Indian Journal of Animal Sciences **96** (4): 317–324, April 2026/Article
https://doi.org/10.56093/ijans.v96i4.176263

Correlation of morphometric and testicular traits with sexual behavior and semen quality parameters in Kajali rams

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Received:19 February 2026; Accepted: 02 July 2026

ABSTRACT

This study examined associations between qualitative and quantitative body and testicular traits with sexual behaviour and semen characteristics to establish baseline reproductive benchmarks for Kajali breeding rams. Twelve healthy rams (1–3 years) of two colour variants maintained under uniform stall-fed management, were evaluated for body morphometry, comprehensive testicular biometry, sexual behaviour along with semen quality parameters, and qualitative testicular traits such as testicular symmetry, scrotal bipartition, testicular shape. Age group showed statistically significant positive associations with two pre-copulatory behaviours: anogenital sniffing frequency (r = 0.870, p = 0.024) and flehmen response (r = 0.834, p = 0.039). Rear-leg circumference was the only morphometric indicator which showed a strong positive correlation with flehmen response (r = 0.864, p = 0.027), although, chest girth and paunch girth also showed moderate positive correlation with total semen volume, average sperm motility, and alive sperm percentage. Among testicular parameters, testicular length showed moderate positive correlations with average pawing (r = 0.791, p = 0.061) and with semen traits such as sperm concentration (r = 0.803, p = 0.055). Testicular weight and volume also showed moderate positive correlation with flehmen response (r=0801; p = 0.055). The findings highlighted age and specific morphometric as well as testicular traits as potential indicators of sexual behaviour and semen quality parameters for selecting superior breeding rams of indigenous breeds under semi-arid conditions.

Keywords: Body measurements, Kajali, Ram, Semen parameters, Sexual behaviour, Testicular traits

Reproductive efficiency of breeding rams is a key determinant of flock productivity in meat-oriented sheep systems, as sire fertility directly affects conception rate, lambing percentage, genetic gain, and overall profitability. Phenotypic indicators such as scrotal circumference, testicular biometry (length, width, and volume), and body morphometry (body weight, body condition score, and linear measurements) are widely used as simple, non-invasive, and repeatable predictors of sperm production and semen quality (Atawalna *et al.* 2022). These traits generally exhibit moderate to high heritability, supporting their use in genetic improvement programmes. Kajali, the only recently registered sheep breed from Punjab (INDIA_SHEEP_1600_KAJALI_14044), is characterized by a large frame, good growth performance, and two predominant coat colour phenotypes—black ("Kali") and white ("Chitti") (Mishra *et al.* 2016). However, despite increasing documentation of its production traits, scientific information on reproductive characteristics of Kajali rams remains scarce (Mishra *et al.* 2016, Bhateshwar *et al.* 2022).

Across breeds, significant associations between testicular biometry and semen quality have been reported, although these relationships are influenced by age, season, nutrition, body condition, and genetic background, necessitating breed-specific evaluation. Recent investigations have also demonstrated significant associations between body morphometric measurements and sperm characteristics in indigenous sheep breeds, suggesting that external phenotypic traits may serve as useful field-level indicators of reproductive performance (Montes-Garrido *et al.* 2023, Maqhashu *et al.* 2024)**.** Despite these advancements, no study has comprehensively evaluated the integrated relationship among non-genetic factors (e.g., coat colour and age), body conformation, detailed testicular measurements, sexual behaviour and semen quality in Kajali rams under stall-fed system. Therefore, the present study was undertaken to investigate the correlations between body morphometric traits, testicular characteristics, sexual behaviour, and semen quality parameters in Kajali rams, with the objective of establishing baseline reproductive benchmarks and identifying potential phenotypic indicators for selection of superior breeding males under semi-arid production systems.

MATERIALS AND METHODS

Experimental location and ethical approval: The present study was conducted at Kajali Sheep Unit, Department

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of Livestock Farm Complex, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Rampura Phul, District Bathinda, Punjab, India.

