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Mastication Muscles in Hoary Fox (*Lycalopex vetulus* - LUND, 1842): Descriptive and Comparative Study

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***Abstract*—** *Mastication muscles are responsible for lowering and elevation of mandible, which four of them are responsible for mandible elevation in Hoary Fox: Masseter, Temporal, Medial Pterygoid and Lateral Pterygoid; and one for lowering: Digastric. Considering anatomical study of these muscles, the present work aimed to describe, analyze and compare the anatomy of Hoary Fox mastication muscles with data described in literature. In this sense, for this work development, two specimens of Hoary fox (Lycalopex vetulus) were used, being fixed in aqueous solution of 10% formaldehyde for conservation, with later description of characteristics, location, size, origin and insertion of muscles. Thus, was observed that Masseter muscle of Hoary Fox is relatively smaller than other species, such as Capuchin Monkey. A slight protuberance was also observed on lateral surface of the face, covering Ramus and Angle of mandible. When analyzed, Medial Pterygoid Muscle is a robust muscle and originates from Palatine and Pterygoid bones, directing dorsocaudally for insertion into medial face of the angle of mandible and adjacent areas, a location that is confused with Masseter (superficial part) insertion. Lateral pterygoid muscle is considerably smaller than medial and extends from sphenoid bone to mandible branch. Temporal muscle is the largest muscle of Hoary Fox head, composed of four parts: Dorsal, Medial, Ventral and Rostral; this muscle has its surface face covered by a thick fascia, the Temporal Aponeurosis.*

Keywords*— *Wild animals, Cerrado Biome, Dissecation and Anatomic Study.

I. INTRODUCTION

Hoary Fox is a wild animal of Carnivorous order and Canidae family, classified as the smallest Brazilian canid, not observed in other soils besides Brazilian, it is omnivorous with a food habit comprising mainly fruits, insects and small vertebrates **[1]**. In Cerrado biome, its habitat is threatened, with an estimated reduction of 10% in the next fifteen years, affecting strongly the population of this specie, being relevant the fact that 30% of specimens are killed by accidental death in roadsides, confrontation with domestic dogs, natural mortality of pups/juveniles, although it is not characterized in extinction, yet vulnerable. In this context, understand its biological system and components this animal habitat, is essential for its conservation **[2-4]**.

The knowledge of biological system can be evidenced based on animal anatomic study and is relevant consider comparative anatomy, a relatively young science whose objective identify and describe differences and similarities of forms and functions in anatomical structures of different taxonomic groups and is essential for knowledge of species, making possible infer about the importance of animal in environment that is inserted and its evolution **[5,6]**. Thus, it is worth mentioning the locomotive apparatus of Hoary Fox, which confers support and allows its movement, determining functions for survival and this animal reproduction **[1,3,5].**

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Anatomical study demonstrates that muscles are developed and defined from morphology and habits of each species **[7]**, showing difficulties in describing muscular system of mammals, given wide variability found among species **[8]**, and macroscopic and comparative analysis is required to obtain classification of taxonomic groups **[9-11]**. In this context, Hoary Fox skeletal striated muscle system contributes to formation of masticatory apparatus **[12]**.

Mastication muscles of vertebrates are initially a single unmatured muscle mass extending from ventral edge of mandible to the base of skull, divided into two parts, the *Superficial Part* located laterally to mandible and the *Deep Part* medially in the same bone. The identification of this part specializes in mammals from the development of mastication by performing more complex movement of mandible. The Superficial Parts evolves to *M. Temporal* and *M. Masseter* and *Deep Part* to *Medial Pterygoid* and *Lateral Pterygoid* **[13]**.

Miller *et al.* (1964) describes that Masseter muscle of Dog is arranged over mandible from ventrocaudal border to zygomatic arch, with surface covered by a thick aponeurosis that emits intermuscular septa. This muscle exhibits differently directed fibers evidencing three layers parts: *Superficial, Medial* and *Deep*. The major part is the superficial that presents origin in ventral border of rostral half of zygomatic arch going caudal and ventrally to insert in ventrolateral face of mandible. Some fibers circumvent ventrocaudal border of mandible, are inserted in ventromedial surface and tendinous raphe, between Masseter muscle and Medial Pterygoid muscle.

