

The Morphometrics and Typology of the Skull in the Ghanaian Local Dog of Non-Descript Breed (*Canis lupus familiaris*)

Morfometría y Tipología del Cráneo en el Perro Local de Ghana de Raza no Definida (*Canis lupus familiaris*)

Opoku-Agyemang, T.¹; Essel Cobbinah, D.¹; Sia, D.D.²; Mukundane Springs S.²; Folitse R. D.² & Emikpe B.O.²

OPOKU-AGYEMANG, T.; ESSEL COBBINAH, D.; SIA, D. D.; MUKUNDANE SPRINGS, S.; FOLITSE, R. D. & EMIKPE, B. O. The morphometrics and typology of the skull in the Ghanaian local dog of non-descript breed (*Canis lupus familiaris*). *Int. J. Morphol.*, 38(3):706-713, 2020.

SUMMARY: The shape of the head is considered the most important criterion in determining the standard breeds of dogs. It is of much significance to study the skull typology of the Ghanaian local dog in order to establish a template of its identification as a breed and to generate data which could be useful in the comparative anatomy of the skulls of dogs. A total of twenty skulls of adult dogs of two age groups were used in this study. 31 parameters were measured and 6 skull indices were calculated on their basis. The group of skulls from older fully grown dogs showed higher values in all parameters. Results of the current study will provide baseline reference data on skull parameters of local dolichocephalic dogs. More importantly, results obtained could be useful in veterinary applied anatomy and clinical practice in areas including forensic medicine, plastic or cosmetic maxillofacial surgery, neurosurgery of the cranium, acupuncture, nerve block and other clinical manipulations involving the head.

KEY WORDS: Ghanaian local dog of non-descript breed (GLND); Skull; Morphometrical study; Indices; Suture closure.

INTRODUCTION

In the many ways of exploitation of animals by man, relationship with the dog is markedly of special significance for several reasons. The dog, popularly referred to as “man’s best friend”, is regarded as the first animal to be domesticated (about 12000 B.C.), as evidenced by drawings in caves of ancient man (Mark, 2019). This may be due to the dog’s easy satisfaction of the major criteria for domestication including availability of diet, size, growth rate, happiness to breed in captivity, pleasant disposition, and unlikely to panic. Man has since used dogs for many purposes including as pets and companions, guards and guides, in security and law enforcement, hunting, warfare, transport, sports, entertainment, etc. Humans have over history continuously transformed dogs to fulfill the desired of these different functions; and breeding has affected the development and characteristics of progeny. (Scott & Fuller, 1974). The various methods of breeding including cross-breeding, in-breeding, line-breeding and selective breeding have in different ways not only produced progeny of different levels at risk of health related problems and vulnerable to genetic

defects and diseases. These methods, especially selective breeding, also impacts on both morphology and behavior. Selective breeding of dogs has modified their size and their shape dramatically so that the more than 400 recorded breeds of dogs are easily recognizable based on their physical characteristics (Adams, 2008). The shape of the skull in dogs shows considerable breed and individual variation in form and size (Sisson *et al.*, 1975). It also appears that there is some correlation between a dog’s head shape and the functions that they perform for humans; for example the sighthounds (who pursue game over open ground) tend to have long narrow heads, while many of the guarding breeds tend to have more square-shaped heads.

The Ghanaian local dogs of nondescript breed (GLND), hereinafter GLND, are predominantly long-headed (apparently dolichocephalic) dogs with mostly light brown, brown-and-white or black-and-white colour; and are assumed to have been originally influenced by Basenji breed.

¹Department of Anatomy and Physiology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

²Department of Pathobiology, School of Veterinary Medicine (SVM), Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

Environmental conditions are known to influence the development of the mammalian body, including the shape of the head. This has been proven even in humans where studies of the children of immigrants to the United States in 1910 to 1912 showed that the children's cephalic index differed significantly from their parents', implying that local environmental conditions had a significant impact on the development of head shape (Boas, 1910, 1912).

There is the absence of research report on the morphology of the skull of local dogs in Ghana. It is, therefore, actual to study the morphometric characteristics of the skull of local dogs in Ghana to establish amongst other things the typology and predominant features.

The current study was carried out to investigate the skull morphometry in the Ghanaian local dog with the aim of generating information useful in breed identification, clinical manipulations involving the head of dogs as well as in the comparative anatomy of the skull of dogs.

