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Biometric and ultrasonographic evaluation on mammary gland of goat

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ABSTRACT

Gross and ultrasonographic studies were conducted on the mammary gland of goat (n=18 for each study) during pre-pubertal, lactating and non-lactating stages. Mammary gland was located into the inguinal region and divided into two halves by mammary groove which was prominent during lactation stage. Each halve had separate glandular body and conical teat divisible into tip, mid and base regions. The mammary gland contained numerous lactiferous ducts which opened into the gland sinus that continued distally as teat sinus and teat canal. The gland sinus and teat sinus were separated from each other by annular folds, which were more prominent in lactating animals. At the junction of teat sinus and teat canal, small mucosal elevation was observed as Furstenberg's rosette. Teat wall was lined by skin, teat internal mucosal layer and teat sinus from outside to inside. Ultrasonographic observations showed that the lactating mammary gland contained an echogenic structure of variable size indicating gland sinus, lactiferous ducts, blood vessels, glandular parenchyma, while the homogenous echogenic component depicting more connective tissue stroma in non-lactating and pre-pubertal goat. The teat wall was made up of innermost hyperechogenic layer (teat mucosa), middle hypoechogenic (fibromuscular) layer and mild hyperechogenic teat skin. Teat sinus was anechogenic, however teat canal was demarcated by hyperechogenic streak. Biometrical and ultrasonographic observations were recorded on teat canal length, maximum diameter of teat, maximum teat wall thickness. Present study showed that there was no significant difference in biometric and ultrasonographic measurements of goat teat. Therefore, it may be concluded that the gross and ultrasonographic observations may be used to diagnose any abnormality in the udder during clinical examination.

Keywords: Goat, Gross, Mammary gland, Ultrasonography

The small ruminants play an important role in milk production. Because of its ease to rear for the landless and poor farmers, goat is considered as Poor man's cow. According to BAHS (2019), the total goat population was 148.48 million which contributes 27.7% of the total livestock population. The goat milk and other goat-derived products are in tremendous use now-a-days, as it consists of several bioactive compounds which are beneficial for human consumption during various chronic illness (Lima *et al*. 2018). The goat milk has higher nutritive value and is easily digestible as compared to cow milk. The quality and quantity of milk is directly dependent on the health status of the mammary gland. Ultrasonography is the quick and fast method to determine the internal anatomy of the udder which can be used to diagnose any diseased condition of udder and teat (Franz *et al.* 2009). Keeping in view the above parameters, the present study was undertaken to provide the basic information on the gross morphometric and ultrasonographic measurements on the mammary gland of pre-pubertal, lactating and non-lactating goats.

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MATERIALS AND METHODS

For gross morphological studies, the mammary gland from 18 goats were collected from the slaughterhouse and post-mortem house. The animals were grouped as pre-pubertal, lactating and non-lactating (n=6 from each groups). After fixation of the tissue in 10% NBF, the gross morphological observations were recorded on shape of udder and teat, lactiferous sinus, gland and teat sinus, annular folds, Furstenberg's rosette and teat canal of different age groups. The biometric observations were recorded on the left and right teats (Fig. 1) as teat length, teat diameter at base, teat diameter at mid, teat diameter at tip, teat canal length, teat wall thickness at base, teat wall thickness at mid, and teat wall thickness at tip. The length of teat and teat canal was measured by using scale and inelastic thread, but the diameter and thickness at different regions of teat were recorded with the help of Vernier callipers.

Ultrasonograpic observations were recorded on mammary gland and teat of 18 goats during pre-pubertal, lactating and non-lactating stages available at Goat Farm, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. The B-Mode 2D ultrasonography was done by using linear transducer with 7.5 to 12.5 MHz

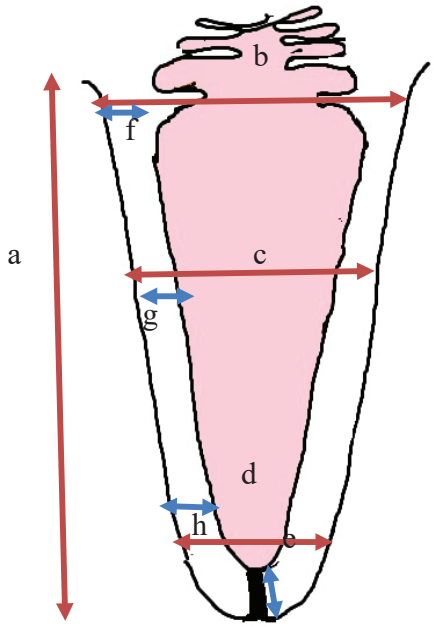

Fig. 1. Schematic diagram showing different sites for biometric observations in goat teat. Teat length (a), teat diameter at base (b), teat diameter at mid (c), teat diameter at tip (d), teat canal length (e), teat wall thickness at base (f), teat wall thickness at mid (g), teat wall thickness at tip (h).