All experimental procedures involving animals were carried out in accordance with ethical standards and were approved by the Institutional Animal Ethics Committee (IAEC) of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India (Approval No. GADVASU/2024/IAEC/76/11).

Housing, feeding and general management: All experimental rams were maintained under a stall-fed system in a well-ventilated single pen, providing approximately 60 ft² space per animal (covered and open area combined). The study was conducted during March, 2025 for a period of 7 days with one-week acclimatization period.

Rams were fed a balanced diet comprising concentrate and roughage. Feeding was carried out twice daily while clean drinking water was available ad libitum throughout the day via regularly cleaned troughs.

All animals were dewormed and vaccinated as per the recommended health management schedule prior to the study, clinically examined to ensure sound health status, and maintained under uniform management conditions throughout the experimental period.

Experimental animals: A total of 12 clinically healthy Kajali rams, (1-3years of age) were grouped based on coat colour (black, locally termed “Kali”, and white, “Chitti” depicted in Figure 1), age class (1–2 years vs. 2–3 years), testicular symmetry (symmetrical vs. asymmetrical), testicular shape (spherical vs. oval), and scrotal bipartition (bipartite vs. conjoined).

Body morphometric traits/linear conformation traits: Body morphometric (linear conformation) traits were recorded daily for 7 consecutive days in the early morning before feeding and prior to semen collection, following the method of Pesmen and Yardimci (2008). Rams were positioned squarely on a level surface, and measurements were taken using a flexible measuring tape. Traits recorded included height at withers (HW), body length (BL), chest girth (CG), paunch girth (PG), and rear leg circumference (RLC).

Testicular biometry: Testicular morphometry included

White "Chitti" Kajali Rams Black "Kali" Kajali Rams

Fig. 1. Two colour variants of Kajali Rams

both qualitative and quantitative assessments. Testicular circumference (TC) was measured at maximum scrotal girth using a flexible tape (Elmore *et al.* 1976). Testicular symmetry (TSY) was evaluated by palpation and visual inspection and classified as symmetrical or asymmetrical (Raji and Ajala 2015). Testicular shape (TSH) was categorized as spherical or oval (Karimi *et al.* 2019), and scrotal bipartition (SBP) was recorded as present or absent (Rocha *et al.* 2018). Linear dimensions such as testicular length (TL), width (TW), and diameter (TD) were measured using a vernier caliper (Pant *et al.* 2003).

Paired testicular volume (TV) was estimated as: TV (cm^3) = 0.0396 × TL × SC^2 (Lunstra and Cundiff 2003), and testicular weight (TWt, g) as: TWt = TV × 1.04, assuming tissue density of 1.04 g/mL (Amann 1990). Gonadosomatic Index (GSI) was calculated as: GSI (%) = [TWt / Body weight (kg) / 1000] × 100, indicating relative reproductive investment (Abba and Igbokwe 2015). The Testicular Shape Index (TSI) was derived as TW/TL to objectively describe testicular form (Bailey *et al.* 1996).

Semen collection procedure: Semen was collected from each ram 12 times over a 7-day period, twice daily following farm breeding management protocols. Ensuring a minimum rest interval of ≥60 minutes between successive collections.

Semen quality parameters: Ejaculates were collected using a standardized artificial vagina for sheep pre-warmed to 40°C (IMV Technologies, L’Aigle, France), with an estrus-induced ewe as teaser to stimulate libido and ensure complete ejaculation. Total semen volume (TSV, mL) was measured in pre-warmed Borosil® graduated tubes (37°C), and average semen volume per ejaculate (ASVL) was calculated across collections per ram. Average sperm concentration (ASC; $\times10^6$ sperm/mL) was determined using a Neubauer hemocytometer after appropriate dilution and cross-validated, where required, using an AccuCell® photometer (IMV Technologies). Average sperm motility (ASM, %) was assessed at 400× magnification across at least five non-overlapping fields. Live sperm percentage was evaluated using eosin–nigrosin staining (Evans and Maxwell 1987), examining a minimum of 200 spermatozoa per smear.

