

MORPHOLOGICAL PARTICULARITIES OF THE ZONOSKELETON, STYLOPODIUM, AND ZEUGOPODIUM OF THE THORACIC LIMB IN THE EURASIAN BROWN BEAR (*Ursus arctos arctos*) - CASE STUDY

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Abstract

This study aims to analyze and describe the morphological features of the bones that comprise the pectoral girdle (zonoskeleton), stylopodium, and zeugopodium of the thoracic limb of the Eurasian brown bear (Ursus arctos arctos) from Romania. The bones of a brown bear specimen, belonging to the collection of the discipline of Anatomy, were used. This species is protected and hunting is restricted. These particularities play an important role in differentiating this species from other carnivores. The data in the specialized literature is limited, to bone pathology, mechanics of the forelimb joints, and skull particularities. The analysis of the bones' morphological particularities leads to the following conclusions. The ratio of the supraspinous fossa and the infraspinous fossa is 1: 1, as seen in most carnivores. In this species, the infraspinous fossa is limited caudally by a straight and high thoracic edge (supplementary spine), smaller compared to the scapular spine. Posterior to the additional spine is another surface, intended to insert the teres major muscle. The humeral tubercles are short, and the lateral epicondyle crest is high, sharp, and drawn craniolaterally.

Key words: bear, infraspinous fossa, humeral tubercles, lateral epicondyle crest.

INTRODUCTION

Eurasian brown bear (*Ursus arctos arctos*) (Linné, 1758) belongs to the Family Ursidae, Genus Ursus, Order Fissipeda. It is a carnivorous species whose habitat extends throughout Europe, and the number of specimens differs from country to country. In Romania, the habitat increases as the species is protected by law.

In the scientific literature, there are studies about the morphology and morphometry of the skull of this species (Mihaylov et al., 2013; Yousefi, 2016; Roșu et al., 2022) but also comparative studies between bones of the appendicular skeleton, between the vertebral skeleton of the bear and different fossils of the Family Carnivora. These studies have highlighted similarities between bones, joints, muscles, and dental morphology (Sorkin, 2006; Argot, 2010; Siliceo et al., 2014). Also, general studies on the morphology of the species or comparative studies on the morphology of the locomotor system at different species of bears

were published (Galateanu et al., 2013; Vonk & Shackelford, 2019).

The descriptions of the morphological particularities of the zonoskeleton, stylopodium, and zeugopodium in the scientific literature are in a small number regarding the species Eurasian brown bear (*Ursus arctos arctos*). However, there are much data on the morphological aspects of the appendicular skeleton in other carnivore species (Getty et al., 1975; König & Liebich, 2020).

MATERIALS AND METHODS

The bones representing the studied material form the zonoskeleton, stylopodium, and thoracic zeugopodium of Eurasian brown bear (*Ursus arctos arctos*) belong to the collection of the Anatomy discipline.

Knowing there are similarities between the proximal extremity of the brown bear's humerus and the human species' humerus, two human humeri belonging to the discipline's collection were used for comparison. The most

interesting aspects were described and photographed. The terminology used for the description and identification complies with *Nomina Anatomica Veterinaria* (N.A.V. 2017).

RESULTS AND DISCUSSIONS

Only the scapula represents the thoracic zonoskeleton in the Eurasian brown bear (*Ursus arctos arctos*). On the lateral face of the scapula, there are two fossae, supraspinous and infraspinous, in a ratio of 1: 1, separated by an oblique and straight scapular spine. At the distal end, the scapular spine ends with a thickened and widened acromion, which exceeds the ventral (articular) angle. A reduced suprahamatus process flanks the acromion (Figure 1).

