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Impact of non-genetic factors on semen characteristics of indigenous bull

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Abstract: In the current study, the effects of age and breed on the quality of the semen of indigenous cattle breeds have been examined. Four indigenous cattle breeds from the sub-tropical region of India, including Gir, Rathi, Sahiwal, and Tharparkar, have been selected to know the effect of non-genetic factors on semen characteristics. The study used the data of three semen traits, viz. total ejaculation volume (EV; in ml), sperm motility (SM), and sperm concentration (SM; in million per ml), for analyzing the impact of age and breed (n = 8477), for the semen collected and preserved by Frozen Semen Bank, Bassi, Jaipur, India, from the pooled dataset of Information Network for Animal Productivity & Health (INAPH, 2017-2022). Except for SM, it was found that the impact was significant in connection to age as well; young age groups (18 to 30 to 31 to 43 months) produced the greatest results for all other semen traits, whereas adult groups (44 to 56 to 57 to 69 months) had the highest estimates for SM. During the study, it was found that Sahiwal bulls gave the highest estimated value for most of the semen traits while Rathi bulls showed the highest estimated values for EV. All seminal features were found to have the lowest values in Tharparkar bulls, and the overall breed influence was found to be non-significant.

Keywords: non-genetic factors; sperm motility; semen traits; ejaculation volume; sperm concentration; indigenous bull

1. Introduction

Semen from indigenous bulls has been known to have high fertility [1], for a very long time; it is still not taken into consideration in programs for breeding when it comes to male reproductive qualities. It is possible to manage and manipulate non-genetic factors to improve the quality of semen in bulls [2]. Different semen traits are influenced by different factors, but age of the bulls has been found to be quite significant for several semen traits [3-5]. The best quality semen was recorded by Saeed [6] at the age of 3–4 years, and he concluded that the bull's age had a major impact on the qualities of the semen. According to the report by Navjanti et al., the bull genotypes differed in terms of sperm concentration, motility, and semen volume [7].

2. Methods

INAPH application and SPSS (version 22) software was used to collect, manage, visualize and analyze an extensive data set of seminal features spanning six years to further depict the stages of the experiment.

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2.1 Data collection of seminal traits

Ejaculation data of indigenous bulls reared at FSB (Frozen Semen Bank, Bassi, India, in the eastern part of Jaipur, Rajasthan), were collected from INAPH application over a period of six years (from 2017-2022).

2.2 Calculation and analysis of seminal traits

Datasets of total ejaculation volume (EV), sperm motility (SM) and sperm concentration (SC) were analyzed to know the effect of age and breed of bull, at the Department of Animal Genetics and Breeding, PGIVER (Jaipur). Bulls were divided into three major age groups (young, adult and old) and six sub-major groups i.e. 18-30 months and 31-43 months in younger group, 44-56 months and 57-69 months in adult group, and 70-82 months and 83-95 months in older group.

Statistical analysis was carried out by IBM's SPSS (version 22) software, using Harvey Model. The Harvey Model is a random effects model considered when unobserved variation remains constant over time and correlated with independent variables [8]. When data is gathered over time for the same subjects, data analysis makes extensive use of the Harvey Model, which aids in comprehending the effects of variables while taking individual variances into consideration that cannot be quantified directly.

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3. Results and discussion

Overall estimated ejaculation volume (EV) was 3.254 mL (table 1) although it was found 19.97% higher in younger bulls than the adult bulls. Age factor showed very significant impact (P<0.001) on the total ejaculation volume (table 2). Rathi bulls had the largest ejaculation volume among all the breeds of indigenous bulls (1.08% higher than Tharparkar bulls).

Table 1. Mean values of estimated semen traits of indigenous cattle (figures in parentheses represent the sample size).

Effect	Total Ejaculated Volume (ml)	Sperm Motility (Proportion)	Sperm Concentration (Million/ ml)
μ ± S.E.	3.254 ± 0.026 (8477)	0.254 ± 0.001 (8477)	1213.466 ± 2.918 (8477)

Table 2. Age-wise distribution of estimated semen traits (figures in parentheses represent the sample size).

