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Analysis of the sexual dimorphism in the basioccipital portion of the dog's skull

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Abstract. Sexual differences in the basioccipital portion of the skull of dogs have been described and an index is presented which reliably predicts the sex of the skull. 92 dolichocephalic skulls (44 male, 48 female) from mongrel dogs were used. In the basioccipital region of the male skulls, a triangular area, which extends from the basion to a line joining the medialmost points of the two jugular foramina, appears narrow and elevated. The pharyngeal tubercle is also prominent. In female skulls the rostral angle of this triangle is wider and the triangular area seems smoother and flat. The anterior half of the female basioccipital portion is wider and smoother than in the male skull.

In order to quantify the observed differences, four indices were calculated. All of the indices were statistically significant. However, only index IV could be reliably used in predicting the sex of an unknown skull:

$$\text{Index IV} = \frac{\text{breadth IV} \times 100}{\text{length II}}$$

was derived from breadth IV (distance between the two temporo-occipital fissures at their lateralmost points) and length II (distance between the basion and a line drawn between the two medialmost points of the jugular foramina in the midline). Values of less than 123 for male and greater than 136 for female placed the skulls in their proper sex group. Skulls that had intermediate values could be placed in correct sex grouping only in conjunction with strong observational criteria. It is suggested that in absence of such strong observational criteria these skulls may belong to immature or castrate animals.

Introduction

Sexual differences in bony structures have served as a valuable tool in anthropologic, anatomic and forensic investigations. Thus, sexual dimorphism in isolated bones has received some attention in recent studies on pelvis [*Gingerich*, 1972; *Leutenegger*, 1973, femora [*Singh and Singh*, 1974], hand and wrist bones [*Thompson et al.*, 1973] and skulls [*Giles and Elliot*, 1963]. In a recent study, *The and Trouth* [1976] described sexual dimorphism in the basilar part of the skull in dogs. However, their attempt to quantify the sexual differences did not yield significant results.

Recent attempts at sexing the cranium have shown considerable variation. The discrepancy has been due to the classification of bones on the basis of purely observational criteria, which is subjective and thus inherently unreliable. Relative measurements provide a more objective approach toward establishing sex differences in the skull. *Giles and Elliot* [1963] found discriminant functional analysis quite useful. However, such an analysis is not always feasible due to the paucity of known sex material.

In the present communication, sexual dimorphism in the basioccipital region of the dog's skull will be reexamined with the aid of relative measurements as well as nonmetric criteria.

Materials and methods

Skulls from 44 male and 48 female adult mongrel dogs were used. This collection was of known sex. Skulls from castrate animals were excluded from this study. The following measurements and calculations of relative indices were made:

Length I	distance between the basion and basioccipital-basisphenoid junction along the midline
Length II	distance between the basion and a line drawn between the two medialmost points of the jugular foramina, in the midline
Breadth I	distance between the two occipital condyles at their lateralmost points
Breadth II	distance between the two jugular foramina at their medialmost points
Breadth III	distance between the lateralmost points of the basioccipital and basisphenoid junction
Breadth IV	distance between the two temporo-occipital fissures at their lateralmost points

$$\text{Index I} = \frac{\text{breadth I} \times 100}{\text{length I}}$$

$$\text{Index II} = \frac{\text{breadth II} \times 100}{\text{length I}}$$

$$\text{Index III} = \frac{\text{breadth III} \times 100}{\text{length I}}$$

$$\text{Index IV} = \frac{\text{breadth IV} \times 100}{\text{length II}}$$

Results and Discussion

All of the skulls used were determined to be of the dolichocephalic type on the basis of the craniofacial index and it was noted that male skulls were generally somewhat larger than female ones [*The and Trouth,* 1976]. A brief description of the basioccipital region and its sexual characteristics is presented below.

The basilar part of the occipital bone extends from the foramen magnum behind, to the junction of the basioccipital with the basisphenoid in front. In the young skull, this spheno-occipital synchondrosis is still present, but in older skulls ossification has already taken place making this boundary almost indistinguishable in many instances.

