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EFFECT OF AGE AND SEASON ON SEMEN CHARACTERISTICS OF BUFFALO BULL - A REVIEW

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ABSTRACT

A large volume of literature on various aspects of semen parameters in buffalo bull at different age and in different seasons has been published with conflicting reports. An effort is made to review the literature gathered from different sources on semen characteristics in buffalo bulls which will be helpful to researchers and allied professionals in future research or policy planning. The review is bifurcated in different sections for easy understanding of the facts. The review suggests and effect of age and season on buffalo bull semen characteristics.

Keywords: Semen characteristics, Buffalo bulls, Age, Season.

1. INTRODUCTION

1.1 Semen Quality

The effect of the season on semen quality of different buffalo breeds has been extensively studied in different parts of the world. The age of the bull influenced the semen quality and later was positively correlated with 5-9 years of age in Nili-Ravi and Surti breed of buffalo bulls (Anzar 1984; Dhami and Kodagali 1988). Similarly, Saeed *et al.* (1988) also reported a significant effect of age on semen quality. They reported that best quality semen was produced from 3-4 years old bulls. Koonjaenak *et al.* (2007) also reported that quality of semen (density and colour) affected by bull age ($P < 0.05$), with an increase with age.

The semen quality as reported by Erb *et al.* (1942) was significantly superior during spring, but inferior in a summer that was similar to findings of Roy *et al.* (1964) in Murrah buffalo bulls. However, Gill *et al.* (1974) and Bhosrekar *et al.* (1992) reported it to be in autumn (September-November) followed by a rainy season, summer and winter. Engelsmann (1986) also reported that best quality semen from Swamp buffalo was obtained in cool months. Heuer *et al.* (1987) also reported that the November semen produced the maximum number of pregnancies of Nili-Ravi bulls. Low quality semen during the summer season has been related with the effect of high environmental temperature and relative humidity on sperm production (Bhavsar *et al.* 1990). Nevertheless, in other parts where the chilling effects of cold (winter) is more it also leads to low quality semen. This probably also varied because of the availability of green succulent fodder in different seasons. Koonjaenak *et al.* (2007) reported quality of semen (PMI and the relative proportion of morphologically normal spermatozoa) highest in summer, and lowest in winter ($P < 0.05$) in swamp buffalo.

1.2 Semen Volume

The frequency of collection, health status of bull

(general and reproductive), age of the bull, and availability of green fodder, genetics and management influence the volume of the ejaculate (Saji,1978; Nazir 1988). The overall mean of an ejaculatory volume of 4.7 ml in Nili-Ravi bulls recorded (Javed 1998) was slightly higher as reported (4.10 ml) for Iraqi buffalo bulls (El-Wishy 1978). Koonjaenak *et al.* (2007) also reported a mean ejaculate volume of 3.5 ml in swamp buffalo. However, Younis (1996) observed semen volume of 2.80±0.07 ml in Nili-Ravi buffalo bulls for 6 months period, while Malik *et al.* (1974) and Ahmad *et al.* (1984) recorded 3.20 and 3.40 ml semen volume, respectively from Nili-Ravi bulls. Vyawanare *et al.* (1989) recorded it to be 3.9 ml in Murrah breed of buffalo from India. Younas (1997) reported higher ($P<0.05$) semen volume from adult (3.03 ml) and older (2.86 ml) than young (2.51 ml) Nili-Ravi bulls. In same breed semen volume of 4.4, 5.0 and 4.8 has been recorded from bulls of <5, 6-10 and >11 years of age with non-significant difference between age groups (Javed, 2000). Younis (1996) and Nordin *et al*. (1990), however, reported higher ($P<0.05$) ejaculatory volume in adult and older than in young buffalo bulls. This suggests that buffalo bulls produce a maximum volume of semen around nine years of age and afterwards it begins to decrease, probably due to the onset of senile changes. Semen volume of 3.3, 2.0, 1.9, 3.1 and 3.4 ml/ejaculate for swamp buffalo bulls of 2, 3, 4, 5 and six years of age, respectively has been recorded (Jainudeen *et al.* 1982). Nordin *et al.* (1990) obtained higher volume in 8-10 years of age in Swamp buffalo bulls. Variation in semen volume reported by different workers might be due to differences in genetics, reproductive health status of bulls, age of bulls, frequency of collection, pooled volume, nutrition, season and management (Nazir 1988; Soderquist *et al.* 1992; Javed 2000,). Pant et al. (2003) reported that scrotal circumference had a significant correlation with semen volume. While scrotal circumference is correlated with age of bulls (Younis *et al.* 2003; Luz *et al.* 2013). Variation can also be due to skill of semen collector/attendant and temperature of AV (Javed, 2000).

