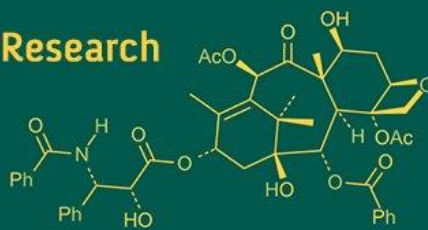


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Gross morphology, morphometry and histomorphology of the adrenal gland in lactating and non-lactating Kosali cow

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Abstract

The present study was conducted on adrenal glands of twelve Kosali cows of lactating and non-lactating stages having 6 animals in each. Glands were located retroperitoneally in abdominal cavity. Left adrenal gland was comma or "C" shaped and located 5-6 cm. cranial to the left kidney while right gland was heart shaped and located 1-2 cm. from the right kidney. Left adrenal gland was heavier and voluminous in both lactating and non-lactating stages. Weight, volume, borders, perimeter, length, width and thickness of left adrenal glands were non-significant for left adrenal gland. While length, perimeter, cranial width and cranial thickness were significantly higher in right adrenal of lactating stage. Thickness of capsule was minimum in non-lactating left adrenal gland and maximum in left lactating adrenal gland. Cortical thickness was higher than medullary thickness and it was non-significantly higher in lactating stage. Cells of zona glomerulosa varied from round oval to polyhedral shape and arranged in irregular manner. The zona fasciculata was the widest zone with cuboidal cell having lighter nuclei than zona glomerulosa. The polyhedral cells of zona reticularis formed the irregular network. The cells of the medulla were granular in appearance and divided into outer dark and inner lighter stained cells.

Keywords: Gross anatomy, histoarchitecture, Kosali cow, lactating stage, non-lactating stage, adrenal gland

Introduction

Livestock play an important role in the agricultural and rural economy of India by providing milk, manure, draught power and employment to farming communities. India possesses a rich diversity of livestock genetic resources with nearly forty recognized breeds of cattle. In the state of Chhattisgarh, livestock rearing is an integral component of the mixed farming system and is closely associated with the socio-economic and cultural life of rural people (Jain *et al.*, 2018) ^[1].

Kosali cattle represent the first registered indigenous breed of Chhattisgarh and have been recognized as the 36th cattle breed of India (Accession No. INDIA CATTLE 2600 KOSALI 03036). The breed derives its name from "Kowshal," the ancient name of the central region of Chhattisgarh. Kosali cattle have evolved over generations under the local agro-climatic conditions and are known for their heat tolerance, adaptability and resistance to diseases (Jain *et al.*, 2017) ^[2]. They are mainly distributed in the Central Plain Region of the state, covering about 68.49 lakh hectares across fifteen districts, with an estimated population of about 31.32 lakh animals (Jain *et al.*, 2018) ^[1]. The breed is traditionally maintained by farming communities such as the Yadava and Rawuth.

Endocrine glands play a vital role in regulating various physiological processes through the secretion of hormones directly into the bloodstream. These hormones regulate metabolism, growth, reproduction and maintenance of homeostasis in animals (Kumar *et al.*, 2018) ^[3]. Among these glands, the adrenal glands are of particular importance as they produce hormones essential for metabolic regulation, stress response and electrolyte balance.

The adrenal cortex secretes mineralocorticoids, glucocorticoids and androgens, which regulate electrolyte balance, carbohydrate metabolism and protein metabolism, respectively, while the adrenal medulla produces catecholamines such as adrenaline and noradrenaline that

influence cardiovascular activity and stress adaptation (Hullinger and Andrisani, 2006 ^[4]; Greco and Stabenfeld, 2007 ^[5]). These hormones are closely associated with physiological processes such as parturition, lactation and stress response in farm animals.

Considering the economic importance of Kosali cattle and the vital physiological role of adrenal hormones in productivity and metabolic regulation, the present study was undertaken to investigate the gross anatomical and histoarchitectural features of the adrenal glands in Kosali cattle.

Materials and methods

The present study was conducted on adrenal glands of twelve Kosali cows. Samples were collected from freshly dead Kosali cows from Rajnandgaon, Durg and Balod, districts of Chhattisgarh. Animals were divided into lactating and nonlactating groups. The adrenal glands were collected in 10% neutral buffered formalin. Biometrical parameters were recorded. The tissue samples were processed and stained by routine method. Micrometry of stained section was done with the help of Labovision KXi2000 photomicroscope. Obtained parameters were statistically analyzed as per standard statistical method.

