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Original Research Article

RADIOLOGIC APPRAISALS OF THORACIC RECESSES IN THE AFRICAN GRASSCUTTTER (*THRYONOMYS SWINDERIANUS*)

[1*]UKAHA, R.O., [2]TCHOKOTE, E.Y., [1]NJOKU, N.U., [1]JEREMIAH, K.T., [1]UKWUEZE, C.O., [1]UNAMBA-OPARAH, C., [3]IBE, C.S. & [2]OKONKWO, C. J.

[1]Department of Veterinary Surgery & Radiology, [2]Department of Veterinary Medicine, [3]Department of Veterinary Anatomy Michael Okpara University of Agriculture, Umudike, Abia State

**Correspondence:* ukaha.rock@mouau.edu.ng; +2348061530565

ABSTRACT

Organ displacement is evidenced by abnormal angular indentation(s). This is often overlooked in radio-diagnosis except in severe cases of anomalous organ location. The objective of the present research was to determine radiologic indices used for appraisals of thoracic angular recesses in the African Grasscutter (AG). Ten healthy AGs, of average body weight: 1.79±0.31 kg (ranging from 0.23 – 3.10 kg), with equal sex distributions were used for the investigation. Two (right lateral and left lateral) thoracic projections of each AG, totaling twenty study radiographs, were obtained. Angular recesses objectively evaluated, were the following: tracheal diameter, postcaval diameter, diameter of tenth vertebra, cardio-sternal recesses, tracheo-vertebral recesses, cardio-caval recesses, and cardio-diaphragmatic sinuses. Indices generated in the views were the cardiac inclination angles (CIA), tracheal inclination angles (TIA), cardio-caval angles (CCA), and the cardiophrenic angles (CPA). Mean ± standard error of mean CIA, TIA, CCA and CPA values were: 28.10 ± 0.53/28.30 ±0 .78; 13.70±0.34/13.30 ±0.37; 42.70 ±0.21/44.90 ±0.23; and 31.10 ±0.60/30.70 ±0.76 for the right and left lateral projections, respectively. The mean ± standard error of mean postcaval diameter (PCD), tracheal diameter (TrD), and tenth vertebral diameter ($T_{10}D$) values were: 5.39±0.39/5.38±0.37; 3.65±0.33/3.63±0.32; and 8.94±0.74/8.94±0.74, in that order. These results are objective, easily reproducible and conveniently applicable in veterinary clinical practice for radiologic thoracic appraisal. The clinical significance of the present research is the determination of reference values of angular recess indices for use by veterinary radiologists, surgeons, clinicians and other animal health scientists in thoracic assessment of the AG.

Keywords: African Grasscutter, Angular recesses, Radiology, Thoracic measurement

INTRODUCTION

The African grasscutter (*Thryonomys swinderianus*) belongs to the order of Rodent and family *Thryonomidae* comprising only one genus, the Thryonomys and only two species recognized as the *T. swinderianus* and the *T. gregorianus* (Dorst & Dandelot, 1969). The AG is widely known in sub-Saharan Africa and it is commonly referred to as cane rat, cutting grass or grasscutter. It is presently and extensively being domesticated in Nigeria and various parts of Africa, and regarded as the continent's number one micro-rodent (Asibey & Addo, 2000). The AG is heavily built, thickset with peculiar short and bristle tail which readily detaches close to the base if seized, as a defensive mechanism. Its body measures 35 - 60 cm long and 5.0 - 7.5 kg in weight, and is covered by coarse bristle hair coat usually dark brown speckled with yellow or grey (Dorst & Dandelot, 1969).

Increasing scientific reports have been documented on the general anatomy (Ibe *et al*., 2023), reproductive system (Addo *et al*., 2002; Adebayo & Olurode, 2010), urinary system (Olukole, 2009), circulatory system (Opara *et al*., 2006) and nervous system (Ibe *et al.*, 2020), skull (Olude *et al*., 2014), etc of the AG. However, aside the study we

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conducted on the radiologic indices of their cardiac mensuration (Ibe *et al.,* 2024), no other radiologic study is visible on the literature, especially on angular relationships of thoracic organs and structures in the AG or other rodents undergoing captive rearing and domestication.