Abnormal sperm concentration (AbnSC; $\times10^6$ sperm/mL) was calculated as:

AbnSC = (Number of abnormal sperm / Total sperm counted) × Sperm concentration.

Morphological defects were classified according to Barth and Oko (1989). All microscopic evaluations were performed using a Zeiss Primostar 3 microscope equipped with an Axiocam 208 color imaging system for accurate visualization and assessment.

Sexual behaviour: Sexual behaviour was assessed through continuous video recording (Canon EOS 1500D DSLR) immediately after exposure to an estrus-induced ewe in a quiet observation pen. Each ram was observed until completion of two consecutive ejaculations, following standardized protocols for libido and serving capacity evaluation (Price *et al.* 1991, Öztürk *et al.* 2020). All behavioural analyses were performed by a single trained evaluator to ensure consistency and minimize observer bias.

From video recordings, both appetitive and consummatory traits were quantified. Total ejaculate number (TEjNo.) represented the cumulative ejaculates per ram, while average ejaculate number (AEjNo.) was the mean ejaculates per session (Price *et al.* 1991). Average anogenital sniffing (AAGS) frequency indicated sexual interest (López-Sebastián *et al.* 1992), and average pawing (AP) reflected pre-copulatory courtship behaviour (Álvarez *et al.* 2003). Flehmen response (FLR) was recorded as lip-curl frequency (Estes 1972). Average tail movement/mounting attempts (ATMM) included total mounting attempts and associated tail movements as indicators of arousal (Price *et al.* 1991). Average reaction time (ART, seconds) was defined as the latency from exposure to first mount or ejaculation (Öztürk *et al.* 2020).

Statistical analysis: All data were compiled and analysed using IBM SPSS Statistics software (Version 22; IBM Corp., Armonk, NY, USA). Associations between morphometric and semen-related traits were evaluated using Pearson's correlation coefficient for variables exhibiting normal distribution, while Spearman's rank correlation coefficient was applied to variables that did not meet normality assumptions. Statistical significance was set at $p \leq 0.05$ for all analyses.

RESULTS AND DISCUSSION

Correlation between non-genetic traits and sexual behaviour in Kajali rams: Correlation analysis demonstrated differential effects of age group and coat colour on sexual behaviour traits in Kajali rams (Table 1). Age showed significant positive correlations with pre-copulatory behaviours, including AAGS (r = 0.870, p = 0.024) and FLR (r = 0.834, p = 0.039), indicating greater sexual interest in older rams, while no significant associations were observed for consummatory traits. The present data showing greater pre-copulatory sexual behaviours (e.g., ano-genital sniffing, and flehmen response) in older Kajali rams aligns with earlier findings in Chios and Karagouniki rams, where mature males (21-month-old) exhibited significantly higher frequencies of courtship behaviours compared with younger rams (9-month-old) (Simitzis et al. 2006). These behavioural response increases with age likely reflect physiological maturation: pubertal development of the hypothalamic–pituitary–gonadal axis, rising testosterone production, and enhanced sensory and motivational drive to respond to ewe pheromones. Indeed, longitudinal observations in crossbred ram lambs have shown that the expression of libido and flehmen behaviour increased steadily between 3 and 17 months of age, concomitant with rising testosterone levels (Maksimović *et al.* 2021, Elaref *et al.* 2021). Nonetheless, the lack of a significant effect of age on consummatory traits (mounting attempts, ejaculation frequency) in the current study may reflect the influence of other modulating factors such as sexual experience, social environment, and individual variation. Sexual-inexperienced yearling rams have earlier been reported to exhibit lower ejaculatory performance and higher rates of sexual inactivity, even if they displayed pre-copulatory interest (Perkins and Roselli 2007, Mostafa and Farghal 2019).

