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Seasonal variation in semen quality of Black Bengal bucks under subtropical conditions in Bangladesh

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ABSTRACT

Seasonal variation in semen quality can influence the planning and efficiency of goat artificial insemination programmes. This study evaluated seasonal variation in fresh semen characteristics of Black Bengal bucks maintained at the Artificial Insemination Center, Bangladesh Agricultural University, Mymensingh, Bangladesh, from July 2013 to June 2014. Ten sexually mature bucks aged 17-23 months were included, and semen was collected weekly using an artificial vagina. Ejaculate volume, sperm concentration, sperm motility, the percentage of live spermatozoa, and the percentage of morphologically normal spermatozoa were compared among winter (November-February), summer (March-June), and the rainy season (July-October), and no seasonal difference was statistically significant ($P > 0.05$) for any of the measured characteristics. Ejaculate volume and sperm concentration were numerically highest in winter (0.9 ± 0.1 mL and 3,978 ± 0.6 million/mL, respectively). Motility and the percentage of live spermatozoa were numerically highest in the rainy season (78.4 ± 1.0% and 90.2 ± 0.7%), whereas the percentage of normal spermatozoa was highest in summer (92.0 ± 1.3%). These results suggest that semen characteristics were broadly similar across seasons under the management conditions studied, and semen collection for artificial insemination does not appear to require restriction to a particular season; however, the findings require cautious interpretation because only ten bucks from a single centre were studied, repeated weekly observations were analysed as independent, and the seasonal sample counts and sperm concentration standard errors require verification. Reanalysis of the original repeated-measures data with a mixed model is recommended before drawing firm conclusions for artificial insemination programmes.

1. Introduction

Black Bengal goats are an important indigenous genetic resource in Bangladesh and contribute to rural livelihoods, household income, and food security. The breed is valued for its adaptation to local conditions, reproductive performance, prolificacy, and meat and skin quality. A review of research on the breed highlights its longstanding importance in Bangladesh and the need to improve its productivity while conserving its genetic resources (Hossain, 2021). Improving reproductive efficiency is therefore important for sustainable goat production and breeding programmes, particularly where smallholder farmers depend on goats as a source of income and animal protein.

Artificial insemination (AI) can accelerate genetic improvement by enabling the use of selected males across a larger number of females (Evans and Maxwell, 1987; Chemineau et al., 1991). The effectiveness of AI programmes depends on appropriate buck selection, reliable semen collection and evaluation, and the maintenance of semen quality during processing, storage, and use (Leboeuf et al., 2000). Commonly assessed semen characteristics include ejaculate volume, sperm concentration, motility, viability, and morphology. These parameters provide complementary information about sperm output, functional status, and structural integrity; they should be considered together rather than treating any single

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characteristic as a complete measure of fertilizing potential (Chenoweth and Lorton, 2014). In Black Bengal bucks, ejaculate volumes of about 0.6-1.0 mL and sperm concentrations of about 2,800-3,100 million/mL have been reported under institutional conditions (Sultana et al., 2013). The production and preservation of goat semen for AI are also influenced by the animal, collection conditions, and processing procedures (Leboeuf et al., 2000).

Environmental conditions may affect male reproductive physiology and semen characteristics through thermoregulation, endocrine activity, nutritional status, and general health. Temperature and humidity can contribute to thermal stress, while seasonal changes in forage availability and diet quality may influence body condition and the nutrients available for spermatogenesis. Photoperiod also regulates reproductive activity in many small ruminants, although the strength and timing of the response vary by breed and geographical location. Research on sheep and goats has demonstrated that light and melatonin are important in the regulation of seasonal reproductive activity (Chemineau et al., 1992). Studies in subtropical goats further show that reproductive responses to photoperiod differ among breeds and management systems (Delgadillo et al., 2004). Seasonal variation in semen characteristics has also been documented in Alpine, Saanen and Damascus bucks in Greece (Karagiannidis et al., 2000).

