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Anatomical Study of Some Selected Bones of the Hind Limb of Local Domestic Dog (*Canis lupus familiaris*)

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Abstract

This study was aimed at investigating the age related changes in the morphometry and biometry of some selected bones of the hind limb of Nigerian local dog (*canis lupus familiaris*). In this study a total of fifteen dogs were used as sample and were grouped into five age categories (group A-E). The dogs were aged by estimation using dentition eruption and wearing. The segment of the hind limb was identified and separated from the rest from other parts. The gross study of the hind limb revealed that the hind limb was composed of: ossa coxarum, femur, patella, tibia, fibula, tarsal and metatarsal bones. The biometric study revealed that the weight, length, width and circumference were found to be increasing with advancement in age. The result revealed that mean weight, length and circumference of various segments of the ossa coxarum, femur and the tibia tends to increase with age across the group that is from group A to group E. However, there is variation in the length of the fibula, width of the obturator foramen and length of the obturator foramen. Base on the above results, it was concluded that base line data was established with the aim of enhancing learning.

Keywords: Anatomy; *Canis lupus familiaris*; Ossa Coxarum; Femur; Tibia; Fibula; Bones

Abbreviations: NLD: Nigerian local dogs.

Introduction

Dogs have been reported to be the earliest domesticated species and thousands of years of selective breeding by humans have led to enormous morphological diversity among dogs [1]. Due to the epochs-long efforts in systematic selection for different purposes and much creative experimentation, most of this morphological variation can now be recognized as breeds in contemporary dogs. From time immemorial, dogs have been reputed to be man's best friend, with different breeds being attributed with different gifts and usefulness. Reports on the morphometric evaluation of the skulls of the archaeological remains of the Stone Age dogs and of modern day dogs have also increased in recent times [2-4]. The shape of the skull in dogs shows considerable breed and individual variation in form and size [5].

The shape of the skull is the most important criterion in determining the standard breeds of dog. This might be one of the reasons, or the major reason why the canine skull of different breeds, both archaeological excavations, and modern day/ contemporary dogs has been studied by different authors. The Nigerian local dogs (NLD) are a breed indigenous to Nigeria; they are popularly referred to as 'mongrels' by indigenes. They are characteristically long-headed (dolichocephalic) dogs [3], and are generally light brown in color. Recent years has shown an increase in the

acquisition of this breed of dog, due to the fact that they are more resistant to some haemo-parasites e.g. babesiosis and trypanosomosis that constantly plague the imported or exotic breeds. The domestic dog (*Ca*nis lupus familiaris when considered a subspecies of the wolf or Canis familiaris when considered a distinct species) is a member of the genus Canis (canines), which forms part of the wolf-like canids and is the most widely abundant terrestrial carnivore. The dog was the first species to be domesticated and has been selectively bred over millennia for various behaviors, sensory capabilities, and physical attributes. Their long association with humans has led dogs to be uniquely attuned to human behavior and they are able to thrive on a starch-rich diet that would be inadequate for other canid species. Dogs vary widely in shape, size and colors.

They perform many roles and functions for humans, such as hunting, herding, pulling loads, protection, assisting police and military, companionship and, more recently, aiding disabled people and therapeutic roles. This influence on human society has given them the sobriquet of "man's best friend ". Bones are a rigid organ that constitutes part of the vertebrate skeleton. Bones protect various organs of the body, produce red and white blood cells, store minerals, provide structure and support for the body and enable mobility. A bone come in a variety of shapes and sizes and has a complex internal and external structure. They are lightweight yet strong and hard, and serve multiple functions. ("Types of bone". mananatomy.com February 2016). Considering the fact that research and documentation on morphometric analysis is scanty in this species of animal especially in my study area (Sokoto state) and researchers in the area are less concerned with dogs, there is a need to form a base line data for researchers in terms of breeding, reproduction, disease control and prevention to grass root in this breed of animal.