Temporal muscle is classified as the largest muscle of head and is situated in Temporal Fossa, its origin occurs in greater proportion in parietal bone and lesser extent in temporal, frontal and occipital bones. Its fibers extend face ventrally until insertion into coronoid process of mandible and ventral margin of masseterine fossa. In the lateral part of coronoid process, temporal fibers mix with Masseter, while in medial side, their fibers contact with Pterygoid muscles. A small portion of Temporal muscle fibers originate in dorsal line of nape near the base of zygomatic process and extend parallel to zygomatic arch, gradually mixing with principal mass **[12,14]**.

The Medial Pterygoid muscle originates on lateral surface of pterygoid, palatine and sphenoid bones, extends posteriorly-laterally inserting below the angle of mandible, in posterior margin and posteromedial surface of mandible, ventrally to Temporal and Lateral Pterygoid muscle insertion. The smallest muscle involved in mastication is Lateral Pterygoid muscle, being short in relation to medial Pterygoid, with origin occurring in sphenoid bone and extending ventrally through fossa alar, orbital fissure and round foramen, inserting in medial surface at mandible condyle, ventrally its articulate face. Digastric muscle originates in jugular process of occipital bone, proceeding to ventral border of mandible, is disposed medially to parotid gland. It has a fleshy insertion in ventromedial border of mandible, approximately 2.5 cm at the level of dorsal canine tooth. A small group of fibers extend forward the mento **[12,14,15].**

In face of the presented evidence, Hoary Fox dissection is necessary for descriptive and comparative anatomic study, contributing for better understanding of this animal mastication muscles, essential pattern for knowledge of particularities inherent it species, that influence in biological system and consequently in behavior importance of Hoary Fox in ecosystem.

II. MATERIAL AND METHODS

The present paper is a descriptive and comparative anatomical study with one male and one female specimen of Hoary Fox, obtained from accidental death on the roadsides of Brazilian Southeast of Goiás, under authorization of SISBIO nº 37072-2. All procedures were conducted in accordance with ethical principles and approved by the Institutional Ethics in Research Committee at the Federal University of Uberlândia (CEUA/UFU nº 067/12).

The study was made in the research laboratory of human and comparative anatomy from the Federal University of Goiás – RC, where the skin head and neck was removed with scissors, scalpel and anatomical tweezers. The adipose tissue of face and epicranium were removed using tweezers and scalpel and muscles of the face and neck were dissected using tweezers, scalpel and scissors subsequently was made a fixation with aqueous 10 % formaldehyde solution to conservation. The preparation of anatomical pieces was performed under consecrated techniques in Macroscopic Anatomy.

The Sony Cyber® digital camera was used to the photographical documentation and the description nomenclature adopted is the standard of *Nomina Anatomica Veterinaria* **(2017) [16]**, elaborated by the International Committee on Veterinary Gross Anatomical Nomenclature. Considering the descriptive approach of this work, statistical analysis is not necessary.

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III. RESULTS

Mastication muscles are meant as a group of muscles responsible for lowering and elevation of mandible. Four muscles are responsible for elevation of mandible in Hoary Fox: *Masseter, Temporal, Medial Pterygoid, Lateral Pterygoid*; and one to lowering: *Digastric*.

Masseter muscle: Small when compared to other species, e.g. Capuchin Monkey. Nevertheless, forms slight protuberance on lateral surface of face, covering branch and angle of mandible. It is covered, on outer surface, by a thick aponeurosis, the *masseterine aponeurosis*. A second aponeurosis is present inside the muscle, giving it appearance in layers or parts. The separation between parties is obscure, with no clear separation between them. Thus, four parts are described: *Surface, Medial, Deep* and *Rostral*.

Superficial part is the most voluminous, originating from ventral border of zygomatic arch. Fascicles muscle are small and involved by thin perimysium, not easily identified with naked eye. The fibers orientate in palmar direction, in direction of branch and angle of mandible, where they are inserted. A group of fibers inserts at caudal border of mandibular branch and the edge of angle of mandible and remainder at ventral border of mandibular body. Any case of fibers extends beyond the edge of bone, becoming protrusions beyond it.

