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ULTRASONOGRAPHIC MEASUREMENTS OF TEAT STRUCTURES DURING MAMMARY GLAND AFFECTIONS IN GIR COWS

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ABSTRACT

The present study entitled "Ultrasonographic measurements of teat structures during mammary gland affections in Gir cows" was conducted to know basic data regarding measurements of internal teat structure in Gir cows during mammary gland affections. The present clinical study was conducted on 100 Gir cows presented to Department of Veterinary Surgery and Radiology, COVSAH, KU, Junagadh during study period. In present clinical work mammary gland affections i.e., involvement of single teat affections were highest (46.51%), followed by double teat (25.58%), four teat (18.60%) and triple teat (6.97%). Teat obstruction contributed for the highest number of cases (42) followed by mastitis (33), udder fibrosis (15), udder abscess (06), and teat fistula (04). The average milk yield of the different groups studied was 12.50±1.72 Kg. The highest milk yield was recorded in teat fistula involved group was 21.15±2.85 Kg. In group involving udder fibrosis milk yield was nil and group involved complete teat obstruction had the lowest milk yield of 2.06±1.20 Kg. The average mean of teat canal diameter was 1.53±0.02 cm in affected teats and 2.07±0.02 cm in normal teats in the current study. In the present analysis, the average teat wall thickness was reported to be 0.66±0.03 cm in affected teats and 0.56±0.03 cm in normal contra lateral teats. In present clinical study, ultrasonographic measurements of teat structures during mammary gland affections in ir cows is found easy, quick and low cost technique.

KEYWORDS: Gir cow, USG, Teat.

INTRODUCTION

In the sector of udder health, milk flow disorders are a big concern. They cause various forms of mastitis, which results in a decline in milk production, negative changes in milk components and raw milk quality, increased costs for animal care, early culling of dairy cows, and, as a result, a negative economic effect (Amin *et al.*, 2017). As a consequence, in animals with udder diseases, a simple and reliable diagnosis and prognosis is necessary, and requires the use of state of the art examination techniques and therapeutic treatments (Kuru *et al.*, 2019).

Evidence-based treatment requires the use of diagnostic imaging. It allows for the visualisation of the mammary glands internal structure as well as disease interpretation (Martin *et al.*, 2018). Radiography, ultrasonography, computed tomography, and magnetic resonance imaging are all examples of diagnostic imaging. Ultrasound is the most commonly used and rapidly growing of all sectional imaging methods today, and it also allows for a huge proportion of many radiology departments' workload. Anatomical imaging, blood-flow assessment, and examination of macro and micro vasculature of deep and superficial organs are all done with it (Dar *et al.*, 2014). In order to understand how ultrasound is produced and an image is created, two basic concepts must be understood. The piezoelectric effect, which explains how ultrasound is generated by ceramic crystals in the transducer, is the first (Santos *et al.*, 2015). An electric current is applied to the crystals by passing through a cable to the transducer, causing them to deform and vibrate. The ultrasound beam is generated by this vibration. The crystals in the transducer decide the frequency of the ultrasound waves emitted (Streeter and Step, 2007). The pulse-echo theory, which describes how the image is produced, is the second main principle. Since the same crystals are used to produce and absorb sound waves, they can't do it at the same time, ultrasound waves are emitted in pulses rather than continuously. The ultrasound beam reaches the patient in the time between pulses and is bounced or transmitted back to the transducer. These echoed sound waves cause the transducer's crystals to move and generate an electrical signal, which is then transformed into an image shown on the monitor. Just 1% of the time does the transducer emit ultrasound; the remainder of the time is spent receiving the returned echoes (Pierson *et al.*, 1988).

Ultrasound transducers are generally in the 2 to 10 MHz range, with 3.5, 5, and 7.5 MHz probes being the most common in large animal general practitioners. The energy of the sound wave generated by the transducer is lost along its direction. Absorption and scatter are the two most common sources of sound wave loss. High-frequency sound waves lose (attenuate) more quickly than low-frequency waves. As a result, high-frequency transducers (7.5 MHz) provide good detail but limited tissue penetration; low-frequency transducers, on the other hand, provide deeper penetration but weaken detail (Szabo and Lewin, 2013).

