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# Effect of Management and Environmental Factors on Semen Production Potential of Indigenous Cattle Breeds

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## ABSTRACT

**Background:** The production of higher number of quality semen doses from the indigenous bulls is required to mitigate the issue of declining population of indigenous cattle breeds. To make the semen production more efficient, the knowledge of factors affecting the semen production is of utmost importance. However, studies on different indigenous breeds are scarcely available and very little information is available on effect of ejaculate number, collection interval, semen collector *etc*. The present investigation was hence focused to study the effect of different management and environmental factors affecting semen production traits in indigenous breeds.

**Methods:** Semen data comprising of 15,435 ejaculates from 60 bulls of 10 indigenous cattle breeds were analysed for semen production traits. Prior to the analysis, data on initial motility was transformed using the arcsine transformation. Least square analysis was carried out using "*lm*" function while ANOVA (Type III sum of square) and Duncan's multiple range test were computed using "*car*" and "*agricolae*" packages from R statistical software.

**Result:** The overall means for the semen production traits: ejaculate volume, sperm concentration, total sperm, initial motility and total motile sperm were 5.62±0.041 ml, 1.42±0.51× $10^9$/ml, 7.96±0.25× $10^9$/ejaculate, 74.77±0.002% and 5.92± 0.11 × $10^9$/ejaculate, respectively. All traits were significantly affected by order of ejaculate, collection interval, age at collection, breed, semen collector, season and year of collection except collection interval which had no effect on motility. Except initial motility, semen characters showed quadratic pattern over the age. Results of the study would help in suggesting suitable management and breeding plans for semen production traits.

**Key words:** Collection interval, Indigenous cattle breeds, Semen production traits.

## INTRODUCTION

India is known for its huge diversified bovine population which can be reflected from 43 registered cattle breeds (NBAGR, 2019a). A large proportion of (approximately 74 per cent) the cattle population is comprised of indigenous and non-descript breeds ($20^{th}$ Livestock census, 2019). The indigenous breeds are known for their ability to withstand extreme climate, disease resistance and capability to produce even on low input (feed and fodder resources) system.

Despite the consistent efforts from Government of India, the indigenous cattle population is declining which could be reflected from the 6 per cent drop in population of indigenous and non-descript population ($20^{th}$ Livestock census, 2019). On the contrary, the crossbred population increased by 26 per cent. The indiscriminate use of exotic and crossbred semen especially on the known indigenous breeds and negligence in putting the breeding plans systematically could be the cause of the declining population. Situation became more serious when only 11 per cent of indigenous bulls' semen were used to inseminate the animals out of total AI coverage (Basic animal husbandry and fisheries statistics, 2017). There is a need to implement efficient semen production to produce higher number of quality semen doses from indigenous bulls to meet the demand and mitigate the issue of declining population of indigenous cattle breeds.

To make the semen production more efficient, the knowledge of different management and environmental factors affecting different traits is highly important. Many studies (Fuerst-Waltl *et al*., 2006; Murphy *et al.,* 2018; Snoj *et al.*, 2013) have reported the effect of different non-genetic factors on semen production traits. Studies related to semen production traits of different indigenous cattle breeds were limited to only raw means, age of bull and seasonal effect (For Sahiwal: Bhakat *et al.,* 2011; Hossain *et al.*, 2012; For Ongole: Talluri *et al.,* 2011; Tiwari *et al.,* 2012 in Red Sindhi).Very little information on effect of different management factors like ejaculate number, semen collector, collection interval etc., on semen production traits is available on the different indigenous cattle breeds. The

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present investigation was hence focused to study the effect of different management and environmental factors affecting semen production traits in indigenous breeds.

