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Original Scientific Paper

COMPARISON OF ROE DEER (CAPREOLUS CAPREOLUS) AND SHEEP (OVIS ARIES) FEMUR MORPHOLOGICAL CHARACTERISTICS AS A METHOD OF DETERMINATION ANIMAL SPECIES

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Summary

Forensic analysis of the osteological characteristics of femurs of roe deer and sheep was performed by the method of comparison. In this study, 6 femurs of adult roe deer and 6 femurs of adult sheep were used. After the soft tissue remains were removed from the bones, they were boiled and then bleached in 3% the solution of hydrogen peroxide (H_2O_2). After bleaching, the bones were air-dried and then photographed.

The roe deer femur is on average 2.3 cm longer than the same bone in sheep. The body of roe deer femur is strongly curved cranially, and in sheep it is slightly curved. The caudal surface of the femur body in sheep has two rough lines that were absent in the middle third in roe deer femoral body. The supracondylar fossa in roe deer is deep and in sheep shallow. The deep fovea in roe deer and shallow fovea in sheep were observed on the middle of the femoral head. The greater trochanter in roe deer femur is higher and narrower in comparison to sheep. The lateral surface of the greater trochanter of femur in roe deer is rough and in sheep it is smooth. The trochanteric fossa in roe deer femur is narrow and deep, while in sheep it is wide and shallow. On the distal extremity of the femur, the trochlea in roe deer is shallower than in sheep. On the lateral condyle, the popliteal muscular fossa in roe deer is narrow and shallow and in sheep wide and deep. The roe deer patella is on average 0.3 cm shorter and 0.4 cm narrower compared to sheep.

Keywords: forensics, osteology, femur, roe deer, sheep

INTRODUCTION

The roe deer (*Capreolus capreolus*), also known as European roe, belongs to the deer family (Cervidae) and the genus Capreolus (Wilson and Reeder, 2005). The species is the most numerous and widespread large venison in Europe. It inhabits areas from the Mediterranean to Scandinavia and from Scotland to the Caucasus. In Serbia, roe deer inhabit areas of Vojvodina and central Serbia.

Deer have long had economic importance to humans. Their economic importance is manifold and includes the use of their highly nutritious meet (Tolušić et al., 2006; Uherova et al., 1992), their skin as soft, strong deer skin and their antlers as knife handles. Due to the wild nature and diet of deer, venison is most often obtained through deer hunting. In our practice, the most frequent cases of illegal hunting were related to the roe deer. The perpetrators hunt illegally in order to gain material benefits by selling venison meat or obtaining expensive trophies of these animals.

In veterinary medicine, forensic DNA methods are used to identify biological material (skin, hair, meat) that is suspected to originate from a wild animal caught during a ban on its hunting. Dimitrijević et al. (2013) presented the first case of introducing the examination of polymorphism of microsatellite genetic markers within forensic analysis in the cases of roebuck poaching in Serbia. It was proved that DNA profiles of the samples taken from roebuck corpse were identical to DNA profile of the meat sample found in the suspect house.

In the absence of roe deer biological material, fresh or boiled bones with pronounced osteological characteristics may be used for forensic analysis. Knowing the osteological differences of bones between domestic and wild animals is one of the safest methods for determining the species of animal. Marković et al. (2014) identified 2585 bones or bone remains of sheep, goats, horses, donkeys and camels from the archeological site Caričin Grad and the Studenica monastery based on knowledge of the osteological characteristics of the bones of these animals.

Various studies have been performed to determine the osteological characteristics of the hind limbs bones of the wild and domestic animal species, ungulates such as the feral pigs (Karan, 2012), camels (Crisan et al., 2009), different species of deer (Schimming et al., 2015; Rajani et al., 2013; Rajani et al., 2012) caws (Salami et al., 2011; Crisan et al., 2009; Sisson and Grossman, 1975), sheep and goats (Alpak et al., 2009; Sisson and Grossman, 1975). The above mentioned authors described the osteological characteristics of the bones of the hind limb after boiling, drying and bleaching these bones. Demircioglu and Ince, (2020) described the morphometric characteristics of the hind limb bones of gazelles using multidetector computerized tomography (MDCT) images. Salami et al. (2011) determined that the examined bones collected in the savannah zone of

Nigeria belonged to Yankasa sheep and Sokoto goats based on the knowledge of the morphological characteristics of the bones of small ruminants. Nešić et al. (2017) showed that knowing the osteological differences of the bones of the leg skeleton and metatarsal bones (Blagojević et al., 2016) between roe deer and sheep is a reliable method in identifying the species of animals.

