Case Report

Anatomical Study of the Thoracic Limb Muscles in the European Badger (*Meles meles*): A Case Report

Mohammad Ali Adibi[1], Babak Rasouli[2*], Mohammad Hasan Yousefi[3], Arad Jahankhani[4]

1. Environmental Research Center of Semnan Province, Semnan, Iran.
2. Department of Basic Sciences, School of Veterinary Medicine, Semnan University, Semnan, Iran.
3. Department of Anatomy, School of Veterinary Medicine, Semnan University, Semnan, Iran.
4. School of Veterinary Medicine, Semnan University, Semnan, Iran.

Use your device to scan and read the article online

How to Cite This Article Adibi, M., Rasouli, B., Yousefi, M. H., & Jahankhani, A. (2026). Anatomical Study of the Thoracic Limb Muscles in the European Badger (*Meles meles*): A Case Report. *Iranian Journal of Veterinary Medicine, 20*(1), 205-218. http://dx.doi.org/10.32598/ijvm.20.1. 1005626

http://dx.doi.org/10.32598/ijvm.20.1. 1005626

Article info:
Received: 15 Sep 2024
Accepted: 23 Nov 2024
Publish: 01 Jan 2026

ABSTRACT

The European badger (*Meles meles*) belongs to the Animalia kingdom, Chordata phylum, Mammalia class, Carnivora order, Caniformia suborder, Musteloidea superfamily, and Mustelidae family. This study compared the muscles of the badger's thoracic limb with those of other carnivores, addressing the lack of information about these muscles, and highlighted their clinical significance in movement and digging, which is essential for the badger's survival and ecological niche. The Environmental Organization of Semnan Province, Iran, found the carcass of this badger, which died of natural causes in the surrounding areas of Semnan, and transferred it to the anatomy hall for anatomical studies. We dissected the extrinsic and intrinsic muscles of the thoracic limb after performing the sample preparation steps. A lot of interesting things were found in the study, like the two layers of the latissimus dorsi muscle, the two parts of the tensor fasciae antebrachii muscle, the thick accessory head of the triceps brachii muscle, and the two parts of the flexor carpi radialis muscle. Examined muscles exhibited similarities with other carnivorous muscles, yet they also showed significant differences in terms of the number of muscle parts and their growth. The muscles of the animals compared in this study were most like those of the dog and most unlike those of the fox. Among the other cases investigated in this study was the clavicle, which is hyaline cartilage in the European badger and is most similar to that of the dogs and neotropical otter (*Lontra longicaudis*).

Keywords: The European badger, Myology, Thoracic limb, Morphology

*** Corresponding Author:**
Babak Rasouli, Assistant Professor.
Address: *Department of Basic Sciences, School of Veterinary Medicine, Semnan University, Semnan, Iran.*
Phone: *+98 (912) 1959072*
E-mail: *b.rasouli@semnan.ac.ir*

Case History

Like other animals, the badger's thoracic limb muscles play a key role in its movement. However, due to their size and structure, these muscles also play a significant role in their extraordinary ability to dig the ground (Moore et al., 2013).

Badgers (*Meles meles*) are diverse creatures with adaptations suited to their environments. From the social European badger to the solitary American badger, each species plays a unique role in its ecosystem. Their burrowing habits contribute to soil health, while their varied diets reflect their omnivorous nature. The genus *Meles* consists of European badgers and is the most widely distributed among mustelids, ranging from the British Isles to South China (Abramov et al., 2009). Badgers are often referred to as ecosystem engineers. They create extensive burrow systems known as setts, which serve multiple ecological functions. These setts disturb the soil, promoting greater plant diversity and providing microhabitats for various species. The disturbance caused by their digging activities enhances species richness in forest ecosystems, making badgers vital for maintaining biodiversity. Their setts can also be utilized by other animals as breeding sites or shelters, further contributing to local biodiversity (Kurek et al., 2022).

Badgers possess hypertrophied shoulder flexors that contribute to their digging efficiency. These muscles stabilize the shoulder joint against high forces generated during digging. The badger, a member of the weasel family, is characterized by its low-slung, short-legged, and long-bodied appearance. It possesses immense power with a very muscular neck, chest, and forelegs, as well as large and strong claws. Badgers possess hypertrophied shoulder flexors that contribute to their digging efficiency. These muscles stabilize the shoulder joint against high forces generated during digging (Moore et al. 2013).

Its face is instantly recognizable, with a white head and two wide black stripes extending from the nostrils to the back of the neck. Short ears tipped with white and relatively small eyes set low on its face complete its distinctive features. White and black stripes are characteristic of the European badger and are not found in other badger species. On the other hand, non-European species do not live in Semnan Province, Iran (Pearce, 2011).

Anatomical studies have been done on this badger, but there are brief studies on the muscles of the thoracic limb of this species (Böhmer, et al., 2020). There have been only a small number of studies conducted on the forelimbs of other Mustelidae species, including the American badger (*Taxidea taxus*) (Moore et al., 2013) and the lesser grison (Ercoli et al., 2015). Additionally, other studies have focused on different target organs such as the lumbar region, tail, hind limbs, and bones (Macdonald & Kneepkens, 1995). The objectives of this study include investigating and comparing the muscles of the badger's thoracic limb with those of other carnivores, addressing the lack of information about these muscles, highlighting their clinical importance, and emphasizing their significant role in movement and digging.

Clinical Presentation

The sent sample was related to a female badger that died due to natural causes and was transferred to the faculty's anatomy hall through the Semnan Environment Department. Animal dissection was done ethically and normally. Observed no signs of injury in the hand, and examined the specimens' teeth and dental formula (I3/3, C1/1, P4/4, M1/2=38) to confirm their complete growth (Kurek et al., 2022). The body length of the badger was 75.2 cm, and the weight was 9.25 kg. The badger's body was fixed and preserved by injecting 500 mL of 10% formalin into the abdominal and thoracic regions, followed by immersing the entire carcass in 10% formalin for 2 weeks. After preservation, the intrinsic and extrinsic muscles of the forelimb were carefully dissected for anatomical examination, which included muscle identification, determination of origin and insertion, and a comparison of significant differences between this species and other carnivores. The results were documented with a digital camera (Canon Legria HF R16E, Canon Inc. Japan).

Extrinsic muscles

The trapezius muscle, which consists of two cervical and thoracic parts, covers the back of the shoulder and neck. The cervical part, which was significantly larger than the thoracic part, directed its fibers caudoventrally, while the thoracic part's fibers directed cranioventrally (Figures 1 and 2). The neck part starts at the nuchal ligament and the spinous process of the third cervical to the third thoracic vertebrae. It connects to the front half of the scapular spine. The thoracic part extended from the third to the eighth thoracic vertebrae and attached to the proximal extremity of the scapular spine (Figures 1 and 2). The rhomboideus muscle was located deep in the trapezius muscle. This muscle was responsible for the protrusion of the withers. This muscle had four parts:

Rhomboideus cervicis, rhomboideus thoracis, rhomboideus capitis, and rhomboideus profundus. This muscle, rhomboideus thoracis, was connected to the dorsal midline raphe by the supraspinous ligament. The third and fourth thoracic vertebrae were attached to it by the same ligament. The scapular cartilage receives the insertion of this muscle and the rhomboideus cervicis (Figure 3). The rhomboideus capitis muscle attaches to the occipital bone at the nuchal crest, close to the cervical part of the serratus ventralis muscle on the scapula's cranial angle. The omotransversarius muscle in the atlas was where the rhomboideus profundus muscle began. It is then attached to the closest part of the scapular spine (Figure 3). The omotransversarius muscle is a cord-shaped muscle between the atlas vertebra and the scapula.

On the other hand, it was located between the brachiocephalicus muscle and the cervical part of the trapezius muscle. Brachiocephalicus covers the upper part of this muscle. The brachiocephalicus muscle originates from the distal part of the scapular spine and inserts into the caudal area of the atlas vertebra's wing (Figure 1). The cranial side of the humeral crest receives the brachiocephalicus muscle, which originates from the head. The clavicular intersection divides the brachiocephalicus muscle into two sections, cleidocephalicus and cleidobrachialis. The cleidobrachialis, also known as the cleidocephalicus, is located between the clavicular intersection and the head region. It contained two parts known as cleidomastoideus and cleidocervicalis (Figure 1). The serratus ventralis muscle was a broad, fan-shaped muscle that originated from the lateral surface of the thorax and neck and extended to the upper extremity of the inner surface of the scapula. It consisted of two parts known as serratus ventralis cervicis and serratus ventralis thoracic (Figure 4). The latissimus dorsi muscle was located under the cutaneous trunci muscle, and the direction of its fibers was cranioventral.