MATERIAL AND METHOD

The current study was conducted, in the Department of Anatomy and Physiology, School of Veterinary Medicine (SVM), Kwame Nkrumah University of Science and Technology (KNUST), on the skulls of twenty (20) dogs, without any apparent skeletal disorders, selected from amongst animals specially procured for practical studies in the Department of Anatomy and Physiology, SVM, KNUST. The selected dogs originated from rural areas of different parts of the country; with minimal probability of cross-breeding with foreign dog breeds. Ethical approval for the study was obtained from the Animal Research Ethics Committee (AREC), KNUST

The animals used were in two age groups of ten each: In the first group were dogs of about 2 years whilst the second group was made up of dogs of 5 years or older. The ages of the dogs were ascertained using their dental formula as described by Dyce *et al.* (2002) and Muylle (2019). All the animals were euthanized using intravenous (IV) injection of Sodium Pentobarbital. The head was removed surgically at the atlanto-occipital joint and skinned. The brain tissue was removed from the brain case; and the skull was maximally prepared with scalpel blades and dental instruments before processing. Warm-water maceration method at 35 °C as described by Sullivan *et al.* (1999) was applied for complete removal of soft tissues and anatomical preparation, taking care to avoid shrinkage of the skull.

A total of 37 morphometric values were determined on each skull and linear measurements were made (Igado, 2014) using mathematical dividers, thread, centimeter rule tape and vernier metric electronic digital caliper (accuracy +0.02 mm). Measurements were recorded in centimeters (cm); and photographs of specimen were taken using a digital camera (24.2 - megapixel DX format camera Nikon D3300).

A total of 31 morphometric parameters of basic features and landmarks of the splanchnocranial and neurocranial sections of the skull were measured. All measurements were taken from the left side for consistency. Six craniometric indices were calculated on the basis of morphometric measurements made.

Parameters considered for measurement, physical features and landmarks of the skull used, and indices calculated on the basis of measurements made are described below.

Morphometric parameters and craniometric indices.

The following morphometric parameters of the skull were determined as earlier reported by Brehm *et al.* (1985); Igado (2001); Onar *et al.* (2001); Endo *et al.* (2002); Al-Sagair & ElMougy (2002).

1. Skull weight (SW): Weight of skull
2. Whole Skull Height (WSH): measured as the distance between the most dorsal point of the frontal bone along the sagittal crest and the most ventral level of the mandible.
3. Whole Skull Length (WSL): prosthion to inion - the total length of the skull measured as the distance from the extreme rostral end of the incisive bone to the most caudal aspect of the occipital bone
4. Height of Top Half of Skull (THSH): height of the top section of the skull (without mandible) measured as the distance from the extreme dorsal aspect of the frontal bone to the lowest level of the jugular process.
5. Maximum Skull Width (MZW): width/breadth of the skull measured between the extreme lateral points of the left and right zygomatic bones.
6. Length of Neurocranium (NCL): inion to nasion - Distance along the midline from the nuchal crest to the junction of the left and right nasofrontal sutures;
7. Length of Splanchnocranium (SCL): nasion to prosthion - Distance along the midline from the junction of the left and right naso-frontal sutures to the rostral tip of the incisive bone
8. Length of frontal bone (FBL): measured from the rostral end of the frontal bone, at its suture with the maxillary and nasal bones, to the caudal margin, at the coronal suture with the parietal bone.

