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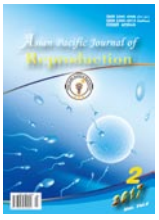

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Prevalence of various pathological conditions in female buffaloes (*Bubalus bubalis*)

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ABSTRACT

The present review article has described the prevalence of various pathological conditions of reproductive system of female buffaloes starting from ovary to vulva and vagina. Various pathological conditions were analyzed and tabulated as the total number of animal examined, number of the animals showed pathological lesions, percentage of animal showed various pathological lesions and percentage of individual pathological lesion in different parts of reproductive system of female buffaloes. The incidence of disorders of female genital organs of buffaloes has been reported by various authors at various percentages in different countries. The incidence of pathological conditions was recorded in clinically infertile cows after slaughtering or from apparently healthy buffaloes slaughtered for human consumption and/or based on postmortem examination. This review is comprehensively covering pathological conditions of female buffalo hitherto which was not previously described at one place. This review will provide a comprehensive knowledge about the prevalence of different pathological condition of different parts of reproductive tract of female buffaloes. The review has six numbers of tables described about the various pathological conditions from ovary to vulva and vagina in female buffaloes. The present review article will be very useful to the buffalo farmers, buffalo breeders and researchers are working in buffalo reproduction & breeding and pathology.

1. Introduction

The buffaloes are very important for improvement of rural economy in agriculture based developing countries. This productive, adoptive and multipurpose domestic animal species has significant attention in national and international livestock arena for augmenting the milk production in recent years. There is higher need for raising and successful maintenance of buffalo milk, milk products and meat production in the agriculture based countries, besides supplying the motive power for agriculture allied activities and transport. There are about 170 million buffaloes in the world[1]. Out of this, 97% of them are water buffaloes and mainly found in the Asian region. Riverine buffaloes (70% of the total world population) are reared in high numbers in South Asia, especially in India and Pakistan[2]. Riverine buffaloes are predominantly used for milk production and are also used for meat and fertilizer production as well as for draught power[3]. Inspite of higher utilization of buffaloes in animal husbandry and dairy sectors, there is less percentage of income in total agricultural income due to the low productivity for which diseases of genital system and infertility play a major role. The genital diseases are prevalent in all species of domesticated animals but they occur with higher frequency in dairy animals particularly in buffaloes. The monetary losses due to reproductive abnormalities are enormous on account of reduction in milk yield, lower calf production and maintenance of unproductive animals.

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The buffalo are considered as poor breeder, because it suffers from many reproductive problems such as delayed puberty, poor estrus expression, poor conception rate and longer post-partum anoestrus and calving to conception interval[4], which are serious limitations for its reproductivity and productivity.

Proper reproductive functioning of animals is one of the major contributing factors to the success of livestock development programmes. In order to have regular breeding of animals for optimum economic return as well as maximum production of healthy offspring of buffaloes, the female genital apparatus should be free of ailments/diseases. Therefore, a systematic and clear review on various affections of female genital organs of buffaloes is of paramount importance to diagnose and thereby control of the economically important maladies affecting the reproductive system of female buffaloes.

2. Reproductive pathology in bubaline species

The occurrence of various reproductive disorders/pathological conditions of female genital tracts of buffaloes as presented by various authors has been depicted in the Table 1. The incidence or prevalence of various pathological conditions was recorded in clinically infertile cows after slaughtering[5,32] or from apparently healthy buffaloes slaughtered for human consumption and/or based on postmortem examination.

Table 1
Incidence of pathological condition of female genital tract of buffaloes.

	References	Number of animals examined	Number of genitalia with pathological conditions	Percentage
1	Rao and Murthy (1971)[5]	1053	1053	100.00
2	Damodaran (1956)[6]	2700	857	31.74
3	Shalash (1958)[7]	606	106	17.50
4	Shokeir (1958)[8]	310	76	24.50
5	Shalash and Sharma (1960)[9]	2109	477	22.60
6	Barr (1963)[10]	2038	265	13.00
7	Elsawaf and Fouad (1965)[11]	242	65	26.80
8	Rao *et al*. (1965)[12]	300	25	8.33
9	Sharma *et al*. (1966)[13]	3684	207	5.61
10	Sharma *et al*. (1967)[14]	3684	2895	78.67
11	Khan and Salam (1967)[15]	972	399	41.04
12	Kodagali and Kerur (1968)[16]	1068	473	44.80
13	Smith *et al*. (1971)[17]	500	137	27.40
14	Kodagali *et al*. (1973)[18]	1837	1134	61.70
15	Rao and Rajya (1976)[19]	7500	800	10.66
16	Elwishy (1979)[20]	488	98	20.20
17	Potekar and Deshpande (1981)[21]	426	76	17.84
18	Hussain and Muniraju (1984)[22]	1155	254	22.00
19	Sharma *et al*. (1993)[23]	1340	108	8.05
20	Singla and Verma (1994)[24]	2410	2410	100.00
21	Tomar *et al*. (2002)[25]	2983	2983	100.00
22	Saxena *et al*. (2006)[26]	760	366	35.00
23	Ananda and Srilatha (2007)[27]	425	44	10.35
24	Azawi *et al*. (2011)[28]	405	216	53.30
25	Mittal *et al*. (2009)[29]	504	20	3.98
26	Mittal *et al*. (2010)[30]	504	33	6.54
27	Modi *et al*. (2011)[31]	11209	11209	100.00