The oval occipital condyles which are located at the inferiolateral border of the foramen magnum is joined by a broad, flat elevated ridge of bone which gives the appearance of being an anterior extension of the occipital condyles. These bilateral ridges form a triangular elevation at the posterior two-thirds of the inferior surface of the basioccipital. The anteriorly directed apex of the triangle is open toward the midline, whereas the posteriorly located base is deeply indented by the foramen magnum. This rough triangular area serves as the medial attachment of the musculi longi capitis et recti capitis ventrales and encloses at its upper one third, along the median line, an elevation of variable prominence – the pharyngeal tubercle. The median line may be prominent forming a ridge which proceeds forwards to about two thirds the

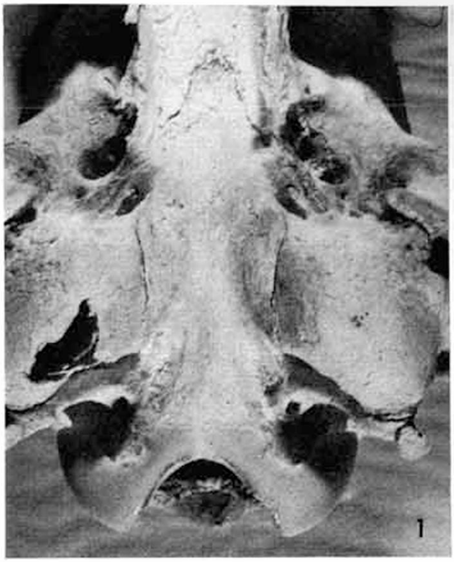

Fig. 1. Basioccipital region of a male dog, type A.

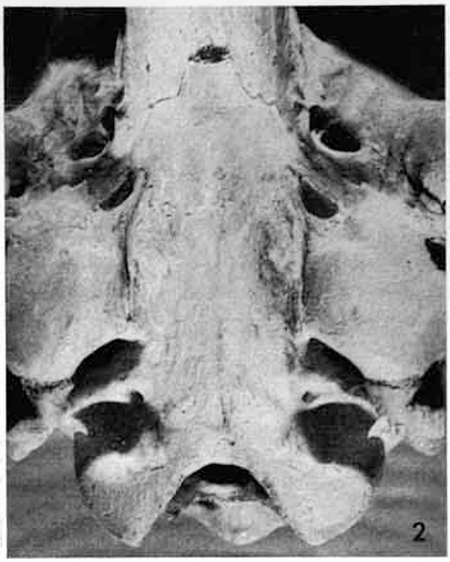

Fig. 2. Basioccipital region of a female dog, type B.

length of the basioccipital, then bifurcates enclosing between its lateral arms a small triangle. The lateral arms of this triangle are reflected backwards at the spheno-occipital junction, and are attached laterally to the temporal bone to form the medial lips of the temporo-occipital fissures.

In the present study it is convenient to subdivide the basioccipital into two parts – a posterior and an anterior portion.

(1) The posterior portion contains the larger triangular area for attachment of the musculi longi capitis et recti capitis ventrales, extends from the level of the basion to the level of the line joining the most medial points of the right and left jugular foramina. Sexual differences in this area may be grouped into three types:

Type A: The two sides enclosing the large triangular area nearly meet at the median line just beyond the middle of the basioccipital. The triangular area is elevated, appears narrow, and the median ridge is prominent. This type is mostly found in male skulls (fig. 1).

Type B: The two sides of the large triangular area are wider apart at the apex. The triangular area itself appears broader and is less elevated, being in some instances barely distinguishable. The median ridge may also appear slight and smooth. This type is mostly found in female skulls (fig. 2).

Type AB: These skulls exhibit characteristics typical to both A and B type skulls.

