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(Review Article)

Reproduction of Buffalo
I—Reproduction in Male

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There are 77 million domestic buffaloes in the world, of which there are 74 in Asia, 2 millions in Africa and half a million in Europe. Most of Indian buffaloes belong to the swamp buffaloes, while the African buffaloes is considered to be river buffalo. Both races belong to the Asiatic buffalo, *Bos (Bubalus) bubalis*, that belong to genus Bos family Bovidae and superfamily Bovoidea. The other species to this genus is *Bos taurus* and *Bos indicus*, the cattle. Accordingly, both species has lot of similarities, yet the buffaloes had not attracted attention like the cattle. The chromosome number of the Egyptian river buffalo is 2 n 50, NF 60, while it was 2 N 48, NF 58 for the Indian swamp buffalo that rise a question whether there are two species in the buffalo. This may clear why two types, the river and swamp buffaloes do not produce offspings when mated to each other.

The habitat of buffaloes in swamps and rivers under lot and humid weather, enables them to withstand unfavourable conditions of hot and undeveloped areas and can give reasonable production of milk and meat beside labour.

Reproduction in Male

Anatomy

The genital organs of the buffalo bull conform to the general mammalian type. There are great similarities between buffalo and cattle bulls with respect to the morphological characters of the genital organs. However, the sheath of the buffalo is longer than in cattle. Its free extremity is not covered with hair, while it is covered with hair in cattle. The distance between the sheath orfice and the naval is longer in the buffalo than in cattle. The scrotum in the buffalo is less pendulous than that of cattle. There is no hair covering the skin of buffalo scrotum. In the river buffalo, the penis hangs in apendulour sheath formed by a fold of skin extending from the umbilicus backwards. The swamp buffalo has the penis contained in a sheath which adheres close to the body except at the umbilical end, where , it hangs free by a short distance of 3 cm. The scrotum in the swamp buffalo is small and has no constriction near the attachment to the abdominal wall forming no neck. In the river buffalo, the scrotum is longer, with a distinct neck that compose one third of the length of scrotum body forming a pendulous scrotum. The scrotum of the buffalo, however, is smaller in size than that of cattle of similar size.

In Egyptian buffaloes the length of the penis from the ventral side is longer than that from the dorsal side. The anatomy of the penis show that its shape is sloping from its root to its sheath (Zaki, 1971). The diameter of the penis larger in cattle than in buffalo. The length and thickness of the corpus prostate are greater in cattle than buffalo, but its width is larger in buffalo than cattle. Also, it was found that the number of mucus folds are more and the thickness of the prostate dessiminata ventrally and dorsally are larger in the buffalo than cattle . Buffalo testis is noticably smaller in buffalo than cattle. The long axis of the testis in cattle is more vertical than in the buffalo. The early studies of Ma Gregor (1941) indicated that the testicles descend in the scrotum when the buffalo calf is about six months old, however, in the Egyptian and Murrah buffalo, the testicles are found in the scrotum at birth.

The length, width and thickness of the seminal vesicle are larger in cattle than in buffalo. These comparison clear up the cause of higher percentage of fructose in cattle than buffalo. The dorsal postion of the ampullae-ductus-openings to the seminal vesiclesducts-openings is more frequent in the

TABLE 1. **The comparison between buffaloes and cattle in the different measurements weights of male genital organs and parts.**

Organs and parts	Buffalo	Cattle
Length of scrotum body cm	16 — 20	25 — 35
Circumference of scrotum body cm . . .	32 — 35	30 — 45
Sheath length cm	36	20 — 30
Penis length during erection cm	36	25 — 30
Penis weight with its sheath g	255	300—420
Testis measurements cm	11 × 5 × 4	14 ×7×7
Testis weight with the epididymis g . . .	107	300 —500
Seminal vesicle measurements cm	7 ×0.9×0.5	14×4×3
Seminar vesicle weight g	9	60 — 75
Ampullae measurements cm	12 × 0.8	14 ×1.2
Ampullae weight g	4.3	—
Dactus deferens measurements cm	82 × 0.2	102 × 0.4
Dactus deferens weight g	4.2	—
Cowper's gland measurements cm . . .	3.7 × 1.4×0.8	—
Cowper's gland weight g	3.2	—

buffalo than in the cattle, while the ventral and intermediate positions are less frequent in buffalo than cattle. The secretory main duct of the Cowper's gland is longer in cattle than in the buflalo. Also, the length of the Cowper's gland is longer in the buffalo than in cattle, while its width and the thickness were less in the buffalo than in cattle. As found previously, the structure of the main and accesory sex organs in the buffalo is like the cattle irrespective to a general trend that the organs of the buffalo are smaller in size. This is not due to differences in body size as the buffalo bull normally weight from 800-1000 kg, which is almost the same like the cattle.