There is no data in the available literature on the morphological characteristics of the femur of roe deer, so the aim of this study was to describe the osteological characteristics of the femur of roe deer and compare it with those of sheep, some deer species and gazelles in order to determine the species.

MATERIALS AND METHODS

For the purpose of investigating comparative characteristics of femurs, the bones of 6 adult roe deer and bones of 6 adult sheep were used.

The roe deer femurs were obtained from hunters during the period of allowed deer hunting. Sheep femurs were obtained from the collection of small ruminant bones from the Department of Anatomy, Faculty of Veterinary Medicine in Belgrade. After the soft tissues remains such as muscles, arterial and venous vessels as well as nerves were removed from the bones with a knife and scalpel. The femur samples were boiled with the addition of detergent to remove the remaining soft and fat tissues. After rinsing bones were placed in 3% solution of hydrogen peroxide (H_2O_2) for bleaching. At the end, they were air dried and photographed with a digital camera.

The lengths of femurs were measured using a ruler. The circumference of the middle part of the body and the prominent bony parts on the femurs were measured using a vernier caliper.

RESULTS AND DISCUSSION

Osteological characteristics of roe deer femur

The femur of the roe deer is a long bone, cylindrical in shape except at its extremities. The average length of the femur is 20.5 cm and the average circumference of the middle part of the body of the femur is 1.1 cm. The slender body of the femur (Figure 1 A6, C6 and Figure 2 A6, C6) is cranially strongly curved, especially in its distal two thirds.

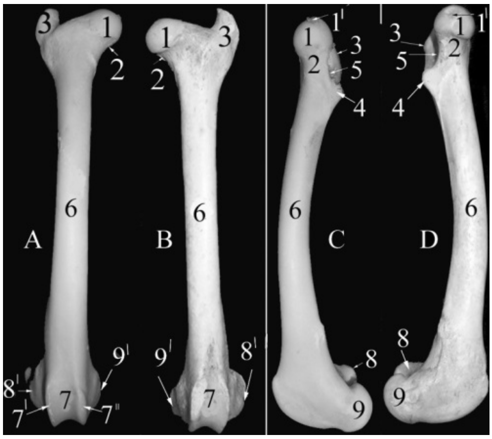

Figure 1. Cranial surface of the right femur of roe deer A and left femur of sheep B. Medial surface of the femur of roe deer C and sheep D (1- Caput ossis femoris, 1' C,D- Fovea capitis, 2- Collum ossis femoris, 3- Trochanter major, 4C,D- Trochanter minor, 5C,D- Fossa trochanterica, 6- Corpus ossis femoris, 7AB- Trochlea ossis femoris, 7', 7"A,B- lateralni i medijalni greben trohlee, 8C,D- Condylus lateralis, 8'A,B- Epicondylus lateralis, 9C,D- Condylus medialis, 9'A,B- Epicondylus medialis)