The dorsolateral position of the thorax and trunk situates this muscle behind the scapula. This muscle's origin was the lateral surface of the 9^{th} to 11^{th} ribs and the spines of the 9^{th} to 13^{th} thoracic vertebrae. The medial surface of the humerus serves as its insertion point. Figures 1 and 5 illustrate the composition of this muscle in the badger, which consists of two superficial and deep layers. The group of pectoral muscles was situated between the ventral part of the thorax on one side, and the brachial region and the distal extremity of the scapula from the thoracic limb on the other. This muscle consisted of three parts: Pectoralis descending, pectoralis ascending, and pectoralis transverse (Figure 6). Located immediately behind the brachiocephalicus muscle, the pectoralis descending muscle originated from the manubrium and inserted itself on the medial surface of the brachium. The pectoral transverse muscle, whose fibers covered parts of the pectoralis descending muscle, was located behind it. One part of the pectoralis ascending muscle originates from the caudal and middle parts of the sternum. In contrast, the other originates from the lateral thorax, covered by the lower latissimus dorsi, and inserts into the medial arm.

Intrinsic muscles

The subscapularis was a broad muscle that covered the subscapular fossa. This muscle consisted of 6 muscular bundles. This muscle originated from the subscapular fossa and connected to the caudal lesser tubercle of the humerus after passing through the medial shoulder joint. The teres major muscle, a long, band-shaped muscle, was situated caudal to the. The teres major muscle started at the back of the scapula, went through the subscapularis muscle, and then joined the teres major tuberosity on the humerus (Figure 4). The coracobrachialis muscle was a band-shaped muscle on the medial surface of the shoulder joint, the humerus, and the lower extremity of the scapula. This muscle began at the coracoid process of the scapula and traveled down to connect with the medial surface of the humerus above the teres major tuberosity. The tendon forms the lower half of this muscle in the badger (Figures 7 and 8). Located in the supraspinous fossa, the supraspinatus muscle extends toward the cranial aspect of the scapula. Its point of origin was the supraspinous fossa, and it inserted onto the greater and lesser tubercles of the humerus (Figures 4, 7, and 8). The infraspinatus muscle was located in the infraspinous fossa and developed towards the caudal of this fossa. The infraspinous fossa served as the muscle's origin, and it inserted itself on the caudal part of the greater tubercle of the humerus. There is a muscle called the teres minor that is part of the deltoideus muscle. It starts at the bottom of the scapula's caudal border and attaches to the humerus at the teres minor tuberosity. The deltoideus muscle consisted of two scapular and acromial parts. The scapular part originates from the scapular spine, while the acromial part originates from the acromion process. Both parts insert their lower ends into the deltoid tuberosity of the humerus. The scapular part was thin and long, while the acromial part was more voluminous (Figure 1). The anconeus muscle was located in the caudal region of the distal extremity of the humerus; this muscle was also located in the depth of the lateral head of the triceps brachii muscle. This muscle originated from the olecranon fossa, and its insertion points were the anconeal process and the lateral surface of the olecranon tuberosity. The brachialis muscle is positioned in the bra-

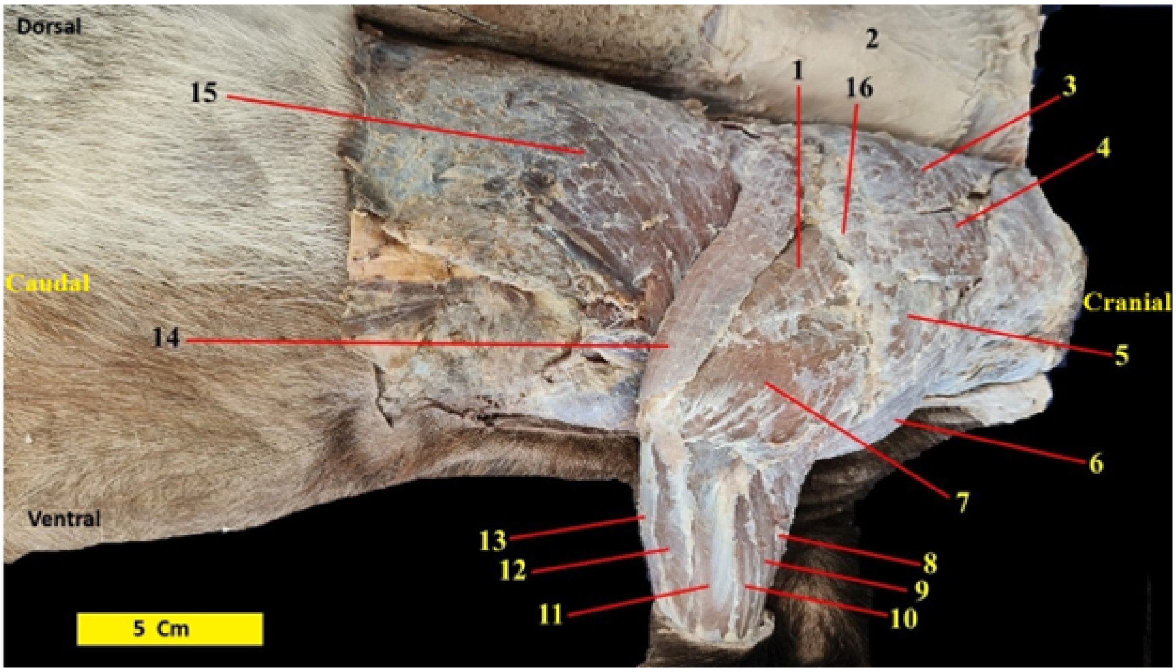

Figure 1. Lateral view of muscles of right forelimb in the studied badger

Note: 1) Long head of triceps brachii muscle, 2) Cutaneous trunci muscle, 3) Cervical part of trapezius muscle, 4) Omotransversarius muscle, 5) Acromial part of the deltoideus muscle, 6) Brachiocephalicus muscle, 7) Lateral head of the triceps brachii muscle, 8) Brachioradialis muscle, 9) Extensor carpi radialis muscle, 10) Common digital extensor muscle, 11) Lateral digital extensor muscle, 12) Extensor carpi ulnaris muscle, 13) Ulnar head of the flexor carpi ulnaris muscle, 14) Tensor fasciae antebrachii muscle, 15) Latissimus dorsi muscle, 16) Scapular part of the deltoideus muscle.

chial groove, resulting in spiral-shaped fibers. The upper third of the caudal surface of the humerus was the origin, and the insertion of this muscle was the upper extremity of the medial border of the radius bone. The biceps brachii muscle, located in the cranial position of the humerus, is a powerful muscle that affects the shoulder and elbow joints. The biceps brachii muscle originates from the supraglenoid tubercle and inserts into the radial tuberosity after passing through the intertubercular groove (Figures 7 and 9). The triceps brachii muscle was a bulky and triangular muscle located in the caudal triangular space of the scapula and humerus. This muscle had 4 heads, including the long head, lateral head, medial head, and accessory head. From the lateral side, the long and lateral heads were visible, and from the medial side, the long, medial, and accessory heads were visible (Figures 1 and 7). The lateral head was the longest of the triceps brachii muscle, which was located in the caudal part of the scapula. The caudal border of the scapula was its origin, and the olecranon tuberosity was its insertion. The lateral head origin was the lateral surface of the humerus above the deltoid tuberosity, and its insertion was the lateral surface and cranial border of the olecranon tuberosity. The humerus's medial surface above the teres major tuberosity served as the origin of the medial head, which then inserted itself into the olecranon tuberosity's medial surface. The caudal surface at the bottom of the humerus's neck also served as the origin for the accessory head of this muscle, which then inserted itself into the cranial border of the olecranon tuberosity. The badger developed an accessory head (Figures 1 and 7). The tensor fasciae antebrachii muscle attaches to the medial surface of the triceps brachii muscle. Positioned slightly behind the triceps brachii muscle, it appears as a thin and wide muscle from the lateral surface. This muscle started from the caudal angle of the scapula, extended to the medial side of the forearm, and finally inserted into the caudomedial part of the antebrachial fasciae of the forearm (Figure 1). In the badger, this muscle had a bulky caudal part and a thin medial part. The latissimus dorsi muscle tendon connected the medial part (Figure 6). The brachioradialis muscle in the badger was broad and completely covered the extensor carpi radialis muscle. The pronator teres muscle starts at the medial epicondyle of the humerus. It ends at the craniomedial position of the upper limb of the radius bone (Figure 10). The cranial surface of the radius is attached to the extensor carpi radialis muscle. The origin of this muscle was the radial fossa. Its insertion was the dorsal surface of the 2nd and 3rd metacarpal bones (Figure 10). The common digital