Normalcy in the chest silhouette of an animal is a function of the health status of its thoracic region. In modern veterinary practices, radiologic appraisals are indicated when patient examinations reveal clinical manifestations of thoracic disorder (Ukaha *et al.*, 2021). Silhouette measurement is generally considered a hallmark of the diagnostic activity and a source of reliable knowledge compared to qualitative modes of anatomic estimation. Repeated attempts to develop a set of appraisal indices universally acceptable for general vet practice have continued to fail due to dissimilarity in body habitus amongst animal breeds (Ukaha *et al*., 2021).In this study, the AG was the animal model used. The animals, different in their ages, were of equal sex distribution. Survey right and left lateral thoracic radiographs were obtained of each rat. Empirical measurements of different thoracic sinuses were taken of each radiograph. The present research sought to document reference values for sizes of thoracic recesses of clinically normal AGs as scientific and diagnostic additions to the awakening understanding of the AGs. Radiologic data obtained were analyzed by means of descriptive statistics leading to the generation of investigative indices and parameters applicable in radiologic biometrics and diagnosis of the AG.

MATERIALS AND METHOD

LOCATION OF THE PROJECT: The project was carried out in the Department of Veterinary Surgery & Radiology of the College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike is located on longitude $7^0$33'E and latitude $5^0$29'N at 122m above sea level with annual rainfall of 1245mm and temperature range of 22.4^0 to 30.6^0C.

ANIMAL POPULATION: Ten healthy AGs (5 males and 5 females) of various ages (6 – 24 months) and mean body weight 1.79±0.31 kg (ranging from 0.23 – 3.10 kg), purchased from wildlife breeders, were used for the investigation. The animals were acclimatized for 4 weeks within which period they were subjected to physical examination and evaluation of physiological parameters. Results of those investigations showed that the AGs were healthy and so the animals were deemed suitable for the study.

ETHICAL ENDORSEMENT

Animal Housing, handling, and all other procedures related to animal management were conducted in line with the standards recommended by the College of Veterinary Medicine Research Ethical Committee (MOUAU/CVM/REC/202214) of the Michael Okpara University of Agriculture, Umudike and with the Helsinki Declaration revised in 2000.

IMAGING PROCEDURES

The animals were restrained with xylazine hydrochloride (XYL-M2®: VMD, Belgium) followed, five minutes later, by ketamine hydrochloride, both given intramuscularly at 2 mg/kg and 8 mg/kg, respectively. Thoracic projections of the animals were taken with a mobile unit (Dynamax, Medical Equipment Group Ltd, England). Exposure factor settings used for focus-film distance, object-film distances, kilovoltage peak and milliamperage were 90 cm, 0 cm, 40 kVp and 5 mAs, respectively. The blue sensitive Begood® film (Medical X-ray, China) was the x-ray film type used to investigate all the AGs.

Right lateral (RtL) and left lateral (LeL) thoracic exposures were made of each giant rat as described by Ukaha *et al.*, 2018. At the end of film processing, a total of 20 right lateral (RtL) and left lateral (LeL) thoracic projections were accepted and evaluated. All artefactual radiographs and those views technically inadequate, such as under-exposed, over-exposed and poorly centred projections, were rejected and excluded from the investigation.

CRITERIA FOR INCLUSION AND EXCLUSION OF STUDY RADIOGRAPHS

Properly processed, duly exposed, and well-centred projections of optimal density and definition were used for the radiographic evaluation. Artefactual radiographs or over-/under-exposed projections, or those views subjected to inadequate dark room procedures were all considered deficient and excluded from the research.

DATA COLLECTION PROCEDURES

By means of a viewing box, data in each of the RtL and LeL thoracic radiographs were carefully taken directly. The inclination borders of the two organs/structures forming a recess were produced with a metre rule to ease angular measurements with a protractor and values recorded in degrees (Figure Ia and c). Digital Vernier callipers were used to measure linear parameters and values recorded in millimetres (Figure I b). In a nutshell, documented data were: (a) linear measurements of tracheal diameter, postcaval diameter and diameter of tenth vertebra, and (b) angular evaluations of cardio-sternal recesses, tracheovertebral recesses, cardio-caval recesses, and cardio-diaphragmatic sinuses.