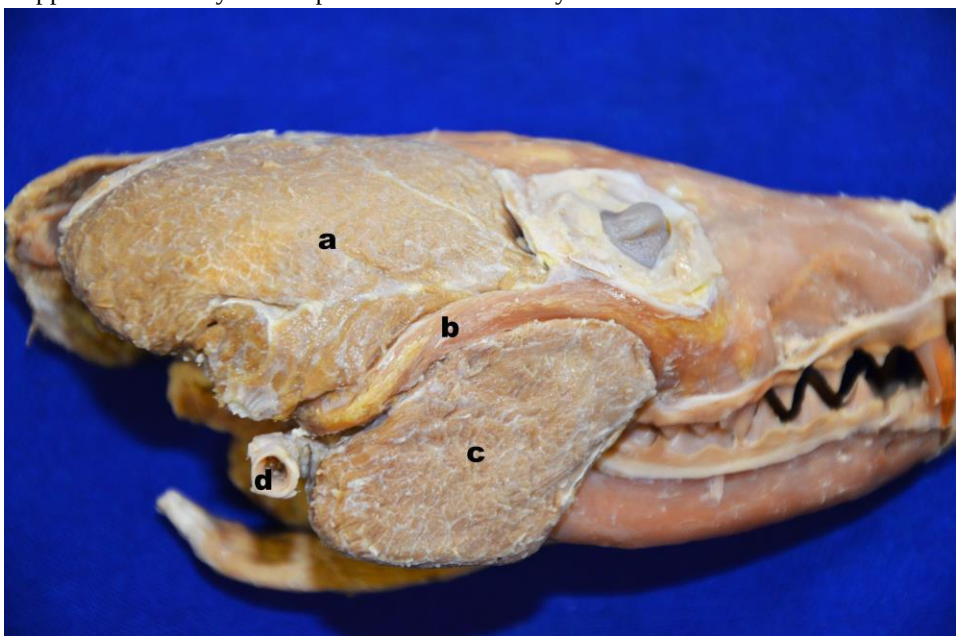

Fig.1: a- Temporal Muscle; b- Zygomatic Arc; c- Superficial part of the Masseter Muscle; d – Auditive Pavilion

Middle Part Masseter muscle is smaller than superficial, is located medially and incompletely separated from this, through an aponeurotic lamina. It presents a quadrilateral form, whose origin occurs in ventral border of rostral half in zygomatic arch. Its fibers are ventrocaudally inserted in ventral edge of masseterina fossa, ventrally to coronoid process of mandible. It covers Deep Part of Masseter muscle and Vertical Part of Temporal Muscle, near its insertion in coronoid process of mandible. Its rostral part is approximately cylindrical, while remainder laminar. Much of its extension is separated from the Deep by an aponeurosis.

Deep Part of Masseter muscle is smaller than superficial part, but larger than Middle Part. Originates from the deep face of caudal half of zygomatic arch, where entirely merged with ventral part of temporal muscle. Its fibers ventrally intrude into the floor of the fossa masseterina, along with the Ventral part of Temporal muscle.

Rostral Part of Masseter muscle is the smallest segment of superficial part, whose origin occurs at rostral base of zygomatic arch and close to mandibular insert, mixed with superficial part of Masseter muscle.

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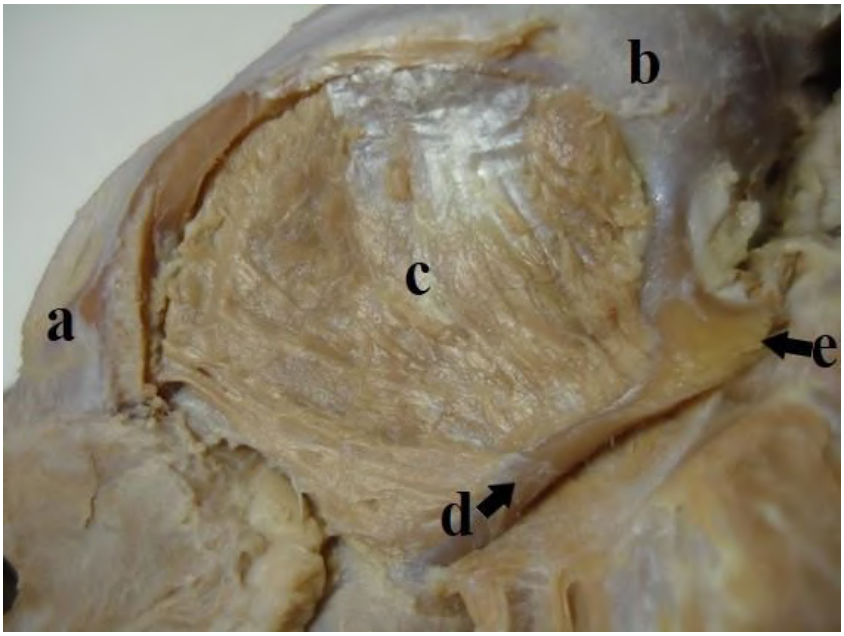

