GROSS MORPHOMETRIC CHARACTERISTICS OF RESPIRATORY ORGANS IN THE SAHELIAN GOATS FOR ASSESSMENT OF LOWER RESPIRATORY DISORDERS

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Received February 08, 2020; Revised March 10, 2020, Accepted March 19, 2020

ABSTRACT

Pulmonary consolidation assessment is relevant in the evaluation of caprine pneumonia especially in resource-poor setting. The study investigates body parameters and gross morphometric characteristics of lungs and trachea, of the Sahelian goat to aid in assessment of lower respiratory conditions. The study utilized 64 healthy (non-pneumonic) lungs collected from Sahelian goats slaughtered at the Kumasi Abattoir. General body characteristics of each animal before and after slaughter; including body length, height at rump and at withers, live weight, whole carcass weight and dressed carcass weight. Morphometric parameters of the lungs and trachea, including weight, length and width of the lungs and of separate lobes, length and width of the trachea, distance between the trachea bronchus and the tracheal bifurcation were measured. The females exhibited higher values of general body characteristics including body length, height, live weight, whole carcass weight and dressed carcass weight. The dimensions of the lungs and trachea were comparatively higher in females than in males. The weights of the whole lung, the right lung and the left lung were all higher in females than in males. The right lung of the Sahelian goat was generally larger and contributes 56.72 % of the whole lung; whilst the left lung contributes 43.22 %. With increasing age, the percentage contribution of the right lung to the whole organ increased whilst that of the left lung decreased. The current study established percentage contribution of lung parts and lobes with reference to the sex and age of Sahelian goat.

Keywords: Sahelian goat, Caprine pneumonia, Respiratory disorders, Lung morphometric

INTRODUCTION

Small ruminants constitute 15.44 % of the livestock population in Ghana (Veterinary Service Directorate, 2013). The population increase of small ruminants from 2009 to 2014 were sheep – 19 % and goats – 30.7 percent; and the average growth rate from 2009 – 2012 was 3.55 for sheep and 5.5 for goats (SRID, 2013). Sheep and goat production are generally widespread in Sub-Saharan Africa because of the low input requirements such as small initial capital, fewer resources and maintenance cost (Kocho, 2011). In most places in West Africa including Ghana, small ruminants not only serve as a source of protein in diets, but also play a major role in the socio-cultural life of the farming communities. Ruminant livestock

comprise a major proportion of the total wealth of the poor families, and are used as payment of dowry, act as a bank and insurance in times of difficulty (Thornton, 2010). In Ghana, sheep and goats are often slaughtered for various occasions and functions such as births, funeral and marriages (Thornton, 2010).

Livestock species populations in Ghana, as of 2014, included 1,657,000 sheep and 4,335,000 goats (SRID, 2013). The production level of small ruminants in Ghana is not enough; and so the country depends on imports of small ruminants from neighbouring countries such as Burkina Faso, Cote D'Ivoire, Mali and Niger.

Popular goat breeds in Ghana include the Sahelian goat also known as *Cheèvre bariolée*, Fulani, Gorane, Nioro, Niafounké, Sahélienne, Sahel, West African Long-legged, Red Sokoto, West African Dwarf and Angora (Wikipedia, 2020). The most common breeds of goat at the Kumasi Abattoir are the Sahelian goat transported mainly from the Northern part of the country and neighboring countries to the abattoir.

Frequently observed lesions in slaughtered small ruminants include abscesses and congestion of the lungs and liver (Ahamad *et al.*, 2016) attributable to strangulation and asphyxia, whilst lung lesion and pneumonia could be due to parasitic, bacterial, mycotic, viral and other infectious agents (Herenda *et al.*, 2000).

Pulmonary consolidation assessment is important in the determination of the severity of caprine pneumonia especially in resource-poor area where pneumonia is assessed grossly. This study evaluates the general body parameters and determines the gross morphometric characteristics of organs of the respiratory system, primarily the lungs and trachea, of the Sahelian goat for assessment of lower respiratory conditions.

