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NOTA BREVE/BRIEF NOTE

## THE MANDIBULAR MUSCLES OF *Puma concolor* (MAMMALIA, CARNIVORA, FELIDAE)

### Músculos mandibulares de *Puma concolor* (Mammalia, Carnivora, Felidae)

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#### ABSTRACT

This manuscript describes the mandibular muscles of the puma (*Puma concolor*), a widely sparse American carnivorous mammal. The muscles on the right and left side of the head of three specimens –two adult males and one young female– were dissected and photographed. This study increases our knowledge on the mandibular soft tissue and adds important anatomical information to the poorly known and documented musculature of this felid, the largest of the subfamily Felinae.

**Keywords:** mandible, musculature, origin and insertion, Puma.

#### RESUMEN

En este trabajo se describen los músculos mandibulares del puma (*Puma concolor*), un mamífero carnívoro de amplia distribución en América. Se diseccionaron y fotografiaron los músculos izquierdos y derechos de la cabeza de tres individuos, dos machos adultos y una hembra juvenil. Este estudio incrementa nuestro conocimiento de los tejidos blandos mandibulares y por lo tanto, aporta información anatómica valiosa de la escasamente conocida y documentada musculatura de este félido, el más grande de la subfamilia Felinae.

**Palabras clave:** mandíbula, musculatura, origen e inserción, Puma.

The puma (*Puma concolor*, Linnaeus 1771) is among the largest felids of the world. Its size is just below the size of tigers (*Panthera tigris*, Linnaeus 1758), lions (*Panthera leo*, Linnaeus 1758), jaguars (*Panthera onca*, Linnaeus 1758) and leopards (*Panthera pardus*, Linnaeus 1758) (Nowell and Jackson, 1996). Nevertheless, specific features (e.g. shape of its nose, morphology of its feet, shape of its pupils, lacking the specialized larynx and hyoid) relate the puma with the smaller felids (Sunquist and Sunquist, 2002). Even, its skull has reached pantherine cranial size but retaining the cranial proportions of small cats (Werdelin, 1983). The species was

originally nested as *Felis concolor* (Linnaeus, 1771) but was recently recognized as *Puma concolor*, with *Puma* accepted as a separate genus by Ewer (1973) (Culver, 2010). It was placed in the subfamily Felinae. This species is also commonly known as the mountain lion, cougar, or catamount (Nowell and Jackson, 1996).

The puma is widely distributed in America, ranging from Alaska to southernmost Chile and Argentina (Currier, 1983; Iriarte *et al.*, 1990; Sunquist and Sunquist, 2002). It occupies diverse habitats, including arid desert, tropical rainforest and cold coniferous forest (from sea level up to 5800 m in



the Andes) (Redford and Eisenberg, 1992). Size of pumas increases with latitude and varies among the subspecies (Iriarte *et al.*, 1990); average weights range between 53 kg and 72 kg for males and between 34 kg and 48 kg for females (Currier, 1983; Nowell and Jackson, 1996). This species is listed in the International Union for Conservation of Nature and Natural Resources (IUCN) red list as Least concern (IUCN, 2015).

There are few studies describing the anatomy of pumas, the second largest feline in America, with an important occurrence not only geographically but also in abundance. Concha *et al.* (2004) described the intrinsic muscles of thoracic limb. The muscles of pelvic limb were reported by Caro-Munizaga and Concha (2014). Antón *et al.*, (2004) provided information on the muscle attachments of the mastoid region of puma. Hast (1989) presented an anatomical study of larynxes of several felid species, including the puma. However, the musculature participating in the movements of the jaw has been poorly studied. Our aim was to describe the muscles of the jaw, which are directly related to masticatory function in the puma, describing their origins and insertions. This study will enhance our understanding of jaw musculature of this American mammal and will also constitute an important source of information on soft tissue anatomy for other studies.