Bangladesh has a monsoon climate with a hot summer, a rainy season, and a comparatively cooler winter. These periods differ in temperature, rainfall, humidity, and the availability and quality of feed resources. Because Bangladesh lies at roughly 20-26°N, annual variation in day length is moderate (approximately 10.5–13.5 hours), so temperature, humidity, and feed availability may be relatively more important than photoperiod**.** Such seasonal conditions could influence the physiological status of breeding bucks and, consequently, the characteristics of their ejaculates. Nevertheless, seasonal responses observed in one breed or production environment cannot automatically be extrapolated to another. For example, Maina et al. (2006) reported seasonal differences in several semen characteristics of Sahel bucks in Nigeria, but their findings may not directly represent Black Bengal bucks managed in Bangladesh.

Locally generated evidence can help AI centres decide whether buck evaluation and semen collection schedules require seasonal adjustment. If semen characteristics remain broadly stable, collection may be feasible throughout the year under appropriate management and routine quality control. Conversely, consistent seasonal reductions in one or more parameters could inform management, collection, or processing decisions. The available evidence for Black Bengal bucks maintained under local institutional conditions therefore needs to be assessed directly.

This study evaluated seasonal variation in fresh semen characteristics of Black Bengal bucks maintained at the Artificial Insemination Center, Bangladesh Agricultural University, Mymensingh. Specifically, it compared ejaculate volume, sperm concentration, sperm motility, the percentage of live spermatozoa, and the percentage of morphologically normal spermatozoa among winter, summer, and rainy seasons.

2. Materials and methods

2.1. Study site, animals, and seasonal classification

The study was conducted at the Artificial Insemination Center, Bangladesh Agricultural University, Mymensingh, Bangladesh (approximately 24°43′ N, 90°26′ E), from July 2013 to June 2014. Ten sexually mature Black Bengal bucks aged 17-23 months were included. Their body weights ranged from 18 to 23 kg, and scrotal circumference ranged from 17 to 20.5 cm. The study period was divided into three seasons: winter (November-February), summer (March-June), and rainy (July-October).

2.2. Animal management

The bucks were housed individually in pens [pen area per animal to be confirmed against the husbandry records; the originally reported 4.3 square feet appears too small for an adult buck. Animals received commercial concentrate and green fodder, including Napier and/or German grass, with clean water available ad libitum. The daily ration was 200 g of concentrate and 1.5 kg of green grass per buck, divided between morning and

afternoon feeding. The concentrate contained 120 g crude protein/kg dry matter and 10.4 MJ metabolizable energy/kg dry matter. Bucks were allowed 1–2 hours of grazing or exercise daily, dewormed with ivermectin three times per year, and vaccinated against peste des petits ruminants.

2.3. Semen collection

Semen was collected once weekly from each buck before 08:30 using an artificial vagina and a teaser animal. Collection equipment was sterilized before use. The artificial-vagina liner was maintained at approximately 42-43°C; the water jacket was filled with water at 52-54°C to achieve the target liner temperature. A sterile, non-spermicidal lubricant was applied before collection. Ejaculates were collected into graduated tubes protected by an insulating jacket and placed in a 37°C water bath for evaluation.

2.4. Semen evaluation

Ejaculate volume was recorded directly from the graduated collection tube. Semen appearance was examined for colour, opacity, and visible contamination (Salisbury et al., 1978). Sperm motility was assessed microscopically using a drop of fresh, undiluted semen on a pre-warmed (37°C) slide (Evans and Maxwell, 1987). Sperm concentration was determined using a haemocytometer according to Herman and Madden (1963).

The percentage of live spermatozoa was assessed using eosin–nigrosin staining. At least 100 spermatozoa were counted per sample; cells taking up the eosin stain were classified as dead, while unstained cells were classified as live. Sperm morphology was assessed using fixed preparations and Williams' stain. At least 200 spermatozoa were examined for acrosome, midpiece, tail, and cytoplasmic-droplet abnormalities, and at least 500 spermatozoa were examined for head morphology (Figs 1 and 2). The percentage of morphologically normal spermatozoa was recorded.

2.5. Statistical analysis

Seasonal means were compared using one-way analysis of variance under a completely randomized design, followed by Duncan's Multiple Range Test (DMRT), using SAS software (SAS Institute Inc., 1998). Differences were considered significant at $P < 0.05$, and data are presented as mean ± standard error. Because semen was collected repeatedly from the same ten bucks, the observations are clustered within animals, which this analysis did not account for. A mixed-effects model with season as a fixed effect and buck as a random effect would be more appropriate and is recommended if the original data are available. Exact P-values and confidence intervals were not available for reporting.