9. Length of the nasal bone (NBL1): measured as the distance from the extreme rostral tip of the nasal bone to its caudal edge, at the suture with the frontal bone, along the midline
 10. Length of the nasal bone (NBL2): measured as the distance from the extreme rostral tip of the nasal bone to its caudal edge, at the suture with the frontal bone, along the side
 11. Width of the nasal bone (NBW): Maximum width of the nasal bone;
 12. Length of parietal bone (PrBL): length from the fronto-parietal (coronal) suture to the nuchal eminence.
 13. Length of Hard Palate (HPL): Length of the hard palate measured as the distance along the midline from the caudal end of the palatine bone (rostral edge of the choanae) to the rostral end of the incisive bone.
 14. Maximum Width of the Hard Palate (HPW): Measured as the distance between the lateral edges of the hard palate at its widest portion
 15. Length of Palatine Bone (PIBL): Length of the palate bone measured as the distance from the caudal end of the palatine bone (rostral edge of the choanae) to its suture with the palatine process of the maxillary bone.
 16. Length of Palatine process of Incisive bone (PPiL): measured along the midline from the rostral end of the palate process of the incisive bone to its suture with the rostral edge of the palate process of the maxillary bone.
 17. Length of Palatine process of Maxillary bone (PPmL1): measured along the midline from the rostral edge of the palate process of the maxillary bone to its suture with the palatine bone.
 18. Length of Palatine process of Maxillary bone (PPmL2): maximum length from the rostral edge of the palate process of the maxillary bone to its extreme caudal end at the suture with the palatine bone, measured along the side.
 19. Length of Tympanic bulla (TBL): measured as the distance from the rostral aspect to the caudal aspect of the bulla.
 20. Width of the tympanic bulla (TBW): measured as the distance from the lateral side to the medial side of the bulla. Measurements were taken consistently from the left side.
 21. Orbital vertical diameter (OVD): height of the orbit, measured from the ventral aspect of the orbital rim (at the zygomatic arch) in a vertical line to the dorsal aspect of the rim. Measurements were taken consistently from the left side.
 22. Orbital horizontal diameter (OHD): width of the orbit, measured as the distance from the point of the zygomatic arch in a straight line to the rim of the orbit at the medial canthus. Measurements were taken consistently from the left side.
 23. Inter-orbital width (IOW): measured as the minimum distance between the upper edges of the orbits measured across the tip of the skull;
 24. Inter-canthi distance (ICD): measured as the minimum distance between the medial canthi of the orbits;
 25. Maximum width of the neurocranium (NCW): measured as the distance between the extreme lateral sinistral and dextral points of the neurocranium
 26. Intercondylar width (ICW): Width between the lateral ends of the occipital condyles;
 27. Length of the mandibular bone (MBL): Length of the mandible, measured as the distance from the most rostral point of the body (pogonion) to the caudal limit of the condyloid process.
 28. Maximum width of the mandibular bone (MBW): Width of the mandible measured as the distance between the lateral edges at the widest part of the mandibular rami.
 29. Length of Mandibular symphysis (MSL): Length of the mandibular symphysis, measured as the distance between its rostral and caudal limits;
 30. Foramen magnum height (FMH): Mid-vertical height of the foramen magnum;
 31. Foramen magnum width (FMW): Largest width of the foramen magnum;
 32. Foramen magnum index (FMI): $(FMH \times 100)/FMW$
 33. Orbital index – the ratio of the greatest height of the orbital cavity to its greatest width multiplied by 100 – $Orbital\ height : Orbital\ width - (OVD \times 100)/OHD$
 34. Cephalic (cranial) index – Ratio of the maximum width (biparietal diameter or BPD, side to side) of the head of an organism (human or animal) multiplied by 100 divided by its maximum length (occipitofrontal diameter or OFD, front to back) $Skull\ width : Skull\ length - (MZW \times 100)/WSL$
 35. Nasal index1 (NI1): $(MZW \times 100)/NBL1$
 36. Nasal index2 (NI2): $(MZW \times 100)/NBL2$
 37. Facial index (FI) – Relation of the length of the splanchnocranium to the maximal width between the zygomatic prominences – $(SCL \times 100)/MZW$
- Statistical Analysis.** The data collected were analyzed using SPSS v. 24 and expressed as mean + SD. The student t-test and ANOVA were used for the comparison of the means and a p-value <0.05 was accepted as statistically significant. The Pearson correlation coefficient (R test) was used to compare the means and the strength between the variables and their relationships.

RESULTS

Results are presented in Tables I-VII and Figures 1-6 below. In the study which involved two age groups, most

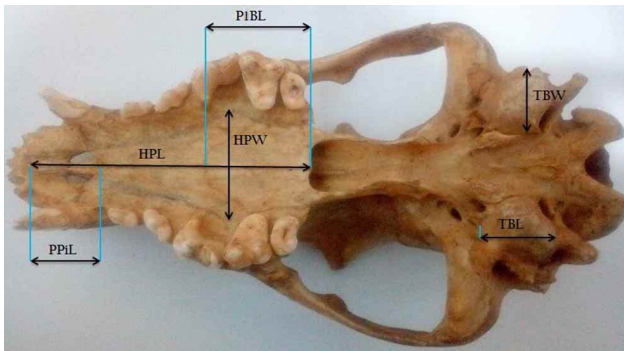


Fig. 1. GLND skull (Group 2). Ventral view of the top half, showing Lengths of hard palate (HPL), palate bone (PIBL), palate process of incisive bone (PPiL), tympanic bulla (TBL), and Widths of the hard palate (HPW) and the tympanic bulla (TPW).

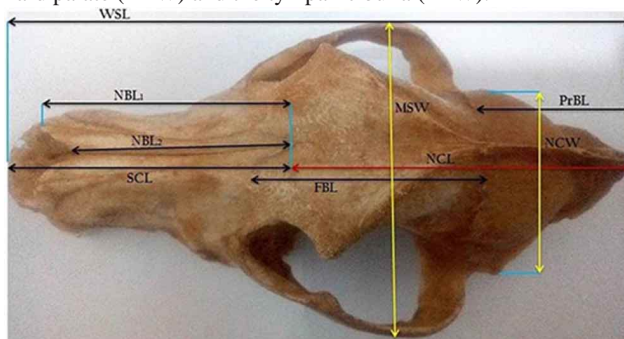


Fig. 2. GLND skull (Group 2). Dorsal view showing Lengths of the skull (WSL), splanchnocranium (SCL), neurocranium (NCL), nasal bone (NBL), frontal bone (FBL), parietal bone (PrBL), and Widths of the whole skull (MSW), and of the neurocranium (NCW).

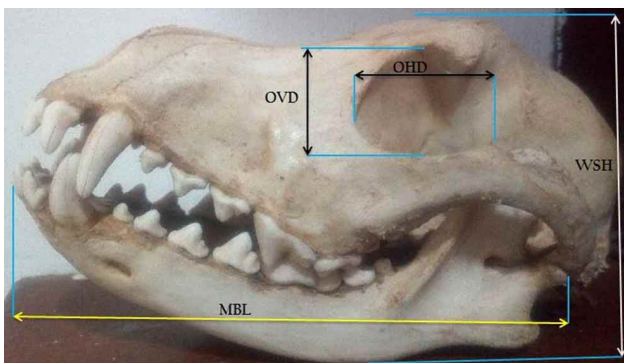


Fig. 3. GLND skull (Group 1). Lateral view showing the height (OVD), and length (OHD) of the orbit, height of skull (WSH), and length of mandible (MBL).

