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RESEARCH REGARDING THE MORPHOLOGY OF THORACIC LIMB BONES IN THE CARPATHIAN LYNX (*Lynx lynx* ssp. *carpaticus* - Linnaeus, 1758)

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Abstract

According to the actual taxonomic classification, Lynx lynx is one of the four species of the Lynx genus. The bones studied belong to individuals originating from the area of the Carpathian Mountains, belonging to the "carpathicus" subspecies. The lynx is a top predator in a food chain, its most important role being to control the populations of small vertebrates in the ecosystem and to maintain the populations of roe deer (Capreolus capreolus) and red deer (Cervus elaphus) under control. Specialty literature includes works of various authors regarding the morphology and morphometry of the locomotor apparatus of the Lynx lynx species and other species of the Lynx genus. However, upon a detailed study of the material, some interesting anatomical aspects could be identified. Worth mentioning are details regarding the contour of the scapula, the morphology of the spina scapularis and the coracoid process, the aspect of the distal extremity of the humerus, the aspect of the radio-ulnar interosseous space, as well as of the distal extremity of the radius and olecranon. These elements may complete existing literature data and may prove useful to clinicians in various interventions (radiological exams, MRI scans or surgical interventions).

Key words: *lynx, scapula, coracoid process, humerus, olecranon.*

INTRODUCTION

The lynx *(Lynx lynx* ssp. *carpathicus)* (Linnaeus, 1758) is classified in the *Carnivora* Order, which includes carnivorous mammals belonging to the *Felidae* Family, *Lynx* Genus. It is a species which inhabits the territory of Romania in the mountainous areas. Their population is relatively low, and they are a protected species (Cotta & Bodea, 1969).

Out of all felines encountered in zoos or reservations, studies were done on the tiger (*Panthera tigris*), the cheetah (*Acinonyx jubatus*), the lion (*Panthera leo*) and the jaguar (*Panthera onca*), regarding the morphology and morphometry of different skeletal components (skull, vertebral column, limb bones) (Belu et al., 2012; Kirberger et al., 2002; Nzalak et al., 2010; Roșu et al., 2016).

Specialty literature includes studies regarding the morphology and morphometry of the locomotor apparatus of the *Lynx lynx* species as well as other species in the *Lynx* genus (Karan et al., 2016; Mandal & Talukder, 1975). In spite of this, following a more detailed study some interesting anatomical aspects were identified.

The study focused on the bones of the appendicular skeleton of the thoracic limb in two lynx (*Lynx lynx*) individuals, and it aimed to present some particularities on the basis of which it can be differentiated from other carnivorous species.

MATERIALS AND METHODS

The study material was represented by the bones of two adult lynx (*Lynx lynx* ssp. *carpathicus*), both males that died of natural causes, one originating from the Bucuresti-Baneasa Zoo and the other from the Grigore Antipa Museum of Natural Sciences.

Maceration was done in containers maintained at a constant temperature for a long time (approximately 50 days) under constant supervision. ***Washing*** was first performed under a continuous stream of water for 24-48 hours. ***Post-maceration cleaning*** was performed with the tip of a scalpel to remove all organic remnants. ***Degreasing*** was done using usual detergents diluted in the wash water. The next step was ***washing using slightly acidic water*** to remove all traces of organic material. ***Drying*** was then performed under constant supervision for 48-56 hours at an average temperature of 18-22^{0}C in order to avoid the fissuring of osseous structures and compromising their integrity.

The most interesting aspects were described and photographed. Describing, identifying and naming of the formations were done according to Nomina Anatomica Veterinaria (N.A.V.) 2017.

RESULTS AND DISCUSSIONS

In lynx *(Lynx lynx* ssp. *carpathicus)* the scapula presents, on the lateral surface, a rectilinear spina scapularis, slightly bent over the infraspinous fossa. On the distal extremity the spina scapularis ends in an acromion, flanked by a well-developed, relatively trapezoid shaped para-acromion, with the lesser side disposed proximally. The ratio between the supraspinous and infraspinous fossae is of 1:1 (Figure 1).

The caudal angle is thickened and the cranial angle is rounded. The suprascapular cartilage is absent, replaced by a thick epiphyseal lip. The caudal border is flattened medio-laterally, and the distal extremity presents a rough articular surface for muscular insertion. The cranial border is rounded. The scapular notch is reduced. The neck of the scapula is very short. On the distal extremity of the supraspinous fossa there is a first order vascular hole.

The subscapular fossa has a groove which corresponds to the detaching place of the spina scapularis on the lateral side - aside from this it is crossed by numerous lines of muscular insertion (Figure 2).

