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Comparative Macroanatomical Studies on Forelimb (Ossa Membri Thoracici) in Hasak and Hasmer Sheep*

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***Abstract**:*
This study was carried out in order to reveal the macroanatomical structure of the bones that form the forelimb extremity skeleton in Hasmer and Hasak sheep breeds. In the study, five Hasak and five Hasmer sheep taken from Konya Bahri Dağdaş International Agricultural Research Institute Directorate, Experimental Animal Unit Unit were used. Forequarters taken from sheep were dissected using maceration techniques and their photographs were taken after macroanatomical examination. It was determined that the forelimb bones of Hasmer and Hasak sheep breeds consisted of scapula, humerus, radius, ulna, ossa carpi, ossa metacarpalia and ossa digitorum manus from proximal to distal. As a result of the measurements made on scapula bones, it was seen that the fossa infraspinata and fossa supraspinata of the Hasmer sheep breed were slightly larger than those of the Hasak sheep race. Humerus sulcus m. It was determined that brachialis was present in both races. It was determined that caput radii, which is the enlarged upper part of the radius, was wider in the Hasmer sheep breed, and the fovea capitis radii in its proximal was slightly deeper than the Hasak breed. It was determined that the tuber olecranii found in the ulna bone was more voluminous in the Hasmer race. Os carpi intermediale was found to articulate with os carpi radiale and os carpi ulnare on both sides with the radius on the proximal side, and with the bone and os carpale IV consisting of os carpale II and III fusion on the medial side. Tuberositas ossis metacarpalis, located in the dorsal of the upper end of the metacarpal bone, was seen in both sheep breeds. Processus extensorius found in Phalanx distalis was determined to be more raised in Hasmer sheep breed than Hasak sheep breed. In this study, great similarities were found between the macroanatomical structures of the findings obtained in the comparison of forelimb bones of Hasmer and Hasak sheep. It was concluded that the results of the research will be used as a reference for other macroscopic and surgical studies.
***Keywords:** Hasak, Hasmer, Ossa membri thoracici.*

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I. INTRODUCTION

Sheep breeding has come to the fore even more because sheep, which is one of the first domesticated animal species, can easily adapt to different conditions, benefit from low quality pastures, require less effort in terms of feeding and care, and the producer costs are less than other farm animals[1-2]. Having different yield characteristics (leather, fertilizer, milk, meat, in addition to the pharmaceutical and cosmetic sector) has made sheep breeding even more attractive. For this reason, no other animal species has been used for different purposes as much as sheep[3-5]. Breeding studies have been carried out in our country since the past years. As a result of crossbreeding studies initiated at Bahri Dağdaş International Agricultural Research Institute in 1989, Hampshire Down (HD), German Black-Headed Meat sheep (ASB) and Hasak sheep breed with high meat yield carrying Akkaraman genotype were developed. Males and females of the sheep breed with a long and thin tail do not have horns[6-7]. As a result of crossing the German Black Head and Hampshire Down (HD) rams with the Merino sheep, the Hasmer sheep breed was developed in the same Institute. Hasmer sheep breed carries the characteristics of the sheep it is crossbred with and adapts well to environmental conditions. It has a large and robust body, a wide and deep chest structure[8]. Although some studies[9-10] were conducted on Hasak and Hasmer

sheep breeds, no studies were found on the forelimb bones. In this study, it was aimed to reveal the macroanatomical structures of the forelimb bones of Hasmer and Hasak sheep breeds.

II. MATERIALAND METHODS

Foreleg bones (ossa membri thoracici) of 5 Hasak and 5 Hasmer sheep breeds were used in the study. These materials were procured from Konya Bahri Dağdaş International Agricultural Institute, Experimental Animals Unit. The forelimb bones were extracted from the cadaver in a way that would not damage the bones, and the methods specified in the literature[11] were applied. The muscle and tissue parts on it were cleaned, and the bones were boiled, with 100 milliliters of washing soda in 1 liter of water. The bones of the foreleg were prepared with the help of scalpel and forceps after 2 hours of heat treatment in order to remove the meat and cartilage structures on the bones by regularly checking the bones during the boiling phase. Then, the bones were boiled until the small pieces of meat were completely removed, the water was drained, then washed with soapy water and left to dry. Some measurements were made with caliper on the bones. The forelimb bones, which were examined macroanatomically, were photographed from various angles. Macroanatomical differences in the bones of Hasmer and Hasak sheep were investigated. Nomina Anatomica Veterinaria[12] was used to name the terminological expressions.

III. RESULTS

Scapula

In Hasak and Hasmer sheep breeds, it was observed that the scapula had two sides, facies costalis and facies lateralis, and three sides, margo dorsalis, margo cranialis and margo caudalis. Cartilago scapulae found in the margo dorsalis of the scapula was detected in both sheep breeds (Figure 1,2). In the measurements made with caliper in the margo dorsalis of the scapula; In Hasak sheep breed, fossa infraspinata is 6.6 cm, fossa supraspinata is 1.6 cm; It was determined that the average fossa infraspinata was 7.2 cm and the fossa supraspinata was 1.8 cm in Hasmer sheep breed. As a result of these measurements, the fossa supraspinata made up 19.51% of the scapula (excluding the collum scapula and its distal end) and 80.49% of the fossa infraspinata in the Hasak sheep breed. It was found that 20% of the scapula (excluding the collum scapula and its distal end) and 80% of the fossa infraspinata. It was observed that the fossa infraspinata of Hasmer sheep breed was 9% larger than the fossa infraspinata of Hasak sheep breed, and the fossa supraspinata of Hasmer sheep breed was 1.25% larger than the fossa supraspinata of Hasak sheep breed (Figure 1).

The fossa subscapularis found in facies medialis showed a certain depth in both sheep breeds (Figure 2). Found in the facies costalis of the scapula, m. It was determined that the facies serrata to which serratus ventralis adhered had a distinctly rough structure in the Hasak sheep breed (Figure 2). It was determined that the spina scapula curved from the part close to the acromion towards the cranial in Hasmer races. Acromion protrusion was prominent in both breeds (Figure 1).

In the collum scapula, the distal protrusion of the tuberculum supraglenoidale was tapered and the processus corocoideus on the inner surface was more prominent in Hasak race, and the oval cavitas glenoidalis was found to be thinner towards the tuberculum supraglenoidale (Figure 1, 2).