Fig.2: a- Frontal Bone; b- Zygomatic Arc; c- Average Part of Masseter Muscle; d- Mandibular Body; e-Angular Process of Mandible.

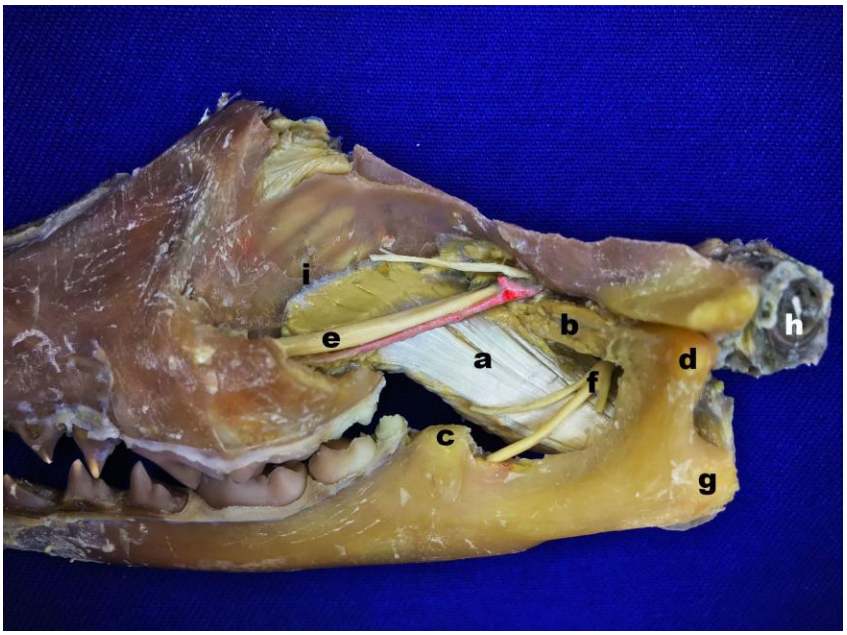

Fig.3: a- Medial Pterygoid; b- Lateral Pterygoid; c- Coronoid process; d - Condylar process of mandible; e-Maxillary Nerve; f- Mandibular Nerve; g- Angular Process of Mandila; h- Hearing Pavilion; i- Pterygoid process.

Medial Pterygoid Muscle: Robust muscle that originates from palatine and pterygoid bone, directed dorsi-caudally to insert into medial aspect of mandible and adjacent areas, where is confused with insertion of Masseter muscle (superficial part).

Lateral Pterygoid Muscle: Smaller than medial and extends from sphenoid bone to mandible branch. Its origin occurs in caudal aspect of sphenoid bone and its fibers are directed rostrocaldally to insert in medial aspect of branch until cranial border of mandible branch, until its condyle.

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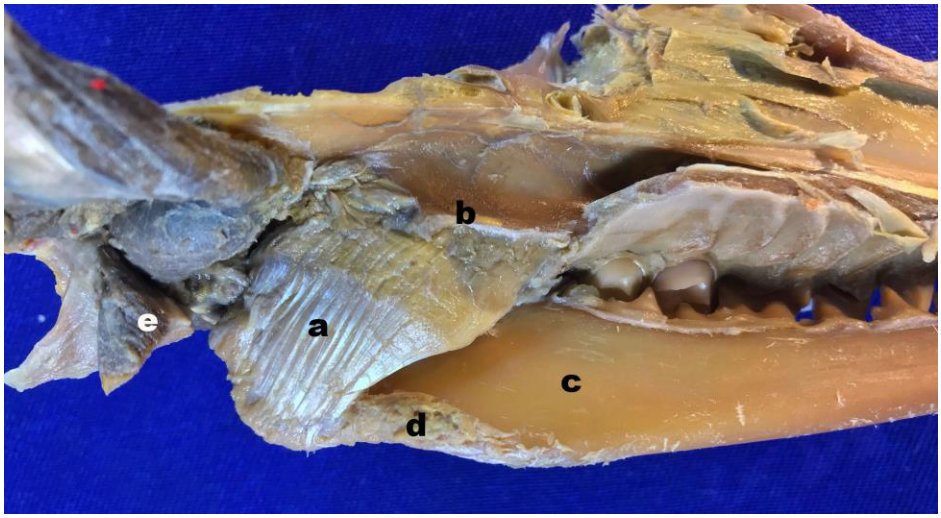

