RESEARCH ARTICLE

Seasonal variations in semen traits of exotic cattle bulls of different age groups in the subtropical region

Manish Goyal[1, 2], Rashmi Tripathi[1], Prakash C Sharma[2*]

ABSTRACT

Background: The age of the bull and season of semen collection may significantly impact semen characteristics, although the results of previously published studies vary somewhat. Unfortunately, breeding programs still do not account for male reproductive traits for a bull's fertility. The effects of season and age on the quality of exotic cattle breeds' semen have been investigated in the current study. *Methods:* Two exotic cattle breeds, Jersey and Holstein Friesian, have been chosen from the subtropical region of India for study. The pooled dataset from the Information Network for Animal Productivity & Health (INAPH, 2017–2022) containing data collected at the Frozen Semen Bank in Bassi, Jaipur, India, on three semen traits was used in the study. Three semen traits of exotic bulls – total semen volume, sperm concentration, and the number of sperms per ejaculation were examined in connection to the influences of age and season. *Results:* The age of the bulls was found to influence the concentration and sperm counts significantly. The semen volume was minimal in the older group, while the sperm concentration was lowest in the adult group. All the tested semen traits were highest in summer and lowest in winter. *Conclusion:* Therefore, it was concluded that the age and seasonal variations significantly influence the semen quality of exotic cattle breeds and suggested that the reproductive traits of the bulls should be considered for the breeding programs.

Keywords: Exotic bulls, Semen volume, Sperm count, Seasonal variations, Age.

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Introduction

To develop cattle resources genetically, breeding bulls with high genetic value must be chosen. It is not always the case that a bull with higher milk production qualities will also have superior semen production traits. Finding bulls with strong genetic merit for production features and good semen-producing abilities thus becomes a challenging endeavor. Sperm quality frequently correlates with age and other variables, such as the season. Season and age are the non-genetic variables that might impact semen output and quality, which determines and enhances a bull's fertility. The bull's semen quality changed from young to adult and old age.[1] The ejaculate volume, concentration, and sperm motility are all influenced by the bull's age at semen collection.[2] Season plays a large role in seminal qualities.[3-5] To increase bull fertility, it is crucial to identify the underlying causes of any conditions that may impact semen output and quality. Other writers.[6, 7] have also discovered the influence of season on semen amount. They have reported on the optimal season for optimal outcomes; nevertheless, contradictory findings have also been published.[8, 9] According to the study of Shawki *et al.*,[10] statistical analysis revealed variations in the impact of season on semen parameters.

In the tropics, seasonal fluctuations in cattle fertility are common.[11] While several factors influence distinct semen qualities, it has been identified that the age of the bulls influences several semen traits significantly.[12-14] The bull's age had a significant influence on the characteristics of the semen, noting that the best-quality semen had been recorded at 3 to 4 years of age.[15]

[1]Department of Bioscience and Biotechnology, Banasthali Vidyapith, Tonk, Rajasthan, India.

[2]Department of Animal Genetics and Breeding, Post Graduate Institute of Veterinary Education and Research, Rajasthan University of Veterinary and Animal Sciences, Jaipur, Rajasthan, India.

***Corresponding author:** Prakash C. Sharma, Department of Animal Genetics and Breeding, Post Graduate Institute of Veterinary Education and Research, Rajasthan University of Veterinary and Animal Sciences, Jaipur, Rajasthan, India., Email: drpcsharma@gmail.com

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Animal semen has a unique climate pattern in terms of quality; a fluctuating mix of temperature and humidity might have a negative impact on semen characteristics.[16] Normal and fertile spermatozoa can only be formed when the testes are 2 to 5°C below body temperature, which makes temperature an essential parameter for both normal testicular function and spermatozoa production.[17, 18] According to Sabes-Alsina *et al.*[19] and Seifi-Jamadi *et al.*,[20] there may be changes in semen samples obtained after the spermatogenetic period due to temperature changes in the testis. The increased relative humidity and temperature may harm spermatogenesis and luteinizing hormone secretion.[21] This could be among the causes of the low fertility in bulls bred in tropical climates.

In light of the aforementioned facts, the exotic bull's semen characteristics were examined in relation to the bull's age and the collection season.

Methods

The experiment was further depicted by collecting, managing, visualizing, and analyzing an extensive set of seminal features' data of exotic bulls maintained at Frozen Semen Bank (FSB), Bassi, India, Jaipur, Rajasthan, spanning six years, using the Information Network for Animal Productivity & Health (INAPH) programme and SPSS (version 22) software.