There are a number of researches carried out in many species and breed of animals regarding the skeleton of the pelvic limb in mouse deer (gross studies on the sacrum and coccygeal vertebrae of chital (Axis axis) but non on dogs. Also there are a number of disease problems that includes both parasitic, infectious and nutritional which affects the structure and functions of the bones frequently encountered in dogs, even trauma plays a role also and this has a negative consequence on the production and breeding of dogs. This study is designed to reveal the slight variations and changes seen grossly using morphometric analysis at different ages. The aim of the study is to conduct morphometry some selected bones of the hind limb of dogs in Sokoto using standard morphometric analysis, through conducting post natal morphometric analysis on selected bones of the hind limb of dog of different age groups and by describe the gross changes associated with the different bones of the hind limb at different age groups.

Materials and Methods

Study Area

The study was conducted at the Department of Veterinary Anatomy of Usmanu Danfodiyo University, Sokoto, Sokoto state. The state is geographically located at the North Western part of Nigeria on latitude 12^0 15N′ to 05^0E and is 308M above sea level. The state shares common borders with Niger Republic to the North, Kebbi State to the west and Southwest, and Zamfara State to the East. The state falls in the dry Sahel surrounded by sandy Sudan type Savannah [6].

Animal Source

The animals used were gotten from the Department of Veterinary anatomy comparative anatomy course which was intended to be used for the purpose of practical. After the practical, they were euthanized and that made as our sample.

Materials

For the purpose of this research, fifteen (15) dogs' specimens of different age group submitted to the Department of Veterinary Anatomy intended for practical constituted the materials for this study.

Preparation of Sample

The sample of use in the study were

- Ossa coxarum
- Femur
- Tibia
- Fibula

The dogs were sexed using the external genitalia.

Dog age estimation

The ages of the dogs were estimated using the dentition eruption and wearing which is as follows

2-6weeks eruption of deciduate teeth commences
3-6months eruption of permanent incisors begins
6months-1year wearing of deciduate teeth
1year-$1^1/_2$years canine is developed
$1^1/_2$years wearing down of I_1
$2^1/_2$years wearing down of I_2
3years and above wearing down of I_3 (I_1, I_2, I_3)

Where, I_1 = Central incisors
I_2 = Second incisors
I_3 = Third incisors

Note that I_1, I_2, and I_3 are of the lower jaw

Based on this aging, the dogs were grouped as follows;

Group A- 0-6 months
Group B- 6months – 1year

Group C - 1year-2years
Group D - 2years-3years
Group E - above 3years

Skinning, Muscle Removal, Dismantling And Boiling

After euthanizing the animals, the skin were removed using skinning knives, after removing the entire skin, the muscle mass was reduced also using knives and scapel blade this was done in order to facilitate boiling.After skinning and removal of the muscle mass, the bones were dismantled at various joints using the hands to disarticulate the joints, some joints were disarticulated using bone cutter and/knife. After dismantling, the bones were boiled in a big pot locally using potash and detergent as catalyst to facilitate the removal of the muscle mass and disarticulate the bones from their point of attachment so that individual bones can be harvested, similarly this can be achieved if the defleshed carcasses are subjected to the hot water maceration technique as previously described by Igado [3].

Washing And Drying

After boiling, the bones were removed from the pot, allowed to cool, then the bones were washed using tap water, and then the bones were shade dried in the lab.

Gross Observations

The bones were observed grossly in terms of

- **Shape:** the bones were observed based on shape as straight, curved, twisted, strongly curved or strongly twisted.
- **Size:** the bones were observed as either small, medium, moderate, or large in shape.
- **Color:** The colors of the bones were also observed as either, yellow, pale-yellowish, deep yellowish and grayish.
- **Articulation:** the bones were also observed for articulation either proximal articulation or distal articulation.
- **Epiphyseal growth plate closure:** The growth plates was observed as open, partially open, close, or partially closed.
- **Location:** most of the bones were located in the ante brachium and pes.
- **Number:** based on their number, the bones were observed to be either single, double or triple bones.
- **Relation:** in terms of relation, the bones were related to another either proximally, distally, laterally or medially.

The bones observed grossly were

- Ossa coxarum
- Femur
- Tibia
- Fibula

Biometrical Observation

The bones were observed biometrically based on anatomical landmarks in relation to the ages as follows;

- Weight
- Length
- Width
- Circumference, in relation to ages.