Results and Discussion

Gross morphology

Right and left adrenal glands were located retroperitoneally in abdominal cavity, however, Barszcz *et al.* (2016) ^[6] have reported location of adrenal glands is intraperitoneally in European bison. In present study right adrenal gland was located at the level of 10-11 intercostal space, 9-10 cm below the transverse process of thoracic vertebrae on right side of median plane and 1-2 cm cranial to the right kidney. Right adrenal gland was anteriorly covered by caudate lobe

of the liver. Right adrenal gland was laterally flattened, heart shaped gland having two surface and three borders viz. dorsal, ventral and caudal with cranial pointed apex. Lateral surface was related with cranial extremity of right kidney. Lateral surface was related to caudal vena cava marked by a groove at the middle of this surface. The medial surface of the right adrenal gland was convex and in close apposition with the right crus of the diaphragm. Dorsal border was longest and related with caudate lobe of liver. Ventral border was shortest and related with posterior vena cava. Present topographical findings corroborated the observations of Konig and Liebich (2004) ^[7], Ye *et al.* (2017) ^[8] and Sharma (2019) ^[9].

Left adrenal gland was roughly comma or C-shaped, situated at 5-6 cm anterior to cranial pole of the left kidney and its long axis was directed cranially and ventrally. It was located at the level of 11th to 12th intercostal space and 12-13 cm below the transverse process of thoracic vertebrae. It had two extremities, two borders and two surfaces. Right surface was related to beginning of jejunum coil and left surface was attached with dorsal sac of rumen. Dorsal border was placed along the caudal vena cava and was convex, also related with beginning of left renal vessels. Ventral border was notched. The position of notch varied from cranial third to caudal third and it was of variable depth. Cranial extremity was conical shaped and bluntly pointed. Caudal extremity was rectangular, broad and flattened. Hilus was present on right surface at cranioventral part. However Left adrenal gland was C-shaped in Jaffarabadi buffalo (Sharma *et al.*, 2020) ^[10], V-shaped in Nili Ravi buffalo (Hussain *et al.*, 2006) ^[11], and oval shaped in camel by Abubakar (2015) ^[12]. Topographical findings were similar to previous observations of Venzke (1975) ^[13] in ruminants and Sharma (2019) ^[9] in Jaffarabadi buffaloes.

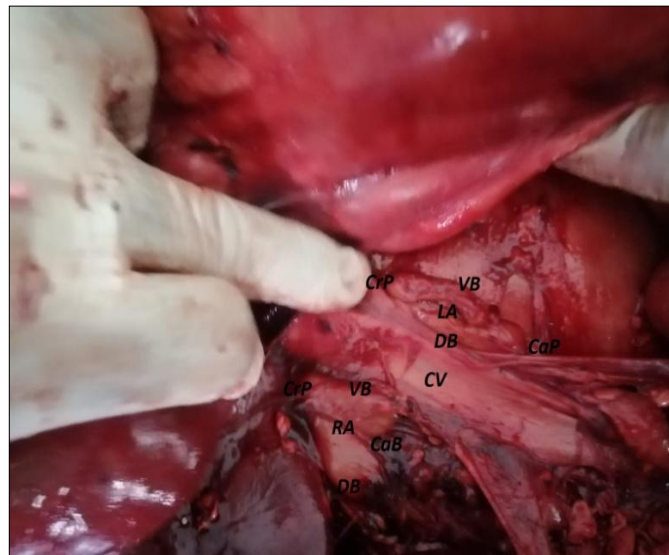


Fig 1: In situ photograph showing right adrenal

The topographic position and shape of adrenal gland did not show any distinguishable differences during lactating and nonlactating stage, However Joshi (2016) ^[14] and Sharma (2019) ^[9] reported seasonal effect in position, shape, colour and topography of the adrenal glands in goats and buffalo respectively.

The mean weight of right and left adrenal of non-lactating Kosali cow was 5.26 ± 0.29 and 5.78 ± 0.42 gm

respectively, while lactating group showed higher and non-significant value viz. 6.42 ± 0.51 and 8.05 ± 0.44 in right and left adrenal respectively. Volume also showed higher value in lactating stage than in non-lactating stage. The recorded weight and volume of left adrenal gland were comparatively higher than right adrenal gland in both the groups. The present study supports the findings of Venzke (1975) ^[13] in cattle and Ye *et al.* (2017) ^[8] in Bactrian camel.

However Sharma (2019) ^[9] reported that the weight of both adrenal glands was maximum during rainy season in

comparison to summer and winter.