## MATERIALS AND METHODS

### Data

The present study was analysed at Department of Animal Genetics and Breeding, Madras Veterinary College, Chennai. Semen quantity and quality data spanning over 9 years [August, 2010 to December, 2018] maintained at BAIF's frozen semen station, Uruli Kanchan, Pune, India, was utilised for the study. Data included 15,435 ejaculates from 60 bulls of 10 indigenous cattle (*Bos indicus*) breeds (Amritmahal (2), Dangi (9), Hallikar (4), Khillar (14), Krishna Valley (6), Ongole (3), Red Kandhari (4), Red Sindhi (7), Tharparkar (7) and Hariana (4)). The information on breed characteristics is available on the national portal of NBAGR website (NBAGR, 2019b).

### Traits studied and influencing factors

The semen traits included in the study were: ejaculate volume (ml), sperm concentration ($10^9$/ ml) and other composite traits included total sperms ($10^9$/ ejaculate, as the product of volume and sperm concentration) and total motile sperm ($10^9$/ ejaculate, as the product of proportion of initial motility and total sperm per ejaculate). The values over and below the raw mean of the trait ± 4 standard deviations (0.1 to 0.4 per cent of data depending on a trait) were considered as outliers and discarded. Young bulls' data during their testing period was not included in the study. As the first collection of every bull from the data did not have any interval, it was excluded from the data during analysis.

The factors influencing semen characteristics which considered in the study were: the order of ejaculate on a same day (first and second), the interval between two consecutive days of collection (1 to 3 days; 4 to 6 days; 7 and above), year (2010 to 2018), age at collection in months (classified as less than 36 to 144 and above months, 11 year classes) and semen collector. Months were also grouped to form three seasons, *viz*. winter (January, February, November and December), summer (March to May) and monsoon (June to October). The breeds were classified individually.

### Statistical analysis

Prior to the analysis, data on initial motility was transformed using the arcsine transformation (Snedecor and Cochran, 1994). The semen production records were subjected to least square analysis using "*lm*" function in R statistical software, version 3.6.2. (R Core Team, 2019). Along with "*lm*" function, "*car*" and "*agricolae*" packages were used for computing ANOVA (Type III sum of square) and Duncan's multiple range test. The model for the analysis is given below:

$$Y_{ijklmnop} = \mu + E_i + C_j + A_k + SC_l + B_m + S_n + P_o + e_{ijklmnop}$$

Where,

$Y_{ijklmnop}$ = Semen production trait

$\mu$ = Overall mean

$E_i$ = Effect of $i^{th}$ order of ejaculate (i = 1,2)

$C_j$ = Effect of the $j^{th}$ collection interval (j = 1 to 3)

$A_k$ = Effect of $k^{th}$ age at collection of a bull (k = 1 to 11)

$SC_l$ = Effect of $l^{th}$ semen collector (l = 1 to 14)

$B_m$ = Effect of $m^{th}$ breed (m = 1 to 10)

$S_n$ = Effect of $n^{th}$ season of collection (n = 1 to 3)

$P_o$ = Effect of $o^{th}$ year of collection (o = 1 to 9)

$e_{ijklmnop}$ = Random error associated with $Y^{ijklmnop}$ which is assumed to be normally and independently distributed with mean zero and constant variance

## RESULTS AND DISCUSSION

The overall means for the semen production traits: ejaculate volume, sperm concentration, total sperm, initial motility and total motile sperm were 5.62 ± 0.041 ml, 1.42 ± 0.51 × $10^9$/ ml, 7.96 ± 0.25 × $10^9$/ejaculate, 74.77 ± 0.002% and 5.92± 0.11 × $10^9$/ejaculate respectively. Table 1 showed the least square means and standard error for different fixed effects. All the factors significantly affected semen production traits except collection interval which had no significant effect on initial motility.

Order of ejaculate showed significant difference between the two ejaculates (P<0.01). The first ejaculate showed higher means than second ejaculate. The lower means in second ejaculate for composite traits, *viz*. total sperm and total motile sperms were the consequences of lower volume, concentration and initial motility in the second ejaculate. The higher values for the first ejaculate are well documented in cattle for sperm concentration, ejaculate volume, total sperm per ejaculate, mass activity and initial motility (Bhakat *et al.,* 2011; Fuerst-Waltl *et al.,* 2006; Murphy *et al.,* 2018; Taylor *et al.,* 1985). The basic reason for collection of two ejaculates on a same day was to increase the number of semen doses produced without affecting sperm quality.

