MACROANATOMIC AND MORPHOMETRIC ANALYSIS OF THE BROWN BEAR (URSUS ARCTOS HORRIBILIS) MANDIBLE

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SUMMARY: Brown bear (Ursus arctos horribilis) is a wild animal in the bear (Ursidae) family. In this study, it was aimed to determine the morphometric values and anatomical structure of the brown bear mandible. After the superficial muscles of the mandible were dissected, the muscles were completely separated from the bones by boiling. 17 morphometric measurements were taken from the right and left mandible of each animal with the help of digital calipers. The mean and standard deviation values of the taken morphometric measurements were analyzed in the SPSS (20.0 version) package program. The mandible length was measured as 250.37 ± 9.75 mm on the right side and 246.83 ± 5.92 mm on the left side. The mandible height was determined as 105.76 ± 4.18 mm on the right and 108.62 ± 3.33 mm on the left. Consequently, the mandible was submitted to the results of the brown bear in the diversity of wildlife found in Turkey. We believe that the presented results will contribute to anatomical, surgical and archaeological studies.

KEY WORDS: Anatomy; Brown bear; Mandible.

INTRODUCTION

Morphometry is a method that allows statistical analysis in terms of numerical or graphical values of the length between two specific points or angles. The variety of geographical areas with habitats of organism, developmental stages, genetic and environmental effects can cause morphometric variations (Rohlf & Marcus, 1993). Bergmann (1847) reported that climatic conditions affect the size of the alive. Accordingly, a lives of larger size live in cold climates and smaller sizes in hot climates. Due to thermoregulation heat loss will be less and the body will not shrink. The studies conducted also support this rule (de Carlis et al., 2005).

Brown bears are among the largest land carnivores. It is classified under Carnivora genus, Ursidae family, Ursus arctos species, horribilis subspecies. It is one of the largest omnivorous animals on earth. Their size is between 1 and 3 meters. Brown bear is the only bear species living in Turkey. They have a large head, a long nose, and a powerful chin. They are distinguished by their fur color and body size. They have a better sense of smell and a longer mouth than black bears. Mouth shape and size are related to eating habits (Marshall Cavendish Corporation, 2010).

The mandible shapes the lower part of the facial skeleton. The mandible is two parts, corpus mandible and ramus mandible. The corpus mandible consists of pars incisiva, pars molaris and pars alveolaris. In carnivores, foramina mentalia lateralia are found on the lateral face of the corpus mandible. In the angulus mandible, only carnivores have processus (proc.) angularis. Fossa masseterica near the angulus mandible is deeper in carnivores compared to other animals (Dursun, 2008; Evans & de Lahunta, 2013; König & Liebich, 2015).

In the present study, macroanatomical and morphometric results of the mandible of brown bears, which established a habitat in Kars/Sarikamıs (Turkey) and a wild animal, were determined. We believe that these results will contribute to anatomical, surgical and archaeological studies.

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MATERIAL AND METHOD

Ethical approval. The necessary permission for this study was obtained by the Ministry of Agriculture and Forestry (E.2242114/2018).

Animals. Three male brown bear mandibles were used in the study. The working material, the mandible, was obtained from the brown bears of the habitat in the Sarıkamış Allahuekber Mountains National Park. These brown bears were injured animals brought to Kafkas University Veterinary Faculty Clinics and Kafkas University Wildlife Rescue and Rehabilitation Center, but could not be saved despite all interventions.

Maceration and morphometric analysis. After the superficial muscles of the mandible were dissected, the bones were completely separated from the muscles by boiling. Sun-dried mandibles were photographed with Canon digital camera zoom lens 5X. 17. Morphometric measurements were taken from the right and left mandible of each animal with the help of digital calipers (0.00, BTS, UK).

Morphometric measurements (abbreviations). Morphometric measurements are shown in Figures 1 and 2.

