

Phenotypic, biometric and genetic characterization of Bundelkhandi goats

PRIYANKA MISHRA¹ AYESHA S ALI² and N K VERMA³

National Bureau of Animal Genetic Resources, Karnal Haryana 132 001 India

Received: 27 January 2012; Accepted: 10 April 2012

Key word: Bundelkhandi, Characterisation, Diversity, Heterozygosity, Microsatellite

Bundelkhandi goats form one of the lesser known populations which contribute to the 70% of total goat population of India. The name of these goats is derived from the region 'Bundelkhand' where they exist. The purest form of Bundelkhandi goats are found in Datia district of Madhya Pradesh and Jhansi district of Uttar Pradesh. Sporadic information is available on the phenotypic traits and performance of Bundelkhandi goats but no information is available on the genetic make up. Therefore, an attempt has been made to study the genetic variability in these goats.

A visit was made to the breeding tract of Bundelkhandi goats to record the data on the biometry. Measurements on different body traits like body length, height at withers, chest girth, paunch girth, face length, horn length, ear length, tail length and body weights were recorded from 34 representative goats of different flocks existing in villages Simardha, Hastinapur, Kanchanpur, of Jhansi taluk (Uttar Pradesh) and Kamrari, Dinara road of Datia taluk (Madhya Pradesh) and from 44 animals maintained at IGFR goat farm. Blood samples were collected from male and female young and adult goats for genetic characterization. Information on managerial practices and performance of these goats was also collected through interaction with the goat keepers. The DNA isolation, PCR and genotyping was carried out as described in our earlier publications (Verma *et al.* 2011, Dixit *et al.* 2010, 2011, and Priyanka *et al.* 2010). Genetic variation was analyzed using 25 microsatellite loci in terms of observed and effective numbers of alleles and observed and expected heterozygosity using POPGENE software (Yeh *et al.* 1999). F-statistics were estimated in accordance with the procedures described by Weir and Cockerhan using the F-stat 2.9.3 (Goudet *et al.* 2001). Bottleneck hypothesis was investigated using BOTTLENECK 1.2.01 (Cornuet and Luikart 1996).

Morphology: The Bundelkhandi goats are large-sized and black-coloured animals with long pendulous ears. The



Fig. 1. Bundelkhandi doe and buck

morphological features are, jet black coat colour, long legs, narrow face, roman type nose, long hair on body, black eyelids and muzzle, long curly and pendulous ears and bushy tail (Fig. 1). The animals are fully black, hardy, have long legs, narrow face and are able to survive in very low and high temperature in different seasons of Bundelkhand region.

Biometry: The average measurements recorded for different body traits on the animals reared in field and in organized flock are given in Tables 1 and 2. The average measurements (cm) of body length, height at withers, chest girth, paunch girth, face length, horn length, ear length, tail length and body weights (kg) in animals reared under extensive management are 78.50, 80.00, 75.50, 68.50, 19.00,

Table 1. Body measurements (cm) and body weights (kg) at different ages in goats under farm condition

Traits	Age groups			
	6–9 Months		Adults	
	Male	Female	Male	Female
Body height	60.00±0.78	55.88±0.93	77.00±1.65	71.63±0.60
Body length	62.44±0.84	56.75±0.84	78.10±1.73	71.93±0.72
Chest girth	57.44±1.28	53.25±0.80	77.40±1.87	72.11±0.83
Paunch girth	56.22±1.27	53.38±1.31	79.50±2.68	72.26±1.03
Face length	14.33±0.29	13.13±0.30	18.40±0.48	12.88±0.92
Horn length	7.67±1.53	3.38±0.32	14.80±0.79	12.67±0.82
Ear length	17.67±0.53	16.25±0.94	19.20±0.63	19.33±0.62
Tail length	14.33±0.33	13.00±0.38	17.20±0.33	15.67±0.31
Body weight	19.89±0.84	15.38±0.75	39.70±2.18	32.90±1.13

Present Address: ¹Ph.D Scholar (miraclepriya@gmail.com), ³Principal Scientist (nkverma.497@gmail.com). ²Associate Professor, Department of Biotechnology Saifia Science College, Bhopal (drayeshariqali@yahoo.com).