COLLATION OF DATA

All radio-anatomic measurements were taken and recorded in prepared, tabulated forms, as follows:

(i) The diameters of the: (a) trachea (taken at the thoracic inlet), (b) postcava (measured just caudal to the cardiac caudal surface) and (c) T_{10} (measured midpoint from the dorsal to the ventral border of the vertebra).

(ii) The angular recesses made by the inclinations of the: (a) cranial surface of the heart to the dorsal board of the sternum (called cardiac inclination angles), (b) ventral surface of thoracic vertebrae to the dorsal border of the tracheal shadow (referred to as tracheal inclination angle), (c) ventral border of the caudal vena cava to the caudal boundary of the heart (known as cavocardial angle), and (d) caudoventral border of heart to copula of the diaphragm (referred to as cardiophrenic angle).

DATA ANALYSES

The raw results of this inquiry were saved in hard copies and also stored in computer hard disc and CDs. Data obtained were analyzed statistically with GraphPad Prism 5.0 software (GraphPad Software Inc, San Diego, CA, USA) for windows. The mean indices obtained between sexes and age brackets in the right lateral versus left lateral radiographs were compared using two-tailed Student's t test.

The mean values (± standard errors of means SEM) and ranges of all the radiographic indices and linear parameters were calculated, for each sex and age group separately, and for all the AGs pooled. Associations between the angular indices and thoracic parameters were evaluated with Pearson's correlation coefficient.

These descriptive statistics were represented in tables. A probability value less than or equal to 0.05 was considered statistically significant.

RESULTS

LATERAL THORACIC RADIOGRAPH

As shown in Figures I, the following organs/structures were identified in the radiograph clearly demonstrated in the annotated diagram: heart which was always in contact with the sternum; the postcaval vein; the trachea (i.e. the tubular lucency); the diaphragm; and the thoracic vertebrae.

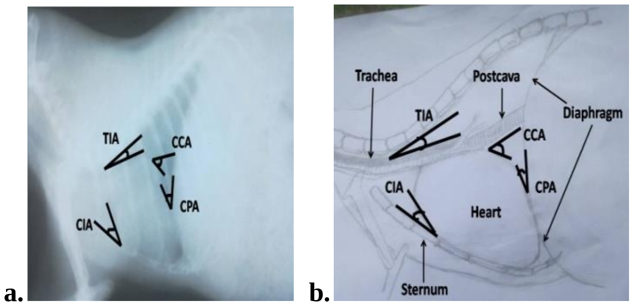

Figure I: (a) Lateral radiograph showing measured thoracic angular recesses (b) Annotated diagram showing measured thoracic angles

Legends:

CIA = cardiac inclination angle

TIA = tracheal inclination angle.

CPA = cardiophrenic angle.

LATERAL THORACIC RADIOGRAPH

As shown in Figures II, the following dimensions were measured in the radiograph and the annotated diagram: tracheal diameter; the postcaval diameter; and diameter of the tenth thoracic vertebra.

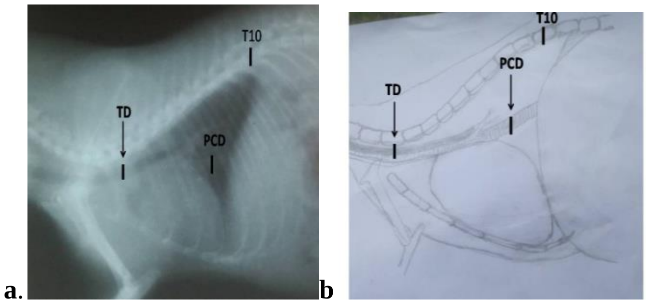

Figure II: (a) Lateral radiograph showing measured linear thoracic dimensions (b) Annotated diagram showing measurement landmarks of linear parameters

Legends:

TD = tracheal diameter

PCD = postcaval diameter

T_{10} = tenth thoracic vertebra

THORACIC RECESSES IN RIGHT AND LEFT LATERAL RADIOGRAPHS OF THE AFRICAN GRASSCUTTERS

Cardiac inclination angle (CIA) pooled mean values in the right (RtL) and left (LeL) lateral thoracic radiographs are slightly but not significantly different from each other as seen in Table I (a) (P≥0.05).