Collection interval showed significant effect (P<0.01) on all the traits except for the initial motility which showed no variation. For initial motility, 4 to 6 days of interval showed higher means, although the differences among the classes were very small. Apart from the motility trait, it was observed that means of other semen production traits increased with increase in collection interval. Interval with 7 or more days produced higher means. For ejaculate volume, interval from 1 to 6 differed significantly from interval with more than 7 days, while for total motile sperms, means of 1 to 3 days of interval was significantly lower than 4 to 7 and more collection interval.

Our results were consistent with the findings of Fuerst-Waltl *et al*. (2006), Mathevon *et al*. (1998a, 1998b), Murphy *et al*. (2018). There are studies who have documented intervals between 2 to 10 days (Berry *et al*., 2019; Burren *et al*., 2019; Fuerst-Waltl *et al.,* 2006; Mathevon *et al.,* 1998a). In commercial AI industry, collection intervals of more than

**Table 1:** Least square means and standard error of non-genetic factors affecting semen production traits.

| Factors | No. of observations | Least square means ± Standard error | | | | |
|---|---|---|---|---|---|---|
| | | Ejaculate volume (ml) | Sperm concentration (× $10^9$ /ml ) | Total sperms (× $10^9$ /ejaculate) | Initial motility (%) | Total motile sperms (× $10^9$ /ejaculate) |
| **Order of ejaculates** | ** | ** | ** | ** | ** | |
| 1 | 12327 | 5.99±0.04$^{a}$ | 1.52±0.58$^{a}$ | 9.21±0.10$^{a}$ | 73.93±0.001$^{a}$ | 6.75a±0.0832a |
| 2 | 3099 | 4.94±0.06$^{b}$ | 1.07±0.53$^{b}$ | 5.55±0.12$^{b}$ | 72.54±0.001$^{b}$ | 3.99b±0.0976b |
| **Collection interval** | ** | ** | ** | NS | ** | |
| 1 to 3 days | 8274 | 5.26±0.04$^{b}$ | 1.23±0.01$^{c}$ | 6.58±0.10$^{c}$ | 73.31±0.001$^{a}$ | 4.81±0.084$^{b}$ |
| 4 to 6 days | 6160 | 5.51±0.05$^{b}$ | 1.33±0.02$^{b}$ | 7.51±0.11$^{b}$ | 73.47±0.001$^{a}$ | 5.51±0.087$^{a}$ |
| ≥7 days | 1001 | 5.62±0.07$^{a}$ | 1.38±0.02$^{a}$ | 8.05±0.15$^{a}$ | 72.69±0.002$^{a}$ | 5.78±0.13$^{a}$ |
| **Age at collection (Months)** | ** | ** | ** | ** | ** | |
| ≤ 36 | 515 | 5.01±0.088$^{b}$ | 1.23 ± 0.027$^{a}$ | 6.05±0.189$^{cd}$ | 74.84±0.003$^{b}$ | 4.56±0.15$^{cde}$ |
| > 36 ≤ 48 | 3025 | 5.03±0.051$^{b}$ | 1.28±0.016$^{a}$ | 6.53±0.109$^{bc}$ | 74.54±0.001$^{bc}$ | 4.87±0.089$^{abc}$ |
| > 48 ≤ 60 | 3007 | 5.29±0.053$^{a}$ | 1.35±0.016$^{a}$ | 7.28±0.112$^{a}$ | 73.01±0.001$^{de}$ | 5.26±0.092$^{ab}$ |
