Phenotypic characterization of distinct indigenous goats from Vindhyan region of Eastern Uttar Pradesh

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ABSTRACT

The present study was aimed to study the morphologic, morphometric, production and reproductive traits of the unexplored native goats from Vindhyan region of Eastern Uttar Pradesh. The data of 308 male and 590 female goats were collected from 45 villages and 449 farmers. The goats are managed under an extensive zero input production system by the poor and marginal farmers for their livelihood security since the time immemorial. These are small sized, black or brown coloured, and primarily raised for meat production. Head is straight to slightly convex, ears are flat, leafy and pendulous, and tail is bunchy and curved upward. Muzzle, eyelids and hooves are predominantly black and the horns are flat, curved and spiral with upward-backward-outward orientation. The average adult body weight was 31.34±0.38 kg in males and 28.78±0.12 kg in females. The means (cm) for body length, height at withers and chest girth were 66.41±0.34, 72.65±0.42 and 77.77±0.58, respectively, in adult males and 65.08±0.14, 69.22±0.24 and 74.35±0.16, respectively, in adult females. These goats are seasonal breeder with major breeding season from May to July and bred through natural service. Age at first estrus was ~9 months and age at first kidding was ~15 months. Twinning was common from second parity onwards. Milk production was found to be very low. The morphological appearance and morphometric measurement indicate that these indigenous goats are phenotypically distinct from the other goats of the adjoining area and can be registered as unique breed for better genetic management.

Keywords: Characterization, Goat, Indigenous, Morphologic, Morphometric

India has huge repository of goat genetic resources with 37 registered breeds (NABGR 2024). The ICAR-National Bureau of Animal Genetic Resources (NBAGR) undertook an initiative "Mission towards Zero Non-descript Animal Genetic resource of India" in the year 2021, to document native animal genetic resources and identifying potential breeds in the country. Over half of the total goat population are still uncharacterized (Sharma *et al.* 2020). Identification and characterization of distinct germplasm in a particular region will help in preserving valuable genetic diversity for breeding programmes. In this context, the Eastern part of the Uttar Pradesh, especially Vindhyan region possess a diverse demographic profile with diverse topography, sub-tropical climate, second highest agricultural sustainability index and livestock counts (Singh and Nayak 2020). Among all livestock, goat rearing has been recognised as an integral component of traditional farming systems and serving as a vital source of livelihood for rural communities (Dubey 2017; Patel *et al.* 2023). Unfortunately, the researchers have paid little attention towards describing the goat population from this zone. However, few study have been conducted on

health aspects of goat husbandry (Singh *et al.* 2020; Yadav *et al.* 2022). The documentation of distinct goats from this zone becomes important for their sustainable use including genetic conservation. The phenotypic traits are keys to identifying genetic relationships, diversity, and similarities among breeds (Kissling *et al.* 2018). Therefore, the present study aimed to characterize indigenous goat populations from the Vindhyan region, focusing on morphological, morphometric, productive and reproductive variations.

MATERIALS AND METHODS

Study area: The study was conducted in the Vindhyan region of Uttar Pradesh, especially in the Sonebhadra district and nearby areas. The region was selected for its distinctive indigenous goat population. This subtropical region, located between 23°52' to 25°32'N latitude and 82°72' to 83°33'E longitude, experiences temperatures from 30°C to 46°C in summer and 2°C to 15°C in winter, with an average annual rainfall of 1036.6 mm. (source: https://sonbhadra.nic.in/).

Sampling strategy: A total 45 villages were selected across nine blocks of Vindhyan region, mostly in Sonebhadra district. These villages were selected while considering the population density, distribution of indigenous goat population, and accessibility. The study included 449 goat rearers with at least four adult goats

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each. In order to maintain genetic variability, data were collected via random sampling method, selecting two goats from each household.