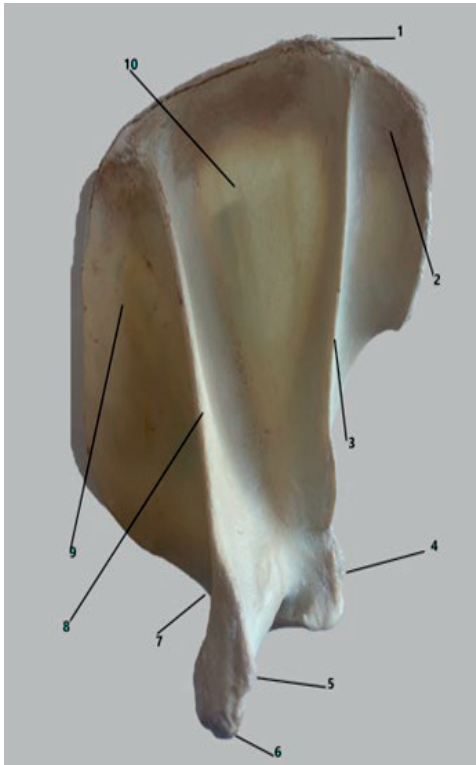


Figure 1. Scapula of the brown bear (*Ursus arctos arctos*) (original) - left limb, lateral face -
 1. Epiphyseal lip; 2. Postscapular fossa; 3. Reduced additional spine; 4. The postglenoid tubercle;
 5. Suprahamatus process; 6. Acromion; 7. Scapular neck;
 8. Scapular spine; 9. Supraspinous fossa;
 10. Infraspinous fossa

The cranial margin, slightly thickened in the middle third, presents at the distal extremity a noticeable scapular notch.

The surface of the infraspinous fossa is slightly wavy, and at the distal extremity, towards the base of the spine, a first-order vascular foramen can be observed (Figure 2). The infraspinous fossa is delimited in the thoracic part by a small additional spine, relatively rectilinear, slightly bent over a small postscapular fossa, which presents a rough surface.

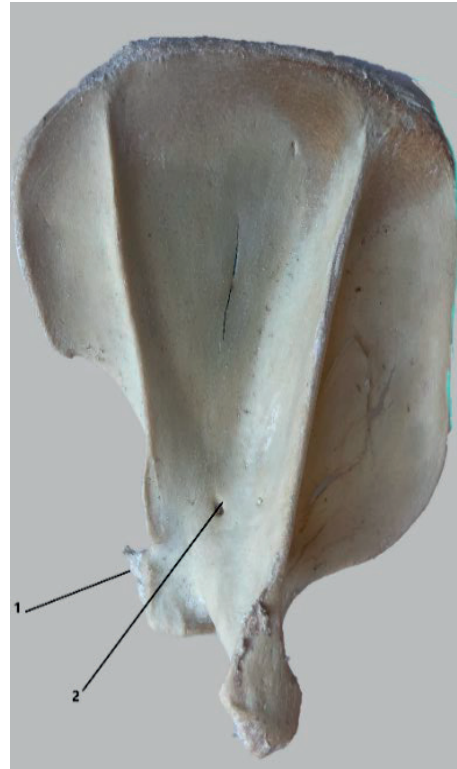


Figure 2. Brown bear scapula (*Ursus arctos arctos*) (original) - right limb, lateral face -
 1. Postglenoid tubercle; 2. First-order vascular foramen

The dorsal margin does not present suprascapular cartilage, but a rough epiphyseal lip replaces it.

The caudal margin presents a well-marked postglenoid tubercle at the distal end.

The medial face shows numerous lines of muscle insertion, and the serrate surface has a comma-like appearance. Also, on this face, a reduced medial ridge can be observed, detached precisely on the line that corresponds laterally to the scapular spine (Figure 3).