Table 2. Means with SE of different body measurement (cm) and body weights (kg) in different age group of Bundelkhandi goats under field conditions

Traits	Age groups			
	6-9 Months		Adults	
	Male	Female	Male	Female
Body height	67.00±0.00	58.25±0.48	78.50±4.50	73.17±0.78
Body length	69.00±0.00	56.00±0.58	80.00±5.00	72.61±1.02
Chest girth	64.50±0.50	53.75±0.85	75.50±5.50	72.43±0.99
Paunch girth	64.00±1.00	54.75±1.89	68.50±4.50	72.52±1.28
Face length	15.00±0.00	12.75±0.25	19.00±1.00	16.96±0.21
Horn length	Polled	4.50±1.06	14.50±0.50	9.63±0.41
Ear length	21.50±0.50	15.50±0.29	18.50±1.50	18.78±0.49
Tail length	15.50±0.50	12.75±0.48	16.00±0.00	15.52±0.27
Body weight	25.50±0.50	15.38±0.63	37.50±6.50	33.13±0.99

14.50, 18.50, 16.00, 37.50 respectively in male ; 73.17, 72.6, 72.43, 72.52, 16.96, 9.63, 18.78, 15.52, 33.13 respectively in female whereas the averages for the same parameters in organized flock were 77.00, 78.10, 77.40, 79.50, 18.40, 14.80, 19.20, 17.20, 39.70 respectively in male, and 71.63, 71.93, 72.11, 72.26, 12.88, 12.67, 19.33, 15.67; and 32.90 respectively in female. The overall average for these body traits in bundelkhandi goats managed under any system are 77.25, 78.42, 77.08, 77.67, 18.50, 14.75, 19.08, 15.60, 33.01 in male and 72.34, 72.24, 72.26, 72.38, 14.80, 11.53, 19.08, 15.60, 33.08 in female. The males reared at farm exhibited better growth than those of field but female goats reared under two different management systems do not show significant difference in their growth (Figs 2 and 3).

These goats are good for milk and meat. Under good feeding and management conditions the peak yield of milk reaches up to 2.8 liters in a day and lactation length reaches up to 220 days. Body weight of about 62 and 48 kg for adult male and female goats have been recorded by Bhushan *et al.* (2010).

Genetic variability: The values of different genetic parameters measuring the genetic variability are given in Table 3. The number of alleles observed across the studied