Fig.4: a- Medial Pterygoid; b- Pterygoid process; c- Jaw Body; d- Insertion of Digastric Muscle; e- Origin of Digastric Muscle.

Temporal Muscle: The largest muscle in this animal head. Consists four parts: *Dorsal, Middle, Ventral* and *Rostral*. The superficial face of Temporal Muscle is masked by a thick fascia, the *temporal aponeurosis*, while a thick deep aponeurosis separates Dorsal Part of muscle in *Superficial* and *Deep fibers*.

Superficial fibers of dorsal part have a broad origin along interparietal crest and deep face of temporal fascia, from frontal bone to occipital, while deep fibers are fixed to surface of parietal bone. Much of superficial and deep fibers, inserts in aponeurosis that separates the two parts. The other fibers, together with refereed aponeurosis and curves, rostroventrally, converging under zygomatic arch and insert into coronode process of mandible.

Ventral fibers constitute a large muscular fascicle that originates in deep face of zygomatic arch, together with fibers of Deep Part of Masseter muscle. Both muscles are fused, constituting a single muscular mass, whose fibers assume ventrorostrally direction by inserting in floor and edges of masseterina fossa of mandible.

Fibers of Rostral Part is smaller than the other four, located medial to temporal process of zygomatic bone and maxillary bone, originate at rostral base of zygomatic arch and adjacent areas of maxillary and frontal bone, ventrally to insert into medial face of mandible coronoid process.

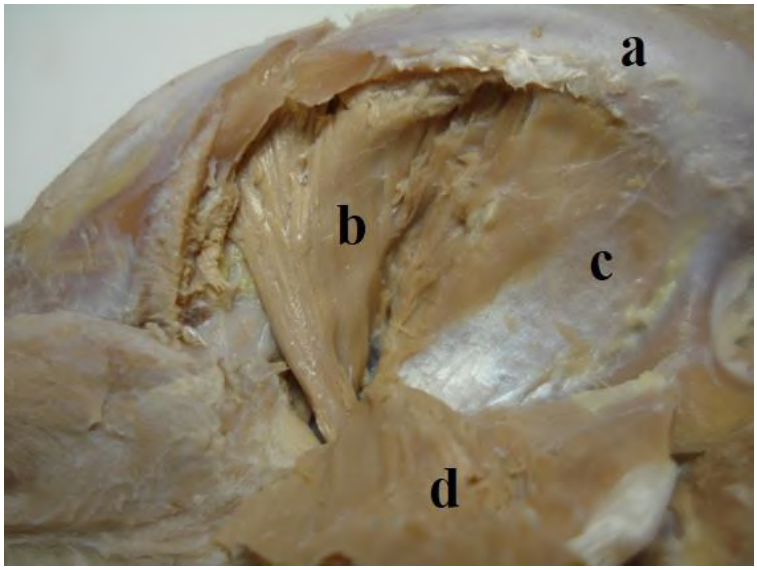

Fig.5: a- Zygomatic Arch; b- Rostral Part of Temporal Muscle; c- Deep Part of Masseter Muscle; d - Temporal Medial Muscle, rebounded.

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Thus, the four parts of temporal muscle forms a large muscle mass orientated from flow to rostral and ventrolaterally, converging beneath rostral part of zygomatic arch, going into coronoid process of mandible and adjacent areas. The fibers of Dorsal Part are, in caudal half, sharply separated from Middle Part, but rostrally they merges.