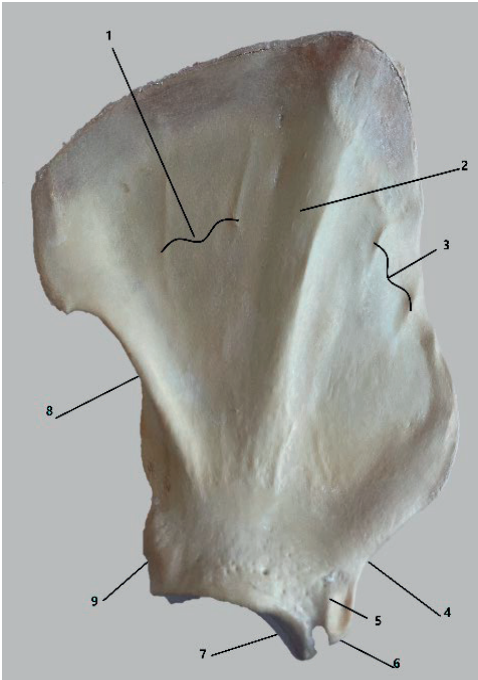


Figure 3. Brown bear scapula (*Ursus arctos arctos*) (original) - left limb - medial face -
 1-3. Rough lines of muscle insertion; 2. Medial ridge;
 4. Scapular neck; 5. Coracoid process; 6. Supraglenoid tuberosity; 7. Glenoid cavity; 8. Thoracic margin;
 9. Postglenoid tubercle

The articular angle is elongated and oval in appearance. From near the cranial edge of the glenoid cavity, the supraglenoid tuberosity emerges cranially, ornamented anteromedially by a reduced coracoid process. At the distal extremity of the tuberosity, a reduced articular surface with an oval appearance is observed (Figure 4).

The humerus represents the thoracic stylopod, which has at the proximal extremity an articular head arranged caudally and slightly elongated distally. Laterally, there is the greater tubercle, and medially, the lesser tubercle, both undivided. The two tubercles are reduced in height and do not exceed the articular surface of the humeral head (Figure 5).

Under the articular head, caudolateral, a pronounced crest is observed. It is directed ventral and craniomedially and reaches the distal third of the bone, creating continuity between the ancone line, the deltoid crest, and the humeral crest (Figure 7).

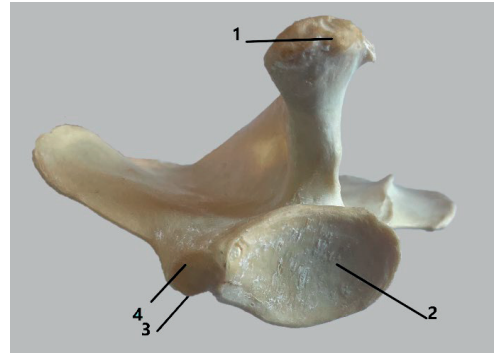


Figure 4. Brown bear scapula (*Ursus arctos arctos*) (original) - left limb, distal extremity - 1. Acromion;
 2. Glenoid cavity; 3. Coracoid process; 4. Supraglenoid tuberosity



Figure 5. The left humerus of the brown bear (*Ursus arctos arctos*) (original) - medial face -
 1. Articular head; 2. The lesser tubercle;
 3. Intertubercular groove; 4. The greater tubercle;
 5. Crest of the greater tubercle; 6. Supratrochlear foramen; 7. The medial lip of the trochlea

The proximal extremity of the diaphysis in the brown bear is highly developed and thick

compared to that of humans, which is thin and cylindroid. However, the proximal epiphysis of the humerus has similar characteristics in both species (stretched articular head surface, reduced humeral tubercles) (Figure 6).

The oval infraspinous surface and a conspicuous tubercle for the teres minor muscle are visible on the lateral side of the proximal extremity.

On the cranial face, the crest of the greater tubercle joins the humeral crest in the distal third of the body.

The brachial groove is weakly highlighted.

The tubercle for the teres major and latissimus dorsi insertion is in the upper third of the medial face.