Humerus

It was observed that the caput humeri, which is located in the proximal part of the humerus, was more swollen in the Hasak race than in the Hasmer race. Where the projections limiting the caput humeri from the front are flatter and located on the outer surface of the tuberculum majus. It was observed that infraspinati was more prominent in Hasak breed (Figure 4). In Hasak sheep, compared to Hasmer sheep, the tip of the Tuberculum minus pars cranialis ends with a sharper protrusion, and the arc-shaped linea m. located behind the tuberculum majus. Tricipitis was found to be more prominent. It was determined that the anterior end of the tuberculum majus pars cranialis of the Hasak sheep has a sharper structure than that of the Hasmer sheep (Figure 3, 4). Collum humeri, located on the underside of the posterior side of the caput humeri, was present in both breeds. Sulcus intertubercularis, located between tuberculum majus and tuberculum minus, was prominently detected in Hasak and Hasmer sheep breeds. It was observed that tuberositas deltoidea, located on the outer lateral surface of the body of the humerus, was more oval in Hasmer race than Hasak race (Figure 3, 4). Crista humeri was observed to progress more sharply in the Hasmer breed (Figure 3). Tuberositas teres major was more prominent in Hasmer sheep. sulcus m. filled with M. brachialis. brachialis was seen in both breeds and this groove was found to have a spiral course (Figures 3, 4). It was determined that tuberositas deltoidea, which is located near the middle of the humerus and has a rough structure on the outer side, is also found in Hasak and Hasmer sheep breeds. It was determined that Tuberositas teres major was located on the middle inner surface of the humerus and was less prominent in both sheep breeds. It was observed that the fossa olecrani, located between the epicondylus lateralis and the epicondylus medialis, was deeper in the Hasak sheep breed (Figure 4).

Skeleton antebrachii

Radius

It was determined that the caput radii, which is the enlarged upper part of the radius, was wider in Hasmer sheep breed and the fovea capitis radii located in the proximal part was slightly more concave compared to the Hasak breed (Figure 6). Tuberositas radii, which is a mound on the front and underside of the head, was found to be approximately the same height and rough structure in both sheep (Figure 5). It was determined that the facies cranialis showed anterior convexity in both breeds, and the corpus radii was observed to be thinner in the Hasak breed. It was determined that crista transversa, located in the distal of facies caudalis, was sharper in Hasak sheep breed than Hasmer sheep breed. In the Hasak sheep breed, the protrusion on the inner side of the lower end of the radius, processus styloideus medialis, was more prominent (Figure 5).

Ulna

It was observed that olecranon exceeded the upper level of the radius and olecranon was smaller in Hasak race than Hasmer race. Tuber olecrani was found to be more voluminous in Hasmer breed (Figure 5). The processus anconeus, located at the anterior margin of Tuber olecrani, was found to protrude bluntly in Hasmer sheep and more pointedly in Hasak sheep (Figure 5). It was observed that incisura trochlearis, located in the lower part of the olecranon, was narrow in the Hasak race and relatively wider in the Hasmer race (Figure 5). Spatium interosseum antebrachii proximale at the upper end was found to be in the form of a wider cavity in Hasak race. The inferior spatium interosseum antebrachii distalis was seen as a very small space in both races (Figures 5, 6). It was observed that the lower end of the ulna continued to the lower end of the radius in both races. It was determined that the processus styloideus ulna in the Caput ulnae formed a sharper protrusion in the Hasmer race than in the Hasak race (Figure 5).

Ossa carpi

In Hasak and Hasmer sheep breeds, it was determined that there were five wrist bones, os carpi radiale, os carpi intermedium, os carpi ulnare in the upper row, os carpale II et III, os carpale IV in the lower row. Os carpale II et III was found to be larger in Hasmer race than Hasak race. It was observed that the protrusions of the os carpi radiale were sharper in the Hasmer breed (Figure 7, 8).

Metacarpus

It was observed that the metacarpus, which comes after the fore ankle bones, and the main metacarpus formed by the fusion of os metacarpale III and os metacarpale IV in Hasmer and Hasak sheep breeds, and the secondary metacarpus consisting of os metacarpale V. It was determined that Canalis metacarpi proximalis et distalis was present at both ends of the metacarpus in Hasak and Hasmer sheep breeds. It was determined that the basis metacarpalis of the normal metacarpal bone and the facies articularis articulating with the carpal bones were present in both races. It was observed that incisura intertrochlearis, which divides the reel-shaped structure at the lower end of the metacarpus into two, was slightly more discrete in Hasak sheep breed. The size of the medial spool was detected in both breeds (Figs. 9, 10).

Ossa digitorum manus

It was observed that the articular pit fovea articularis on the basis of the phalanx proximalis and the nodules eminentia palmaris medialis and lateralis on the sides that provide the adhesion of the ligaments were similar in both sheep breeds. It was observed that the abaxial of the articular pits in the proximal part was wider, the axial one was narrower, and it was deeper in the Hasmer breed compared to the Hasak breed. It was determined that the rough structure on the back of the body of the phalanx proximalis of the Hasak sheep and the dorsal face were more oval in shape. It was observed that the sagittal groove in the middle of the trochlea in Caput phalangis was more prominent in the Hasak race (Figure 11).

It was determined that the phalanx medialis was half as long as the first phalanx and the phalanx medialis of the Hasak sheep breed was smaller than the Hasmer sheep breed. In Hasak and Hasmer sheep breeds, it was observed that the medial one of the two articular pits at the upper end of the phalanx media, which articulates with the caput of the phalanx proximalis, was wider (Figure 12). It was determined that Processus extensorius was more fluffy in Hasmer sheep breed compared to Hasak sheep breed. An articular surface was seen on the plantar of facies articularis, located proximal to the fascia solearis, and it was determined that the os sesamoidea distalis was located on this articular surface. It was observed that this articular surface was wider in the Hasak breed. It was observed that Facies solearis was pointed to the front and was more pointed in Hasmer sheep breed compared to Hasak breed (Figure 13).

IV. DISCUSSION

It covers 19.51% of the scapula (excluding the collum scapula and its distal tip), 80.49% of the fossa infraspinata in the Hasak sheep breed, and the fossa supraspinata of the scapula (collum scapula) in the Hasmer sheep breed. and its distal end) and the fossa infraspinata constituted 80% of the scapula. This finding was found to be the same as in Hasmer sheep and very close to Hasak sheep, with Dursun[13]reporting that the ratio between fossa supraspinata and fossa infraspinata in sheep is ¼. It was determined that the margo cranialis of the scapula showed convexity in Hasak and Hasmer sheep breeds. Taşbaş[14]reported that margo cranialis is more prominent in wild goats in his study in goats. Taşbaş[15]stated that the length of the margo dorsalis of the scapula was 8.2 cm in Akkaraman sheep and 11.7 cm in wild sheep. In the measurements made, it was determined that the length of the margo dorsalis was 8.2 cm in the Hasak sheep and 9 cm in the Hasmer sheep. As stated in the literature[16-17], the fossa subscapularis had a certain depth in both species. It has been reported that in sheep[17-19], the cavitas glenoidalis of the scapula is oval, while in wild sheep[15] and roe deer[20] it is round. In the study, it was determined that the cavitas gleonoidalis was oval in both species.