Figure 1. Lateral surface of scapula in lynx (*Lynx lynx* ssp. *carpathicus*): 1. Supraspinous fossa; 2. Infraspinous fossa; 3. Scapular spine; 4. Caudal border; 5. Cranial border; 6. Rough epiphyseal lip; 7. Paraacromion; 8. Acromion; 9. Supraglenoidal tuberosity

On the medial surface of the scapula in the distal extremity, nearing the neck of the scapula, there is a first order vascular hole.

Figure 2. The medial surface of the scapula in lynx (*Lynx lynx* ssp. *carpathicus*): 1. Muscular insertion lines; 2. First order vascular hole; 3. Scapular notch; 4. Coracoid process

The glenoid cavity is circular in shape, and from the glenoid cavity detaches the supraglenoidal tuberosity, disposed cranially. From the supraglenoidal tuberosity the coracoid process detaches, very well developed and oriented cranio-medio-distally (Figure 3).

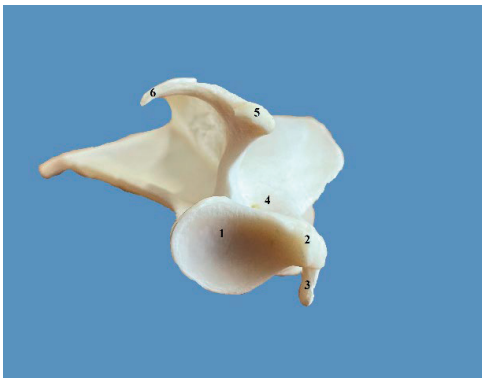

Figure 3. Distal extremity of scapula in lynx *(Lynx lynx* ssp. *carpathicus*): 1. Glenoid cavity; 2. Supraglenoidal tuberosity; 3. Coracoid process; 4. First order vascular hole; 5. Acromion; 6. Paraacromion

The humerus has the articular head oriented caudally, with the articular surface elongated cranio-caudally. The greater tubercle, undivided, slightly overtakes the articular surface of the humeral head. Immediately under this tubercle the relatively circular *facies infraspinata* can be evidenced, disposed laterally. On the proximal extremity of the humerus, on the lateral side there is a reduced tubercle for the *teres minor* muscle.
The lesser tubercle is reduced, with a rough elongated surface. The intertubercular groove is wide and shallow (Figure 4).

Figure 4. Medial side of the humerus in *lynx* (*Lynx lynx* ssp. *carpathicus*): 1. Greater tubercle; 2. Lesser tubercle; 3. Intertubercular groove; 4. Articular head; 5. Tubercle for the teres major muscle; 6. Supracondylar foramen; 7. Medial lip of the trochlea

In the proximal and middle third, on the cranial side, a rough crest can be observed.
On the medial side, in the superior third of the humerus, there is a reduced tubercle for the *teres major* muscle.

Figure 5. Cranial side of the humerus in lynx (*Lynx lynx* ssp. *carpathicus*): 1. Greater tubercle; 2. Lesser tubercle; 3. Rough crest; 4. Supracondylar foramen; 5. Coronoid fossa; 6. Radial fossa; 7. Condyle; 8. Trochlea

On the lateral side of the body, on the proximal extremity, there is an obvious anconeal crest, which continues distally with a sharp deltoid crest. The body of the humerus is slightly curved, relatively S-shaped, similar to the one in canides.
The distal extremity of the humerus presents, on the caudal side, a wide and deep olecranon fossa, and on the cranial side a superficial radial fossa, disposed above the humeral trochlea and a coronoid fossa which is more reduced, disposed above the condyle (Figure 5)
The articular surface is represented by a reduced trochlea, oblique, with unequal lips, the medial one being taller and sharper. The lateral lip of the trochlea is laterally flanked by a reduced condyle, visible on the cranial side. Above the medial lip of the trochlea there is an elongated supracondylar foramen.
The distal articular surface is flanked by the two epicondyles, lateral and medial. The crest of the lateral epicondyle is tall, ending in the inferior third of the caudal side of the humerus (Figure 6).

Figure 6. Lateral side of the humerus in the lynx (*Lynx lynx* ssp. *carpathicus*): 1. Greater tubercle; 2. Anconeal crest; 3. Deltoid crest; 4. Tubercle for the *teres minor* muscle; 5. Supracondylar foramen; 6. Crest of the lateral epicondyle; 7. Condyle; 8. Trochlea; 9. Coronoid fossa; 10. Radial fossa

The radius and ulna articulate only at the level of their extremities, delimiting a large interosseous space.

The radius has a relatively rectilinear body.

On the proximal extremity it presents an elliptic glenoid cavity.