Age group	Total Ejaculated Volume (ml)	Sperm Motility (Proportion)	Sperm Concentration (Million/ ml)
18-30 months	3.612 ± 0.115 (210)	0.232 ± 0.011 (210)	1285.194 ± 37.747 (210)
31 - 43 months	3.110 ± 0.041 (2225)	0.264 ± 0.004 (2225)	1213.660 ± 13.461 (2225)
44 - 56 months	3.011 ± 0.036 (3146)	0.267 ± 0.003 (3146)	1177.245 ± 11.818 (3146)
57 - 69 months	3.305 ± 0.047 (1650)	0.251 ± 0.005 (1650)	1204.803 ± 15.456 (1650)
70 -82 months	3.293 ± 0.062 (849)	0.248 ± 0.006 (849)	1197.096 ± 20.318 (849)
83 - 95 months	3.191 ± 0.089 (397)	0.262 ± 0.009 (397)	1202.799 ± 29.372 (397)

The findings from this study corroborate with the findings of [9] who found that an animal's semen quality improves up until a particular age and then declines. The results conflict with the publication [10].

Sperm motility (SM) was assessed to be 0.254 (table 1). The group of adult bulls exhibited 15.08% higher sperm motility than those of younger bulls (table 2). Older bulls had a middle range values for SM. Age have been an extremely significant factor ($p < 0.001$) in influencing SM. Sahiwal bulls had 6.97% greater SM than Tharparkar bulls.

The sperm concentration was determined to be 1213.466 million per ml (table 1). SC of the young bulls were 9.17% greater than the adult bulls. SC is also impacted significantly by age. Sahiwal bulls have 2.4% greater SC than Tharparkar bulls. The semen characteristics corroborated with the reports by Pino et al., suggesting that the sperm concentration declines with aging [11], however, the current findings doesn't find any agreement with the findings of Mathevon et al. that the sperm concentration increases with the aging of the bull [12].

Table 3. Breed-wise distribution of estimated semen traits (figures in parentheses represent the sample size).

Breed	Total Ejaculated Volume (ml)	Sperm Motility (Proportion)	Sperm Conc. (Million/ ml)
Gir	3.243 ± 0.037 (3989)	0.258 ± 0.004 (3989)	1218.364 ± 12.211 (3989)
Rathi	3.277 ± 0.056 (1079)	0.253 ± 0.005 (1079)	1212.941 ± 18.331 (1079)
Sahiwal	3.254 ± 0.043 (2751)	0.261 ± 0.004 (2751)	1225.688 ± 14.101 (2751)
Tharparkar	3.242 ± 0.071 (658)	0.244 ± 0.007 (658)	1196.873 ± 23.332 (658)

4. Conclusion

The effect of non-genetic factors such as age and breed were analyzed on semen parameters of Indo-Brazilian breeds of bulls. The results showed that bulls of 18 to 43 months of age provided semen of higher quality in terms of volume and concentration than the older bulls. However, analysing by age groups, sperm motility was the highest in the older bulls aged between 44 and 69 months. As such, evidence seems to indicate that young bulls may perform well in some of these characteristics; however, adult bulls could offer greater value in a breeding program where motility is central.

As it pertains to breed differences, estimated breed values suggested that Sahiwal bull contained highest estimated values for all the semen traits showing their possibility of being used as breeder into programs. In many parameters Rathi bulls also proved excellent especially in the volume of the crude semen. On the other hand, Tharparkar bulls were the least input in all the observed traits, thus confirming their inferiority in this study. Nevertheless, the findings were quite surprising since the breed factor as whole exhibited no significant overall impression on the quality of the semen samples Thereby, these observations suggest that the breed choice is essential in improving semen quality.

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The consequences of these findings are manifold and bear great relevance on aspects related to bull selection and management within breeding plans. It is hypothesized that younger bulls should be prioritized for semen collection to achieve a high volume and concentration, however adult bulls would be preferred when high motility is desirable. Furthermore, the results suggest that enhancing use of Sahiwal and Rathi breeds might result in better results in the transportation of gametes such as chilled/semen during artificial insemination.

Future studies should seek to examine the physiological basis of these differences with respect to age and breed. Investigating the association of such non-genetic factors with environmental factors and management could also provide more understanding into improving the process of optimal semen yield in indigenous cattle breeds. This way, breeders are in a position of improving fertility standards besides influencing indigenous cattle genetic pool.

Declarations

Author Contribution: PCS conceptualized the presented idea of the manuscript, MG performed literature search, data analysis and prepared the manuscript. RT and PCS reviewed, edited and approved the manuscript.

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