| > 60 ≤ 72 | 2357 | 5.23±0.056$^{a}$ | 1.40±0.017$^{a}$ | 7.55±0.120$^{ab}$ | 71.44±0.001$^{cd}$ | 5.34±0.098$^{a}$ |
| > 72 ≤ 84 | 2046 | 5.50±0.060$^{a}$ | 1.30±0.018$^{c}$ | 7.30±0.128$^{de}$ | 72.54±0.002$^{a}$ | 5.23±0.10$^{cdef}$ |
| > 84 ≤ 96 | 1650 | 5.27±0.069$^{a}$ | 1.32±0.021$^{c}$ | 7.13±0.147$^{ef}$ | 72.69±0.002$^{a}$ | 5.16±0.12$^{efg}$ |
| > 96 ≤ 108 | 1161 | 5.35±0.075$^{a}$ | 1.39±0.023$^{c}$ | 7.78±0.159$^{d}$ | 74.24±0.004$^{a}$ | 5.73±0.13$^{bcd}$ |
| > 108 ≤ 120 | 589 | 5.63±0.093$^{b}$ | 1.37±0.028$^{b}$ | 7.92±0.198$^{de}$ | 72.38±0.005$^{e}$ | 5.70±0.16$^{g}$ |
| > 120 ≤ 132 | 419 | 6.04±0.101$^{b}$ | 1.36±0.031$^{b}$ | 8.46±0.217$^{de}$ | 72.85±0.005$^{bc}$ | 6.10±0.17$^{defg}$ |
| > 132 ≤ 144 | 358 | 5.90±0.107$^{b}$ | 1.27±0.032$^{c}$ | 7.87±0.229$^{f}$ | 74.08±0.006$^{a}$ | 5.77±0.18$^{fg}$ |
| > 144 | 308 | 5.82±0.115$^{c}$ | 1.17±0.035$^{d}$ | 7.32±0.240$^{g}$ | 72.85±0.006$^{cd}$ | 5.33±0.20$^{h}$ |
| **Semen collector** | ** | ** | ** | ** | ** | |
| 1 | 2444 | 5.42±0.06$^{ef}$ | 1.39±0.02$^{d}$ | 7.77±0.14d$^{ef}$ | 73.31±0.002$^{cd}$ | 5.56±0.11$^{cde}$ |
| 2 | 536 | 5.09±0.10$^{ef}$ | 1.54±0.03$^{a}$ | 8.32±0.21$^{ab}$ | 70.17±0.005$^{fg}$ | 5.64±0.17$^{cd}$ |
| 3 | 3442 | 5.27±0.06$^{fg}$ | 1.40±0.01$^{d}$ | 7.62±0.13$^{def}$ | 72.38±0.002$^{cde}$ | 5.35±0.10$^{def}$ |
| 4 | 335 | 5.25ef±0.11$^{ef}$ | 1.35±0.03$^{f}$ | 7.40±0.24$^{ef}$ | 73.16±0.007$^{de}$ | 5.22±0.20$^{f}$ |
| 5 | 542 | 5.25±0.09f$^{gh}$ | 1.30±0.02$^{ef}$ | 7.13±0.19$^{ef}$ | 72.54±0.004$^{cd}$ | 5.04±0.16$^{ef}$ |
| 6 | 1547 | 5.16±0.07$^{gh}$ | 1.39±0.02$^{def}$ | 7.35±0.15$^{f}$ | 72.69±0.002$^{cd}$ | 5.14±0.125$^{f}$ |
| 7 | 800 | 5.31±0.08$^{ef}$ | 1.48±0.02$^{ab}$ | 8.17±0.19$^{bc}$ | 70.33±0.004$^{f}$ | 5.67±0.157$^{cd}$ |
| 8 | 428 | 4.90±0.11$^{h}$ | 1.51±0.03$^{bc}$ | 7.86±0.23$^{cd}$ | 70.65±0.006$^{f}$ | 5.18±0.196$^{ef}$ |
| 9 | 820 | 5.71±0.08$^{cd}$ | 1.39±0.02$^{cd}$ | 8.28±0.18$^{abc}$ | 71.28±0.003$^{e}$ | 5.81±0.154$^{bc}$ |
| 10 | 628 | 5.37±0.09$^{ef}$ | 1.58±0.02$^{a}$ | 9.04±0.20$^{a}$ | 68.08±0.004$^{g}$ | 5.91±0.167$^{cd}$ |
| 11 | 84 | 5.96±0.27$^{bc}$ | 1.078±0.08$^{de}$ | 6.66±0.58$^{ab}$ | 77.81±0.03$^{bc}$ | 5.59±0.478$^{ab}$ |
| 12 | 2044 | 6.75±0.19$^{a}$ | 1.001±0.06$^{ef}$ | 6.99±0.42$^{a}$ | 77.52±0.02$^{bc}$ | 5.87±0.348$^{a}$ |
| 13 | 49 | 5.06±0.31$^{de}$ | 0.86±0.09$^{h}$ | 4.33±0.67$^{g}$ | 76.49±1.05$^{ab}$ | 3.73±0.553$^{g}$ |