3. Results

3.1. Seasonal variation in ejaculate volume and sperm concentration

Ejaculate volume and sperm concentration showed numerical variation across the three seasons; however, there were no statistically significant seasonal differences for either parameter ($P > 0.05$). The mean ejaculate volume was highest during winter (0.9 ± 0.1 mL), whereas lower values were recorded during summer and the rainy season (0.7 ± 0.1 mL in both seasons). Thus, the observed mean volume was numerically greater in winter than in the other two seasons (Table 1).

Table 1. Seasonal variation in fresh semen characteristics of Black Bengal bucks (mean ± SE)

Semen characteristic	Winter	Summer	Rainy season
Ejaculate volume (mL)	0.9 ± 0.1	0.7 ± 0.1	0.7 ± 0.1
Sperm concentration (million/mL)	3,978 ± 0.6	3,016 ± 0.6	3,045 ± 0.7
Sperm motility (%)	76.3 ± 0.9	78.0 ± 0.9	78.4 ± 1.0
Live spermatozoa (%)	89.0 ± 0.6	89.8 ± 0.6	90.2 ± 0.7
Normal spermatozoa (%)	88.6 ± 1.3	92.0 ± 1.3	89.6 ± 1.4

Values are reported as mean ± standard error. No statistically significant seasonal differences were reported for the five parameters (P > 0.05).

Sperm concentration followed a similar seasonal pattern, with the highest mean in winter (3,978 ± 0.6 million/mL), followed by the rainy season (3,045 ± 0.7 million/mL) and summer (3,016 ± 0.6 million/mL). Although the winter mean was numerically higher, the seasonal effect was not statistically significant. These numerical differences should therefore be interpreted as descriptive patterns rather than evidence of a confirmed seasonal influence.

3.2. Seasonal variation in sperm motility and viability

Sperm motility and the percentage of live spermatozoa were numerically highest during the rainy season. Mean sperm motility was 78.4 ± 1.0% in the rainy season, compared with 78.0 ± 0.9% in summer and 76.3 ± 0.9% in winter (Table 1). The difference between the highest and lowest seasonal means was 2.1 percentage points. Nevertheless, the seasonal difference was not statistically significant ($P > 0.05$).

The percentage of live spermatozoa also showed a gradual numerical increase from winter to summer and the rainy season. The means were 89.0 ± 0.6%, 89.8 ± 0.6%, and 90.2 ± 0.7%, respectively. The rainy-season mean was 1.2 percentage points higher than the winter mean. However, this difference was not statistically significant. Taken together, these findings indicate that motility and viability were broadly similar across seasons in the studied bucks, although their highest numerical values occurred during the rainy season.

3.3. Seasonal variation in sperm morphology

The percentage of morphologically normal spermatozoa varied numerically among the seasons, with the highest mean during summer (92.0 ± 1.3%). The corresponding values were 89.6 ± 1.4% in the rainy season and 88.6 ± 1.3% in winter. The difference between the highest and lowest seasonal means was 3.4 percentage points. This difference was not statistically significant ($P > 0.05$). Representative normal and abnormal spermatozoa are shown in Figs 1 and 2.

