting (Barone 1997, Verstraete and Tsugawa 2015). On each jaw, the dental arches (A*rcus dentalis superior et Arcus dentalis inferior*) described an arc, the upper one being wider and stretched compared to the lower jaw arch. The inferior dental arch showed a deeper curvature, was narrower and shorter compared to the superior arch.

Canines (*Dentes canini*), or "fangs" as they are called, were highly developed, conical shaped, having a distal (caudal) and concave tilting. Compared with the incisors, canine's neck was less marked (Figure 8). The vestibular surface was convex and smooth. The lingual surface was crossed by a lingual groove limited by a
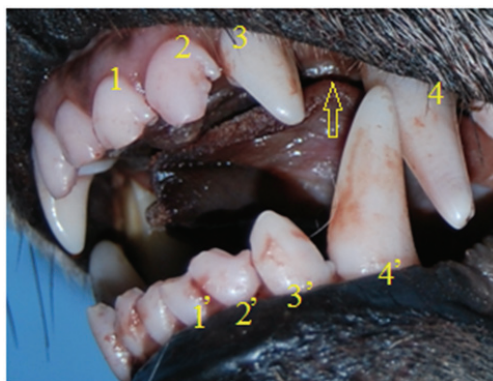

Figure 7. The crown of superior lateral incisors-3, are largest and slightly hooked caudally similar with the next canine tooth. A small *diastema*-arrow, separated the lateral superior incisors from the canine teeth

Figure 8. Detailed image of a superior canine tooth. A small ridge on the lingual side-arrow delineates a reduced groove. Note the conned shape, distally oriented and rounded apex-A, of the canine tooth

small ridge at the edge of its mesial surface (Figure 8).The superior canines appeared stronger than the lower ones, their roots being twice as long as the crown. On the distal edge, near the cingulum the canines' circumference was visibly increased. The canines were less titled on the vestibular surface, their crown being less outwards inclined. In occlusion, the lower canine is placed in front of the upper canine, which in turn, sits next to a small diastema. This diastema separates the lower canine from the first premolar (Figure 9).
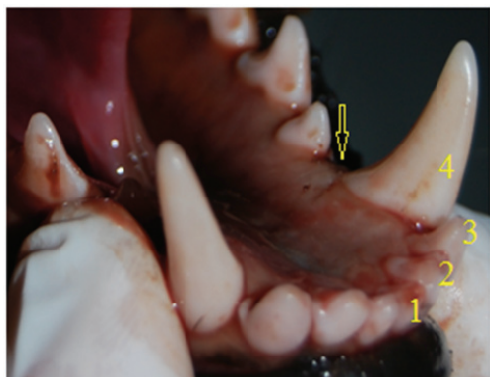

Figure 9. A small *diastema* separate the inferior canine tooth-4, from first premolar tooth-arrow

According to the anatomical rule, on each arch the premolars (*Dentes premolares*) and molars (*Dente smolares*) were classified in mesio-distal direction (rostro-caudal) in: precarnassials, carnassial or sectorius (*dentes sectorius*) and postcarnassial or tuberculosis teeth (Figure 10). Thus, the last upper premolar
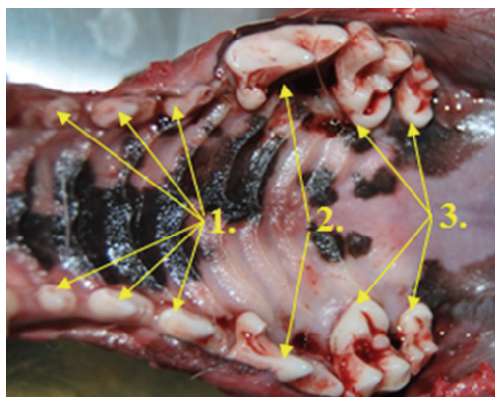

