Buffalo Bulletin (July-September 2023) Vol.42 No.3
https://doi.org/10.56825/bufbu.2023.4233507

ULTRASONOGRAPHIC CHARACTERISTICS OF PROSTATE AND SEMINAL VESICLE GLANDS IN DEVELOPING MURRAH BUFFALO BULLS

Lal Chand Ranga[1], Ramesh Kumar Chandolia[2], Laxman Singh[3] and Ravi Dutt[2,*]

Received: 05 April 2020
Accepted: 29 September 2023

ABSTRACT

The study was performed in Murrah buffalo-bull calves to assess the developmental dimensions of the prostate and seminal vesicle (SV) glands from 1 to 30 months of age with transrectal ultrasonography. The width of prostate gland ranged between 1.39±0.07 and 2.65±0.14 cm. The rate of change in the mean width of the gland was gradual and almost same from one to thirty month ($P<0.05$). The correlation co-efficient between width of prostate gland and age was $r^2 = 0.73$. The mean circumference and length of the SV gland at one month to thirty months of age ranged from 6.14±0.32 to 13.05±0.34 cm and 2.61±0.09 to 6.02±0.27 cm, respectively. The correlation co-efficient between length and age, width and age, and circumference of SV gland and age were $r^2 = 0.68$, $r^2 = 0.55$ and $r^2 = 0.74$, respectively. From this study, it is concluded that the ultrasonographic evaluation of prostate and SV along with growth rate could be very practical tool for the assessment of puberty.

Keywords: *Bubalus bubalis*, buffaloes, dimensions, Murrah bull, prostate gland, seminal vesicle, ultrasonography

INTRODUCTION

Buffaloes play pivotal role in agricultural economy for meat and milk yield, as well as work output in difficult conditions superior to cows and is recognized by their high fertility, indurance, feed conversion efficiency and productivity in comparison to cows (Bernardes, 2007). The total buffaloes in India are 109.85 million where female buffalo population has risen by 8.61% and male buffalo is reported to be decreased by 42.35% in last five years (Livestock Census, 2019). The cow bull has been studied extensively for semen characteristics, but much important information is missing about age of puberty, sexual maturity and developmental dimension of testes and accessory sex gland.

Ultrasonography (USG) is an imaging format that is being applied on a large scale in veterinary field because it can be used for more specific studies about the integrity of organs

[1]Department of Animal Husbandry and Dairying, Haryana, India
[2]Lala Lajpat Rai University of Veterinary and Animal Sciences, Haryana, India, *E-mail: raviduttvets@yahoo.co.in
[3]Dr Bhimrao Ambedkar University, Uttar Pradesh, India

and the monitoring of bodily processes (Abdel-Razek and Ali, 2005). Further, ultrasonography has advantages for the diagnosis of functional conditions and for monitoring of the development of the genital organs (Camela *et al*., 2017). Even with the great prospective in veterinary andrology, USG is rarely used, especially for appraisal of the internal genital organs. Although USG is extensively used both as research and clinical tool for non-invasive evaluation of the genital tract in cows, it has been used more scarcely in the bull. USG is also useful in assessing progressive developmental changes that occur in testes at various stages of maturation (Ahmad and Noakes, 1995). To judge sexual development, one needs data on scrotal circumference, sperm concentration and motility and morphology and dimensions of accessory sex glands. To access developmental dimensions of accessory sex glands there is need of *in-situ* monitoring and this can be done with USG. There are several studies on ultrasonographic assessment of testes and accessory sex glands in cow bulls and other species (Pechman and Eilts, 1988; Cartee *et al*., 1989; Chandolia *et al*., 1997; Gouletsou *et al*., 2003; Kastelic and Brito, 2012; Manda *et al*., 2012; Sunder *et al*., 2013; Singh *et al*., 2015; Schnobrich *et al*., 2015; Rodrigues *et al*., 2020). Ranga *et al.* (2014) has reported developmental changes of the Cowper's gland from 1 to 30 months of age in Murrah buffalo male calves through transrectal ultrasonography. However, such information is lacking for buffalo bull. Presently for this breed even the basic information *viz.* co-relation of age and body weight with testicular circumference, size (length, breadth etc.), prostate and SV gland are not adequately reported. Though ultrasonography has been applied for diagnosis of infertility (Ali *et al*., 2011) and testicular pathologies (Chandolia *et al*., 2018) in buffalo bulls but the reports on developmental dimensions of testicles and accessory sex glands are meagre. Keeping the above fact in mind this extensive study regarding the developmental dimensions of prostate and SV was carried out.