Elwishy (1978) recorded higher semen volume in autumn (4.1 ml) followed by summer (3.4 ml), spring (2.5 ml) and winter (3.4 ml) in the Iraqi buffalo breed. The Murrah and Surti buffalo bulls, however produced good quantity semen with the maximum amount in summer (6.05 ml) followed by a rainy season (5.72 ml) and winter (5.40 ml) (Reddy *et al.*, 1983). Ibrahim *et al.* (1983) recorded it to be in spring. Similarly, semen produced by Nili-Ravi breed was maximum in spring (3.23 ml) followed by summer (3.10 ml), winter (3.06 ml) and autumn (2.88 ml) (Nazir *et al.* 1988). Further studies on same breed revealed average volume of 3.2 ml in summer and 3.3 ml in September to November (Nazir *et al.*,1988). Almost similar findings were by Bajwa *et al.* (1982) in a previous study on the same breed. Younas (1997) compared only two seasons, i.e., low (summer) and peak breeding (autumn) and reported higher ($P<0.05$) volume during low breeding (3.44 ml) than peak breeding (2.57 ml) season in Nili-Ravi bulls. Igboeli *et al.* (1987) recorded semen volume of 1.8, 2.3 and 2.0 ml in dry, rainy and the late rainy/early dry season. Singh *et al.* (1992) reported no effect of season on semen volume of Murrah breed during summer and winter. Semen volume of 4.5, 3.7, 6.0, 4.2, 5.0 and 4.7 in a dry summer, humid summer, autumn, winter and spring has been recorded from Nili-Ravi bulls with significantly higher volume in autumn and low in humid summer (Javed, 2000). This is like findings of El-Wishy (1978) in Iraqi buffalo and Gupta *et al*. (1978) in Surti buffalo bulls. However, higher volume in summer has been reported in Surti and Murrah (Reddy *et al*., 1983), Egyptian (Shalash, 1984), Nili-Ravi (Younis, 1996) and in Italian buffalo bulls (Terezinha *et al*., 1991). Variation in different reports regarding semen volume in different seasons might be

due to a difference in genetics, the number of observations made, and length of the study period (Javed, 2000). Besides age and season, ejaculatory volume is also influenced by the frequency of semen collection and the method of semen collection (Saji, 1978).

1.3 Mass Activity

The mass activity (MA) is usually recorded in numerical values ranging from 0-5, 0 being the lowest and five the highest (Nazir, 1988). It shows variation in different ages and in different seasons.

The overall mass activity of 2.65 recorded for Nili-Ravi bulls by Javed *et al*. (2000) was close to 2.93 and 2.53, reported for Nili-Ravi and Indian buffalo bulls (Heuer *et al*. 1982; Vyawanare *et al*. 1989) respectively. However, Younis (1996) observed it to be 1.88±0.07 over a 6-month period in Nili-Ravi buffalo bulls. The variation in the two studies may be due to a difference in judgment of mass activity, the difference in total number of observations made, or quality of bulls (Javed *et al*., 2000). In Murrah breed better MA was recorded from bulls in 3-4 years of age (Dutta and Deka 1993). Younas (1997) recorded higher ($P<0.05$) MA in adult (2.18) than young (1.93) and old (1.53) Nili-Ravi buffalo bulls. Similar were the findings of Saeed (1988) who reported it to be 2.95 in young, while 3.49 in adult bulls. Javed *et al*. (2000) recorded significantly better mass activity in adult (2.9) and younger (2.8) than older (2.3) bulls. Significant ($P<0.05$) difference in mass activity in different age groups has also been reported by other workers (Dhami and Kodagali 1988; Nazir 1988; Dutta and Deka 1993). The higher mass activity in adult bulls was probably due to higher sperm concentration in these bulls and low sperm abnormalities (Dhami and Kodagali 1988). However, Koonjaenak *et al.* (2007) reported non-significant effect of age on mass activity.

The mass activity observed in Nili-Ravi bulls by Javed *et al*., (2000) was higher ($P<0.05$) in autumn (2.97) and spring (2.87) than in humid summer (2.50) and winter (2.28) and was in line with the findings of Younis (1996) of higher ($P<0.05$) mass activity in autumn (2.27) than in summer (1.49) in Nili-Ravi buffalo bulls. Nazir (1988) reported 2.55 MA in non-breeding and 2.60 in breeding season in Nili-Ravi buffalo bull. Gill *et al.* (1974) and Bajwa *et al.* (1982) reported best MA in Nili-Ravi buffalo bull in summer (3.48 and 2.56, respectively) and lowest in winter (3.06 and 2.23, respectively). Dumitrescu *et al.* (1988) reported highest MA in October and lowest in May. Similar were the findings of Tomar *et al.* (1985) in a study from India. Heuer *et al*. (1987) and Nazir (1988), however, reported no effect of seasons on mass activity in Nili-Ravi buffalo bulls. Similarly, Koonjaenak *et al.* (2007) also reported no effect of seasons on mass activity in swamp buffalo. As is obvious from these reports, it can be inferred that the water buffalo bull possesses better mass activity during autumn and lower in the winter season, and that this may be related to sperm concentration.

1.4 Progressive Motility

The motility of spermatozoa is a useful predictor of fertility of bulls. Age of the bull and season affects sperm motility. Bishop *et al.* (1954) reported good motility in bulls of young age as compared with older ones. Similarly, maximum sperm motility was observed in 2-3 years (62%) and 3 years (51.90%) of age in Nili-Ravi bulls (Khan 1990) and Surti bulls (Gupta *et al.*, 1978), respectively. Nordin *et al.* (1990) reported that motility of spermatozoa increased with age and was 50.1 at the age of 29 months and 57.9 at the age of 30-72 months. Younas (1997) reported significantly ($P<0.05$) higher motility in young (60.69%) and adult (62.50%) bulls compared to old (58.16%) bulls. The motility percentage of 51.60 was reported by Chaudhry (1971) of semen of adult Nili-Ravi bulls. Another study reported 55.20, 59.50 and 58.60% motility of the semen of Nili-Ravi bulls of <5 years, 6-10 and >11 year of age (Javed *et al*., 2000).