Simple linear array, convex linear array, sector scanner, phased array, and annular array are all examples of ultrasound transducers. Because of their versatility, simple and convex linear array transducers are most widely used in large animal practice. The relatively large footprint (surface area for patient contact), which becomes problematic in narrow areas such as the intercostal zone, and the reduced penetration depth compared to other technologies are their major drawbacks. For regular ultrasound tests, the authors' clinical service almost exclusively uses simple and convex linear transducers (Rajamahendran *et al.*, 1994).

Ultrasonography (USG) is a technique for detecting morphological anomalies in the mammary glands canals, sinuses, and glandular tissue (Twardon *et al.*, 2001). Obstructions of the teat and udder cistern, both congenital and acquired, are typical causes of milk flow problems in cattle (Dinc *et al.,* 2000). Inflammation, mucosal lesions, tissue expansion, foreign bodies, milk stones, congenital changes, hematoma, and abscess are all abnormal udder changes that can be diagnosed with USG. In cattle, linear-array transducers with frequency ranges of 5.0 MHz, 7.5 MHz, and 10 MHz are most widely used to perform ultrasound examinations (Szencziová and Strapak, 2012).

MATERIALS AND METHODS

The current research “Ultrasonographic measurements of teat structures during mammary gland affections in Gir cows” was conducted on 100 Gir cows of various age groups at the department of veterinary surgery and radiology, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Junagadh during year 2021. The collection of patient data, clinical examinations as well as ultrasonographic examinations was performed in Gir cows presented at the Department of Veterinary Surgery and Radiology and Department of Teaching Veterinary Clinical Complex, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Junagadh. A total of 100 Gir cows with mammary gland disease were screened and divided in different five groups.

Ultrasonography of udder and teat

Complete history pertaining to age, post calving period and average milk production was recorded in the evolved Performa prior to the ultrasonography in all animals. A detailed examination of udder and teat was performed in all animals using ultrasonography.

Clinical evaluation of udder and teat.

Prior to ultrasonography, all the animals underwent detailed clinical evaluation as given below.

History

Age, lactation stage, day postpartum and average milk yield, time between first noticing symptoms and referral to the clinic, and pretreatment regimen, if any, were all reported.

Clinical examination

Visual inspection of the affected teat and quarter involved looking for swelling of the udder and teat, discomfort on contact, and hardness of the udder and teat. The bovine's four quarters were visually and physically examined.

By extracting a few squirts of milk from each teat and rolling each teat between fingers to determine any pain elicited as well as the position and size of any obstructive tissue present, the gland and teat were fully palpated.

Ultrasonographic Evaluation

The results of ultrasonography of the udder and teat in affected animals were reported. The animals were subjected to ultrasonography without sedation after proper physical restraint

Instrumentation

The ultrasound system e-Saote with multi frequency probes is available at the Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, Kamdhenu University. Ultrasonographic studies were done with this system. To ensure proper skin and transducer touch, sterile ultrasound coupling gel was used.

Techniques (Rambabu *et al*., 2008)

The surface of the linear transducer with coupling gel was mounted directly on the skin surface of the teat and udder in the contact gel technique. In water bath technique, the teat was embedded in a small plastic jar (decapped disposable usual saline plastic bottle) or container filled with water, and the probe with the gel was applied to the container's external surface.

Ultrasonography of udder

Using two-dimensional, grey scales, B-mode ultrasound unit, the normal Gir cow's udder was scanned to determine its ultrasonographic anatomy, while the affected Gir cow's udder was scanned similarly to arrive at a diagnosis.

Preparation of site and positioning

The animals were restrained in a travis and the hind and forelegs were covered with a rope for Ultrasonographic examination of cow udder. Shaving and thorough cleaning of the area with diluted potassium permanganate solution were used to prepare the site.

Ultrasonographic evaluation of udder

The contact gel application with a 3.5 or 5 MHz frequency probe by direct contact of the probe on the udder skin was the primary method of ultrasound analysis of the mammary gland parenchyma in animals. The probe was mounted on the caudal surface of each half along its longitudinal axis and rotated upward and downward to scan the entire udder (Flock and Winter, 2006). The probe was positioned with an 80^0 scanning angle cranially just above the teat insertion to examine the gland cistern (Ayadi *et al.*, 2003). The probe was mounted on the dorsal and lateral to the caudal aspect of the udder halves to examine supramammary lymph nodes (Hussein *et al.,* 2015).