MATERIALS AND METHODS

The study was carried out on six developing Murrah buffalo male-calves. USG was performed every month on these male calves commencing from one month of age till 30 months of age (expected puberty age). To visualise and freeze ultrasound images of the prostate and SV, a real time B-mode ultrasound machine (Philips, Pie Medical, The Netherlands), assembled with a rectal probe with dual frequency 5.0 and 7.5 MHz attached with Panasonic VCR for documentation. Further, a thermal printer for printing was also used. USG is non-invasive, so repetitive scanning was tolerated well by the male calves without administration of any sedative. Each animal was restrained in a simple cattle crush. In the young calves the transrectal USG was performed by fixing the probe firmly to a thick round and half feet long glass rod using transparent adhesive packaging tape to avoid insertion of hand in rectum of young calves. The probe was moved along the dorsal surface of the genital tract for orientation. Removal of the faeces from the rectum before transrectal scanning facilitated the entry of probe and proper visualization of the internal genital organs. Face of the probe was lubricated coupling medium (gel) and was covered with lubricated condoms before introduction into the rectum through anus. The face of the probe was pressed firmly along the rectal wall. The probe was moved across the genital tract in a systemic manner as advocated by

Ribadu and Nakao (1999).

Keeping the statistical view in mind, the age groups of male calves from 1 to 30 months were further divided into 5 blocks i.e., 1 to 6 month (Block 1); 7 to 12 month (Block 2), 13 to 18 (Block 3); 19 to 24 (Block 4) and 25 to 30 months (Block 5). Data generated was analyzed at two levels i.e., within block and between blocks. The data were analyzed using One Way Analysis of Variance (ANOVA).

RESULTS AND DISCUSSIONS

Prostate gland

Circumference and length of prostate gland could not be measured properly because the dimensions of both these parameters were actually bigger than the probe of the ultrasound Machine. The mean width of prostate gland from 1 (1.39±0.07 cm) to 30 months (2.65±0.14 cm) increased significantly ($P<0.05$) 0.042 cm per month (Table 1, Figure 1 and Figure 2). The mean width of prostate gland among all 5 blocks of 6 months 1, 2, 3, 4 and 5 was 1.44±0.03, 1.59±0.03, 1.69±0.04, 1.93±0.06 and 2.32±0.07 cm, respectively. It was significant ($P<0.05$) among each other. In 1st block the width of prostate gland among 1st to 6th month was non-significant. In 2nd block the width of the gland between 7th and 8th month and 9th, 10th and 11th month was non-significant. The width at 12th month was significantly different from others in the block ($P<0.05$). In the 3rd block of six months, the mean width of prostate gland among 13th, 14th, 15th, 16th and 17th month was non-significant. The mean width of prostate gland at 18th month was also non-significant with all others in the block. In 4th block the width of the gland between 19th and 20th month was non-significant. It was also non-significant among 21st, 22nd and 23rd month, similarly at 24th it was not significantly different from 21st, 22nd and 23rd in the block. In 5th block the width of the gland between 25th and 26th month was non-significant. The width at 27th, 28th and 29th month was also non- significant among each other, similarly at 30th month it was also not significantly different from 28th and 29th in the block.

The rate of change in the mean width of the gland was gradual and almost same from 1st to 30th month ($P<0.05$). The correlation co-efficient between width and age of prostate gland in the present study was $r^2 = 0.73$.

Seminal vesicle circumference

The mean circumference of the SV glands from 1st (6.14±0.32 cm) to 30th month (13.05±0.34 cm) increased significantly 0.23 cm per month ($P<0.05$) (Table 2, Figure 3 and Figure 4). The mean circumference of the SV gland among all 5 blocks of 6 months 1, 2, 3, 4 and 5 was 7.17±0.17, 8.92±0.19, 9.65±0.19, 10.65±0.21 and 11.24±0.25 cm, respectively. It was significantly different ($P<0.05$) among them. In 1st block, the mean circumference of the SV gland of 1st month was significantly ($P<0.05$) different from 2nd, 3rd, 4th, 5th and 6th month. The mean circumference of SV glands in the block among 2nd, 3rd, 4th, 5th, and 6th month was also non-significantly different. In 2nd block, the change in mean circumference of the SV glands between 7th and 8th was non-significantly different. The change in mean circumference of the SV gland between 8th and 9th month was also non-significantly different. The mean circumference of SV gland in the block among 10th, 11th and 12th month was also non-significantly different. In 3rd block, the mean circumference of SV gland between 13th to 17th month was non-significantly different, similarly at 18th month it was also non-

significantly different from all others in the block.

In 4th block, the mean circumference of SV gland among 19th, 20th and 21st was non-significantly different (P<0.05), similarly it was also non-significantly different among 22nd, 23rd and 24th month. The mean circumference of SV gland between 23rd and 24th was non-significantly different (P>0.05). At 24th month, it was non-significantly different (P>0.05) with others in the block. In 5th block, the mean circumference of SV gland among 25th, 26th, 27th and 28th was non-significantly different (P<0.05), whereas it was significantly different (P<0.05) between 29th and 30th month and with others in the block. The mean circumference at 1 month of age was 6.14±0.32 cm whereas at 2nd month it raised up to 7.09±0.27 cm. At 8 months of age it reached up 8.41±0.48 cm. The change from 1 to 8 months increased significantly 0.28 cm per month. It was significantly higher than the overall mean change from 1 to 30th month. From 9th to 27th month, the change observed was 0.10 cm per month, which was significantly lower (P<0.05) than the overall average of 1 to 30th month. The increase from 28th (11.52±0.35 cm) to 30th month (13.05±0.34 cm) was 0.51 cm per month which was highly significant (P<0.01). The correlation co-efficient between circumference of SV gland and age in the present study was $r^2 = 0.74$.