Coat colour did not show any statistically significant association with the measured sexual behaviour traits ($p > 0.05$). Coat colour is generally considered a qualitative, non-adaptive trait, and its influence on reproductive behaviour has not been consistently supported in sheep. Similar findings were also reported by Chenoweth (1981). The trends observed here warrant further study with larger sample sizes to clarify whether colour-associated behavioural tendencies exist within the Kajali breed. Overall, the results indicate that age, rather than coat colour, is a more influential factor affecting selected libido-related behaviours in Kajali rams, particularly those associated with sexual interest and pre-copulatory activity.

Correlation between non-genetic traits and semen quality parameters of Kajali rams: Correlation analysis revealed no statistically significant associations between the non-genetic traits evaluated (age group and coat colour) and any of the measured semen quality parameters (Table 2). Age group showed weak and non-significant correlations with total semen volume (TSV; r = 0.170, p = 0.748), average semen volume per ejaculate (ASVL;

Table 1. Correlation between non-genetic traits and sexual behavior of Kajali rams

	Age group		Color	
	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
TEjNo.	0.139	0.793	-0.603	0.205
AEjNo.	0.447	0.374	0.447	0.374
AAGS	.870*	0.024	0.348	0.499
AP	0	1	-0.707	0.116
FLR	.834*	0.039	0	1
ATMM	-0.046	0.93.	-0.696	0.125
ART	-0.288	0.58	-0.732	0.098

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2. Correlation between non-genetic traits and semen quality parameters of Kajali rams

	Age group		Color	
	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
TSV (ml)	0.17	0.748	-0.6	0.208
ASVL (ml)	0.17	0.748	-0.6	0.208
ASC ($\times 10^6$ sperm/ml)	-0.016	0.976	-0.519	0.292
ASM (%)	0.014	0.979	-0.588	0.219
AbnSC ($\times 10^6$ sperm/ml)	0.17	0.748	-0.539	0.269
Alive (%)	0.124	0.815	-0.591	0.216

r = 0.170, p = 0.748), abnormal sperm concentration (r = 0.170, p = 0.748), average sperm motility (r = 0.014, p = 0.979), sperm concentration (r = –0.016, p = 0.976), and live sperm percentage (r = 0.124, p = 0.815). These findings indicated that variation in semen quality among Kajali rams was not markedly influenced by chronological age within the 1–3 years range studied. In a study of Morada Nova rams (18 vs. 30 months old), semen volume and sperm concentration did not differ significantly between age groups, although younger rams had slightly poorer sperm morphology and motility (Pereira *et al.* 2014). Similarly, in Ouled-Djellal rams, while adult rams had higher motility and concentration than young rams, ejaculate volume did not differ significantly (Benia *et al.* 2018).

Similarly, coat colour phenotype (black "Kali" vs. white "Chitti") did not show significant correlations with any semen traits (p > 0.05). Although moderate negative correlations were observed for several parameters such as TSV (r = –0.600), ASVL (r = –0.600), sperm concentration (r = –0.519), motility (r = –0.588), abnormal sperm concentration (r = –0.539), and live sperm percentage (r = –0.591), these associations remained non-significant. In the present study, a declining trend in semen quality parameters was observed with increasing darkness of coat colour. However, the differences did not attain statistical significance (p > 0.05), indicating that coat colour alone did not exert a decisive influence on semen quality under the prevailing management and environmental conditions. This trend may be biologically explained by the greater absorption of solar radiation by darker coat colours, which could marginally elevate scrotal and testicular temperatures and thereby influence spermatogenic efficiency (Faye and Konuspayeva 2012). Nevertheless, the absence of statistically significant differences suggests that effective thermoregulation, uniform housing, and controlled nutritional management likely mitigated any potential adverse thermal effects associated with darker pigmentation.