TABLE I(a): MEAN VALUES OF THORACIC ANGULAR RECESS: CIA, TIA, CCA AND CPA IN THE RIGHT AND LEFT LATERAL PROJECTIONS OF THE AFRICAN GRASSCUTTERS, IN DEGREES

No.	CIA		TIA		CCA		CPA	
	RtL	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**
1	30^0	30^0	15^0	15^0	43^0	45^0	35^0	35^0
2	29^0	31^0	13^0	12^0	42^0	45^0	30^0	30^0
3	28^0	30^0	14^0	14^0	43^0	44^0	32^0	35^0
4	30^0	32^0	16^0	14^0	42^0	46^0	33^0	30^0
5	30^0	28^0	14^0	12^0	43^0	44^0	29^0	29^0
6	27^0	28^0	13^0	14^0	42^0	44^0	32^0	31^0
7	27^0	28^0	13^0	14^0	43^0	45^0	30^0	30^0
8	25^0	25^0	13^0	12^0	43^0	46^0	29^0	30^0
9	27^0	26^0	13^0	14^0	44^0	45^0	31^0	29^0
10	28^0	25^0	13^0	12^0	42^0	45^0	30^0	28^0
Sum	**281**	**283**	**137**	**133**	**427**	**449**	**311**	**307**
Mean	**28.10^0**	**28.30^0**	**13.70^0**	**13.30^0**	**42.70^0**	**44.90^0**	**31.10^0**	**30.70**

Sex differences in thoracic recesses in right lateral versus left lateral views of AGs

TABLE I(c): MEAN VALUES OF THORACIC ANGULAR RECESS: CIA, TIA, CCA AND CPA IN THE RIGHT AND LEFT LATERAL PROJECTIONS OF ADULT AND JUVENILE AFRICAN GRASSCUTTERS, IN DEGREES

Age/No	**CIA**		**TIA**		**CCA**		**CPA**	
	Rt	**Le**	**Rt**	**Le**	**Rt**	**Le**	**Rt**	**Le**
Adult (n = 5)	29.20±0.35	29.73±0.53	14.35 ±0.51	13.42 ±0.60	42.50 ±0.23[a]	44.82 ±0.21 [b]	31.10 ±0.11	31.84 ±1.32
Juvenile (n – 5)	27.00±0.47	26.86±0.65	13.05± 0.01	13.18 ±0.49	42.90 ±0.73[a]	45.08 ±0.37 [b]	31.10 ±0.51	29.56 ±0.51

[a,b]Mean index values between projections with different alphabet superscript are significantly different ($P \leq 0.05$)

TABLE 1(b): MEAN VALUES OF THORACIC ANGULAR RECESS: CIA, TIA, CCA AND CPA IN THE RIGHT AND LEFT LATERAL PROJECTIONS OF THE MALE AND FEMALE AFRICAN GRASSCUTTERS, IN DEGREES

Sex/No	**CIA**		**TIA**		**CCA**		**CPA**	
	RtL	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**
Male (n = 5)	28.40 ±0.40	28.70 ±0.66	14.40 ±0.51	13.40 ±0.60	42.60 ±0.25[a]	44.80 ±0.37[b]	31.80 ±1.07	31.80 ±1.32
Female (n – 5)	27.80 ±0.49	27.90 ±0.68	13.00± 0.00	13.20 ±0.49	42.80 ±0.37[a]	45.00 ± 0.32[b]	30.40 ±0.51	29.60 ±0.51
Pooled (n=10)	**28.10±0.53**	**28.30±0.78**	**13.70±0.34**	**13.30±0.37**	**42.70±0.21[a]**	**44.90±0.23[b]**	**31.10±0.60**	**30.70±0.76**
Range (n=10)	25 - 30	25 – 31	13- 16	12 – 15	42 – 44	44 - 46	29 - 35	28 - 35

[a,b]Mean values between views with different alphabet superscript are significantly different ($P \leq 0.05$)