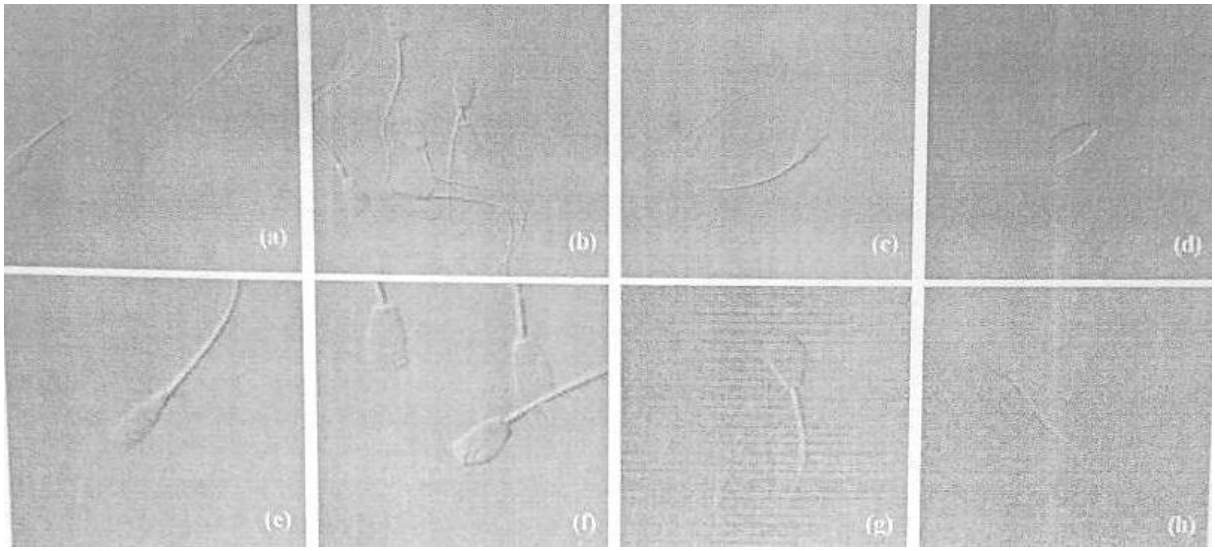


Fig. 1: Representative micrographs of buck spermatozoa showing normal and abnormal head morphology (1,000× magnification, DIC optics): (a) normal head, (b) small head, (c) pyriform head, (d) detached head, (e) narrow head, (f) abnormally shaped head, (g) pear-shaped head.

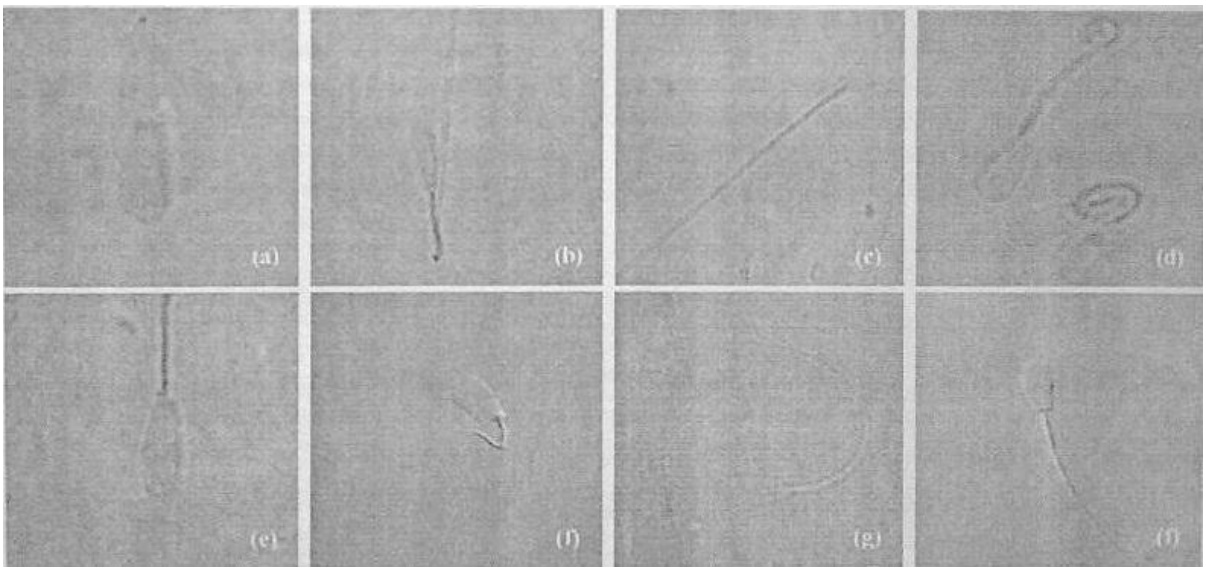


Fig. 2: Representative micrographs of buck spermatozoa showing abnormal acrosome, midpiece, and tail morphology (1,000×, DIC optics): (a) detached head, (b) broken midpiece, (c) proximal cytoplasmic droplet, (d) corkscrew tail, (e) broken tail, (f) abaxial tail, (g) simple bent tail.

3.4. Overall comparison of semen-quality characteristics

Across the five evaluated semen characteristics, none differed significantly among winter, summer, and the rainy season. Ejaculate volume and sperm concentration had their highest numerical means during winter, sperm motility and viability were highest during the rainy season, and normal sperm morphology was highest during summer. These findings suggest that the seasonal ranking depended on the parameter being evaluated rather than showing a uniform pattern across all semen characteristics.