Acquisition of Seminal Traits Data

Over the course of six years, from 2017 to 2022, ejaculation data from exotic bulls maintained at FSB were gathered from INAPH applications. The FSB Bassi is situated in a hot, semi-arid subtropical region of India with a typically dry environment that features long, scorching summers and mild to warm winters.

Analyzing and Computing Semen Characteristics

To determine the impact of bull age and season, datasets from semen volume, sperm concentration in semen, and number of sperms per ejaculation were analyzed at the Department of Animal Genetics and Breeding, Post Graduate Institute of Veterinary Education and Research (PGIVER) in Jaipur. The collected samples were grouped into young, adult, and old age groups, with two subgroups in each group. The young group (18–43 months) is divided into 18 to 30 months (AG1) and 31 to 43 months (AG2), the adult group (44–69 months) is divided into 44 to 56 months (AG3) and 57 to 69 months (AG4), and the old group (70-95 months) is divided into 70 to 82 months (AG5) and 83 to 95 months (AG6). On the other hand, based on the time of collection, the collected samples were grouped into four seasons: Winter (between December and February), Summer (between March and June), Monsoon (between July and August), and Post-monsoon (between September and November).

Using the following model, statistical analysis was performed using SPSS (version 22) software.[22]

$Y_{ijk} = \mu + A_i + B_j + e_{ijk}$…….. (1)

Y_{ij} = observation of the l^{th} individual in i^{th} age group and j^{th} season.

μ = overall population mean.

A_i = effect of i^{th} age group on semen parameters.

B_j = effect of j^{th} season on semen parameters.

E_{ijk} = random error, NID.

Results

Data on semen quality was available for 3389 samples between 2017 and 2022. Contributions of different studied age groups in the year-wise collections of samples and in the total sample counts are depicted in Figure 1. On the other hand, Figure 2 depicts the distribution of sample collection in four seasons. Overall, the mean volume of semen samples

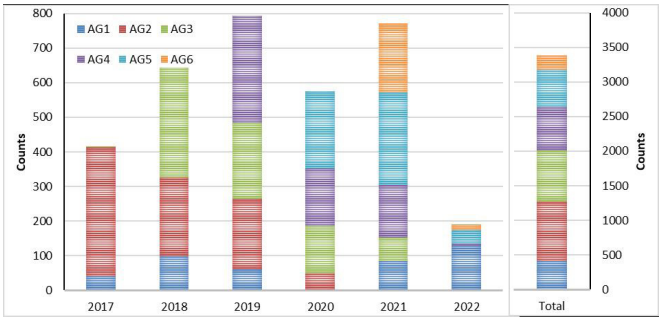

Figure 1: Contributions of different age groups in the collected samples each year and as a total

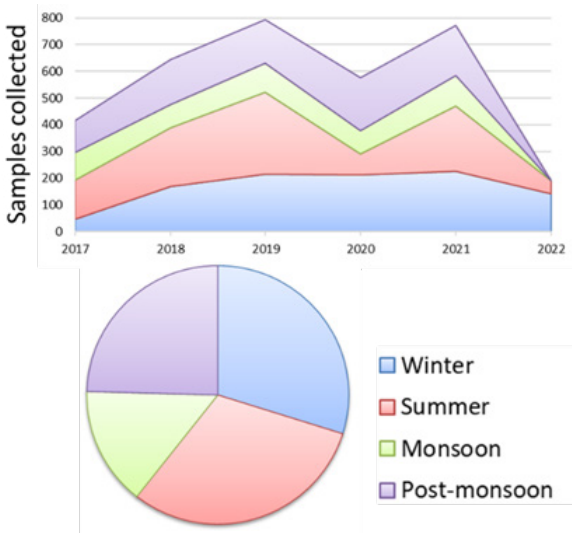

Figure 2: Year-wise distribution of sample collections in four different seasons (Stack area graph). The pie diagram indicates the percentage of total samples collected in four different seasons

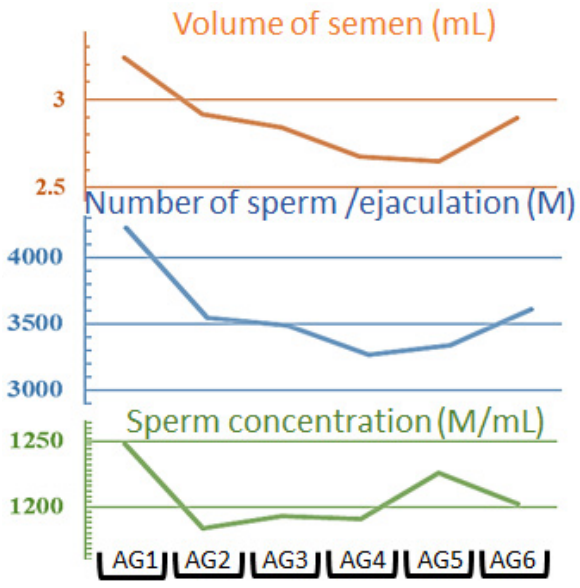

Figure 3: Variations in volume, number of sperm per ejaculation and sperm concentration in different age groups