- L1. Total length: length from proc. condylaris-infradentale
- L2. Length: the proc. angularis-infradentale
- L3. Length from the indentation between the proc. condylaris and the proc.angularis-infradentale
- L4. Length: the proc. condylaris-aboral margin of the canine alveolus
- L5. Length from the indentation between the proc. angularis and the proc. condylaris-aboral margin of the canine alveolus
- L6. Length: the proc. angularis-aboral margin of the canine alveolus
- L7. Length: the aboral margin of the alveolus of M3-aboral margin of the canine alveolus
- L8. Length of the cheektooth row, P4-M3, measured along the alveoli
- L9. Length of the molar row, measured along the alveoli
- L10 (L). Length of P4, measured at the cingulum
- L10 (W). Width of P4, measured at the cingulum
- L11 (L). Length of M1, measured at the cingulum
- L11 (W). Width of M1, measured at the cingulum
- L12 (L). Length of M2, measured at the cingulum
- L12 (W). Width of M2, measured at the cingulum
- L13 (L). Length of M3, measured at the cingulum
- L13 (W). Width of M3, measured at the cingulum
- L14. Height of the vertical ramus (Ramus mandibulae): basal point of the proc. angularis-coronion
- L15. Height of the mandible behind M2, measured on the buccal side
- L16. Height of the mandible between P4 and M1, measured on the buccal side
- L17. Length of canin tooth

Anatomical features. Anatomical features of the mandible were recorded based on Nomina anatomica veterinaria (International Committee on Veterinary Gross Anatomical Nomenclature, 2017).

Statistical analysis. The mean and standard deviation values of the morphometric measurements taken were determined in the SPSS (20.0 version) package program. In addition, the obtained morphometric values were compared with the ”Independent-T” test according to the direction (right-left) (P <0.05).
RESULTS

Foramina mentalia lateralia usually consisted of 2-3 holes in the ventral of the midpoint of PM1 ( premolar 1) and C (canine) teeth. Foramen mandibulae were located at the 27.30 mm caudomedial of the last grinding tooth (Fig. 3). The length of the margo interalveolaris was determined as 32.17 mm.

The ventral edge was convex approximately at the anterior 1/4, and the concave in the posterior 1/4 was flat. There were 3I (incisive), 1C, 4PM, 3M (molar) teeth in a single jaw half. Fossa masseterica was in the form of a deep pit on the ramus mandible. There was a distinct proc. angularis on the angulus mandible, which is the junction of the corpus mandible and the ramus mandible. The caput mandible of the proc. condylaris was convex. Proc. coronoideus was perpendicular to the horizontal plane and its upper edge was ventro-dorsally oriented.

Morphometric results of the mandible are presented in Table I. Mandible length, the mean was 250.37 ± 9.75 mm on the right and 246.83 ± 5.92 mm on the left. Mandible height, the mean was 105.76 ± 4.18 mm on the right side and 108.62 ± 3.33 mm on the left side.

When the morphometric parameters of the right and left mandible were compared, it was seen that there was no statistically significant difference (P> 0.05).

DISCUSSION

Previous morphometric values of the mandible were found in sheep, goat, roe deer (Onuk et al., 2013; Dalga et al., 2017), German shepherd dog (Onar et al., 1999), Tuj and Morkaraman sheep (Demiraslan et al., 2014), some species of rodents (Mohamed, 2018; Ren et al., 2019) have been reported. However, there are studies on mandibular

| Length | Right mean ± sd (mm) | Right mean ± sd (mm) | General mean ± sd (mm) |
|--------|----------------------|----------------------|------------------------|
| L1     | 250.37 ± 9.75        | 246.83 ± 5.92        | 248.60 ± 7.47          |
| L2     | 243.73 ± 5.87        | 243.73 ± 5.69        | 243.73 ± 5.17          |
| L3     | 227.10 ± 5.46        | 230.17 ± 9.75        | 228.63 ± 7.27          |
| L4     | 216.88 ± 5.97        | 220.41 ± 9.70        | 218.65 ± 7.46          |
| L5     | 210.33 ± 17.63       | 206.90 ± 5.54        | 208.62 ± 11.48         |
| L6     | 217.20 ± 5.72        | 213.80 ± 5.80        | 215.50 ± 5.48          |
| L7     | 119.13 ± 1.71        | 121.43 ± 7.44        | 120.28 ± 4.99          |
| L8     | 39.96 ± 0.90         | 40.41 ± 1.26         | 40.18 ± 1.01           |
| L9     | 39.17 ± 1.36         | 40.09 ± 1.84         | 39.63 ± 1.53           |
| L10(L) | 13.28 ± 2.16         | 13.20 ± 1.95         | 13.24 ± 1.84           |
| L10(W) | 10.16 ± 1.06         | 10.48 ± 1.47         | 10.32 ± 1.16           |
| L11(L) | 12.74 ± 0.84         | 9.81 ± 0.92          | 11.27 ± 1.79           |
| L11(W) | 12.92 ± 1.14         | 12.48 ± 0.74         | 12.70 ± 0.89           |
| L12(L) | 11.71 ± 2.60         | 12.18 ± 1.63         | 11.95 ± 1.89           |
| L12(W) | 12.69 ± 2.90         | 12.38 ± 0.36         | 12.53 ± 1.88           |
| L13(L) | 15.55 ± 4.81         | 15.49 ± 4.69         | 15.52 ± 4.25           |
| L13(W) | 13.70 ± 1.33         | 14.08 ± 1.49         | 13.89 ± 1.28           |
| L14    | 105.76 ± 4.18        | 108.62 ± 3.33        | 107.19 ± 3.73          |
| L15    | 48.34 ± 2.87         | 47.56 ± 4.2          | 47.95 ± 3.42           |
| L16    | 46.75 ± 4.65         | 43.75 ± 2.39         | 45.25 ± 3.69           |
| L17    | 33.78 ± 4.78         | 33.00 ± 5.03         | 33.39 ± 4.41           |