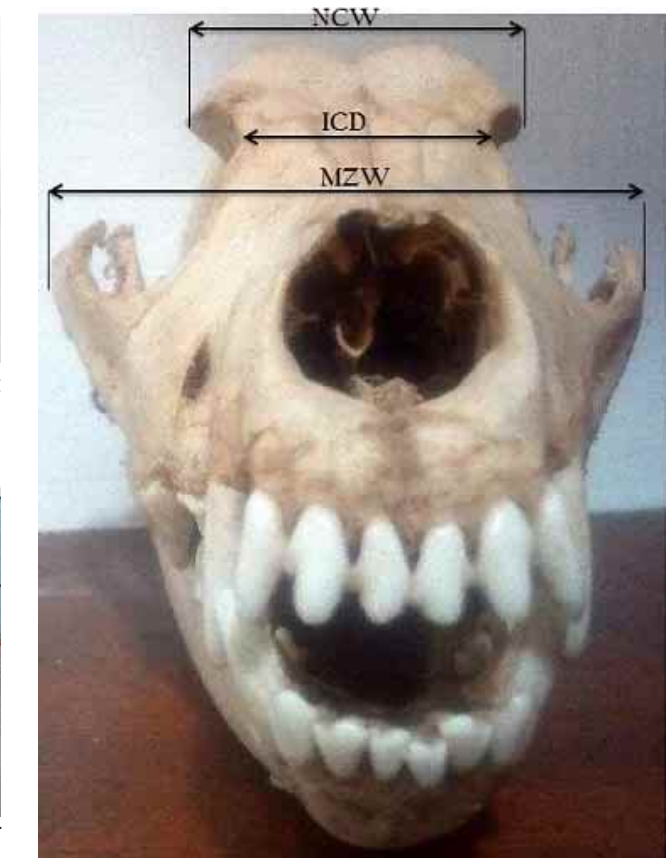
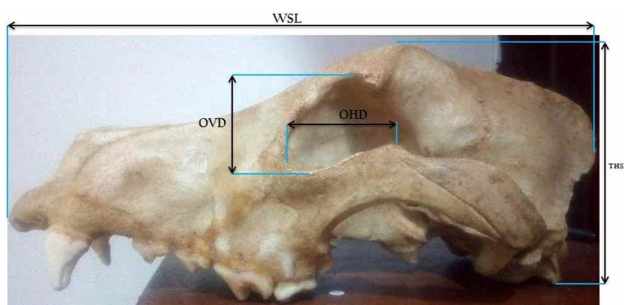


Fig. 5. GLND skull (Group 1). Anterior view showing width of neurocranium (NCW), inter-canthal distance (ICD), zygomatic width (MZW)

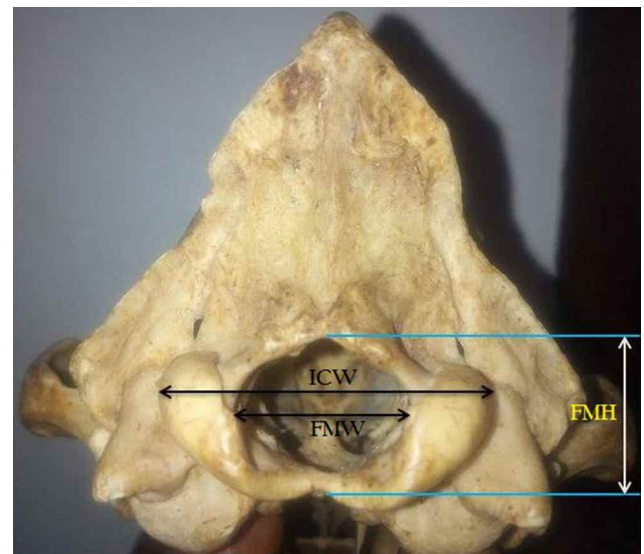


Fig. 6. Posterior view of the GLND skull (Group 2), showing intercondylar width (ICW), height (FMH), and width (FMW) of the foramen magnum.

Fig. 4. GLND skull (Group 2). Lateral view showing the length of skull (WSL), height (OVD), and length (OHD) of the orbit, height of the top half of the skull (THSH).

morphometric parameters of the skull were observed to be higher in Group 2, which had older animals, than in Group 1 (Table I). No statistically significant differences were

registered between the groups. The craniometric indices determined, however, were comparable in both age groups. Correlation of WSL, WSH and MZW with other measured

Table I. Skull measurements of the GLND (*Canis lupus familiaris*) (Mean + Standard deviation).