**Table 1: Continue...**

**Table 1: Continue...**

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | 1736 | 5.97b ± 0.19$^{b}$ | 1.034 ± 0.06$^{g}$ | 6.40±0.42$^{de}$ | 77.95 ± 0.02$^{a}$ | 5.45 ± 0.34$^{cd}$ |
| **Breed** | ** | ** | ** | ** | ** | |
| Amritmahal | 1416 | 4.65e±0.09$^{e}$ | 0.92±0.028$^{f}$ | 4.29±0.19$^{h}$ | 74.69±0.004$^{c}$ | 3.42±0.16$^{g}$ |
| Dangi | 1043 | 5.52d±0.10$^{d}$ | 1.36±0.031$^{a}$ | 7.53±0.21$^{cd}$ | 71.76±0.005$^{e}$ | 5.38±0.17$^{de}$ |
| Hallikar | 1509 | 4.72e±0.09$^{e}$ | 1.41±0.02$^{b}$ | 6.75±0.20$^{h}$ | 76.05±0.004$^{b}$ | 5.28±0.16$^{de}$ |
| Khillar | 5051 | 5.69c±0.08$^{c}$ | 1.30±0.02$^{bc}$ | 7.54±0.18$^{de}$ | 76.49±0.003$^{b}$ | 5.90±0.15$^{c}$ |
| Krishna Valley | 651 | 4.63d±0.11$^{d}$ | 1.17±0.03$^{e}$ | 5.34g±0.24$^{g}$ | 78.39±0.006$^{b}$ | 4.45±0.19$^{f}$ |
| Ongole | 1108 | 6.86b±0.10$^{b}$ | 1.16±0.03$^{d}$ | 8.74b±0.22$^{b}$ | 75.01±0.005$^{c}$ | 6.83±0.18$^{b}$ |
| Red Kandhari | 373 | 5.64c±0.12$^{c}$ | 1.46a±0.03$^{a}$ | 8.31c±0.26$^{c}$ | 69.85±0.008$^{de}$ | 5.67±0.22$^{d}$ |
| Red Sindhi | 2754 | 6.38a±0.17$^{a}$ | 1.346f±0.05$^{f}$ | 8.74e±0.36$^{e}$ | 75±0.015$^{a}$ | 6.16±0.30$^{c}$ |
| Tharparkar | 313 | 5.01±0.13$^{c}$ | 1.27±0.04$^{c}$ | 6.56±0.29$^{de}$ | 66.44±0.010$^{d}$ | 4.07±0.24$^{ef}$ |
| Hariana | 1217 | 5.52±0.18$^{b}$ | 1.67±0.05$^{bc}$ | 10.01±0.38$^{a}$ | 67.26±0.017$^{c}$ | 6.52±0.31$^{a}$ |
| **Season of collection** | ** | ** | ** | ** | ** | |
| Winter | 4985 | 5.46±0.05$^{b}$ | 1.31±0.01$^{b}$ | 7.33±0.11$^{b}$ | 72.69±0.001$^{b}$ | 5.29±0.09$^{b}$ |
| Summer | 3801 | 5.53±0.05$^{a}$ | 1.34±0.02$^{a}$ | 7.65±0.11$^{a}$ | 73.78±0.001$^{a}$ | 5.63±0.097$^{a}$ |
| Monsoon | 6649 | 5.40±0.06$^{b}$ | 1.29±0.01$^{b}$ | 7.16±0.10$^{b}$ | 73.16±0.001$^{b}$ | 5.18±0.08$^{b}$ |
| **Year of collection** | ** | ** | ** | ** | ** | |
| 2010 | 355 | 6.12±0.11$^{c}$ | 1.38±0.04$^{a}$ | 8.74±0.3$^{b}$ | 78.39±0.003$^{b}$ | 6.82±0.007$^{b}$ |
| 2011 | 642 | 6.31±0.08$^{a}$ | 1.35±0.03$^{a}$ | 8.93±0.18$^{a}$ | 76.49±0.004$^{a}$ | 6.78±0.003$^{a}$ |