Figure 10. The upper precarnassials-1, carnassials-2 (premolars) and postcarnassials (molars)-3 teeth. Note the strong development of the carnassials and postcarnassials teeth

tooth will be described as upper carnassial and the first lower molar tooth as lower carnassial tooth. These teeth were the largest shearing teeth on both dental arches. These characteristics are similar to those of domestic dogs (Barone 1997, Evans and de Lahunta 2013). Except the last two molars, due to their blade like pattern, slicing and chapping function, on each arc all teeth have achieved a perfect secodont type of dentition. In dogs, deciduous dentition includes on the upper jaw, besides the incisors, two precarnassials, the carnassial and one postcarnassial or tuberculosis tooth. The lower jaw includes three precarnassials and one carnassial tooth (Barone 1997). In the deciduous dentition the first premolar is sometimes described as a precursor, lacking the permanent tooth (Verstraete and Tsugawa 2015), but in accordance with this paper, rather it should be considered a persistent deciduous tooth (milk) continuing in the permanent dentition. The rest of the teeth resemble the shape and disposition as in adults, but are smaller, sharper, having narrower cusps. Their occlusion is as in adults.

The permanent dentition of the golden jackals from the present study included six cheek teeth (premolars and molars) on each superior quadrant and seven cheek teeth on each inferior quadrant (Figure 10). The first three premolar teeth are the precarnassial teeth. The first was smallest with a simple, pointed crown, whose lingual surface shows a small cingulum and a reduced distal lobe (Figure 11). The next two premolar teeth, larger than the first, slightly

Figure 11. Upper-5,6,7 and lower 5', 6', 7', 8' premolar teeth (precarnassials). The last upper premolar-8 is the carnassial or sectorial tooth

flattened and compressed laterally show three lobes: a prominent intermediate lobe, a short and slightly detached mesial lobe and a long distal lobe (Figure 11). The last precarnassial tooth has a prominent cingulum and a well delineated distal tubercle (Figure 12).
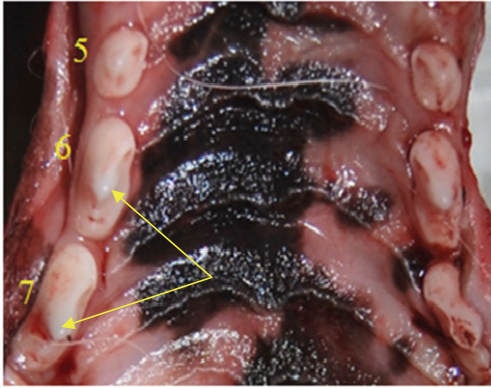

Figure 12. A small, simple crowned of the first upper precarnassial and a well developed intermediate lobe-arrows, of the last precarnassials-6,7

The superior carnassial (or the last premolar tooth) was the stongest tooth on the quadrant. (Figure 13). Three lobes were identified: two of them were stronger, being the tooth body, the mesial lobe, named *paracone,* being more prominent than other lobes. The mesial lobe was connected by a sharp ridge to the distal lobe, named *metacone*, which was smaller than the mesial lobe. The third lingual lobe, named *protocone,* was like a reduced, accessory lobe which was connected to the base of the main lobe (paracone) by a girdle or a small crest (Figure 13).
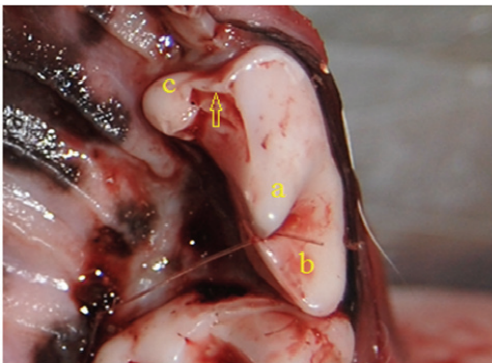
The last two upper molars (or postcarnassial teeth) were well developed (Figure 14). Their crown, short and wide, very rough, was much more developed in the transverse direction than inthe mesio-distal direction. The first postcarnassial tooth (or tuberculosis tooth) was longitudinally shorter than the carnassial, but more developed transversally. Its crown was bordered by a girdle (cingulum), which was extended up to the vestibular surface at the base of two vestibular cusps (Figure 14). Of the two cusps, the mesial one, named *paracone,* was taller. On the lingual surface the cingulum inflated to form a large and short rounded lingual lobe, named *protocone.* Its occlusal surface was subdivided in small tubercles among which the heels of the lower carnassials tooth, affront.