SN	Parameters (cm)	Group 1 (age approx. 2yrs)	Group 2 (age > 5yrs)
1	SW (g)	132.285 ± 3.902	155.756 ± 2.912
2	WSH	9.091 ± 1.249	12.055 ± 1.493
3	WSL	18.535 ± 1.977	22.847 ± 0.927
4	MZW	8.581 ± 1.168	12.440 ± 0.831
5	THSH	6.078 ± 1.290	8.197 ± 0.578
6	NCL	8.152 ± 1.126	11.890 ± 0.793
7	SCL	8.462 ± 1.225	12.339 ± 1.186
8	FBL	3.924 ± 0.800	7.687 ± 0.629
9	NBL1	5.149 ± 1.003	7.534 ± 0.930
10	NBL2	5.857 ± 1.185	8.483 ± 0.885
11	NBW	1.529 ± 0.220	1.963 ± 0.461
12	PrBL	7.831 ± 1.230	10.663 ± 1.140
13	HPL	4.099 ± 0.824	4.399 ± 0.565
14	HPW	5.251 ± 0.954	6.561 ± 0.686
15	PIBL	3.248 ± 0.718	3.819 ± 0.499
16	PPiL	2.075 ± 0.649	3.334 ± 0.413
17	PPmL1	3.013 ± 0.734	3.893 ± 0.397
18	PPmL2	4.417 ± 0.856	6.538 ± 0.354
19	TBL	1.845 ± 0.453	2.121 ± 0.195
20	TBW	1.734 ± 0.913	2.268 ± 0.345
21	OVD	2.810 ± 0.741	3.487 ± 0.326
22	OHD	2.794 ± 0.670	3.655 ± 0.318
23	IOW	3.845 ± 0.809	5.825 ± 0.682
24	ICD	3.181 ± 0.647	5.903 ± 0.414
25	NCW	5.158 ± 1.206	7.306 ± 0.503
26	ICW	2.938 ± 0.922	4.442 ± 0.382
27	MBL	12.137 ± 1.968	16.858 ± 1.455
28	MBW	7.447 ± 1.605	8.452 ± 0.730
29	MSL	3.290 ± 0.794	3.969 ± 0.454
30	FMH	1.408 ± 0.536	1.724 ± 0.317
31	FMW	1.569 ± 0.623	2.003 ± 0.286
32	Cephalic index (%)	46.294	54.448
33	Facial index (%)	98.614	99.191
34	Nasal index1 (%)	166.647	165.115
35	Nasal index2 (%)	146.510	146.639
36	Orbital index (%)	100.558	95.417
37	Foramen magnum index (%)	89.705	86.072

parameter using Pearson's correlation (R test) showed high values in Group 1 between the three selected (WSL, WSH, MZW) and all other parameters, with the exception of nasal bone width (NBW); whilst in Group 2, only skull length (WSL) and height (WSH) showed high values in comparison with the other parameters.

Correlation between Skull weight (SW) and craniometric indices CI, FI, NI, OI, FMI were evaluated using the Pearson's correlation test. In Group 1, highest values of correlation were recorded between the SW and the nasal indices NI1 and NI2 (Table II).

In Group 2, highest values of correlation with Skull Weight were registered between SW and nasal index (NI), facial index (FI), and the foramen magnum index (FMI) (Table III).

Three major parameters of the skull, namely length (WSL), height (WSH) and width (MZW) were compared with all the other parameters using the Pearson's correlation test. In Group 1, high values of correlation were recorded between WSL, WSH and MZW and all the other parameters, except nasal bone width NBW (Table IV).

Table II. Pearson's Correlation Coefficient values among Skull Weight, Cephalic Index, Facial Index, Nasal Index, Orbital Index and Foramen Magnum Index in adult Ghanaian local dog (GLND). Group 1

	SW	CI	FI	NI ₁	NI ₂	OI	FMI
SW	1	0.5695	0.2146	-0.7847	-0.8518	0.4715	-0.1869
CI	0.5695	1	-0.5724	-0.1783	-0.1600	0.1286	-0.5187
FI	0.2146	-0.5724	1	-0.5508	-0.5912	0.1203	0.1936
NI ₁	-0.7847	-0.1783	-0.5508	1	0.8455	-0.5946	-0.1759
NI ₂	-0.8518	-0.1600	-0.5912	0.8455	1	-0.3184	0.0729
OI	0.4715	0.1286	0.1203	-0.5946	-0.3184	1	0.3143
FMI	-0.1869	-0.5187	0.1936	-0.1759	0.0729	0.3143	1

Table III. Pearson's Correlation Coefficient values among Skull Weight, Cephalic Index, Facial Index, Nasal Index, Orbital Index and Foramen Magnum Index in adult Ghanaian local dog (GLND). Group 2.