The progressive motility in Swamp (Jainudeen *et al.*, 1987), Murrah (Vyawanare *et al*. 1989; Suryaprakasam and Rao 1993) and Nili-Ravi buffalo bulls (Heuer *et al.* 1982) recorded was 67.00±7.00, 73.95±5.21, 69.00±0.86, and 71.69%, respectively. The difference in motility in various reports is related to variation in the judgment of motility or number of bulls included in the study or difference of seasons of studies (Javed *et al*., 2000). Koonjaenak *et al.* (2007) reported initial sperm motility ranged from 72.8% to 75.2% in five Thai swamp buffalo bulls aged 10.0 ± 4.5 years (mean ± SD, range 6–18 years) and observed that average initial sperm motility was affected by age ($P < 0.05$).

The variation in motility in different seasons has also been reported by various workers. Gill *et al.* (1974) reported higher motility in winter (65%) as compared to summer (60%) in Murrah breed. Mohan *et al.* (1977) also observed higher motility in winter (75%) as compared to summer, in bulls of young age. Significantly higher ($P<0.05$) motility in autumn (62.35%) than summer (58.56%) in Nili-Ravi bulls have been reported (Younas, 1997). It was similar in another report in bulls of 6-10 and >11 years old where higher ($P<0.05$) motility was observed in autumn than summer and winter, while no effect of the season was recorded in bulls of <5 years of age (Javed *et al*., 2000). Bajwa *et al.* (1982) and Ibrahim *et al.* (1983) however, reported significantly higher motility in spring season. The opposite observations were made by Singh *et al.* (1992), they reported it to be significantly ($P<0.05$) higher in summer as compared to winter in Murrah breed, while no effect of season on sperm motility has also been reported in Nili-Ravi and Swamp buffalo bulls (Saeed *et al.* 1988; Nordin *et al*., 1990). Koonjaenak *et al.* (2007) reported initial progressive sperm motility (%) 75.2 ± 1.3 in rainy season, 74.5 ± 1.3 in winter and 72.8 ± 1.4 in summer. They said that initial progressive sperm motility was non-significantly affected by season differences.

1.5 Sperm Concentration

The sperm concentration of 0.97/µl in Swamp buffalo (Jainudeen *et al*., 1982), 1.06/µl in Nili-Ravi (Heuer *et al*. 1982), 0.94/µl in Surti and 1.05/µl in Murrah (Rahman *et al*. 1991) breed of buffalo has been reported. El-Wishy (1978), Raizada *et al*. (1988), Nazir (1988) and Terezinha *et al*. (1991) reported sperm concentration of 1.65, 2.90, 1.15 and 1.33/µl in buffalo bulls. Sperm concentration of 1090 million/ml in buffalo bulls has been recorded by Gupta *et al.* (1978) at 7-9 years of age, whereas Nordin *et al*. (1990) reported 5390 and 1130 million/ml in bulls of 29 and 45 months of age. Javed *et al*., (2000) reported significant differences in sperm concentration with higher sperm concentration in bulls of <5 years (1.07) than bulls of >11 years (0.90) of age that is related with senile changes in older bulls, while Younis (1996) reported non-significant difference between bulls of young, adult and old age. Younas (1997) reported non-significant difference in sperm concentration between bulls of young, adult and old age groups. Similar were the findings of Heuer *et al.* (1987), Jainudeen *et al.* (1982) and Rahman *et al.* (1991). Koonjaenak *et al.* (2007) reported sperm concentration range of 1.1-1.2 billion/ml in swamp buffalo bulls aged 10.0 ± 4.5 years. They claimed that the average sperm concentration was influenced by bull age ($P < 0.001$, increasing with the age of the sire). The average total sperm number per ejaculate ranged from 3.6 ± 0.3 to 4.3 ± 0.3 × 10^9 spermatozoa, being also affected by bull age ($P < 0.05$, increasing with age). Pant et al. (2003) reported average sperm output of 15.3, 18.2, 19.8 and 23.6 x 10 (9) per week in 4 groups of bulls which were 25-36, 37-48, 49-60, of >60 months of age. However, they mentioned that scrotal circumference had a significant correlation with sperm concentration. While scrotal circumference is correlated with age of bulls (Younis *et al.* 2003; Luz *et*

al. 2013).

Such variations can always be expected from workers working at different places with a variation in the number of animals selected, which may be belonging to different age groups. However, it can be inferred from these reports that the buffalo bull produces semen with a sperm concentration of between 0.90 - 1.65 x10^6/µl.