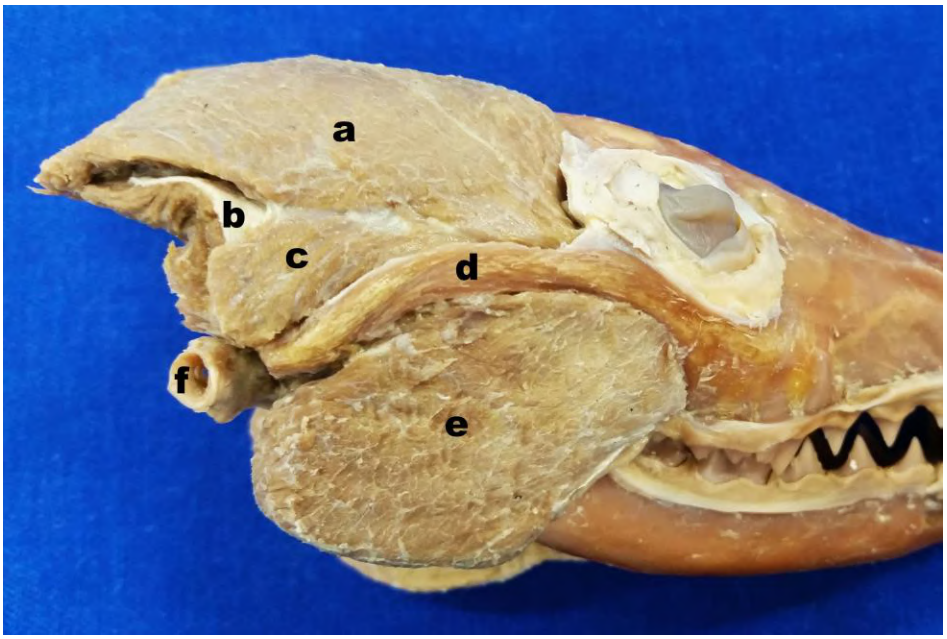

Fig.6: a- Superficial Part of Temporal muscle; b- Deep Part of Temporal Muscle; c- Media Part of Temporal muscle; d- Zygomatic arch; e- Muscle Masseter; f- Auditory Pavilion.

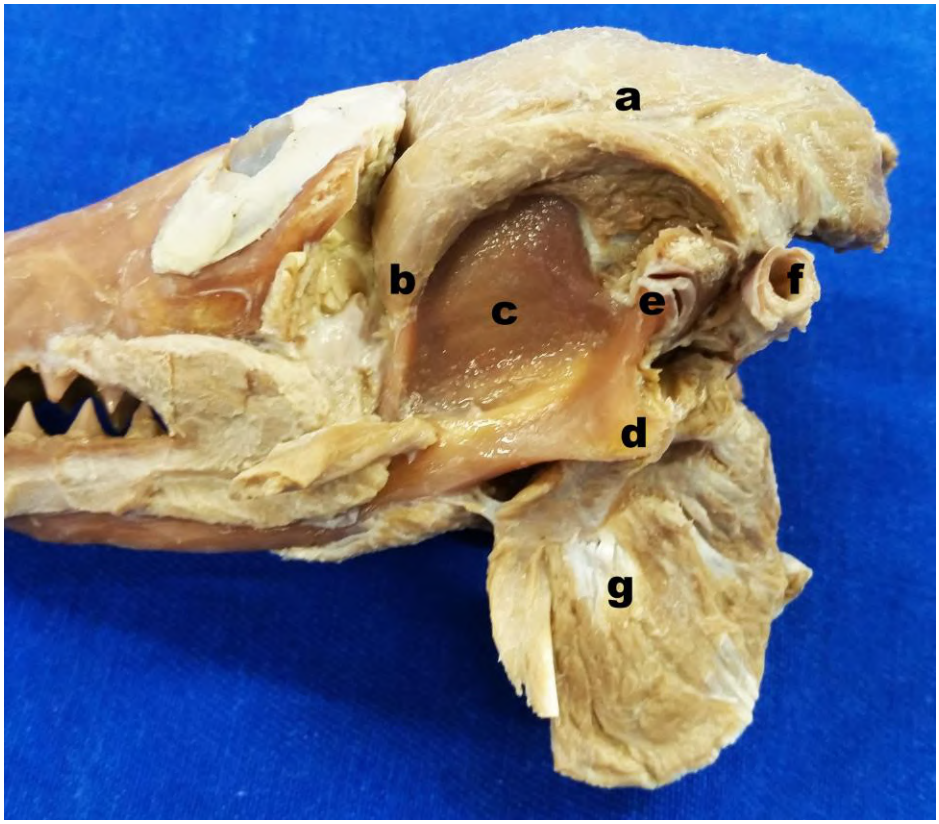

Fig.7: a- Temporal Muscle; b- Insertion of Temporal Muscle; c- Mandible Masseterine Fossa; d- Angular process of mandible; e- Temporomandibular Joint; f- Auditory Pavilion; g - Muscle Masseter rebated.

