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Malabari goats: Characterization, management, performance and genetic variability

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ABSTRACT

Malabari goats inhabit the Calicut, Kannur, Waynad and Malappuram districts of Kerala, India. They are medium to small size animals having varied coat colour ranging from white to admixtures and black. These goats are reared mainly for meat. Phenotypic and genetic characterization of Malabari goats was carried out by using the information collected from breeding tract of these goats. The measurements on body traits of 323 animals from about 65 flocks were recorded. Information on performance traits, managemental practices were collected by interviewing the goat keepers individually. Blood samples collected at random from unrelated 48 animals from breeding tract were utilised for genetic characterization. The average height at wither, body length, heart girth, paunch girth, face length, measured 41.87, 39.20, 38.93, 38.13, 10.27 cm, respectively, at the weaning age (3 months) whereas in adult animals it measured 68.41, 70.30, 73.17, 75.04, 17.28 respectively. The body weights at 3, 6, 9 and 12 months of age were 5.73, 9.20, 13.27, 20.54 kg, respectively, and that of adult goats were 30.68 and 41.20 in female and male respectively. The animals are kept under semi intensive management. Malabari goats show early maturity and conceive at an age of 8 to 10 months. The male starts breeding at an age of 9–12 months. The breed is having a good prolificacy i.e. 50% twinning, 25% triplets and 5% quadruplets. The milk yield varies from 0.5 to 1.5 litre/day. The microsatellite based genetic analysis indicated the number of alleles varying from 4 to 26 with an overall mean of 0.36. The average observed heterozygosity varied from 0.033 to 0.979 whereas expected heterozygosity ranged from 0.152 to 0.925 with mean of 0.689. The gene diversity varied from 0.153 to 0.927 and allelic richness varied from 3.61 to 20.96. The values of the F_{IS} ranged from 0.028 (ILSTS002) to 0.0.924 (ETH 225). The heterozygotic deficiency observed might be due to the inbreeding caused due to indiscriminate and unplanned mating among the animals and lack of sufficient number of good breeding bucks.

Key words: Characterization, Heterozygosity, Malabari goats, Management, Microsatellites, Performance

The Malabari breed of goat (Accession # INDIA_Goat_0009_Malabari_06014) is famous for its low fat meat and high prolificacy (Bablu 2005, ICAR 2008). Animals are well adapted to the hot and humid conditions of Kerala state. These goats inhabit Calicut, Kannur, Waynad and Malapuram districts of Kerala state of India. The breeding tract lies at the longitude ranging from 11.15' to 11.52' N and latitude 75.25' to 75.49 E. The climate is hot and humid where average monthly temperature ranges from 23.7 to 30.7°C. The humidity ranges from 75 to 80%. Malabari goats are reared mainly for meat. Malabari bucks have been used for upgrading the non-descript goats of its area. The study was undertaken to characterize the breed for its phenotypic traits as well as to know the genetic variation using microsatellite based genotyping. An attempt has also been made to know the managemental practices followed by the farmers to rear these animals.

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MATERIALS AND METHODS

Visits were made to the different villages (16) of Calicut (Kozhikode), Kannur, Waynad and Malapuram districts comprising the breeding tract of Malabari goats. The villages were selected in consultation with the Department of Animal Husbandry on the basis of goat population existing there and flocks were selected at random. The body measurements on 323 animals were recorded from 65 flocks and information on performance traits and managemental practices were collected through interviews/personal interaction with the goat keepers. Blood samples collected at random from unrelated 48 animals from breeding tract were subjected to genomic DNA isolation using the standard phenol/chloroform protocol of Sambrook *et al*. (1989). Twenty-five microsatellite markers used earlier for genetic diversity of Sirohi goats (Verma *et al.* 2007) were used for genetic characterization of this breed. Polymerase chain reaction (PCR) was carried out using the "touchdown" PCR protocol as described by Verma *et al.* (2007). PCR products (6 ml)

were loaded on to a 2% agarose gel and electrophoresed. The gel was visualized over UV light after ethidium bromide staining to detect the amplification. After ensuring the amplification, the PCR products were run on automated DNA sequencer.

Data analysis: Average means for body length, height at withers, chest girth, paunch girth, face length, ear length, horn length and tail length were estimated using SPSS 11.5 for Windows. The genetic data were analysed using POPGENE (Yeh *et al*. 1999) to calculate the allele frequencies, observed and effective number of alleles (Kimura and Crow 1964), observed and expected heterozygosity (Levene 1949, Nei 1973). Poly information content (PIC) values were estimated as per Botstein *et al.* (1980). Allelic richness was calculated with FSTAT (Goudet 1995). The bottleneck hypothesis was investigated using BOTTLENECK 1.2.02 and mode shift (Cornuet and Luikart 1996) to detect any recent reduction in the effective population size of Malabari goats. In the first approach, based on the heterozygosity excess, three different tests namely, 'Sign test', 'Standardized differential test' and 'Wilcoxon sign rank test' were used under different models of microsatellite evolution like the infinite allele model (Ohta and Kimura 1973), stepwise mutation model (Kimura and Crow 1964) and two–phase model (Di Rienzo *et al.* 1994).