Seminal vesicle length

The mean length of SV gland ranged from 2.61±0.09 to 6.02±0.27 cm during from 1st month to 30th month (Table 2, Figure 5 and Figure 6). The overall length increased significantly 0.11 cm per month (P<0.05). The mean length of the SV gland among all 5 blocks of 6 months 1, 2, 3, 4 and 5 was 3.09±0.09, 3.85±0.09, 4.06±0.09, 4.39±0.09 and 4.92±0.16 cm, respectively. There was significant difference (P<0.05) among them. In 1st block, the mean length of SV gland between 1st and 2nd month was significantly different from 3rd, 4th, 5th and 6th month, whereas among 3rd, 4th, 5th and 6th month it was non-significantly different. In 2nd block, the mean length of SV gland between 7th and 8th month was non-significantly different. The mean length of SV gland among 8th, 9th, 10th, 11th and 12th month was also non-significantly different. In 3rd block, the mean length of SV gland among 13th, 14th, 15th, 16th, 17th and 18th month was non-significantly different. In 4th block, mean length of SV gland among 19th, 20th, 21st, 22nd and 23rd month was non-significantly different. At 24th month, it was also non-significantly different from all others in the block. In 5th block, the mean length of SV gland between 25th and 26th month was non-significantly different. The mean length of SV gland among 25th, 26th and 27th month was also non-significantly different. The mean length of SV gland among 25th, 26th, 27th and 28th month was non-significantly different. There was also non-significant (P>0.05) difference between 29th and 30th month (P<0.05). At 1st and 2nd month, it was 2.61±0.09 cm and 3.07±0.14 cm, respectively. At 7th month, mean length was up to 3.38±0.08 cm, whereas mean change from 8th month (3.80±0.19 cm) to 25th month (4.95±0.22 cm) was 0.06 cm per month exhibiting a lower significant change (P<0.05). The change in length of the gland from 26th (4.99±0.24 cm) to 30th month (6.02±0.27 cm) exhibited a highly significant change 0.20 cm per month (P<0.01). The correlation co-efficient between age and length of SV gland in the present study was $r^2 = 0.68$.

Seminal vesicle width

The mean width of the SV gland ranged from 1st month (0.69±0.07 cm) to 30th month (1.76±0.04 cm) (Table 2, Figure 7, and Figure 8). It increased significantly 0.036 cm per month

Table 1. Ultrasonographic measurements of width of prostate gland (cm, mean±SE) with age in Murrah buffalo calves/bulls where n=6 (each month).

Block **	Age (Month)	Width*
1^{A}	1	1.39 ± 0.07^{a}
	2	1.41 ± 0.03^{a}
	3	1.42 ± 0.05^{a}
	4	1.49 ± 0.05^{a}
	5	1.49 ± 0.05^{a}
	6	1.59 ± 0.05^{a}
2^{B}	7	1.60 ± 0.07^{abc}
	8	1.63 ± 0.07^{abc}
	9	1.65 ± 0.08^{bc}
	10	1.66 ± 0.04^{bc}
	11	1.67 ± 0.04^{bc}
	12	1.68 ± 0.02^{c}
3^{C}	13	1.79 ± 0.04^{ab}
	14	1.82 ± 0.07^{ab}
	15	1.83 ± 0.12^{ab}
	16	1.83 ± 0.06^{ab}
	17	1.81 ± 0.09^{ab}
	18	1.93 ± 0.05^{b}
4^{D}	19	1.95 ± 0.09^{ab}
	20	2.02 ± 0.12^{ab}
	21	2.11 ± 0.07^{bc}
	22	2.13 ± 0.08^{bc}
	23	2.14 ± 0.08^{bc}
	24	2.28 ± 0.18^{c}
5^{E}	25	2.29 ± 0.07^{ab}
	26	2.36 ± 0.13^{ab}
	27	2.39 ± 0.06^{b}
	28	2.43 ± 0.06^{bc}
	29	2.51 ± 0.04^{bc}
	30	2.65 ± 0.14^{c}

*Superscript small alphabets denote significant difference within all groups of 6 months ($P<0.05$).

**Superscript capital alphabets denote significant difference among all 5 blocks ($P<0.05$).

Table 2. Ultrasonographic dimensions of seminal vesicle gland, (cm, mean±SE) with age in Murrah buffalo calves/bulls where n=6 (each month).