Ultrasonography of teat

Using two-dimensional, grey scales, B-mode Ultrasonography device, bovine teats were scanned ultrasonographically. Various systems of common and affected bovine teats were photographed in the United States.

Preparation of site and positioning

The animals were restrained in a travis, and the teats were shaved and cleaned with potassium permanganate solution to prepare the site.

Ultrasonographic evaluation of teat

After immersing the teat in a water-filled plastic container, the probe was applied sagittally, beginning at the distal end and working its way to the gland's lactiferous sinus. The probe was also used transversely, at a 90 degree angle to the teat, to observe transverse teat bits (Rambabu *et al.,* 2008).

The normal and abnormal echogenicity of the various structures were determined using sonography. The teat's ultrasonographic appearance was reported and compared to its usual appearance using two-dimensional grey scale B-mode ultrasound at different frequencies (3.5-5 MHz). Teats of bovines suffering from affections were also scanned to investigate the anomaly.

RESULTS

The current research was carried out at the Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, Junagadh, Kamdhenu University, Gandhinagar. In Gir cows presented at the university clinic, patient data was collected and ultrasonographic examinations were performed. During the given work period, a total of 100 Gir cows were clinically examined.

Table no. 1: Distribution of milk flow disorders in bovine.

Group	Affections			Animals	
				Cows (n=100)	Teats (n=83)
I	Teat Obstruction (n=42)	Ia	Obstruction at the tip of the teat	14	16
		Ib	Obstruction at the middle of the teat	11	15
		Ic	Obstruction at the base of the teat	09	22
		Id	Full teat fibrosis	8	30
II	Teat Fistula			4	4
III	Mastitis			33	0
IV	Udder Abscess			6	0
V	Udder Fibrosis			15	0

Table No.2: Occurrence of teat affections in Gir cows.

Number of teats affected	Cows (n= 43)
One	46.51% (n=20)
Two	25.58% (n=11)
Three	6.97% (n=3)
Four	18.60% (n=8)

In present study cows, single teat affections were highest (20, 46.51%), followed by double teat involvement (11, 25.58%), followed by four teats involvement (8, 18.60%) while four teats were involved in 3 cases (3, 6.97%). Out of all the affections presented during the course of present study, obstructive lesions contributed for the highest number (n=42) followed by mastitis (n= 33), udder fibrosis (n=15) udder abscess (n= 6) and teat fistula (n=4).

Ultrasonography

In present study, after restraining the animal in the travis, Sonography of the teat and udder was performed in the standing position. B mode ultrasonography was performed on the affected and contra-lateral normal teats and udder with ExaGo veterinary ultrasound scanner using a convex linear 3.5 MHz or convex linear 5 MHz transducer of USG machine. The scanning was done in longitudinal and transverse planes using a direct contact technique in case of scanning of udder and for scanning of teat water bath technique is used.

Ultrasonography of normal contra lateral teat

B mode ultrasonography of the normal contra lateral teats was performed using linear transducer of 3.5 MHz frequency. Examination of the normal teat was done using water bath technique. On the longitudinal scan, the teat canal appeared as a thin, bright, hyperechoic line, bordered on each side by parallel, thick hypo-echoic bands. The rosette of Furstenberg, which connects the teat canal and the teat cistern, was visualised as a hyperechoic structure. When the teat cistern was filled with milk, three layers of the teat wall were clearly distinguished: outer hyperechoic (skin), hypo echoic (musculature), and inner hyperechoic (mucosa). Blood vessels in the teat wall's middle layer emerged as anechoic cavitations. Anechoic vessels from the venous ring of the rosette of Furstenberg could be seen at the junction between the teat and gland cisterns. Annular folds separated the teat and gland cisterns.