The absence of statistically significant differences should not be interpreted as proof that the seasons are equivalent. The strength of this conclusion depends on the number of independent animals, the distribution of repeated semen collections, the precision of the estimates, and the suitability of the statistical analysis. With only ten bucks, the study may also have had limited power to detect moderate seasonal effects, particularly for variable traits such as ejaculate volume and sperm concentration. Confirmation of the number of observations per season and of the standard errors, together with an analysis that accounts for repeated observations, is needed to establish the precision of the seasonal comparisons.

4. Discussion

The main finding of this study was that seasonal differences in ejaculate volume, sperm concentration, motility, viability, and normal morphology were not statistically significant in the ten Black Bengal bucks studied. The numerical pattern was not uniform across outcomes: volume and concentration were highest in winter, motility and viability were highest in the rainy season, and normal morphology was highest in summer. These results are consistent with broadly similar semen characteristics across the three seasons under the management conditions described, but they do not establish that season has no biological effect. Mean ejaculate volume (0.7-0.9 mL) was within the range reported for Black Bengal bucks at the same university (Sultana et al., 2013), and the summer and rainy-season concentrations (about 3,000 million/mL) were close to the values reported there; the winter concentration (3,978 million/mL) was higher and should be verified.

The numerically higher winter ejaculate volume and sperm concentration contrast with the rainy-season peaks observed for motility and live sperm

percentage. This variation among endpoints is biologically plausible because ejaculate volume, sperm concentration, motility, viability, and morphology measure different aspects of semen quality and may not respond identically to environmental conditions. In Sahel bucks in Nigeria, Maina et al. (2006) reported significantly better values for several semen characteristics in the dry season than in the rainy season. The difference between that report and the present findings may reflect differences in breed, climate, feeding, management, collection methods, or statistical power; comparisons should therefore be made cautiously. Seasonal variation has also been documented in Alpine, Saanen and Damascus bucks in Greece (Karagiannidis et al., 2000), where annual photoperiod variation is wider than in Bangladesh.

Seasonal reproductive activity in goats is influenced by photoperiod and latitude, but the magnitude of seasonality differs among breeds and production systems (Chemineau et al., 1992; Delgadillo et al., 2004). The present study was conducted at a single location in Bangladesh and did not report concurrent measurements of temperature, relative humidity, rainfall, or feed quality. It is therefore not possible to determine which environmental factors, if any, contributed to the numerical differences observed. The adaptation of Black Bengal goats to local conditions should not, by itself, be interpreted as proof that reproductive characteristics are unaffected by seasonal conditions.

Several limitations affect the strength of inference. First, only ten bucks from one AI centre were studied over one year, which limits generalizability. Second, weekly observations from the same bucks are repeated measurements and cannot be assumed to be independent. The analysis used ANOVA under a completely randomized design followed by DMRT and should be repeated using a model that accounts for buck-level clustering. Third, the number of observations per season needs clarification: weekly collection would give about 52 collections per buck over the year, whereas the original data table lists 52 observations per season. Fourth, the standard errors reported for sperm concentration are unusually small relative to the means and require confirmation. Finally, exact P-values, confidence intervals, and complete statistical output were not available. These issues should be resolved before the results are interpreted as definitive evidence of seasonal stability.

From a practical perspective, the present findings do not indicate that semen collection must be restricted to a particular season in bucks managed under similar conditions. However, AI-centre decisions should be based on routine assessment of each buck and each ejaculate, along with validated semen-quality criteria. Further studies should include more animals, more than one year, clearly documented seasonal sample sizes, measurements of local environmental conditions, and statistical models suitable for repeated observations.

5. Conclusion

In this one-year study of ten Black Bengal bucks maintained at Bangladesh Agricultural University, no statistically significant seasonal differences were detected in ejaculate volume, sperm concentration, sperm motility, live sperm percentage, or normal sperm morphology. The numerical ranking of seasons differed among parameters, and the seasonal sample counts and the standard errors for sperm concentration require verification. Reanalysis of the original data using a method that accounts for repeated observations from the same bucks is recommended before drawing firm conclusions or making recommendations for Black Bengal goat AI programmes across Bangladesh.

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