In studies[13,21], it was determined that sheep and goat humerus have two ends and one body, as in ruminant animals. In the literature[14], it has been reported that the tip of the pars cranialis of tuberculum minus in mohair and hair goats has a sharp pointed structure. In the study, it was determined that this formation was sharp in both races, but it was determined that it ended with a sharper protrusion in the Hasak race than in the Hasmer race.

Dursun[13] reported that tuberculum majus was higher than caput humeri in sheep and goats. In this study, in both species, tuberculum majus was higher than caput humeri and facies m. It was observed that infraspinati was more prominent in Hasak sheep. Taşbaş[14]determined in his study that fossa nudata synovialis is on the lateral part of facies articularis, and it was observed that it was more prominent in Hasak and Hasmer sheep. Nickel et al.[16]reported that the tuberositas deltoidea of the humerus in small ruminants is in the form of a raised protrusion or a rough swelling, while Barone[22] and Getty[23] reported that this formation is less protruding, closer to the proximal end of the bone. Taşbaş[15], on the other hand, reported that this formation is very evident in the wild sheep and indeterminate in the Karaman sheep. Lochi et al.[21] stated that it is less pronounced and smooth in goats. In the study, it was observed that tuberositas deltoidea was prominent in both species, but it was more oval in Hasmer race than Hasak race.

Blagojevic et al.[24]reported that tuberositas teres major is generally not observed in sheep and deer humerus. In this study, tuberositas teres major was found to be more prominent in Hasmer sheep than in Hasak sheep. Taşbaş[15]reported in his study that the ulna formed a clear border with the radius in karaman sheep and descended to the distal, but this border was quite unclear in wild sheep. In the study, it was determined that the mentioned border was more pronounced in Hasak sheep than in Hasmer sheep.

Dursun[13]found that olecranon had two protrusions in small ruminants, Gültekin[25], Taşbaş[15] had a single protrusion, Taşbaş[15]found that tuber olecrani had a more pointed structure in karaman sheep compared to wild sheep and in both sheep breeds. that this formation has only one protrusion, also proc. reported that the width of anconeus was greater in wild sheep. In the present study, it was determined that tuber olecranon in both sheep species was single-protruded in accordance with Gültekin[25]and Taşbaş[15]reports and was more bulky in Hasmer sheep than in Hasak sheep. In addition, processus anconeus, located at the anterior edge of tuber olecrani, was found to protrude bluntly in Hasmer sheep and more pointedly in Hasak sheep.

In the study, it was reported in the literature[13,26,27] that the head of the radius is wider, it articulates with the humerus at the upper end and the metacarpus at the lower end, and there is a rough ridge on the front of the collum radii. It was determined that tuberositas radii, which is the most common lesion, was found, corpus radii had two faces as facies cranialis and facies caudalis, facies cranialis was anterior and showed convexity, facies caudalis was the face facing the ulna and showed concavity.

Gudea and Stan[27] stated that the tuberous structure at the upper end of the ulna is the olecranon. As stated by Siddiqui et al.[26], Dursun[13], Gudea and Stan[27], that the ulna extends to the distal end of the radius, and that there are two spaces formed at the lower end and the upper end of these two bones, these spaces are found in Hasak et al. It was also seen in Hasmer sheep breeds.

As Dursun[13], Bahadır and Yıldız[28]reported, in both sheep species used in the study, 3, 4, and 5 metacarpuses of the metacarpus were found, and the 3 and 4 metacarpuses were fused, dorso-palmar It was determined that it forms a single main metacarpus (os metacarpale III et IV), flattened in the direction, and metacarpus no. 5 is secondary and attached to the upper outer side of metacarpus no. 4 as a small bone, and metacarpus no. 1 and 2 are absent. was done.

It has been reported that the phalanxes of the foreleg are generally the same as the phalanxes of the hind legs, but the phalanx proximalis and phalanx media of the forefoot are longer than those of the hindfoot. As reported by Nickel[29] and Raghavan[30] in cattle and Duncan et al.[31] in sheep, phalanx medialis was found to be approximately half the size of phalanx proximalis. Duncan et al.[31] reported that the phalanx distalis in sheep has dorsal and solear faces that are similar to the shape of the nail. It has been reported that on the proximal part of the phalanx distalis, there is a protrusion that joins with a sagittal groove that articulates with the medial

phalanx. In the present study, it was determined that the facies articularis in both sheep breeds was pit-shaped and separated into axial and abaxial faces with a small protrusion, and the axial articular surface was wider and the abaxial face was narrower.

V. CONCLUSIONS

It has been determined that the structures of the front leg bones of Hasmer and Hasak sheep breeds, which were examined macroscopically, have some differences from each other and from other sheep breeds.

Foreleg bones of Hasak and Hasmer sheep breeds, which were developed with the aim of increasing carcass and meat yield, were examined macro-anatomically. It was concluded that the data obtained in this study will contribute to the lack of knowledge on this subject and to surgical practices.

Ethical statement: Ethics Committee approval was obtained for the study from Atatürk University Faculty of Veterinary Medicine Unit Ethics Committee (Date/No: 2018/49).

Conflict of Interest

The authors declare that there is no conflict of interest.

