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Anatomical Study of Extrinsic and Some Intrinsic Muscles of the Thoracic Limb in Iranian Pine Marten (*Martes Martes*): A Case Report

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Abstract:

The study of myology is relevant for both functional understanding of and distinguishing different species. The pine marten (*Martes martes*) is a small carnivore found in Europe and Western Asia and belongs to the Mustelidae family. For the purpose of this study, a fresh carcass which was found in the hunters' trap, was brought to the anatomy hall of veterinary faculty, for anatomical studies. After the routine preparation of the specimen, extrinsic muscles of forelimbs and intrinsic muscles situated on the shoulder and brachium regions were studied by gross dissection. Here we aim to describe the morphology of extrinsic as well as shoulder and brachium muscles of pine marten forelimb and compare them to the other carnivores. Overall, our findings indicated that forelimb muscles in pine marten are highly conservative. However, some significant differences in origin, insertion and the number of sections were observed in some muscles. These results will be useful for comparative myological studies of Mustelidae family and other carnivores. Meanwhile, further studies with more samples are needed to present clear information for Mustelidae family.

Keywords:

Anatomy, Marten, Morphology, Muscle, Thoracic limb

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Case history

The study of myology is relevant for both understanding of the muscular system and distinction of different species. Carnivores are the order of mammals which are successful in hunting, currently with about 128 living species (Wilson, 2009). However, in comparison with this diversity, the documented knowledge of myological variation within this order is still scarce, except for the canine and feline (Evans, 1993). Particularly for mustelids, a clade with broad locomotion strategies, only a few publications have dealt with postcranial musculature (Fisher et al. 2008). In this family, some of the characteristics of the muscular system have been considered useful in order to distinguish between species. (Fisher et al. 2008; Moore et al. 2013).

Extrinsic muscles of the forelimb are the muscles that arise from the neck, thorax, or cranium and extend to the forelimb. All the extrinsic muscles of pine marten are visually distinguishable. The extrinsic muscles are divided into two divisions: 1. The dorsal division includes the trapezius, rhomboideus, latissimus dorsi and omotransversarius and 2. The ventral division which includes the serratus ventralis, omotransversarius, brachiocephalicus and pectoral muscles. Intrinsic muscles include those that are associated only with the limb itself and situated on the scapula, brachial and antebrachial regions. These muscles act (extension or flexion) on shoulder, elbow, carpal and digital joints (Dyce et al. 2018).

The Iranian pine marten (*Martes martes*) is a species, distributed in Europe and Western Asia belonging to the Mustelidae family. They have a cream to yellow color bib-like marking on their throats (Hickman et al. 2008).

All the previous myological studies for the Mustelidae family have been collected and presented by Ercoli et al. in 2014. To the authors' knowledge, there are no myological descriptions of Iranian pine marten and all the previous studies were related to other species. Only a few studies have been performed on forelimb of other Mustelidae species such as American badger (*Taxidea taxus*) (Moore et al. 2013; Hall, 1926), American Martes (*Martes americana*) (Leach , 1977), Lesser Grison (Ercoli et al. 2014) and other studies had different target organs such as lumbar region, tail, hind limbs and bones (Maed et al. 2000; Macdonald et al. 1995). Also, almost all presented pictures in literature studies were drawings and overall, few high resolution images for comparison can be found in the literature.

For these reasons, the principal goal of this study is to present a general description of muscles of forelimbs of pine marten and present high quality photographs instead of drawings. We hope that in the future, more morphologic and morphometric findings and a more comprehensive comparison of carnivorous fore limb myology will be presented.