Block **	Age (Month)	Circumference*	Length*	Width*
1^{A}	1	6.14 ± 0.32^{a}	2.61 ± 0.09^{a}	0.69 ± 0.07^{a}
	2	7.09 ± 0.27^{b}	3.07 ± 0.14^{ab}	0.80 ± 0.02^{ab}
	3	7.37 ± 0.28^{b}	3.22 ± 0.06^{b}	0.94 ± 0.12^{bc}
	4	7.56 ± 0.28^{b}	3.26 ± 0.19^{b}	0.98 ± 0.08^{bcd}
	5	7.59 ± 0.40^{b}	3.27 ± 0.07^{b}	1.09 ± 0.10^{cd}
	6	7.61 ± 0.14^{b}	3.35 ± 0.12^{b}	1.15 ± 0.07^{d}
2^{B}	7	8.11 ± 0.27^{a}	3.38 ± 0.08^{a}	1.18 ± 0.04^{abc}
	8	8.41 ± 0.48^{ab}	3.80 ± 0.19^{ab}	1.19 ± 0.05^{abc}
	9	9.26 ± 0.20^{bc}	3.99 ± 0.18^{b}	1.29 ± 0.05^{abc}
	10	9.45 ± 0.30^{c}	4.19 ± 0.14^{b}	1.32 ± 0.09^{bc}
	11	9.52 ± 0.32^{c}	4.22 ± 0.09^{b}	1.37 ± 0.04^{c}
	12	9.88 ± 0.35^{c}	4.31 ± 0.24^{b}	1.39 ± 0.06^{c}
3^{C}	13	9.76 ± 0.21^{ab}	4.36 ± 0.11^{a}	1.41 ± 0.02^{abc}
	14	9.90 ± 0.19^{ab}	4.37 ± 0.06^{a}	1.45 ± 0.03^{abc}
	15	10.05 ± 0.49^{ab}	4.42 ± 0.19^{a}	1.46 ± 0.08^{abc}
	16	10.07 ± 0.38^{ab}	4.43 ± 0.13^{a}	1.48 ± 0.07^{abc}
	17	10.15 ± 0.10^{ab}	4.47 ± 0.13^{a}	1.53 ± 0.04^{bc}
	18	10.53 ± 0.08^{b}	4.52 ± 0.08^{a}	$^{***D}1.55\pm0.05^{c}$
4^{D}	19	10.63 ± 0.34^{abc}	4.62 ± 0.09^{ab}	$^{D}1.59\pm0.05^{abc}$
	20	10.65 ± 0.32^{abc}	4.64 ± 0.22^{ab}	$^{D}1.60\pm0.05^{abc}$
	21	10.76 ± 0.39^{abc}	4.66 ± 0.14^{ab}	$^{D}1.64\pm0.05^{bc}$
	22	11.03 ± 0.09^{bc}	4.73 ± 0.14^{ab}	$^{D}1.66\pm0.04^{bc}$
	23	11.21 ± 0.27^{c}	4.76 ± 0.13^{ab}	$^{D}1.67\pm0.05^{c}$
	24	11.21 ± 0.36^{c}	4.80 ± 0.15^{b}	$^{D}1.68\pm0.10^{c}$
5^{E}	25	11.40 ± 0.31^{ab}	4.95 ± 0.22^{abc}	$^{D}1.69\pm0.09^{ab}$
	26	11.44 ± 0.39^{ab}	4.99 ± 0.24^{abc}	$^{D}1.71\pm0.06^{ab}$
	27	11.52 ± 0.33^{ab}	5.07 ± 0.22^{bc}	$^{D}1.71\pm0.09^{ab}$
	28	11.57 ± 0.35^{ab}	5.09 ± 0.09^{c}	$^{D}1.71\pm0.09^{ab}$
	29	12.12 ± 0.57^{b}	5.59 ± 0.41^{d}	$^{D}1.74\pm0.05^{ab}$
	30	13.05 ± 0.34^{c}	6.02 ± 0.27^{d}	$^{D}1.76\pm0.04^{b}$

*Superscript small alphabets denote significant difference within all groups of six months ($P<0.05$).

**Superscript capital alphabe.

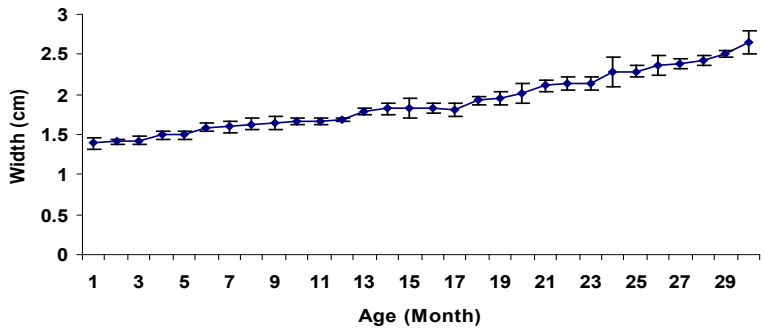

Figure 1. Width of prostate gland with age in Murrah buffalo calves/bulls.