3. Pathology of ovary

The incidences of various ovarian lesions in buffaloes and their pathological conditions have been reported in the Table 2. The incidence was ranged from 3.22% to 48.90%[33,34]. Absence of one or both the ovaries is called ovarian aplasia or agenesis and it is a hereditary defect due to autosomal dominant gene and this condition is also due to inbreeding. The incidence of gonadal agenesis in heifers is mainly due to XY genotype[42]. The affected animals are normal during early stage but in later stage, the animal fail to express the heat signs and breeding. Congenital aplasia of the ovaries is a rare condition and occasionally associated with freemartinism. This is congenital condition, in which the development of ovaries are improper and is caused by a single recessive autosomal gene with incomplete penetrance. This hereditary defect affects both male and female in equal frequency. The affected ovaries may be partially or completely hypoplastic and it may unilateral or bilateral. Depending upon the severity of this condition, the animal may be sterile or infertile. In bilateral complete hypoplastic condition, the animal will be anestrous and the genital tract is juvenile (under developed genitalia). In total hypoplastic condition, there is absence of primordial follicle in the ovary. In bilateral ovarian hypoplasia, the ovary is so small and it may be difficult to detect. It is a thin, narrow structure of firm consistency, in severe cases only a cord like thickening in the cranial border of the ovarian ligament. The ovary is shriveled, shrunken appearance. In some cases, the ovary appears as kidney shaped and surface is smooth and stretched. In bilateral total hypoplasia, the heifer is like a steer with long legs, narrow pelvis, poorly developed udder, small teats and small and poorly developed uterus. In the affected infertile condition, hairs are presented in the udder and teats, and the perineal region becomes shrinkage. In buffalo heifers, the ovary normally smaller in size and it may be erroneously be diagnosed as hypoplastic ovaries. The affected heifers do not come to estrus and remain in anestrous. The secondary sexual organs and characteristics are absent due to lack of secretion of estrogen. The incidences of ovarian hypoplasia in Indian cattle and buffalo have been reported lower (0.08%-4.30%) than exotic and crossbred cattle (10%-23%)[36–39]. This condition is due to hereditary, so treatment is not possible and should not be done and affected animal are culled from the herd. The incidence of hypoplastic ovaries in buffaloes was less than 1%[6,19], while Kodagali *et al*.[16] and Khan[40] reported an incidence of 1.64% and 1.39%, respectively. In severe case of hypoplasia, the affected gonads varied in size from a cord like thickening with glandular and uneven surface to a flatten, smooth, firm, bean shaped structures[41]. The hypoplastic ovaries measured as 1.0 cm to 1.5 cm × 0.4 cm × 0.2 cm in size[19]. Histopathological study revealed that the tunica albuginea was thick and covered by low cuboidal epithelium. Follicles are completely absent. The stroma is dense and made up of thick fibrous tissue with several anovulatory cords of type I and

a few type II. Type I cords are more often elliptical or rounded and are filled with 3 to 4 rows of irregularly arranged epithelial cells. The nucleus of the cells adjacent to basement membrane is oval with diffuse chromatin. Type II cords are also elliptical or rounded but slightly larger than type I cords. The cells are arranged in one or two layers with basally situated elongated nuclei along with the basement membrane[19]. Bilateral hypoplasia results in total sterility and is considered to be hereditary and is caused by two recessive genetic factors[36,42]. The ovario bursal adhesion condition is a common condition where adhesion develops between ovary and ovarian bursa *i.e.* between mesosalpinx and mesoovarium and often such adhesions develop between fimbriae and ovary. This condition is uncommon in heifers, arising as a result of mis-handling of the ovary particularly during rectal palpation of the ovary, manual enucleation of corpus luteum, rupture of ovarian cysts or due to infections. Slaughter house survey revealed that the higher incidence of ovaro bursal adhesion in buffalo (10.9% *vs.* 1.8%) than in cattle[43], however, incidence in clinical surveys in buffaloes ranges from 0.8% to 2.0%[38,44]. Sharma *et al.*[23] reported the cases of ovaro bursal affection (19.17%), smooth ovaries (7.29%), follicular cysts (3.75%), oophoritis (3.33%), ovaro-bursal adhesions (2.08%), par-ovarian cysts (1.25%), right side follicular cysts (2.51%), left side follicular cysts (0.41%) and bilateral cysts (0.83%). The common inflammatory condition of the buffalo ovary is peri-oophoritis while oophoritis is rare[33]. Hansen[45] noticed tuba ovarian abscess. Bhattacharya *et al.*[33], Damodaran[6], Saxena[34], Dwivedi *et al.*[46] and Kumar *et al.*[47] have described the occurrence of haematoma in the buffalo ovary and its incidence ranged from 0.26% to 1.43%. Cystic ovarian degeneration has reported by many workers[7,15,48-53]. Varying histological pictures was reported in these cysts. Garm[54] observed degeneration of the theca layer and thin degenerating granulose cell layers in the small cysts. Granulose cell membranes were absent in larger cysts. The maximum size of the cysts was 3.12 cm × 4.05 cm and right side ovary has more involvement than the left side ovary[23,55]; (50% *vs.* 20%)[15]. The occurrence of cystic corpus luteum has been reported by various workers in buffaloes[6,19,46,47,56,57]. The incidence of cystic corpus luteum was found to be next to cystic degeneration of Graafian follicle. The histology of these cysts was described by Dwivedi *et al.*[46]. Sclerosis or indurations of ovaries has been reported in buffaloes as a frequent sequel to primary uterine infection[14,19,46,58]. Grossly, there was no developing corpus luteum apparent at surface. The cut surface revealed a firm, partially fibrosed stroma. Histopathologically, the surface epithelium was almost missing with some remaining patches. Tunica albugenia was thicked dense fibrous tissue. Some small follicles were present showing various features of atresia[46]. Persistent corpus luteum

