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Investigation of macroanatomical and morphometric on the skull bones of Aksaray Malakli dogs

R. İlgün et al., Anatomy of skull bones of Aksaray Malakli dogs

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Abstract

Background: The skull is an important anatomical structure to discern dog breeds and wolves from dogs. For this purpose, skull morphology and some morphometric measurements of Malakli dogs, a local breed in the Aksaray region, were examined.

Materials and methods: Thirty-two distances were measured, and seven ratio’s calculated, in nine skulls of adult dogs. In our study, different morphological features and statistical findings that were not revealed by taking measurements from thirty-two distinct anatomical points of Aksaray Malakli dog skull bones were determined in accordance with the literature.

Results: Processus zygomaticus was found to be long and pointed in the Aksaray Malakli dogs. The morphometric analysis results, facial index value $107.68 \pm 4.98$, nasal index value $19.61 \pm 3.25$, cranial index value $56.17 \pm 2.52$, basal index value
30.57 ± 1.30, skull index 54.68 ± 3.01, palatal index I value 56.76 ± 1.89 in Aksaray Malakli dog and palatal index II value was calculated as 59.83 ± 2.23.

Conclusions: It can be concluded from the present investigation that the neurocranium length, facial index, cranial index, basal index, skull index, palatal index values were statistically different from other dog breeds.

Key words: neuroanatomy, macroanatomy, morphometric, cranial index

INTRODUCTION

Turkey grown intensively in the region of the dog race Aksaray Malakli dog and the environment is therefore of "Malakli of Aksaray" is called. According to the findings in the genetic studies on dog breeds, it is reported that Mastif type dogs may be a different breed due to their genetic similarity from Akbaş, Kars and Kangal shepherd dogs [2, 3, 4]. Aksaray Malakli dog has a gray-colored, large body and drooping lips in appearance. The paws are bigger and thicker than the Kangal dog, which breeders mostly compare. However, it is reported that it is not preferred in herd management because it is not resistant to cold climate and because of the saggy nature of its lips, it drains the mouth salivates while drinking water and they are tired quickly after the herd [2, 3, 5, 26, 27]. The skull is an important anatomical structure to discern dog breeds and wolves from dogs, plus add refs on wolves. In the skull literature studies, the Carnivors [1, 9, 11, 12, 28], Kangal and Malakli dogs [10, 17, 21], Tarsus Çatalburun dog [18], German wolf dog [19, 20], Gray wolf [14]. It has been found that there are many studies on skull morphology and morphometry in Lynx [7], Red fox [22], Vulpes [25] and Golgen jackal [15]. In our study, the measurements taken from thirty-two anatomical points of Aksaray Malakli dog skull bones were compared with other dog breeds by making statistical calculations in line with the literature information. The results of the examination were compared with other carnivores. Significant differences were detected.

The aim of this study is to study Aksaray Malakli dog skulls morphometrically in detail. By doing so we hope to contribute to the international morphology database on dog breeds.
MATERIALS AND METHODS

Sample collection and processing

The skulls of nine Aksaray Malakli dogs, aged 4-5 years old, regardless of the difference in weight and gender, that had died of various reasons at the Veterinary Health and Practice and Research Center of Aksaray University Veterinary Faculty between 2015-2019, were used in this study.

Skulls were harvested and cleaned according to a standard protocol [13, 24]. In short this protocol consisted of boiling the skinned skull in 5-10% NaHCO₃ for 1 day, cleaned from soft tissue manually thereafter, then immersed in a 10% hydrogen peroxide solution for 2-3 days. Skulls were prepared for measurements after maceration [24].

Morphometry

In the literature examinations made about skull measurements, Simoens et al. [23] Peking dog, Onar [19] German wolf dog, Onar et al. [21] Kangal dog reported measurement locations and methods were applied. Of the forty-four measurement points reported in the literature [23, 19, 20] thirty-two measurement points that are prominent in the Aksaray Malakli dog were selected. Thirty two measurements were made with a digital caliper [A Brand, 200 mL, Germany]. Seven index ratios were calculated. In the calculations, the calculation methods in the Kangal dog morphometry study in the literature [21] were applied. One measurement was taken from each skull [Fig 1-4]. In the measurements, the average of both sides of the skull was taken. Images were taken with a camera [Canon CE500]. The nomenclature used in this study is according to Nomina Anatomica Veterinaria [16].