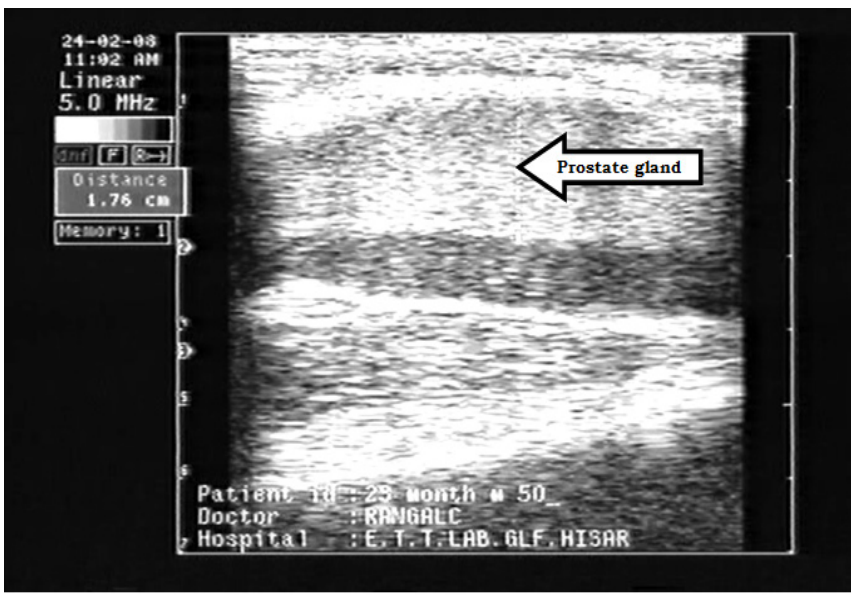

Figure 2. Measurement of width of prostate gland by transrectal ultrasonography.

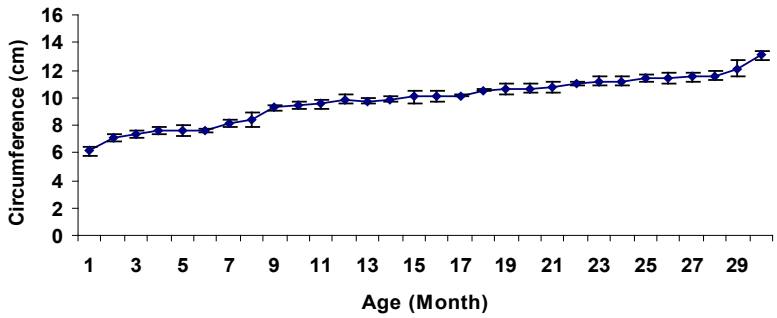

Figure 3. Circumference of seminal vesicle gland with age in Murrah buffalo calves/bulls.

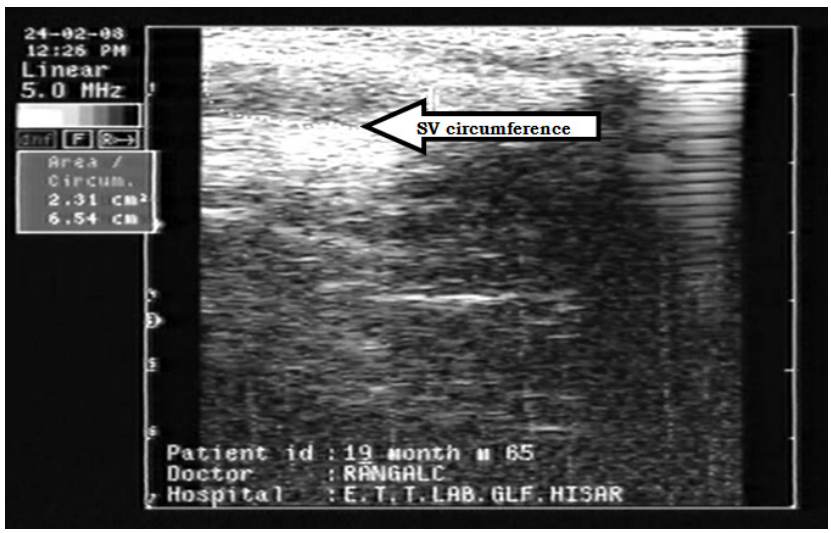

Figure 4. Measurement of circumference of seminal vesicle by transrectal ultrasonography.

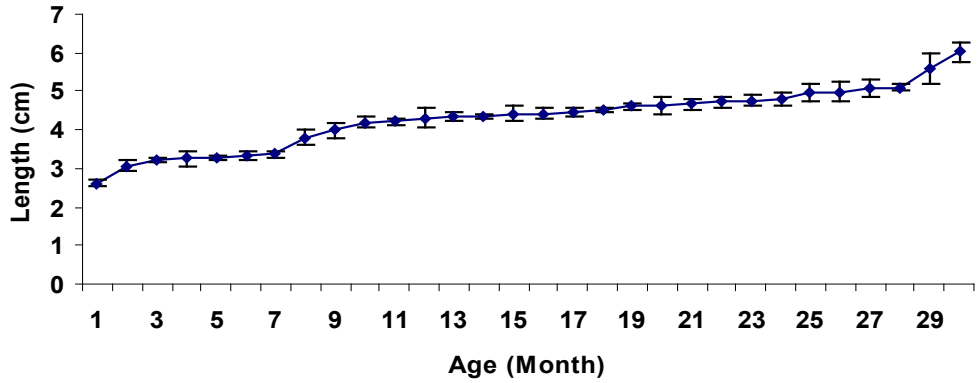

Figure 5. Length of seminal vesicle gland with age in Murrah buffalo calves/bulls.