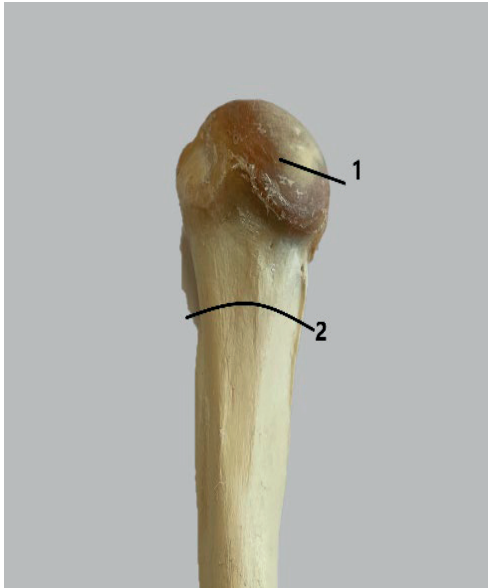


Figure 6. The right humerus of the brown bear (*Ursus arctos arctos*) (original) - lateral, cranial view - 1. The greater tubercle; 2. The proximal extremity of the diaphysis

Distally, the lateral epicondyle's crest is highly developed, an essential differential character compared to the humerus of any large European species (Figure 7).

Although, in the vast majority of studies on the bear humerus, the absence of the supratrochlear foramen is specified, in the studied specimen, this foramen appears on the right limb, allowing the communication of the olecranon and coronoid fossae (Figure 9). In the humerus on the left side, a thin bony blade covers the

foramen, so fossae mentioned above are separated (Figure 7)

The distal articular surface presents a condyle laterally and a trochlea with unequal lips medially, the medial one being higher and with a slightly sharp edge.

The humeral epicondyles do not extend beyond the distal articular surface.

Dorso-cranial from the distal articulation surface, the coronoid and radial fossae are present, separated by a small ridge, and caudally, at the same level as the two, is the olecranon fossa (Figure 8).

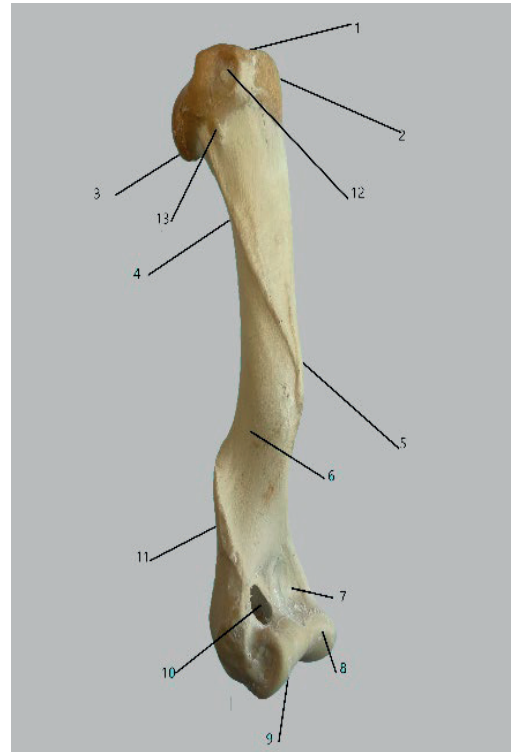


Figure 7. The right humerus of the brown bear (*Ursus arctos arctos*) (original) - lateral-cranial face - 1. The greater tubercle; 2. The lesser tubercle; 3. Articular head; 4. Deltoid crest; 5. Humeral crest; 6. Brachial groove; 7. Radial fossa; 8. The medial lip of the trochlea; 9. Humeral condyle; 10. Supratrochlear foramen; 11. Crest of the lateral epicondyle; 12. Facies infraspinatus; 13. Teres minor tubercle

Two bones, the radius and the ulna represent the thoracic zeugopodium and are articulated at the extremities.

The radius presents at its proximal extremity a single glenoid cavity elongated, slightly

oblique mediolaterally, and relatively oval (Figure 10).

The radial notch is on the cranial edge of the glenoid cavity, with a single articulation surface for the ulna. The cranio-medial edge of the glenoid cavity shows a small prominence.

A rough surface of muscle insertion occurs at the proximal extremity of the body of the radius, on the medial side.

In the middle third, the body of the radius is slightly curved laterally. On the medial edge of the body, from the middle third to the distal extremity, there is a ridge, very evident in the distal portion.