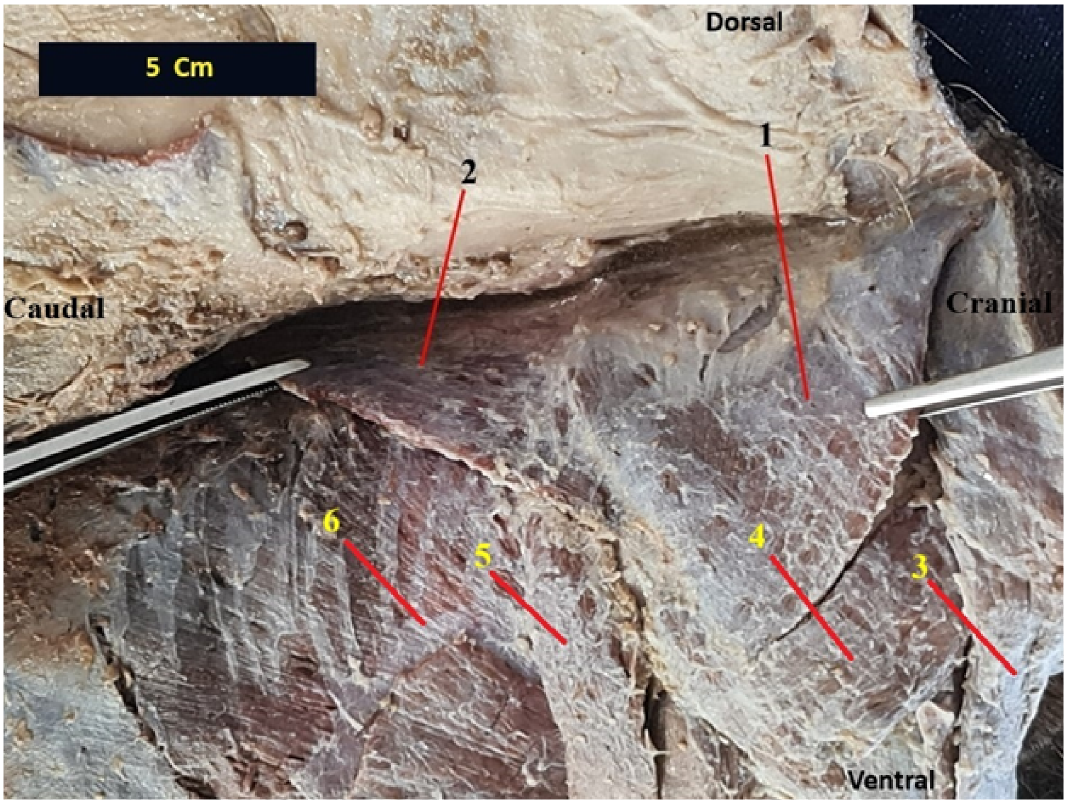

Figure 2. Parts of the trapezius muscle in the right forelimb of the studied badger

Note: 1) Cervical part of the trapezius muscle, 2) Thoracic part of the trapezius muscle, 3) Brachiocephalicus muscle, 4) Omotransversarius muscle, 5) Tensor fasciae antebrachii muscle, 6) Latissimus dorsi muscle.

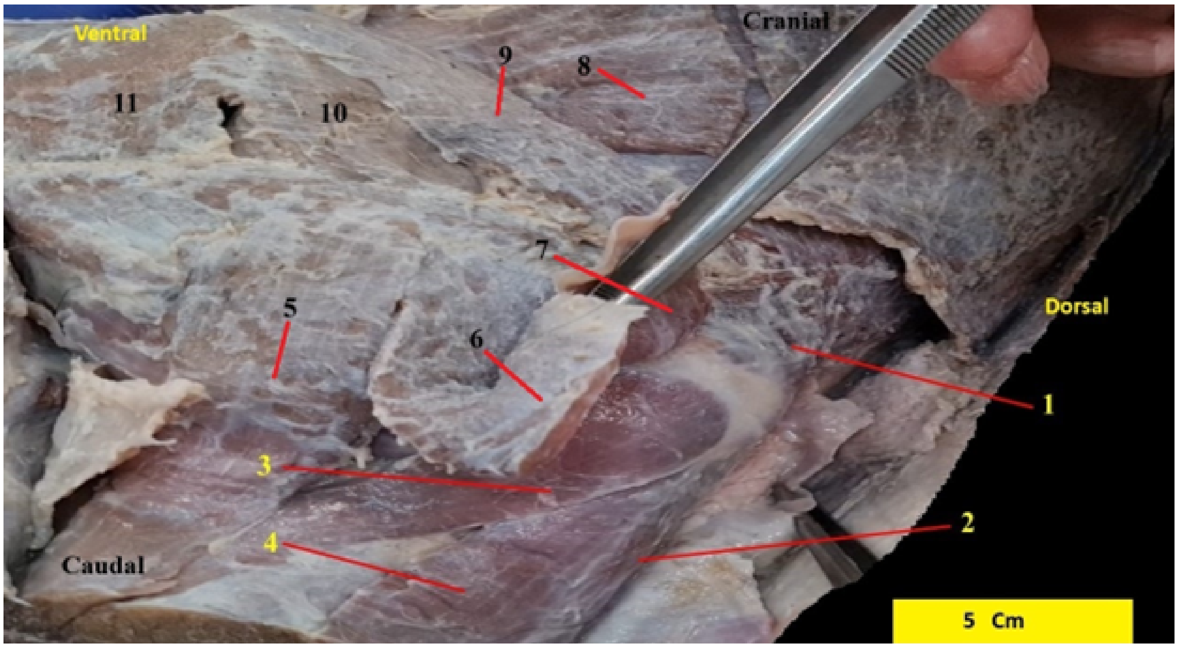

Figure 3. Parts of the rhomboideus muscle in the right forelimb of the studied badger

Note: 1) Rhomboideus thoracis, 2) Rhomboideus cervicis, 3) Rhomboideus profundus, 4) Rhomboideus capitis, 5) Omotransversarius muscle, 6) Cervical part of trapezius muscle, 7) Thoracic part of trapezius muscle, 8) Latissimus dorsi muscle, 9) Tensor fasciae antebrachii muscle, 10) Long head of triceps brachii muscle, 11) Lateral head of the triceps brachii muscle.