Table 2
Incidence of ovarian lesion in buffaloes.

	References	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Rao and Murthy[5]	1393	261	18.73	0	0	0.00	25.00	0	76	0	0	68	1.00	405
2	Kumar and Singh[32]	485	122	25.60	47	0	68.00	0.00	0	0	0	7	0	0.00	0
3	Damodaran[6]	2700	413	15.80	95	0	114.00	31.00	109	5	7	49	0	0.00	3
4	Shalash[7]	606	44	07.20	0	0	6.00	20.00	0	0	0	0	16	2.00	0
5	Shokeir[8]	310	32	07.40	0	0	0.00	9.00	1	9	0	5	8	0.00	0
6	Shalash and Salama[9]	2109	279	13.20	0	0	109.00	40.00	117	13	0	0	0	0.00	0
7	Barr[10]	3525	1226	34.80	0	0	0.00	0.00	0	0	0	0	969	257.00	0
8	Sharma *et al.*[13][14]	3684	1518	40.91	163	0	311.00	284.00	0	304	21	15	420	0.00	0
9	Khan and Salam[15]	972	286	29.42	19	0	266.00	0.00	0	0	1	0	0	0.00	0
10	Kodagali and Kerur[16]	1068	126	11.78	6	0	94.00	2.00	8	0	0	0	0	16.00	0
11	Rao and Rajya[19]	7500	578	7.70	33	134	0.00	45.00	83	14	0	49	0	6.00	254
12	Elwishy[20]	488	24	4.90	0	0	0.00	0.00	0	0	0	0	0	0.00	214
13	Sharma *et al.*[23]	1340	55	4.10	8	0	5.00	18.00	3	0	0	0	19	1.00	1
14	Singla and Verma[24]	2410	823	34.14	0	0	2.00	18.00	0	0	0	0	803	0.00	0
15	Saxena *et al.*[26]	760	116	16.26	9	8	0.00	31.00	11	10	0	0	24	10.00	13
16	Ananda and Srilatha[27]	425	28	6.58	0	0	0.00	28.00	0	0	0	0	0	0.00	0
17	Mittal *et al.*[30]	504	33	6.54	3	2	0.00	10.00	14	2	1	0	0	1.00	0
18	Modi *et al.*[31]	11209	1500	13.40	0	0	0.04	0.17	0	0	0	0	0	13.19	0
19	Bhattacharya *et al.*[33]	1020	499	49.90	85	56	184.00	14.00	31	21	14	9	85	0.00	0
20	Saxena[34]	465	15	3.22	2	0	7.00	2.00	2	0	0	2	0	0.00	0
21	Khan[48]	1280	394	30.70	43	0	92.00	32.00	19	0	0	5	158	18.00	17
22	Hansen[45]	739	80	11.24	1	0	0.00	39.00	23	0	0	16	0	1.00	0
23	Dwivedi and Singh[46]	1725	794	48.00	0	141	0.00	40.00	179	0	7	29	0	0.00	0
24	Bhattacharya *et al.*[48]	1800	231	12.80	65	0	93.00	0.00	0	0	0	0	0	0.00	0
25	Malik *et al.*[49]	1000	114	11.40	47	0	0.00	18.00	0	0	0	23	0	7.00	19
26	Elsawaf and Schmidt[59]	930	66	9.00	0	0	0.00	51.00	0	0	0	15	0	0.00	0
27	Luktuke *et al.*[60]	1728	810	46.90	0	0	87.00	49.00	0	0	0	3	400	17.00	91
28	Azawi *et al.*[61]	405	68	16.79	0	0	26.00	12.00	18	0	0	1	6	0.00	5

1. Number of animals examined, 2. Number of animal showing ovarian lesions, 3. Percentage of animal showing ovarian lesions, 4. Oophoritis and perioophoritis, 5. Sclerosed ovaries, 6. Adhesion and encapsulation, 7. Ovarian cysts, 8. Para ovarian cysts, 9. Persistent Corpus Luteum, 10. Haematoma, 11. Teratoma and other tumors, 12. Sub-active ovaries, 13. Hypoplasia and 14. Others.