TABLE II(a): MEAN VALUES OF THORACIC DIMENSIONS: PCD, TRD, AND T10D IN THE RIGHT AND LEFT LATERAL PROJECTIONS OF THE MALE AND FEMALE AFRICAN GRASSCUTTERS, IN MILLIMETRES

Sex/No	PCD		TrD		T_{10}D	
	RtL	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**
Male (n = 5)	5.84 ±0.22	5.80 ±0.15	4.03 ±0.04	4.00 ±0.04	9.06±0.37	9.07 ±0.38
Female (n – 5)	4.95 ± 0.42	4.96 ±0.41	3.27 ± 0.31	3.26 ±0.30	8.81 ±0.69	8.81 ±0.69
Pooled (n=10)	**5.39±0.39**	**5.38±0.37**	**3.65±0.33**	**3.63±0.32**	**8.94±0.74**	**8.94±0.74**
Range (n=10)	3.51 – 6.95	3.52 – 6.65	1.71 – 4.62	1.72 – 4.63	4.57 – 11.99	4.56 – 12.01

Mean index values between sexes and between projections are not significantly different (P ≥ 0.05)

TABLE II(b): MEAN VALUES OF THORACIC DIMENSIONS: PCD, TRD, AND T_{10}D IN THE RIGHT AND LEFT LATERAL PROJECTIONS OF THE ADULT AND JUVENILE AFRICAN GRASSCUTTERS, IN MILLIMETRES

Age/No	PCD		TrD		T_{10}D	
	RtL	**LeL**	**RtL**	**LeL**	**RtL**	**LeL**
Adult (n = 5)	5.94 ±0.20	6.20 ±0.10	4.53 ±0.04	4.33 ±0.04	10.20±0.27	10.07 ±0.38
Juvenile (n – 5)	3.81 ± 0.12	3.83 ±0.61	2.52 ± 0.33	2.31 ±0.30	7.01 ±0.55	7.00 ±0.39

Mean values, for each index, between ages (columns) are significantly different (P ≤ 0.05), but mean values between views (rows) are not significantly different (P≥0.05)

Similarly, the means of tracheal inclination angle (TIA) and cardiophrenic angles (CPA) are slightly different but do not vary significantly between the RtL and LeL views (P≥0.05). However, the mean values of the LeL cavocardiac angle (CCA) are consistently and significantly greater than the RtL values in the pooled, male and female radiographs (P≤0.05).

SEX DIFFERENCES IN THORACIC RECESSES IN RIGHT LATERAL VERSUS LEFT LATERAL VIEWS OF AFRICAN GRASSCUTTERS

In Table 1 (b), the angular means between males and females and between radiographic (RtL and LeL) views vary slightly and not significantly (P≥0.05) in CIA, TIA and CPA. However, the RtL mean CCA values of both males and females are significantly lower than LeL mean values (P ≤ 0.05). There is no sexual dimorphism in any of the CIA, TIA, CCA, and CPA means obtained (P≥0.05).

DIFFERENCES IN THORACIC RECESSES IN RIGHT LATERAL VERSUS LEFT LATERAL VIEWS OF ADULT AND JUVENILE AFRICAN GRASSCUTTERS

In Figure I(c), right lateral (RtL) and left lateral (LeL) mean values of cardiac inclination angles (CIA) were not significantly different in the adult radiographs (P≥0.05) and juvenile views (P≥0.05) but significantly different between the two age brackets being greater in the adult radiographs than the juvenile projections (P≤0.05). There is no statistical difference in the means of tracheal inclination angle (TIA) and cardiophrenic angle (CPA) between views and age bracket (P≥0.05). Conversely, significant differences exist in the cavocardiac angular (CCA) means between the RtL and LeL projections and between adult versus juvenile radiographs (P≤0.05).