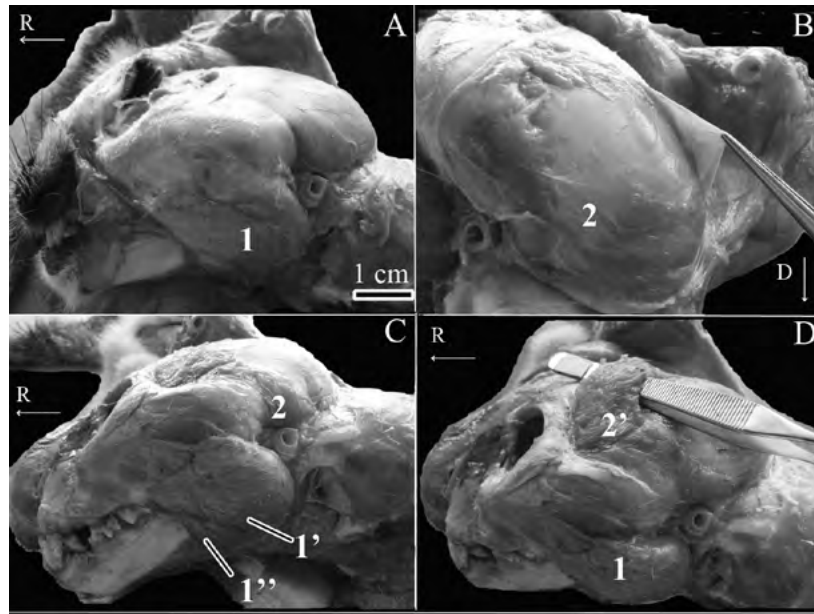
The muscles on the right and left side of the head of three specimens of puma, *Puma concolor puma*, were dissected. Faunal Department of Chubut Province (*Dirección de Fauna y Flora Silvestre del Chubut*, DFyFS) granted these puma specimens for the study. Collection numbers (DFyFS 288, 501 and 2e) are tentative until DFyFS completed the inventory of this faunal collection (housed at the *Instituto Patagónico de Ciencias Sociales y Humanas*, CENPAT-CONICET).

DFyFS 288 and DFyFS 501 corresponded to heads of adult males (between two and three years old). These animals were hunted in 2011 and 2013 in sheep ranges at the Biedma and Telsen departments respectively (north of Chubut Province, Patagonia, Argentina) and their heads were stored at the *Centro Nacional Patagónico* (CENPAT-CONICET). They were hunted by sheep farmers with permission of the provincial government. In 2005 puma was declared an injurious species for livestock in Chubut province and its capture is bounty (Law N° XVII 52). DFyFS 288 was preserved in 10% formaldehyde, so the observation of muscle fibers had some limitations related to this kind of preservation. DFyFS 501 was frozen at -20° C until dissection which took place 48 hours after freezing. DFyFS 2e corresponded to a young female (between eight months and one year old). This animal was hit by a car on August 2013 near Itsmo Ameghino, Peninsula Valdes Protected Area (Chubut Province, Argentina) and then transported to CENPAT for its study. The animal was frozen at -20° C until dissection. DFyFS 501 and DFyFS 2e were fresh, so the observation of muscle fibers was optimal.

In all specimens, dissection proceeded from the most external muscle layer and each muscle was documented with digital photographs. The origins and insertions of each muscle were recorded. A skull of puma was available for comparison and identification of skulls features during dissection. The muscular nomenclature used by Diogo *et al.* (2012) was employed. The following masticatory muscles were dissected in order to determine their origin and insertion: the masseter, temporalis, digastricus, pterygoideus medialis, pterygoideus lateralis, and mylohyoideus.

The masseter (Fig. 1A) is a broad muscle on the lateral side of the face and its function is to elevate the mandible. This muscle has been described in felids such as domestic cat (*Felis catus*, Linnaeus 1758), serval (*Leptailurus serval*, Schreber 1776), and tiger (*Panthera tigris*) (Sasaki *et al.*, 2000; Laison *et al.*, 2001; Diogo *et al.*, 2012). In *L. serval* and *P. tigris*, the masseter is divided into three layers (ventral, superficial and deep bundles) but in the present study only two layers were distinguishable: a superficial bundle (superficialis), which was the largest, and a deeper bundle profundus. The division of the masseter muscle into three layers or bundles is a feature well represented within felids (Diogo *et al.*, 2012). Nevertheless, in the *P. concolor* only two layers were present as in the small felids such as *F. catus* (Marcelo Carrera Pers. Obs., but see Laison *et al.*, 2001). This muscular configuration could be related particularly to the taxonomic relationship of *P. concolor* within Felidae (i.e., the most closet relationship between Domestic cat lineage and Puma lineage versus Caracal + Panthera lineages, see Johnson *et al.*, 2006). The masseter originates on the ventral border of the zygomatic arch and inserts onto the ventral part of the masseteric fossa. The origin and insertion are by tendons and fleshy fibers. The small deeper or ventral layer of the masseter attach to ventral and ventromedial portion of the ramus of the mandible. The layer superficialis, which occupies the major portion of the masseteric fossa, inserts mainly on the ventrolateral surface of the mandible (i.e., angular part). Both layers and bundles of the masseter muscle blended, posteriorly, the pterygoideus (see below).