Histology

Histological examinations of testis indicate that each seminiferous tubule contains spermatogonia, primary sparmatocyte, secondary spermatocytes and spermatids. The largest external diamter of seminiferous tubule is 222μ. The diameter of the four types of cells and their nuclei are on the average 13, 20, 11 and 9μ for the cells and 6, 10, 6 and 4μ for their nuclei respectively. Each tubule contains 8 sertoli cells of 29 μ diameter and 14μ diamter for its nuclei. The average number of interstitial cells is 35. Their largest diameter and their nuclei are 21 and 17 μ respectively. The largest external diameter of both the testis blood vessels and capillaries are 42 and 14 μ.

The largest external diameter of epididymal tubule is 38 2 μ. Each tubule contains 3 types of cells, the ciliated non-ciliated and basal. The largest diameter of the three types of cells and their nuclei are 45, 29 and 24μ for cells and 14,14 and 8 μ for nuclei. The hight of cilia is 16 μ, and the distance from the basal membrane of the epididymal tubule and its lumen including the cilia is 96 μ.

The largest external diameter of the seminal vesicle tubile is 237 μ. Each of these tabules has 3 types of cells A, B and C, lined in two layers. The largest diameter of these cells and their nuclei are 25, 12 and 24 μ for the cells and 10 9 and 10 μ for the nuclei respectively. The average number of these types o cells in each tubule are 60, 39 and 8 cells respectively. The thickness of the longitudinal, circular and longitudinal plus circular muscle septa are 253 312 and 387 respectively.

Prostate tubule is of 99 μ in diameter and contain 28 cells of 17 μ in diameter. Cowper's gland tubule is of 96 μ, diameter which contains almost 25 cells of 18 μ in diameter. The external diameter of the ampulla is 150 μ, each tubule has 37 cells of 28 μ in diameter.

Puberty

The transition period from the infantile stage to the sexually functional male calfs last approximately 23 weeks. Buffalo bulls reach puberty at mean age of 81 weeks, ranging from 66-89 weeks. Five stages preceed the onset of puberty. The first from 59-63 weeks of age, after the infantile stage, the calf begins smelling and licking the other sex calves. The second, when the male calves are left with females, they mount them without erection, during the period from 63 to 64 weeks of age. During the third stage, the young bulls began to erect without ejaculation when mounting females during a period

from 64 to 70 weeks of age. The fourth stage begin when the bulls mount, erect and ejaculate with gradual improvement of semen quality, during the period from 70 to 81 weeks of age.

After attaining sexual maturity, ejaculates were obtained each 10 days. All the physical characters of semen are improved until the 8th ejaculate, then the characters remains almost constant. However, chemical analysis of semen samples show slight improvement. Accordingly it is recommended that buffalo bulls should not be placed in service until they are at least 2 years old (Sayed, 1958).

In the study of Baker *et al.* (1953), he found that the young male buffaloes attain full puberty later than the Freisian bulls when compared under the same conditions.

In normal practice in Egypt, however, the buffalo bulls are first used at service at 3.7 years. Their average useful life is 4 $\frac{1}{2}$ years (El-Itriby and Asker 1957). In India the buffalo bull is put to service at about the same age (Perry, 1960). However, Sayed (1958) obtained ejaculates with good quality and quantity earlier than that age at almost 2 years.