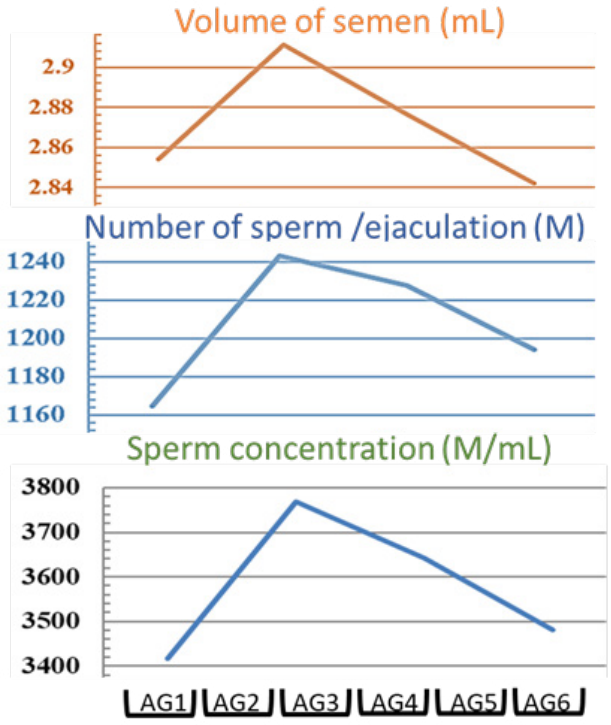

Figure 4: Variations in volume, number of sperm per ejaculation and sperm concentration in different seasonal collections

was 2.87 ± 0.04 mL with a mean sperm count of 1207.38 ± 4.16 million/mL, amounting to 3576.74 ± 16.17 million sperms per ejaculation (Table 1). The data suggest quite constancy of the semen volume, sperm concentration, and total sperm count per ejaculation.

The collection counts per year are presented in Figure 1. The total specimens available are 415, 643, 793, 576, 772, and 190 for the years 2017, 2018, 2019, 2020, 2021, and 2022, respectively. On the other hand, a total of 1012, 1042, 502, and 833 samples were available for winter, summer, monsoon, and post-monsoon collections, respectively (Figure 2). The comparison between semen volume, sperm concentration, and total sperm counts in different age groups (AG) is presented in Figure 3, while the comparison between seasonal collections for these parameters is presented in Figure 4. The variance analyses of these parameters are presented in Table 4.

Discussion

The study showed that although there was not much variation in the overall mean semen volume of the exotic bulls, younger bulls had the highest value (22.48%) of semen volume compared to older bulls with the lowest value. In adult bulls, intermediate results were seen (Table 2). Age factor had a very high significant influence ($p < 0.001$) on semen volume (Table 4). The season's maximum semen volume was recorded in the summer, 2.42% greater than the lowest value during the post-monsoon period. Table 3 shows that the winter and monsoon seasons displayed intermediate semen volume levels.

The results validate the observation reported by Abah *et al.*,[1] who pointed out that an animal's quality of semen increases until a specific age and then decreases. However, the results of the current study did not conform with the earlier findings of Furest-Waltl *et al.*[23] The outcomes confirm the observations reported by Bhakat *et al.*,[24] who reported a maximum value of semen volume during the hot, humid season. Nevertheless, some reports contradict the current observation. The results contradict this report that the most plausible explanation for higher failure rates in the warm/hot months was temperature.[9]

Bulls aged 18 to 30 months had semen concentration values that were 5.43% greater than bulls aged 31 to 43 months. The semen concentration levels of adult and older bulls were in

Table 1: Mean values for particular traits of *exotic cattle*

Semen properties	*Total Volume of ejaculation (mL)*	*Sperm concentration (M/mL)*	*Number of sperm per ejaculation (M)*
Mean ± SEM (n)	2.871 ± 0.037 (3389)	1207.382 ± 4.165 (3389)	3576.740 ± 16.168 (3389)