Correlation between quantitative body morphometric traits and sexual behaviour in Kajali rams: Correlation analysis between quantitative body morphometric traits with sexual behaviour in Kajali rams is depicted in Table 3. Body length (BL), chest girth (CG), height at withers (HW), and paunch girth (PG) showed no significant correlations, although CG and PG exhibited moderate, non-significant positive trends with TEjNo. (r = 0.782, p = 0.066; r = 0.738, p = 0.094) and ATMM (r = 0.745, p = 0.090; r = 0.719, p = 0.107). Rear leg circumference (RLC) was the only trait significantly associated with behaviour, showing a strong positive correlation with flehmen response (FLR; r = 0.864, p = 0.027), suggesting greater hind-limb muscling may be linked to enhanced pheromone-mediated pre-copulatory activity. These findings suggested that skeletal conformation per se may not substantially influence libido once rams attain sexual maturity, consistent with reports that age and growth, rather than specific linear

Table 3. Correlation between quantitative body phenotypic traits and sexual behavior of Kajali rams

		TEjNo.	AEjNo.	AAGS	AP	FLR	ATMM	ART (sec)
BL	Pearson Correlation	-0.055	0.113	-0.019	0.089	0.6	-0.246	-0.32
	Sig. (2-tailed)	0.918	0.832	0.972	0.867	0.208	0.638	0.537
CG	Pearson Correlation	0.782	-0.394	-0.169	0.584	0.408	0.745	0.688
	Sig. (2-tailed)	0.066	0.44	0.749	0.223	0.422	0.09	0.131
HW	Pearson Correlation	0.393	-0.262	0.027	0.414	0.633	0.212	0.133
	Sig. (2-tailed)	0.441	0.616	0.959	0.414	0.178	0.686	0.801
PG	Pearson Correlation	0.738	-0.498	-0.403	0.437	0.219	0.719	0.718
	Sig. (2-tailed)	0.094	0.314	0.428	0.386	0.677	0.107	0.108
RLC	Pearson Correlation	0.409	0.12	0.209	-0.189	.864*	0.153	-0.03
	Sig. (2-tailed)	0.421	0.822	0.691	0.72	0.027	0.772	0.956

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation between quantitative body phenotypic traits and semen quality parameters of Kajali rams

		TSV (ml)	ASVL (ml)	ASC ($\times10^6$ sperm/ml)	ASM (%)	AbnSC ($\times10^6$ sperm/ml)	Alive %
BL	Pearson Correlation	-0.067	-0.067	-0.087	-0.062	-0.087	-0.075
	Sig. (2-tailed)	0.899	0.899	0.871	0.906	0.869	0.888
CG	Pearson Correlation	0.785	0.785	0.58	0.738	0.77	0.763
	Sig. (2-tailed)	0.064	0.064	0.228	0.094	0.073	0.078
HW	Pearson Correlation	0.367	0.367	0.387	0.407	0.271	0.381
	Sig. (2-tailed)	0.474	0.474	0.448	0.423	0.603	0.456
PG	Pearson Correlation	0.735	0.735	0.552	0.732	0.751	0.724
	Sig. (2-tailed)	0.096	0.096	0.257	0.098	0.085	0.104
RLC	Pearson Correlation	0.429	0.429	0.097	0.331	0.552	0.384
	Sig. (2-tailed)	0.396	0.396	0.854	0.522	0.256	0.452

traits, are associated with sexual-motivated behaviours (Maksimović *et al.* 2021). Evidence further indicate that body condition and nutritional status exert stronger effects on sexual behaviour and semen quality than skeletal size (Maurya *et al.* 2010; Sifuentes-Lamónt *et al.* 2022). This body-condition effect may derive from improved energy reserves, hormonal status (e.g., testosterone), and overall metabolic health which support both libido and sperm production. Given the lack of literature linking hind-limb circumference with libido, interpretations of the observed significant correlation between rear-leg circumference and flehmen response may be considered exploratory rather than conclusive.

