

Macroanatomic and Morphometric Analysis of the Brown Bear (*Ursus arctos horribilis*) Mandible

Análisis Macro Anatómico y Morfométrico de la Mandíbula del Oso Pardo (*Ursus arctos horribilis*)

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SUMMARY: Brown bear (*Ursus arctos horribilis*) is a wild animal from 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 incisivae, 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/Sarıkamış (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 Sarikamis 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.

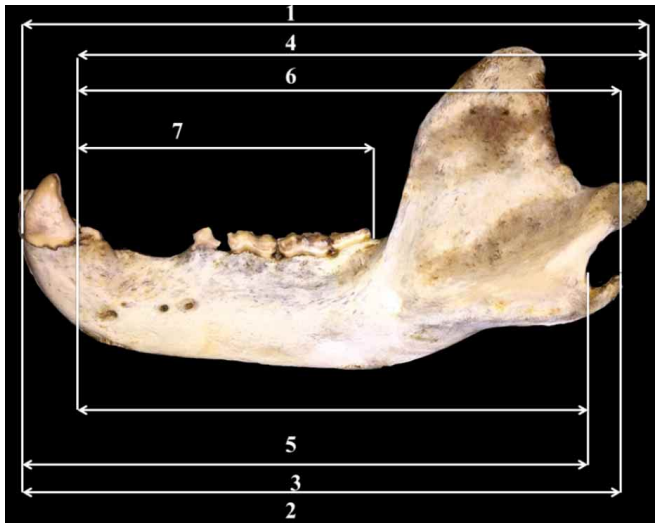


Fig. 1. Measurement points between L1-L7 taken from the lateral of the brown bear mandible.

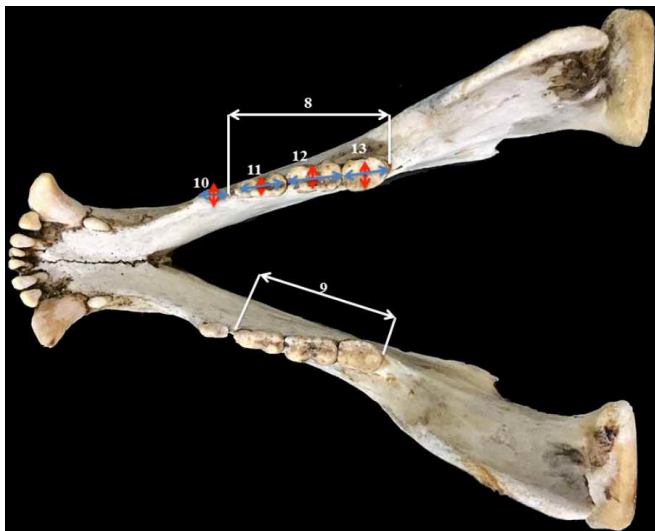


Fig. 2. Measurement points between L8-L13 taken from the dorsal of the brown bear mandible.

Maseration 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-infracdentale
- L2. Length: the proc. angularis-infracdentale
- L3. Length from the indentation between the proc. condylaris and the proc. angularis-infracdentale
- 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

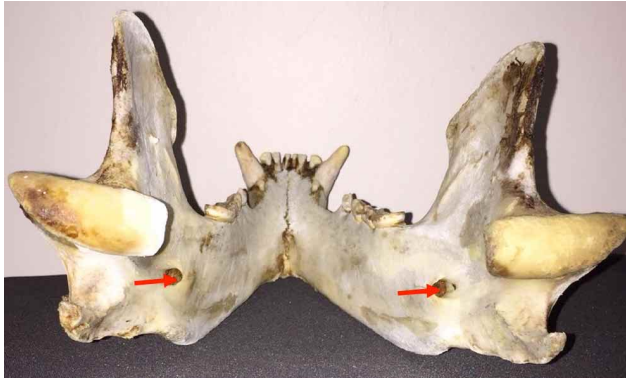


Fig. 3. View of the mandible from the caudal (Red arrow: For. mandibula).