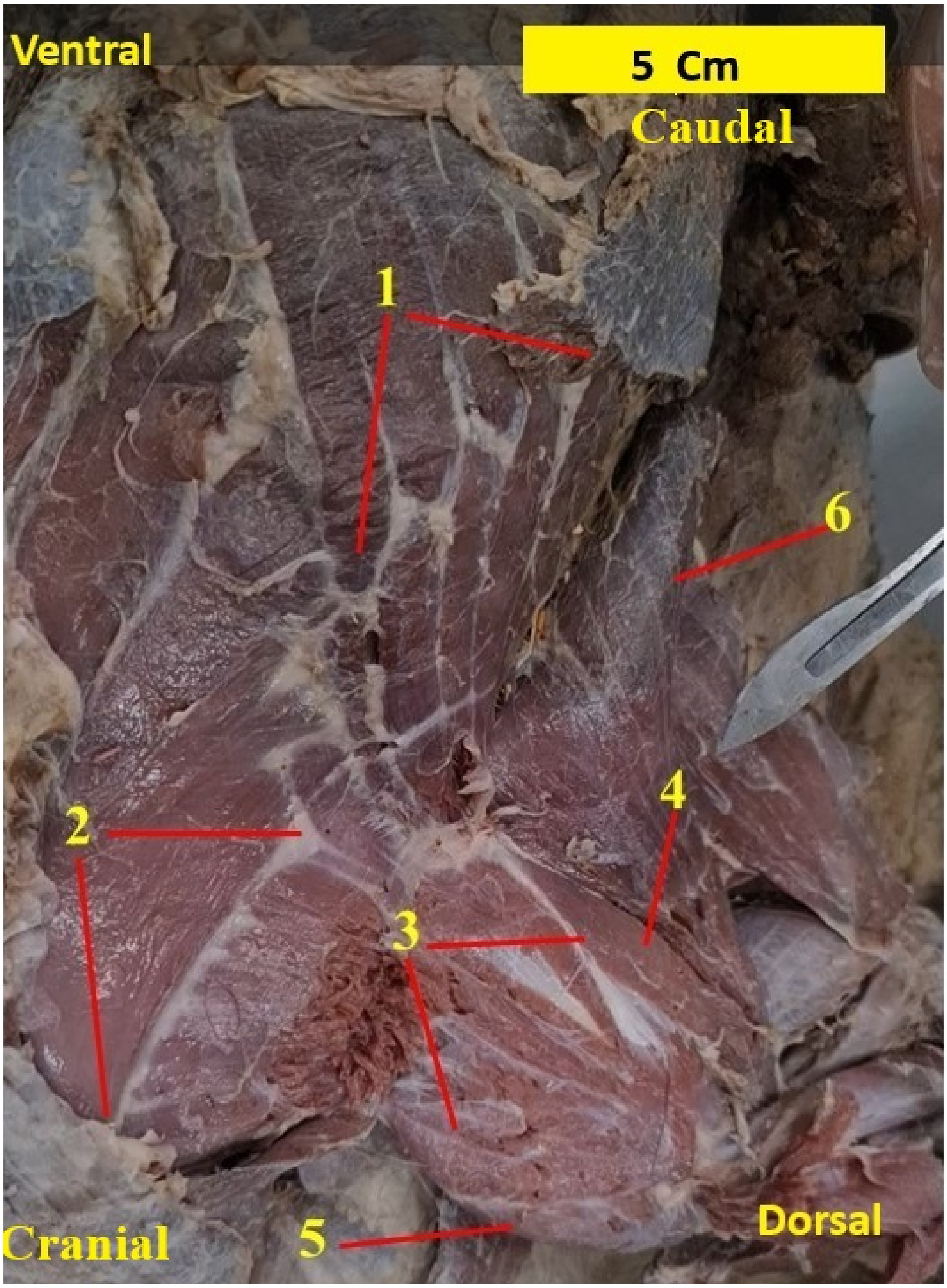

Figure 4. Medial view of some thoracic limb muscles in the right forelimb of the studied badger

Note: 1) Serratus ventralis thoracic, 2) Serratus ventralis cervicis, 3) Subscapularis muscle, 4) Teres major muscle, 5) Supraspinatus muscle, 6) Deep layer of the latissimus dorsi muscle.

extensor muscle, which originated from the lateral humeral epicondyle and was inserted on the ungular process of the dorsal surface of the distal phalanx of digits 2–5, was located between the extensor carpi radialis and lateral digital extensor muscles (Figure 10). The lateral digital extensor muscle is located in the lateral position of the forearm, slightly caudal to the common digital extensor muscle. The lateral epicondyle of the humerus serves as its origin, and it inserts into the dorsal portion of the distal phalanges of digits three to five (Figure 10). The extensor carpi ulnaris muscle is located at the back and side of the forearm. This muscle extended from the lateral epicondyle of the humerus to the upper extremity of the 5th metacarpal bone (Figure 10). The extensor carpi obliquus muscle was on the outside of the thigh bone's lower end, between the extensor digitorum and extensor carpi radialis muscles. The lower third of the lateral edge of the radius bone was the origin of this mus-

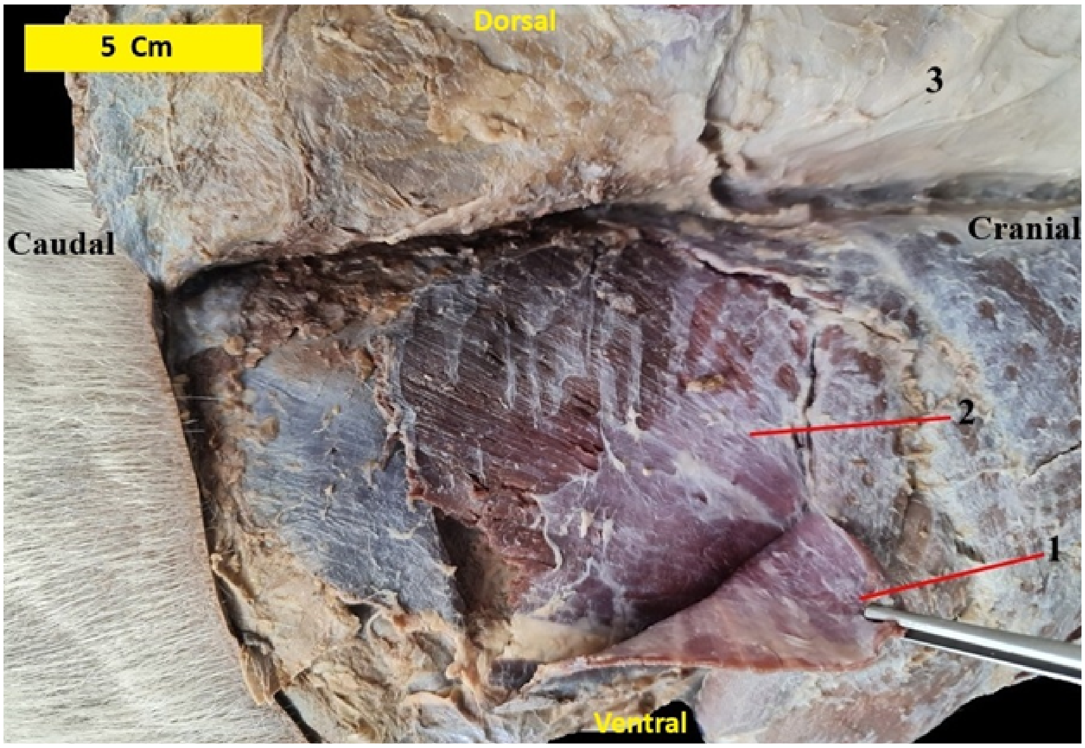

Figure 5. Layers of the latissimus dorsi muscle in the right forelimb of the studied badger

Note: 1) Superficial layer of the latissimus dorsi muscle, 2) Deep layer of the latissimus dorsi muscle, 3) Cutaneous trunci muscle.