Statistical analysis

Statistical significance of skull measurements was evaluated. Correlation test was used to determine whether there is a relationship between the variables and if so, in which direction and to what extent. The mean, standard deviation and correlation values of all measurements obtained were determined in the SPSS [18.0] version program [6].
RESULTS

According to the macroanatomical findings of the Aksaray Malaklı dog skull, the os frontale and os parietale bones, which are prominent in the dorsal, were the main parts of the os temporale bone skull, which is located in the lateral state. It was deep and prominent to the foramen infraorbital towards cranial Tuber faciale structure was not apparent. Processus zygomaticus Aksaray Malaklı dog was found to be tall and sharp. It was determined that the foramen magnum of os occipitale was surrounded by oval and condylus occipitalis, and the processus jugularis were curved towards the ventral. A thick arcus zygomaticus was prominent on the sides of the Ossa cranii (Fig. 1-2). In the craniofacial index findings of the Aksaray Malaklı dog skull, the relevant mean and standard deviation values are shown in Table 1. Facial index value 107.68 ± 4.98, nasal index value 19.61 ± 3.25, cranial index value 56.17 ± 2.52, basal index value 30.57 ± 1.30, skull index 54.68 ± 3.01, palatal index I value 56.76 ± 1.89 in Aksaray Malaklı dog and the palatal index II value was calculated as 59.83 ± 2.23. In the study, the average and standard deviation values of the Aksaray Malaklı dog's skull are shown in Table 2. (Fig.1, Table 2).

Condylar length of Aksaray Malaklı dog 227.03 ± 12.63 mm, basal length 214.80 ± 10.93, neurocranium length 139.43 ± 3.37 mm, upper neurocranium length 67.66 ± 13.54 mm, facial length 154.76 ± 18.48 mm, height of the foramen magnum 20.09 ± 2.05. The Greatest inner height of the orbit height was measured as 37.16 ± 1.60 mm [Table 1]. (Fig.2, Table 2).

According to the correlation analysis findings of the Aksaray Malaklı dog skull measurements, the length is between pl and cbl, ssl, fcl, fabo, bl, ssl, fcl, length between cbl and bl, unl and fabo, length bl to fabo, length pmp and opl there was a very strong positive correlation between length fcl and fabo length, length nl and lmr length, and length gbap and length infl. On the other hand, it was found that there is a strong negative correlation between length ssl and pmp length [Table 3].

DISCUSSION

Atalar et al. [1] reported that the dorsal part of the neurocranium, which forms the skull, consists of os frontale and os parietale bones in wolves and foxes, and the lateral
part of the os temporal bone. Similar findings were detected in the Aksaray Malakli dog.

Karan et al. [11, 12] reported that foramen infraorbitale was shaped narrow and oval in dogs, and tuber faciale was absent. The study material was deep and prominent in foramen infraorbital in Aksaray Malakli dog, similar to the literature, tuber faciale could not be detected.

In the study, the facial index of the Aksaray Malakli dog was found to be 107.68 ± 4.98. The facial index was reviewed in literature reviews in Collie [8, 21] and Russian Wolfhound [8, 21] dogs 81, German shepherd [8, 21], Beagle [8, 21] and Setter [8, 21] dogs were identified as 111, Boston Terrier [8, 21] and Pekingese dogs [8, 21] were 215. The facial index of Aksaray Malakli dog according to index values is Collie [8, 21], Russian Wolfhound [8, 21], German shepherd [8, 21], Beagle [8, 21] and Setter [8, 21] was higher than dogs, lower than Boston Terrier [8, 21] and Pekingese [8, 21] dogs.

In our study, the cranial index value of Aksaray Malakli dog was 56.17 ± 2.52. Collie and Russian Wolfhound reported 48 dogs in dogs, 57 dogs in German shepherd, Beagle and Setter dogs, and 81 dogs in Boston Terrier and Pekingese dogs [8, 21]. It was calculated as 73.24 in German wolf dog [20] and 71.28 in Golgen jackal [15]. Cranial index value of Aksaray Malakli dog was higher than Collie [8, 21] and Russian Wolfhound [8, 21] dogs, German wolf dog [19], Golgen Jackal [15], German shepherd [8, 21], Beagle [8, 21]. It was observed to be lower than Setter [8, 21], Boston Terrier [8, 21] and Pekingese [8, 21] dogs.