The higher sperm concentration is recorded in summer by many workers (Erb *et al.* 1942; Heuer *et al.* 1987; Mohan *et al.* 1977). Mohan *et al.* (1977) reported higher sperm concentration in the summer (1181 X 10^6/ml) as compared to winter (1179 X 10^6/ml) in bulls of 3-4 years of age. While Dumitrescu *et al.* (1988) reported it to be higher in October (1078 million/ml) and low in May (716 million/ml). Similarly, Zafar *et al.* (1988) reported highest sperm concentration during April (1063 million/ml) followed by October (1006 million/ml), July (949 million/ml) and December (933 million/ml). Shalash (1972) recorded lower sperm concentration in the summer (701 million/ml) and highest in winter (1260 million/ml). Weirzbowsky *et al.* (1980) also reported highest values in breeding season (October-November, autumn) as compared with other seasons. Similarly, Younas (1997) observed it in autumn (1.19 billion/ml) than summer (1.05 billion/ml) with non-significant difference between seasons. El-Wishy (1978) reported higher values in autumn (1655 million/ml) and lower in winter (1183.3 million/ml). Javed *et al*. (2000) reported non-significant difference in sperm concentration between seasons of bulls of <5 and 6-10 years of age, while recorded significantly higher sperm concentration during autumn (1.19/µl) than winter (0.65/µl) in bulls of >11 years of age. This shows the effect of the season is probably more pronounced at old age than at other ages. Decrease in sperm concentration in buffalo bulls may occur due to degenerative changes in testes (Javed *et al*. 2000; Ahmad *et al*. 1988). However, Koonjaenak *et al.* (2007) reported non-significant effect of season on total sperm number.

1.6 Semen pH

Alexander *et al.* (1971) reported semen pH of 6.51 in buffalo bulls. Terezinha *et al.* (1991) and Younis (1996) reported it to be 6.26±0.05 and 6.38±0.19 from Murrah and Nili-Ravi buffalo bulls, respectively. Gomes (1991) reported a range of 6.82-6.93 in buffalo bulls. The pH of semen did not differ statistically between age groups in Nili-Ravi buffalo bulls as reported by Younas (1997) and was 6.34 in young, 6.16 in adult and 6.27 in old bulls. However, the significant difference in semen pH has been reported with lower ($P<0.05$) pH in bulls of 6-10 years old (6.45) than >11 years old (6.67) bulls. Koonjaenak *et al.* (2007) reported statistically no difference of pH in five Thai swamp buffalo bulls of different age.

The pH in Murrah breed of buffalo is reported to be 6.82, 6.83, 6.92 and 6.93 in spring, summer, autumn and winter, respectively with non-significant difference between seasons (Terezinha *et al.* 1991). However, significantly lower ($P<0.05$) pH in autumn (6.18) compared with summer (6.33) is reported by Younas (1997). Javed *et al*. (2000) recorded significantly lower pH in autumn (6.05, 6.05) than other seasons (dry summer 6.51, 6.70; humid summer 6.46, 6.69; winter 6.71, 6.99; spring 6.72, 6.80) in bulls of < 5 and > 11 years of age. They also found it lower in autumn (6.0), while significantly higher in winter (6.75) than all other seasons in bulls of 6-10 years of age (Javed *et al*. 2000). The pH showed a negative correlation with sperm concentration ($r = -0.37$) (Javed *et al*. 2000) as has been said by other workers also that samples with thick density are known to have lower pH values than thin semen samples (Shalash 1972; Wacol 1991). It is also reported to be influenced by frequency of semen collection (Barnabe *et al.* 1992; Madhumeet *et al.* 1992). Koonjaenak *et al.* (2007) recorded average pH of 6.9–7.0 in swamp buffalo, across the different

seasons which are non-significant.

1.7 Live/Dead Sperm Percentage

The literature shows a significant effect of age on live/dead sperm percentage. Higher dead sperm percentage was observed in 3-4 years (17.81 %) and above nine years (19.97 %) of age bulls than bulls under three years (13.84 %) of age (Gupta *et al.* 1978). Tomar *et al*. (1985) reported that dead sperm percentage increases with age. Nordin *et al.* (1990) recorded 64.2, 67.4, 66.99, 65.5 and 69.9 percent live sperm at the age of 29, 33, 42, 54 and bulls of more than 65 months, respectively. Younas (1997) reported significantly higher dead sperm percentage in older (14.57%) than young (13.96%) and adult (12.04%) bulls. Javed *et al*. (1997) found 14.79, 14.91, 21.16 and 14.44% of dead sperms in bulls of 3-4, 6-7, 8-9 and 12-15 years of age with significant difference between them and higher dead sperm percentage in bulls of 8-9 years old than other age groups. In the later study the overall dead sperm percentage recorded was 16.25. The live sperm percentage in Egyptian bulls was 58.4 (Osman and El-Azab 1974) and in Murrah breed 72.89 (Guha *et al*. 1959). Cook *et al.* (1994) reported that the increased number of dead sperm percentage in semen from bulls of any age group might be due to degenerative changes of the testes which are higher in older bulls because of the age factor. Galloway and Norman (1980) proposed a limit of 50% normal sperms as an indicator of normal reproductive function.

The season also significantly affected live sperm percentage (Bhosrekar *et al.* 1992; Barnabe *et al.* 1992; Cook *et al.* 1994). Dumitrescu *et al.* (1988) reported higher live sperm percentage in July (93.60 %) while lowest in May (90.2 %) and October (87.3 %). Similarly, Singh *et al.* (1992) reported higher live percentage in summer than winter. Significantly higher dead sperm percentage was recorded in buffalo bulls during summer (Ahmad *et al.* 1984; Barnabe *et al.* 1992; Cook *et al.* 1994; Younas 1997). Kapoor (1973) recorded 83.50, 85.40, 85.40 and 86.50 percent; while Gupta *et al.* (1978) recorded 78.60, 72.20, 73.20 and 77.40 percent live sperm in winter, summer, autumn and spring, respectively with non-significant difference in respect to season. Javed *et al*. (1997) reported significantly lower ($P<0.05$) dead sperm percentage in autumn (13.0%) than dry summer (19.58%) and humid summer (18.10%). The higher dead sperm percentage in summer has been ascribed to impairment of spermatogenesis due to environmental and nutritional stress (Ahmad *et al.* 1984; Younas 1997).