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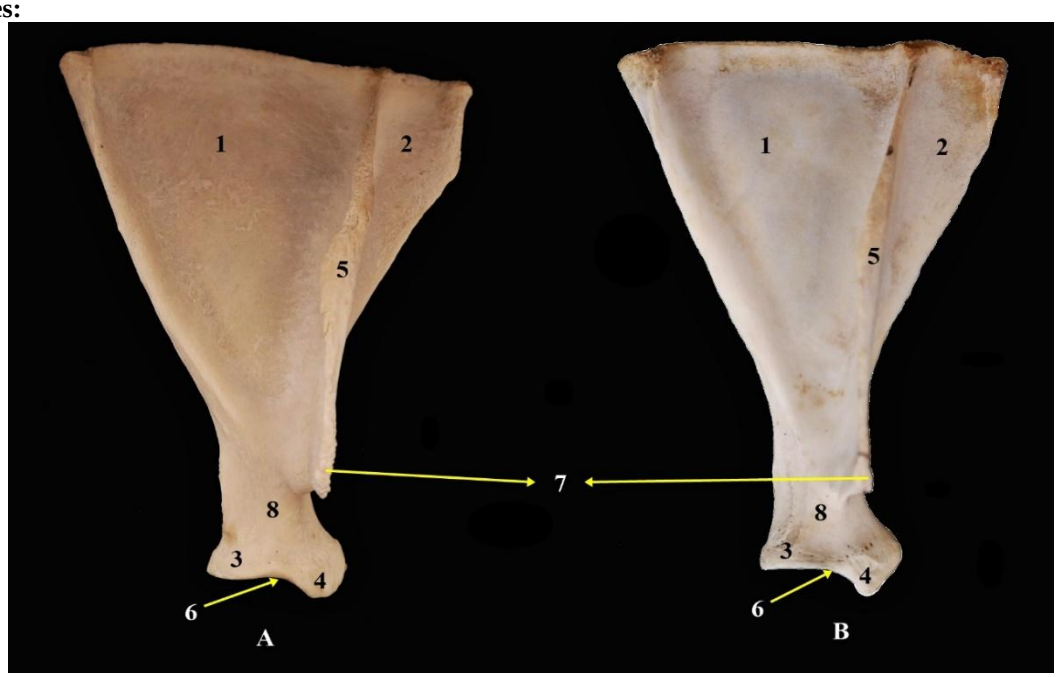

Figure 1. Lateral view of the scapula in Hasmer (A) and Hasak (B) sheep breeds.
1. Fossa infraspinata, 2. Fossa supraspinata, 3. Tuberculum infraglenoidale
4. Processus coracoideus, 5. Tuber spina scapula, 6. Cavitas glenoidalis, 7. Acromion.

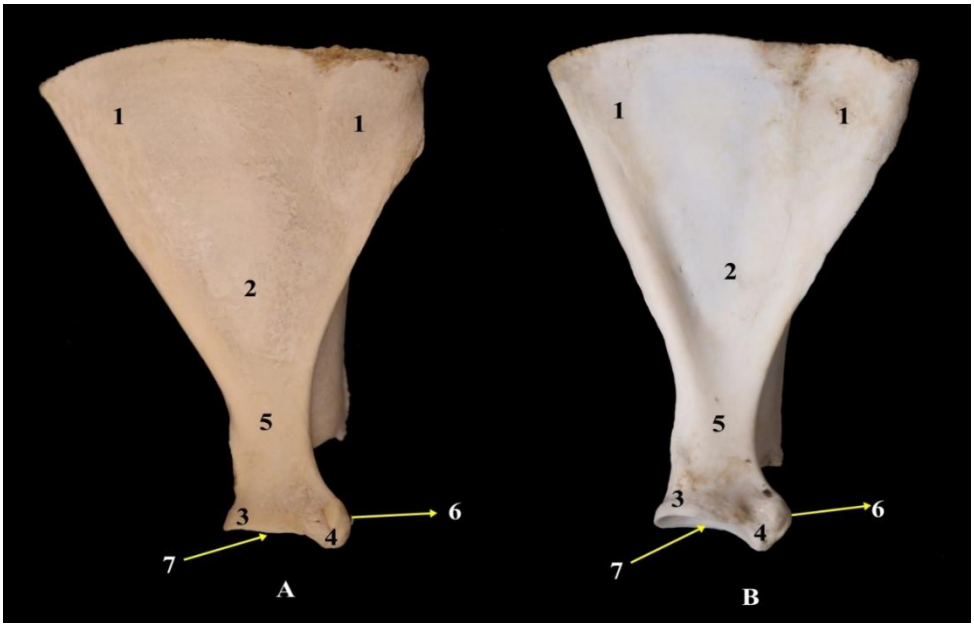

Figure 2. Medial view of the scapula in Hasmer (A) and Hasak (B) sheep breeds.
1. Facies serrata, 2. Fossa subscapularis, 3. Tuberculum infraglenoidale
4. Tuberculum supraglenoidale, 5. Collum scapulae, 6. Processus coracoideus
7. Cavitas glenoidalis.

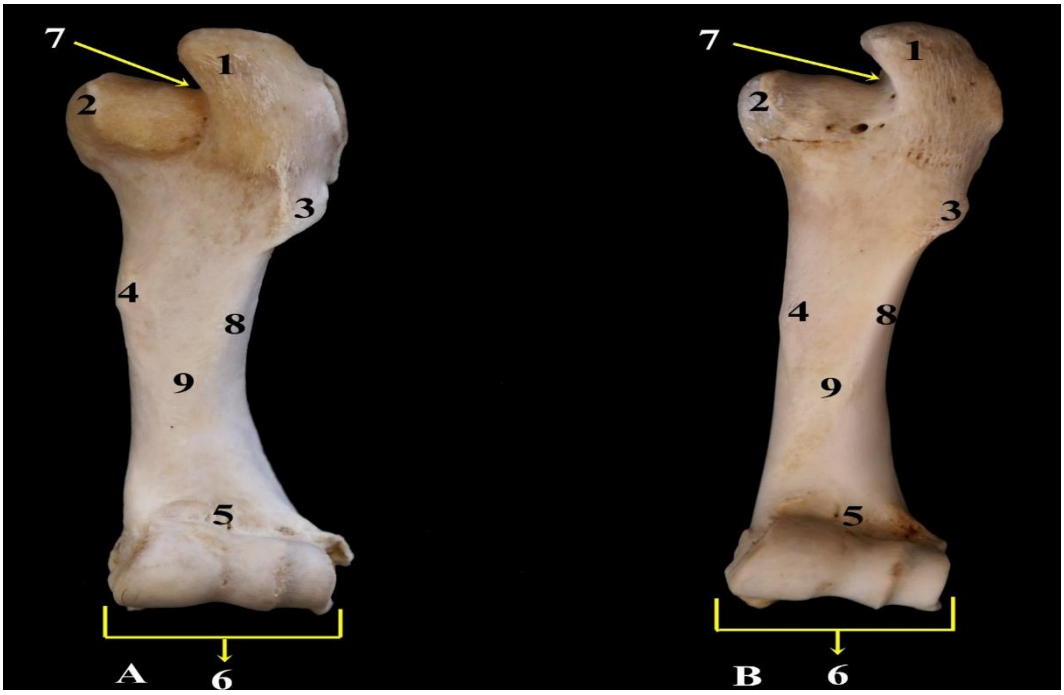

Figure 3. Cranial view of the humerus in Hasmer (A) and Hasak (B) sheep breeds.
1. Tuberculum majus pars cranialis, 2. Tuberculum minus pars cranialis
3. Tuberositas deltoidea, 4. Tuberositas teres majör, 5. Fossa radialis
6. Condylus humeri, 7. Sulcus intertubercularis. 8. Crista humeri, 9. Corpus humeri.