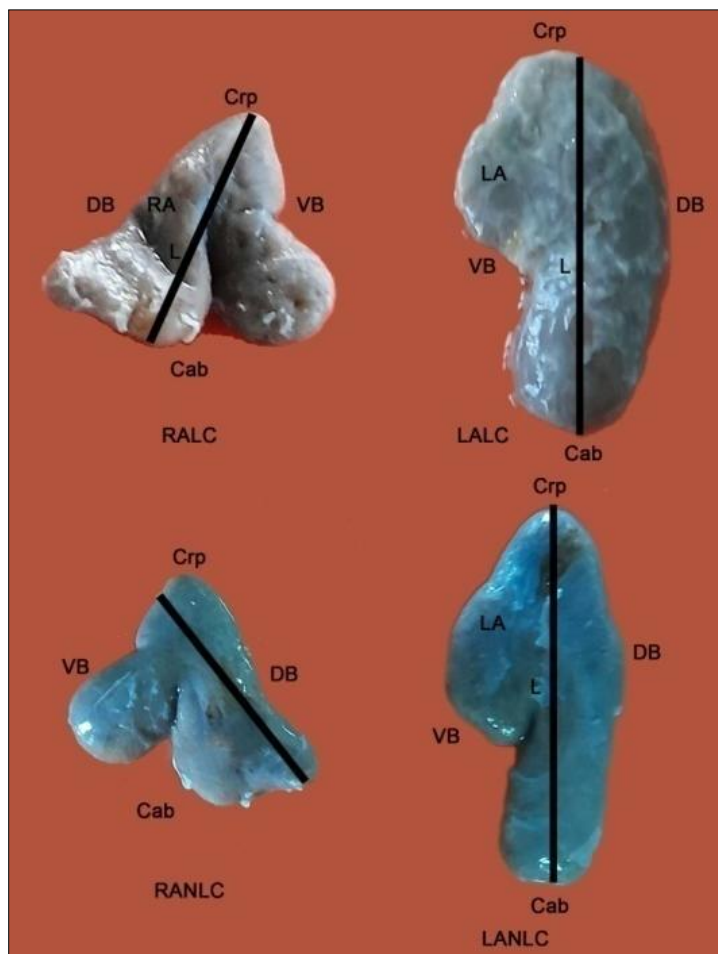


Fig 2: Photograph of right and left adrenal gland

Recorded length of right adrenal gland was significantly higher in lactating stage than non-lactating stage. The ratio of length between lactating and non-lactating stage was 2.50: 3.0. Whereas, the length in lactating stage was higher in decimal value in left adrenal gland and was not significant. Recorded length of left adrenal gland was more than right adrenal gland. While length of right and left adrenal gland was 6.69 ± 0.09 cm. and 6.85 ± 0.10 cm respectively in Nili Ravi buffalo (Hussain *et al.*, 2006) ^[11]. Sharma (2019) ^[9] reported slightly shorter right adrenal gland than the left in Jaffarabadi buffalo.

Recorded width of right adrenal gland was maximum at caudal end and it was 2.93 ± 0.23 cm. for non-lactating and 3.20 ± 0.58 for lactating group. While width of left adrenal gland was maximum at middle and it was 2.33 ± 0.10 cm. and 2.60 ± 0.18 cm. for non-lactating and lactating group respectively. Cranial width of lactating Kosali cow was significant. The borders of right (dorsal, ventral and caudal) and left (dorsal and ventral) adrenal gland was longer in lactating stage and was non-significant. Perimeter of right adrenal gland was significantly higher in lactating stage whereas it was non-significant for left adrenal gland.

Left and right adrenal glands were thickest at mid region in both the groups. Maximum thickness of the left adrenal gland was 1.08 ± 0.09 cm for non-lactating and 1.14 ± 0.05 cm. for lactating left adrenal gland. Maximum thickness of right adrenal gland was 1.16 ± 0.04 cm. and 1.18 ± 0.04 cm. for non-lactating and lactating stage respectively. Cranial

thickness of right adrenal gland was significantly higher in lactating stage than in non-lactating stage. Right adrenal gland was thicker than left adrenal gland in both groups. Present findings are supported by the report of Ye *et al.* (2017) ^[8] in Bactrian camel and Sharma (2019) ^[9] in Jaffarabadi buffalo.

The values of cross sectional area of right and left adrenal gland were non-significant and higher in lactating stage. It was maximum in right adrenal gland of lactating stage followed by non-lactating right adrenal, lactating left adrenal and non-lactating left adrenal gland.