Clinical presentation

The carcass of one male adult pine marten was provided by the environmental department of Semnan province in Iran. The animal was caught in the hunter's trap and died in Golestan province. Because of the scarcity of this species, environmental department separated the head, fore limb and hind limb paws in order to prepare taxonomy and statistical samples. For this reason,

the rest of the thoracic limb muscles on the fore arm could not be studied. The carcass was sent to the faculty of veterinary medicine of Semnan University for anatomical studies. To increase the durability and fixation of the carcass, 500 ml of 10% formalin was injected into the abdominal and the thoracic cavity, and the carcass was placed into 10% formalin for 10 days. After the fixation period, extrinsic and intrinsic muscles on the shoulder and brachium of the forelimbs were studied by gross dissection. The judgment of muscle size was done visually. At each stage of the dissection, the relevant description and also the clear images of the sample were taken.

Extrinsic muscles: The brachiocephalicus was extended from the arm to the head and neck. It was made up of two portions including cleidobrachial and cleidocephalic, and most likely the cleidocephalic consisted of the clediomastoid and the cledicervical. The Proximal cleidobrachialis was separated from the cleidocephalic by a typical claviclular intersection just cranial of the shoulder joint. The cleidobrachialis originated from the clavicular intersection and inserted on the cranial of humeral crest just distal to the insertion of the deltoideus. The omohyoideus could be seen after removal of cleidomastoid muscle which originates from the cranial border of scapula and is attached to the sternothyrohyoid in its path (Fig.1).The delicate fibers connected to the cleidobrachial were probably cutaneous coli muscles.

The trapezius was segregated into two portions including cervical and thoracic, which were joined by a typical aponeurosis. Also, it was noticeable that the distal end of this aponeurosis terminated just about the caudal angle of the scapula. The cervical portion was larger in comparison to the thoracic portion and it covered some parts of the infraspinatus and the supraspinatus muscle. It just started caudally to cleidocephalic of brachiocephalicus and originated from nuchal ligament and spinous process of the 3rd cervical to 3rd thoracic vertebrate, independently and was inserted in the proximal half of the scapular spine. The thoracic portion stretched from 3rd to 8th thoracic vertebrae and inserts on the proximal extremity of the scapular spine (Fig. 1 and 2).

Omotransversarius was a strong, belt-like muscle originating from caudoventral of the atlas wings and runs caudoventrally to the medial side of the brachiocephalicus. It was inserted on distal of the scapular spine and the suprahamate process of the scapula (Fig. 1 and 2).

The rhomboideus muscle could be exposed after removal of trapezius, omotransversarius and brachiocephalicus muscles. It contained four parts: the thoracis, cervicis, capitis and atlantis (Fig. 3).

Rhomboideus thoracis was the largest division of this muscle. It originated from the dorsal midline raphe and the supraspinous ligament associated with the third and fourth thoracic vertebrae. The rhomboideus cervicis and the rhomboideus thoracis inserted on the scapular cartilage (Fig.3).

Regarding the animal size, rhomboideus capitis had a significant size. It originated from the nuchal crest of the occipital bone and inserted near the cervical portion of the serratus ventralis on the cranial angle of the scapula. The rhomboideus atlantis was originated from near the omotransversarius in atlas and inserted on the most proximal part of the scapular spine, and its fibers were not associated with the other two muscles (Fig. 3).

The serratus ventralis was a well devel-

Figure 1. Superficial muscles of the left forelimb. (Lateral view). 1. Latisimus dorsi. 2. Trapezius / cervicis (a) thoracis (b). 3. Omotransversarius. 4. Brachiocephalicus (cleidocephalicus). 5. Brachiocephalicus (cleidobrachialis). 6. Deltoideus (Scapular part) .7. Deltoideus (Acromial part). 8. Tensor Fascia antebrachii. 9. Triceps (Lateral head). 10. Triceps (Long head).