The parameters observed in the samples as landmarks are as adopted by Igado [7] as follows, A-P. Data obtained were presented in mean ± standard deviation. Using Microsoft excel 2007.

- **Weight of the entire ossa coxarum:** all the entire pelvic bones were weighed in grams using an electronic weighing balance.
- **Weight of the femur:** The whole femurs were weighed in grams using an electronic weighing balance.
- **Weight of the tibia:** the whole tibia was weighed in grams using an electronic weighing balance.
- **Weight of the fibula:** The whole fibulas were weighed in grams using an electronic weighing balance.
- **Length of the ilium:** The entire lengths were measured using measuring tape from the tuber sacrale to tuber coxae and recorded in centimeters.
- **Length of the ischium:** the entire length of the ischium from the ischiatic tuberosity mid-way to an imaginary line set at the acetabulum using a measuring tape and recorded in centimeters.
- **Length of the pubis:** the entire length of the pubis was measured from the pectin ossis pubis to the floor of the pubis using a measuring tape and recorded in centimeters.
- Length of the obturator foramen was also taking and recorded in centimeters.
- **Length of the femur:** the total length of the femur was measured from the neck to the point of intra condyla fossa using a measuring tape and recorded in centimeters.
- **Length of the tibia:** the total length was measured using a measuring tape and was recorded in centimeters.
- Length of the fibula was also taken using a measuring tape and recorded in centimeters.
- **Widths of the Ilium at different points:** the greater width, lesser width and width of the body respectively were taken using measuring tape and were recorded in centimeters. The width of the obturator foramen was also taken and recorded in centimeters

- **Circumference of the femoral neck:** the distance round the neck was taken using a measuring tape and recorded in centimeters
- **Circumference of the femoral shaft:** the total distance round the shaft femur was taken at three different points, the proximal shaft, mid shaft and distal shaft using measuring tape and was recorded in centimeters
- **Circumference of the tibial shaft:** the total distance round the tibial shaft was taken at three different points, the proximal shaft, mid shaft and distal shaft using measuring tape and was recorded in centimeters

Result and Discussion

Gross observation

The bones as seen grossly are shown in plate.

- Indicating the various age groups.
- Grossly, the hind limb was examined and was seen to compose of ossa coxarum which is formed by three different bones (ilium, ischium and pubis) as shown in plate.
- it is also composed of the acetabulum, obturator foramen, isciatic notch as well as the pelvic symphysis, all these features becomes prominent with the advancement in age as shown in plate.
- The femur which articulate with the pelvis at the acetabulum, it is a long bone. It has different segments, the head, neck, tubercle (which becomes more prominent with advancement of age), the shaft which is divided into proximal shaft, mid shaft and distal shaft as shown in plate.
- The shaft is regularly cylindrical, except near the extremities, where it is wider and compressed backward as shown in plate 4.3. It is strongly curved in its lower two thirds, convex in front. The posterior surfaces are flattened transversely, narrow in the middle, and widens toward each end. The tibia is about the same length as the femur. The shaft forms a double curve, the upper part is convex internally, the lower part externally. The proximal third is prismatic, but is compressed laterally and is long from before backward as shown in plate.
- It has a tibial crest and a point of attachment of the fibula bone as seen in plate 4.4. The remainder is almost regularly cylindrical. The fibula extends the entire length of the region. It is slender, somewhat twisted, and enlarged at either end. It also has three basic regions, the proximal shaft, mid shaft region and the distal shaft region as shown in plate.
- The upper part of the shaft is separated from the tibia by a considerable interosseous space, but the lower part is flattened and closely applied to the tibia.

Figure 1: Photograph of some Hind limb bones of Mongrel Dog showing various identification and classification of the samples, 0-6 month (1), 6month-1 year (2), 1-2 years (3), 2-3years (4) and above 3 years (5), Ossa coxarum (A), Femur (B), Tibia (C) and Fibular bone (D).