	SW	CI	FI	NI ₁	NI ₂	OI	FMI
SW	1	-0.08749	0.71178	-0.67773	-0.77910	0.14420	0.77041
CI	-0.08749	1	-0.59594	0.07244	0.58719	0.17568	-0.35507
FI	0.71178	-0.59594	1	-0.44242	-0.86511	0.07639	0.69382
NI ₁	-0.67773	0.07244	-0.44243	1	0.63713	-0.01570	-0.43336
NI ₂	-0.77910	0.58719	-0.86511	0.63713	1	-0.06588	-0.67296
OI	0.14420	0.17568	0.07639	-0.01570	-0.06588	1	-0.21788
FMI	0.77041	-0.35507	0.69382	-0.43336	-0.67296	-0.21788	1

Table IV. Pearson's Correlation Coefficient values of WSL, WSH and MZW against other parameters of skull morphometry in adult Ghanaian local dog of nondescript breed (GLND). Group 1.

	WSL	WSH	MZW	THSH	NCL	SCL	FBL	NBL ₁	NBL ₂	NBW
WSL	1	0.9840	0.9581	0.9606	0.9081	0.9806	0.9821	0.9644	0.9861	0.4338
WSH	0.9840	1	0.9395	0.9793	0.9372	0.9934	0.9787	0.9692	0.9948	0.5070
MZW	0.9581	0.9395	1	0.9716	0.9098	0.9532	0.9486	0.9611	0.9645	0.4020
	PrBL	HPL	HPW	PIBL	PPiL	PPmL ₁	PPmL ₂	TBL	TBW	OVD
WSL	0.9630	0.9714	0.9651	0.9651	0.9784	0.9735	0.9805	0.8930	0.9510	0.9791
WSH	0.9730	0.9861	0.9828	0.9596	0.9789	0.9858	0.9666	0.9118	0.9377	0.9860
MW	0.9602	0.9566	0.9158	0.8824	0.9624	0.9630	0.9468	0.8972	0.9200	0.9546
	OHD	IOW	ICD	NCW	ICW	MBL	MBW	MSL	FMH	FMW
WSL	0.9730	0.9881	0.9664	0.9786	0.9636	0.9776	0.9525	1.0000	0.9809	0.9630
WSH	0.9903	0.9864	0.9771	0.9778	0.9773	0.9762	0.9679	0.9783	0.9710	0.9723
MZW	0.9621	0.9626	0.9520	0.9778	0.9678	0.9625	0.9166	0.9617	0.9589	0.9691

Table V. Pearson's Correlation Coefficient values of WSL, WSH and MZW against other parameters of skull morphometry in adult Ghanaian local dog of nondescript breed (GLND). Group 2.

	OHD	IOW	ICD	NCW	ICW	MBL	MBW	MSL	FMH	FMW
WSL	0.9041	0.9508	0.9045	0.9143	0.9014	0.9215	0.9568	0.9471	0.9398	0.9105
WSH	0.9528	0.9571	0.9243	0.9952	0.9790	0.9902	0.9660	0.9677	0.9806	0.9655
MZW	0.5120	0.4751	0.4369	0.5784	0.4811	0.5373	0.5357	0.5534	0.4649	0.5352
	HPL	HPW	PrBL	PIBL	PPiL	PPmL ₁	PPmL ₂	TBL	TBW	OVD
WSL	0.9541	0.9148	0.9190	0.8961	0.9250	0.9490	0.8702	0.9399	0.9473	0.9104
WSH	0.9599	0.9561	0.9176	0.9203	0.9724	0.9571	0.8847	0.9438	0.9760	0.9466
MZW	0.4467	0.6035	0.5866	0.4873	0.5362	0.5806	0.4735	0.4584	0.5151	0.5773
	OHD	IOW	ICD	NCW	ICW	MBL	MBW	MSL	FMH	FMW
WSL	0.9041	0.9508	0.9045	0.9143	0.9014	0.9215	0.9568	0.9471	0.9398	0.9105
WSH	0.9528	0.9571	0.9243	0.9952	0.9790	0.9902	0.9660	0.9677	0.9806	0.9655
MZW	0.5120	0.4751	0.4369	0.5784	0.4811	0.5373	0.5357	0.5534	0.4649	0.5352

In Group 2, only skull length (WSL) and skull height (WSH) showed high values of correlation with the other parameters (Table V).

Differences recorded between mean values of craniometric indices of the two groups were not indicative of statistical significance (p-value >0.05) (Table VII).

DISCUSSION

The present study, comprising of thirty seven morphometric parameters and cranial indices, is one of the most comprehensive studies of morphological characteristics of the canine skull; and about the first of its kind in Ghanaian

Table VI. Results of t-Test using all Parameters and Indices.

	<i>132.2853</i>	<i>155.7561</i>
Mean	22.32706677	23.8759753
Variance	1786.292546	1707.12480
Observations	36	3
Pooled Variance	1746.708676	
Hypothesized Mean Difference	0	
Df	70	
t Stat	-0.157235928	
P(T<=t) one-tail	0.437755785	
t Critical one-tail	1.666914479	
P(T<=t) two-tail	0.875511571	
t Critical two-tail	1.994437112	

local dogs of non-descript breed. The study results confirm the GLND as a predominantly dolicocephalic breed; with a Cranial Index of <75.