1.8 Total Abnormal Spermatozoa

The morphological abnormalities of spermatozoa were also significantly affected by age (Kumi-Diaka *et al.* 1980; Saeed *et al.* 1987; Soderquest *et al.* 1992; Koonjaenak *et al.* 2007) and season (Ahmad *et al.* 1984; Nazir *et al.* 1987; Javed 1998; Koonjaenak *et al.* 2007).

Guraya and Sidhu (1976) and Gopalakrishna and Rao (1979) reported total sperm abnormalities to be 28.6 and 18.6 percent, respectively in buffalo bulls. Anzar (1984) reported it to be 15.04 4.53 and 35.90 8.83 percent, in Nili-Ravi bulls examined by light microscope (nigrosin staining) and phase contrast microscope (formal saline), respectively. Similarly, 18.2 to 23.7 percent average sperm abnormalities have also been reported from Nili-Ravi bulls (Younis *et al.* 1980). Lower average sperm abnormalities from buffalo bulls has been reported by Malik *et al.* (1974), Heuer *et al.* (1982), Ahmad *et al.* (1987c) and Saeed *et al.* (1990). They observed it to be 11.91, 13.0, 9.93 and 11.5 percent, respectively. Javed (1998) recorded overall sperm abnormalities to be 17.69%. There appears variation in percent sperm abnormalities as evident from different reports which could be due to subjective variation in recording system or difference of season of study or selection or non-selection of bulls for the study or the method of study.

Ahmad *et al.* (1984) and Younis (1996) reported

higher (P<0.05) abnormal sperms in older bulls, while Nordin *et al.* (1990) reported a curvilinear decrease in bulls of 2.5 to 5.5 years. They reported total abnormalities of 12.3±1.7, 11.1±1.5, 11.5±1.3, 13.2±4.0 and 10.6±1.0 percent in 29, 33, 42, 54 and more than 65 months of age, respectively, with non-significant difference in different ages. Gupta *et al.* (1978) reported higher total abnormalities in bulls of less than four years of age. Ahmed *et al.* (1976) reported abnormal spermatozoa to be 12.96±3.68 percent in 4-5 year's old bulls and 13.0±2.94 percent in 7-8 years old Nili-Ravi bulls. They further reported that percentage of abnormal spermatozoa in semen of growing, adult and abnormal bulls were 13.0±3.7, 13.0±2.9 and 20.9±4.8, respectively. Younas (1997) reported higher (P<0.05) abnormal sperm in ejaculates of older (14.29%) than adult (12.22%) and younger (13.02%) Nili-Ravi bulls. According to Saeed *et al.* (1990) the best quality of semen with low sperm abnormalities was recorded in 6-8 years old bulls. Javed (1998) did not find significant difference in three age groups he studied over a period of one year and the total sperm abnormalities varied from 18.20 to 23.82%.

Total sperm abnormalities varied in different seasons and Javed (1998) found higher (P<0.05), sperm abnormalities in winter (30.12%) followed by summer (22-24%), while lowest in autumn (14.92%). Singh *et al.* (1992) and Igboeli *et al.* (1987) also reported higher sperm abnormalities in winter. Heuer *et al.* (1987), Bhavsar *et al.* (1990) and Younis (1996) observed higher percentage of sperm abnormalities in buffalo bulls during summer season, while Ahmad *et al.* (1984) reported it autumn in Nili-Ravi buffalo bulls. Sekoni *et al.* (1988) observed higher abnormal sperms in summer (14.73%) than winter (11.53%) and related it to the effect of heat stress. The higher sperm abnormalities during the winter have been related to effect of cold or improper handling during semen collection (Javed, 1998). Heuer *et al.* (1987) reported 25.2 percent abnormal spermatozoa in hot and humid season in buffalo bulls as compared to 14.8 percent in breeding season. Similarly, Bhavsar *et al.* (1990) reported significantly (P<0.05) higher sperm abnormalities during hot season. Ahmed *et al.* (1984) observed total abnormalities of 12.68±7.06, 9.83±3.64, 11.48±6.57 and 15.04±6.59 percent in winter, spring, summer and autumn, respectively (lowest in spring and highest in autumn). Younas (1997) reported it to be higher in low breeding (13.74%) than peak breeding (11.94%) season. Igboeli *et al.* (1987) reported 70.0±3.1, 79.1±2.6 and 79.8±2.3 percent normal sperms in dry, rainy and the late rainy/early dry season. Dumitrescu *et al.* (1988) reported lower in August (1.65 %) and highest in July (4.85 %). Koonjaenak *et al.* (2007) reported overall total mean percentages of sperm abnormalities of buffalo bull spermatozoa (13.7 ± 0.5%) in the rainy season, (12.4 ±0.5%) in winter and (10.7 ± 0.5%) in summer.