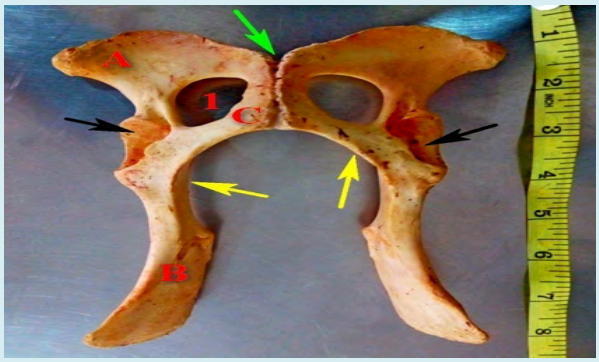

Figure 2: Photograph of the dorsal view of Mongrel Dog Ossa coxarum above 3years showing ilium (B), ischium (A), and pubis (C); Acetabulum (black arrow); isciatic notch (yellow arrow) and pubic symphysis (green arrow).

Figure 3: Photograph of the lateral view of Mongrel Dog Femur at 2-3 years showing the three (3) basic regions proximal (A), mid shaft region (B) and distal region (C); Head of the femur (green arrow), greater tubercle (black arrow), and neck of the femur (blue arrow).

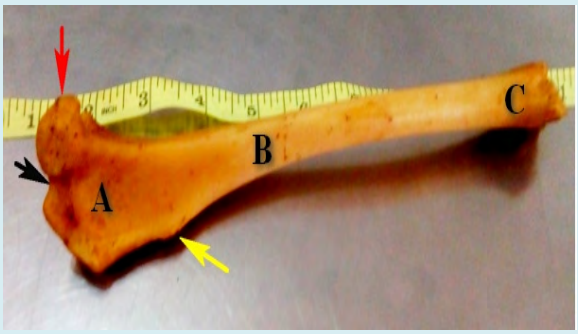

Figure 4: Photograph of the lateral view of Mongrel Dog tibia at 2-3 years showing the three (3) basic regions proximal (A), mid shaft region (B) and distal region (C); tibial crest (black arrow) and point of proximal attachment of fibular (red arrow).

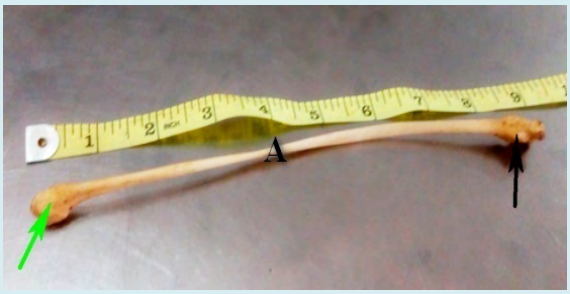

Figure 5: Photograph of the lateral view of Mongrel Dog fibular at 2-3 years showing the three (3) basic regions proximal (green arrow), mid shaft region (A) and distal region (black arrow).

The various bones varied in sizes, the fibula is a long, small, paired bone, tibia is a long, medium, paired bone, and the femur is a long paired bone. The ossa coxarum is a fused big bone. The coloration varies with age, at the early stage (0-6months) the bones are gray in color, as the age advances the bones later becomes pale, then becomes white as seen in group C (1-2years) and finally it becomes yellowish in color. Based on the number of bones, the ossa coxarum consists of 3 bones (ilium, ischium and pubis), the tibia and fibula are two bones that are paired.As the age advances the epiphyseal growth plate closes and by 2 years of age it is completely closed.

Biometric Study

The biometric study of some selected bones of the hind limb of dogs shows that the various selected bones had different mean, weight value at different age categories in which there is an increase in the value with age. Similarly, the length, width and circumference also increase with age. This is in line with the findings of Garcia-Perea,[8]; Getty, [5]; Igado, [3]; Igado, [7]; Freedman, et al. [9]; Similarly, the values of some of the bones are statistically significant, that is to say there are great variation, while some are statistically insignificant as seen in tables 1-4 respectively. Also from the results, it showed that as the age is advancing, the color, the weight, length, and other observable prominent features are seen grossly.