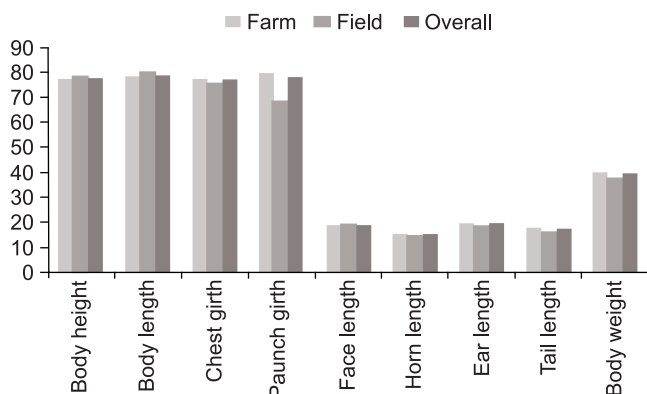


Fig. 2. Comparative biometry of farm and field reared males

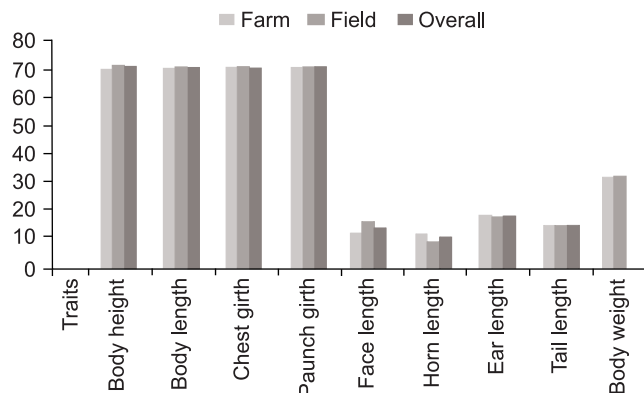


Fig. 3. Comparative biometry of farm and field reared females

microsatellite loci varied from 2 (ILSTS044) to 20 (OarFCB304) with an overall mean of 11.08 which is higher than the Kanniadu, Sangamneri and Osmanabadi goat breeds studied by Dixit *et al.* (2011), and less than the Sangamneri goat (9.08) studied by Verma *et al.* (2011). The polymorphism exhibited by the markers indicated their suitability for genetic diversity analysis. Microsatellites markers having PIC values higher than 0.5 are considered highly informative (Botstein *et al.* 1980). PIC value estimated in Bundelkhandi goats ranged from 0.54 (OarJMP29) to 0.91 (OarAE129, ILSTS059 and OMHC1) with an average 0.82 which clearly indicated the suitability of markers for Bundelkhandi goats. The average expected heterozygosity within the population ranged from 0.06 (ILSTS044) to 0.89 (ILSTS059 and OarHH64) with an average of 0.73, whereas observed heterozygosity ranged from 0.06 (ILSTS044) to 0.98 (RM088) with an average of 0.69. The average genetic variation (0.69) observed in the present study was lower than that of Black Bengal (Behl *et al.* 2003), Barbari goat (Ramamoorthi *et al.* 2009), but higher than those of many Indian breeds (Dixit *et al.* 2010, 2011), Asian and Australian breeds (Barker *et al.* 2001), Swiss goats (Saitbekova *et al.* 1999), Korean goats (Kim *et al.* 2002), Jamunapari (Gaur *et al.* 2006). Nei's heterozygosity ranged from 0.05 (ILSTS044) to 0.89 (ILSTS059) with an average of 0.72. About 64% of

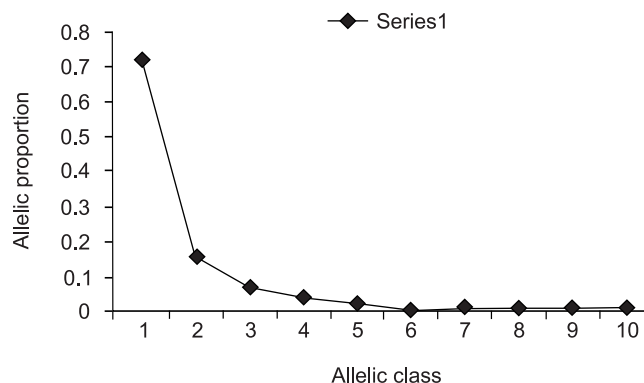


Fig. 4. L-shaped graph

Table 3. Genetic diversity measures and F-statistics

Locus	Na	Ne	Heterozygosity		Nei	Hd	PIC	Fis	Genetic diversity
			Ho	He					
ILSTS30	10.00	6.14	0.75	0.84	0.83	-0.10	0.89	0.84	0.11
ILSTS033	13.00	4.66	0.94	0.79	0.78	0.18	0.82	0.79	-0.18
ILSTS005	8.00	3.22	0.55	0.69	0.69	-0.20	0.79	0.69	0.19
ILSTS065	9.00	1.87	0.30	0.47	0.46	-0.36	0.68	0.47	0.35
ILSTS087	11.00	6.68	0.81	0.85	0.85	-0.04	0.89	0.86	0.05
OaeAE129	11.00	6.40	0.57	0.85	0.84	-0.32	0.91	0.85	0.33
ETH225	12.00	5.73	0.77	0.83	0.82	-0.07	0.87	0.83	0.07
ILSTS58	17.00	7.80	0.94	0.88	0.87	0.06	0.88	0.88	-0.06
ILSTS059	19.00	9.10	0.80	0.89	0.89	-0.10	0.91	0.90	0.11
OARHH64	12.00	8.40	0.57	0.89	0.88	-0.31	0.92	0.89	0.36
ILSTS008	9.00	5.00	0.90	0.80	0.80	0.12	0.85	0.80	-0.11
ILSTS019	9.00	4.68	0.76	0.79	0.78	-0.03	0.86	0.79	0.04
ILSTS34	14.00	4.14	0.82	0.76	0.75	0.07	0.88	0.76	-0.07
ILSTS082	14.00	5.97	0.76	0.84	0.83	-0.09	0.90	0.84	0.09
RM4	7.00	3.68	0.66	0.73	0.72	-0.09	0.82	0.73	0.10
OarFCB304	20.00	5.92	0.82	0.83	0.83	-0.84	0.90	0.84	0.02
OarFCB48	11.00	4.81	0.84	0.80	0.79	0.05	0.84	0.80	-0.05
OarJMP29	9.00	1.31	0.12	0.24	0.24	-0.50	0.54	0.24	0.50
ILSTS029	10.00	2.24	0.52	0.55	0.55	-0.05	0.73	0.56	0.07
ILSTS044	2.00	1.06	0.06	0.06	0.05	0.00	0.41	0.06	-0.02
ILSTS049	7.00	4.47	0.80	0.78	0.77	0.02	0.84	0.78	-0.02
ILSTS002	80.00	5.07	0.82	0.81	0.80	0.01	0.85	0.81	-0.01
RM088	13.00	4.92	0.98	0.80	0.79	0.22	0.83	0.80	-0.22
OMHC1	13.00	8.16	0.92	0.88	0.87	0.04	0.91	0.88	-0.03
ILSTS022	9.00	2.58	0.58	0.61	0.61	-0.04	0.75	0.62	0.06
Mean	11.08	4.96	0.69	0.73	0.72	-0.05	0.82	0.73	0.06