Histomorphology

Histoarchitectural organization of the gland consisted of peripheral large cortex and small inner medulla, which was similar to the previous description of to the adrenal gland of Kuehnelt (2003) ^[15], Hullinger and Andrisani 2006 and Ye *et al.* (2017) ^[8]. Adrenal cortex was divided into three zones on the basis of morphology of cells, their arrangement and the staining characteristics as outermost narrow zona glomerulosa, intermediate zona fasciculata and zona reticularis was similar to the findings of Barszcz *et al.* (2016) ^[6] in European bison and Sharma (2019) ^[9] in Jaffarabadi buffalo. In contrast to the present findings, an additional zona intermedia was reported between zona glomerulosa and zona fasciculata by Hullinger and Andrisani (2006) ^[6] and Ye *et al.* (2017) ^[8]. The adrenal cortex constituted the outer largest part of the adrenal glands.

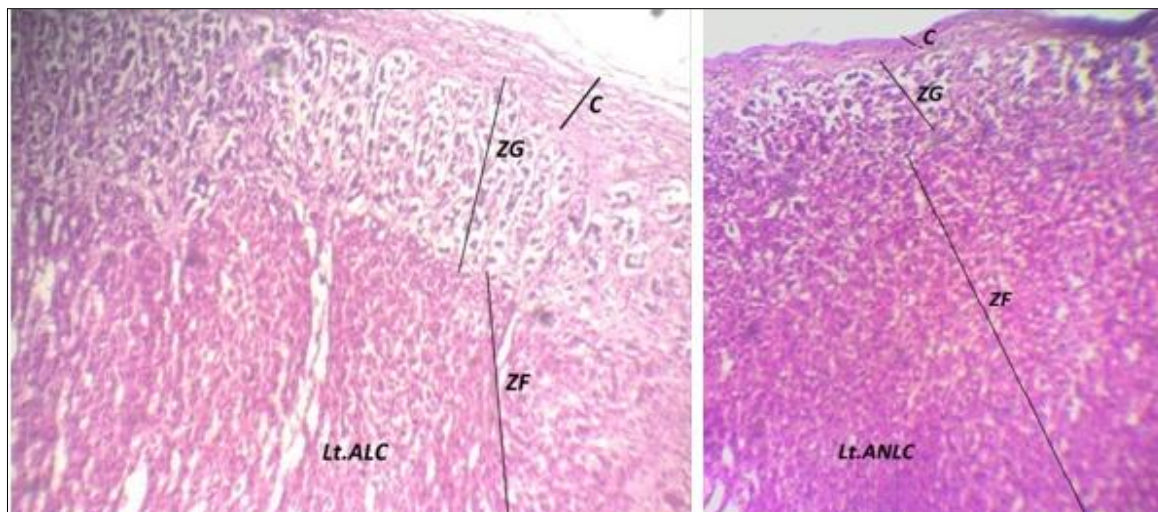


Fig 3: Photomicrograph of adrenal gland in lactating Kosali cow

Thickness of capsule was minimum ($20.17 \pm 1.78\mu\text{m}$) in non-lactating left adrenal gland and maximum ($33.17 \pm 6.36\mu\text{m}$) in left lactating adrenal gland and it was non-significant in both right as well as in left adrenal gland. The outer adrenal cortex surrounded the medulla. Cortical thickness was higher than medullary thickness. Cortical thickness in non-lactating left adrenal gland was minimum ($712.00 \pm 77.01\mu\text{m}$) and maximum in lactating left adrenal gland ($1016.17 \pm 133.04\mu\text{m}$). The recorded cortical thickness was non-significant. Present recorded thickness was less than the findings of Sharma (2019) [9] in Jaffarabadi buffalo.

Cells of zona glomerulosa varied from round oval to polyhedral shape and arranged in irregular manner. The nuclei of the zona glomerulosa cells were deeply stained which supported the findings of Kuehnelt (2003) [15]. Recorded thickness of zona glomerulosa was more in lactating stage and non-significant. It was minimum in right adrenal gland in non-lactating stage and maximum in left adrenal gland lactating stage. The cells of widest zone - zona fasciculata were cuboidal with lighter nuclei than zona glomerulosa. The cells were mostly arranged in columns with one cell thick. In some places cells were present in the

form of round aggregations. Recorded thickness of zona fasciculata was higher in lactating adrenal gland and was maximum in lactating left adrenal gland. The polyhedral cells of zona reticularis were arranged in anastomosing cords and formed irregular network support the findings of Kuehnelt (2003) [15] and Hullinger and Andrisani, (2006) [4]. No significant difference in thickness of zona reticularis was observed in both the glands in present study.