S/N	Parameters	Age Groups					
		A	B	C	D	E	SEM
1	Weight(g)	35.50e	44.50d	65.00c	84.00b	79.00a	6.306
2	**Length of Iliac wing(cm)**						
	Left iliac wing(cm)	6.70d	7.65c	8.40b	8.60b	10.40a	0.411
	Right iliac wing(cm)	7.30c	7.35c	7.75cb	8.50b	9.35a	0.269
3	**Width of the iliac wing(cm)**						
	Greater width						
	Left greater width(cm)	4.20c	4.75cb	4.75cb	5.20b	5.95a	0.206
	Right greater width(cm)	4.30b	4.35b	5.15ba	5.20ba	6.00a	0.23
	Lesser width(cm)						
	Left lesser width(cm)	2.55c	3.40b	4.05b	4.90a	5.00a	0.316
	Right lesser width(cm)	2.80c	3.95b	4.25b	4.90a	5.10a	0.275
	Width of the body of the iliac wing(cm)						
	Left width(cm)	1.80d	2.20dc	2.40bc	2.40ba	2.95a	0.137
	Right width(cm)	2.00c	2.05c	2.10c	2.40b	2.90a	0.113

4	**Length of Ischium(cm)**						
	Left of the Ischium(cm)	3.85c	4.70b	4.95b	6.05a	6.15a	0.29
	Right of the Ischium(cm)	3.60c	4.85b	5.00b	6.00a	6.10a	0.305
5	**Length of pubis(cm)**						
	Left length(cm)	5.70c	5.70dc	5.90c	6.10b	6.40c	0.086
	Right length(cm)	6.00c	6.05c	6.15c	6.45b	6.85a	0.106
6	**Width of pubis(cm)**						
	Left width(cm)	1.90c	3.05b	3.10b	3.25b	4.35a	0.262
	Right width(cm)	2.10c	2.90b	3.00b	3.15b	4.25a	0.234
7	**Length of obturator foramen(cm)**						
	Left length(cm)	2.75a	2.80a	2.80a	3.05a	3.05a	0.087
	Right length(cm)	2.70b	2.85ba	2.85ba	2.90ba	3.10a	0.051
8	**Width of obturator foramen (cm)**						
	left width (cm)	1.90c	2.05c	2.20bc	2.45ba	2.65a	0.095
	Right width(cm)	2.10b	2.10b	2.25ba	2.35ba	2.80a	0.104

Table 1: Showing the Biometric data of the *Ossa coxarum* in relation to age of Dogs.
KEY: Group A: 0-6 month, Group B: 6 month-1year, Group C: 1-2years, Group D: 2-3 years, Group E: above 3years; CM=centimeter; g = grams; SEM= Standard error of mean.

S/N	Parameters	Age Groups					
		A	B	C	D	E	SEM
1	**Weight(g)**						
	Left femur(g)	12.50a	37.00b	39.75c	54.25d	60.00e	5.532
	Right femur(g)	13.00a	38.00b	39.50c	53.75d	59.25e	5.393
2	**Length of femur(cm)**						
	Left femur(cm)	11.65c	16.90b	17.10b	17.75b	19.55a	0.886
	Right femur(cm)	11.35c	17.00b	17.10b	18.10b	19.95a	0.964
3	Circumference of femoral neck(cm)						
	Left neck(cm)	4.25c	5.25b	5.85b	6.35a	7.15a	0.336
	Right neck(cm)	4.10e	4.85d	5.60c	6.50b	7.25a	0.376
4	**Circumference of shaft(cm)**						
	Proximal Shaft(cm)						
	Left proximal shaft(cm)	5.30d	5.45c	5.95bc	6.30ba	6.45a	0.174
	Right proximal shaft(cm)	4.90c	5.40cb	6.00ba	6.00ba	6.40a	0.188
	Mid shaft(cm)						
	Left mid shaft(cm)	3.50d	4.25c	4.75cb	5.15ab	5.70a	0.258
	Right mid shaft(cm)	3.60d	4.25c	4.75cb	5.20b	6.00a	0.278
	Distal shaft(cm)						
	Left Distal shaft(cm)	4.60c	6.00b	6.10b	7.20a	7.50a	0.344
	Right distal shaft(cm)	4.70d	6.05c	6.45c	7.15b	7.75a	0.35

KEY: Group A: 0-6 month, Group B: 6 month-1year, Group C: 1-2years, Group D: 2-3 years, Group E: above 3years; CM=centimeter; g = grams; SEM= Standard error of mean.
Table 2: Showing the Biometric data of the Femur in relation to age of Dog.