Data collection: Data were recorded from 308 males and 590 females. Information on managemental practices (feeding, housing, breeding and health management) and reproductive traits were collected from the response of goat keepers while data on morphology, morphometry and production were recorded from the respective goats individually, according to the breed descriptor of the National Bureau of Animal Genetic Resources (NBAGR), India. The morphological traits such as patterns of colour, horns, ears, head, tail, beard and wattle were recorded by visual observation. Morphometric traits related to body weight at different ages were recorded using suspended electronic weighing balance with an accuracy of ±10.0 g while that of body length, chest-girth, and height at wither, and length of horns, ears, and tail were recorded, using a measuring tape. The collected data were analysed using appropriate descriptive statistical measures and results are presented as mean and standard error, percentage and range.

RESULTS AND DISCUSSION

Management:

Housing management: The majority of goat houses across the study area were closed (81.48%), with 67.90% being fully walled and 32.10% half-walled. Open houses were 18.52%. These houses were constructed either separately (43.21%) or as part of the farmer's residence (56.79%), featuring thatch roofs and walls made from mud, bricks, shrubs, or wooden logs. All types of houses, including floors, were kutcha (100%). No pucca houses were observed in the studied area. Goats were housed overnight in winter and both midday and overnight in summer. Similar housing practices have also been reported from adjoining areas (Ahmad *et al.* 2020; Rashmi *et al.* 2021; Singh *et al.* 2021; Singh *et al.* 2023).

Nutritional management: All the goat keepers in the study area practiced extensive rearing system, due to plenteous forest cover. In winter, goats were allowed to graze for 6-8 h daily, while in summer, they grazed for 3-4 h each morning and evening, covering approximately 3-5 km/day in forest, barren land or hilly terrain. These goats were raised exclusively on grazing, even during periods of seasonal shortage of feed and water, without the supplementation of concentrates or mineral mixtures. Only during parturition or some special conditions goats were offered with some bran, wheat flour or broken rice. Drinking water was accessible from tube wells, rivers, ponds and other natural resources. A more or less similar trend of rearing the goats on extensive or semi intensive system with limited to no supplementation of concentrates, but significant periods of grazing on barren or forest land has been reported by several other authors (Rather *et al.* 2020; Sharma *et al.* 2020; Singh *et al.* 2021; Silva *et al.*

2022; Alam *et al.* 2023). This indicates a low input goat farming system with reliance on forest vegetation for nutritional requirement.

Breeding management: The studied goat population are bred through natural service. No artificial insemination is practiced in this region. Most of the goat keepers maintained one to two breeding bucks, called '*Biju Bakra'* based on the body weight and size which also serves the other goats of village. Farmers used to sell their males at younger age due to their high demand and price, leading to low breeding male to female ratio. This might be leading to inbreeding in the population. No scientific breeding practices were found to be followed. Similar breeding practices have also been reported in other studies (Ahmad *et al.* 2020; Rashmi *et al.* 2021; Singh *et al.* 2023).

Healthcare management: In this region, inadequate health care measures were evident, with minimal efforts made to prevent diseases. Farmers were reluctant to spend money on prevention and treatment of disease due to financial constraints stemming from poor economic conditions. Vaccination and deworming was found to be done occasionally. Healthcare practices were predominantly traditional, reflecting a lack of scientific knowledge. Negligence and little awareness in healthcare management by goat keepers have also been documented by other researchers (Yadav *et al.* 2020; Singh *et al.* 2021).