Khosravi et al. [14] reported basal index value in gray wolf is 60.56 ± 3.99, cranial index value is 60.66 ± 2.94, Onar et al. [22] evaluated basal index value as 37.75 and 35.34, and cranial index value as 62.37 and 57.92 in Red Foxes. It was observed that the basal index value was 30.57 ± 1.30, the cranial index value was 56.17 ± 2.52, lower than Gray Wolf [14] and Red Fox [22] in our Aksaray Malakli dog.

Onar et al. [21] reported the skull index value as 64.00 in Husky du Labrador dog, 63.00 in Pointer dog, 60.17 in St Bernard dog, Khosravi et al. [2012] 53.13 ± 3.35 in Gray wolf. In another study, it was reported that Red Foxes [22] were calculated as 52.52 and 52.53. The skull index value of Aksaray Malakli dog was found to be 54.68
± 3.01 higher than Gray Wolf [14] and Red Fox [22] while it was lower than Husky du Labrador dog, Pointer dog and St Bernard dog [21].

Onar et al. [22] evaluated the palatal index I value as 56.52 and 54.11, and the palatal index II value as 57.95 and 55.10 in their study in Red Foxes. The palatal index I value of Aksaray Malakli dog was 56.76 ± 1.89, and the palatal index II value was 59.83 ± 2.23 higher than the Red Foxes.

In the literature studies, while condylobasal length measurement was reported as 215.76 ± 12.22 in Gray wolf [14], basal length measurement was 206.79 ± 11.13 mm, in this study, condylobasal length of Aksaray Malakli dog was 227.03 ± 12.63 mm and basal length value was 214.80 ± 10. Has been found to be 93. According to these evaluations, the condylobasal length and basal length of Aksaray Malakli dog was longer than Gray Wolf [14].

In the study, the length of neurocranium length in Aksaray Malakli dog was determined as 139.43 ± 3.37 mm. This measurement value was reported to be 74.21 ± 8.91 in Gray wolf [14]. According to the measurement values, it was determined that the length of neurocranium length of Aksaray Malakli dog was longer than Gray wolf [14].

In the skulls of the Aksaray Malakli dog skulls examined, the upper neurocranium length was 67.66 ± 13.54 mm. In the literature studies, upper neurocranium length measurement was reported to be 58.56 ± 5.99 mm in Gray wolf [14]. Our investigation material revealed that Aksaray Malakli dog’s upper neurocranium length is longer than Gray wolf [14].

İlgün and Özkan [10] reported greatest inner height of the orbit height as 31.06 ± 1.15 mm in Kangal dog. In our research material Aksaray Malakli dog, this height was measured as 37.16 ± 1.60 mm. According to the measurement values, the Greatest inner height of the orbit height of the Aksaray Malakli dog was longer than the Kangal dog [10].

In our study, the height of the foramen magnum of Aksaray Malakli dog was measured as 20.09 ± 2.05 mm. In the İlgün and Özkan [10] Kangal dog, the height of the foramen magnum height is reported as 24.86 ± 0.59 mm. The height of the
foramen magnum of Aksaray Malakli dog was found to be shorter than the Kangal dog.

CONCLUSIONS

According to the results of the study, it is thought that the skull measurements and index calculations of Aksaray Malakli dog will contribute to the creation of a databank in racial discrimination. It is also thought to provide resources for disciplines working in different disciplines such as Anatomy, Morphology, Osteo-archeology and can be used in determining the taxonomic classification of carnivorous species. However, it was concluded that more sample studies are needed to obtain more absolute data in the relationships between statistical parameters.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest among the authors.

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Table 1. Craniofacial indices of Aksaray Malaklı dog skulls (n = 9)

| Akmlk | Facial index mean±SD | Nasal index mean±SD | Cranial index mean±SD | Basal index mean±SD | Skull index mean±SD | Palatal index1 mean±SD | Palatal index2 mean±SD |
|--------|---------------------|---------------------|----------------------|---------------------|---------------------|------------------------|------------------------|
|        | 107.68±4.98         | 19.61±3.25          | 56.17±2.52           | 30.57±1.30          | 54.68±3.01          | 56.76±1.89             | 59.83±2.23             |

**Facial index:** maximum zygomatic width x 100/viscerocranial length, **Nasal index:** greatest breadth across the nasals x 100/ greatest length of the nasals, **Cranial index:** maximum width of the neurocranium x 100/cranial length, **Basal index:** maximum width of neurocranium x100/basal length, **Skull index:** maximum zygomatic width x 100/skull leng, **Palatal index-1:** greatest breadth of the palate 100/median palatal length, **Palatal index-2:** greatest breadth of the palate 100/palatal length.