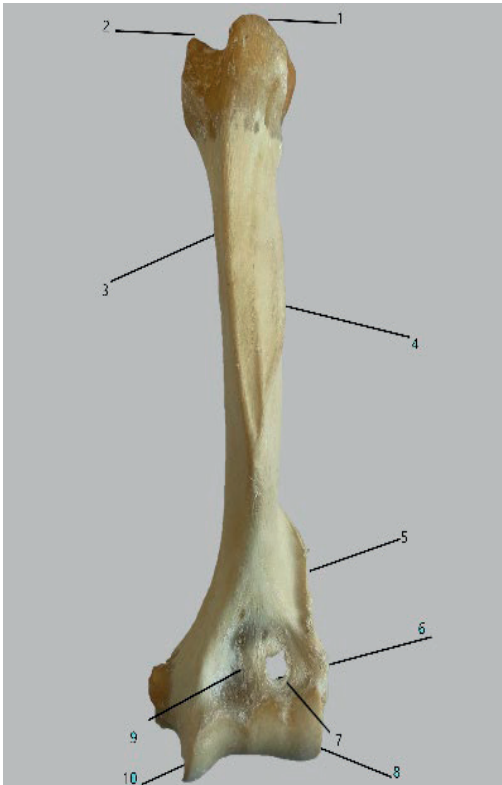


Figure 8. Right humerus of brown bear (*Ursus arctos arctos*) (original) - cranial face - 1. The lesser tubercle; 2. The greater tubercle; 3. The crest of the greater tubercle; 4. Deltoid crest; 5. Crest of the lateral epicondyle; 6. Supratrochlear foramen; 7. Coronoid fossa; 8. Humeral condyle; 9. Radial fossa; 10. The medial lip of the trochlea

A rugose surface is observed from the proximal to the middle third, placed on the caudomedial side.

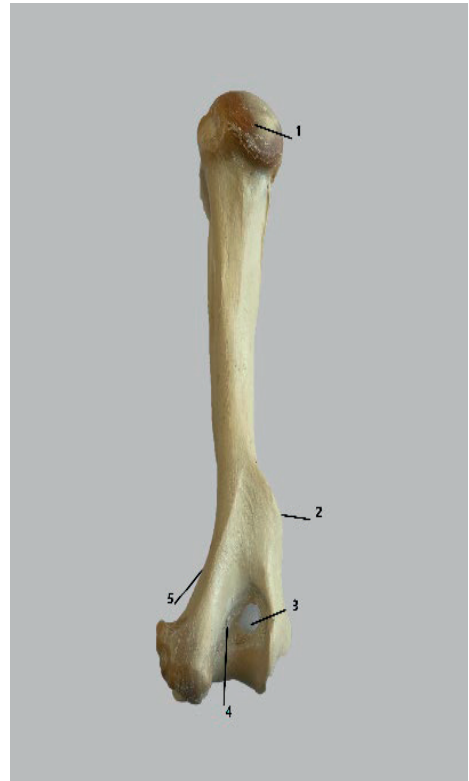


Figure 9. Right humerus in the brown bear (*Ursus arctos arctos*) (original) - caudal face - 1. Articular head; 2. Crest of the lateral epicondyle; 3. Supratrochlear foramen; 4. Olecranon fossa; 5. Crest of the medial epicondyle

The distal articular surface is elongated mediolaterally, being wider medially and narrower laterally.

The ulna has a body slightly curved medially, and a rough surface is on the medial face in the middle third.

On the cranial face at the level of the distal extremity, three tendinous grooves are visible, two arranged longitudinally and one obliquely cranio-distal. On the lateral side of the distal extremity, there is an obvious radial styloid apophysis, and medially, there is an articulation surface for the ulna (Figure 11).

At the proximal extremity of the ulna is the olecranon with a relatively rectangular appearance, which presents an obvious olecranon tuberosity of a relatively triangular appearance, decorated in the central part with a prominent tubercle (Figure 13).