Morphologic characters:

Colour pattern: The predominant coat colour observed was black, followed by light to dark brown (Table 1 and Fig. 1). In addition, light to dark or white strip on lateral aspect of head extending from base of the horn to muzzle, black hair line along with the vertebra extending from nose to switch of tail in both sexes and black ring around neck in adult male was found to be present exclusively in brown coat coloured goats. The colour of skin and horn was grey in all goats; muzzle colour was predominantly black followed by brown whereas colour of hooves and eyelids was black and light to dark black, respectively. The higher prevalence of black coats might be due to the local preference. The colour patterns differed from the goats of adjoining area. *Bundelkhandi* and *Palamu* goats found to be uniform black coloration in their coat, muzzle, eyelids, and hooves (Mishra *et al.* 2012; Sharma *et al.* 2020). *Rohilkhandi* goats were predominantly reported to have black coats (Singh *et al.* 2019), whereas a variegated coat has been reported in *Black Bengal* and *Chhattisgarhi* goats

Fig 1. Morphological appearance of indigenous goats of Vindhyan region.

Table 1. Morphologic characteristics

Characteristic		Male (N=74); %	Female (N=294); %	Total (N=368); %
Coat colour	Black	68.92	63.27	64.40
	Brown	31.08	36.73	35.60
Skin colour	Gray	100.0	100.0	100.0
Horn colour	Gray	100.0	100.0	100.0
Eyelids colour	Light to dark black	100.0	100.0	100.0
Muzzle colour	Black	81.08	78.91	79.34
	Brown	18.92	21.09	20.66
Hooves colour	Black	100.0	100.0	100.0
Horn shape	Straight	6.76	6.80	6.79
	Curved & Spiral	93.24	93.20	93.21
Horn orientation	Upward-Backward	6.76	6.80	6.79
	Upward-backward-outward	93.24	93.20	93.96
Ear shape	Leafy & flat	100.0	100.0	100.0
Ear orientation	Pendulous	100.0	100.0	100.0
Forehead shape	Straight to slightly convex	100.0	100.0	100.0
Beard	Present	27.03	38.44	36.14
	Absent	72.97	61.56	63.86
Wattle	Present	1.35	1.70	1.63
	Absent	98.65	98.30	98.37
Tail shape	Bunchy	100.0	100.0	100.0
Tail orientation	Curved upward	100.0	100.0	100.0

(Bhuarya *et al.,* 2014; Kumari *et al.* 2015). Furthermore, the coat color has been found to be associated with adaptation and heat regulation in the local environment (Arenas-Baez *et al.* 2023).

Horns pattern: Horns of both the sexes were uniformly flat, predominantly curved and spiralled, followed by straight. These horns were mainly oriented upward, backward, and outward followed by upward and backward (Table 1; Supplementary Fig. 1 and Supplementary Fig. 2). The horn pattern observed in these goats were distinctive as goat of adjoining area including *Bundelkhandi*, *Palamu*, *Rohilkhandi* exhibited straight horn with an upward-backward orientation (Verma and Mishra 2014; Singh *et al.* 2019; Sharma *et al.* 2020). The horns of *Black Bengal* goats were found to be oriented upward (Kumari *et al.* 2015). Bhuarya *et al.* (2014) have reported nearly equal proportions of straight and curved horns with upward-backward orientation in *Chhattisgarhi* goats. The presence of horns indicates adaptation under an extensive system where goats compete with their competitors for feed, water and breeding partners.

Head, ears, and tail pattern: The pattern of head, ears and tail is mentioned in Table 1; Supplementary Fig. 1 and Supplementary Fig. 2. In all studied goats, the forehead was straight to slightly convex, the nose was straight, the ears were leafy, flat and pendulous, and the tail was bunchy and curved upward. Ears and tail of *Palamu* and *Rohilkhandi* goats were also found to be pendulous and bunchy, respectively but unlike the present study head was convex (Singh *et al.* 2019; Sharma *et al.* 2020). The head was observed to be straight in *Chhattisgarhi* goats (Bhuarya *et al.* 2014). The ribbon-type curly (tubular) and

pendulous ears with Roman nose have been documented in *Bundelkhandi* goats (Mishra *et al.* 2012).