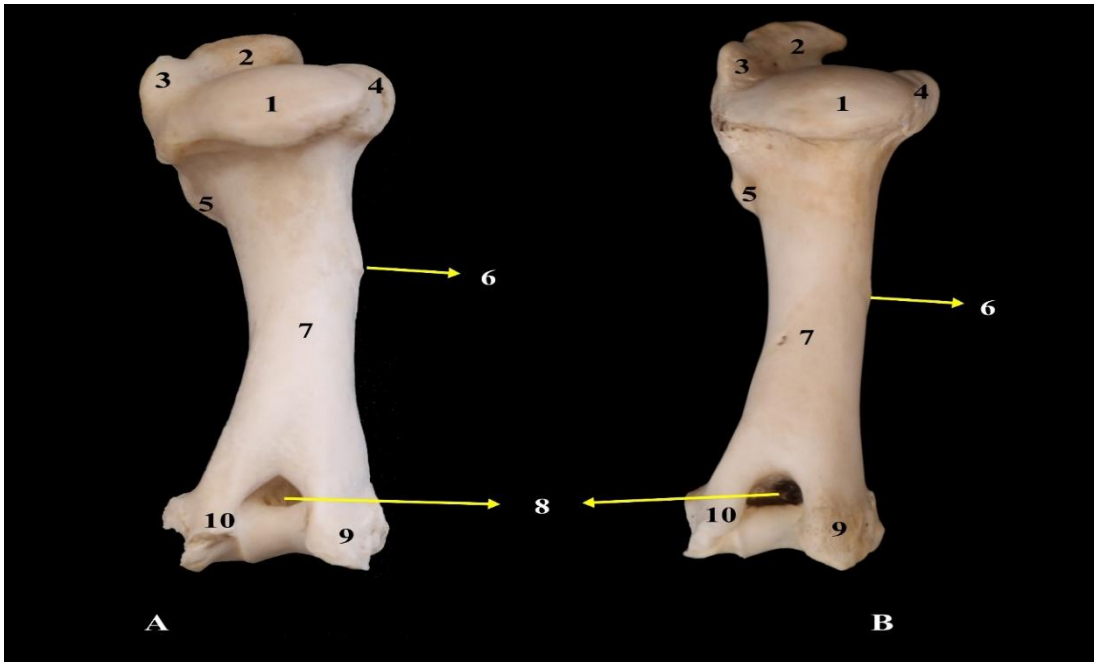

Figure 4. Caudal view of humerus in Hasmer (A) and Hasak (B) sheep breeds.
1. Caput humeri, 2. Tuberculum majus pars cranialis, 3. Tuberculum majus pars caudalis, 4. Tuberculum minus pars cranialis, 5. Tuberositas deltoidea, 6. Tuberositas teres majör, 7. Corpus humeri, 8. Fossa olecrani, 9. Epicondylus medialis, 10. Epicondylus lateralis.

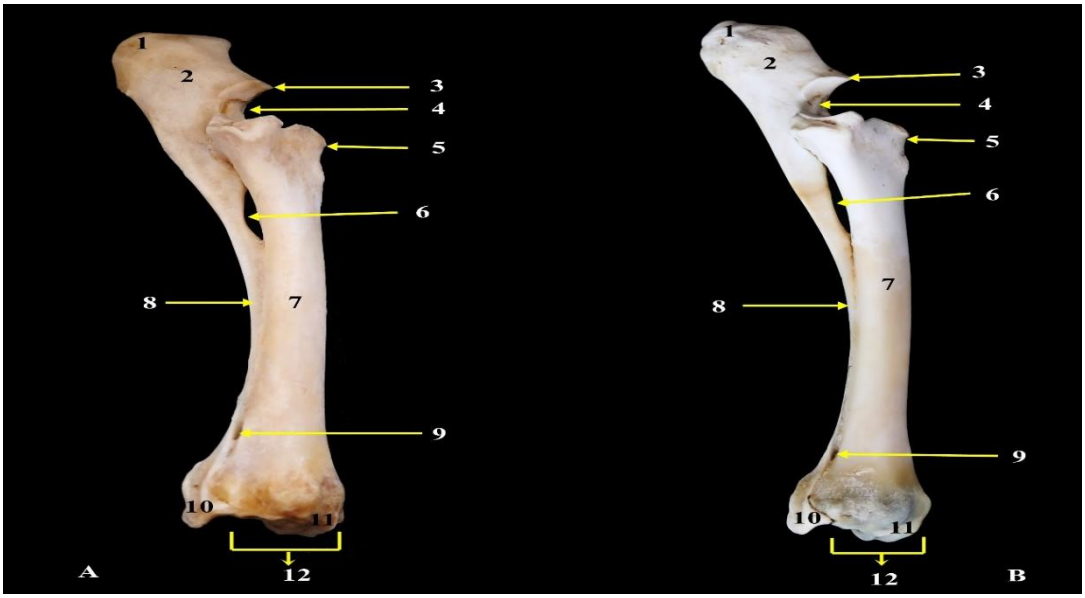

Figure 5. Lateral view of the antebrachium in Hasmer (A) and Hasak (B) sheep breeds.

1. Tuber olecrani, 2. Olecranon, 3. Processus anconeus, 4. İncisura trochlearis, 5. Tuberositas radii, 6. Spatium interosseum antebrachii proximalis, 7. Corpus radii, 8. Corpus ulnae, 9. Spatium interosseum antebrachii distalis, 10. Processus styloideus ulnae, 11. Processus styloideus radii, 12. Trochlea radii.