The medial tubercle is well evidenced in the proximal extremity of the medial margin, under the articular cavity (Figure 7). Latero-caudally, on this extremity, there is an obvious oval-shaped tubercle. Distally, the cranial surface of the body presents three obvious tendinous grooves, two of them disposed longitudinally and one oblique medio-distally.

The distal articular surface has the aspect of an elongated cavity. On the distal extremity of the lateral margin there is a relatively oval articular surface for the ulna. Distally, on the medial margin of the radius there is an obvious notch.

The ulna presents an obvious olecranon, with an olecranal tuber that is divided cranially by a median groove, resulting in two tubercles, lateral and medial, with the medial one being more prominent. The beak of the olecranon is pulled cranially, the large semilunar notch is semicircle shaped and the radial notch is pulled medially (Figure 8).

Figure 7. The medial surface of the radius and ulna in the lynx (*Lynx lynx* ssp. *carpathicus*): A. Radius; B. Ulna: 1. Glenoid cavity; 2. The medial tubercle; 3. The large semilunar notch; 4. The beak of the olecranon; 5. Olecranal tuber; 6. Distal articular surface; 7. Lateral crest

The body of the ulna is flattened latero-medially, with the caudal margin widened in the superior and middle thirds while in the inferior third it is thin and sharp. On the lateral side in the middle third there is an obvious groove. The ulnar styloid process is also evident, with an articular surface for the carpal bones.

Figure 8. The proximal extremity of the radius and ulna in the lynx (*Lynx lynx* ssp. *carpathicus*): 1. Glenoidal cavity; 2. Large semilunar notch; 3. The olecranal tuber; 4. Radial notch; 5. Olecranon tuberosity

The carpal bones are seven in number, with the most voluminous one being represented by the radial carpal bone (Figure 9).
The radial carpal is the biggest carpal bone, presenting, proximally, a convex articular surface for the radius. Medio-palmar there is an obvious tubercle. Distally, it presents an articular surface for the bones in the second row, dorso-medially to the second carpal bone and latero-palmar for the third and second carpal bones.
The accessory carpal bone, located in the proximal row of carpal bones, presents on the free extremity an elongated tuberosity and two articular surfaces: a proximal one for the ulnar bone and a distal one for the ulna. Also in the proximal row is the ulnar bone which presents articular surfaces for the ulna, accessory carpal and fourth carpal bones.

Figure 9. Carpal bones in the lynx (*Lynx lynx* ssp. *carpathicus*): 1. Accesory bone; 2. Ulnar carpal bone; 3. Intermediate carpal bone; 4. Fourth carpal bone; 5. Third carpal bone; 6. Second carpal bone; 7. First carpal bone

In the distal row, the following bones are disposed latero-medially: fourth carpal bone, which articulates with the proximal extremity of the IV and V metacarpals, the third carpal bone articulates distally with the proximal extremity of the III metacarpus, the second carpal boned articulates with the II metacarpus and the first carpal bone articulates with the I metacarpus.
There are 5 metacarpal bones, of which metacarpus I is the shortest (Figure 10). At the level of the proximal extremity there are articular surfaces for the carpal bones on one side and on the other surfaces for articulating with each other. The distal extremity of the metacarpals presents articular surfaces for the phalanges and sesamoid bones.

Figure 10. Thoracic autopodium in lynx (*Lynx lynx* ssp. *carpathicus*): 1. Carpal bones; I - Metacarpus I; II - Metacarpus II; III - Metacarpus III; IV - Metacarpus IV; V - Metacarpus V; 2. Claw processes

The phalanx of the I digit is the shortest, the others with lengths directly proportional to the corresponding metacarpals. The middle phalanges act similarly to the proximal ones, corresponding to the metacarpals II, III and IV. The most developed middle phalanges are represented by digits III and IV.
On the distal phalanges well developed, recurved claw processes can be observed. The claw process of the first finger is the most well developed.

CONCLUSIONS

The spina scapularis ends with an acromion flanked by a well-developed para-acromion.
In the distal extremity of the supraspinous fossa there is a first order vascular hole.
The medial surface is crossed by numerous lines of muscular insertion.
The coracoid process is well developed and oriented cranio-medio-distally.
In the proximal and middle third of the humerus, on the cranial surface, there is a rough crest.
The anconeal crest and the deltoid crest are well evidenced.

The crest of the lateral epicondyle is tall, ending in the distal third of the caudal side of the humerus.

On the medial margin of the distal extremity of the radius there is an obvious ridge.

The thoracic autopodium has no particular characteristics compared to other felines.

All of these are characteristics which allow establishing the species and reduce the risk of confusion upon examination.

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