to examine the mammary gland in standing position on non-slippery surface. Echogenicity was observed in different age groups. The udder was examined transversely by direct contact method and teat was examined longitudinally by water bath method while keeping the transducer vertically to examine the long axis of teat.

Ultrasonographically, the size of alveoli, blood vessels, gland sinus, teat sinus, annular folds, Furstenberg's rosette and teat canal at different stages were studied. Measurements were recorded for Teat canal length, Maximum diameter of teat, Maximum diameter of teat sinus, Maximum teat wall thickness and Teat diameter at Furstenberg's rosette on teats on all the age groups.

The gross and ultrasonographic observations were compared to observe normal gross morphology during different stages of development.

RESULTS AND DISCUSSION

Gross anatomy: The mammary gland in goat was located in the inguinal region and was separated from each other by well-defined mammary groove (Fig. 2A). The groove was very prominent in lactating than the non-lactating and pre-pubertal animals. Each mammary gland consisted of a body and teat (Fig. 2C). The body was mostly conical in shape but in lactating animals, it was bowl shaped. The teats were conical in shape and were presented vertically from the mammary body but during lactation the teats were oriented laterally due to storage of milk at this stage. Dyce *et al*. (2002) stated that teats originated from the body of the mammary gland gradually in mare and doe but abruptly in cow, sow, ewe and bitch. Externally each gland was covered by skin which was thin and loose at the body of mammary gland and was firmly attached and coarser and denser at the base, which increased in thickness from base to tip of teat. Unlike large ruminants, both udder and teat skin were covered by fine hairs which were more at the base followed by mid and tip of the teat. However, the thickness of skin was reported to be maximum at the tip which decreased in the mid and base regions of the teat. Similar findings were reported in mammary glands of ewe (Senthilkumar *et al*. 2020a) and goat (Adam *et al*. 2017).

Internally, the mammary body was divided into left and right halves by a well-developed median suspensory groove as the median ligament was not developed in goat (Fig. 2B). Pandey *et al* (2018) also observed that right and left halves of udder in cows was demarcated by longitudinal intermammary groove. Each half showed numerous lactiferous ducts which opened into the gland sinus which was wide pouch-like structure. The gland sinus continued distally as teat sinus with longitudinal mucosal folding in goat as noticed by Atyia (2009) in small ruminants and Senthilkumar *et al* (2020a) in ewes. The gland sinus and teat sinus were separated from each other by annular folds, which were more prominent in lactating animals. Distally, the teat sinus continued a teat canal which opened at teat orifice (Fig. 2D). At the junction of teat sinus and teat canal, small mucosal elevations were observed as Furstenberg's rosette, which were more prominent in adult animals at lactating stage as compared to pre-pubertal stage. The gross parameters were similar to the observations of other authors in sheep (Senthilkumar *et al*. 2020a), goat (Adam *et al*. 2017) and buffalo (Sarangi 2022). It was noticed that goat had a single mammary complex as also