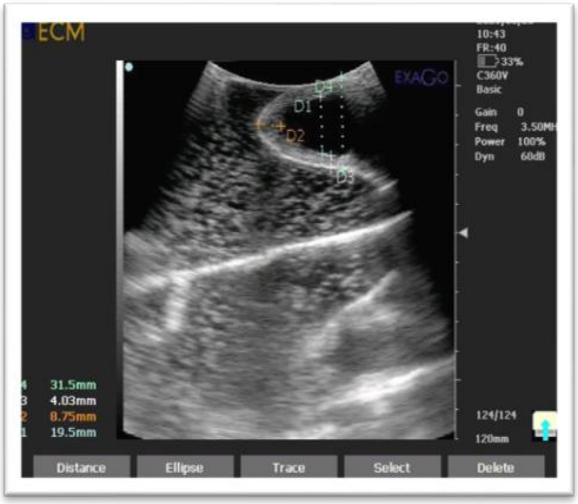

Plate 1 Ultrasonography of normal contra lateral teat.

The rosette of Furstenberg has been defined as a short hyper echoic line extending from the teat canal into the teat cistern, bordered on each side by parallel hypo echoic lines.

Ultrasonography of normal udder

After applying a cupious amount of acoustic gel to the udder skin, ultrasonographic imaging of the udder parenchyma was performed utilizing a 3.5 MHz or 5 MHz convex transducer on the udder skin. The transducer was placed on the caudal surface of each half along its longitudinal axis and moved upward and downward to scan the entire udder. The glandular parenchyma of the bovine udder was found to be homogeneous hypo echoic with anechoic alveoli in this investigation.

Plate 2 Ultrasonography of normal udder.

Ultrasonography of the affected mammary gland

Abnormalities at the level of the teat canal and the Furstenberg rosette were seen in animals suffering from obstruction at the tip of the teat (group Ia). Fibrosis was found in the area of Furstenberg's rosette in this group, and the rosette was not clearly delineated.

Plate 3 Ultrasonography of affected teat.

In group Ib animals, obstruction in the middle of the teat could be seen ultrasonographically as a hyper echoic nodule or echogenic mass in the teat cistern lumen, partially impeding milk flow.

Sonographic measurements of teat structures.

Prior to draining of teats, all of the animals were scanned. However, in cases of teat fistula the milk drained through the opening spontaneously and scanning was performed immediately on presentation. When the image quality was satisfactory, the image was frozen on the ultrasound machine. According to Neijenhuis *et al.* (2001) callipering of the teat anatomical structures was done by a single observer using the same approach in all teats. The following were the parameters for measuring teat structures.

1. Teat Canal Diameter (TCD): This was recorded as the width of hyperechoic line measured at the half length of the teat canal.
2. Streak Canal Length (SCL): The diameter of the hyperechoic structure distal to the teat canal was measured.
3. Teat Wall Thickness (TWT): This was determined at the same level as TCsD. This was determined by measuring the distance between the mucosa and the skin.
4. Whole Teat Diameter (WTD): This was recorded as the width of hyperechoic line measured at dorsal border of skin to ventral border of skin.

Table no. 3: Mean ± Standard Error of Teat Canal Diameter and Teat Wall Thickness (cm) in diseased and contra lateral normal teats in animals belonging to various groups.

Sr. No.	Groups	TCD (Affected)	TCD (Normal)	TWT (Affected)	TWT (Normal)
Ia	Obstruction at tip of the teat	1.09±0.03	2.12±0.03	0.55±0.05	0.50±0.03
Ib	Obstruction at middle of the teat	1.03±0.01	1.05±0.01	0.78±0.05	0.59±0.01
Ic	Obstruction at base of the teat	1.07±0.03	1.06±0.02	0.59±0.04	0.54±0.01
Id	Full teat obstruction	0.04±0.01	0.05±0.01	0.57±0.02	0.59±0.04
II	Teat Fistula	1.06±0.01	1.07±0.01	0.83±0.02	0.52±0.04
III	Mastitis	-	-	-	-
IV	Udder Abscess	-	-	-	-
V	Udder Fibrosis	-	-	-	-

Table no. 4: Mean ± Standard Error of Whole Teat Diameter (WTD) and Streak Canal Length (SCL) (cm) in diseased and contra lateral normal teats in animals belonging to various groups.