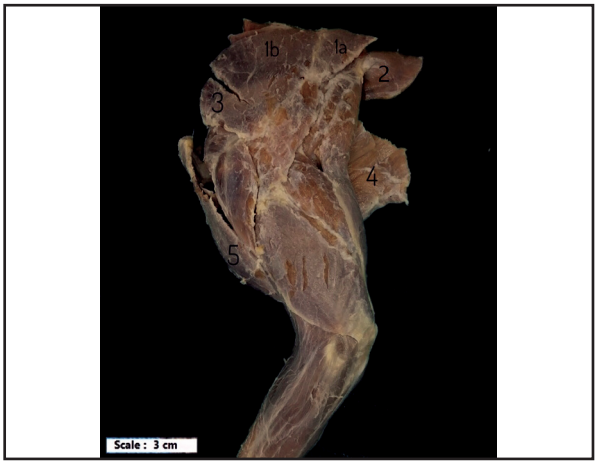

Figure 2. Insertions of some extrinsic muscles of the left forelimb. (Lateral view). 1. Trapezius (a) thoracis (b) cervicis. 2. Serratus ventralis thoracis. 3. Omotransversarius. 4. Latissimus dorsi. 5. Cliedobrachialis.

oped, fan-shaped muscle which had strong muscular digitations. It arose from the transverse processes of the last five cervical vertebrae and lateral surface of the first seven ribs. The muscle inserted on two small serrated faces located on the medial surface of the scapula and scapular cartilage. The thoracic part had more tendentious intersection (Fig.4).

The latissimus dorsi was a wide muscle which originated from the lateral surface of the 9th to 11th ribs and the spines of the 9th to 13th thoracic vertebrae. The muscle became narrower as it went to the insertion. The lower end of this muscle was located next to the ascending pectoral muscle and finally inserted on the medial surface of humerus next to the insertion of the teres major (Fig. 1, 4 and 6).

The pectoral muscle was divided into three well-developed heads including P. ascending, P. descending, and P. transverse. The P. descending and P. transverse were superficial and P. ascending had superficial and deep portions. The deep portion was situated in medial and upper than the superficial portion and inserted on the medial surface of the clavicular intersection. Also, the superficial portion of the P. ascending was more oblique while the deep portion was approximately straight. The P. ascending originated from the ventral surface of the sternum and the lower half of the costal cartilages (7th to 8th) and finally inserted on the cranial surface of the proximal extremity of the humerus. Regarding the animal size, the P. ascending was big and bulky and the fibers of P. ascending muscle were strait (Fig. 5 and 6).

The P. descending originated from the cranial 1/3 of the sternum and inserted in humeral crest of humerus. The P. transverse was located between P. descending and P. ascending. This muscle was the smallest head of pectoral muscle and it originated from the cranial half of the ventral border of sternum from the second to fourth costal cartilages and inserted on the medial surface of humeral fascia (Fig. 5 and 6).

Intrinsic muscles: Scapular and brachial muscles were also dissected. Like the domestic cat, mustelidae family had

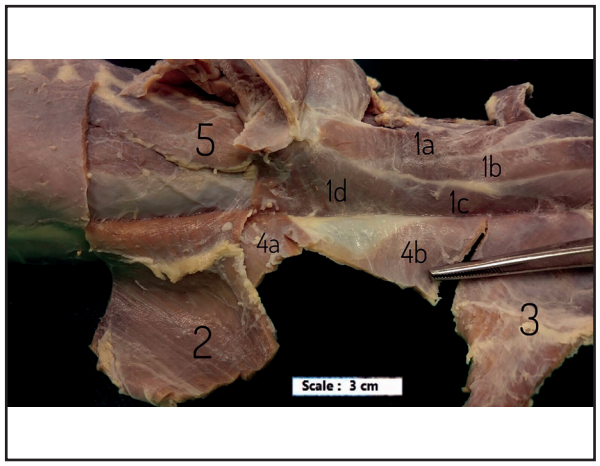

Figure 3. Some deep extrinsic muscles of the right forelimb (Dorsal view). 1a. Rhomboideus atlantis. 1b. Rhomboideus capitis. 1c. Rhomboideus cervicis. 1d. Rhomboideus thoracis. 2. Latissimus dorsi. 3. Cleidocephalicus. 4a. Trapezius thoracis. 4b. Trapezius cervicis. 5. Serratus ventralis cervicis.