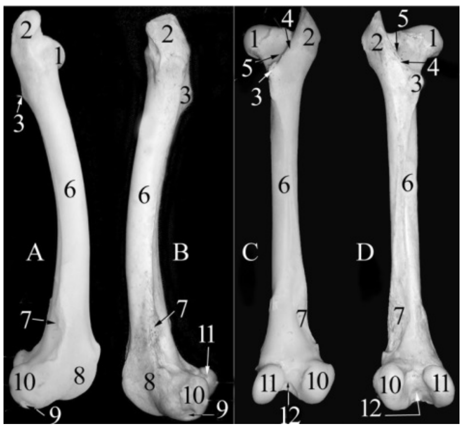

Figure 2. Lateral surface of the right femur of roe deer A and left femur of sheep B. Caudal surface of the femur of roe deer C and sheep D (1- Caput ossis femoris, 2- Trochanter major, 3- Trochanter minor, 4C, D- Crista trochanterica, 5C, D- Fossa trochanterica, 6- Corpus ossis femoris, 7- Fossa supracondylaris, 8A, B- Fossa extensoria, 9A, B- Fossa m.poplitei, 10- Condylus lateralis, 11- Condylus medialis, 12C,G- Fossa intercondylaris)

The proximal extremity of the femur is on average 0.5 cm wider than the distal extremity. The proximal extremity consists of the head, neck and two trochanters.

The femoral head (*caput ossis femoris*) (Figure 1 A1, C1 and Figure 2 A1, C1) is smooth and strongly curved toward the medial surface of the femur. It is supported by a distinct neck (*collum ossis femoris*) (Figure 1 A2, C2) that is long and narrow. The fovea of the head (*fovea capitis*) (Figure 1 C1') is a small but deep depression on the middle of the femoral head. The greater trochanter (*trochanter major*) (Figure 1 A3 and Figure 2 A2, C2) average length 3.4 cm and average width 1.3 cm is plate-shaped and extends proximal above the head of the femur. Its lateral surface has the rough muscle lines to attach the muscles. The lesser trochanter (t*rochanter minor*) (Figure 1 C4 and Figure 2 A3, C3) has the form of a rough tuberosity, and is situated on the proximal extremity of the femur, on its medial caudal surface. The intertrochanteric crest (c*rista intertrochanterica* (Figure 2 C4) connects the greater and lesser trochanters. The trochanteric fossa (*fossa trochanterica*) (Figure 1 C5 and Figure 2 C5) is narrow and deep.

The body of the femur (*corpus ossis femoris*) (Figure 1 A6, C6 and Figure 2 A6, C6) is cylindrical, except near its ends, where it is wider and compressed cranio-caudally. The average body circumference is 1.1 cm. Cranial, medial and lateral surface of the body are continuous and smooth. Caudal surface of the distal half of the femoral body is bounded by two rough lines, the lateral and the medial, which diverge toward the lateral and medial condyles. The lateral rough line is more pronounced than the medial rough line. The supracondylar fossa (*fossa supracondylaris*) (Figure 2 A7, C7) is very deep and is situated at the distal femoral body on its caudo-lateral surface.

The distal extremity of the femur comprises the trochlea and two condyles. The trochlea (Figure 1 C7), 3.1 cm long and 1.4 cm wide is identified at the distal extremity of the femur, on its cranial surface. It consists of two ridges which are parallel and slightly oblique. The medial trochlear ridge (Figure 1 A7'') is more prominent than the lateral ridge (Figure 1 A7').

Both condyles (C*ondylus medialis* and *Condylus lateralis*) identified caudally in the femoral distal extremity are well developed and they separated by a shallow and narrow intercondylar fossa (*Fossa intercondylaris*) (Figure 2 C12). The lateral condyle (Figure 1 C8 and Figure 2 A10, C10) is convex and larger than the medial condyle (Figure 1 C9 and Figure 2 C10). The lateral condyle has narrow and shallow fossa that corresponds to the popliteal muscle fossa (*fossa m. poplitei*) (Figure 2 A9). The deep extensor fossa (Figure 2 A8) located between the lateral trochlear ridge and lateral condyle. Proximal and lateral to the medial and lateral condyles are lateral and medial epicondyles (Figure 1 A8' and Figure 1 A9').

The patella is long and narrow with an average length, width of its base and apex of 2.3 cm, 1.4 cm, 0.3 cm, respectively. Its cranial surface (Figure 1-3) is convex and has a prominent tuberosity. The caudal surface of the patella is its articular surface, which is divided by a smooth, rounded ridge into a medial large and a lateral smaller articular surface.