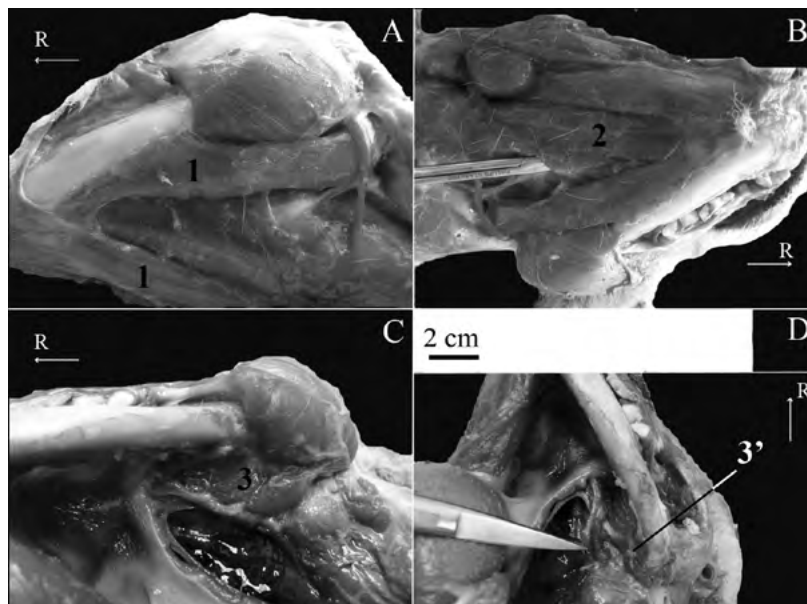
The temporalis (Fig. 1B) is a large muscle in carnivores (Turnbull, 1970) and its function is to elevate the mandible. As observed by Diogo *et al.*, (2012) in servals and tigers and by Laison *et al.*, (2001) in domestic cats, the temporalis is divided into two parts, superficial pars suprazygomatrica and the largest portion of the muscle, the deeper main body (Fig. 1C). Both parts are separated by an aponeurosis, important feature of the temporalis muscle in carnivores. The main body is subdivided into an anterior and posterior superficial layer. The well-developed pars suprazygomatrica (Fig. 1D) arises from the posterolateral portion of the skull and the medial side of the zygomatic arch. This muscle reaches the lateral part of the temporal crest. Both, the origin and the insertion, are via tendon and fleshy fibers. The largest layer of the temporalis (i.e., the deeper main body),



**Figure 1.** Female skull of the *Puma concolor* (the musculature is similar in males) showing the different mandibular muscles dissected. A. In lateral view. B. In dorsal view. C. In lateral view. D. In dorsolateral view. References: R, Rostral; D, Dorsal; 1, Masseter; 1', Masseter: superficialis layer, 1'', Masseter: profundus or ventralis layer; 2, Temporalis (main body); 2', superficial pars suprazygomatica.

originates from the temporal lines and the temporal fossa of the skull, also covering the caudal margin of the orbital ligament, whereas its insertion is in the coronoid process. The main body and its corresponding subdivision of the temporalis, is found in most groups of carnivores as well as other mammals, but the broad attachment of the deeper layer is a common feature present in carnivorans and just few other mammals (Diogo *et al.*, 2012).

The digastricus, a mandibular depressor muscle (Fig. 2A), is divided into two parts: rostral and caudal portions (named as digastricus anterior and digastricus posterior by Diogo *et al.*, 2012). The former is a mandibular muscle whereas the caudal portion is a hyoid muscle. Therefore, because the aim of this work was focused on the mandibular muscles, just the rostral portion of the digastricus is currently described. This is a relatively long and thin muscle. This ventral mandibular



**Figure 2.** Female skull of the *Puma concolor* (the musculature is similar in males) showing the different mandibular muscles dissected. A-D. In ventral view. References: R, Rostral; 1, Digastricus; 2, Mylohyoideus; 3, Pterygoideus medialis; 3', Pterygoideus lateralis.

muscle originates at the mastoid process of temporal and jugular process of occipital of skull and inserts via fleshy fibers in the ventromedial surface of the mandible.

The mylohyoideus (Fig. 2B) is a flat muscle and blind to the geniohyoideus muscle. It extends from the mylohyoid line running from the ventromedial portion of the body of the mandible. This muscle, related to the movements of the tongue and the elevation of the hyoid, inserts via a flat tendon (i.e., aponeurotically) to the hyoid apparatus as in other felids (see Diogo *et al.*, 2012).

Within the ventral mandibular muscles is the pterygoideus medialis and lateralis (Fig. 2C-D). The pterygoideus medialis is a robust muscle whereas the lateralis is a relatively thin muscle. The pterygoideus medialis, which is blended for the masseter, originates at the pterygopalatine fossa and inserts via tendon and fleshy fibers to the ventrolateral portion of the mandibular ramus. The pterygoideus lateralis, which is blended for the pterygoideus medialis (a feature present in all major carnivoran groups, see Diogo *et al.*, 2012) originates at the lateral surface of the pterygoid bone and adjacencies and inserts to the condylar process of the mandible via a well-marked tendon.

The *P. concolor* is a widely sparse carnivoran mammal; however, several aspects particularly those related to its soft tissue anatomy are poorly known. In this context, this study provides novel information which can be used as a source for further studies for this or others species of Felidae. This study augments our knowledge of soft tissue mandibular anatomy of this still enigmatic American felid.

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