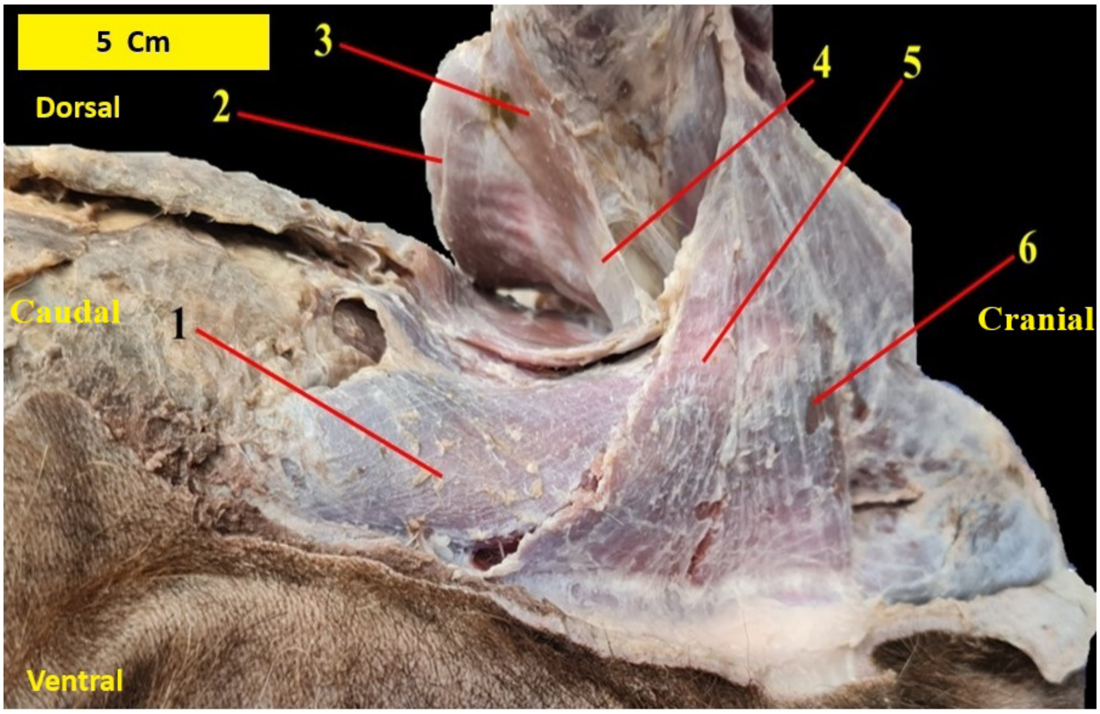

Figure 6. Parts of the pectoral and tensor fasciae antebrachii muscles in the right forelimb of the studied badger

Note: 1) Pectoralis ascending muscle, 2) Caudal part of the tensor fasciae antebrachii muscle, 3) Medial part of the tensor fasciae antebrachii muscle, 4) Tendon of the medial part of the tensor fasciae antebrachii muscle, 5) Pectoralis transverse muscle, 6) Pectoralis descending muscle.

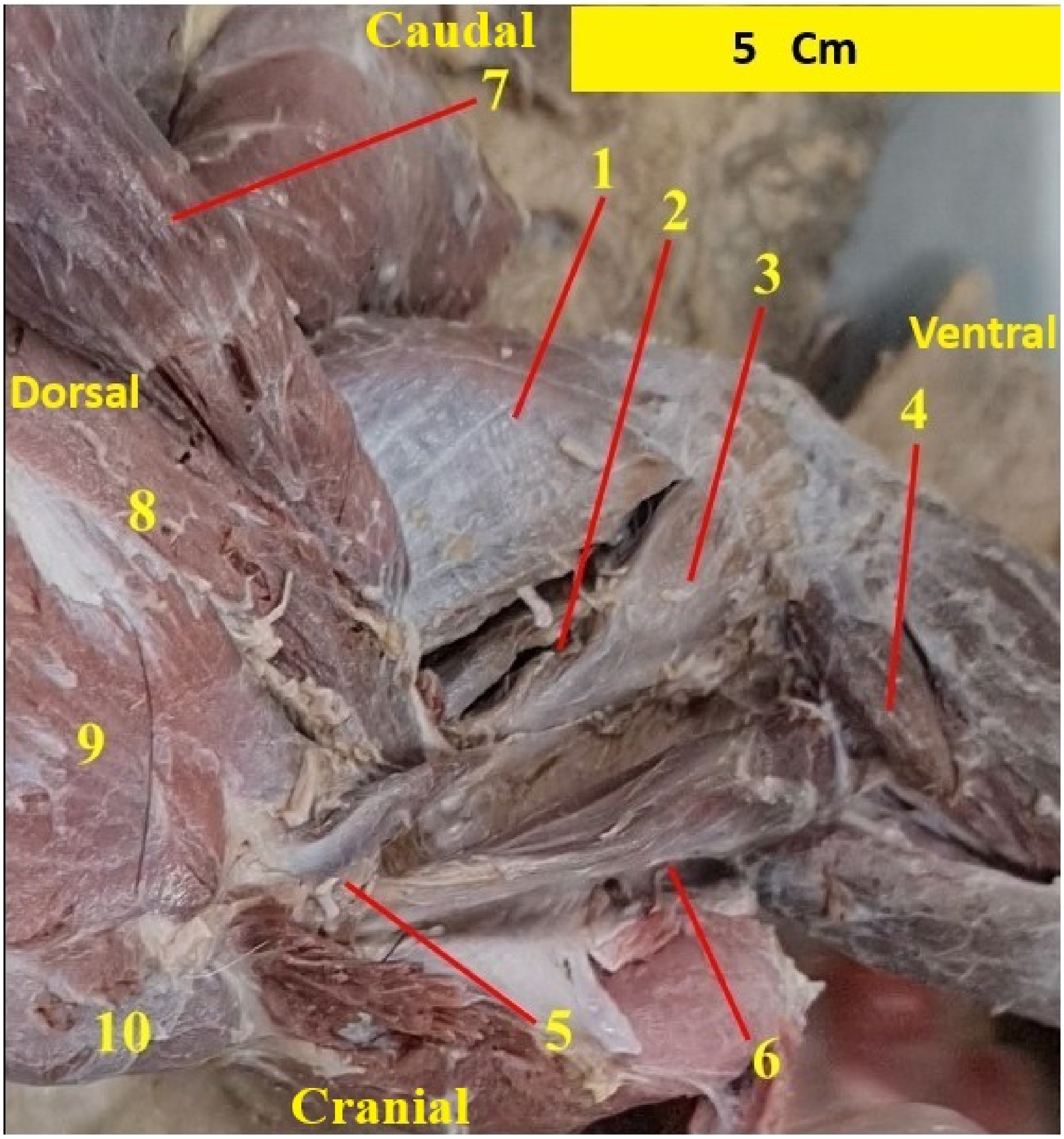

Figure 7. Medial view of scapular and brachial muscles in the right forelimb of the studied badger

Note: 1) Long head of the triceps brachii muscle, 2) Accessory head of the triceps brachii muscle, 3) Medial head of the triceps brachii muscle, 4) Pronator teres muscle, 5) Coracobrachialis muscle, 6) Biceps brachii muscle, 7) Latissimus dorsi muscle, 8) Teres major muscle, 9) Subscapularis muscle, 10) Supraspinatus muscle.

cle, and its insertion was the upper extremity of the metacarpal bone. The flexor carpi radialis muscle was positioned medially in the forearm, slightly posterior to the medial border of the radius. The origin of this muscle was the medial epicondyle of the humerus, from which it extended to the upper extremity and the palmar surface of the metacarpal bones 2 and 3. This muscle was divided into two parts in the badger (Figures 8 and 9). The flexor carpi ulnaris muscle is located caudal to the flexor carpi radialis muscle and on the medial surface of the forearm. This muscle had two heads: The ulnar head and the humeral head. The origin of the ulnar head was the olecranon tuberosity, and the origin of the humeral head was the medial epicondyle of the humerus. The accessory carpal bone of the carpus also served as the insertion point for the mentioned muscle (Figures 8 and 9). The supinator muscle was located deep between the common digital extensor and the extensor carpi radialis. This muscle originated from the lateral epicondyle of the humerus, and its insertion was the cranial surface of the upper extremity of the radial bone. The superficial digital flexor muscle, which is at the same level as the flexor carpi ulnaris muscle, could be seen in the caudomedial position of the forearm. The medial epicondyle of the humerus gave rise to this muscle, which attached itself to the palmar surface of the second phalanx of digits two to five (Figures 8 and 9). The deep digital flexor muscle was located at the caudal of the forearm and between the