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

Table I. Mean and standard deviation values of the lengths measured from the mandible of male brown bears (L1-L17).

Length	Right mean \pm sd (mm)	Right mean \pm sd (mm)	General mean \pm 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 ± 0.56	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

morphometry 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.

Kırbas, *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 (Kırbas *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 (Kırbas *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 (Kırbas *et al.*), 103 mm in tiger (Tiwari *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

Table II. Comparison of some lengths taken from the right-left mandible according to different animal species.

Animals	Direction	Length of mandibula (mm)	Height of mandibula (mm)
Bear brown	Right mean±sd	250.37 ± 9.75	105.76 ± 4.18
	Left mean±sd	246.83 ± 5.92	108.62 ± 3.33
	General mean±sd	248.60 ± 7.47	107.19 ± 3.73
Wolf (Gürbüz <i>et al.</i> , 2015)	Right mean±sd	180.45 ± 13.51	74.14 ± 9.09
	Left mean±sd	182.81 ± 11.47	73.86 ± 9.41
	General mean±sd	181.63 ± 13.51	74.00 ± 9.09
Malayan sun bear (Kalita <i>et al.</i> , 2019)		146	70
Tiger general mean±sd (Tiwari <i>et al.</i> , 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/Sarıkamış. 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).

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RESUMEN: El oso pardo (*Ursus arctos horribilis*) es un animal salvaje de la familia de los osos (Ursidae). El objetivo de este estudio fue determinar los valores morfométricos y la estructura anatómica de la mandíbula del oso pardo, luego de la disección de los músculos superficiales de la mandíbula. Los músculos fueron separados por completo de los huesos mediante ebullición. Se tomaron 17 medidas morfométricas de la mandíbula derecha e izquierda de cada animal con la ayuda de calibradores digitales. Los valores de desviación estándar y media de las medidas morfométricas tomadas se analizaron en el programa SPSS (versión 20.0). El largo determinando de la mandíbula fue de $250,37 \pm 9,75$ mm en el lado derecho y $246,83 \pm 5,92$ mm en el lado izquierdo; la altura de la mandíbula era de $105,76 \pm 4,18$ mm en el lado derecho y $108,62 \pm 3,33$ mm en el izquierdo. Los resultados morfométricos obtenidos de la mandíbula del oso pardo en la diversidad de vida silvestre que se encuentra en Turquía contribuirán con el conocimiento anatómico y para los estudios quirúrgicos y arqueológicos.

PALABRAS CLAVE: Anatomía; Oso pardo; Mandíbula.

REFERENCES

Baryshnikov, G. F. & Puzachenko, 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 Wärmeökonomie 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 Carlis, A.; Alluvione, E.; Fonte, A.; Rossi, M. & Santi, G. Morphometry of the *Ursus speleus* 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 Publication, 2008.

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

Gürbüz, I.; Demiraslan, Y.; Aslan, K. & Kırbas, G. *Erkek kurt mandibula'sın in morfometrik analizi*. 9. Ulusal Veteriner Anatomi Kongresi, 7-10 September 2015.

Gürbüz, I.; Demiraslan, Y.; Gülbaz, F. & Aslan, K. Malakan atı 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. *Atatürk 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. & Liebich, 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 Apennine brown bear (*Ursus arctos marsicanus*) 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.

Onar, V.; Kahvecioglu, O.; Mutus, R. & Alpak, H. Alman kurt köpeklerinde mandibula'nın morfometrik analizi. *Türk. J. Vet. Anim. Sci.*, 23:329-334, 1999.

Onuk, B.; Kabak, M. & Atalar, K. Anatomic 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.; Zanolida, E. & Tintori, A. *Ursus speleus* from Grotta Sopra Fontana Marella Campo dei Fiori Massif (Varese, Italy): Morphometry and Paleocology. *Riv. Ital. Paleontol. Stratigr.*, 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. F. 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.*, 8(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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