and embedded corpus luteum had been noticed frequently in buffaloes[6,8,9,19,20,46]. Small, capsulated dark brown corpus luteum was embedded in the thick fibrous stroma of the cortex, but did not protrude from the surface. Microscopically, embed corpus luteum had normal group of lutein cells breaking up into irregular masses by thick fibrous connective tissue septa. Subsurface epithelial growth and cyst *adeno fibro* papillary growth in buffalo ovaries were described by Dwivedi *et al.*[46], Rao *et al.*[19] and Luktuke *et al.*[62]. In addition, they recorded an ovular corded in the ovaries of 144 animals out of 600 genital organs examined. Teratoma was commonest neoplastic condition in buffalo ovaries[6,19,32,40,46,49,63]. The cysts replaced most of the ovarian stroma, cavities of these cysts contained whitish yellow to dark grey colourded sebaceous waxy material mixed with hairs. The wall of the dermoid cysts was lined by squmaous epithelium, fibrous tissues plaques, sebaceous glands and hair follicles. In some cases, the cysts wall contained mammary tissues[6,20], cartilage[63], respiratory and intestinal epithelium[32] and nervous tissue[64]. Other ovarian tumors were encountered were cyst adenoma[6,32,53], heamangiomas[6,32], folliculoids[19,53] and granulose cell tumor[65].

4. Pathology of fallopian tube

Oviductal disorders occur more frequently and thus constitute as an important cause of infertility in buffaloes. Salpingitis, hydrosalpinx, pyosalpinx, adhesion of salpinx and aplasia of oviduct are the major oviductal disorders. The occurrence of pathological condition in fallopian tube, described by various workers which is presented in Table 3 and was ranged from 0.07% to 29.00%[5,66].

Table 3
Incidence of fallopian tube lesion in buffaloes.

	References	1	2	3	4	5	6	7
1	Rao and Murthy[5]	1393	10	0.07	7.00	3	0	0
2	Damodaran[6]	2700	176	6.52	114.00	62	0	0
3	Shalash[7]	606	28	4.62	0.00	28	0	0
4	Shokeir[8]	310	14	4.50	14.00	0	0	0
5	Shalash and Salama[9]	2109	22	1.04	11.00	11	0	0
6	Elsawaf and Fouad[11]	242	10	4.01	6.00	2	0	0
7	Rao *et al.*[12]	300	9	3.00	3.00	5	1	0
8	Sharma *et al.*[14]	3684	152	4.11	74.00	38	22	18
9	Khan and Salama,[15]	972	111	11.60	77.00	5	11	18
10	Kodagali and Kerur[16]	1068	17	1.59	11.00	6	0	0
11	Rao and Rajya[19]	7500	141	1.77	11.00	130	0	0
12	Sharma *et al.*[23]	1340	3	0.22	3.00	0	0	0
13	Modi *et al.*[31]	11209	69	0.62	0.62	0	0	0
14	Bhattacharya *et al.*[33]	1020	58	5.73	9.00	48	1	0
15	Saxena[34]	465	2	0.43	2.00	0	0	0
16	Hansen[45]	739	8	1.08	0.00	8	0	0
17	Kumar and Singh[47]	485	64	13.20	50.00	6	0	8
18	Malik *et al.*[49]	1000	164	16.40	139.00	25	0	0
19	Nagarajan *et al.*[66]	245	71	29.00	39.00	19	0	13
20	Azawi *et al.*[67]	405	51	12.59	12.00	20	9	10
21	Dwivedi[68]	1175	65	5.60	26.00	39	0	0

1. Number of the animals examined, 2. Number with pathological conditions, 3. Percentage of pathological conditions, 4. Salpingitis, 5. Hydrosalpinx, 6. Pyosalpinx and 7. Others.

Published reports on the incidence of oviductal abnormalities in buffaloes, though not very common in India (0.31% to 0.62%) and are considerably higher in areas like Latin America (1.3% to 5.2%), Egypt (1.7% to 5.9%), and Pakistan (10.9%)[69,70]. Hydrosalpinx, an oviductal disorder in buffalo, has been reported to occur in 1.8% to 2.2% cases of slaughtered animals in India[46]. In a survey of morbid genitalia, Azawi[67] reported 71.4% of the hydrosalpinx were unilateral while the rest were of the bilateral type. Two types of hydrosalpinx could be distinguished grossly and histopathologically, (a) hydrosalpinx simplex and (b) hydrosalpinx follicularis. Grossly in the simple form, the fallopian tube is consideredably distended, elongated and tortuous forming several cords in mesosalpinx. The wall was thin, translucent and distended with 4.0 mL to 200 mL clear fluid. In the follicular form, the tube was distended with little fluid, hard tortuous and irregularly beaded. Histologically, the mucous folds in the simple form were considerably atrophied and lined by low cuboidal to columnar type of epithelium, devoid of cilia. In the follicular form, the fibrous septa were usually thin and the tuberculae were lined by low cuboidal or flat epithelium on both the sides[6,19,46]. Highest incidence of hydrosalpinx (3.1% *vs.* 1.0%) have been reported in buffaloes than the Indian and crossbred cattle[37,43,71]. This condition may occur as a secondary to segmental aplasia of the paramesonephric duct and other anomalies of the reproductive tract and also due to adhesions at the proximal or distal ends of the oviduct.