Sd: standard deviation, mm: millimeter, L: length, W: width
morpometry in cave bears (Baryshnikov & Puzachenko, 2020) and Malayan sun bear (Kalita et al., 2019). However, no evidence of a morphometric and macroanatomic study of male living brown bears mandible in Turkey. In the study, it was aimed to determine the macroanatomical values and morphometric parameters of the male brown bear mandible.

Kirbas, et al. (2017) reported that foraminae mentalia consists of 2 holes. Similarly, in brown bears, it was observed that foraminae mentalia consisted of 2-3 holes. Fossa masseterica was reported as shallow in cave bears (Perego et al., 2001), while it was deep in brown bears.

It has been reported that genetic variation (Ketani & Sagsöz, 2009) and gender factor (Onar et al.) are effective in the morphometric development of the mandible. In New Zealand rabbit where morphometric values were compared according to gender, it was reported that the total length of the mandible in males was greater than in females. Similarly, the length of the mandible in the German Shepherd was 89.82 mm in males and 86.63 mm in females (Onar et al.). Likewise, it has been reported that the mean length of the Malakan horse mandible is longer in males than in females, but there is no statistical difference (Gürbüz et al., 2016). However, in a study conducted on foxes, it was observed that the mandible was longer in females than males (Kirbas et al.). This study contains some limitations in terms of the number of mandibles. The statistical values of the number of mandibles used in the study remained minimal due to the conservation of brown bears and the difficulty of finding a dead brown bear. Therefore, in the study, comparison of the morphometric values of the mandible according to sex could not be made.

The mean length of the mandible in the tiger was found to be 201 mm (Tiwari et al., 2011). Mandible length is reported as the red fox males 34.40 ± 3.87 mm (Kirbas et al.). While the length of the mandible in the Malayan sun bear was 146 mm (Kalita et al.), the length of the mandible in the male brown bear was determined as 248.60 ± 7.47 mm. According to these researched data, it is seen that the male brown bear has the largest mandible length. However, Gürbüz et al. (2015) reported that the length of the mandible in male worms was 180.45 ± 13.51 mm on the right side and 182.81 ± 11.47 mm on the left side, and there was no statistically significant difference between the parameters obtained. Similarly, in the study conducted, it was observed that there was no statistical difference when mandible length was compared according to direction (P> 0.05).

Mandibula height, 34.40 mm in male fox, 35.58 mm in female fox (Kirbas et al.), 70 mm in Malayan Sun bear (Kalita et al.), in male wolf right side 74.14 ± 9.09 mm, left at 73.86 ± 9.41 mm (Gürbüz et al., 2015), the mean male malakan horse 253.20 ± 4.56, female malakan horse 249.65 mm ± 0.99 mm (Gürbüz et al., 2016) was measured. In brown bears, it was determined as 105.76 ± 4.18 mm on the right and 108.62 ± 3.33 mm on the left. When the mentioned articles were examined, it was reported that although the morphometric values of mandible height showed millimetric differences on the right and left sides, this difference was not statistically significant (P> 0.05).