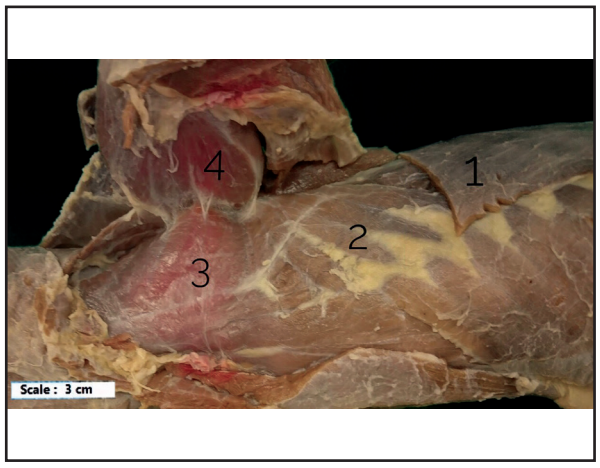

Figure 4. Some deep extrinsic muscles of the left forelimb. 1. Latissimus dorsi. 2. Serratus ventralis thoracis. 3. Serratus ventralis cervicis. 4. Subscapularis.

well-developed flexor and extensor muscles surrounding the shoulder joint. Important flexors of this joint, such as the triceps brachii (long head), deltoideus, teres major, and infraspinatus, were particularly well developed as extensors such as the biceps brachii and supraspinatus.

The deltoideus was composed of two portions that fuse and act in the shoulder. These two heads were completely divided and well developed. The smaller scapular portion arose from the length of the scapular spine and covered the infraspinatus muscle. The larger acromial portion of the deltoideus arose by fleshy fibers from both hamate and suprahamate processes (acromion and metacromion processes) and has a fusiform shape. Both portions of the muscle fused before they inserted on the deltoid tuberosity of the humerus by a strong flat tendon (Fig. 3 and 4).

The supraspinatus which was almost twice as wide and bulkier than the infraspinatus, was largely covered by the trapezius cervicis and the omotransversarius. It lied in the supraspinous fossa and extended over the cranial border of the scapula. However, it was bigger than the fossa and thus could be seen from medial view. It originated from supraspinous fossa in the scapular cartilages and inserted on both greater and lesser tubercle of the humerus (Fig. 7).

The infraspinatus was a fusiform muscle which lied in the infraspinatus fossa and extended caudally beyond it. The infraspinatus originated from the supraspinatus fossa in the lateral aspect of the scapula. It inserted on the caudal part of greater tubercle of humerus (Fig. 7).

The teres minor, a very small fusiform muscle, was located in the caudal of the shoulder joint. It was covered superficially by scapular part of the deltoideus. It originated from distal part of the caudal border of the scapula's adjacent edge of the glenoid region. It inserted on the greater tubercle, caudoventral to the insertion point of the infraspinatus (Fig. 7).

The multipennate subscapularis occupied the entire subscapular fossa. The supraspinatus was closely associated with it cranially, whereas the teres major had a similar relation caudally. It had six different parts which were easily differentiable and sepa-

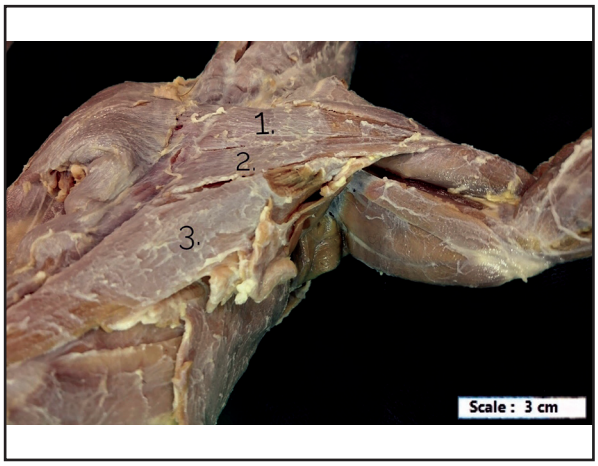

Figure 5. Pectoral muscles of the left forelimb.(Ventral view). 1. Pectoralis descending. 2. Pectoralis transversus. 3. Pectoralis ascending.