Correlation between quantitative body morphometric traits and semen quality parameters: The relationship between linear body morphometric traits and semen quality parameters in Kajali rams is presented in Table 4. BL showed weak negative correlations with semen traits (r = –0.062 to –0.087; $p > 0.86$). CG demonstrated the strongest positive trends with TSV (r = 0.785, $p = 0.064$), ASVL (r = 0.785, $p = 0.064$), motility (r = 0.738, $p = 0.094$), abnormal sperm concentration (r = 0.770, $p = 0.073$), and live sperm percentage (r = 0.763, $p = 0.078$). PG showed similar moderate positive correlations with TSV (r = 0.735, $p = 0.096$), ASVL (r = 0.735, $p = 0.096$), motility (r = 0.732, $p = 0.098$), abnormal sperm concentration (r = 0.751, $p = 0.085$), and live sperm percentage (r = 0.724, $p = 0.104$). HW and RLC displayed weak to moderate associations. This lack of significant correlation suggested that general linear conformation measurements do not reliably predict ejaculated semen characteristics in Kajali rams under uniform management. Similar findings have been reported in Bapedi rams (Maqhashu *et al.* 2024). It is well understood that semen quality is more strongly influenced by testicular volume, endocrine status particularly circulating testosterone and spermatogenic efficiency rather than by phenotypic growth traits (El-Sherbiny *et al.* 2023, Aibazov *et al.* 2024). Therefore, the negligible associations observed in the present study are consistent with fundamental reproductive physiology.

Although not statistically significant, the moderate-to-high positive correlations observed for chest girth (CG) and paunch girth (PG) with several semen traits may carry biological meaning. CG and PG are indicators of thoracic and abdominal capacity, respectively, and have been linked to metabolic reserves, feed intake capacity, and rumen fill—factors associated with improved reproductive performance in sheep and goats (Mebratie *et al.* 2022). These trends could reflect the indirect relationship between better body condition and sustained endocrine function resulting in better ejaculate characteristics (Assan, 2020).

Correlation between testicular traits and sexual behaviour of Kajali rams: The correlations between testicular morphometric traits and sexual behaviour in Kajali rams are depicted in Table 5. Although no associations reached statistical significance ($p > 0.05$), several biologically relevant trends were observed. TSY showed moderate positive correlations with AAGS (r = 0.554) and FLR (r = 0.295), and negative correlations with ATMM (r = –0.514) and ART (r = –0.596). Scrotal bipartition (SBP) displayed an opposite pattern, while testicular shape (TSH) showed moderate negative correlations with TEjNo. (r = –0.59), ATMM (r = –0.645), and ART (r = –0.596). Among quantitative traits, TL was strongly positively correlated with AP (r = 0.791, $p = 0.061$) and moderately with TEjNo. (r = 0.622) and AAGS (r = 0.467). TD showed a moderate negative correlation with AP (r = –0.786, $p = 0.064$). TV and TWt demonstrated moderate-to-strong positive correlations with FLR (r = 0.801, p = 0.055) and AAGS (r = 0.638), while GSI showed a high positive correlation with AAGS (r = 0.770, p = 0.073). TSI exhibited moderate-to-strong negative correlations with TEjNo., FLR, ATMM, and ART (r = –0.42 to –0.725). Although correlation analysis in the current study revealed trends suggesting that increased testicular length and volume may coincide with more frequent pre-copulatory behaviours (e.g., pawing, anogenital sniffing, Flehmen) in Kajali rams, there is no published empirical study to date that combines testicular morphometry with detailed sexual-behaviour metrics in rams. However, several biological trends align with this finding related to established reproductive physiology. Testicular size is a well-established predictor of Leydig cell

Table 5. Correlation between testicular morphometric traits and sexual behavior of Kajali rams