The last postcarnassial tooth (or last molar), was smaller, the two vestibular cusps being reduced and the lingual lobe, *protocone,* being slightly larger, but less mamelonated (Figure 14).

The lower precarnassials were the four lower premolars (Figure 15). The first premolar, like its superior counterpartbut smaller than it, presented a cingulum too and a reduced distal tubercle. The following precarnassials were larger. Their crowns were three-lobed, presenting like the superior premolars, a stronger distal lobe (metaconid) extended in mesio-distal direction. From the second to the fourth premolar, the subdivision of this lobe was clearer.
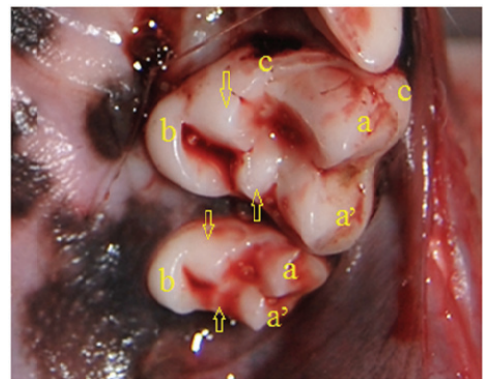

Figure 13. The upper carnassial. a-the mesial lobe (paracone); b-the distal lobe (metacone); c-the lingual lobe (protocone) connected by a small ridge to the base of paracone-arrow

Figure 14. The upper postcarnassials. a (paracone) and a'-the two vestibular cusps; b-lingual rounded lobe (protocone) subdivided in two small tubercles-arrows. c-cingulum
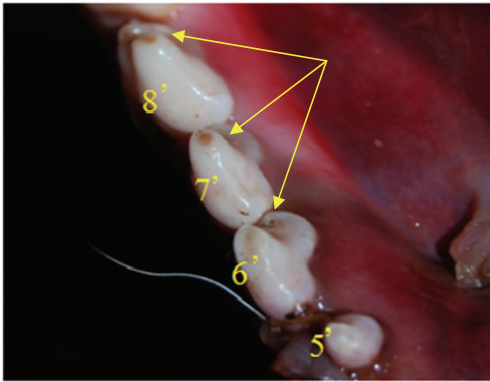
Figure 15. Lower precarnassials 5', 6', 7', 8'. The first premolar-5' is small. The distal lobe (metaconid) is prominent and subdivided, starting from the second premolar-arrows

The lower carnassial appeared stronger than the superior carnassial (Figure 16). The cingulum was relatively small, but the crown was clearly three-lobed. The intermediate lobe, sharp and strong (protoconid) was obviously flanked at its base by a small accessory tubercle distalo-lingual oriented (Figure 16). The mesial lobe (paraconid), shorter, was nevertheless visible, slightly reduced on the lingual part. The short but large caudal lobe has been subdivided into two secondary parts-vestibular (metaconid) and lingual (entoconid).

These parts were separated by a depression, adapted to receive the upper postcarnassial relief, called "heel".