| 2012 | 1316 | 5.80±0.07$^{e}$ | 1.18±0.02$^{cd}$ | 7.11±0.15$^{ef}$ | 72.54±0.002$^{c}$ | 5.09±0.002$^{c}$ |
| 2013 | 1483 | 5.36±0.07$^{f}$ | 1.25±0.021$^{b}$ | 6.88±0.15$^{f}$ | 67.75±0.002$^{e}$ | 4.60±0.002$^{g}$ |
| 2014 | 1455 | 4.96±0.07$^{g}$ | 1.31±0.03$^{b}$ | 6.77±0.15$^{e}$ | 70.97±0.003$^{d}$ | 4.78±0.002$^{ef}$ |
| 2015 | 2401 | 5.12±0.06$^{cd}$ | 1.35±0.02$^{b}$ | 7.10±0.14$^{d}$ | 74.84±0.002$^{b}$ | 5.28±0.002$^{c}$ |
| 2016 | 2688 | 5.04±0.05$^{e}$ | 1.36±0.018$^{d}$ | 7.04±0.12$^{fg}$ | 73.78±0.002$^{c}$ | 5.15±0.001$^{cd}$ |
| 2017 | 2201 | 5.27±0.05$^{b}$ | 1.34±0.02$^{bc}$ | 7.11±0.12$^{d}$ | 73.47±0.004$^{c}$ | 5.15±0.001$^{cd}$ |
| 2018 | 2894 | 5.19±0.06$^{de}$ | 1.30±0.02$^{a}$ | 6.74±0.13$^{c}$ | 70.33±0.003$^{e}$ | 4.66±0.001$^{de}$ |

**Significant at P< 0.05; NS- Non Significant at P>0.05.

7 days is impractical. The longer collection interval yields less number of semen doses which is not economically viable. To illustrate this, a theoretical comparison was carried out based on our results. The average bull with collection intervals of either 7, 4 and 2 days produces a total of 550, 950 and 1350 doses a week. Therefore, it can be concluded that with intervals between 2 to 4 days, it is possible to produce a substantially larger number of doses without hampering semen quality.

Age at semen collection of bull holds importance in AI industry as performance of bull may become better or worse with the age. In the present study, except initial motility all the semen production traits slowly increased up to 72 to 84 months and later declined up to 108 months. There was a characteristic increase after 108 months for a short time and declined later after 120 months. Initial motility showed irregular pattern as the age progressed. The result of ejaculate volume were consistent with study of Fuerst-Waltl *et al*. (2006) Mathevon *et al*. (1998a), where after a brief increase, volume decreased as bulls get older. The result of sperm concentration, total sperm and total motile sperm followed similar pattern.