The femur is the long bone of the hindlimb of sheep (König and Liebich, 2009; Sisson and Grossman, 1975), Morkaraman sheep (Alpak et al., 2009), some deer species such as roe deer, marsh deer (Schimming et al., 2015) and Patagonian huemul deer (Flueck and Smith-Flueck, 2011) and gazelles (Demircioglu and Ince, 2020).

In the present study, the femur of sheep is on average 1.3 cm shorter than that of the roe deer, and the average body circumference of the femur is 0.6 cm larger than that of roe deer.

The proximal extremity of the femur is wider than the distal extremity in both sheep and deer. The femoral head of sheep (Figure 1 B1, D1 and Figure 2 B1, D1) and roe deer is smooth, spherical and placed medially. A similar head position and shape has been described in gazelles (Demircioglu and Ince, 2020) and some deer species (Schimming et al., 2015; Rajani et al., 2013; Rajani et al., 2012). The fovea on the head of sheep femur (Figure 1 D1') is much smaller compared to roe deer. Small fovea was also described by Rajani et al. (2012) in samba deer, Crisan et al. (2009) in camels and Demircioglu and Ince (2020) in gazelles.

The neck of the femur is prominent in both sheep and deer, but in sheep (Figure 1 B2, D2) it is short and wide and in roe deer long and narrow.

At the proximal extremity of the femur, the greater trochanteris is at the same level as the head of the femur in gazelles (Demircioglu and Ince, 2020) sambar deer (Rajani et al., 2012) and spotted deer (Islam et al., 2018). Schimming et al. (2015) noted that in marsh deer, greater trochanter is divided into cranial and caudal portions. However, in camels (Crisan et al., 2009) the greater trochanter is lower than the femoral head.

In our study it was found that the greater trochanter was raised above the level of the femoral head in both sheep and roe deer. Such finding was also described by Rajani et al. (2013) in Indian muntjak, Crisan et al. (2009) in cows and König and Liebich (2009) in large ruminants. The greater trochanter in sheep (Figure 1 B3, D3 and Figure 2 B3, D3) is on average 0.3 cm lower and 0.3 cm wider than in roe deer. In roe deer, the lateral surface of the greater trochanter has rough lines while in sheep it surface is smooth.

The intertrochanteric crest connects the large and small trochanters in both, sheep (Figure 2 D4) and roe deer, as well as Morkaraman sheep (Alpak et al., 2009), gazelles (Demircioglu and Ince, 2020), sambar deer (Rajani et al., 2012) and marsh deer

(Schimming et al., 2015). However, Crisan et al. (2009) found that the intertrochanteric crest was present in cows and absent in camels.

In a study by Schimming et al. (2015) conducted on marsh deer it was shown that the lesser trochanter appears on the body of the femur, on its proximal part. In our study, the lesser trochanter was the part of the proximal extremity of the roe deer femur. There was no difference in the shape of the lesser trochanter in sheep, roe deer, gazelles, sambar deer and marsh deer.

The trochanteric fossa has been observed in sheep (Sisson and Grossman, 1975), gazelles (Demircioglu and Ince, 2020) and some deer species (Islam et al., 2018; Schimming et al., 2015; Rajani et al., 2013; Rajani et al., 2012). The trochanteric fossa of sheep (Figure 1 D5 and Figure 2 D5) is wide and shallow and in roe deer narrow and deep.

The femoral body of sheep (Figure 1 B6, D6 and Figure 2 B6, D6) (Sisson and Grossman, 1975), Morkaraman sheep (Alpak et al., 2009) is cranially slightly curved in comparison with the body of the same bone in roe deer, where it is strongly curved in its distal two thirds.

Cranial, medial and lateral surface of the body of the femur in sheep and roe deer as well as spotted deer (Islam et al., 2018) and marsh deer (Schimming et al., 2015) are continuous and smooth.

The nutrient foramen described by Rajani et al. (2012) in sambar deer and Islam et al. (2018) in spotted deer on the proximal third of the cranial surface of the body of the femur of these deer was not observed in sheep and roe deer.