MATERIALS AND METHODS

Study Location: The study was conducted at the Kumasi Abattoir Company Limited (KACL), situated on Latitude 6.6506° N and Longitude 1.6061° W in Kaase, a city in Kumasi, Ghana (Frimpong *et al.*, 2012). KACL enclosed in 254 square kilometers is well laid out with a livestock market, kraals and pens, holding pen/lairage, slaughter house, a defunct waste treatment plant and abandoned fish ponds (Frimpong *et al.*, 2014). KACL organizes slaughter of cattle, pigs, sheep and goats for processing and packaging for the Ghanaian market. The original daily slaughtering capacity of the abattoir was 200 cattle, 100 pigs, and 250 sheep and goats. However these numbers are seen to be exceeded in recent times as per records of slaughtered animals at the abattoir.

Animal Species and Breed Used: Sahelian goats of both sexes ranging between 0 and 4.5 years of age were used in the current studies. A total of 64 samples of healthy organs of the respiratory system were collected from freshly slaughtered animals for the study. Age of the animals was estimated by dentition procedure and eruption of permanent incisors (Lasisi *et al.*, 2002), and were confirmed from abattoir records of slaughtered animals. General body characteristics including body length, height at rump, height at withers and heart girth were measured with a measuring tape. Weight of live animals was estimated by using the measured heart-girth and applying the weight chart for goats as prescribed by Bacon (1982). Weight of whole carcass and dressed carcass were determined using a measuring scale.

Sample Collection: Samples of healthy respiratory organs including lungs and trachea (together with the heart in pericardium) were collected from 64 freshly slaughtered goats of Sahelian breed. The samples were labeled at the point of collection and records were appropriately made of the age, sex, weight and other body characteristics. The lungs were inspected to exclude pathological conditions and confirm their non-pneumonic, non-tuberculous, non-emphysematous and non-fibrotic status. The heart and trachea were removed and weighed separately.

The samples were weighed after removal of the heart and trachea to determine the weight of the whole lungs. The right and left lungs were separated and weighed; then the individual lobes were separated and weighed.

Weighing was done using electronic digital scale SF-400 of 10000 g capacity. The following measurements were made using a measuring tape: length and width of each lung lobe, length and width of trachea, distance between trachea bronchus and tracheal bifurcation.

Statistical Analysis: The data was analyzed using Analysis of Variance (ANOVA) and Pearson's Correlation Coefficients. The results were presented as means and standard error of means.

RESULTS

Distribution of Study Animals: A total of 64 Sahelian goats were sampled out of which 34 were males and 30 were females. Four animals were below 2 years of age, 28 were between 2 and 3.5 years and 32 were older than 3.5 years (Table 1).

Table 1: Age and sex distribution of Sahelian goats slaughtered in Kumasi abattoir used in the lung morphometry

Age	Male (bucks)	Female (does)	Total
< 2 years	4	0	4
2 – 3.5 years	22	6	28
> 3.5 years	8	24	32
Total	34	30	64

General Body Characteristics: The current study showed that the females were generally bigger and heavier than the males. General body parameters of the females were higher than those of the males. Values recorded for body length, height at rump and height at withers, as well as heart girth were all higher in females than in males. Records of live weight, whole carcass weight and dressed carcass weight were also higher in the females (Table 2). Live weight, whole carcass weight and dressed carcass weight were higher in older animals. The height of the animals was seen to increase with age; however, the length of the body was highest in animals of the middle age group (between 2 and 3.5 years).

Morphometric Values of the Trachea and Lungs: The results of the study indicated that female goats had longer and wider trachea male goats. The distance from the trachea bronchus to the bifurcation was also longer in the does than in the bucks. The tracheal length and width, as well as the distance between the trachea bronchus and the bifurcation, increase with increasing age and are highest in the oldest age group (>3.5 years) of goats (Table 3).