Sr. No.	Groups	WTD (Affected)	WTD (Normal)	SCL (Affected)	SCL (Normal)
Ia	Ia Obstruction at tip of the teat	3.75±0.53	3.15±0.33	1.25±0.31	1.05±0.31
Ib	Ib Obstruction at middle of the teat	3.89±0.63	3.05±0.43	1.28±0.26	1.18±0.26
Ic	Ic Obstruction at base of the teat	3.35±0.43	3.21±0.41	1.31±0.28	1.15±0.28
Id	Id Full teat obstruction	3.45±0.33	3.16±0.37	1.27±0.33	1.11±0.33
II	II Teat Fistula	3.36±0.23	3.18±0.31	1.35±0.23	1.19±0.23

Teat Canal Diameter (TCD) and Streak Canal Length (SCL)

The average mean of teat canal diameter was 1.53±0.02 cm in affected teats and 2.07±0.02 cm in normal teats in the current study.

The TCD was assessed in 16 affected teats 1.09±0.03 cm in group Ia obstruction at the teat tip (n=14) and found to be lower than those of the normal teat (2.12±0.03 cm). This decrease in teat canal diameter could be due to milk stagnation in obstructed teats, which could have caused teat canal distension.

The TCD of affected animals (1.03±0.01 cm) was as similar as to that of normal teats (1.05±0.01 cm) in animals of group Ib with obstruction at the mid and group Ic with obstruction at the base of the teat. This could be because in these groups, the majority of the animals had partial obstruction and there was no milk stagnation in the teat. Teat canal diameter in affected teats (1.06±0.01 cm) was similar to that in normal teats (1.07±0.01 cm) in animals suffering from teat fistula (group II). This could be related to milk stagnation in the teat canal and spontaneous leakage through fistulous opening.

Out of 32 teats (N=8) 30 teats having full fibrosis (group Id), the measurements of TCD was possible in 20 teats while in 12 teats teat canal could not be identified clearly and it was not possible to measure the teat canal in these teats. In this group the teat canal diameter in affected teats (0.04±0.01 cm) was almost similar to the contra lateral teats (0.05±0.01 cm). In few cases where contra lateral teats were also fibrosed, measurements of the adjacent normal teats were recorded.

Teat Wall Thickness (TWT) and Whole Teat Diameter (WTD)

In the present analysis, the average teat wall thickness was reported to be 0.66±0.03 cm in affected teats and 0.56±0.03 cm in normal contra lateral teats. In contrast, higher values were recorded by Thomas *et al.* (2004), Klein *et al.* (2005) Flock and Winter (2006) and Raj *et al.* (2010) ranging around 2.40 cm in normal teats of bovine. This could be due to variation in breed, size and lactation status of the animal.

The teat wall thickness of affected teats was 0.55±0.05 cm in animals with obstruction at the tip of the teat (group Ia), which was higher than that of contra lateral normal teats (0.50±0.03 cm). This could be due to milk stagnation in the obstructed teat's teat cisterns, resulting in increased turgidity.

The teat wall thickness of affected teats was observed to be larger (0.78±0.05cm) than that of contra lateral normal teats (0.59±0.01 cm) in animals suffering from obstruction in the middle of the teat (group Ib). Teat wall thickness in affected teats was higher (0.59±0.04 cm) than normal contra lateral teats (0.54±0.01 cm) in animals suffering from obstruction at the base of the teat (group Ic). Franz *et al.* (2009) also discovered that obstructions at the base or slightly proximal to the middle of the teat resulted in a significant increase in the thickness of the teat wall.

The teat wall thickness of affected teats (0.57±0.02 cm) was almost similar to that of contra lateral teats (0.59±0.04 cm) in animals with full teat fibrosis (group Id). In few cases where contra lateral teats were also involved, the adjacent normal teat was used to take measurements. This could be due to thickened teat walls due to fibrosis.

The teat wall thickness of affected teats (0.83±0.02 cm) was observed to be higher than that of normal contra lateral teats (0.52±0.04 cm) in animals suffering from teat fistula (group II). This could be caused to a severe injury to the teat causing inflammation of the teat wall.