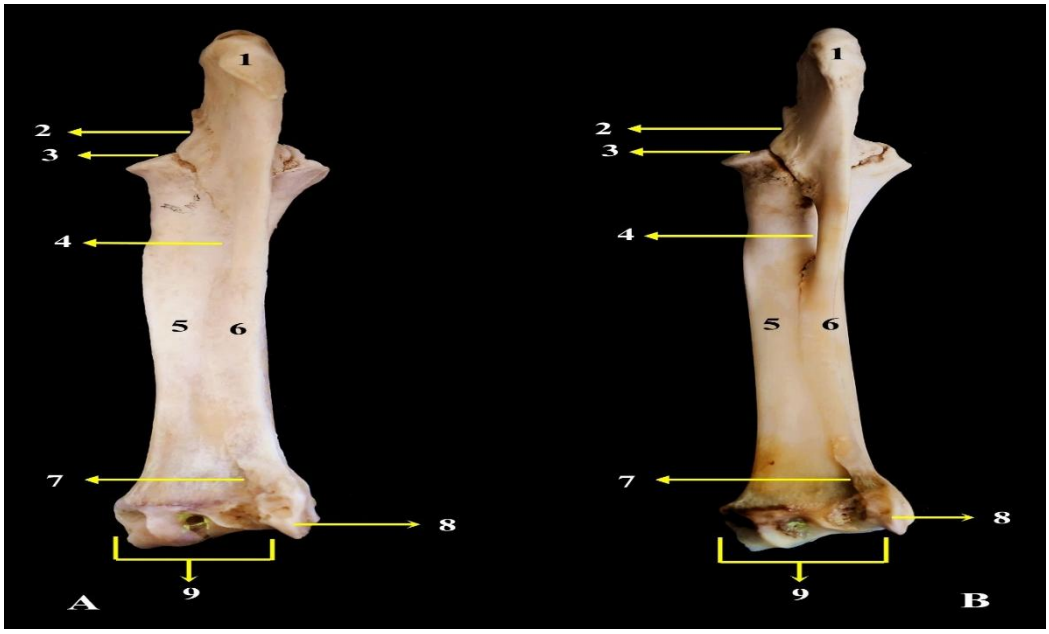

Figure 6. Caudal view of antebrachium in Hasmer (A) and Hasak (B) sheep breeds.
1. Tuber olecrani, 2. İncisura trochlearis, 3.Fovea capitis radii, 4. Spatium interosseum antebrachii proximalis, 5. Corpus radii, 6. Corpus ulnae, 7. Spatium interosseum antebrachii distalis, 8. Processus styloideus lateralis, 9. Trochlea radii.

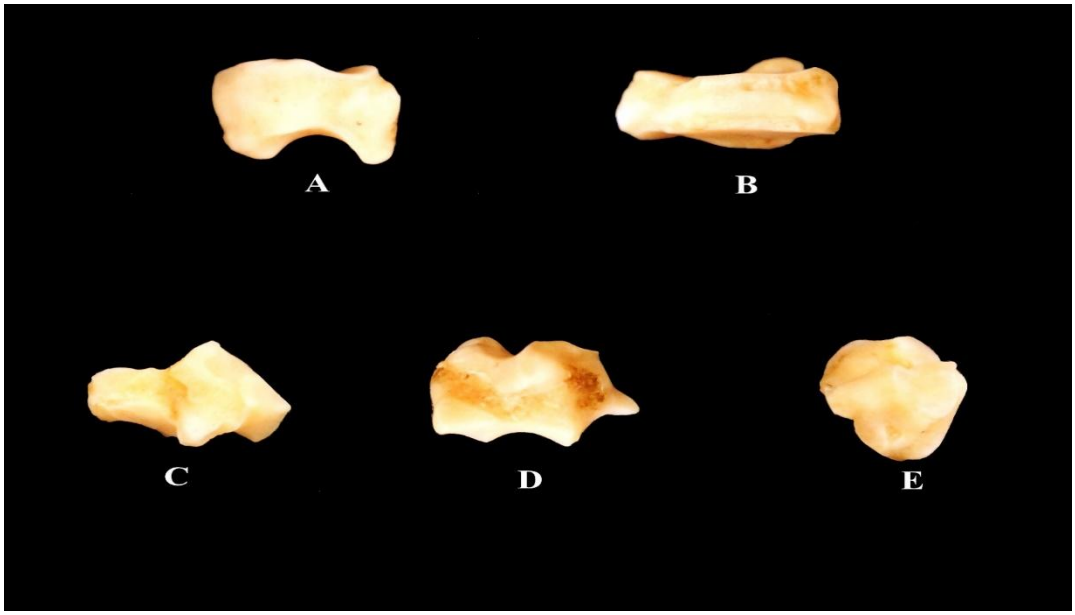

Figure 7. The appearance of the carpus in Hasmer sheep breed.
A. Os carpale II et III, B. Os carpale IV, C. Os carpi intermedium,
D. Os carpale radiale, E. Os carpi ulnare.

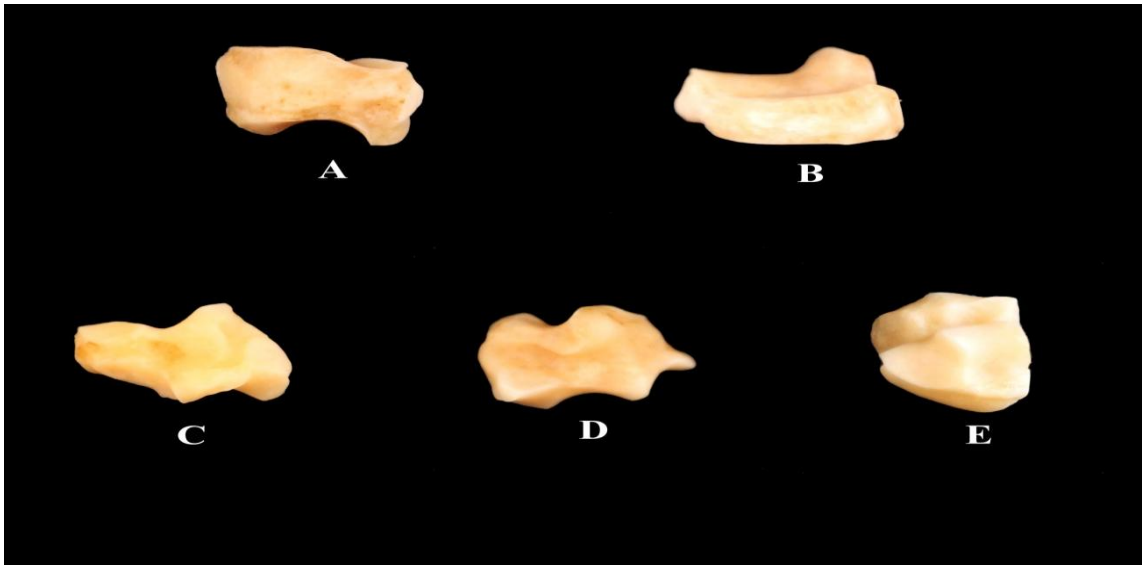

Figure 8. The appearance of the carpus in Hasak sheep breed.
A. Os carpale II et III, B. Os carpale IV, C. Os carpi intermedium,
D. Os carpale radiale, E. Os carpi ulnare.