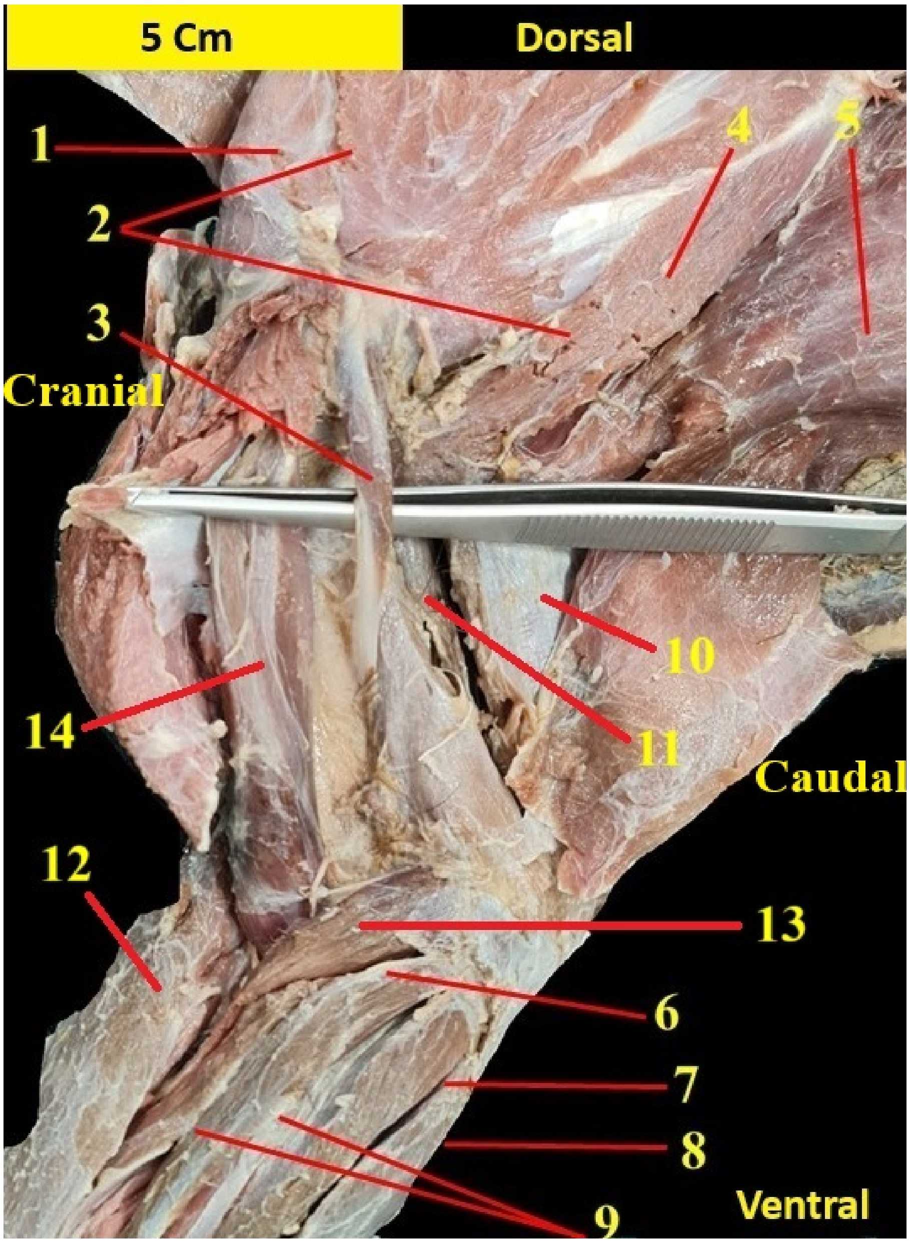

Figure 8. Medial view of scapular, brachial, and antebrachial muscles

Note: 1) Supraspinatus muscle, 2) Subscapularis muscle, 3) Coracobrachialis muscle, 4) Teres major muscle, 5) Latissimus dorsi muscle, 6) Pronator teres muscle, 7) Humeral head of the flexor carpi ulnaris, 8) Superficial digital flexor muscle, 9) Flexor carpi radialis, 10) Long head of the triceps brachii muscle, 11) Accessory head of the triceps brachii muscle, 12) Brachioradialis muscle, 13) Pronator teres muscle, 14) Biceps brachii muscle.

flexor carpi ulnaris and extensor carpi ulnaris muscles. This muscle had three heads named humeral, radial, and ulnar. The origin of the radial head was the caudal surface of the radius bone, and the origin of the ulnar head was the caudal border of the ulna bone. The muscle is inserted into the flexor tubercle at the base of the third digit phalanx.

The digital flexors are characterized by greater pennation and shorter fascicle lengths compared to the triceps, which enhances force production during the flexion of the carpus and digits. This specialization is critical for gripping and manipulating soil while digging.

Assessments

In this study, it was shown that the pectoral muscles in this badger include three parts: 1- p. ascending, 2- p. descending, and 3- p. transverse. This situation is similar in dogs and cats. Still, in the Pampas fox (*Lycalopex gym-*

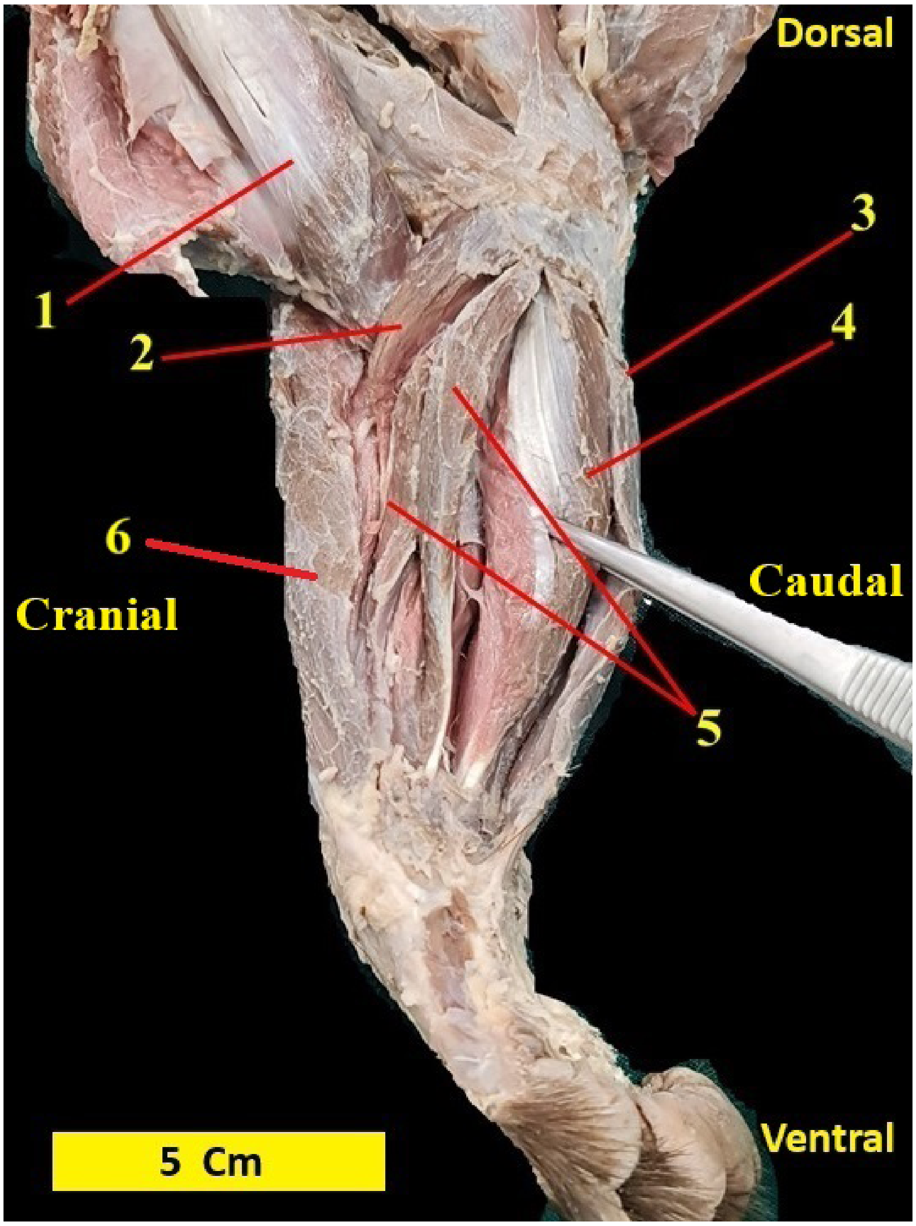

Figure 9. Medial view of antebrachial muscles in the right forelimb of the studied badger

Note: 1) Biceps brachii muscle, 2) Pronator teres muscle, 3) Superficial digital flexor muscle, 4) Humeral head of the flexor carpi ulnaris muscle, 5) Flexor carpi radialis muscle, 6) Brachioradialis muscle.