The study showed that the right lungs were longer than the left lungs. The left cranial lobes were longer than the right cranial lobes, but the two were of about the same width. Amongst the caudal lobes, the left lobes were shorter but wider than the right lobes (Table 3). The lengths of the left cranial lobe, right cranial lobe and the left caudal lobe increase with increasing age and show highest values in the oldest animal group (>3.5 years) (Table 3).

Weight of Lung Lobes: The right lungs were heavier than the left lung in all groups. The caudal lobe had the highest weight, followed by the cranial lobe, the middle lobe and the accessory lobe in that order. The right caudal lobes were heavier than the left caudal lobe and the right cranial lobe had heavier weight than the left cranial lobe (Table 4).

The whole lungs were heavier in females than in males. Both the right lung and the left lung were heavier in females than in males. The same trends of higher values in females were recorded for the weights of the separate lobes. The middle age group of animals (2 – 3.5 years) recorded the highest values in the weight of whole lungs, weights of the right and left halves, and of individual lobes. The weight of whole lungs was relatively higher in the oldest animal group (>3.5 years) than in the youngest (<2 years). The right lung was heavier in the oldest animals (>3.5 years) than in the youngest group (<2 years); the left lung, on the contrary, was found to be slightly heavier in the youngest group than in the oldest (Table 4).

The caudal lobe of both right and left lungs was found to be heavier in the oldest group of animals (>3.5 years) as compared to the youngest group (<2 years).

Table 2: Weight, dressed carcass weight and other morphometric body parameters of Sahelian goats slaughtered in Kumasi abattoir

Weights and morphometric body parameters	Sex			Age		
	Combine sex	Male	Female	>2 years	2-3.5 years	>3.5 years
Body Length (cm)	62.53 ± 5.11	61.66 ± 6.30	63.50 ± 2.97 *	55.88 ± 2.93 [a]	64.44 ± 5.86 [b]	61.99 ± 3.98 [c]
Height at rump (cm)	71.86 ± 3.30	70.88 ± 3.65	72.97 ± 2.43 *	72.39 ± 1.47 [a]	70.29 ± 3.55 [b]	73.17 ± 2.69 [c]
Height at withers (cm)	68.60 ± 2.74	68.09 ± 2.81	69.00 ± 2.61 *	67.94 ± 3.67 [a]	68.59 ± 2.54 [b]	68.85 ± 2.49 [b]
Heart girth (cm)	67.67 ± 4.55	65.15 ± 5.56	69.50 ± 2.30 *	66.04 ± 1.47 [a]	66.95 ± 4.66 [b]	69.25 ± 2.38 [b]
Live weight (kg)	23.38 ± 2.71	22.00 ± 2.06	24.93 ± 2.52 *	20.50 ± 0.58 [a]	22.75 ± 2.10 [b]	24.28 ± 3.01 [c]
Whole carcass weight (kg)	12.47 ± 1.13	12.37 ± 0.97	12.58 ± 1.27 *	12.30 ± 0.58	12.19 ± 0.99	12.73±1.26
Dressed carcass weight (kg)	10.41 ± 1.01	10.23 ± 0.81	10.60 ± 1.15	9.80 ± 0.11 [a]	10.19 ± 0.93 [b]	10.70 1.08 [b]

**Significant means tested by t-test. Same superscript in the same row indicates that the mean differences between the general body parameters for age group were not significantly different at P>0.05*

Table 3: Linear measurements of the trachea and lung lobes of Sahelian goats slaughtered in Kumasi abattoir