Azawi[67] reported hydrosalpinx was found in 28 (6.9%) cases of which 20 (71.4%) were found unilaterally and 8 (28.6%) bilaterally. In hydrosalpinx cases, dilatation of the oviduct are due to clear amber fluid accumulation were detected. In 8 cases, an extreme dilatation were observed with the oviduct having maximum diameter of 30 mm. Pyosalpinx was recorded in 12 (2.9%), characterized by dilatation of the oviduct due to a thick whitish yellowish pyogenic fluid. Unilateral pyosalpinx was observed in 11 (91.7%) cases and bilateral pyosalpinx was found in 1 (8.3%) case. Gross examination of oviducts affected with hydrosalpinx and pyosalpinx revealed that the obstruction in these tubes were mostly near the *utero*-tubal junction or the end part of isthmus. Three cases (0.7%) of oviducts filled with blood were recorded. Obstruction of oviducts was recorded in 5 (1.2%). Adhesions between mesosalpinx and perisalpingeal tissues were observed in 7 (1.7%) cases. One case of double oviduct was found in the left side of the tract examined. Histological examination of these two tubes confirms this diagnosis. The cases of blind fallopian tube in buffalo were reported by Elsawaf *et al.*[11]. Occurrences of mucosal cysts in the percentage of 2.4% to 4.7% were reported by Sharma *et al.*[72], Dwivedi *et al.*[46], respectively. Nagarajan *et al.*[66] observed that salpingitis was the most common lesion histologically. Tuberculous salpingitis was also reported by Calaprice[73], Kodagali *et al.*[16] and Kumar *et al.*[47]. Dawson[74], Dwivedi *et al.*[46] and Rao *et al.*[19] noticed chronic

bursitis and ovaro bursal adhesion. It was estimated that 2.8% cases of unilateral and 12.8% cases of bilateral ovaro bursal adhesion were infertile[53]. Sevimli *et al.*[75] observed in his study that oviduct cysts is surrounded by epithelium differing from a single layer of flat epithelium to cubic epithelium were observed at the serosa of the right and left uterine horn. Some of the cysts were empty inside; however, some of them were enclosed by homogeneous, vacuolar and amorphous structures pink in colour. But no myometrial, endometrial and ovarian lesions were found in the uterus. Cysts similar to the uterine cysts were seen also in the oviduct. Sharma *et al.*[23] reported that the incidence of salpingitis was 1.25% and histologically characterized by focal or diffuse infiltration of lymphocytes in the lamina propria of mucosal folds and fimbriae. Mild inflammatory lesions of oviducts were likely to go unnoticed since they do not show any palpable alterations in size, but muscular contractions, cilliary actions and currents of fluid in oviductal lumen were altered to a great extent.

5. Pathology of uterus

The various uterine lesions were isolated by various workers and is reproduced in Table 4. The lowest and highest incidence of uterine lesions among buffaloes was recorded as 2.61% and 68.40% by Sharma *et al.*[23] and Bhattacharya *et al.*[33], respectively. Among the congenital abnormalities, infantile uterus was observed in buffalo by Sharma *et al.*[14] and Kodagali *et al.*[16]; malformed uteri by Hansen[45], uterus unicornis by Shokeir[8], Malik *et al.*[49], Elsawaf *et al.*[11] and Sharma *et al.*[23]. Based on gross examination, several workers have reported endometritis, hydrometra, and pyomtera. According to Bhattacharya *et al.*[33], Damodaran[6], Shalash *et al.*[63], Prasad *et al.*[76], Velhankar *et al.*[77] and Sharma *et al.*[23], pyometra was fairly common finding in buffalo. Dwivedi *et al.*[78], Rao *et al.*[19] and Sharma *et al.*[23] reported that endometritis was the commonest lesion. Sharma *et al.*[23] reported that the endometritis was recorded as 13.75% and histologically, the condition was classified as sub-acute, acute and chronic. Further, he reported there was mild oedema and moderate infiltration of lymphocytes in the subepithelial tissue was seen in subacute cases, while in acute endometritis degeneration of the glandular epithelium and severe congestion and oedema were observed. In chronic endometritis there was aggregation of mononuclear cells in the perivascular as well as periglandular regions. The occurrence of lymphoproliferative polyserositis in the uterus of Indian water buffaloes has been reported by Iyer[79]. Grossly, small, grayish-white, mustard sized raised foci were evenly distributed on the dull looking serosal surface. Microscopically, this lesion exhibited the presence of lymphoid follicles comprised of large number of small and medium sized lymphocytes, plasma cells and few macrophages. There was no infiltration into underlying parenchyma and the capsule formed a firm boundary. Other usually uncommon conditions like cystic endometrium, macerated fetus, endometriosis, perimetrial abscess, senile atrophy, perimetrial

Table 4
Incidence of uterine lesion in buffaloes.