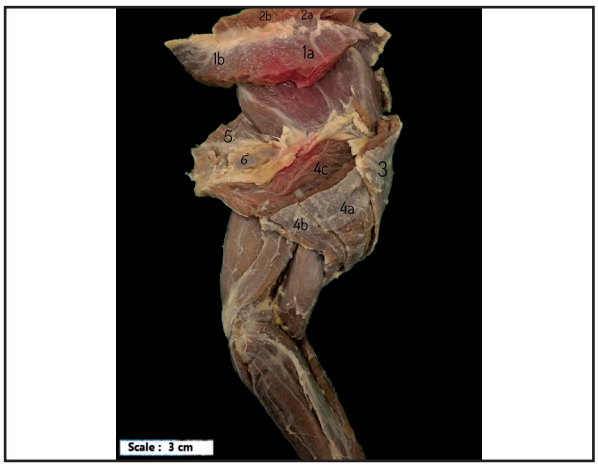

Figure 6. Insertions of some extrinsic muscles of the left forelimb. (Medial view). 1. Serratus ventralis (a) cervicis (b) thoracis. 2. Rhomboidus (a) cervicis (b) thoracis. 3. Cleidobrachialis. 4. Pectoralis (a) descending (b) transvers (c) ascending. 5. Latissimus dorsi. 6. Axilary limph node.

rated by deep notches. It originated from all of the subscapular fossa and inserted by a thick tendon on the caudal part of lesser tubercle of the humerus (Fig. 8).

The teres major muscle was also very well developed. Its proximal extremity arose from the proximal half of the caudal border of the scapula by fleshy fibers. It inserted on the teres major tuberosity, which was located on the medial surface of the proximal third of the humerus (Fig. 6).

The single and fleshy coracobrachialis muscle was fairly large regarding the animal size and originated from the coracoid process of the scapula and ran distally on the middle third of the medial face of the humerus (Fig. 8).

The tensor fascia antebrachii was a well-developed, thin strap muscle which had two portions in pine martens. The first part arose from the caudal angle of the scapula in the caudal border of the teres major and the second part arose from the fascia on the latissimus dorsi. Also, the first portion was thicker and situated in the lateral surface in the back of the triceps brachii. One part inserted on the proximal extremity and caudal border of olecranon and the other part inserted on the medial surface of the long head of triceps brachii (Fig. 1 and 8).

The triceps muscle consisted of four strongly developed heads including a long head, lateral head, medial head and accessory head, all of which inserted on the olecranon tuberosity (Fig. 3 and 4).

The lateral head arose from the tricipital line just caudal to the greater tubercle of the humerus by a short flat tendon. The lateral head was larger than the long head. This portion inserted on the lateral surface of the olecranon. The medial head arose from a ridge situated just under the humerus. This portion blended with the long head and inserted on the medial side of the olecranon. The long head was a large muscle that originated on the caudal border of the scapula immediately caudal to the glenoid cavity. It inserted by a strong tendon to the dorsal and cranial aspects of the olecranon. Accessory head originated from the common tendon of insertion of the teres major and latissimus dorsi and inserted on the medial face of the olecranon (Fig. 8).

The biceps brachii was a large fusiform

Figure 7. Some intrinsic muscles of the left forelimb. (Lateral view). 1. Triceps (Long head). 2. Triceps (Lateral head). 3. Triceps (Accessory head). 4. Brachialis. 5. Teres minor. 6. Teres major. 7. Supraspinatus. 8. Infraspimatus.