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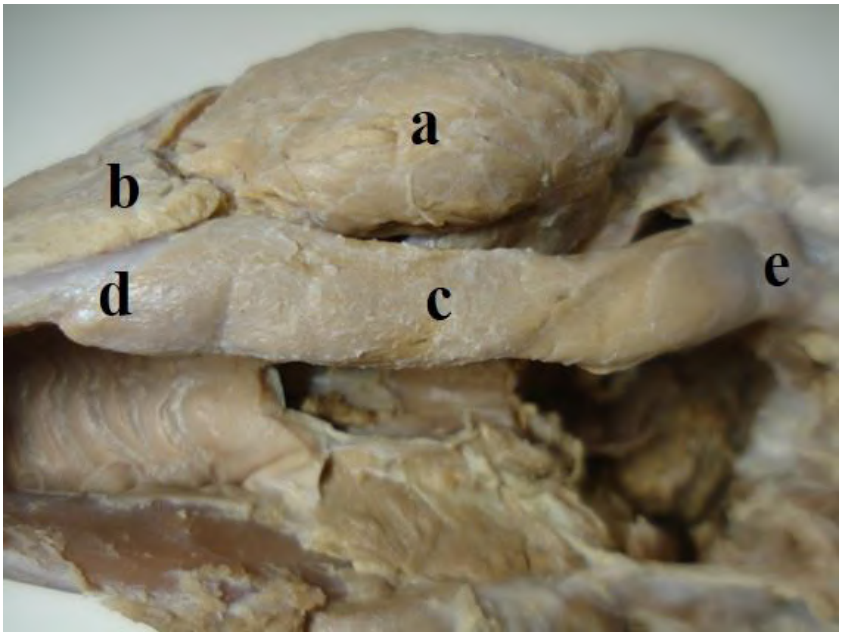

Fig.8: a- Masseter muscle; b- Mandible; c- Digastric Muscle; d- Mandibular insertion of Digastric Muscle; e- Occipital insertion of Digastric Muscle.

Digastric Muscle: This muscle, beside the name, is monogastric, since there is no intermediate tendon. The muscle extends from occipital bone (origin) to the angle and ventral edge of mandible. Both origin and insertion are apparently meaty, since the fixation tendons cannot be identified. Its shape is approximately cylindrical exhibiting the same dimensions throughout its length

IV. DISCUSSION

Hoary Fox Masseter muscle produces a slight protuberance on lateral face, disposed on branch of mandible, covered by a thick aponeurosis called *Masseterina Aponeurosis*. Inside the muscle there is a second aponeurosis that contributes to partially separate muscle mass into layers.

Miller *et al.* (1964) **[12]** described in dogs Masseter muscle, the presence of a superficial aponeurosis covering the muscle and its division into three layers: *Superficial, Medial* and *Deep*, with fibers directed in different directions. Turnbull (1970) also identifies, in mammals, a division of masseter, but describes only two layers: *Superficial* and *Deep*. In Hoary Fox, there is a division into four parts: *Superficial, Meadial, Deep* and *Rostral*, where Superficial Part being the largest. Its fascicles are small with a thin perimísio making visualization difficult to naked eye. Here, superficial part presents an origin in ventral border of zygomatic arch, its fibers follow palmar palate until insertion in the angle of mandible, in caudal border of mandibular branch, in the border of the mandible angle and ventral border of mandibular body. The fibers projection beyond the insertion edge, produces a protrusion beyond the edge of the bone.

Miller *et al.* (1964) **[12]** describes the origin of dog Masseter muscle with the origin at ventral border of zygomatic arch, from rostral half. When its fibers follow caudal and ventrally, inserting in ventrolateral face of mandible body and ventromedial surface to tendinous raphe, between Masseter and Medial Pterygoid. Turnbull (1970) **[17]** identifies the origin of Masseter in zygomatic arch, in its lateral bony border, where the fibers follow ventrocaudally, until its insertion in ventrolateral border of mandible body, angle and angular process of mandible.