Schimming et al. (2015) in marsh deer and Islam et al. (2018) in spotted deer found two rough lines on the caudal surface of the femoral body of these animals, with the lateral line being more pronounced than the medial line. In our study, rough lines were observed on the entire caudal surface of the sheep femur body and in the proximal fifth and distal half of the femoral body of deer. Rough lines were not mentioned by Sisson and Grossman (1975) on the body of the femur in sheep.

The body circumference of sheep femur is on average 0.6 cm larger than that of roe deer.

At the distal extremity of the femur, the trochlea is surrounded by prominent medial and lateral smooth trochlear ridges, with the medial ridge being thicker and elevated than lateral ridge, described by Demircioglu and Ince (2020) in gazelle, Rajani et al. (2013) in Indian muntjac and Rajani et al. (2012) in sambar deer. The trochlea of sheep (Figure 1 B7) is on average 0.4 cm longer and 0.4 cm wider than of roe deer. In both, sheep and roe deer the medial ridge is thicker than the lateral ridge.

Crisan et al. (2009), describing condyles at the distal extremity of the femur of cows, mares and camels, observed that in cows and mares both condyles are approximately equal in size, while in the camels the lateral condyle is much more developed than the medial condyle. Our results on condyles of sheep and roe deer are in agreement with those described by Demircioglu and Ince (2020) in gazelles, Rajani et al. (2012) in sambar deer and Crisan et al. (2009) in camels, where the lateral condyle is larger than the medial condyle.

Epicondyles, medial and lateral, were well developed in sheep (Figure 1 B9' and 1 B8') and roe deer. The epicondyles were also mentioned by Demircioglu and Ince (2020) in gazelles and Schimming et al. (2015) in marsh deer.

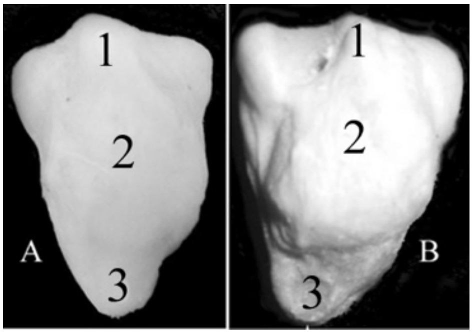

Figure 3. Patella of roe deer A and sheep B, cranial surface (1- Basis patellae, 2- Corpus patellae, 3- Apex patellae)

The patella has pointed apex in sheep (Figure 3 B3) (König and Liebich, 2009; Sisson and Grossman, 1975) and roe deer, as well as in gazelles (Demircioglu and Ince, 2020) and some species of deer (Schimming et al., 2015; Rajani et al., 2012). In camels, the patella is an elongated bone whose length is twice its width (Crisan et al., 2009). Patella in marsh deer is triangular, narrow and thick bone, with the base facing upward and the apex pointed face down (Schimming et al., 2015). Rajani et al. (2012) described that the patella of sambar deer was ovoid, long and narrow bone. Our results on patella of sheep (Figure 3B) and roe deer are in agreement with those described by Schimming et al. (2015) in marsh deer where the cranial surface of the patella is convex and quite irregular. The depression on the cranial surface of the patella base in sheep is wide and deep, in roe deer narrow and shallow. The patella of sheep (Figure 3B) is on average 0.3 cm longer and 0.4 cm wider in its base than the patella of roe deer. The caudal articular surface of the patella in the sambar deer (Rajani et al., 2012) showed a blunt sagittal ridge. The blunt rounded ridge separated articular surface of the patella both, sheep and roe deer on medial larger and lateral smaller articular surface.

CONCLUSION

Studies of the osteological characteristics of the femur of roe deer and sheep are important in distinguishing the animal species, as well as assistance in forensic cases during the ban on roe deer hunting. In cases of roe deer poaching, due to the lack of biological material from the roe deer femur, fresh or cooked femurs can be used for forensic analysis. Comparing the osteological characteristics of the femur between deer and sheep is one of the safest methods for determining the species of animal.

Conflict of interest statement: The authors declare that there is no conflict of interest.

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