(2) The anterior portion extends from the level of the line joining the medial tips of the left and right jugular foramen to the spheno-occipital junction, is bounded laterally by the left and right temporo-basioccipital fissures. The female skull appears broader in this half, and the ridges are usually less prominent and smoother than in the male skull.

This difference has acquired much significance for researchers working on the ventro-

Table I. Length and breadth measurements (mean and standard deviation in millimeters) of basioccipital in dog skulls

	Length		Breadth			
	I	II	I	II[1]	III[1]	IV[1]
Male	28.0 ± 1.7	14.0 ± 09	36.3 ± 1.4	16.4 ± 1.4	15.3 ± 1.4	16.4 ± 1.2
Female	27.1 ± 1.7	13.6 ± 08	36.4 ± 2.7	17.4 ± 1.2	16.5 ± 1.3	19.4 ± 1.2

[1] Statistically significant (< 0.001) between male and female.

Table II. Basioccipital indices in dog skulls

	Index[1]			
	I	II	III	IV
Male	129.7 ± 6.2	58.7 ± 4.2	54.8 ± 5.4	117.2 ± 11.5
Female	134.3 ± 5.5	64.2 ± 5.6	61.1 ± 4.9	142.9 ± 13.6

[1] All indices show statistically significant (< 0.001) sexual dimorphism.

lateral regions of the medulla oblongata via the ventral approach where accessibility of more laterally located structures is essential.

In our previous study, we indicated our difficulty in categorizing the skulls of castrates into male and female types appropriate to their genitalia. *Sicher and DuBrul* [1970] observed that sex differences of the skull are mainly due to the functional state of the musculature during growth and development. However, *Crelin* [1960] demonstrated that sexual dimorphism in the pelvis occurred even in the absence of the functional pelvic musculature. Sexual differences could not be established in the pelvis prior to puberty [*Morton*, 1942; *Crelin*, 1960] and the female-type pelvis was consistently observed following gonadectomy [*Crelin*, 1960; *Bernstein and Crelin*, 1967]. Only in the presence of androgen the male-type pelvis was formed. The adrenal steroids coulp well play a role especially in castrates in the elaboration of sexual characteristics of bones. Furthermore, it would appear that the age at which desexing was performed could be a factor in determining the final form of the bone.

Measurements and analysis

The six measurements chosen to quantitate sexual differences in the basioccipital region are summarized in table I. Length I and II and breadth I showed little or no significant statistical difference between male and female, while breadths II–IV showed significant ($p < 0.001$) sexual differences. The width of the basioccipital, which was visually found to be greater in the female than male, did show statistical difference while the length did not.

This suggests that the fundamental sexual difference is one of breadth.

In order to sex crania which differ in size, since the width varies with size, the indices I–IV were calculated. They are summarized in table II. All of these indices showed statistical significance ($p < 0.001$) and should reliably predict the sexual dimorphism in this part of the cranium.

The mean and standard deviation presented here describe the distribution of our sample. These statistics cannot be expected to be exactly equivalent to the ones of any single skull. The confidence interval (99.9%) in our sample (size 92) was estimated at 0.35 standard deviation on either side of the mean. When individual skulls were examined using one half of standard deviation around the mean, the indices I and II were found not to be reliable. However, index IV, due to the large variance between the sexes, was highly reliable. Index IV values of < 123 for male and > 136 for females placed 82% of the skulls in correct sex grouping. The remaining 18% were placed in their correct sex group with the use of observational criteria. However, when a skull falls between the two values and does not have strong observational criteria, it could be assumed to come from an immature or castrate animal.

It was noted that length II was roughly half of the length I, therefore, in cases where the complete basioccipital region is not available (e.g. when one edge of the foramen magnum is chipped), one could reliably substitute the distance between the basioccipital-basiphenoid junction and a line drawn between the two medialmost points of the jugular foramina along the midline for length II. One could also double the distance between the lateralmost point of the temporo-occipital fissure and midline and use as breadth IV. This further increases the usefulness of this index.

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