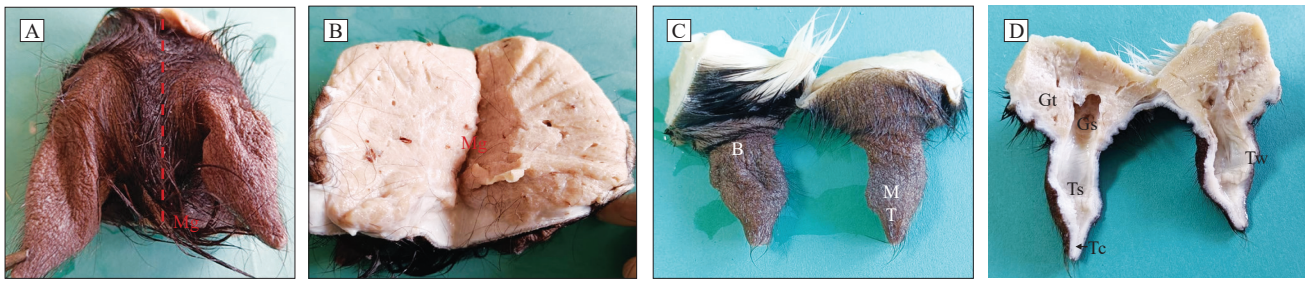

Fig. 2. Photograph showing gross morphology of udder and teat of goat: A. Ventral face of udder showing left and right halves with distinct mammary groove (Mg); B. Dorsal face of base of udder showing separation of right and left halves internally by median suspensory groove (Mg); C. Tip (T), mid (M), base (B) region of the goat teat; D. Longitudinal sections of teat showing glandular tissue (Gt), gland sinus (Gs), teat sinus (Ts), teat wall (Tw) and teat canal (Tc).

Table 1. Biometric observations (cm) on different components of goat teat at different age groups (Mean±S.E)

Parameter	Pre-pubertal	Lactating	Non-Lactating
Teat length	2.69±0.21[a]	4.75±0.48[b]	5.67±0.24[b]
Teat diameter at base	1.40±0.29[a]	3.09±0.51[b]	3.93±0.35[b]
Teat diameter at mid	1.23±0.29[a]	3.33±0.47[b]	3.20±0.46[b]
Teat diameter at tip	0.80±0.26[a]	1.69±0.51[a]	1.08±0.16[a]
Teat canal length	0.40±0.05[ab]	0.57±0.10[a]	0.68±0.03[b]
Teat wall thickness at base	0.36±0.10[a]	0.39±0.03[a]	0.49±0.05[a]
Teat wall thickness at mid	0.44±0.09[a]	0.50±0.04[a]	0.52±0.05[a]
Teat wall thickness at tip	0.49±0.10[a]	0.58±0.09[a]	0.55±0.07[a]

Figures having atleast one similar superscript do not differ significantly (p>0.05).

described by Trautmann and Fiebiger (2002) that single mammary unit is present in humans, horses and small ruminants, whereas two in cows, four to five in cat and dog on each side.

Biometrical observations revealed that between pre-pubertal and lactating and pre-pubertal and non-lactating goat, the teat length, teat diameter at base, mid were different significantly (p<0.05) while teat diameter at tip and teat canal length showed non-significantly difference (p>0.05) except teat canal length which varied significantly in pre-pubertal and non-lactating (p<0.05) goats. However, among lactating and non-lactating groups, no significant difference (p>0.05) was seen in above parameters. Teat wall thickness at base, mid and tip were non-significantly different in all the age groups. The teat length, teat diameter at base, mid and teat wall thickness at tip was less in pre-pubertal animals which became almost double in adult goat (Table 1). The present data was analysed by paired t-test and indicated that maximum growth of the teat occurred from pre-pubertal to adult goat.

Ultrasonography: Ultrasonographic observations were conducted on mammary gland of goat in pre-pubertal, lactating, non-lactating animals. It was found that mammary gland parenchyma contained anechogenic structures of variable sizes indicating gland sinus, lactiferous ducts, blood vessels, glandular parenchyma (Fig. 3A) and alveoli which were more prominent in the lactating animals. However, the amount of anechogenic structures showing alveoli, blood vessels and lactiferous duct were less in the non-lactating animals. The present ultrasonographic observations depicted that the amount of glandular tissue parenchyma was more in the lactating animals. The homogenous and uniform echogenic component in the present study indicated the amount of connective tissue stroma was comparatively more in non-lactating (Fig. 3B) and pre-pubertal goat. The hyperechogenic white line showed the udder skin which was corrugated as seen earlier by Adam *et al*. (2017).