Table 2. Of 32 morphometric parameters in Aksaray Malaklı dog skulls (mean ± SD)(n=9).

| Akmlk | Parameters | Mean±SD |
|--------|------------|---------|
|        | pl         | 245.78±15.35 |
|        | cbl        | 227.03±12.63  |
|        | bl         | 214.80±10.93  |
|        | ssl        | 143.95±22.38  |
|        | pmp        | 69.17±14.18   |
|        | nl         | 139.43±3.37   |
|        | vl         | 114.39±3.93   |
|        | mfl        | 135.06±12.55  |
|        | unl        | 67.66±13.54   |
|        | fcl        | 154.76±18.48  |
|        | ais        | 177.65±8.34   |
|        | glf        | 40.95±3.79    |
|        | gln        | 85.74±5.49    |
|        | slfl       | 115.67±4.68   |
|        | fabo       | 158.95±7.29   |
|        | del        | 117.00±5.97   |

Table 3. Correlation values of different skull measurements in the Aksaray Malaklı dog (n=9; *p<0.05, **p<0.01, ***p<0.001)
| pl  | cbl  | 0.948*** | bl  | ssl  | 0.852* | mfl  | unl  | 0.840* | fcl  | ais  | 0.890** |
|-----|------|----------|-----|------|--------|------|------|--------|------|------|----------|
| bl  | 0.956*** | vl  | 0.779* | fcl  | 0.916** | fabo | 0.970*** |     |      |          |          |
| ssl  | 0.962*** | mfl  | 0.814* | ais  | 0.972*** | del  | 0.765* |      |      |          |          |
| pmp  | -0.784* | unl  | 0.914** | fabo | 0.853* | op1  | -0.784* |     |      |          |          |
| mfl  | 0.927**  | fcl  | 0.949** | op1  | -0.874** | giho | 0.904** |      |      |          |          |
| unl  | 0.919** | ais  | 0.822* | giho | 0.788* | gmb  | 0.904** |      |      |          |          |
| fcl  | 0.994*** | gln  | -0.779* | gmb  | 0.763* | gbc  | 0.891** |      |      |          |          |
| ais  | 0.907** | fabo | 0.949*** | ais  | 0.850* | gbfm | 0.793** |      |      |          |          |
| gln  | -0.786* | del  | 0.904** | op1  | -0.817* | gbp  | 0.787* | fi1  |      |          |          |
| fabo | 0.972*** | giho | 0.943** | gmb  | 0.771* | gbfm | 0.846** |     |      |          |          |
| del  | 0.777* | gmb  | 0.955** | gmb  | 0.770* | gbfm | hfm  | 0.829* | fi1  |      |          |
| opl  | -0.795* | gbc  | 0.931** | gln  | fabo  | -0.794* |      |      |          |          |
| giho | 0.888** | gbp  | 0.899** | gncb | -0.849* | infl  | 0.757* |      |      |          |          |
| gmb  | 0.901** | gbfm | 0.789* | gbp  | -0.822* | del  | lcr  | 0.901** |      |      |          |
| gbc  | 0.872* | gbp  | 0.796** | slf1 | lcr   | 0.755* | lpr  | 0.822* |      |      |          |
| gbfm | 0.790* | infl | 0.873** | lpr  | 0.797* | giho | 0.853** |      |      |          |          |
| gbp  | 0.779* | pmp  | 0.834* | grpb | 0.901*** | gmb  | 0.856** |      |      |          |          |
| infl | 0.863* | mfl  | -0.782* | fabo | 0.810** | gbfm | 0.782* |      |      |          |          |
| cbl  | 0.980*** | fcl  | -0.771* | giho | 0.853* | gbp  | 0.848** |      |      |          |          |
| ssl  | 0.850* | opl  | 0.963*** | gmb  | 0.846* | gbp  | 0.773** |      |      |          |          |
| vl  | 0.838* | llp  | 0.926** | gbc  | 0.897* | infl  | 0.791* |      |      |          |          |
| mfl  | 0.822* | lmr  | 0.912** | gbp  | 0.763* | nl  | opl  | 0.784* |      |      |          |          |
| unl  | 0.966*** | hfm  | -0.824* | gbp  | 0.840* | llp  | 0.862* |      |      |          |          |
| fcl  | 0.955** | ssl  | 0.920** | infl  | 0.886** | lmr  | 0.982*** |      |      |          |          |
| ais  | 0.836* | mfl  | 0.912** | lpr  | 0.759* | vl  | unl  | 0.763* |      |      |          |          |
| fabo | 0.966*** | unl  | 0.858* | gbc  | 0.797* | fcl  | 0.802* |      |      |          |          |
| del  | 0.905** | Fcl  | 0.955** | lbo  | 0.767* | lcr  | 0.840* |      |      |          |          |
| lcr  | 0.823* | ais  | 0.882** | gbp  | 0.847* | lpr  | 0.887** |      |      |          |          |
| lpr  | 0.819* | gln  | -0.802* | infl  | 0.891** | giho | 0.879** |      |      |          |          |
| giho | 0.945** | fabo | 0.939** | grpb | 0.759* | gmb  | 0.841* |      |      |          |          |
| gmb  | 0.915** | opl  | -0.905** | giho | 0.947*** | gbc  | 0.812* |      |      |          |          |
| gbc  | 0.925** | lmr  | -0.755* | gbc  | 0.910* | infl  | 0.886** |      |      |          |          |
| gbp  | 0.837* | gmb  | 0.781* | gbp  | 0.859* | llp  | lmr  | 0.935** |      |      |          |          |
| gbap | 0.816* | gbc  | 0.771* | infl  | 0.814* | hnmf | gncb | 0.843* |      |      |          |          |
| infl | 0.898** | hfm  | 0.762* | gbc  | 0.889** | gncb | gbp  | 0.756* |      |      |          |          |
| lcr  | 0.937** | gbap | 0.779* | gbo  | 0.866* | lbo  | gbp  | 0.862* |      |      |          |          |
| giho | 0.797* | infl | 0.827* | gbfm | 0.869* | gbap | infl  | 0.953*** |      |      |          |          |
| infl | 0.773* | opl  | lhp  | 0.989** | gbo  | 0.762* |      |      |      |          |          |
| grpb | 0.760* | lmr  | 0.877** | infl  | 0.877** |      |      |      |      |          |          |
**Figure 1.** Measurements of the skull of Aksaray Malaklı dog (I. ventral view, II. caudal view).