Head abnormalities observed by Javed (1998) were lower (3.04±0.30%) than reported by Younis (1996), Gopalakrishna and Rao (1979), Guraya and Sidhu (1976), Rao (1971), Saeed *et al.* (1990) and Malik *et al.* (1974) in buffalo bulls (6.54±0.26, 7.4, 12.8, 6.0, 5.18, and 6.19%, respectively). However, these were higher than reported by Heuer *et al.* (1982), Prabhu and Sharma (1953), Bhavsar *et al.* (1990) and Ahmad *et al.* (1987c) in buffalo bulls (1.8, 0.6, 1.85, and 1.84%, respectively). The abnormal heads are eliminated in efferent ductules by phagocytosis (Crabo *et al.* 1971) but mainly in the caput epididymis (Rao *et al.*, 1980). A low frequency of such cells in ejaculates may reflect normal spermatogenesis (Heuer *et al.*, 1982). The rate and pattern of sperm removal seemed to depend particularly on the quality of spermatozoa (Rao *et al.*, 1980). The maximum allowed limit for bulls is 10 percent for young and 20 percent for older bulls with 18 percent upper limit in all bulls (Lagerlof 1934).

The head abnormalities as recorded by Javed (1998) showed a linear decrease in with age from 4.16 (< 5 years) to 2.36 percent (> 11 years old bulls). However, Rao (1971) observed a linear increase in sperm head abnormalities (4.8% in young, 6% in middle aged, and 11% in old bull). Younas (1997) reported higher (P<0.05) sperm head abnormalities in older (6.05%) than young (4.33%) and adult (4.26%) bulls. Similarly, Ahmad *et al.* (1987b) reported a higher percentage of head abnormalities in older (5.29%) than young (4.00%) and adult (3.23%) bulls. Galloway and Norwan (1980) reported that up to 20 percent of head abnormalities in ejaculates may be considered normal. In Thailand, a study on 5 bulls of different age (Koonjaenak *et al.*, 2007) revealed that the average total of morphologically deviating sperm heads were influenced by the age of buffalo bull ($P < 0.001$), with the percentage being 1.5 ± 0.2% in the 6-year-old bull (Bull I), (1.0 ± 0.1)% in the 7-year-old bulls (Bull II and III), (1.3 ± 0.2)% in the 12- year-old bull (Bull IV) and (5.9 ± 0.2)% in the 18-yearold bull (Bull V). They also found that Pear shaped sperm heads, abnormal contour, loose abnormal heads, undeveloped sperm heads and variable size were affected by bull age ($P < 0.001$–0.05, increasing with age), Furthermore, the interaction between bull age and season affected pear-shaped heads ($P < 0.05$) and heads with abnormal contour ($P < 0.05$).

The Head abnormalities varied in different seasons as Javed (1998) found higher (P<0.05) head abnormalities in autumn (and lower in winter. Younas (1997) reported it to be higher in low breeding (5.34%) than peak breeding (3.74%) season in Nili-Ravi bulls. Igboeli *et al.* (1987) reported it to be higher (P<0.05) in December to March (4.10±0.4%) than April-August (3.1±0.5%) and lower (P<0.05) in September-November (2.2±0.3%) in Muturu bulls of Nigeria. Koonjaenak *et al.* (2007) reported that in abnormalities of the sperm head, abnormal contour was highest ($P < 0.05$) in the rainy season, whereas the variable size of the sperm head was highest in the winter ($P < 0.05$). Rao (1971) reported that 11.6% abnormal heads entering efferent ductules reduced to 9.2% in the ejaculate. He further stated that the decrease was more pronounced in bulls with testicular degeneration and stated that the disappearance of sperms is selective. Higher (P<0.05) head abnormalities during autumn may reflect the bad effect of humid summer on the developing spermatocytes in the testis which appear in the ejaculate in early autumn, although the number was not too high (Javed, 1998).

Among various head abnormalities observed by Javed (1998) included tailless heads (1.05%), narrow at base (0.43%), pyriform (0.41%), misshapen (0.32%) and elongated (0.28%) heads in Nili-Ravi bulls studied over one-year period. Younis (1996) reported detached heads (1.75%), macro heads (1.25%), pyriform (0.88%), micro (0.83%), elongated (0.51%) and double heads (0.24%) in Nili-Ravi buffalo bulls.

The tail abnormalities observed in Nili-Ravi buffalo bulls by Javed (1998) were (17.69%) higher than 3.39, 3.86±0.91 and 5.20±0.29% reported in the same breed by Ahmad *et al.* (1984), Malik *et al.* (1974) and Younis, (1996), respectively. In Indian buffalo bulls tail abnormalities have been reported to be 7.9 and 4.55% (Gopalakrishna and Rao 1979, Bhavsar *et al.*, 1990, respectively). The maximum allowed limit of tail abnormalities is bent tail <15% and other defects < 10%, including cytoplasmic droplets (Larson, 1982).