In the study of Marsika brown bear, P4 length was reported as 13.00 ± 0.50 mm in males and, 12.30 ± 1.10 mm in females (Loy et al., 2008). Similarly, the length of P4 in the study was measured as 13.24 ± 1.84 mm. The width of P4 was reported as 10.10 ± 0.6 mm in male Marsika brown bear and 8.90 ± 0.5 mm in female (Loy et al.). In the study, the P4 width was determined as 10.32 ± 1.16 mm in accordance with the male Marsika brown bear (Loy et al.).

Margo interalveolaris (diestema) length between PM4 and C in Marsika brown bears has been reported as 32.70 ± 4.90 mm in males and 31.40 ± 4.10 mm in females (Loy et al.). In the study, this length was measured as 32.17 mm. It was observed that the obtained result was similar to the literature (Loy et al.).

The male of American black bears excavated from the excavation measured M2 length 27.83 ± 1.18 mm and M2 width as 17.02 ± 0.91 mm (Wolverton, 2008). In this study, M2 length was 11.27 ± 1.79 mm and, M2 width was 12.53 ± 1.88 mm. American black bears appear to have more teeth length and width than brown bears.

In American black bears, M3 length was reported as 15.89 ± 0.92 mm, M3 width

| Animals                  | Direction | Length of mandibula (mm) | Height of mandibula (mm) |
|-------------------------|-----------|--------------------------|--------------------------|
| Bear brown              | Right     | 250.37 ± 9.75            | 105.76 ± 4.18            |
|                         | Left      | 246.83 ± 5.92            | 108.62 ± 3.33            |
| Wolf (Gürbüz et al., 2015) | Right     | 248.60 ± 7.47            | 107.19 ± 3.73            |
|                         | General   | 180.45 ± 13.51           | 74.14 ± 9.09             |
| Malayan sun bear        | Right     | 182.81 ± 11.47           | 73.86 ± 9.41             |
| (Kalita et al., 2019)   | General   | 181.63 ± 13.51           | 74.00 ± 9.09             |
| Tiger                   |           | 146 ± 4.90               | 70 ± 0.92                |
| general mean±sd (Tiwari et al., 2011) | 201 ± 18.33 | 107.19 ± 3.73 |
| Koala                   | general mean±sd (Saber, 2015) | 98 ± 56 | - |
| Wombat                  | general mean±sd (Saber, 2015) | 127 ± 88 | - |

Sd: standard deviation
as 13.21 ± 1.11 mm (Wolverton), while average length was determined as 15.52 ± 4.25 mm and width 13.89 ± 1.28 mm in brown bears. It seems that the results are similar.

Morphometric parameters of mandible length and height in some carnivora species are shown in Table II. According to the animal species compared, it was observed that the longest mandible was in the brown bear.

CONCLUSION

Consequently, the results of the mandible of a wild animal brown bears, which were obtained in Turkey/ Sankamis. We believe that these findings will contribute to anatomical and archaeological studies. It is also thought to support surgical operations such as mandibulectomy in these animals (Mylniczenko et al., 2005).

REFERENCES

Baryshnikov, G. F. & Puzchenko, A. Y. Morphometry of lower cheek teeth of cave bears (Carnivora, Ursidae) and general remarks on the dentition variability. Boreas, 49(3):562-93, 2020.

Bergmann, K. Über die Verhältnisse der wärme ökonomie der Thiere zu ihrer Grösse. Göttinger Studien, 3(1):595-708, 1847.

Dalga, S.; Aslan, K. & Kırbas, Dogan, G. Morphometric analysis on the mandible of hemsin sheep. Atatürk Üniv. J. Vet. Sci., 12(1):22-7, 2017.

de Carli, A.; Alluvione, E.; Fonte, A.; Rossi, M. & Santi, G. Morphometry of the Ursus spealeus remains from Valstrona (Northern Italy). Geo. Alps, 2:115-26, 2005.

Demiraslan, Y.; Gülbaz, F.; Özcan, S.; Dayan, M. O. & Akbulut, Y. Morphometric analysis of the mandible of Tuj and Morkaraman sheep. J. Vet. Anat., 7(2):75-86, 2014.

Dursun, N. Veterinary Anatomy III (in Turkish). 7th ed. Ankara, Medisan, 2008.