The cells of the medulla were large dark polyhedral shaped in outer layer and smaller lighter in inner lighter layer. The cells were granular in appearance. The large ganglionic cell with colloid was apparently observed. Trabecular and muscular veins were seen. Apparently no remarkable differences were observed in histoarchitecture of lactating and non-lactating Kosali cows. Histoarchitectural findings were similar to the previous observations of medulla by Barszcz *et al.* (2016) [6], Ye *et al.* (2017) [8] and Sharma (2019) [9]. Thickness of medulla was more in lactating stage than non-lactating stage in right as well as in left adrenal gland. Recorded medullary thickness was minimum in non-lactating left adrenal gland and maximum in left lactating adrenal gland.

Table 1: Mean $\pm$ SE of gross parameter of left and right adrenal gland of lactating and non-lactating Kosali Cow

S. No.	Parameters	Left adrenal gland		Right adrenal gland	
		Non-lactating	Lactating	Non-lactating	Lactating
1	Weight (g)	5.78 ± 0.42	8.05 ± 0.44	5.26 ± 0.29	6.42 ± 0.51
2	Volume (cc)	6.17 ± 0.60	8.08 ± 0.66	5.17 ± 0.31	6.83 ± 0.60
3	Length (cm)	5.12 ± 0.11	5.20 ± 0.21	2.82 ± 0.23	$3.35 \pm 0.04^*$
4	Maximum middle width (cm)	2.33 ± 0.10	2.60 ± 0.18	2.93 ± 0.23	3.20 ± 0.58
5	Ventral border (cm)	4.43 ± 0.06	5.18 ± 0.08	2.30 ± 0.09	2.82 ± 0.15
6	Dorsal Border (cm)	4.83 ± 0.14	4.95 ± 0.13	1.20 ± 0.10	$1.59 \pm 0.25^*$
7	Perimeter (cm)	12.55 ± 0.29	13.00 ± 0.24	3.95 ± 0.53	4.03 ± 0.24
8	Cross sectional area (mm^2)	203.17 ± 18.55	205.17 ± 19.40	2.37 ± 0.28	2.65 ± 0.28
9	Cranial thickness (cm)	0.77 ± 0.02	0.98 ± 0.07	2.55 ± 0.29	3.37 ± 0.10
10	Middle thickness (cm)	1.08 ± 0.09	1.14 ± 0.05	10.85 ± 0.75	$11.22 \pm 0.26^*$
11	Caudal thickness (cm)	0.94 ± 0.08	0.97 ± 0.10	221.50 ± 9.54	279.67 ± 29.23

Mean values with (*) superscripts show significant different ($p < 0.05$)

Legends of photograph

- Fig 1:** In situ photograph showing right adrenal (RA), cranial pole (CrP), caudal border (CaB), dorsal border (DB), ventral border (VB), caudal venacava (CV), left adrenal (LA) and its cranial pole (CrP), caudal pole (CaP), dorsal border (DB), ventral border (VB) of non-

lactating Kosali cow

- Fig 2:** Photograph of right and left adrenal gland, showing the length (dark line), cranial pole (Crp), caudal border (Cab), dorsal border (DB), ventral border (VB), right adrenal (RA), left adrenal (LA), caudal pole

(Cap), in non-lactating (RANLC and LANLC) and lactating (RALC and LALC) Kosali cow

- **Fig 3:** Photomicrograph of left adrenal gland in lactating Kosali cow (Lt.ALC) and non-lactating Kosali cow (Lt.ANLC) showing capsule (C), zona glomerulosa (ZG) and zona fasciculata (ZF) (H&E, 200X)

Conclusion

The present study provides a detailed account of the gross morphology, morphometry and histomorphology of the adrenal glands in lactating and non-lactating Kosali cows. Both adrenal glands were located retroperitoneally in the abdominal cavity and exhibited distinct asymmetry in shape and position. The right adrenal gland was heart-shaped and situated slightly cranial to the right kidney, whereas the left adrenal gland was comma or C-shaped and positioned cranially to the left kidney with its long axis directed cranio-ventrally. The topographical relationships of the glands with adjacent organs such as the liver, rumen, caudal vena cava and kidneys were consistent with earlier reports in ruminants. No marked differences in the position or general morphology of the adrenal glands were observed between lactating and non-lactating cows.

Morphometrical observations revealed comparatively higher weight, volume and dimensions of adrenal glands in the lactating stage, although most parameters showed non-significant differences. The left adrenal gland generally exhibited greater weight and length, whereas the right gland was relatively thicker. Histologically, the adrenal gland consisted of an outer cortex and inner medulla. The cortex was differentiated into zona glomerulosa, zona fasciculata and zona reticularis with typical cellular arrangement. Although cortical and medullary thickness tended to be higher during lactation, the overall histoarchitecture remained similar in both physiological stages.

Thus, the adrenal glands of Kosali cows demonstrate typical ruminant morphology with minor morphometric variations during lactation, while maintaining a consistent structural organization.

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