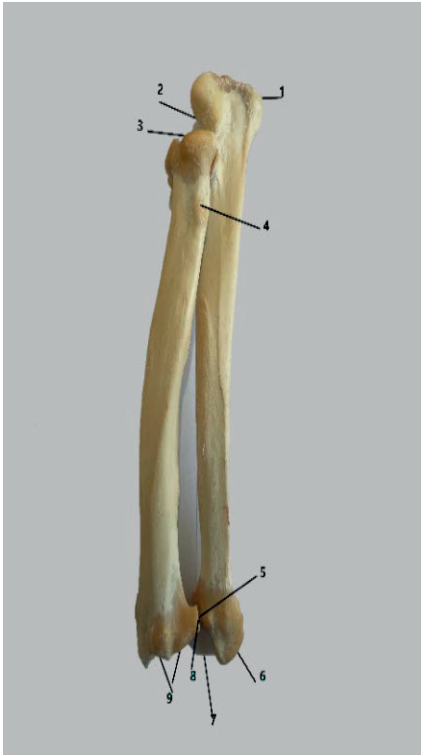


Figure 10. Radius and ulna of the left limb of the brown bear (*Ursus arctos arctos*) (original) - lateral view - 1. Olecranon tuberosity; 2. Trochlear notch; 3. Glenoid cavity; 4. Lateral tuberosity; 5. The articular surface for the ulna; 6. Ulnar styloid apophysis; 7. Carpal joint surface; 8. The articular surface for the radius; 9. Tendon grooves

The anconeal process is drawn cranially, and from its level descends a large trochlear notch, with an articular surface arranged obliquely cranio-laterally and slightly twisted (Fig. 12).

At the proximal extremity, the ulna has a single articulation surface for the radius.

A small muscular crest is at the distal extremity of the body, on the lateral side.

The distal extremity presents an articulation surface for the radius, arranged medially, and an oval articulation surface for the carpal bones.



Figure 11. Radius and ulna in the brown bear (*Ursus arctos arctos*) (original) - left side - 1. Olecranon tuberosity; 2. Anconeal process; 3. Trochlear notch; 4. The articular surface for the radius; 5. Ulnar styloid apophysis; 6. Glenoid cavity; 7. Lateral tuberosity; 8. The articular surface for the ulna; 9, 10. Tendon grooves

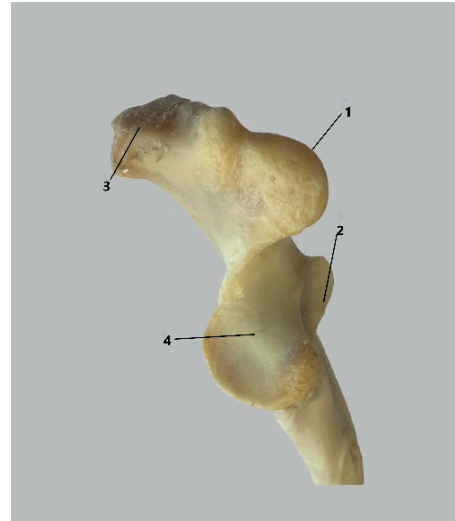


Figure 12. Left ulna in the brown bear (*Ursus arctos arctos*) (original) - dorsal view of the proximal extremity - 1. Anconeal process; 2. Radial incision; 3. Olecranon tuberosity; 4. Trochlear notch



Figure 13. Left ulna in the brown bear (*Ursus arctos arctos*) (original) - lateral view - 1. Olecranon tuberosity; 2. Anconeal process; 3. Trochlear notch; 4. Radial incision; 5. Ulnar styloid apophysis; 6. The articular surface for the radius

CONCLUSIONS

1. The supraspinous fossa and infraspinous fossa are divided by an oblique, rectilinear scapular spine, having a ratio of 1: 1.
2. The acromion is thick and wide and exceeds the articular angle of the scapula.
3. The presence of an additionally reduced spine in the thoracic part of the infraspinous fossa delimits a reduced postscapular fossa.
4. The presence of a postglenoid tubercle at the distal end of the thoracic edge of the scapula.
5. There is a reduced, oval-shaped articular surface at the distal extremity of the supraglenoid tuberosity.
6. The humeral tubercles are undivided, very low in height, and do not exceed the articular surface of the humeral head.
7. The infraspinous surface has an oval appearance, and the tubercle for the small round is well highlighted.