The tail abnormalities showed non-significant difference in age groups (Javed, 1998; Younis, 1996). The tail abnormalities were 5.00 percent in old, again 5.00 percent in adult and 5.60 percent in young bulls, respectively (Younas, 1997). Javed (1998) recorded 15% tail abnormalities in bulls of >11 years of age and 19% in bulls of <10 years of age. Koonjaenak *et al.* (2007) reported average total tail defect was affected

by the age of buffalo bull, being (2.3 ± 0.3%) in the 6-year-old bull, (3.6 ± 0.3%) in the 7-year-old bulls, (3.9 ± 0.3%) in the 12-year-old bull and (7.6 ± 0.3%) in the 18-year-old bull. However, tail abnormalities varied significantly in different seasons and were higher (P<0.05) in winter followed by summer than other seasons (Javed, 1998). These were 19.77, 20.66, 8.97, 27.98 and 11.07 in a dry summer, humid summer, autumn, winter and spring, respectively (Javed, 1998). Singh *et al.* (1992) also reported higher tail abnormalities in winter in Indian buffalo bulls. Bhavsar *et al.* (1990) reported a negative correlation of tail abnormalities with humidity (r = -0.35) and temperature (r = -0.38) in Mehsana buffalo bulls. Younis (1996) reported comparably low (5.05±0.26%) tail abnormalities in summer than autumn (5.35%). Koonjaenak *et al.* (2007) reported tail defects in swamp buffalo AI-bull semen ranged from 3.2% to 5.3% across seasons, being highest in the rainy season and lower in summer ($P < 0.001$). The percentages of spermatozoa with simple bent tails and coiled tails under the head were lowest in summer ($P < 0.001$) and were found to be affected by bull age ($P < 0.001$), showing an increase with age, and in the interaction between age and season ($P < 0.05$).

The overall higher tail abnormalities have been related to improper handling of semen, particularly during winter (Javed, 1998). It has also been related with epididymal dysfunction (Ott, 1991). The latter is associated with higher oestrogen (Galloway, 1982). Galloway (1982) further stated that epididymal function is changed when normal sperm number is not present in the epididymis.

Among various tail abnormalities bent tail (11.29%), coiled tail (2.23%), tail containing proximal droplet (1.88%) and tail coiled around the head (0.71%) were the most reported abnormalities in one study in Nili-Ravi bulls (Javed, 1998). Younis (1996) also reported bent tail (1.46%), distal cytoplasmic droplet (1.39%), loop tail (0.54%) and strongly coiled tail (0.53%) as the main tail abnormalities in Nili-Ravi bulls. Heuer *et al.* (1982), Bhosrekar *et al.* (1992) and Dutta and Deka (1993) reported bent tail, coiled tail and proximal droplet as most frequent types of abnormalities in buffalo bulls. Gustafsson (1965) reported that primary factor in producing a higher percentage of bent and coiled tail might be dysfunction of the epididymal epithelium associated with oestrogen concentration. Bane (1982) reported that removal of abnormal sperms in epididymis occurs, but of those having severely damaged or misshapen heads. The latter are less resistant to phagocytosis and digestion, while tail abnormality increases in the epididymis.

In overall, the mid piece abnormalities observed by Javed (1998) were lower (0.69±0.49%) than 1.78±0.10 and 1.53±0.03 percent as reported by Younis (1996) and Bhavsar *et al.* (1990) in buffalo bulls. Heuer *et al.* (1982) reported that the mid piece abnormalities were seen rarely. Javed (1998) observed higher (P<0.05) mid piece abnormalities in old bulls (1.03%). However, Younis (1996) reported non-significant difference in age groups. Javed (1998) did not observe significant differences in mid piece abnormalities between seasons but reported that they were relatively higher in autumn. Younis (1996) also observed higher percentage of these in autumn than summer. Higher mid piece abnormalities from April to August has been reported by Igboeli *et al.* (1987) in Muturu bulls.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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Table 1: Effect of season on various semen parameters of buffalo bulls as reported by different workers.

Breed	Winter	Summer	Autumn	Spring	Monsoon	Reference
Volume (ml)						
Murrah	3.45	3.29	3.74	3.95	-	Kapoor. (1973)
Murrah	5.40	6.05	5.72	-	-	Reddy *et al.* (1983)
Iraqi buf.	3.40	3.40	4.10	2.50	-	El-Wishy (1978)
Surti	3.50	3.30	4.20	3.90	-	Gupta *et al.* (1978)
Surti	2.39	2.31	-	-	2.44	Raja (1981)
Nili-Ravi	3.04	3.03	2.80	3.44	-	Bajwa *et al.* (1982)
Nili-Ravi	3.06	3.10	2.88	3.23	-	Nazir (1988)
Nili-Ravi	-	3.44	2.57	-	-	Younis (1996)
Nili-Ravi (< 5 years)	4.07	4.05, 3.82	5.80	4.00	-	Javed *et al*. (2000)
Nili-Ravi (6-10 years)	4.46	4.82, 3.95	5.85	5.71	-	Javed *et al*. (2000)
Nili-Ravi (< 11 years)	4.04	4.67, 3.40	6.40	5.35		Javed *et al*. (2000)
Initial Motility (%)						
Murrah	65.00	60.00	-	-	-	Gill *et al.* (1974)
Murrah	68.75	68.83	-	-	68.83	Gill *et al.* (1974)
Murrah	77.4	78.70	-	-	77.00	Haranath *et al.* (1982)
Buffalo	75.00	70.00	-	-	-	Mohan *et al.* (1977)
Surti	68.46	66.41	-	-	70.83	Raja (1981)
Nili-Ravi	-	58.56	62.35	-	-	Younis (1996)
Nili-Ravi (< 5 years)	52.95	55.50, 57.89	57.63	52.00		Javed *et al*. (2000)
Nili-Ravi (6-10 years)	52.70	61.50, 60.29	62.00	59.7		Javed *et al*. (2000)
Nili-Ravi (< 11 years)	51.45	54.50, 57.50	60.75	60.00		Javed *et al*. (2000)
Sperm concentration (10^6/mL.)						
Murrah	0.848	1.034	0.92	0.99	-	Kushwaha *et al*. (1955)
Murrah	1.43	1.26	1.41	1.39		Kapoor (1973)
Murrah	1.04	1.14	-	-	1.09	Gill *et al.* (1974)
Murrah	-	1.179	1.18	-	-	Mohan *et al.* (1977)
Murrah	1.06	1.13	-	-	1.15	Haranath *et al.* (1982)
Egyptian	1.26	0.7	-	-	-	Shalash (1972)
Iraqi buf.	1.18	1.42	1.65	1.23	-	El-Wishy (1978)
Surti	0.85	0.992	0.97	0.79	-	Gupta *et al.* (1978)
Surti	0.86	0.85	-	-	0.87	Raja (1981)
Buffalo	-	0.72	-	1.08	-	Dumitesicu *et al.* (1988)
Buffalo	0.93	0.95	1.01	1.06	-	Zafar *et al.* (1988)
Nili-Ravi	-	1.05	1.19	-	-	Younis (1996)
Nili-Ravi (< 5 years)	1.03	1.10, 0.87	1.12	1.24		Javed *et al*. (2000)
Nili-Ravi (6-10 years)	0.85	1.12, 0.99	1.19	1.08		Javed *et al*. (2000)
Nili-Ravi (< 11years)	0.65	0.78, 0.92	1.18	0.98		Javed *et al*. (2000)