TABLE 2. **Physical and chemical characters of young buffalo bulls semen.**

Semen characters	Range between first and 8*th* ejaculate after sexual maturity	Range of ejaculate after the 8*th* ejaculate until the 10*th* one
Volume cm^3	1.0 — 2.3	2.3 — 2.4
pH	7.28 — 8.94	6.96 — 6.92
Concentration $cm^3 \times 10^6$	13 —544	634 —732
Motility %	0 — 56	62 — 64
Live %	56 — 85	86 — 88
Abnormalities %	36 — 19	17 — 17
Fractose mg/100 cm	316 —667	573 —576
Non Protein nitrogen mg/100 cm	108 —116	120 —126
Total protein g	2.3 — 3.4	2.5 — 3.1
Total phosphorus	55 — 77	76 — 76
Inorganic phosphorus mg/100 cm	6.1 — 9.0	7.8 — 10.0
Organic phosphorus mg/100 cm	48 — 63	66 — 68
Creatinine mg/100 cm	4.9 — 5.8	4.9 — 5.2
Chloride mg/100 cm	292 —326	286 —296

Mating behaviour

In young buffalo bulls ranging in age from 8-14 months erection took place before mounting while pratrusion penetration and ejaculation came later. Before ejaculation the penis herdened but without great enlartargement and tibrated rapidly. Violent impression is observed only at the time of ejaculation.

The buffalo bull smell receptive females licked their external genitalia raised his head and sniffed. Erection took place before mounting whilst prot rustion penetration and ejaculation and ejacuation came last. Before ejaculation the glans penis hardened but without any great enlargement and and vibrated repidly. Fiereceness is only ovderved at the of ejaculation. The males did not show offensive reaction towards the buffaloes after mating. Mating patterns of the cattle bull differs grdeatly than that of bufflo bull. In the cattle the protrusion of the penis occurs before mounting whilst in thə buffalo mounting occurs before protrusion and actual penetration.

The time internal betwen two successive copulat ions ranged from 30 to 20 minutes. According to sequence of service and the degree of receptivity of the female. After three condecutive services the buffalo bull shows exhuustion and efforts in mounting. Sometimes he explored genitolia dna do not attempt to mount. At least four hr of rest has elapse to revive sexual libids.

Sex drive exhibited by the buffalo bull is considerably variable according to size and age of female. The different to particular females. Certain buffalo bulls show greater sexual interest towards by size females than to their age mates. When ther is big size difference between the two sexes the male tends to ejaculate with less certainity to penetrate. After force mating nonreceptive females the male is greatly attracted to them. When an apron is used to cover the whole belly and external genitalia of the male his sexual bilbide do not decrease either during or after removing the apron. Heavy rainfalls and severe hot climatic conditions depress the sexual desire, whilst water sprinkling stimulates teasing action (Hafez 1953).

In normal mating, the time elapsing from exploring the female geniralia to ejaculation is prolonged when the interval between ejaculations is curtailed. The copulatory pattern in the buffalo under natural mating conditions is similar to that when using the artificial vagina (Hafez and Darwish (1956).

The reaction time of buffalo bulls in artificial collection of semen, is influenced by season and frequency of collection. The average reaction time is 46-48 seconds. Collection of the first ejaculate take a longer time (64 seconds) than the second ones (32 seconds), although the number of sperms per ejaculate is greater in the first than in the second. The shorter reaction time is in autumn (42 seconds),followed by the winter (43 seconds , spring (79 seconds and summer (56 seconds). There is no correlation between reaction time and semen characteristics. Also, there is to statistically significant differences in either the reaction time or semen production between the buffalo bulb artifically mated to tesser cows of different estrus stages.

The swamp race is of a nocturnal mating type, while the river race is of a daytime mating type.

Semen characters

The most suitable temperature for the artificial vagina for buffaloes is 39°C. The normal colour of buffalo semen is milky white with a tinge of blue, while that of the cattle is milky white with a yellowish tinge. The average volume per ejaculate of buffalo semen is 3.5 cm ranging from 1.2 to 6 cm. The sperm sediment is 17.32% of the total volume. When in good condition, buffalo semen is creamy thick, however, with the rise in atmospheric temperature the viscosity decreases to a watery thin state. The velocity of buffalo sperm measured in vitrs is 1.65 mm per minute (Mahmoud, 1952). The number of sperms ranges from 210,000 to nearly 2 millions per cubic millimeter with an average of 800, 000 spermatozoa. Motility rating ranges between 40 to 70 % with an average of 60 % (Sayed, 1958). In a comparative study of buffalo and cattle sperm measurements, Mahmoud (1952) found that buffalo sperms have smaller sperms than the cattle (Table 3). A comparison between the averages of buffalo and cattle semen physical and chemical characteristics is reviewed in Table 4. The general picture of the semen of buffalo and cattle bulls is almost the same with slight variations in physical characters. However, chemical analysis of the semen of both cattle and buffalo shows a quite lot of variations. This is mainly attributed to the previously mentioned differences in accessory sex organs of male buffalo and cattle, especially in the seminal vesicle size. This reflects on the types of secretions and the concentration of different constituents.