SOME THORACIC LINEAR DIMENSIONS IN RIGHT AND LEFT LATERAL RADIOGRAPHS OF THE MALE AND FEMALE AFRICAN GRASSCUTTERS

As seen in Table II(a), the pooled mean values of postcaval diameter (PCD), tracheal diameter (TrD), and the diameter of the tenth thoracic vertebra (T_{10}) between the right (RtL) and left (LeL) lateral thoracic radiographs are not significantly different from each other (P≥0.05). There is also, no significant difference in the mean values of postcaval diameter (PCD), tracheal diameter (TrD), and the diameter of the tenth thoracic vertebra between radiographic views (RtL and LeL) of the male (P≥0.05) and female AGs (P≥0.05). However, the mean values of the three parameter, (PCD, TrD, and T10) obtained for the male animals in the RtL and LeL views were consistently significantly different from the means got for the females between the views (P≤0.05).

DIFFERENCES IN SOME THORACIC DIMENSIONS IN RIGHT LATERAL VERSUS LEFT LATERAL VIEWS OF ADULT AND JUVENILE AFRICAN GRASSCUTTERS

In Table II(b), and for each index, the RtL and LeL mean values of postcaval diameter (PCD), tracheal diameter (TrD), and the diameter of the tenth thoracic vertebra (T_{10}) are larger in adults than in juveniles and are significantly varied from each other (P≤0.05). However, the index means in the RtL and LeL thoracic radiographs of either the adults or the juveniles are not significantly different (P≥0.05).

DISCUSSION

Knowledge of the angular relationships or the spatial orientation and positioning of major thoracic organs is important in veterinary medicine, anatomy, and comparative biology. These angular relationships are vital for understanding the anatomy and physiology of thoracic organs, aiding in diagnostic and surgical applications. However, variability exists among species, particularly in livestock and companion animals, highlighting the importance of comparative anatomy in veterinary practice.

The thorax should be examined with a minimum of two orthogonal radiographic projections; but there are circumstances in which the two-orthogonal-projection approach is suboptimal making a three-view thoracic study, using right lateral, left lateral and ventrodorsal or dorsoventral radiographs, the routine standard of investigation in small animal practice (Barthez *et al*., 1994; Ober & Barber, 2006). In the present investigation, the angular recesses studied are only observable in the lateral plane and so the radiographic indices obtained were determined in the right lateral and left lateral views.

The heart and other thoracic organs and structures were displayed in the lateral projections of the grass-cutters. Most of the thoracic anatomic structures were also seen to have assumed angular relationships with one another. For instance, in all the lateral thoracic projections, the heart was normally slanted on its cranial surface to the dorsal board of the sternum forming the sternocardiac sinus (or the cardiac inclination angle, CIA), while the dorsum of the trachea was observed to be inclined to the ventral border of the vertebral column at an angle known as spinotracheal recess (or the tracheovertebral angle, TIA). Equally observed in thoracic silhouettes of the present work were cardiocaval recesses (or angle between the caudoventral surface of the heart and the cranioventral board of the postcaval vein) and cardiophrenic space (the cardiophrenic angle, CPA), which is located in the most inferior aspect of the cranial mediastinum and is bordered by the heart, diaphragm, and thoracic wall (Ferguson and Berkowitz, 2012).

The cardiophrenic space, in normal conditions, is occupied by fat, the amount of which is usually increased in obese animals. However, according to Pineda *et al.* (2007), various types of lesions and radiographic opacities may occur in the cardiophrenic space, including pericardial fat pad, pericardial fat necrosis, mediastinal tumours, pericardial cyst, diaphragmatic hernia, and lymphadenopathy (Pineda *et al*., 2007). Pineda *et al.* (2007) suggested that this fat accumulation correlates with the risk of cardiovascular disease. Inflammatory lesions such as pericardial fat necrosis and tumoral masses are sometimes seen. Lymphoma is a major but not exclusive cause of cardiophrenicadenopathy. Other masses or pseudo masses occurring in this region include pericardial cysts, mediastinal tumours, and diaphragmatic hernia. Computed tomography and magnetic resonance imaging of the thorax are helpful in characterizing cardiophrenic lesions that are usually and initially identified at plain radiography. Reference CPA, as measured in the present report for the AG (Table I a - c), can be used in this species to identify pathological alterations in terms of diameter and angulation of the cardiophrenic space. Scientific information on CPA in animals is not reported yet, but the mean values we determined in the present study, Table I (a), for the RtL (31.10±0.60) and LeL (30.70±0.76) views are not widely different from the result 30^0 documented average healthy men (Armato *et al.*, 1998).