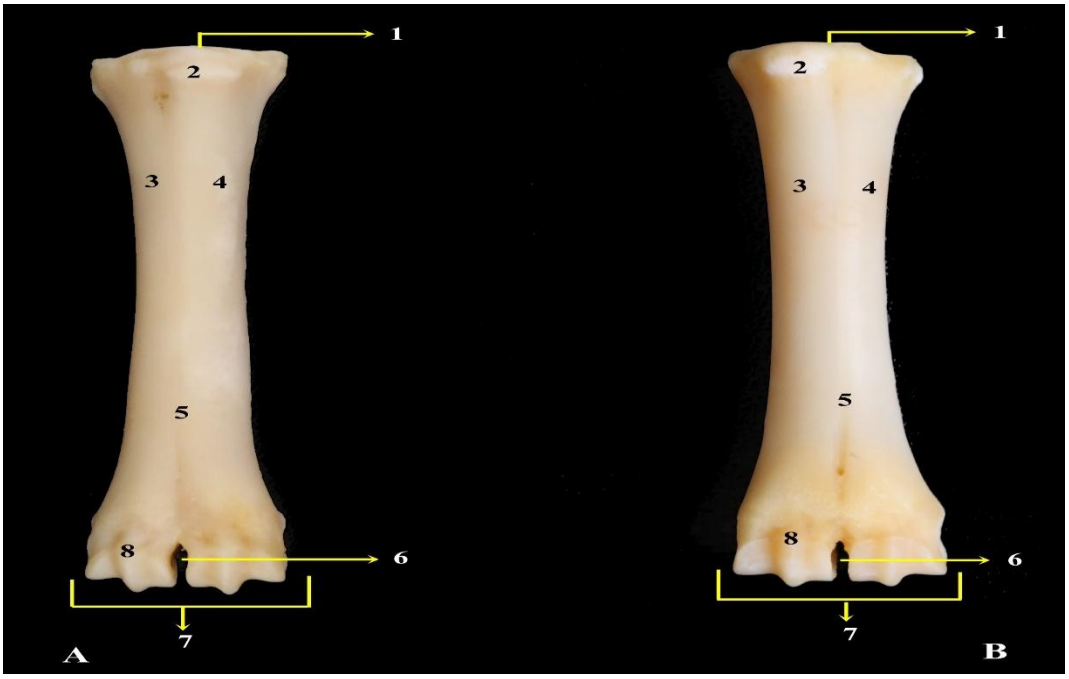

Figure 9. Dorsal view of the metacarpus in Hasmer (A) and Hasak (B) sheep breeds.
1.Basis metacarpalis, 2.Tuberositas ossis metacarpalis III, 3.Os metacarpalia III
4.Os metacarpalia IV, 5.Sulcus longitudinalis dorsalis, 6.İncisura intertrochlearis
7.Caput metacarpalis, 8.Vertricullus.

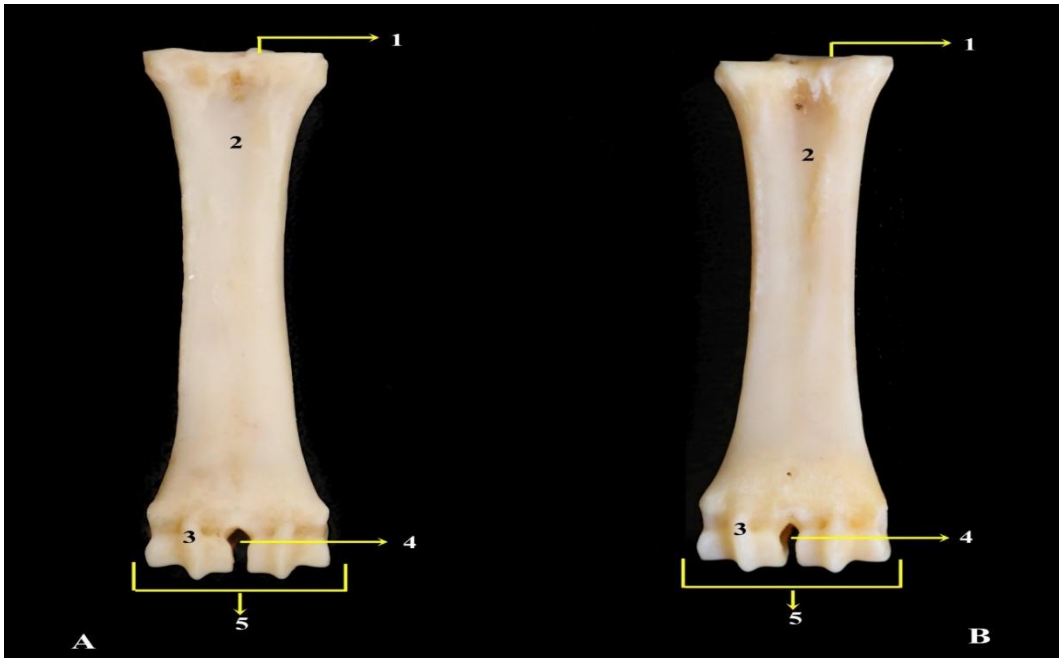

Figure 10. Palmar view of metacarpus in Hasmer (A) and Hasak (B) sheep breeds.

1.Basis metacarpalis, 2.Sulcus longitudinalis palmaris, 3.Vertricullus
4.İncisura intertrochlearis, 5.Caput metacarpalis.