Organs	Dimension of Organs (cm)					
	Sex			Age		
	Combine sex	Male	Female	<2 years	2 – 3.5 years	>3.5 years
Trachea Length	25.13 ± 2.11	24.42 ± 1.66	25.93 ± 2.26 *	23.83 ± 1.22 [a]	24.63 ± 1.64 [b]	26.13 ± 2.19 [c]
Trachea Width	1.93 ± 0.21	1.86 ± 0.20	2.26 ± 0.21 *	1.83 ± 0.12 [a]	1.87 ± 0.93 [a]	2.01 ± 0.20 [b]
Trachea bronchus to bifurcation	3.45 ± 0.77	3.37 ± 0.66	3.53 ± 0.88 *	3.08 ± 0.78	3.60 ± 1.70	3.62 ± 0.72
Left Cranial Lobe, Length	14.37 ± 2.39	13.56 ± 2.57	15.29 ± 1.77 *	12.93 ± 2.05 [a]	14.33 ± 5.61 [b]	15.29 ± 2.30 [c]
Left Cranial Lobe, Width	5.66 ± 1.22	5.26 ± 1.20	6.11 ± 1.08	5.46 ± 1.30	5.05 ± 2.71	6.01 ± 1.18
Left Caudal Lobe, Length	14.47 ± 1.76	13.91 ± 1.64	15.11 ± 1.68 *	13.73 ± 1.38 [a]	13.93 ± 5.89 [a]	15.13 ± 1.64 [b]
Left Caudal Lobe, Width	8.60 ± 0.98	8.85 ± 0.82	8.32 ± 1.07	8.83 ± 0.82	8.90 ± 4.01	8.34 ± 0.98
Right Cranial Lobe, Length	12.02 ± 1.65	11.71 ± 1.56	12.38 ± 1.68	11.97 ± 1.63	10.85 ± 5.55	12.49 ± 1.69
Right Cranial Lobe, Width	5.94 ± 1.19	5.95 ± 1.29	5.94 ± 1.08	5.94 ± 1.40	5.42 ± 2.27	6.14 ± 1.05
Middle Lobe, Length	10.67 ± 2.35	10.53 ± 2.32	10.82 ± 2.39	10.69 ± 1.97	9.98 ± 5.80	10.91 ± 2.53
Middle Lobe, Width	4.59 ± 0.94	4.30 ± 0.90	4.92 ± 0.87	4.49 ± 0.90	4.08 ± 2.34	4.84 ± 0.86
Right Caudal Lobe, Length	14.63 ± 2.30	13.78 ± 1.65 *	15.59 ± 2.55	13.91 ± 1.51 [a]	14.83 ± 7.09 [b]	15.01 ± 1.73 [c]
Right Caudal Lobe, Width	8.07 ± 1.40	7.99 ± 1.57	8.17 ± 1.18 *	8.59 ± 1.60	7.77 ± 3.85	7.86 ± 1.15
Accessory Lobe, Length	6.53 ± 0.98	6.30 ± 0.86	6.79 ± 1.03	6.16 ± 0.80	6.28 ± 2.77	6.86 ± 1.03
Accessory Lobe, Width	4.17 ± 0.73	4.24 ± 0.66	4.09 ± 0.79	4.12 ± 0.71	3.98 ± 1.78	4.27 ± 0.73

**Significant means tested by t-test. Same superscript in the same row indicates that the mean differences between the general body parameters for age group were not significantly different at P>0.05*

Table 4: Weight of the lungs and morphometry of different lobes of Sahelian goats slaughtered in Kumasi abattoir