On the other hand, the *Middle Part*, which is smaller than superficial part, is identified together with rostral part, the latter having a cylindrical shape rostral and laminar caudally. The Middle Part is located medial to Surface Part. Its shape is quadrilateral and its origin occurs on ventral border of rostral half of Zygomatic Arc. Its fibers follow ventrocaudally, inserting in ventral border of masseterina fossa and ventrally to coronoid process of mandible.

As described by Miller *et al.* (1964) **[12],** the middle part as being the thinnest, originating from Zygomatic Arc and caudally in relation to surface layer. Most of its fibers follow ventrally and insert into ventral margin of Masseterina Fossa of mandible. In Hoary Fox is observed that a group of fibers presents insertion in ventral border of Masseterina Fossa, ventrally to coronoid process of mandible.

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The Deep Part of Masseter, is larger than Medial. Its origin occurs in deep face of caudal half on zygomatic arch, merged with Ventral Part of Temporal. Is possible observe that its fibers follow ventrorostrally and inserted in floor of Masseterina Fossa of mandible, together with ventral part of Temporal muscle. These observations are similar to Miller *et al*. **[12]** descriptions, that state identification of Deep Part is not easy due its mixed fibers with those of Temporal muscle and the Deep Part is inserted in Masseterina Fossa **[15]**. The Rostral Part of Masseter muscle, seen in Hoary Fox, is not described in other species.

Medial Pterygoid Muscle of Hoary Fox is robust, presenting origin in Palatine and Pterygoid bones, its fibers follow dorsocaudally, inserting itself in medial aspect of angle mandible and in adjacent areas. In this region there is also insertion of superficial part of Masseter muscle, there being a mixture of fibers of both parts. In dog, according to Miller *et al*. (1964) **[12]**, Medial Pterygoid muscle originates from bones: Pterygoid, Palatine and Sphenoid, in line with Hoary Fox observations. The fibers of this muscle extend posteriorly and laterally to insert into the angle, caudal margin and caudally medial aspect of mandible, ventrally to insertion of Temporal and Pterygoid Lateral muscles [12,14,15].

In turn, in Hoary Fox, *Lateral Pterygoid muscle* is smaller than medial, the origin occurs on caudal surface of sphenoid bone and its fibers continue to palpably insert into medial aspect of mandible branch, up to condyle. On the other hand, Digastric Muscle in Hoary Fox is monogastric, since there is no intermediate tendon, although the same authors state that there is independent innervation for each part of muscle. In Hoary Fox its origin, in occipital bone, is fleshy and its fibers insert in angle and ventral border of the mandible body, in agreement with Miller *et al*. (1964) **[12]** descriptions in dog.

Temporal Muscle of Hoary Fox, as well in dogs **[12]**, is the largest muscle in head. In Hoary Fox there are four parts: *Dorsal*, *Medial*, *Ventral* and *Rostral*. The Dorsal, Middle and Rostral parts converge under rostral part of zygomatic arch to insert into coronoid process of mandible and adjacent regions. In turn, the temporomandibular muscle in dog **[12]**, without divisions, and originated in parietal, temporal, frontal and occipital bone, whose insertion occurs also in Coronoid Process and ventral margin of Masseterine Fossa, sometimes mixed with Masseter fibers. As related by Miller *et al*. (1964) **[12]**, in dog, a small portion of fibers presents origin near zygomatic process of temporal bone, in dorsal line of nape and inserts in zygomatic arch mixing with the main mass of Temporal muscle. This part of the muscle, in dog, corresponds to average part verified in Hoary Fox.

CONCLUSION

The present work demonstrated that Hoary Fox mastication muscle shows similarities with other canids; however, anatomical pattern demonstrated through dissection that Masseter muscle produces a slight lateral protuberance on face, disposed on the branch of mandible, covered by a thick aponeurosis called Aponeurosis Masseterina and inside the muscle, there is a second aponeurosis contributing in separation of muscle mass in layers. Thus, the present paper presents unpublished data about Hoary Fox anatomy, contributing to the knowledge and understanding of this group of muscles, which some particularities influence in biological system of this species, its behavior and importance in ecosystem.

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