Liver sperm percentage						
Murrah	84.50	64.60	86.30	95.70	-	Sen-Gupta *et al* 1963
Murrah	83.50	85.40	85.40	86.50	-	Kapoor 1973
Buffalo	83.00	84.00	-	-	-	Mohan *et al.* 1977
Surti	78.60	72.80	73.20	77.40	-	Gupta *et al.* 1978
Nili-Ravi	-	85.70	87.26	-	-	Younis, 1996
Nili-Ravi (< 5 years)	87.19	78.76, 83.17	90.06	86.79	-	Javed *et al*. (2000)
Nili-Ravi (6-10 years)	85.64	86.92, 81.00	95.76	83.91	-	Javed *et al*. (2000)
Nili-Ravi (< 11 years)	84.13	82.77, 85.75	85.73	89.71	-	Javed *et al*. (2000)
Sperm abnormalities (%)						
Murrah	7.70	7.40	7.60	5.90	-	Kushwaha *et al.* 1955
Surti	11.30	13.70	12.8	10.60	-	Gupta *et al.* 1978
Buffalo	11.53	14.73	-	-	-	Sekoni *et al.* (1988)
Nili-Ravi	12.68	11.48	15.04	9.83	-	Ahmad *et al.* 1984
Nili-Ravi	25.20	14.80	-	-	-	Heuer *et al.* (1987)
Nili-Ravi	13.74	14.80	-	-	-	Younis (1996)
Nili-Ravi (< 5 years)	31.33	23.46, 30.24	16.59	17.48		Javed *et al*. (2000)
Nili-Ravi (6-10 years)	35.08	24.57, 20.01	17.2	14.38		Javed *et al*. (2000)
Nili-Ravi (< 11 years)	23.94	19.35, 22.68	10.96	14.04		Javed *et al*. (2000)

Table 2: Semen characteristics of different breeds of buffalo bulls as reported by different workers

Breed	***Volume (ml)***	***pH***	***Sp.Conc. X 10^6/µL***	***Mass activity***	***Live (%)***	***Motility (%)***	***Total abn. sperms (%)***	***Reference***
Nili-Ravi	-	-	-	-	-	-	11.01	Malik *et al.* (1974)
Iraqi	4.10	-	1.65	-	74.10	74.70	25.90	El-whishy (1978)
Nili-Ravi	2.78	-	0.95	2.93	90.00	71.69	13.80	Heuer *et al.* (1982)
Swamp	3.10	-	0.97	2.70	58.00	70.00	9.60	Jainudeen *et al.* 1982)
Nili-Ravi	-	-	-	-	-	-	12.96	Ahmad *et al.* (1984)
Nili-Ravi	3.02	7.2	1.15	2.90	-	60.00	18.70	Nazir (1988)
Murrah	3.06	-	2.90	-	78.00	75.00	19.20	Raizada *et al.* (1988)
Murrah	-	-	-	-	80.47	73.95	-	Vyawanare *et al.* (1989)
Swamp	2.50	-	0.30	-	65.50	62.00	13.20	Nordin *et al.* (1990)
Murrah	3.88	6.9	1.12	-	28.50	-	-	Rattan (1990)
Italian	3.48	6.9	1.05	2.10	73.00	56.43	14.79	Galli *et al.* (1991)
Surti Murrah	2.88 2.89	- -	0.97 1.05	- -	90.70 87.90	78.50 -	- -	Rahman *et al.* (1991)
Murrah	2.81	-	-	-	78.80	74.10	14.50	Rath *et al.* (1991)
Murrah	3.25	6.3	1.33	-	77.00	65.00	-	Terezinha *et al*. (1991)
Murrah	3.28	-	0.78	-	72.90	75.00	31.95	Mahalinga *et al.* (1993)
Murrah	2.87	-	0.71	2.03	-	69.00	-	Suryaprakasam and Rao (1993)
Nili-Ravi	2.80	6.4	1.12	1.88	86.48	60.45	12.97	Younis (1996)