Pectus deformities (pectus excavatum or bulging out of the sternum and pectus carinatum or caving in of the sternum) have been reported in dogs, cats and other animals including man (Suita *et al.*, 2001; Gurkok, *et al.*, 2003). Most pectus anomalies are typically associated with sternal, vertebral and costal defects, attributed to excess traction of the diaphragm during early stages of late intrauterine or early neonatal development. This sternal disorder is associated with varying degrees of local and regional thoracic shape anomaly causing an increase (p. carinatum) or decrease (p. excavatum) in the cardiosternal recess. The cardiosternal angle is also increased or reduced in cardiomegaly or in microcardia (small heart), respectively. Therefore, CIA is clearly useful in the diagnosis of cardiosternal recess size anomalies.

Between the RtL and LeL projections of the grass-cutters used in the present research, (Tables I a - c), there was no significant sexual difference (p≥0.05) in CIA mean values and between adult and juvenile means. Investigations on sternocardiac angles of grass-cutters are either not yet documented or invisible in literature. In the agouti, Diniz*et al.* (2013) reported a CIA value of $21.2±6.4^0$ which is significantly different from the mean value obtained in the present study probably due to species differences. Diniz*et al.* (2013 recorded a significant difference (p≤0.05) between female (22.80±8.50) and male (16.73±7.12) CIA mean values, respectively, contrary to our own observation of absence of statistical difference in sex mean CIA values in the grasscutter.

In Small Animal practice, the application of cardiocaval angle (CCA) as a routine index for cardiothoracic evaluation is either not yet documented or invisible in literature. The mean CCA values established in the present investigation (See Table I a-c.) between right and left lateral views of the pooled samples, sexes (males versus females), and age brackets (adults versus juveniles) were all statistically quite different (p≤0.05) probably due to the influence of the right-sided location of postcaval vein. The lopsided anatomic position of the caudal vena cava may be responsible for the significant differences in the cardiocaval angles observed between the RtL and LeL radiographic views. Klein & Peterson (2010) reported that severe hypovolaemia occasioned by extreme dehydration, acute haemorrhage or Addison's disease usually results reduced heart size and diminished postcaval diameter. Therefore, CCA will probably be a handy guide for the evaluation of cardiovascular size status.

The trachea of AGs forms a relatively straight, slight angulation with the thoracic inlet and the vertebral column. The angle so formed between spine and trachea is tracheovertebral angle or tracheal inclination angle (TIA). Space-occupying lesions within the cranial thoracic cavity will result in an increase or decrease of TIA. In lateral projection, dorsal displacement of the caudal thoracic trachea and carina (tracheal bifurcation) reduces the TIA as seen with (left-sided) cardiomegaly due to left heart failure or endocardiosis. The trachea, situated on top of the left atrium (sitting on the left atrial roof), at the point of the carina, becomes elevated. The trachea loses its normal caudoventral angulation with vertebral column, and may become parallel with the thoracic vertebrae dorsally depending on the severity of the left-sided cardiomegaly, thereby diminishing the TIA. On the other hand, ventral displacement of the trachea may be associated with enlargement of tracheobronchial lymph glands resulting in increased tracheal inclination angle. Other causes of abnormal TIA values include tracheal stenosis, oesophageal enlargement and other space-occupying lesions within the neighbourhood like cervical and precardial mediastinal tumours. The TIA is a useful method for the assessment of the tracheovertebral recess.

Bahr (2013) reported that, in lateral projection, hypertrophic elongation of the left ventricle can lead to elevation of the entire intra-thoracic trachea from the thoracic inlet to the carina, thus reducing the TIA. However, Snyder *et al.* (1990) disclosed that pleural effusion may cause a similar tracheal displacement, at least in cats, even in the absence of significant cardiomegaly. These authors opined that the tracheovertebral angle was therefore not a reliable sign of left ventricular elongation, when the cardiac silhouette is obscured by the presence of pleural fluid.