The lower postcarnassials were the last two molars, much smaller than those from the upper arch. The first postcarnassial (or the second molar tooth), held a low crown, slightly wider
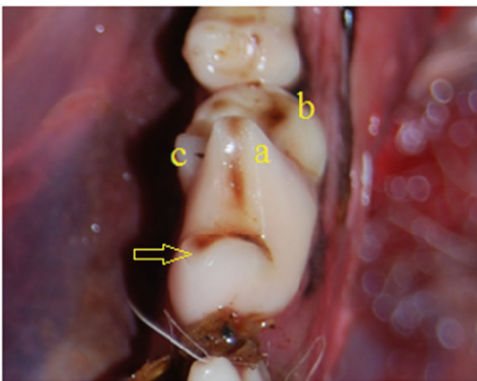
mesio-distal than in the transverse direction. Its occlusal surface was mamelonated, the distal tubercles being the lowest. The third (or last molar), was very small, having a simple, rounded, less mamelonated crown (Figure 17).

Occlusion of the molar arch was highly efficient on the carnassials tooth due to the maximum development of these teeth. Carnassials teeth were convex on the vestibular side; their aggregate draws a kind of rostral narrow lira, especially on the upper jaw. In the inferior arch the carnassials where less divergent in caudal (aboral) direction. Thus, lower carnassials slid over the lingual surface of the upper counterparts and over the vestibular adjacent lobes of the superior postcarnassials. The sharpest and higher lobe (protoconid) of the lower carnassial, sits in the notch of the first postcarnassial tooth (between metacone and protocone), while the heel facing strong protocone of the upper postcarnassial. Therefore, this complex is permanently sharpened. Because of its positioning in the caudal part of the oral cavity this complex can apply maximum force, easily scissoring the toughest elements, (bones and tendons) without a possible separation. Other teeth have very limited role. Precarnassials are not adjacent; they are arranged alternately, inferiors being placed rostral to the superiors. Due to the reduced volume, the last postcarnassials have only a very superficial action, most often, the inferior postcarnassials are not in contact with their superior counterparts. These features are specie characteristic and are not related with the breed variations of jaws, compared to the incisors disposition, which is strongly related to the breed.

Figure 16. The lower carnassial tooth. The strong intermediate (protoconid) lobe-a. The caudal lobe was subdivided in vestibular (metaconoid)-b and lingual (entoconid)-c lobes. Small accessory tubercle at protoconid base-arrow
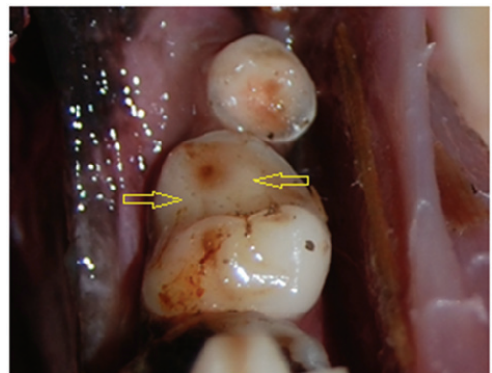

Figure 17. Small distal tubercles-arrows, of the first lower mamelonated postcarnassial tooth, and the smallest last lower precarnassial tooth

In dog the Triadan system is available to identify specific teeth. The number of a tooth is composed of three digit number each of it indicate: the first (in a system of hundreds) indicate the quadrant of the dental arch,1(00) being the upper right; 2(00) being the upper left 3(00) being the lower left and 4(00) being the lower right quadrant. The next two digits indicate the location of the tooth related with the median line, the 01 digit indicate the first central incisor, or the most mesial position of the tooth (Verstraete and Tsugawa 2015). Due to the similarities presented in this paper the Triadan system could be used for reference of the specific tooth in golden jackal.

CONCLUSIONS

The Golden Jackal dentition is similar to that of the dog being: diphyodont, heterodont, brachyodont and secodont type of dentition. In Golden Jackal, the upper dental arch is slightly longer than the lower one, the upper teeth occlusion beind made on the lingual side of the upper teeth, in a "scissor" like action.

Similar to domestic dogs, the Golden Jackal have specialized functional pair of sectorial (carnassials) teeth that consist of the last upper premolar and the first lower molar.

The Triadan system could be used to reference specific teeth in Golden Jackal.

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