	References	1	2	3	4	5	6	7	8	9	10
1	Rao and Murthy[5]	1053	326	30.95	318.00	6.00	2.00	0.00	0.00	0.00	0.00
2	Damodaran[6]	2700	201	7.44	134.00	10.00	0.00	10.00	0.00	42.00	5.00
3	Shalash[7]	606	22	3.63	0.00	15.00	0.00	0.00	5.00	0.00	2.00
4	Shokeir[8]	310	26	8.40	17.00	0.00	0.00	0.00	2.00	2.00	5.00
5	Elsawaf and Fouad[11]	242	15	6.20	11.00	0.00	0.00	0.00	2.00	0.00	2.00
6	Sharma *et al.*[14]	3684	1156	31.40	210.00	341.00	88.00	250.00	0.00	107.00	163.00
7	Kodagali and Kerur[16]	1068	234	21.90	9.00	5.00	97.00	20.00	3.00	16.00	84.00
8	Rao and Rajya[19]	7500	228	2.87	60.00	0.00	5.00	36.00	5.00	45.00	77.00
9	Hussain and Muniraju[22]	1155	97	8.39	74.00	23.00	0.00	0.00	0.00	0.00	0.00
10	Sharma *et al.*[23]	1340	35	2.61	33.00	2.00	0.00	0.00	0.00	0.00	0.00
11	Singla and Verma[24]	2410	172	7.13	103.00	0.00	0.00	0.00	0.00	0.00	69.00
12	Tomar *et al.*[25]	2983	296	9.92	296.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Saxena *et al.*[26]	760	135	17.76	52.00	0.00	0.00	14.00	1.00	9.00	59.00
14	Ananda and Srilatha[27]	425	14	3.29	14.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Mittal *et al.*[29]	504	20	3.92	0.79	0.39	1.19	0.38	0.00	0.59	0.58
16	Modi *et al.*[31]	11209	5503	49.08	48.80	0.22	0.00	0.05	0.01	0.00	0.00
17	Bhattacharya *et al.*[33]	1020	698	68.40	389.00	46.00	49.00	67.00	-	17.00	130.00
18	Saxena[34]	465	16	3.40	11.00	0.00	3.00	1.00	1.00	0.00	0.00
19	Hansen[45]	739	117	16.83	11.00	0.00	0.00	0.00	2.00	0.00	104.00
20	Kumar and Singh[47]	485	217	44.70	54.00	4.00	59.00	7.00	0.00	0.00	93.00
21	Bhattacharya *et al.*[48]	1800	456	25.30	91.00	0.00	0.00	137.00	0.00	0.00	288.00
22	Malik *et al.*[49]	1000	182	18.20	113.00	34.00	0.00	27.00	3.00	0.00	5.00
23	Azawi *et al.*[67]	405	88	21.72	61.00	2.00	15.00	4.00	0.00	0.00	6.00
24	Dwivedi[68]	1125	530	52.44	502.00	0.00	0.00	3.00	2.00	0.00	23.00
25	Velhankar *et al.*[77]	205	40	19.51	38.00	2.00	0.00	0.00	0.00	0.00	0.00

1. Total number of animal examined, 2. Number of animals showing uterine lesions, 3. Percentage of animal showing uterine lesions, 4. Endometritis/Metritis, 5. Pyometra, 6. Perimetritis, 7. Hydrometra and Mucometra, 8. Macerated fetus/Mummified fetus, 9. Perimetrial cysts and 10. Others.

cysts have been described by various workers[19,75,78,80]. Hyaline degeneration of endometrial stroma and arteriosclerosis of blood vessels in buffalo cows was mentioned by Chatterjee *et al.*[81]. Janakiraman *et al.*[82] described the uterine gland characteristics during estrous cycle in the water buffalo. Serosal vascular protrusions in the uterus were first time noticed by Calaprice *et al.*[73] and afterwards by Rao *et al.*[19]. The important infections affecting the buffalo uterus have been considered as tuberculosis, brucellosis and trichomoniasis. Tuberculosis metritis in buffalo was mentioned by number of workers[16,19,47,79,83,84]. The various neoplasms reported in buffalo uterus were fibroma[19,85,86]. Histopathologically, the growth was composed of closely packed bundles of spindle shaped fibroblasts and collagens fibers arranged in different directions. Leiomyoma in uterus was reported by Damodaran[6]. Dwivedi[68] and Deeb *et al.*[87] reported fibroma on the uterus of buffalo. Adenoma and lipoma in buffalo uterus were recorded by Kumar *et al.*[32]. In adenoma, a large nodule surrounded by dense capsule was noticed in the endometrium. In the centre of the nodule, connective tissue component was of loose texture, moderately cellular and was concentrically arranged the glandular structure indicating adenomatous hyperplasia. Hyperplastic glandular epithelial cells with granular cytoplasm and irregular hyperchromatic nuclei could be noticed. Lipoma was observed on the serosal surface and penetrated up to myometrium separating muscle by soft whitish grey mass. Tumor contained mature adipose tissue with fibro collagenous interstitial tissue. Endometrium was atrophied and necrotic. Myoma and haemangioendothelioma of uterus were mentioned by Singh and Singh[88]. Microscopically, the tumour cells were rounded or satellite in appearance with infrequent mitotic figures. There were serous exudation and hemorrhage. Lymphosarcoma particularly affecting the serous surface of the uterus was described by Singh[89] and Singh *et al.*[90]. Lymphofollicular aggregates were evident on the serosal surface. In some cases, these neoplastic cells invaded into the myometrium and endometrium too.