nocercus), the p. ascending includes three parts: Cranial, medial, and caudal (de Souza Junior et al., 2018; Singh, 2018). The present study reveals that the lower half of the coracobrachialis muscle is a tendon, while it is completely muscular in dogs and most carnivores (Böhmer et al., 2020; Hermanson & De Lahunta, 2018). In this study, it was found that the deltoideus muscle, located on the lateral side of the European badger's shoulder, like dogs, foxes, and wolves, has two acromial and scapular parts (Attia & Wissdorf, 1987; de Souza Junior et al., 2018). In the study, it was discovered that the latissimus dorsi muscle in this badger has two superficial and deep layers. In contrast, it has only one layer in dogs (Singh, 2018), foxes (de Souza Junior et al., 2018), and the Iranian pine marten (Yousefi et al., 2018), and most of the carnivores (Böhmer et al., 2020). In this study, it was found that the rhomboideus muscle in the European badger has 4 sections: Cervicis, thoracis, capitis, and profundus parts. In contrast, in dogs and foxes, this muscle has 3 sections: Cervicis, thoracis, and capitis parts. In the study conducted on the Iranian pine marten in 2018, it was concluded that the rhomboid muscle in this animal also has 4 sections named cervicis, thoracis, capitis, and atlantis (de Souza Junior et al., 2018; Singh, 2018;

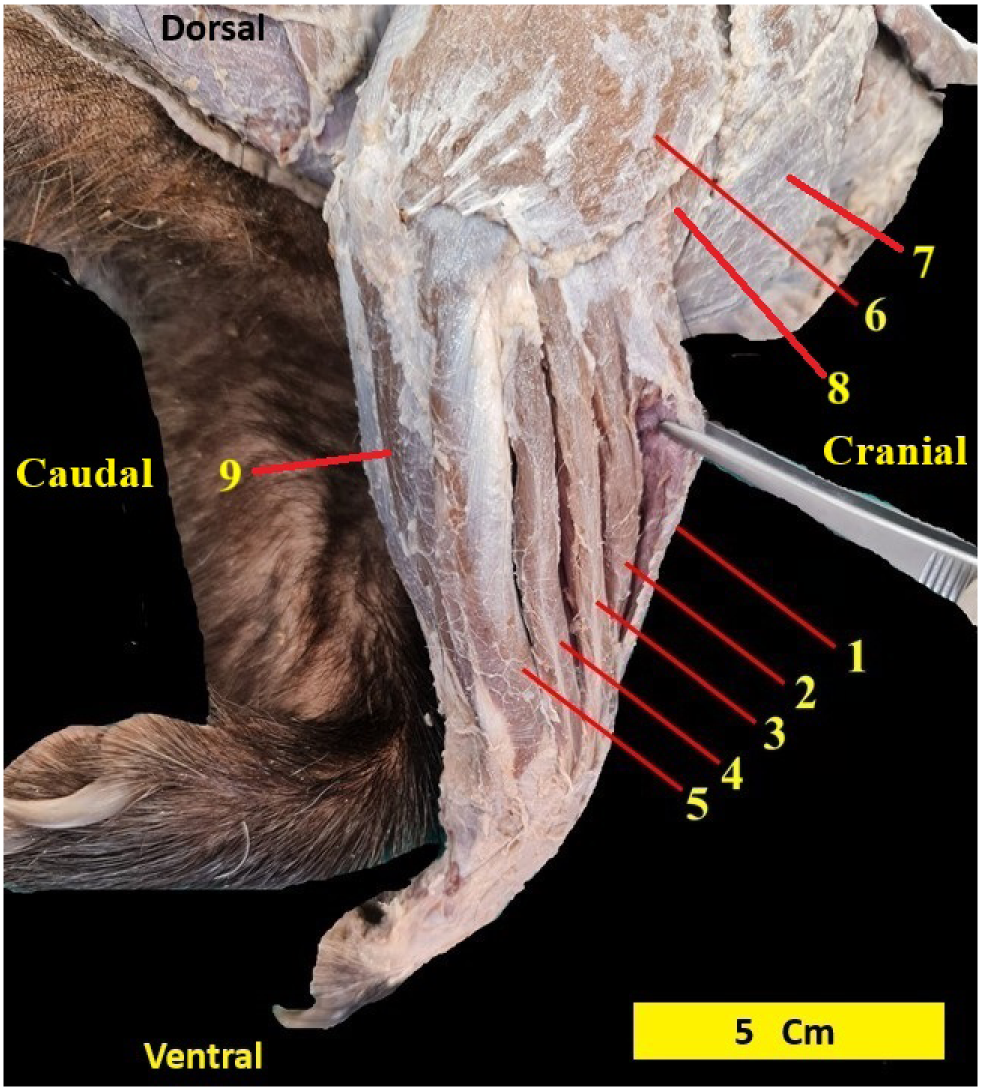

Figure 10. Lateral view of antebrachial muscles in the right forelimb of the studied badger

Note: 1) Brachioradialis muscle, 2) Extensor carpi radialis muscle, 3) Common digital extensor muscle, 4) Lateral digital extensor muscle, 5) Extensor carpi ulnaris, 6) Lateral head of the triceps brachii muscle, 7) Brachiocephalicus muscle, 8) Brachialis muscle, 9) Ulnar head of flexor carpi ulnaris.

Yousefi et al., 2018). In this study, it was observed that the supraspinatus muscle originates from the supraspinous fossa and is inserted into the greater and lesser tubercles of the humerus. In contrast, the wolf's deep pectoral muscle tendon is intermingled with certain fibers of this muscle (Attia & Wissdorf, 1987). This study concluded that the triceps brachii muscle in the European badger comprises four heads: Long, lateral, medial, and auxiliary. This similarity exists in domestic animals such as dogs as well as some wild animals such as hyenas (Spoor & Badoux, 1986). In the European badger, the accessory head of the triceps brachii muscle is much thicker than in the dog.

The triceps brachii is notably massive in badgers, featuring long fascicles that allow for substantial shortening during contraction. This architecture supports high power output, essential for effective digging. The two biarticular heads (long and medial) of the triceps are particularly adapted to apply high torques at the shoulder joint, facilitating powerful retraction of the forelimb during the digging power stroke (Moore et al., 2013).

In a previous study on the American badger (*T. taxus*), it was observed that the triceps brachii muscle strangely has only two long and medial heads originating from the scapula, while in this study on the European badger, It was determined that this muscle has four long, medial, lateral, and accessory heads (Moore et al. 2013).

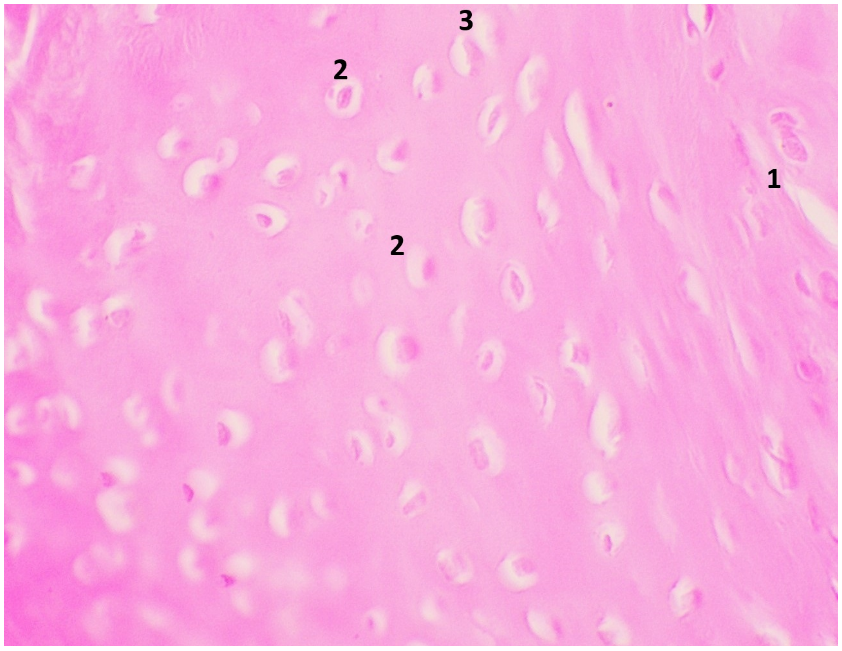

Figure 11. Photomicrograph of the clavicular intersection in the studied badger, showing the remains of the clavicle as hyaline cartilage

Note: 1) Chondrogenic layer of perichondrium, 2) Chondrocytes, 3) Isogenic group.