		TEjNo.	AEjNo.	AAGS	AP	FLR	ATMM	ART (sec)
TSY	Pearson Correlation	-0.393	0.316	0.554	-0.125	0.295	-0.514	-0.596
	Sig. (2-tailed)	0.44	0.541	0.254	0.813	0.57	0.297	0.212
SBP	Pearson Correlation	0.393	-0.316	-0.554	0.125	-0.295	0.514	0.596
	Sig. (2-tailed)	0.44	0.541	0.254	0.813	0.57	0.297	0.212
TSH	Pearson Correlation	-0.59	0.316	-0.369	-0.125	0.074	-0.645	-0.596
	Sig. (2-tailed)	0.217	0.541	0.471	0.813	0.89	0.166	0.212
TL	Pearson Correlation	0.622	-0.5	0.467	0.791	0.233	0.616	0.555
	Sig. (2-tailed)	0.187	0.312	0.35	0.061	0.657	0.193	0.253
TD	Pearson Correlation	-0.235	0.199	-0.17	-0.786	-0.297	-0.224	-0.191
	Sig. (2-tailed)	0.654	0.706	0.747	0.064	0.568	0.669	0.716
TV	Pearson Correlation	0.571	-0.069	0.638	0.45	0.801	0.403	0.21
	Sig. (2-tailed)	0.237	0.896	0.173	0.37	0.055	0.428	0.69
TWt	Pearson Correlation	0.571	-0.069	0.638	0.45	0.801	0.403	0.21
	Sig. (2-tailed)	0.237	0.896	0.173	0.37	0.055	0.428	0.69
GSI	Pearson Correlation	0.331	-0.042	0.77	0.342	0.551	0.207	0.05
	Sig. (2-tailed)	0.521	0.937	0.073	0.507	0.257	0.695	0.925
TSI	Pearson Correlation	-0.674	0.309	-0.42	-0.219	-0.016	-0.725	-0.653
	Sig. (2-tailed)	0.142	0.552	0.407	0.677	0.976	0.103	0.16

mass, testosterone production, and spermatogenic activity in rams (Mostafa and Farghal 2019). Testosterone directly modulates sexual motivation and libido behaviours, and rams with larger testes typically exhibit higher circulating androgen concentrations. Most existing literature relates testicular size to semen output and sperm production but does not assess behavioural parameters. Therefore, our observations should be regarded as preliminary and exploratory, and demands a longitudinal design to validate whether anatomical testicular traits can reliably predict libido and mating behaviour in this and other breeds.

Correlation between testicular morphometric traits and semen quality parameters: The correlations between qualitative testicular traits (TSY, SBP, TSH) and semen

Table 6. Correlation between testicular morphometric traits and semen quality parameters of Kajali rams

		TSV (ml)	ASVL (ml)	ASC ($\times 10^6$ sperm/ml)	ASM (%)	AbnSC ($\times 10^6$ sperm/ml)	Alive %
TSY	Pearson Correlation	-0.406	-0.406	-0.217	-0.387	-0.501	-0.386
	Sig. (2-tailed)	0.424	0.424	0.679	0.449	0.312	0.45
SBP	Pearson Correlation	0.406	0.406	0.217	0.387	0.501	0.386
	Sig. (2-tailed)	0.424	0.424	0.679	0.449	0.312	0.45
TSH	Pearson Correlation	-0.598	-0.598	-0.544	-0.576	-0.572	-0.608
	Sig. (2-tailed)	0.21	0.21	0.264	0.232	0.236	0.2
TL	Pearson Correlation	0.591	0.591	0.803	0.649	0.341	0.639
	Sig. (2-tailed)	0.217	0.217	0.055	0.164	0.508	0.172
TD	Pearson Correlation	-0.212	-0.212	-0.375	-0.235	-0.006	-0.231
	Sig. (2-tailed)	0.687	0.687	0.463	0.654	0.992	0.66
TV	Pearson Correlation	0.573	0.573	0.49	0.504	0.471	0.562
	Sig. (2-tailed)	0.235	0.235	0.324	0.308	0.346	0.246
TWt	Pearson Correlation	0.573	0.573	0.49	0.504	0.471	0.562
	Sig. (2-tailed)	0.235	0.235	0.324	0.308	0.346	0.246
GSI	Pearson Correlation	0.322	0.322	0.408	0.303	0.169	0.339
	Sig. (2-tailed)	0.534	0.534	0.421	0.559	0.75	0.511
TSI	Pearson Correlation	-0.687	-0.687	-0.596	-0.64	-0.655	-0.688
	Sig. (2-tailed)	0.132	0.132	0.212	0.171	0.158	0.13