Ultrasonographic image of teat showed that the teat

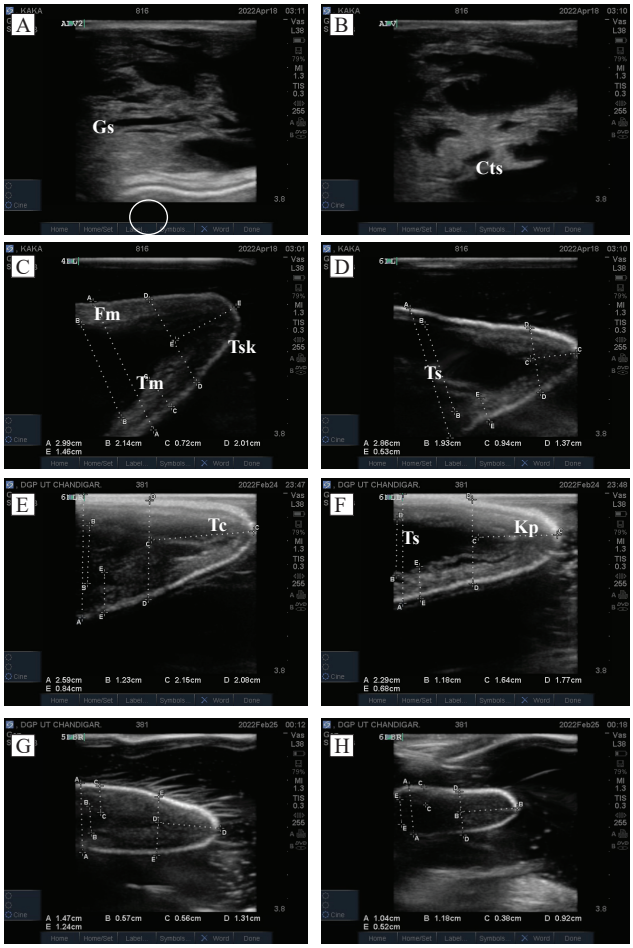

Fig. 3. Ultrasonographic image of glandular tissue and teat of lactating goat: A. Anechogenic structure showing gland sinus (Gs), lactiferous duct (Ld) and glandular parenchyma and stroma (circle) and hyperechoic skin of udder (Us) in lactating goat; B. Homogenous and uniform echogenic component in connective tissue stroma (Cts) in non-lactating goat; C and D. Hyperechogenic teat muscosa (Tm), homogenous hypoechogenic fibromuscular (Fm), mild hyperechogenic teat skin (Tsk), anechogenic teat sinus (Ts) in lactating goat; E and F. Anechogenic teat sinus (Ts), hyperechogenic teat canal (Tc) and keratin plug (Kp) in non-lactating goat; G and H. Less diameter of teat sinus (Ts), more fibromuscular homogenous hypoechogenic layer, hyperechogenic hair shaft (Hs) in prepubertal goat.

wall was tri-laminar structure. The innermost layer was hyperechogenic indicating the teat mucosa, middle layer was homogenous and thick with hypoechogenic appearance represented the fibromuscular layer, however the teat skin showed mild hyperechogenicity (Fig. 3 C and D). Teat sinus was an anechogenic structure present in the centre of teat. Teat canal was demarcated by their hyperechogenic line between teat wall. Teat sinus was more anechogenic in lactating animals than non-lactating and pre-pubertal animals (Fig. 3E, F, G and H). In few cases (two non-lactating and two pre-pubertal) the teat canal was visualized as hyperechogenic streak. This could be attributed to the presence of keratin plug in these animals which are in dry phase or in near to dry phase. However, this finding

Table 2. Ultrasonographic observations (cm) on different components of goat teat at different age groups (Mean±S.E)

Parameter	Pre-pubertal	Lactating	Non-Lactating
Teat canal length	0.69±0.13[a]	0.79±0.08[a]	1.21±0.19[b]
Maximum diameter of teat	1.09±0.04[a]	3.43±1.14[b]	2.61±0.13[c]
Maximum diameter of teat sinus	0.44±0.05[a]	2.36±0.14[b]	1.42±0.10[c]
Maximum teat wall thickness	0.36±0.03[a]	0.55±0.33[b]	0.64±0.05[b]
Teat diameter at Furstenberg's rosette	0.84±0.06[a]	1.83±0.14[b]	1.67±0.09[b]

Figures having at least one similar superscript do not differ significantly (p>0.05).