TABLE 3. **Sperm measurements in buffalo and cattle (microns)**

Parts of sperm	Buffalo	Cattle
Head (length × arterior breadth × posterior breadth)	3.44× 4.26× 3.17	9.13× 4.73× 2.73
Neck	0.44	0. 65
Middle piece (length × breadth)	11.65× 1.1	12.56× 1.1
Tail length	42.88	46.28

Seasonal variations in semen characteristics of buffalo and cattle bulls are studied in subtropical and tropical localities. Most of these studies indicated that the physical and chemical characteristics exhibit seasonal trends (Table 5). The quality of semen in both species is better in winter than in other season due to the fine weather of this season in subtrop ical and tropical countries, where buffaloes are prevailing. However sem en quantities give another trends, giving their best values during spring and

Table 4. Comparison between buffalo and cattle semen in physical and chemica characters (mg/100 ml)*

Items	Buffalo	Cattle
Volume cm	2.5 — 3.5	3.4
Motility %	40 — 77	64 — 75
pH	6·8 — 7.0	6.7 — 6.9
Ratio of sperms/plasma	16.4	16.6
Concentration per ml.× 10^6	1208 —1264	1327 —1456
Live %	68—81—91	73—79—91
Total abnormalities %	5—11—17	5—11—15
Fructose	355 — 478	402 — 610
Total nitrogen	485	756
Nonprotein nitrogen	109 — 171	48
Calcium	28 —40 —60	25 — 44
Chlorides	328 — 373	247 — 369
Magnesium	2.97	3.32
Lactic acid	26.1	23.4
Ascorbic acid	4.13	14.29
Citric acid	489	720
Total phosphorus	60 — 95	41 — 74
Organic phosphorus	68	73
Inorganic phosphorus	6.3 — 9.1 17	5.9--2.9—9.0
Acid-soluble phosphorus	72	29
Acid phosphatase activity (bodansky unit)	308	145
Alkaline phosphatase activity (Piodensky unit)	251	134

* Means secured from different sources (Sayed, 1952; Perry, 1960 and Ibrahim, (196

early summer Semen quality includes motility and percentages of live and abnormal sperms, whilst semen quantities includes semen volume and concentration. Chemical composition of semen is not affected greatly by the season in both species except for magnesium creatinine, nonprotein nitrogen and total protein contents. Significant negative correlations are found between air temperature and sperm motility and concentration. Some semen characteristics are positively correlated with each others. These are sperm motility X live sperm % (r =0.617), total protein X semen volume (r= 0.617), pH X motility (r= 0.688), sperm concentration X semen volume (r = 0.456), X total phosphorus (r = 0.308), X total protein (r= 368) and total phosphorus X organic phosphorus (r = 0.961).

Sayed and Shafie (1963) estimated the total phosphate in blood and semen collected from cattle and buffalo and observed highly sigaificant positive correlation between total and inorganic phosphorus content in blood and semen of both species. Also, Ibrahim (1969) in a similar study observed significant negative correlations between calcium and alkaline phosphatase in blood and semen, while it is positive with respect to lactic acid.

Reproductive efficiency

Buffalo and cattle are non-photoperiodic animals which are independent of photoperiodicity. This is mainly attributed to the high levels of domestication acheived by these animals. Also, these animals have originated in tropical and subtropical zones where there is no marked seasonal variation in daylength. Accordingly, buffaloes have not acquired any photoperiodic response since the conditions of feeding, shelter and improvement for the survival of young are favourable. Matings and parturitions occur throughout the year irrespective of the gestation period or the daylength.