Beard and wattle: Beard was present in both males and females, with a proportionally higher occurrence in females. The presence of wattles was observed at a very low frequency. Unlike the present study, beard and wattle were found to be absent in *Palamu* and *Rohilkhandi* goat (Singh *et al.* 2019; Sharma *et al.* 2020), however, these traits were present in *Bundelkhandi* and *Chhattisgarhi* goats but not in all goats (Bhuarya *et al.* 2014; Verma and Mishra 2014). Recent study indicated a positive correlation between the presence of beard and secretion of androgens in both sexes (Ofori *et al.* 2021). Therefore, beardedness has potential to enhance reproductive functions during breeding. Additionally, wattles have been linked to adaptation, thermoregulation (Ofori *et al.* 2021), increased fertility, conception rates, prolificacy, litter size, and milk yield (Yakubu *et al.* 2010). The presence of a beard in relatively higher proportion (36.14%) of the studied goat population highlights it as one of the characteristic traits within the studied goat population.

Morphometric characters:

Body weight: In the present study, male goats were found to be consistently heavier than females across all age groups (Table 2). The birth and adult body weight of these indigenous goats were found to be lower than the *Bundelkhandi* goats (Ahmad *et al.* 2020) but higher than the *Black Bengal*, *Palamu* and *Rohilkhandi* (Kumari *et al.* 2015; Singh *et al.,* 2019; Sharma *et al.* 2020), however it was comparable to goats of Chhattisgarh plains (Bhuarya *et al.* 2014). In addition, the average daily weight gain at

Table 2. Body weight at different age groups, weight gain and morphometric measurements

Weight (kg)	Male			Female		
	N	Mean±SE	Range	N	Mean±SE	Range
Weight at birth	308	1.96±0.03	1.3-2.6	590	1.74±0.02	0.8-2.5
Weight at 3 months	289	6.60±0.07	3.8-9.8	584	6.12±0.04	3.5-9.5
Weight at 6 months	246	11.52±0.15	8.2-14.6	545	10.02±0.07	7.1-14.3
Weight at 9 months	183	15.28±0.13	12.1-20.0	446	13.71±0.08	10.5-18.5
Weight at 12 months	124	20.29±0.37	15.1-29.1	419	17.32±0.15	13.6-26.3
Adult weight (6 teeth)	74	31.34±0.38	22.5-41.4	294	28.78±0.12	20.9-35.5
Weight gain (g/day) (Up to 3 months)	289	51.42±0.05	15.5-92.2.4	584	48.74±0.01	23.3-85.5
Weight gain (g/day) (Up to 12 months)	74	51.13±1.02	35.5-76.9	294	43.21±0.41	34.2-68.1
Body length (cm)	74	66.41±0.34	61.1-75.5	294	65.08±0.14	57.6-71.5
Height at wither (cm)	74	72.65±0.42	63.4-85.1	294	69.22±0.24	58.5-80.1
Chest-girth (cm)	74	77.77±0.58	67.4-88.3	294	74.35±0.16	65.0-80.9
Horn length (cm)	74	14.63±0.27	9.5-22.5	294	12.85±0.10	7.9-16.7
Ear length (cm)	74	17.70±0.21	15.2-23.3	294	17.69±0.06	15.1-21.2
Tail length (cm)	74	15.88±0.39	11.1-24.9	294	15.81±0.14	11.1-21.7

weaning and 12 months of age was found to be higher in males compared to females. The body weight and size play crucial roles in determining the economic value of goats as they directly reflect a farmer's income.

Body measurements: The mean body length showed minimal disparity between both sexes, whereas height at the withers and chest girth was observed relatively greater in males compared to females (Table 2). The body measurements of these goats were higher compared to *Black Bengal*, *Palamau* and *Rohilkhandi* goats (Kumari *et al.* 2015; Singh *et al.,* 2019; Sharma *et al.* 2020), but lower in comparison to *Bundelkhandi* goats (Ahmad *et al.* 2020). In general, males tends to be heavier and taller than the females probably due to effect of growth stimulating hormone, testosterone. The measurements indicate that the studied goat population is of small size.