Table 3. Comparison of biometric and ultrasonographic observations (cm) on different components of goat teat at different age groups (Mean±S.E)

Parameter	Pre-pubertal		Lactating		Non-Lactating	
	Biometric	USG	Biometric	USG	Biometric	USG
Teat canal length	0.40±0.05	0.69±0.13	0.57±0.10	0.79±0.08	0.68±0.03	1.21±0.19
Maximum diameter of teat	1.23±0.29	1.09±0.04	3.33±0.47	3.43±1.14	3.20±0.46	2.61±0.13
Maximum teat wall thickness	0.44±0.09	0.36±0.03	0.50±0.04[a]	0.55±0.33	0.52±0.05	0.64±0.05

was not consistently observed in all the animals. Similar findings have been reported by Senthilkumar *et al* (2020b) in goat, Franz *et al.* (2009) in ewes. However, Ragab *et al.* (2009) demonstrated five layers of teat wall in buffalo by ultrasonography and classified these layers based on different echogenicity as skin, musculature, connective tissue, mucosa and submucosa.

Ultrasonographic examination of teat showed that teat canal length, maximum diameter of teat, teat sinus diameter, teat wall thickness, diameter at Furstenberg's rosette showed significant difference (p<0.05) among lactating and non-lactating, pre-pubertal and lactating, pre-pubertal and non-lactating goats (Table 2). However, teat canal length among pre-pubertal and lactating animals, teat wall thickness and diameter at Furstenberg's rosette among lactating and non-lactating animals did not show any significant difference (p>0.05).

The present data depicted that all the ultrasonographic values on the teat canal length, diameter of teat and thickness of teat wall were more in different age groups of goat except the biometric measurement of maximum diameter of the teat in pre-pubertal animals and thickness of teat wall in pre-pubertal and non-lactating animals (Table 3). It was also observed that there was no significant difference in the measurement of different parameters recorded by varnier caliper and ultrasonographic machine. Therefore, it may be concluded that the observations recorded in fixed specimens were slightly lesser than those of ultrasonographic images on live animals and it can be used to diagnose any abnormality occurring in the teat during pre-pubertal, lactating and non-lactating goats.

REFERENCES

Adam Z E A S, Ragab G A N, Awaad A S, Tawfiek M G and Maksoud M K M A. 2017. Gross anatomy and ultrasonography of the udder in goat. *Journal of Morphological Sciences* **34**(03): 137–42.

Atyia A. 2009. Anatomical, histological and radiological study of the mammary gland of small ruminants. *Basrah Journal of Veterinary Research* **8**(2): 10–22.

Basic Animals Husbandry Statistics. 2019. Animals Husbandry Statistics Division Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India.

Bhasin H, Gupta A, Mohindroo J, Bansal N and Uppal V. 2017. Gross biometric and ultrasonographic studies on the buffalo heart. *Ruminant Science* **6**(1): 47–50.

Dyce K M, Sack W O and Wensing C J G. 2002. *Text book of Veterinary Anatomy*. 3rd Edn. pp. 723 – 731. W B Saunders Company, Philadelphia.

Franz S, Floek M and Hofmann-Parisot M. 2009. Ultrasonography of the bovine udder and teat. *Veterinary Clinics: Food Animals Practice* **25**(3): 669–85.

Lima M J R, Teixeira-Lemos E, Oliveira J, Teixeira-Lemos L P, Monteiro A and Costa J M. 2018. Nutritional and health profile of goat products: focus on health benefits of goat milk. *Goat Science*: 189–232. IntechOpen. https://doi.org/10.5772/66562

Pandey Y, Taluja J S, Vaish R, Pandey A, Gupta N, and Kumar D. 2018. Gross anatomical structure of the mammary gland in cow. *Journal of Entomology and Zoology Studies* **6**(4): 728–33.

Ragab G H, Seif M and Hofmann-Parisot M. 2009. Ultrasonography of the mammary gland in ruminants. *Journal of Veterinary Medical Research* **24**(1): 1–4.

Sarangi S. 2022. 'Age related gross, histomorphochemical, ultrastructural and immunohistochemical studies on mammary gland of buffalo (*Bubalus bubalis*).' Ph.D. Dissertation, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana.

Senthilkumar S, Kannan T A, Gnanadevi R, Ramesh G and Sumathi D. 2020a. Comparative histoarchitectural studies on teat of small ruminants. *Indian Journal of Veterinary Anatomy* **32**(1): 40–42.

Senthilkumar S, Kannan T A, Ramesh, G, Sumathi D and Gnanadevi R. 2020b. Ultrasonographic evaluation of mammary gland in Boer local goat. *International Journal of Livestock Research* **10**(7): 54–59.

Trautmann A and Fiebiger J. 2002. *Fundamentals of Histology of Domestic Animals*. pp. 350–55. Cumstock Publishing Associate.