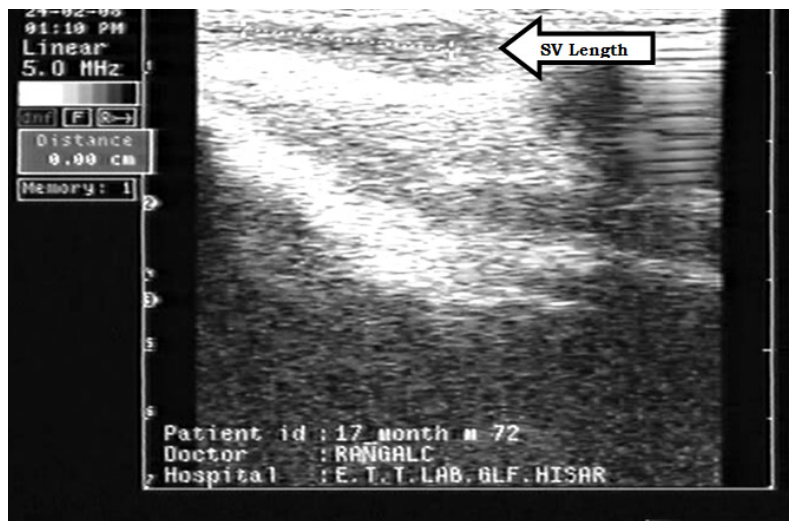

Figure 6. Measurement of length of seminal vesicle by transrectal ultrasonography.

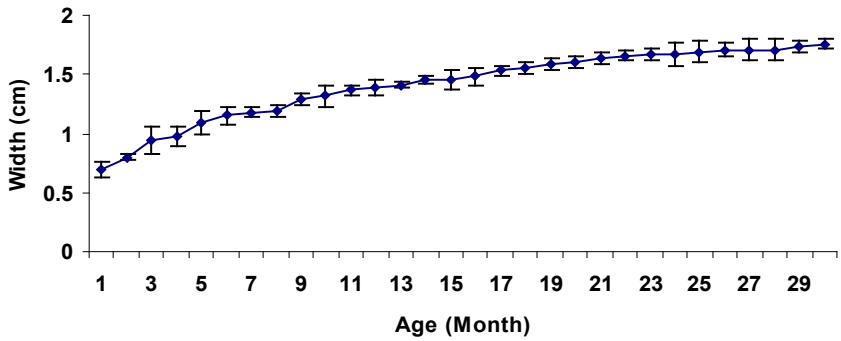

Figure 7. Width of seminal vesicle gland with age in Murrah buffalo calves/bulls.

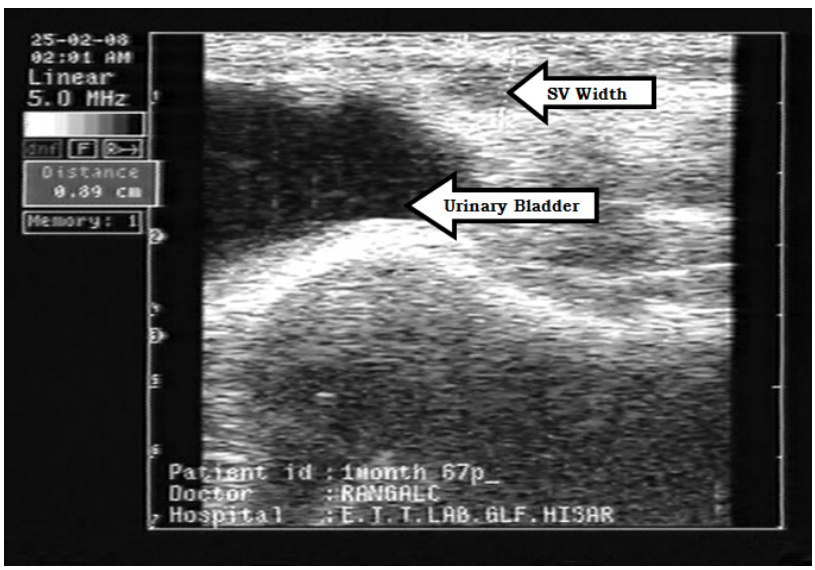

Figure 8. Measurement of width of seminal vesicle by transrectal ultrasonography.