Lungs	Weight of Lungs (g)					
	Sex			Age		
	Combine sex	Male	Female	Age < 2 years	Age 2-3.5 years	Age >3.5 years
Whole Lung	210.83 ± 19.30	178.33 ± 12.92	243.33 ± 41.15 *	190.33 ± 38.89	297.03 ± 21.15 [a]	198.53 ± 37.51
Right Lung	119.50 ± 25.01	101.02 ± 4.97	138.03 ± 23.28 *	106.33 ± 2.62	167.04 ± 14.98	115.51 ± 21.52
Right Cranial Lobe	31.50 ± 5.99	27.67 ± 2.05	35.33 ± 6.18 *	29.33 ± 0.94	44.02 ± 7.32 [a]	28.53 ± 3.51
Right Middle Lobe	13.00 ± 1.83	13.00 ± 1.41	13.02 ± 2.16 *	12.33 ± 2.05	15.03 ± 1.92 [a]	13.00 ± 10
Right Caudal Lobe	69.17 ± 16.13	56.00 ± 1.63	82.33 ± 13.07 *	60.00 ± 4.32	98.01 ± 1.45 [a]	68.52 ± 14.53
Accessory Lobe	6.17 ± 2.48	4.67 ± 0.94	7.67 ± 2.62 *	4.67 ± 0.94	10.04 ± 1.02 [a]	6.51 ± 2.52
Left Lung	91.33 ± 20.45	76.67 ± 8.58	106.04 ± 18.24 *	84.00 ± 4.97	131.01 ± 19.87 [a]	82.50 ± 16.50
Left Cranial Lobe	25.67 ± 6.82	25.33 ± 7.41	26.02 ± 6.16	28.00 ± 4.97 [a]	34.03 ± 5.26 [b]	18.01 ± 1.03 [c]
Left Caudal Lobe	65.33 ± 16.89	51.67 ± 2.05	79.03 ± 13.88 *	56.00 ± 4.32 [a]	96.04 ± 3.78 [b]	64.03 ± 15.04 [c]

**Significant means tested by t-test. Same superscript in the same row indicates that the mean differences between the body parameters for age group were not significantly different at P>0.05*

However, whilst the right cranial lobe was about same between the two extreme age groups, the left cranial lobe was found to be significantly heavier in the youngest group (<2 years) as compared to the oldest group of animals (>3.5 years)

Percentage Contribution of Separate Lung Lobes: The right lung contributed 56.72 % of the whole lung; whilst the Left Lung contributed 43.22 %. Out of the 56.72 % contributed by the right lung, separate contributions of the individual lobes were as follows: right cranial lobe – 15.03 %; right middle lobe – 6.32 %; right caudal lobe – 32.70 %; accessory lobe – 2.85 %. Out of the 43.22 % contribution by the left lung, the left cranial and left caudal lobes separately contributed 12.36 % and 30.74 % respectively.

Influence of Sex: The current study shows that females have higher values than males in absolute and lobular portions of the lungs. Both the right and left lungs are heavier in females than in males. All lobes of the lung recorded values ranging from very to slightly significantly heavier in females than in males (Table 5).

Influence of Age: The results of this study showed that the lung increases in weight with increasing age, and attained peak weight in middle age, and then begins to decline in weight. Animals within the middle age range of 2 – 3.5 years had the highest weights of the whole lung, the right and left lungs and the individual lobes. The lungs of animals older than 3.5 years were heavier than those of animals below 2 years.

The percentage contribution of the right lung increased, whilst that of the left lung decreased, with increasing age. Considering the contribution of the individual lobes, the right cranial lobe and middle lobe decreased in percentage contribution both to the whole lung and the right lung. With increasing age, the left cranial lobe showed a decrease, whilst the left caudal lobe increased in their respective percentage contributions to the left lung and the whole lung (Table 5).

DISCUSSION

The results showed that amongst the goats encountered at the KACL, females recorded higher values in all the general body parameters including body length, height, live weight, whole carcass weight and dressed carcass weight. This observation was in contradiction with the accepted norm, whereby bucks are generally expected to record higher values in height and weight than does (Frimpong *et al.* 2012), and this can be explained by the fact that there were notably more young males than females amongst goats slaughtered at KACL. Even though slightly more males were sampled than females in the current study, it was significantly obvious that majority of goats in the youngest age group (<2 years) were bucks whilst the oldest age group (>3.5 years) comprised mostly of does. In livestock management, farmers prefer to send bucks for slaughter at a lower average age than does, which are kept for purposes of reproduction (Frimpong *et al.* 2012; Atawalna *et al.*, 2013).