Of the two lengths measured of the nasal bone, the length along the side was found to be longer than that along the midline i.e. the nasal bone is longer along the side than the midline. The foramen magnum was found to have a greater width than height. The orbits, which are placed in a fronto-lateral oblique plane, showed an inter-canthi distance lesser than the inter-orbital width. The hard palate is broadest in the middle; the width of the hard palate increases caudally from the premolars to reach a maximum at around molar 1, then reduces thereafter i.e. the hard palate and the maxillary bones are observed to be narrower behind and wider in the middle. The palate bone is wider in its anterior portion; the greatest width is observed at the level of molar 1. The palatine process of the maxillary bone has a lesser length along the midline than by the sides. It is wider in its caudal part, the widest portion being observed at the level of the mesial surface of molar 1.

The foramen magnum is ovoid in shape, the horizontal diameter being greater than the vertical; thereby giving a Foramen Index value of <100 %. Common characteristic features of the GLND per the skull samples examined include

a prominent external sagittal crest and a visible fibro-cartilagenous mandibular symphysis which was observed to be non-ossified in samples of Group 1, and completely ossified in those of Group 2.

The external sagittal crest, a bony ridge that runs along the median of the skull, serves the function of attachment for muscles including the m. temporalis – a major masticatory muscle. Strong jaws are known to be characteristic of mesaticephalic and even more in brachycephalic dogs. However, earlier works have also indicated that a prominent sagittal crest may indicate possession of strong jaw muscles (Sisson *et al.*; Dyce *et al.*, 2002). The current study, therefore, shows that the GLND possess very strong masticatory muscles. Such adaptive development could be attributed to the fact that the GLND has, over the generations, been mostly used for hunting in the rural areas of the country.

Cranial sutures and synchondroses are observed to be at varying stages of closure in the two groups, per suture closure scores as described in earlier studies (Rager *et al.*, 2014; Geiger & Haussman, 2016). In Group 1, most fibrous sutures, including incisivo-maxillary, naso-frontal, maxillo-nasal, maxillo-palatine, pterygo-palatine, lacrimo-frontal, as well as the cartilagenous synchondroses including basispheno-presphenoid and basispheno-basioccipital are clearly visible, implying a “closing state”, and the fibrous inter-nasal suture is “open” (Geiger & Haussman). In skulls of Group 2, some of the fibrous sutures, mostly of the splanchnocranium, including the incisivo-maxillary, naso-frontal, maxillo-nasal and maxillo-palatine can still be classified as “closing”. However, the inter-palatine and most of the neurocranial sutures e.g. interfrontal, lacrimo-frontal, fronto-parietal, temporo-parietal are completely obliterated implying a “closed state”. This same (closed state) is observed with the speno-occipital cartilagenous synchondrosis and the fibro-cartilagenous mandibular symphysis. The complete fusion of a particular cranial suture or synchondrosis is known to imply the discontinuation of

Table VII. Results of ANOVA Anova: Single Factor.

SUMMARY						
Groups	Count	Sum	Average	Variance		
132.2853	36	803.7744038	22.3270668	1786.29255		
155.7561	36	859.5351111	23.8759753	1707.12481		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	43.18411777	1	43.1841178	0.02472314	0.87551	3.97777939
Within Groups	122269.6073	70	1746.70868			
Total	122312.7915	71				

any further growth in that location and studies have shown that there is a species-specific pattern in the sequence after which sutures and synchondroses close (Rager *et al.*). It could be inferred that the dogs in Group 1 of the current study, though mature, had skull bones that still allow growth and expansion; whilst skulls of the dogs in Group 2, at the age of their use in the study, had attained the size close to the maximum for the GLND.

CONCLUSION

The current study provides useful information on the characteristics of the skull of the GLND as a variation of the standard typology of the dolicocephalic breed, possibly due to the local environmental conditions and genetic makeup of the GLND over generations. The study results draw attention to relationship of skull morphology and attainment of maturity of skull bones. Results obtained from this study could be very useful in neurosurgery of the cranium, plastic or cosmetic maxillofacial surgery, acupuncture, nerve block and other clinical manipulations involving the head; as well as for breed classification and drawing of criteria for dog exhibitions in the local Ghanaian dog-breeding arena.

OPOKU-AGYEMANG, T.; ESSEL COBBINAH, D.; SIA, D. D.; MUKUNDANE SPRINGS, S.; FOLITSE, R. D. & EMIKPE, B. O. Morfometría y tipología del cráneo en el perro local de Ghana de raza no definida (*Canis lupus familiaris*). *Int. J. Morphol.*, 38(3):706-713, 2020.