SUMMARY AND CONCLUSIONS

A detailed clinical study was carried out on 100 Gir cows presented for milk flow disorders in the Department of Veterinary Surgery and Radiology, College of veterinary science and animal husbandry, KU, Junagadh. In present study on Gir cows single teat affections were highest (46.51%), followed by double teat (25.58%), four teat (18.60%) and triple teat (6.97%) inv olvement. Teat obstruction contributed for the highest number of cases (42) followed by mastitis (33), udder fibrosis (15), udder abscess (06), and teat fistula (04). Teat obstruction was found to be partial in 54.76% of cases and full in 45.24%. According to the findings, 33.33% of teats are obstructed at the tip or teat canal, 26.19% in the middle, 21.42% at the base, and 19.04% involve the entire teat orteat cistern. The average mean of Teat Canal Diameter (TCD) was 1.53±0.02 cm in affected teats and 2.07±0.02 cm in normal teats in the current study. In the present analysis, the average teat wall thickness was reported to be 0.66±0.03 cm in affected teats and 0.56±0.03 cm in normal contra lateral teats. The Ultrasonographic appearance of mammary gland in Gir cows clearly visible by linear transducer (3.5 MHz) especially teat canal, rosette of Furstenberg, teat cistern and teat wall as compared to linear transducer (5 MHz). In present study, Ultrasonography is found easy, quick and low cost technique for diagnosis and differential diagnosis of teat and udder lesions in Gir cows. Water bath technique of Ultrasonography for teat affections in Gir cows provides rapid and more accurate technique for determination of features and size of teat structures. It also allows for detection of alterations in affected teats, teat canal, shortening and teat wall thickening. Clinical and hematological parameters are found within the normal range except udder abscess and mastitis in which number of neutrophils are higher in mammary gland affections in Gir cows.

REFERENCES

1. Amin, N. R.; Patil, D. B.; Kelawala, D. N.; Parikh, P. V.; Mer, D. R.; Gameti, K. S. and Gohil, K. M. 2017. Ultrasonography of udder and teat in dairy animals. *Ruminant Science*, 6(1): 173-177.
2. Anant, M. A. 2016. Ultrasonographic evaluation and management of surgical affections of teat in bovine.Thesis, M.V.Sc. Maharashtra Animal and Fishery Sciences University, Nagpur, India.
3. Ayadi, M.; Caja, G.; Such, X. and Knight, C 2003. Use of ultrasonography to estimate cistern size and milk storage at different milking intervals in the udder of dairy cows. *Journal of Dairy Research*, 70: 1–7.
4. Dar, M.; Tiwari, D.; Jhala, S.; Patil, D.; Parikh, P.; Joy, N. and Wadhwani, 2014. Ultrasonography of teat in Surti goats. *Indian Journal of Animal Reserch*, 48(3): 59-62.
5. Dinc, D. A.; Sendag, S. and Aydin, I. 2000. Diagnosis of teat stenosis in dairy cattle by real-time ultrasonography. *The Veterinary Record*, 147(10): 270.
6. Flock, M. and Winter, P. (2006). Diagnostic ultrasonography in cattle with diseases of the mammary gland. *Veterinary Journal*, 171: 314–321.
7. Franz, S.; Floek, M. and Hofmann-Parisot, M. 2009. Ultrasonography of the bovine udder and teat. *Veterinary Clinics of North America: Food Animal Practice*, 25: 669–685.
8. Hayward, P. and Currie, D. 2006. Radiography of welds using Selenium 75, IR 192 and X-Rays. *12th A-PCNDT*, 7(3): 50.
9. Hussein, H.; Khabaz, K. and Malek, S. 2015. Is udder ultrasonography a diagnostic tool for subclinical mastitis in sheep?, *Small Ruminant Research*, pp.1-8.
10. Jhala, S. 2012. Studied on incidence, diagnosis and surgical management of milk flow disorders with special reference to theloresectoscopy in dairy animals Phd thesis submitted to Anand Agricultural University, Anand.
11. Kadu, B. M. and Gahlod, B. M. 2013. Surgico-Therapeutic Management of Teat affections in bovine. Thesis, M.V.Sc. Maharashtra Animal and Fishery Sciences University, Nagpur, India.
12. Kotb, E.; El-Fattah, A.; Ola, A.; Azab, A. M. and Leil, A. Z. 2020. Ultrasonography, histopathological udder alterations and bacteriological investigations for diagnosis of mastitic goats. *Journal of Applied Veterinary Sciences*, 5(2): 77-86.
13. Kuru, M.; Oral, H. and Kulaksiz, R. 2019. Determination of gestational age by measuring defined embryonic and foetal indices with ultrasonography in Abaza and Gurcu goats. *Acta Veterinaria Brno*, 87(4): 357-362.
14. Martin, L. M.; Stöcker, C.; Sauerwein, H.; Büscher, W. and Müller, U. 2018. Evaluation of inner teat morphology by using high-resolution ultrasound:

Changes due to milking and establishment of measurement traits of the distal teat canal. *Journal of Dairy Science*, 101(9): 8417-8428.
15. Miranda, F. G.; Cabala, R. W.; Lima, J. A. M.; Nepomuceno, A. C.; Torres, R. C. S. and Gheller, V. A. 2017. Ultrasonography and theloscopy for the diagnosis of obstructive fibrosis in the Furstenberg venous ring in the four quarters of the udder of a cow: a case report. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia*, 69(5): 1125-29.
16. Pierson, R. A.; Kastelic, J. P. and Ginther, O. J. 1988. Basic principles and techniques for transrectal ultrasonography in cattle and horses. *Theriogenology*, 29(1): 3-20.
17. Ragab, G.H.; Seif, M.M. and Qutp, M.M. 2016. Ultrasonography of the mammary gland in ruminants. *Journal of Veterinary Medical Research*, 23(2): 125-132.
18. Rajamahendran, R.; Ambrose, D. J. and Burton, B. 1994. Clinical and research applications of real-time ultrasonography in bovine reproduction: a review. *The Canadian Veterinary Journal*, 35(9): 563.
19. Ramanbhai, A. N. 2016. Ultrasonography of udder and teat in dairy animals.Thesis, M.V.Sc. Anand Agricultural University, Anand, Gujrat, India.
20. Rambabu, K.; Sreenu, M.; Kumar, R. V. and Rao, T. S. C. 2008. Ultrasonography of udder and teats in buffaloes. *Buffalo Bulletin*, 28(1): 5-10.
21. Santos, V.; Simplıcio, K.; Sanchez, D.; Coutinho, L.; Teixeira, P.; Barros1, F.; Almeida1,V.; Rodrigues, L.; Bartlewski, P.; Oliveira1, M.; Feliciano, M. and Vicente. W. 2015. B-Mode and Doppler Sonography of the Mammary Glands in Dairy Goats for Mastitis Diagnosis, *Reprod Dom Anim*, researchgate.net/publication.
22. Stocker, H.; Battig. U.; Duss, M. Zahner, M.; Fluckiger, M.; Eicher, R. and Rusch, P. 1989. Clarification of teat stenosis in cattle by ultrasound. *Tierarztlliche Praxis journal impact factor*, 17: 251-56.
23. Streeter, R. N. and Step, D. L. 2007. Diagnostic ultrasonography in ruminants. *Veterinary Clinics of North America: Food Animal Practice*, 23(3): 541-574.
24. Syed, A. M.; Digraskar, S. U. and Awaz, K. B. 2009. Evaluation of buffalo milk with reference to somatic cell count and antitrypsin. *Veterinary World*, 2(7): 267.
25. Szabo, T. L. and Lewin, P. A. 2013. Ultrasound transducer selection in clinical imaging practice. *Journal of Ultrasound in Medicine*, 32(4): 573-582.
26. Szencziova, I. and Strapak, P. 2012. Ultrasonography of the udder and teat in cattle: perspective measuring technique. *Slovak Journal of Animal Science*, 45(3): 96-104.
27. Twardon, J.; Dzieciol, M.; Nizanski, W. and Dejneka, G. J. 2001. Use of ultrasonography in diagnosis of the teats disorders. *Medycyna Weterynaryjna*, 57(12): 874-875.
28. Wells, P. S.; Hirsh, J.; Anderson, D. R.; Lensing, A. W.; Foster, G.; Kearon, C. and Girolami, A. 1995. Comparison of the accuracy of impedance plethysmography and compression ultrasonography in outpatients with clinically suspected deep vein thrombosis. *Thrombosis and Haemostasis*, 74(12): 1423-1427.