The increase in the semen production performance between the 96 to 132 months was illustrated with a simple observation. After the age of 8 years, only 15 bulls were maintained for semen production program, which was caused due to culling of 74 per cent of bulls from semen production program. The reason could be attributed to a decrease in performance of most of the bulls by the age of 96 months and selection of high demand selected bulls with better semen production. The result of the study could be used to formulate the culling level of indigenous breed bulls as the performance of the bull declined with the age. Frozen semen stations are highly interested in producing maximum semen doses from the high demand bulls, while less demanded bulls may not reach the age allowing only selected to bulls to reach the higher age classes.

There was a significant impact of semen collector on semen production traits which could be seen from the variation in the performances of different semen collectors. Fuerst-Waltl *et al*. (2006) reported significant effect of semen collector on all five semen production traits, while Mathevon *et al*. (1998a) found volume, total sperm and total motile sperm were affected by semen collectors. Dominguez *et al*. (1994) showed that the sperm output was dependent on the sexual preparation and handling of bull during the semen collection process. The sexual preparation will be helpful in young bulls especially during their early days of collection as the young bulls are less experienced and any bad experience during semen collection could cause problem in semen collection process. Mader and Price (1984), showed that better sexual performance could be observed when one bull watches other while mounting. Semen collectors have to be very careful during the collection procedure of adult bulls, as they have more economic impact on the frozen semen station.

Breed wise variation (P<0.01) was observed among the different breeds for all semen production traits. Least square means of volume, concentration, total sperms and total motile sperms for Amritmahal and Krishna Valley were found lower than rest of the breeds, while breeds like Hariana, Ongole and Red Sindhi showed higher means for the given traits. Initial motility showed completely different pattern among the breeds. The means of semen production traits presented in the study were higher than the different reports published on indigenous breeding bulls (Brito *et al*., 2004; Ray and Ghosh, 2013; Tiwari *et al*., 2012; Tiwari *et al*., 2013). It could be observed that heavier breeds have higher means compared to lower body weight breeds as body weight is positively correlated with scrotal circumference (Gopinathan, 2014).

Season of collection too affected the semen production traits (P<0.01), with higher means observed during the summer months. Means for the summer season were significantly different from the monsoon and winter season for all the traits. Murphy *et al*. (2018) reported similar results in Holstein Friesian, while Taylor *et al*. (1985) found higher volume in summer season. Except initial motility, all the traits showed similar trend. Higher means were found in summer followed by winter and then monsoon. Influence of change in environmental condition might have affected the sensitive stages of spermatogenesis. This could well be the reason why the means of semen production traits were higher in summer than winter season. A better climatic conditions in winter could have resulted in higher semen attributes in summer.

Year of collections showed variation (P<0.01) among the bulls' performance over the years. The 2010 and 2011 years were observed for higher means in semen production traits, while 2013, 2014 and 2018 years reported comparatively lower means for total sperms, initial motility and total motile sperms. The change in a pattern of semen production parameters were attributed to management decision made during the course of years. To illustrate this fact, during 2010 to 2012, the number of bulls were less than 10. On contrary, during 2014 to 2018, more number of bulls (20 to 33) were inducted for semen collection. The maximum number of bulls were present during 2018. Also the number of young bulls inducted were higher during 2017 and 2018 which resulted in lower semen attributes. Apart from that, the targets set to achieve by frozen semen station and demand for indigenous bulls were different for different years.

## CONCLUSION

It could be said that apart from environmental factor, the management practices can produce significant impact on the semen production traits. Collection of two ejaculates with interval of 2 to 4 days could yield higher semen doses which ultimately increased the total productivity per bull. Age of bull at collection showed quadratic pattern, although it might strongly influenced due to demand of the semen from adult bulls than young. Season of collection might have influenced the spermatogenesis process resulted in higher means during summer. Regular training of certain low performing employees could be helpful for future production purpose. The results of this study will be a reference with respect to semen production traits of important indigenous breeds of India.

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