(P<0.05). The change in the mean width of the SV glands among 1st, 2nd and 3rd block of 6th month was 0.97±0.04, 1.02±0.04, 1.07±0.04 cm, respectively and it was significant (P<0.05), whereas it was non-significant (P>0.05) between 4th (1.33±0.04 cm) and 5th block (1.38±0.04 cm). In 1st block, the mean width of the SV gland between 1st and 2nd month was non-significantly (P>0.05) different. The mean width of the SV glands between 3rd and 4th month was also non-significantly (P>0.05) different., similarly it was also non-significantly (P>0.05) different between 5th and 6th month. In 2nd block, the mean width of the gland among 7th, 8th and 9th month and between 11th and 12th month it was also non-significantly (P>0.05) different. In 3rd block, mean width of the SV gland among 13th, 14th, 15th, and 16th was non-significantly (P>0.05) different.

There was non-significant difference (P>0.05) between 17th and 18th month. In 4th block, the mean width of the SV glands between 19th, 20th, 21st and 22nd month was non-significantly (P>0.05) different. The mean width of the SV gland between 23rd and 24th was also non-significantly (P>0.05) different. In 5th block the mean width of the gland among 25th, 26th, 27th 28th, 29th and 30th month was non-significantly (P>0.05) different. From 1st month (0.69±0.07 cm) to 8th month (1.19±0.05 cm), it increased 0.06 cm per month which was highly significant (P<0.01) than the overall mean. From 9th month (1.29±0.05 cm) to 30th month (1.76±0.04 cm) the width of the gland increased significantly 0.02 cm per month (P<0.05). The correlation co-efficient between age and width of SV gland in the present study was $r^2 = 0.55$.

The body of prostate gland in ultrasound image appeared as an evenly hyperechoic structure recognised dorsal to the neck of the urinary bladder in the pelvic cavity. El-Khawaga *et al.* (2012) in pre-pubertal buffalo bulls (15 to 18 months age) recorded the dimensions of prostate gland and SV. The transrectal ultrasonographic image of body of prostate gland is in the current investigation was corroborated with the findings of Abdel-Razek and Ali (2005). SV gland which appeared as meaty lobulated structure with central dilatations was in agreement to the findings of Gnemmi and Lefebvre (2009). Singh *et al.* (2015) recorded diameter of SV and prostate gland in high and low breeding buffalo bulls as 1.54±0.05 and 1.73±0.08 cm, and 1.28±0.09 and 1.22±0.09 cm, respectively. Ultrasonographic findings of cattle bull testes and secondary sex glands have been observed by Pechman and Eilts (1988); Weber *et al*. (1988). Recently, Rodrigues *et al.* (2020) have studied ultrasonographic features of the testes, epididymis, and secondary sex glands in peri- and post-pubertal Nellore and Caracu cow bulls.

Therefore, it can be concluded that ultrasonography rather than other diagnostic tools, gives noticeable benefits in assessing the developmental changes of the prostate and seminal vesicle.

REFERENCES

Abdel-Razek, A.Kh. and A. Ali. 2005. Developmental changes of bull (*Bos taurus*) genitalia as evaluated by caliper and Ultrasonography. *Reprod. Domest. Anim*., **40**(1): 23-27. DOI: 10.1111/j.1439-0531.2004.00549.x

Ahmad, N. and D.E. Noakes. 1995. Ultrasound imaging in determining the presence of testicular degeneration in two male goats. *Brit. Vet. J*., **151**(1): 101-110. DOI: 10.1016/s0007-1935(05)80069-7

Ali, M.K., N. Ahmad, N. Akhtar, S. Ali, M. Ahmad and M. Younis. 2011. Ultrasound imaging of testes and epididymides of normal and infertile breeding bulls. *Pak. Vet. J.*, **31**(4): 345-350.

Bernardes, O. 2007. Buffaloes breeding in Brazil: Position and economic relevancy. *Revista Brasileira de Reprodução Animal*, **31**: 293-298.

Camela, E.S.C., R.P. Nociti, V.J.C. Santos, B.I. Macente, G.S. Maciel, M.A.R. Feliciano, W.R.R. Vicente, I. Gill, P.M. Bartlewski and M.E.F. Oliveira. 2017. Ultrasonographic characteristics of accessory sex glands and spectral Doppler indices of the internal iliac arteries in peri- and post-pubertal Dorper rams raised in a subtropical climate. *Anim. Reprod. Sci*., **184**: 29-35. DOI: 10.1016/j.anireprosci.2017.06.010

Cartee, R.E., B.W. Grey, T.A. Powe, R.S. Hudson and J. Whitesides. 1989. Preliminary implications of B-mode ultrasonography of the testicles of beef bulls with normal breeding soundness examination. *Theriogenology*, **31**(6): 1149-1157. DOI: 10.1016/0093-691x(89)90083-6