the loci showed higher expected heterozygosity than the observed values. As shown in Table 3, the heterozygotic deficiency (Hd) estimated using the formula $(H_o - H_e)/H_e$, exhibited a wide range of values from -0.84 (OarFCB304) to 0.22 (RM088). This indicated the positive deviations from Hardy Weinberg equilibrium. The gene diversity across the studied loci for Bundelkhandi goat population varied from 0.24 (OarJMP29) to 0.90 (ILSTS059) with an overall mean of 0.7. In the present study, F is varied from 0.06 (ILSTS044) to 0.90 (ILSTS059) with average 0.73 which indicated good amount of homozygosity in the population resulting from inbreeding.

The L-shaped mode-shift curve drawn for Bundelkhandi population (Fig. 4) indicates that this population has not undergone any recent bottleneck. In case of existence of bottleneck event the rare alleles are lost more often due to their low frequency than the commonly occurring alleles and consequently there is a reduction in population size. Allele loss does not occur at the extreme of allele size distribution so the range in allele size remains constant.

From the neighbor-joining tree (Fig. 5) it is obvious that individuals selected for genotyping were genetically unrelated and thus shows the random distribution of alleles in the selected population.

The result of this study suggests that there is substantial

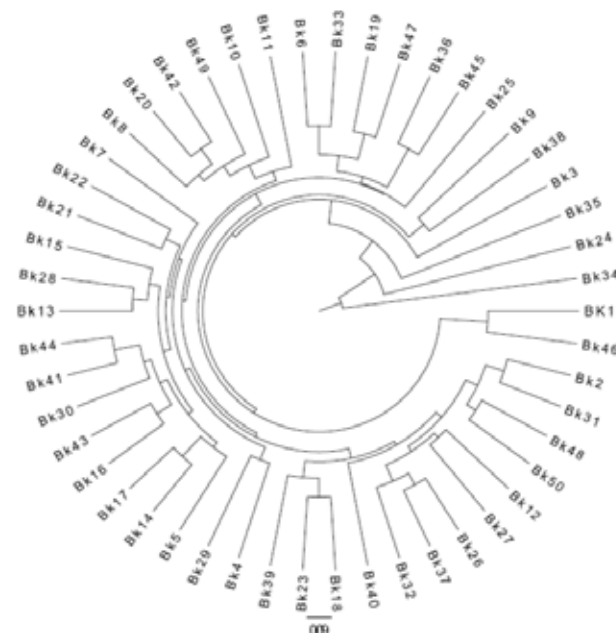


Fig. 5. Genetic relationship among sampled individuals

genetic variation and polymorphism across the studied loci in Bundelkhandi goats. The bottleneck analysis supported for the non-existence of any bottleneck in Bundelkhandi goat

in recent past. An appropriate strategies is required for their improvement so that the goat keepers can be benefited more by enhancing their livelihood. The study suggests scope for its further genetic improvement and to undertake appropriate breeding strategies to avoid inbreeding in the population.

SUMMARY

Bundelkhandi goats are found in Bundelkhand region of Madhya Pradesh and Uttar Pradesh. The morphological features are jet black coat color, long legs, narrow face, roman type nose, long hair on body, black eyelids and muzzle, long curly and pendulous ears and bushy tail. The overall average recorded for body length, height at withers, chest girth, paunch girth, face length, horn length, ear length, tail length and body weights in bundelkhandi goats managed under any system were recorded. The males reared at farm exhibited better growth than those of field but female goats reared under two different management systems do not show significant difference in their growth. Genetic diversity was analysed in randomly selected unrelated 50 goats using FAO recommended 25 microsatellite markers. The observed number of allele ranged from 2 to 20 with an overall mean of 11.08 and the effective average number of allele was 4.96. The PIC value ranged between 0.41 to 0.92 and the highest value of the observed heterozygosity was 0.94 and the lowest was 0.06 and the expected heterozygosity was 0.73 to 0.89 respectively. The bottleneck analysis revealed the absence of any bottleneck in Bundelkhandi goat in recent past.

ACKNOWLEDGEMENTS

We are thankful to the Director, NBAGR for providing facilities to carryout this work. Our sincere thanks are due to the incharge farm IGFR, Jhansi for his help and cooperation, in recording the data on farm goats. The cooperation of goat keepers during our field visit is duly acknowledged.

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