Evans, H. E. & de Lahunta, A. Miller’s Anatomy of the Dog. 4th ed. Philadelphia, WB Saunders Company, 2013.

Gürbüz, I.; Demiraslan, Y.; Aslan, K. & Kırbas, G. Erkek kurt mandibula’nın morfometrik analizi. Ulusal Veteriner Anatomı Kongresi, 7-10 September 2015.

Gürbüz, I.; Demiraslan, Y.; Gülbaz, F. & Aslan, K. Malakan alt mandibulasının cinsiyete göre morfometrik özellikleri. Eurasian J. Vet. Sci., 32(3):136-40, 2016.

International Committee on Veterinary Gross Anatomical Nomenclature. Nomina Anatomica Veterinaria (NAV), 6th ed. Hanover, World Association of Veterinary Anatomists, 2017.

Kalita, P. C.; Singh, T. S.; Choudhary, O. P.; Debroy, S.; Kalita, A. & Doley, P. J. Morphological and applied anatomical studies on the head region of Malayan sun bear (Helarctos malayanus). J. Anim. Res., 9(5):753-8, 2019.

Ketani, A. M. & Sagsöz, H. Histomorphometrical evaluation of the effects of gender on the mandibular condyle in rats. Ataturk Univ. Vet. Bil. Derg., 4(1):31-9, 2009.

Kırbas, G.; Akbulut, Y. & Ilgün, R. Morphometric analysis of the mandible in terms of gender of red fox (Vulpes vulpes) located in Kars. Fourth International VET Istanbul Group Congress, 2017.

König, H. E. & Liebsch, H. G. Veterinary Anatomy (Domestic Animals). 6th ed. Viyana-Münih, Medipress, 2015.

Loy, A.; Genov, P.; Galfa, M.; Jacobone, M. G. & Vigna Taglianti, A. Cranial morphometrics of the Apenine brown bear (Ursus arctos mariscanus) and preliminary notes on the relationships with other southern European populations. Ital. J. Zool., 75(1):67-75, 2008.

Marshall Cavendish Corporation. Mammal Anatomy: An Illustrated Guide. New York, Marshall Cavendish, 2010. pp.104-12.

Mohamed, R. Anatomical and radiographic study on the skull and mandible of the Common opossum (Didelphis marsupialis) Linnaeus, 1758) in the Caribbean. Vet. Sci., 5:44, 2018.

Mylniczenko, N. D.; Manharth, A. L.; Clayton, L. A.; Feinmehl. R. & Robbins, M. Successful treatment of mandibular squamous cell carcinoma in a Malayan sun bear (Helarctos malayanus). J. Zoo Wildlife Med., 36(2):346-8, 2005.

Nar, V.; Kahvecioglu, O.; Mutus, R. & Alpak, H. Alman kurt köpeklerinde mandibula’nın morfometrik analizi. Turk. J. Anim. Sci., 23:329-334, 1999.

Onuk, B.; Kabak, M. & Atalar, K. Anatomical and craniometric factors in differentiating Roe deer from sheep (Ovis aries) and goat (Capra hircus) skulls. Arch. Biol. Sci. Belgrade, 65(1):133-41, 2013.

Perego, R.; Zanalda, E. & Tintori, A. Ursus spealeus from Grotta Sopra Fontana Marella Campo deifiori Massif (Varese, Italy): Morphometry and Paleoecology. Riv. Ital. Paleontol. Stratig., 107(3):451-62, 2001.

Ren, X. Y.; Zhang, D. & Zhu, W. L. Geometric morphometry of skulls characteristics of nine species of Eothenomys. Pak. J. Zool., 51(2):467-74, 2019.

Rohlf, F. J. & Marcus, L. A. Revolution morphometrics. Trends Ecol. Evol., 8(4):129-32, 1993.

Saber, A. S. Clinical anatomy of the mandible of three Marsupial species (Koala, Wombat, Wallaby). J. Vet. Anat. 81(1):1-11, 2015.

Tiwari, Y.; Taluja, J. S. & Vaish, R. Biometry of mandible in Tiger (Panthera tigris). Annu. Rev. Res. Biol., 1(1):14-21, 2011.

Wolverton, S. Characteristics of late Holocene American black bears in Missouri: evidence from two natural traps. Ursus, 19(2):177-84, 2008.

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