6. Pathology of cervix

The occurrences of cervical lesions as recorded by different workers are represented in Table 5. Among the congenital abnormalities, double cervix was reported in buffaloes by Shokeir[8] and Kodagali *et al.*[16], a solitary case of os-triplex by Kodagali[93], double external os with a band of tissue situated dorsoventrally at the external os by Reddy[94] and Rao *et al.*[19] Sharma *et al.*[13] and Deep *et al.*[87] noticed complete absence of cervix in a buffalo each.

Dilatation of cervix was mentioned by Damodaran[6] on association with closure of vagina. Cervical stenosis was rarely reported in a buffalo by Kodagali *et al.*[16]. Incomplete closure and bending of cervix was recorded in buffalo by Malik *et al.*[49], Dwivedi[68] and Kodagali *et al.*[16]. Cervical cysts of varying sizes and shapes have been described in buffalo by various workers[6,13,19,33,45,47,74,91 ,95]. Generally, cysts (2.5 cm–9.5 cm in diameter) were found at the external orifice of the cervix having inspissated cervical mucus. According to Sane *et al.*[91], these were retention cysts associated with chronic cervicitis. Deeb *et al.*[87] and Kumar *et al.*[47] mentioned the histopathological changes of the female genital tract of buffaloes with cervical Nabothian cysts. The cysts of various size and shape, some being round and the other elongated. Their size varied from that of a pea to that of anterior part of the thumb. On palpation, the cysts were fluctuating nature and could be differentiated from tumours which were hard in consistency. When cut, the thick white semisolid jelly likes mass came out which was free from odour[13].

6.1. Double cervix

The cervix was divided into two parts due to thick fibrous band or septum. The fibrous band extending from the dorsal border to the

Table 5
Incidence of cervical lesion in buffaloes.

	References	No. of animal examined	No of animals with pathological condition	Percentage	Cervicitis	Cysts	Abnormalities	Others
1	Damodaran[6]	2700	29	1.07	18.00	8	0	3.00
2	Shalash[7]	606	3	0.50	0.00	0	1	2.00
3	Shokeir[8]	310	11	3.50	5.00	4	1	1.00
4	Kodagali and Kerur[16]	1068	30	2.80	6.00	0	23	1.00
5	Rao and Rajya[19]	7500	43	0.53	37.00	6	0	0.00
6	Singla and Verma[24]	2410	19	0.78	19.00	0	0	0.00
7	Modi *et al.*[31]	11209	71	0.63	0.36	0	0	0.28
8	Bhattacharya *et al.*[33]	1020	111	10.88	107.00	4	0	0.00
9	Saxena[34]	465	15	3.22	4.00	0	11	0.00
10	Kumar and Singh[47]	485	127	26.00	120.00	4	0	3.00
11	Malik *et al.*[49]	1000	227	22.70	99.00	0	128	0.00
12	Dwivedi[68]	1175	307	26.10	22.00	23	262	0.00
13	Sharma *et al.*[73]	3684	207	5.60	187.00	5	10	5.00
14	Sane *et al.*[94]	1900	12	0.60	0.00	11	1	0.00
15	Bhandari *et al.*[99]	139	43	32.06	43.00	0	0	0.00

ventral border divided the opening into two parts, but the cervical canal was single. This condition was designated as false double cervix[13]. In true double cervix, a complete septum divided the cervical canal longitudinally into two parts, each opening leading to a separate horn[13].

6.2. Absence of cervix

The absence of cervix was characterized by the absence of external os, cervical canal and internal os. The vagina was separated from the uterus by means of anterior wall of the vagina. The uterine horns were very much enlarged, flaccid, and atonic. The internal surface of the horns was smooth and devoid of cotyledons. The ovaries of these organs were smooth and disappeared sub-active or non-functional[13]. Cervicitis either alone or associated with metritis and vaginitis had been found to be a frequent condition in buffalo and was classified as acute, chronic, and necrotic[6,19,47,96-98]. Tuberculosis of the cervix has been occasionally reported along with lesions in other parts genitalia[96]. The inflammation of cervix varied from localized mild congestion of cervical rugae to quite severe type characterized by profuse swelling of the external folds. In acute inflammation of cervix, the external os was enlarged and the external folds were thrown in to the vagina. The cervix was oedematous on palpation and was purple to dark red color. The annular folds of canal were enlarged and occluded the opening of the cervix. Dark colored was seen hanging out from the cervical opening of the cervix. The discharge coming out fouls smelled. The cervix was hard on palpation. Sharma *et al.*[23] reported the cervicitis was associated with metritis and endometritis in 157 (4.2%) cases. Cervical tumors are considered rare in buffaloes and were varying in sizes and were attached to the cervix and laying in the cervical canal. Dwivedi[68], Kodagali and Kerur[16] and Sharma *et al.*[23] recorded a case of fibroma in buffalo cervix. The biggest tumour (75 cm) as well as smallest (1.5 cm) were recorded and were hard on palpation and had consistency of firm tissue[23] and he reported the incidence of tumour is 0.13%.