Figure 8. Intrinsic muscles of the left forelimb. (Medial view). 1. Teres major. 2. Subscapularis. 3. Coracobrachialis. 4. Tensor fasciae antebrachii. 5. Triceps (Long head) 6. Triceps (Medial head). 7. Triceps (Accessory head). 8. Biceps brachii.

muscle that originated from the supraglenoid tubercle of the scapula and was inserted by a strong, flat tendon to the radial tuberosity of the radius (Fig.8).

Assessments

The present study reveals that brachiocephalicus is composed of cleidocephalicus and cleidobrachialis, and cleidocephalicus muscle like the other carnivores has two heads: clediomastoidus and cledicervicalis (Fig. 3.) (Dyce et al. 2018). However, it has been mentioned that in American marten, cleidocephalicus is consisted of cleidomastoideus and cleido-occipitalis. (Leach, 177). The clavicular intersection of Iranian pine marten is well developed like other cats (Getty, 1975).

The present study also shows that the trapezius is clearly separated into a larger cervical part and a smaller thoracic part, which is joined by a typical aponeurosis, around the caudal angle of the scapula (Fig. 1). In other carnivores, this ridge is placed slightly ahead (Getty, 1975). The cervical part of trapezius in this specimen inserts in the proximal half of the scapular spine, while this part of the trapezius inserts along the entire length of the scapular spine and metacromion process in American marten (Leach, 1977).

The present work showed that rhomboideus muscle contained four parts: the thoracis, cervicis, capitis and atlantis, with the thoracic part, being the largest of them all (Fig. 3). Studies on other carnivores showed that in these animals, rhomboideus muscle has three parts. In cheetah, ocelot, cat and dog rhomboideus is composed of cervicalis, capitis and thoracis. Unlike the literature studies, the fibers of the rhomboideus capitis and rhomboideus cervicis are completely separate in their insertion on the scapula (Dyce et al. 2018; Hudson et al. 2011; Julik et al. 2012). Also, in grison there are cervicis, thoracis, capitis and profundus divisions with the cervical division being the largest (Ercoli et al. 2014). In American marten, this muscle is made up of cervicalis, capitis and profundus (deep part) (Leach, 1977). However, due to attachments of the muscle in grison and American marten, the deep part is equipollent of rhomboideus atlantis.

Our case showed that latissimus dorsi is

an integrated muscle which originates from the spines of the 9th to 13th thoracic vertebrae (Fig. 1). While in American marten and ocelot this muscle originates from the spines of the 4th to 10th and 7th to 9th thoracic vertebrae respectively and divides near its insertion point into a dorsal and ventral part (Leach, 1977; Julik et al. 2012).

Concerning the pectoral muscle, this study showed that the muscle can be divided into four well-developed heads and P. ascending has two separated deep and superficial divisions itself (Fig. 6 and 7). These results correspond to a study done by Leach in 1977, however, with the difference that in American marten, two bellies of pectoral ascending are fused at their insertion. In other carnivores, pectoral muscle is divided into three divisions (Evans, 1993).

This research showed that the smaller scapular portion arises from the length of the scapular spine, while in ocelot and American marten this portion originates from the caudal border of the metacromion process (Fig. 3 and 4) (Leach, 1977; Julik et al. 2012). In the other carnivores like dog, cat, and grison, the scapular is larger and bulkier and originates from the scapular spine (Getty, 1975; Ercoli et al., 2014).

The subscapularis muscle in the Iranian Pine Marten consisted of six muscular bundles which were separated by some deep notches (Fig. 7). This is in agreement with previous observations about the dog, cat, cheetah, and grison (Dyce et al. 2018; Julik et al. 2012; Ercoli et al., 2014). However, this feature has not been reported in American marten (Leach, 1977).

The present work also reported that coracobrachialis is an integrated muscle which, compared to the size of the animal, is a relatively large muscle (Fig. 8). However, a similar study on American marten showed that coracobrachialis is a small muscle and consists of two bellies: a short belly inserts on the humerus at a point caudodorsal to the teres major tuberosity and the main belly passes distally to insert on the medial surface of the humerus just proximal to the supracondyloid foramen. (Leach, 1977).