Size of horns, ears and tail: The horns were short (<15.0 cm), with males having relatively larger horns than females (Table 2). The size of ears and tail was nearly equal in both the sexes. The size of horns were found to be comparable in *Bundelkhandi* and *Chhattisgarhi* goats (Mishra *et al.* 2012; Bhuarya *et al.* 2014), but larger than those of Black Bengal, *Palamu* and *Rohilkhandi* (Kumari *et al.* 2015; Singh *et al.* 2019; Sharma *et al.* 2020). Further, literatures on length of ears and tail were inconsistent (Kumari *et al.* 2015; Singh *et al.* 2019; Ahmad *et al.* 2020; Sharma *et al.* 2020).

Productive traits: The productive parameters are presented in Table 3. Average daily milk production was

Table 3. Production and reproduction performance

Parameter		N	%/Mean ± SE	Range
Production parameter				
Milk production	Morning (ml)	50	229.27 ± 7.84	100 – 550
	Evening (ml)		165.13 ± 7.51	100 – 470
Dressing %		48	47.6 ± 0.31	44.3 1- 51.33
Reproduction parameter				
Age at first estrus (days)		64	273.32 ± 8.84	160-432
Duration of oestrous cycle (days)		64	20.05 ± 0.29	17-25
Duration of oestrous (hours)		64	28.51 ± 1.34	12-48
Gestation length (days)		50	150.94 ± 0.29	148-155
Age at first kidding (month)		50	452.04 ± 8.50	230-582
Age at weaning (month)		50	545.44± 8.54	415-664
Service period (month)		45	176.13 ± 5.90	107-318
Kidding interval (month)		45	315.89 ± 7.23	213-468
Seasonality	Summer (%)	50	68.00	
	Rainy (%)		26.00	
	Winter (%)		6.00	
Birth	Single (%)	49	63.26	1-2
	Twin (%)		36.74	
Litter size		49	1.37	

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very low, with lactation lengths ranging from 90-120 days. The milk production was reported to be higher in Bundelkhandi and Rohilkhandi goats (Bhusan *et al.* 2010; Singh *et al.* 2019) but lower in *Black Bengal* and *Palamu* goats (Kumari *et al.* 2015; Sharma *et al.* 2020) compare to the present study. The longer lactation length was reported in *Bundelkhandi* goats (Bhusan *et al.* 2010) but shorter in *Black Bengal* and *Palamu* goats (Sharma *et al.* 2020). The dressing percentage was comparable to the *Palamu* goats (Kumari *et al.* 2015; Sharma *et al.* 2020).

Reproductive traits: The different reproductive traits are presented in Table 3. Twin births were observed, with most goats having single births in their first parity and twins thereafter, indicating attainment of full reproductive capacity by the second parity. These goats have potential to be prolific; however, no specific strategies have been implemented yet. Twining was also reported in *Bundelkhandi*, *Palamu* and *Rohilkhandi* goats in different proportions (Singh *et al.* 2019; Sharma *et al.* 2020), whereas *Black Bengal* goats have instances of triplets and quadruplets in addition to twining (Kumari *et al.* 2015). These goats were seasonal breeders, primarily breeding from May to July, though seasonality varies by agro-climatic zone (Dixit *et al.* 2013; Singh *et al.* 2019; Alam *et al.* 2023). The onset of puberty appears to be delayed, possibly due to stress induced by nutritional deficiencies and parasitic infestations. *Palamu* goats attain puberty much earlier (Sharma *et al.* 2020).

In conclusion, the indigenous goats studied from Vindhyan region are small sized with distinctive phenotypic traits. This goat may be recognised as 'Sonebhadri goat'. These goats represent an important genetic resource possessing promising potential for meat production in their native tract. The present study highlights the inevitability for the genetic improvement programs to enhance productivity of this distinct goat thereby integrating them into regional breeding policies.

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