Table 2: Age wise distribution of estimated semen traits of *exotic cattle*

AG1 (18–30 months)	3.242 ± 0.081 (413)	1248.122 ± 29.849 (413)	4223.052 ± 149.899 (413)
AG2 (31–43 months)	2.918 ± 0.068 (853)	1183.803 ± 25.170 (853)	3545.744 ± 126.400 (853)
AG3 (44–56 months)	2.842 ± 0.065 (743)	1193.131 ± 24.072 (743)	3484.565 ± 120.885 (743)
AG4 (57–69 months)	2.677 ± 0.073 (634)	1190.818 ± 26.862 (634)	3263.591 ± 134.896 (634)
AG5 (70–82 months)	2.647 ± 0.086 (530)	1226.105 ± 31.821 (530)	3338.089 ± 159.800 (530)
AG6 (83–95 months)	2.898 ± 0.124 (216)	1202.312 ± 45.776 (216)	3605.400 ± 229.878 (216)

Table 3: Season wise distribution of estimated semen traits of *exotic cattle*

Winter (December - February)	2.854 ± 0.056 (1012)	1164.484 ± 20.786 (1012)	3416.104 ± 104.386 (1012)
Summer (March - June)	2.911 ± 0.058 (1042)	1243.283 ± 21.241 (1042)	3768.102 ± 106.671 (1042)
Monsoon (July - August)	2.876 ± 0.073 (502)	1227.537 ± 26.956 (502)	3641.704 ± 135.368 (502)
Post-monsoon (September - November)	2.842 ± 0.059 (833)	1194.223 ± 21.654 (833)	3481.052 ± 108.744 (833)

Table 4: ANOVA mean sum of square for non-genetic factors affecting *exotic cattle*

Source of variation	*Total Volume of ejaculation*	*Sperm concentration*	*Number of sperm per ejaculation*
Age at ejaculation	14.865***	224065.146	38660346.596***
Season of ejaculation	0.804	1054705.948*	22226807.331*
Error	2.267 (3378)*	308050.139 (3378)*	7768645.109 (3378)*

*Figure in Parenthesis shows df (degree of freedom)

the median range (Table 2).With a rating 6.77% higher than winter's, summer had the highest semen concentration value. The monsoon and post-monsoon seasons showed intermediate-range serum concentration levels (Table 3). The current study, therefore, observed a significant impact ($p < 0.05$) of the seasonal variation on the semen concentrations.

The results agree that with bulls aging, the concentration of semen is reduced.[25] Meanwhile, Bhakat *et al.*[24] published that semen concentration increased as the bull's age increased. A concurring report by Netherton *et al.*[9] indicates good quality sperm in summer, whereas a contradictory report by Seifi-Jamadi *et al.*[20] states that sperm concentration is lower in bulls that undergo exposure to summer heat stress.

The young bull group's number of sperms per ejaculate values was 29.40% higher than those of the adult bull group. Older bulls' number of sperms per ejaculate range values fell in the middle (Table 2). Table 4 shows that age has a highly significant impact ($p < 0.001$) on the number of sperms per ejaculate. The number of sperms per ejaculate value was highest in the summer, 10.30% higher than that in the winter. The number of sperms per ejaculate level was in the middle range during the monsoon and post-monsoon seasons (Table 3). The season had a significant ($p < 0.05$) impact on the number of sperms per ejaculate value.

Results support Snoj *et al.*[26] declaring in adult bulls, the overall quantity of spermatozoa decreased. The current results differ from those of Schenk *et al.*,[27] who screened a higher number of sperm ejaculated by mature bulls than by young bulls. The outcomes are consistent with those of Netherton *et al.*,[9] who stated that winter is the least productive season for semen quality compared to summer. The outcomes conflict with Seifi-Jamadi *et al.*[20] whose findings say that high humidity and warmth in summertime can worsen the quality of spermatozoa.

The findings of the current study indicated that young bulls not only showed the best values of all the semen qualities but also improved semen characteristic values when compared to mature and old bulls. All semen qualities performed best in the summer, while winter brought the lowest values for semen concentration and number of sperms per ejaculate and the lowest estimations of semen volume in the post-monsoon season.

A near positive association between the sperm quality traits and age (Figure 2). On the season axis, however, the summer season displayed the greatest values of all seminal qualities, and a positive correlation could be observed between all seminal traits (Figure 4). Based on the findings, it can be suggested that for most seminal qualities, age and environment have a significant impact. The study results will allow breeders to develop breeding tactics based on the findings to enhance the quantity and quality of semen produced by exotic bulls.

The notable non-genetic factors point to a practical way to improve the semen quality that bulls generate, subsequently increasing fertility. So, it would be feasible to improve the performance of desired breeds through artificial insemination utilizing frozen semen doses of bulls. These breeds may then be more extensively distributed to farmers to increase herd productivity.[28]

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.