8. Although the proximal epiphysis of the bear humerus is very similar to that of the human species, the proximal third of the diaphysis is thick in the bear and progressively connects to the humeral head. In humans, the bulky proximal epiphysis connects to a much-reduced epiphysis.
9. The anconeal, deltoid, and humeral crests, of equal height, form a continuous line without a clear demarcation line between them.
10. The crest of the lateral epicondyle is very high, a differential character from the humerus of any large domestic or wild European species.
11. The supratrochlear foramen, well highlighted in the humerus on the right side, is covered by a thin bony membrane in the humerus on the left side.
12. The olecranon presents a cranially drawn anconeal process and a sizeable trochlear notch. The articular surface is arranged obliquely cranio-laterally and slightly twisted.

REFERENCES

- Argot, C. (2010). Morphofunctional analysis of the posteranium of *Amphicyon major* (Mammalia, Carnivora, Amphicyonidae) from the Miocene of Sansan (Gers, France) compared to three extant carnivores: *Ursus arctos*, *Panthera leo*, and *Canis lupus*. *Geodiversitas*, 1, 65–106. <https://doi.org/https://doi.org/10.5252/g2010n1a2>
- Galateanu, G., Hildebrandt, T. B., Szentiks, C. A., Frey, R., Saragusty, J., & Göritz, F. (2013). Comparative morphology of the scapular architecture in bears (ursidae) as revealed by high-resolution computed tomography. *International Conference on Diseases of Zoo and Wild Animal*.
- Getty, R., Grossman, J. D., & Sisson, S. (1975). *Sisson and Grossman's The anatomy of the domestic animals* (5th ed.). Saunders.
- König, H. E., & Liebich, H. G. (2020). *Veterinary Anatomy of Domestic Mammals: Textbook and Colour Atlas* (7th ed.). Thieme Medical Publishers, Incorporated.
- Mihaylov, R., Dimitrov, R., Raichev, E., Kostov, D., Stamatova-Yovcheva, K., Zlatanova, D., & Bivolarski, B. (2013). Morphometrical features of the head skeleton in brown bear (*Ursus arctos*) in Bulgaria. *Bulgarian Journal of Agricultural Science*, 19.
- Roşu, P. M., Georgescu, B., Belu, C. R., Purdoi, L., Mihai, S. A., Guresoae, E., & Dancau, V. (2022). Morphological features of the skull in the Eurasian Brown Bear (*Ursus arctos arctos* - Linnaeus, 1758):

- CASE STUDY. *Scientific Works. Series C. Veterinary Medicine, LXVIII*(1).
- Siliceo, G., Salesa, M. J., Antón, M., Pastor, J. F., & Morales, J. (2014). Comparative anatomy of the shoulder region in the Late Miocene Amphicyonid *magericyon anceps* (Carnivora): Functional and paleoecological inferences. *Journal of Mammalian Evolution*. doi: 10.1007/s10914-014-9270-9
- Sorkin, B. (2006). Ecomorphology of the giant bear-dogs *Amphicyon* and *Ischyrocyon*. *Historical Biology*, 18(4), 375–388.
<https://doi.org/10.1080/08912960600618073>
- Vonk, J., & Shackelford, T. K. (Todd K. (2019). Encyclopedia of animal cognition and behavior / editors, Jennifer Vonk, Todd Shackelford. In *Encyclopedia of animal cognition and behavior* (Living edition.). Springer.
- Yousefi, M. H. (2016). Anatomical study of the Iranian brown bear's skull (*Ursus arctos*): A case report. *Iranian Journal of Veterinary Medicine*, 10, 237–244.
- ****Nomina Anatomica Veterinaria*, Fifth edition, Published by the Editorial Committee Hannover (Germany), Ghent (Belgium), Columbia, MO (U.S.A.), Rio de Janeiro (Brazil) (2017)