The limiting factor, thense, that determine the calving and mating season of buffalo, is the other components of the environment such as temperature, relative humidity , rainfall, animal management, plane of nutrition, disease, agricultural policies and culture. Sex drive of the male, which is independent of sperm production, is generally less in summer months than in other seasons. The maximum percentage of successful conceptions under free mating conditions occurs during the months of October, November and December, while the minimum is during the months of July, August and September. The frequency of successful matings is reversely related to both air temperature and daylength. The rice in successful mating during October to December may be due to the mild weather associated with the high plane of nutrition available during this period . The buffaloes conceiving during October to December, calve during September to Novebmber, which are the most favourable for both dams and offsprings (Badreldin, 1952).

The average number of services per conception is 1.93 in cattle and 1.46-1.51 in buffaloes. 56% of the conceptions require one service, 22 % require two services, while 7% require three or more. The aborted buffalo-cows require more services than old or calving ones (Rasheed, 1958).

TABLE 5. Seasonal variations in physical and chemical characteristics of semen

Items		Spring	Summer	Autumn	Winter
Volume cm	1	2.4—3.5	2.6—3.9	2.9—3.3	3.2—3.3
	2	4.8	5.7	6.0	6.1
Motility ×	1	61—68	61—75	64—73	54—81
	2	51	62	69	74
pH	1	6.9—7.1	6.8—7.1	6.9—7.1	6.2—6.9
	2	6.8	6.8	6.6	6.7
Concentration/ml × 10^6	1	1047—1563	1037—1277	865—1098	795—1295
	2	1537	1456	1037	1638
Live %	1	62—76—81	63—82—86	80—82	69—82—85
	2	68—75	67—84	72—80	73—87
Abnormal%	1	9.9-11.7-21.1	8.7-9.9-15.2	10.4-11.6-12.4	10.1-12.1-23.6
	2	11.9-14.0	11.4—11.6	10.8—17.8	11.1—23.3
Fructose (mg/100 ml)	1	368—661	386—728	426—683	431—647
	2	519	612	618	617
Nonprotein nitrogen(11)	1	150	158	265	143
Total protein	1	2.5	3.8	3.0	2.6
Lactic acid (mg/100ml)	1	35	33	40	41
	2	31	32	38	29
Calcium (11)	1	11.9	11.5	10.2	10.6
	2	9.8	9.2	8.7	8.6
Magnesium (11)	1	2.47	2.51	2.52	1.73
	2	1.9	1.9	1.8	1.6
Total phosphorus (11)	1	98	105	100	87
Inorganic phosphorus (mg/100 ml)	1	7.1—10.1	700—9.7	7.6—10.3	7.8. 8.7
	2	6.0	6.3	7.1	6.4
Organic Phosphorus	1	87	96	89	78
Alkaline phosphorus	1	8.4	8.8	5.6	7.3
	2	7.5	7.7	6.9	8.2
Creatinine		5.8	4.1	5.4	5.6
Chloride		299	378	308	296

* Means secured from different sources (Sayed, 1952, Perry, 1960 and Ibrahim 1969)

1. Buffalo.
2. Cattle.

The average number of services per buffalo bull per year in Egypt is 84. 75% of the services occurs during four months of November, December, January, and February. During these four months 74 to 83% of buffaloes are served. This causes the rise of buffalo bulls during this period at least three times a week for service during the service season. Such heavy use of bulls, may be responsible for producing semen of inferior quality and conseqnently may lead to low conception rate ordinarily observed in buffalo in Egypt. (Asker and El- Itriby, 1958).

The buffalo bulls are first at service at 3.7 years which is much higher than the 12-15 months which is the average for bulls belonging to different dairy breeds in temperature countries. However, the useful life is longer in buffalo bulls and 62% of them are still in service for 13 years, whilst the useful life for cattle bulk ranges from 1.85-2.25 years. The reasons for disposal of cattle bulls are 25% of the bulb become sterile, 14% are discarded because of bad disposition, 21% died for various reasons and 10 % are culled because of the low production of their daughters. In buffalo bulls 21 % are discarded because of various types of infertility, 9%due to bad disposition, 32% due to senility and 38% due to low production of dams. The annual replacement rate of buffalo bulls is about 5% (El-Itriby and Asker, 1957).

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