Chandolia, R.K., A. Honaramooz, B.C. Omeke, R. Pierson, A.P. Beard and N.C. Rawlings. 1997. Assessment of development of the testes and accessory glands by ultrasonography in bull calves and associated endocrine changes. *Theriogenology*, **48**(1): 119-132. DOI: 10.1016/S0093-691X(97)00195-7

Chandolia, R.K., G. Singh, A. Kumar, R. Dutt and D.K. Tiwari. 2018. Testicular microlithiasis in a buffalo bull - A rare case. *Haryana Veterinarian*, **57**(1): 1222-123. Available on: https://www.luvas.edu.in/haryana-veterinarian/download/harvet2018-june/40.pdf

El-Khawaga, A.R.M., M.M.M. Kandiel, G.A. Sosa, M.E.A.A. El-Roos, A.E. Abdel-Ghaffar and A.E.S. El-Azab. 2012. Ultrasound imaging of the testes and accessory sex glands in buffalo bulls treated with gonadotrophic releasing hormone. *J. Reprod. Infertil*., **3**(1): 8-16. DOI: 10.5829/idosi.jri.2012.3.1.63186

Gnemmi, G. and R.C. Lefebvre. 2009. Ultrasound imaging of the bull reproductive tract: An important field of expertise for veterinarians. *Vet. Clin. N. Am. Food A.*, **25**(3): 767-779. DOI: 10.1016/j.cvfa.2009.07.006

Gouletsou, P.G., G.S. Amiridis, P.J. Cripps, T. Lainas, K. Deligiannis, P. Saratsis and G.C. Fthenakis. 2003. Ultrasonographic appearance of clinically healthy testicles and epididymides of rams. *Theriogenology*, **59**(9): 1959-1972. DOI: 10.1016/s0093-691x(02)01259-1

Kastelic, J.P. and L.F.C. Brito. 2012. Ultrasonography for monitoring reproductive function in the bull. *Reprod. Domest. Anim*., **47**(Suppl. 3): 45-51. DOI: 10.1111/j.1439-0531.2012.02042.x

Livestock Census. 2019. *20th Livestock Census*, Department of Animal Husbandry and Dairying. Available on: https://dahd.nic.in/sites/default/filess/Key%20Results%2BAnnexure%2018.10.2019.pdf

Manda, S., S. Makkena, B.R. Kakani, S. Chintamaneni and S.N. Kakarla. 2012. Diagnostic applications of ultrasonography to testes and accessory sex glands in Ongole (*Bos indicus*) bulls. *Journal of Advanced Veterinary Research*, **2**(4): 239-243. Available on: https://www.advetresearch.com/index.php/AVR/article/view/189/186

Pechman, R.D. and B.E. Eilts. 1987. B-mode

ultrasonography of the bull testicle. *Theriogenology*, **27**(2): 431-443. DOI: 10.1016/0093-691x(87)90231-7

Ranga, L.C., R.K. Chandolia, S.K. Phulia and L. Singh. 2014. Ultrasono graphic measurements of bulbo urethral glands in developing Murrah buffalo. *Indian Journal of Animal Reproduction*, **35**(1): 14-17.

Ribadu, A.Y. and T. Nakao. 1999. Bovine reproductive ultrasonography: A review. *J. Reprod. Develop.*, **45**(1): 13-28. Available on: https://www.jstage.jst.go.jp/article/jrd/45/1/45_1_13/_pdf/-char/en

Rodrigues, N.N., G.F. Rossia, D.P. Vrismana, A.R. Tairaa, L.L. Souzab, M.F. Zorzettob, N.M. Bastosa, C.C.P. de Pazb, V.F.M.H. de Limaa, F.M. Monteirob and M.E.F. Oliveiraa. 2020. Ultrasonographic characteristics of the testes, epididymis and accessory sex glands and arterial spectral indices in peri- and postpubertal Nelore and Caracu bulls. *Anim. Reprod. Sci.*, **212**: 1-10. DOI: 10.1016/j.anireprosci.2019.106235

Schnobrich, M.R., R.O. Turner, C.N. Belcher and J. Slack. 2015. Transrectal ultrasonographic characterization of the accessory sex glands, pelvic urethra, and ureters in normal geldings. *Theriogenology*, **85**(2): 186-192. DOI: 10.1016/j.theriogenology.2015.09.008

Singh, K., A. Kumar, M. Honparkhe and D. Dadarwal. 2015. Ultrasonographic approaches for breeding soundness evaluation of high and low libido buffalo bulls. *Indian J. Anim. Sci.*, **85**(5): 451-453.

Sunder, S., U. Singh, R.K. Chandolia and J. George. 2013. Diagnosis of prostate hyperplasia in a dog using 3D/4D ultrasonography. *Haryana Vet.*, **52**: 133-134. Available on: https://www.luvas.edu.in/haryana-veterinarian/download/harvet2013/39.pdf

Weber, J.A., C.J. Hilts and G.L. Woods. 1988. Ultrasonographic appearance of bull accessory sex glands. *Theriogenology*, **29**(6): 1347-1353. DOI: 10.1016/0093-691X(88)90015-5