RESUMEN: La forma de la cabeza se considera el criterio más importante para determinar las razas estándar de perros. Es relevante estudiar la tipología del cráneo del perro local de Ghana para establecer una plantilla de su identificación como raza y generar datos que puedan ser útiles en la anatomía comparativa de los cráneos de perros. En este estudio se utilizaron un total de veinte cráneos de perros adultos de dos grupos de edad. Se midieron 31 parámetros y se calcularon 6 índices de cráneo sobre la base de ellos. El grupo de cráneos de perros mayores completamente desarrollados mostró valores más altos en todos los parámetros. Los resultados del estudio actual proporcionarán datos de referencia sobre los parámetros del cráneo de los perros dolicocefálicos locales. Más importante aún, los resultados obtenidos podrían ser útiles en la anatomía veterinaria aplicada y la práctica clínica en áreas que incluyen medicina forense, cirugía plástica o cosmética maxilofacial, neurocirugía del cráneo, acupuntura, bloqueo nervioso y otras manipulaciones clínicas que involucran la cabeza.

PALABRAS CLAVE: Perro local ghanés de raza no definida (GLND); Cráneo; Estudio morfométrico; Índices; Cierre de sutura.

REFERENCES

- Adams, J. U. Genetics of dog breeding. *Nat. Educ.*, 1(1):144, 2008.
- Al-Sagair, O. & ElMougy, S. A. Post-natal development in the linear and tric morphometrics of the camelidae skull. *Anat. Histol. Embryol.*, 31(4):232-6, 2002.
- Boas, F. Changes in the bodily form of descendants of immigrants. *Am. Anthropol.*, 14(3):530-62, 1912.
- Boas, F. *Report Presented to the 61st Congress on Changes in Bodily Form of Descendants of Immigrants*. Washington, Government Printing Office, 1910.
- Brehm, V. H.; Loeffler, K. & Komeyli, H. Schädelformen beim hund. *Anat. Histol. Embryol.*, 14(4):324-31, 1985.
- Dyce, K. M.; Sack, W. O. & Wensing, C. J. G. *Textbook of Veterinary Anatomy*. 3rd ed. Philadelphia, Saunders, 2002. pp.57-68.
- Endo, H.; Hayashi, Y.; Yamazaki, K.; Motokawa, M.; Pei, J. C. K.; Lin, L. K.; Chou, C. H. & Oshida, T. Geographical variation of the mandible size and shape in the wild pig (*Sus scrofa*) from Taiwan and Japan. *Zool. Stud.*, 41(4):452-60, 2002.
- Geiger, M. & Haussman, S. Cranial suture closure in domestic dog breeds and its relationships to skull morphology. *Anat. Rec. (Hoboken)*, 299(4):412-20, 2016.
- Igado, O. O. & Ekeolu, O. K. Morphometric investigation of the occipital area of the adult Nigerian local dogs. *Afr. J. Biomed. Res.*, 17(2):125-8, 2014.
- Igado, O. O. Neurometry and neurocraniometry of the Nigerian local dog (*Canis lupus familiaris*). *J. Vet. Anat.*, 4(2):99-109, 2001.
- Mark, J. J. *Dogs in the Ancient World*. In: Ancient History Encyclopedia. Web Site. 2019. Available from: <https://www.ancient.eu/article/184/>
- Miller, M. E. *Anatomy of the Dog*. Philadelphia, Saunders, 1964.
- Monfared, A. L. Anatomical study of the skull of the adult dogs and its clinical value during regional anesthesia. *Global Vet.*, 10(4):459-63, 2013.
- Muylle, S. *Estimation of age by examination of the teeth*. In: MSD MANUAL Veterinary Manual. Web Site. 2019. Available from: <https://www.msdsmanual.com/digestive-system/dental-development/estimation-of-age-by-examination-of-the-teeth>
- Onar, V.; Ozcan, S. & Pazvant, G. Skull typology of adult male Kangal dogs. *Anat. Histol. Embryol.*, 30(1):41-8, 2001.
- Rager, L.; Hautier, L.; Forasiepi, A.; Goswami, A. & Sánchez-Villagra, M. R. Timing of cranial suture closure in placental mammals: phylogenetic patterns, intraspecific variation, and comparison with marsupials. *J. Morphol.*, 275(2):125-40, 2014.
- Scott, J. P. & Fuller, J. L. *Genetics and the Social Behaviour of the Dog*. Chicago, University of Chicago Press, 1974.
- Sisson, S.; Grossman, J. D. & Getty, R. *Sisson and Grossman's The anatomy of the domestic animals*. Vol. 2. Carnivore osteology. 5th ed. Philadelphia, Saunders, 1975. pp.1467-8.
- Sullivan, L. & Romney, C. P. Cleaning and preserving animal skulls. The University of Arizona Cooperative Extension, AZ1144, 1999. Available from: <https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1144.pdf>

Corresponding author:

Emikpe benjamin

Professor, Diagnostic Pathology

Department of Pathobiology

School of Veterinary Medicine

Kwame Nkrumah University of Science and Technology

Kumasi - GHANA

Email: banabis2001@yahoo.com

Received: 31-08-2019

Accepted: 20-12-2019