**Figure 2.** Measurements of the skull of Aksaray Malaklı dog (III.lateral view, IV.dorsal view). **Akmlk:** Aksaray Malaklı dog, **pl:** Profile length, **cbl:** Condylobasal length, **bl:** Basal length, **ssl:** Short skull length, **pmp:** Premolare – prosthion, **nl:** Neurocranium length, **vl:** Viscerocranium length, **mfl:** Median frontal length, **unl:** Upper neurocranium length, **fcl:** Facial length, **ais:** Akrokranion-infraorbitale of one side, **gll:** Greatest length of the lacrimal, **gln:** Greatest length of the nasals, **slfl:** Short lateral facial length, **fabo:** From the aboral border of one occipital condyle to the infraorbitale of the same side, **del:** Dental length, **opl:** Oral palatal length, **llp:** Lateral length of the premaxilla, **lcr:** Length of the cheektooth row (measured along the alveoli), **lmr:** Length of the molar row (measured along the alveoli on the buccal side), **lpr:** Length of the premolar row (measured along the alveoli on the buccal side), **giho:** Greatest inner height of the orbit, **gmb:** Greatest mastoid breadth, **gbc:** Greatest breadth of the occipital condyles, **gbp:** Greatest breadth at the bases of the paraoccipital processes, **gbfm:** Greatest breadth of the foramen magnum, **hfm:** Height of the foramen magnum, **gncb:** Greatest neurocranium breadth, **lbbo:** Least breadth between the orbits, **gbap:** Greatest breadth across the premaxillae, **infl:** Distance between two infraorbitals, **grpb:** Greatest palatal breadth.