The height of the animals, especially at the rump, as well as live weight, whole carcass weight and dressed carcass weight were seen to increase with increasing age (Adeyinka and Mohammed, 2006) and attained highest values in the oldest animal group (>3.5 years). However, the length of the body was seen to increase with age to its highest value in animals of the middle age group (between 2 and 3.5 years) and decline to the least in the oldest animals (>3.5 years) (Adeyinka and Mohammed, 2006).

The current study confirmed a greater contribution of the right lung than the left lung to the total lung weight. The study also showed that the percentage contribution of the right lung increased whilst that of the left lung decreased with increasing age. These findings were in agreement with results of similar studies in other breeds of goats by Mohammed and Al-Sultan (2018) and Aghogho *et al.* (2019) who concluded that this may be underlying cause for the severe prognosis of pneumonia in young animals.

Table 5: Percentage contribution of different lobes in Sahelian goats slaughtered in Kumasi abattoir

Lungs	Contribution of Individual Lobes (%)					
	Sex			Age		
	Combine sex	Male	Female	< 2 years	2 – 3.5 years	>3.5 years
Right Lung Portion of Whole Lung	56.72	56.74	56.71	55.89	56.23	58.22[a]
Cranial lobe portion of whole lung	15.03	15.53	14.53	15.43	14.81	14.54
Cranial lobe portion of right lung	26.51	27.37	25.66	27.60[a]	26.35	24.98
Middle lobe portion of whole lung	6.32	7.29 *	5.35	6.49	5.05	6.69
Middle lobe portion of right lung	11.15	12.86 *	9.43	11.64 [a]	8.98 [b]	11.49 [a]
Caudal lobe portion of whole lung	32.70	31.51	33.89 *	31.49	33.00	34.35
Caudal lobe portion of right lung	57.63	55.51	59.76 *	56.36	58.68	59.02
Accessory lobe portion of whole lung	2.85	2.62	3.07	2.47	3.37	3.15
Accessory lobe portion of right lung	5.00	4.61	5.40	4.41	5.99	5.41
Left Lung Portion of Whole Lung	43.22	42.87	43.58	44.10	44.11	41.47
Cranial lobe portion of whole lung	12.36	13.99	10.73	14.70 [a]	11.45 [b]	9.30 [c]
Cranial lobe portion of left lung	28.45	32.39 *	24.52	33.27 [a]	25.95 [b]	22.47 [c]
Caudal lobe portion of whole lung	30.74	29.06	32.42 *	29.41 [a]	32.32 [b]	31.95 [b]
Caudal lobe portion of left lung	68.91	68.05	74.51 *	66.78 [a]	73.28 [b]	77.02 [b]

**Significant means tested by t-test. Same superscript in the same row indicates that the mean differences between the body parameters for age group were not significantly different at P>0.05*

The study showed a persistent pattern of a trachea bronchus branching off to the right cranial lobe at a significant distance before the bifurcation of the trachea into right and left principal bronchi. This distance which was slightly greater in females than in males, and was also shown to increase with increasing age, confirms findings by other researchers in similar works and the inference of possible earlier damage to the right cranial lobe in case of entry of pathogenic agents through the respiratory tract before other lobes could be affected (Emikpe and Akpavie, 2011).

Conclusion: The current study affirmed the effect of sex and age on general body parameters of the Sahelian goat. The results also confirmed that sex and especially age, to a larger extent, had significant effect on the size and weight of organs of the respiratory system as well as the percentage contribution of each lung lobe to the total lung weight. Results of this study and proper evaluation of the morphometric characteristics of organs of the respiratory system can serve as basis for assessment of pathological conditions of the trachea, bronchi and lungs in the Sahelian goat.

ACKNOWLEDGEMENTS

The staff of Kumasi Abattoir Company Limited are appreciated for their assistance in the collection of lung samples used in the study.

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