7. Pathology of the vagina and vulva

Various pathological conditions involving vagina and vulva of buffaloes were reported by various workers presented in Table 6. An incidence of 0.2% to 0.7% was reported by Damodaran[6], Shokeir[8], Elsawaf *et al.*[11], Kodagali *et al.*[16] and Rao *et al.*[19]. Higher incidence ranging from 18.08% to 78.00% was recorded by Bhattacharya *et al.*[33] and Malik *et al.*[49]. Congenital abnormalities of the vagina and vulva other than those encountered in freemartins have been occasionally reported in buffalo. Nimbalkar[99] described a case of imperforate vagina in a buffalo hermaphrodite. Imperforate hymen has been observed particularly in association with white heifer disease in buffalo by Rao *et al.*[19]. Sprigs[100] reported that this abnormality was due to the arrest in the mullerian duct system. Malik *et al.*[49] reported a case of double vagina. Thick vertical bands of tissues named median vertical band at the level of vulvo-vaginal junction of buffalo have been reported by Perkins *et al.*[95], Damodaran[6], Malik *et al.*[49] and Rao *et al.*[19]. A variety of acquired abnormalities such as occlusion of vagina has been reported by Bhattacharya *et al.*[33] and Damodaran[6], uro-vagina by Malik *et al.*[49]. The occurrence of retention cysts in the vulva from the Bartholin's glands and cysts along the course of Gartner's canal have been described by Damodaran[6], Kodagali *et al.*[16] and Rao *et al.*[19]. Bhattacharya *et al.*[33], Shokeir[8], Malik *et al.*[49], Rao *et al.*[19], Raman *et al.*[98] and Kumar *et al.*[47] have reported vaginitis which in majority of cases co-existed with vaginitis. It was classified as acute, chronic and ulcerative/necrotic. The occurrence of vaginal melanosis ranging from 0.37% to 0.89% was reported by Damodaran[6], Kodagali *et al.*[16] and Rao *et al.*[19]. Grossly, the pigmented area was black in colour, about (2–8) cm in length all along the vaginal circumference. Histologically, pigments were noticed more in the basal layer of the epithelium and sometimes around the blood vessels[6,19].

7.1. Granular vulvo–vaginitis

The disease is ubiquitous in nature and has been reported from many parts of world. Bhattacharya *et al.*[33] recorded an incidence of 5.0% to 11.6% from many parts of India, where as Rao *et al.*[19] observed GVV in 0.28% cases. Kumar *et al.*[47] examined the genitalia of 495 she buffaloes having history of infertility and found 15.67% cases having GVV lesions. Grossly, the lesions were in the form of millet size nodules, slightly raised, greyish to greyish-pink in color, arranged linearly in a radiating fashion on the dorsal, ventral

Table 6
Incidence of pathological condition of vagina and vulva.

	References	No. of animals examined	No. of animals with pathological condition	Total percentage	Vaginitis	Cysts	Persistent Hymen	G.V.V.	Melanosis	Others
1	Damodaran[6]	2700	74	2.74	6	14	25	0	24	5
2	Kodagali and Kerur[16]	1068	18	1.68	4	1	6	3	4	0
3	Rao and Rajya[19]	7500	211	2.60	86	31	0	22	70	2
4	Bhattacharya *et al.*[33]	1020	184	18.80	170	0	0	0	0	14
5	Kumar and Singh[47]	485	173	35.66	97	0	0	76	0	0
6	Malik *et al.*[49]	1000	255	25.50	243	0	8	0	0	4

and ventro-lateral surfaces of the vulvar mucosa. Microscopically, the epithelium was thin at the summits of the sub-epithelial lymphoid aggregates. In the lamina propria, diffuse infiltration of lymphocytes and plasma cells was noticed and capillaries adjacent to lymphoid aggregates were engorged[19]. Squamous cell carcinoma in vagina and vulva was reported by Nair *et al.*[37], Rao *et al.*[19] , Thilakrajan[101] and Damodaran[6] described a case of papillary carcinoma in vagina, while fibroma in vagina was recorded by Rao *et al.*[19].

7.2. Future prospects

The future prospects to improve the reproductive traits and eliminate the reproductive disorders in female buffalo are mentioned below.

There is a need to study on sexual development, attainment of puberty, sexual maturity and reproductive performance of female buffaloes at greater extent. Study of molecular marker (DNA/gene) assisted selection and cytogenetic studies linked to gene of interest with major effects on reproduction need to be strengthened for selection of breedable female in bubaline species at the early age. This cytogenic marker would help to cull/eliminate that particular female from the herd to prevent to spread the genetic/congenital defective gene from dam to future offspring and to prevent reproductive disorders.

Realistic remedial measures for reducing infertility and enhancing fertility need to be emphasized for the effective control of various reproductive disorders.

Biosafety measures for production disease free germ plasm and registration of all A.I. bulls by a national society to initiate a certified disease free semen services for the whole nation need to be addressed. Thus prevent spreading of the genetic, infectious and congenital causes of infertility in buffaloes.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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