The mean TIA values between RtL and LeL views of the pooled samples (Table Ia-c) were not significantly varied ($p \geq 0.05$). The male versus female TIA mean values, and in the adults versus juveniles TIA mean results, respectively, were equally not statistically different ($p \geq 0.05$). However, in agouti, a different animal species with different thoracic conformation, Diniz *et al.* (2013) obtained a mean TIA value for males (9.93 ± 3.23^0) which was different from the mean TIA value obtained for females (8.40 ± 0.30^0).

Tracheal enlargement can cause narrowing of the airway, causing a hoarse breathing sound called stridor, or even cause complete blockage (Kuo & Parikh, 2014). Tracheal hypoplasia, tracheal stenosis or tracheal collapse usually causes life-threatening respiratory distress in dogs requiring evaluation and intervention (Ludwig, 2000). Several imaging methods for canine tracheal size evaluation have been documented (Kara *et al.*, 2004; Clarke *et al.*, 2011; Ingman *et al.*, 2014; Montgomery *et al.*, 2015). Thus, radiographic assessment of tracheal diameter was proven to be essential for diagnosing tracheal hypoplasia or stenosis and consequently for the necessity for surgery, as well as for selecting the proper sizes of tracheal stent and endotracheal tube (Nelson, 1993; Fingland *et al.*, 1995). The commonly utilized radiographic procedures included measurement of the TrD at the thoracic inlet (Komsta *et al.*, 2019; Regier, *et al.*, 2020). In the right lateral thoracic projection of non-brachycephalic dogs, Mostafa & Berry (2022) got mean TrDs of 13.4±2.9, 10.6±2.7, and 11.9±3.0 mm at the caudal cervical, thoracic inlet, and intrathoracic levels, respectively, with an average of 11.9±2.8. In the present research, we obtained mean TrD values of 3.65±0.33 mm and 3.63±0.33 mm in the right lateral and left lateral radiographs of the animals studied. Unfortunately, results in the dog cannot be used to compare findings in the AG.

In the present work, mean postcaval diameters (PCD) of 5.39±0.39 mm and 5.38±0.37 mm (range: 3.51- 6.95 mm and 3.52 – 6.65 mm) were obtained in the RtL and LeL projections, respectively (Table IIa). These results do not compare with the mean diametric values (1.20±0.03 cm) established by Ukaha *et al.* (2022c) in both the right and left lateral views of the Nigerian Indigenous Dogs, probably due to the differences between body habituses of the canine and Thryonomys species. According to Lehmukhl*et al.* (1997), the postcaval vein should be considered enlarged if it is consistently larger than 1½ times the diameter of the descending aorta. Again, Root & Bahr (2002) opined that right-sided congestive heart failure should be considered if the caudal vena cava is persistently large. However, if the caval vein is smaller than normal in both lateral and dorsal/ventral projections, or in repeated radiographs, hypovolaemia should be considered. In the dog, Bahr (2013) also found that dilatory cardiomyopathy is often associated with pulmonary oedema secondary to left ventricular failure in addition to radiographic signs of right-sided heart failure which include postcaval distension, hepatic enlargement, and pleural effusion. In other words, variations in PCD are diagnostic of cardiovascular pathology.

In small breed dogs, and probably other small animals, the tenth vertebra (T10) is usually considered and designated as the anticlinal vertebra (*vertebra antinalis*), being the point in the caudal thoracic vertebral column at which vertebral anatomic features change, the spinous process is perpendicular to the body and the preceding vertebrae incline caudally. However, the anticlinal vertebra differs between species and in subspecies (T16 in the horse, T11 in the large or medium dogs, and T11 to T13 in the ox). The intervertebral disc space between T10 and T11 is narrower than adjacent disc spaces in most dogs. The *vertebra antinalis* is used as a point of reference in diagnostic imaging studies (Baines *et al.*, 2009), and so its parametric features should be established to qualify it for use as an anatomic landmark. In the present study, we determined the diameter of the tenth thoracic vertebra in the AG and found that there was no statistical difference ($P \geq 0.05$) between mean diameter values obtained in the RtL versus LeL projection of the AGs (Table II b)

CONCLUSION

The present study has evaluated the radiologic indices used for appraisals of thoracic angular recesses in the African Grasscutter. The evaluated angular recesses and generated indices will be beneficial for clinical and research purposes that concern cardiac conditions in the adult African grasscutter.

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