S/N	Parameters	Age Groups					
		A	B	C	D	E	SEM
1	**Weight(g)**						
	Left tibia(g)	13.25a	27.50b	38.50c	46.20d	60.00e	5.324
	Right tibia	13.75a	26.75b	38.25c	46.00d	59.50e	5.249
2	**Length of the tibial(cm)**						
	Left (cm)	13.00d	16.75c	18.75b	19.25b	26.50a	1.48
	Right (cm)	13.00c	16.75b	18.75b	19.20b	26.30a	1.464
3	**Circumference of shaft(cm)**						
	Proximal Shaft(cm)						
	Left tibia(cm)	4.25c	4.90b	4.90b	5.20b	6.00a	0.196
	Right tibia(cm)	4.25d	4.75c	5.10cb	5.25b	6.10a	0.208
	Mid shaft(cm)						
	Left tibia(cm)	3.50c	4.00cb	4.50ab	4.50ba	4.90a	0.167
	Right tibia(cm)	3.30c	4.25b	4.50ba	4.65ba	5.15a	0.217
	Distal Shaft(cm)						
	Left tibia(cm)	4.05d	4.90c	5.10c	6.00b	6.75a	0.311
	Right tibia(cm)	4.05c	4.95bc	5.35b	5.70ab	6.75a	0.314

KEY: Group A: 0-6 month, Group B: 6 month-1year, Group C: 1-2years, Group D: 2-3 years, Group E: above 3years; CM=centimeter; g = grams; SEM= Standard error of mean.

Table 3: Showing the Biometric data of tibia in relation to age of Dogs.

S/N	Parameters	Age Groups					
		A	B	C	D	E	SEM
1	**Weight(g)**						
	Left fibula	2.00c	2.70c	3.70b	4.40ab	5.10a	0.383
	Right fibula	2.25c	3.25c	4.00ab	4.50ab	5.00a	0.343
2	**Length of fibula(cm)**						
	Right fibula(cm)	12.10c	17.25b	17.40b	20.40a	22.00a	1.185
	Left fibula(cm)	12.10c	17.10b	17.15b	20.15a	21.90a	1.158

KEY: Group A: 0-6 month, Group B: 6 month-1year, Group C: 1-2years, Group D: 2-3 years, Group E: above 3years; CM=centimeter; g = grams; SEM= Standard error of mean.

Table 4: Showing the biometric data of Fibula of dog in relation to their age.

This research work showed that the hind limb of Nigerian local dog was located at the rear and consists of several segments (thigh, leg and crus) and several bones (*ossa coxarum*, femur, tibia, fibula, tarsal and metatarsal bones). This is in line with the findings of Sisson and Grossman [10]; Igado, [4]. As observed in this research, the coxal bone (os coxae) of the Nigerian local dog varies with that of other domestic species, similarly the fovea capitis is centrally located on the femoral head as oppose to other species, the bones varied grossly in their appearance.The femur, on its overall shows no major difference with other domestic species but in the goat it is stouter, this is in line with the findings of Sisson and Grossman [10], Agur, Anne [11]; Adriana, et al. [12]; Igado [7].

The head of the femur, mainly the articular surface is circular and slightly extending towards the major trochanter as seen in sheep. The tibia and fibula showed no major differences as seen in other domestic species [2,13-20] Igado OO, [7]. The weight of various bones taken increased with age, the mean width, length and circumference of various segments also increases with age for all the groups and the

values obtained were statistically significant except for the fibula, in which the values obtained were almost similar and statistically the same [20-25].

Conclusion and Recommendation

In this research project, except for the mean length of the fibula, all other parameters for the various selected bones increased with age across the groups and are statistically significant with some parameters having closeness in the range of the data between age groups. The result of this study provides a baseline data on the morphometric and biometric data of the ossa coxarum, femur, tibia and fibula of the Nigerian local dog (*Canis lupus familiaris*) at different ages, respectively. It is therefore recommended that further work and studies to be carried out on other breeds of dogs in Nigeria as well as studies on the differences among gender in respect to the various parameters and other parameters and parts of the fore limbs and hind limbs bone be explored and measured. Other measuring and biometrical equipment should also be considered when carrying out further research.

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