quality parameters are shown in Table 6. TSY showed weak-to-moderate negative correlations (r = –0.217 to –0.501), whereas SBP showed positive trends with semen volume, motility, and abnormal sperm percentage (r = 0.217 to 0.501). TSH exhibited moderate negative correlations with semen traits (r = –0.544 to –0.608), suggesting comparatively poorer semen characteristics in rams with more spherical testes. In contrast, quantitative traits showed clearer biological trends: TL was positively correlated with sperm concentration (r = 0.803, $p = 0.055$), motility (r = 0.649), live sperm percentage (r = 0.639), and semen volume (r = 0.591). TV and TWt also demonstrated moderate positive associations with semen traits (r = 0.471–0.573), while GSI showed weak-to-moderate positive correlations (r = 0.339–0.408). Testicular diameter showed weak negative trends. TSI displayed strong negative correlations with semen volume, sperm concentration, motility, abnormal sperm %, and live sperm (r = –0.596 to –0.688), though non-significant.

Moderate-to-strong positive correlations of quantitative testicular measurements (especially TL, TV, TWt) with semen volume, sperm concentration, motility, and viability aligned with classical reproductive biology (Amann 1990; Lunstra and Cundiff 2003). Strong associations between testicular circumference or length and sperm concentration have been reported across ruminants, including Bonsmara bulls, Ghanaian west African dwarf rams and Kivircik rams (Swanepoel *et al.* 1993; Atawalna *et al.* 2022, Elmaz *et al.* 2007).

The negative association between TSI and semen traits suggested that more spherical testes may be less efficient in spermatogenesis. As reported by Bailey *et al.* (1996) in bulls.

Qualitative traits such as testicular symmetry, scrotal bipartition, and subjective shape categories did not show statistically significant associations in the present study, and the available literature provides only limited or inconsistent support for their functional relevance. While some studies from tropical and semi-arid regions have documented the presence of scrotal bipartition and suggested it may alter scrotal anatomy or heat dissipation, direct evidence linking this trait to improved semen quality or fertility in ruminants remains largely inconclusive. Therefore, any potential role of bipartition or external symmetry in enhancing reproductive performance should be interpreted cautiously and considered hypothetical rather than established.

To our knowledge, robust peer-reviewed data evaluating testicular symmetry or scrotal bipartition in temperate-climate sheep breeds are scarce or absent. Conversely, qualitative traits such as symmetry and bipartition showed no definitive functional associations, and existing literature provides limited or inconclusive evidence regarding their reproductive relevance.

This study presents a preliminary evaluation of relationships among body morphometric traits, testicular characteristics, sexual behaviour, and semen quality parameters in Kajali rams under semi-arid conditions. Age and rear-leg circumference showed positive correlation with certain pre-copulatory behaviours, while selected testicular traits exhibited moderate positive trends with semen quality. However, most relationships were non-significant and should be interpreted cautiously owing to limited sample size and correlation analysis, restricting broader generalization.

ACKNOWLEDGEMENTS

We acknowledge the Department of Animal Husbandry and Dairying, Government of India for fully funding the project titled “Technological Interventions for development of Sustainable Kajali Sheep Production Model vis a vis prevailing intensive paddy wheat cropping system of Punjab” under the scheme National Livestock Mission.

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