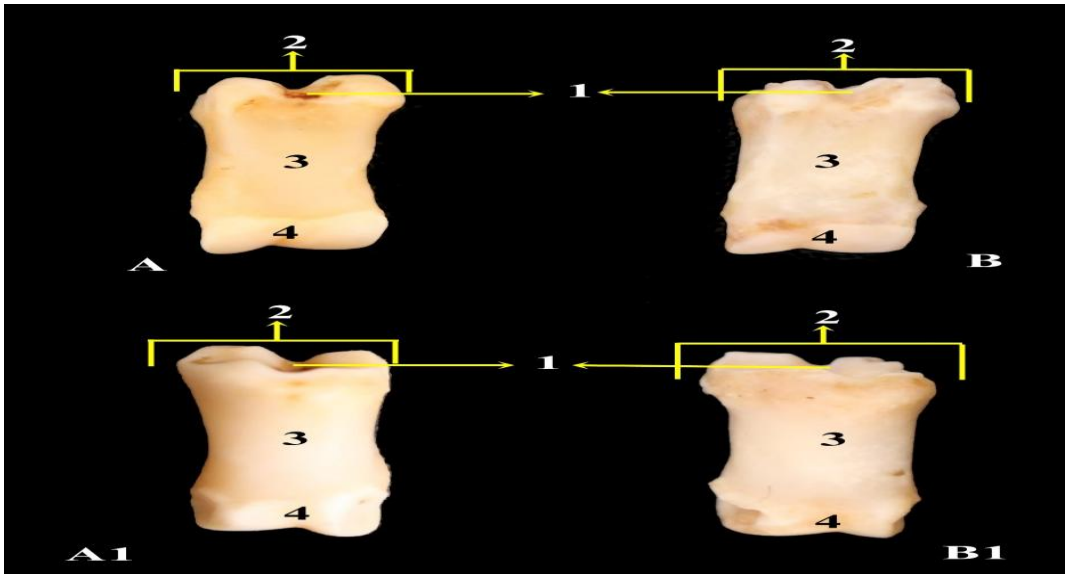

Figure 11. The appearance of phalanx proximalis in Hasmer and Hasak sheep breeds.
- Plantar (A) and dorsal (A1) view of phalanx proximalis in Hasmer sheep.
- Plantar (B) and dorsal (B1) view of phalanx proximalis in Hasak sheep.
1.Fovea articularis, 2.Basis phalangis proximalis, 3.Corpus phalangis proximalis, 4.Caput phalangis proximalis.

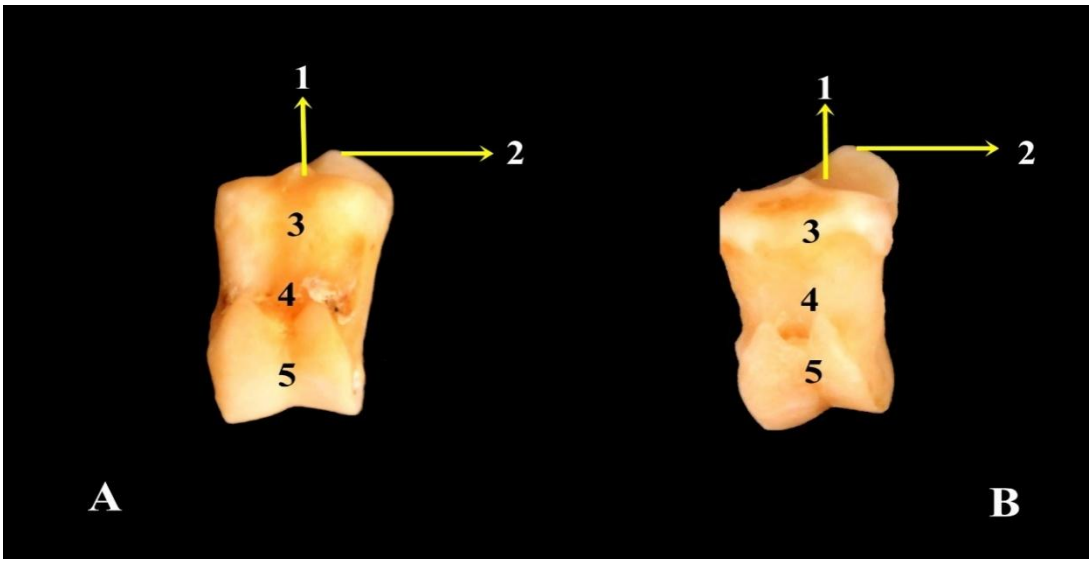

Figure 12. Palmar view of the phalanx media in Hasmer (A) and Hasak (B) sheep breeds.
1.Fovea articularis, 2.Processus extensorius, 3.Basis phalangis media
4.Corpus phalangis media, 5.Caput phalangis media.

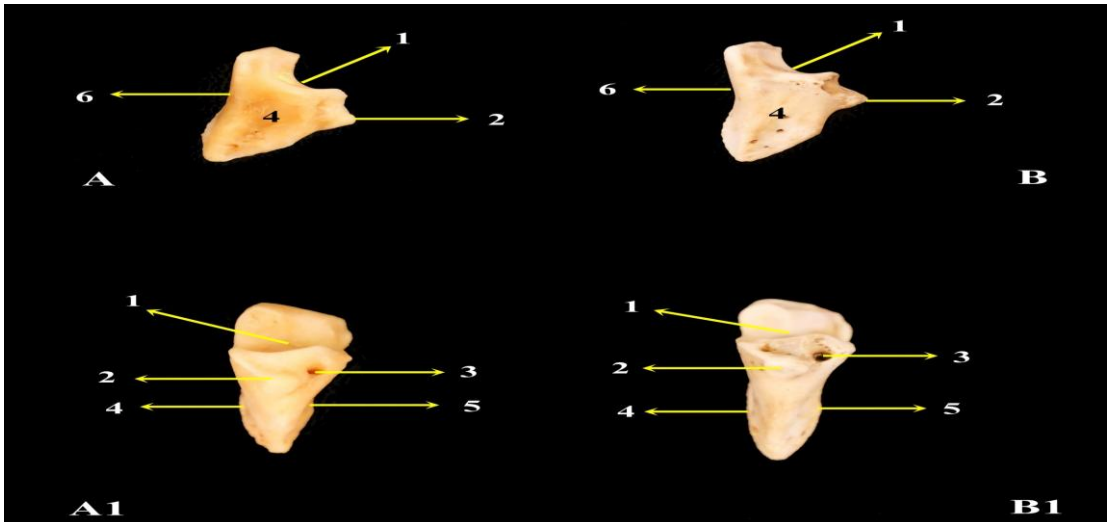

Figure 13. The appearance of the phalanx distalis in Hasmer and Hasak sheep breeds.
- Dorsal (A) and medial (A1) views of the phalanx distalis in a Hasmer sheep.
- Dorsal (B) and medial (B1) view of phalanx distalis in Hasak sheep.
1.Facies articularis, 2.Proc. extensorius, 3.Foramen axiale
4.Facies axialis, 5.Facies abaxialis, 6.Facies solearis