A 2013 study on the American badger observed that the deep digital flexor muscle has five heads. In contrast, the current research on the European badger found that this muscle has only three heads: Humeral, radial, and ulnar (Moore et al. 2013).

This study investigated the two parts of the tensor fasciae antebrachii muscle in European badgers, a caudal and thick part, and a medial and thin part, compared to the single part in dogs (König & Liebich, 2020; Orsini et al., 2021). In the study conducted in 2014 on lesser grison, it was mentioned that this muscle is absent or deformed (Ercoli et al., 2015). In this study, it was noted that the flexor carpi radialis muscle, which is located in the medial position of the forearm, has two parts, while it has one part in the dog, lesser grison, and the fox (de Souza Junior et al., 2018; Ercoli et al., 2015; König & Liebich, 2020). In this study, it was shown that the cervical part of the trapezius muscle originates from the nuchal ligament and the spinous process of the third cervical to the third thoracic vertebrae. The thoracic part of the trapezius muscle originates from the third to the eighth thoracic vertebrae.

In contrast, in lesser grison, the cervical part originates from the cervical raphe around C3-4 and extends to T1, and the thoracic part originates from the thoracic raphe around T2 to T8 (Ercoli et al., 2015). In the pampas fox, the cervical part of the trapezius originates from the median raphe from C4 to C7, and the thoracic part originates from the median raphe from T1 to T9 (de Souza Junior et al., 2018). In a study that was conducted on the pampas fox (de Souza Junior et al., 2018), and with the conclusions mentioned in that article, which was based on older studies conducted on hyaenids and canids (Feeney, 1999; Spoor & Badoux, 1986), it was mentioned that brachioradialis muscle in canids and hyaenids tends to be small or absent, while in this study it was shown that the brachioradialis muscle in the European badger, is well developed to the point where it covers almost all of the extensor carpi radialis muscle. However, since this study was conducted on a limited number of badgers, the results cannot be generalized.

The digital flexors are characterized by greater pennation and shorter fascicle lengths compared to the triceps, which enhances force production during the flexion of the carpus and digits. This specialization is critical for gripping and manipulating soil while digging.

In this study, it was determined that the clavicle of the European badger is made of hyaline cartilage, which is similar to the clavicle in dogs, especially the Neotropical otter (*Lontra longicaudis*). Also, by hematoxylin and eosin staining of the cougar *(Puma concolor*) clavicle and toluidine blue staining of the crab-eating fox (*Cerdocyon thous*) clavicle in a study in 2020, they concluded that the clavicle in these animals is bony (Figure 11) (de Souza Junior et al., 2020).

Conclusion

The muscles of the badger's thoracic limb are generally similar to the muscles of other carnivores. Still, among the animals examined and compared in this study, it has the most similarity with the dog and the most difference with the fox.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

Funding

This study was supported by the Research Council of Semnan University, Semnan, Iran.

Authors' contributions

Supervision: Mohammad Hasan Yousefi; Conceptualization and methodology: Babak Rasouli; Providing the carcass: Mohammad Ali Adibi; Investigation and dissection: Arad Jahankhani.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

Rasoul Rostami and Morteza Saberi, senior technologists at the Faculty of Veterinary Medicine, Semnan University, Semnan, Iran, deserve the author's gratitude for their significant assistance in preparing and fixing the carcass.

References

Abramov, A. V., Puzachenko, A. Y., & WIIG, Ø. (2009). Cranial variation in the European badger Meles meles (Carnivora, Mustelidae) in Scandinavia. *Zoological Journal of the Linnean Society, 157*(2), 433-450. [DOI:10.1111/j.1096-3642.2009.00507.x]

Attia, M., & Wissdorf, H. (1987). Morphologicl study on the muscles of the shoulder joint of the wolf (Canis lupus L. 1758). *Assiut Veterinary Medical Journal, 18*(35), 1-10. [DOI:10.21608/avmj.1987.189407]

Böhmer, C., Theil, J. C., Fabre, A. C., & Herrel, A. (2020). *Atlas of terrestrial mammal limbs.* Boca Raton: CRC Press. [DOI:10.1201/b22115]

de Souza Junior, P., Santos, L. M. R. P. D., Viotto-Souza, W., de Carvalho, N. D. C., Souza, E. C., & Kasper, C. B., et al. (2018). Functional myology of the thoracic limb in Pampas fox (Lycalopex gymnocercus): A descriptive and comparative analysis. *Journal of Anatomy, 233*(6), 783–806. [DOI:10.1111/joa.12892] [PMID]

de Souza Junior, P., Viotto-Souza, W., Mendes, V.P., Bernardes, F.C.S., Dos Anjos, B.L., Abidu-Figueiredo, M. & Santos, A.L.Q., (2020). Clavicle in carnivorans: A forgotten bone. *The Anatomical Record, 303*(7), 1831-1841. [DOI:10.1002/ar.24294.] [PMID]

Ercoli, M. D., Álvarez, A., Stefanini, M. I., Busker, F., & Morales, M. M. (2015). Muscular anatomy of the forelimbs of the lesser grison (Galictis cuja), and a functional and phylogenetic overview of Mustelidae and other Caniformia. *Journal of Mammalian Evolution, 22*(1), 57-91. [DOI:10.1007/s10914-014-9257-6]

Feeney, S. (1999). Comparative osteology, myology, and locomotor specializations of the fore and hind limbs of the North American foxes Vulpes vulpes and Urocyon cinereoargenteus [doctoral dissertation]. Amherst: University of Massachusetts Amherst. [Link]

Hermanson, J. W., & De Lahunta, A. (2018). *Miller and Evans' anatomy of the dog-E-book*. Edinburgh: Elsevier Health Sciences. [Link]

König, H. E., & Liebich, H. G. (2020). *Veterinary anatomy of domestic animals: Textbook and colour atlas. Stuttgart:* Georg Thieme Verlag. [Link]

Kurek, P., Piechnik, Ł., Wiatrowska, B., Ważna, A., Nowakowski, K., & Pardavila, X., et al. (2022). Badger meles meles as ecosystem engineer and its legal status in Europe. *Animals, 12*(7), 898. [DOI:10.3390/ani12070898] [PMID]

Macdonald, A. A., & Kneepkens, A. F. (1995). Descriptive and comparative myology of the hindlimb of the babirusa (Babyrousa babyrussa L. 1758). *Anatomia, Histologia, Embryologia, 24*(3), 197–207. [DOI:10.1111/j.1439-0264.1995.tb00035.x] [PMID]

Moore, A. L., Budny, J. E., Russell, A. P., & Butcher, M. T. (2013). Architectural specialization of the intrinsic thoracic limb musculature of the American badger (Taxidea taxus). *Journal of Morphology, 274*(1), 35–48. [DOI:10.1002/jmor.20074] [PMID]

Orsini, J. A., Grenager, N. S., & De Lahunta, A. (2021). *Comparative veterinary anatomy: A clinical approach*. Cambridge: Academic Press. [Link]

Pearce, G. E. (2011). *Badger behaviour, conservation & rehabilitation: 70 years of getting to know badgers*. London: Pelagic Publishing. [Link]

Singh, B. (2018). *Dyce, Sack, and Wensing's textbook of veterinary anatomy*. London: Saunders, An Imprint of Elsevier Limited. [Link]

Spoor, C. F., & Badoux, D. M. (1986). Descriptive and functional morphology of the neck and forelimb of the striped hyena (Hyaena hyaena, L. 1758). *Anatomischer Anzeiger, 161*(5), 375-387. [PMID]

Yousefi, M. H., Rasouli, B., Ghodrati, S., Adibi, M. A., Taherdoost, M., & Omidbakhsh, S., et al. (2018). Anatomical study of extrinsic and some intrinsic muscles of the thoracic limb in Iranian pine marten (Martes martes): A case report. *Iranian Journal of Veterinary Medicine, 12*(3), 273-281. [DOI:10.22059/ijvm.2018.252150.1004876]