This research reported that tensor fascia antebrachii has two divisions which arise from the caudal angle of scapula and fascia on the latissimus dorsi respectively (Fig. 8). This is similar to the observations in study of leach in 1977 and differs from other carnivores. In other carnivores, this muscle is originated from latissimus dorsi muscle individually. (Dyce et al. 2018). Also, Ercoli et al. in 2014 reported that this muscle is absent or modified in grison because no belly originating from the latissimus dorsi reaches the olecranon. It seems due to attachments of the muscle in grison, angular part of triceps brachii is equipollent of tensor fascia antebrachii.

Our study showed that triceps brachii possesses four well-developed heads of origin: a long, a lateral, a medial and an additional accessory head (Fig. 7 and 8). This result is matched with previous observations about dog and cat, but is different from studies on ocelot, American marten, and grison. In these species, the medial head of triceps brachii has two separated divisions itself (Dyce et al. 2018; Hudson et al. 2011; Julik et al. 2012; Ercoli et al. 2014).

This study provided, for the first time, a detailed description of fore limb muscles morphology in Iranain Pine Marten. According to our study, it could be concluded that the extrinsic, shoulder and brachial muscles of the thoracic limb in the marten resembles closely that of American marten

and other carnivores in general. However, there are also certain differences in origin, insertion and number of bellies of some muscles which were detected in the present study. These results will be useful for comparative myological studies of Mustelidae family and other carnivores. Meanwhile, further studies with more samples are needed to present clear information for Mustelidae family.

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مجله طب دامی ایران، ۱۳۹۷، دوره ۱۲، شماره ۳، ۲۸۱-۲۷۳

مطالعه آناتومیکی عضلات غیر خودی و برخی از عضلات خودی اندام حرکتی سینه‌ای در سمور جنگلی (*Martes martes*): گزارش موردی

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چکیده

مطالعه علم عضله شناسی با هدف درک عملکردی عضلات و تمایز گونه‌های مختلف دارای اهمیت می‌باشد. سمور جنگلی گوشتخوار کوچکی است که در اروپا و آسیای غربی یافت می‌شود و به خانواده راسویان (Mustelidae) تعلق دارد. لاشه تازه این حیوان بوسیله اداره محیط زیست سمنان در تله شکارچیان پیدا شد و برای بررسی‌های کالبدشناسی به سالن آناتومی دانشکده دامپزشکی دانشگاه سمنان ارجاع داده شد. پس از اقدامات معمول آماده سازی نمونه، عضلات خارجی اندام قدامی و عضلات داخلی واقع در ناحیه شانه و بازو تشریح و شد. هدف ما از این مطالعه بررسی و توصیف ریخت شناسی عضلات غیر خودی اندام حرکتی قدامی و خودی در نواحی شانه و بازوی سمور جنگلی و هم چنین مقایسه آن با سایر گوشتخواران بود. به طور کلی یافته‌های ما نشان داد که عضلات اندام قدامی در سمور جنگلی بسیار شبیه به سایر گوشتخواران است. با این وجود، برخی تفاوت‌های قابل توجه در خاستگاه، پیوستگاه و تعداد قسمت‌ها در برخی عضلات مشاهده شد. نتایج به دست آمده می‌تواند برای مطالعات کالبد شناسی مقایسه‌ای خانواده راسویان و گوشتخواران دیگر مفید باشد. اگر چه بدیهی است که مطالعات تکمیلی و مورفومتریک با نمونه‌های بیشتر برای ارائه اطلاعات ریخت شناسی واضح پیرامون خانواده راسویان نیاز است.

واژه‌های کلیدی: کالبد شناسی، سمور جنگلی، ریخت شناسی، عضله، اندام حرکتی سینه‌ای

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