RESULTS AND DISCUSSION

Phenotypic characterization: The Malabari goats also known as Tellicherry goats are small to medium size animals (Fig.1). They are generally maintained for meat purpose. The coat colour of these goats varies from complete white, admixtures of white and brown, black and brown to complete black. About 40% of the goats have long hair; 20% of animals (male and females) have beard. The horns are slightly twisted, directed upward and backward sometimes curved downward touching the skin. The muzzle is pinkish red. Eye lids are pinkish white. The nose is straight. The ears are directed outwards and downwards reaching up to the nose. The tips of the ear in some animals were curved and in some animals almost folded (Fig. 2). The reason of folding of ear tip is not clear. The tail is small and thin. Udder is small and round with medium size teats.

Fig. 1. Malabari doe.

Fig. 2. Folded ears of Malabari goat.

Table 1. Average body measurements (cm) and body weights (kg) of Malabari goats

Age (months)	Sex	Traits									
		N	HW	BL	HG	PG	FL	HN	EL	TL	WT (kg)
3	F	17	44.71±1.10	44.65±1.29	44.47±1.42	44.29±1.70	11.47±0.35	1.06±0.34	14.00±0.49	11.53±0.30	9.12±0.89
	M	31	45.19±0.78	44.23±1.02	44.58±1.09	45.16±1.26	11.35±0.20	1.35±0.28	13.94±0.33	11.26±0.27	8.68±0.79
	Overall	48	45.02±0.63	44.38±0.69	44.54±0.86	44.85±1.00	11.40±0.18	1.25±0.22	13.96±0.27	11.35±0.21	8.83±0.83
6	F	16	49.13±1.08	50.69±1.02	51.31±1.05	53.25±1.30	12.56±0.34	1.94±0.34	14.63±0.38	12.88±0.26	12.63±0.61
	M	24	52.33±0.72	52.63±0.92	52.00±0.94	52.50±1.08	13.21±0.31	3.54±0.45	15.79±0.31	12.75±0.25	14.54±0.77
	Overall	40	51.05±0.65	51.85±0.70	51.73±0.70	52.80±0.82	12.95±0.23	2.90±0.33	15.33±0.25	12.80±0.18	13.78±0.83
12	F	99	60.32±0.43	62.68±0.51	64.48±0.52	67.36±0.72	15.44±0.11	6.79±0.47	16.85±0.17	14.18±0.14	23.86±0.46
	M	27	60.78±1.23	61.15±1.13	60.41±1.17	63.07±1.70	15.00±0.32	7.04±0.87	16.85±±0.38	14.67±0.35	21.93±1.07
	Overall	126	60.42±0.43	62.35±0.47	63.61±0.50	66.44±0.69	15.35±0.11	6.84±0.41	16.85±0.15	14.29±0.13	23.44±1.18
Adult	F	85	64.46±0.44	68.38±0.47	73.00±0.54	79.27±0.75	16.73±0.12	11.56±0.71	18.18±0.19	15.32±0.20	34.25±0.85
	M	24	76.29±1.03	77.29±1.22	79.17±1.60	77.75±1.61	18.58±0.34	12.83±1.79	19.38±0.49	18.50±0.39	43.63±2.51
	Overall	109	67.06±0.63	70.34±0.58	74.36±0.60	78.94±0.69	17.14±0.14	11.84±0.68	18.44±0.15	16.02±0.22	36.31±2.37

Biometry: The body measurements of different traits and body weights of female and male animals at different age groups are given in Table 1. The average height at wither (HW), body length (BL), heart girth (HG), paunch girth (PG), face length (FL), horn length (HN), ear length (EL) and tail length (TL) are given in Table 1. Animals with better biometry were seen in Kannur, and Malappuram districts. Male animals exhibited most of the body measurements better than their female counterparts.

Body weights: The body weights of females and males at 3, 6, 12 months of age and of adult goats are given in Table 1. The average weights of different age group animals were 8.83 (3 month), 13.78 (6 month), 23.44 (12 month) and 36.31 kg (>18 month) respectively. Because of smaller size the body weights of kids are not very different however, the average body weight of adult female and male goats were significantly different. Birth weight is affected significantly by age of dam, season of birth, sex and litter size. Kumar *et al.* (2008) reported a significant effect of season on the birth weight of Malabari kids. Kids born in rainy season were heavier than those born in other seasons. Male kids are usually heavier than the female and single birth is having more birth weight than multiple births (Neeru *et al*. 2004).

Management: The animals are kept on semi-intensive management with 4–6 h grazing and on stall feeding in the evening. In some cases the goats are kept on stall feeding and not sent for pasture grazing. The flock size ranges from 2 to 60 animals consisting of kids and adults of both sexes. The average flock size was 4.9. About 54% of the flocks maintained the breeding bucks. Leaving the organized farms where breeding bucks were prepared specifically for distribution to the farmers, 1 to 3 breeding bucks per flock were observed under field conditions. Sex ratio (male: female) in the flocks varied from 1:2 to 1:19.

Animals are fed with local green grass, jackfruit leaves, coconut leaves, banana leaves, palm leaves, Coimbtore–3 (CO3) grass etc. Milking goats and the pregnant animals are given extra ration in the form of rice soup (local name *kanzi*) and mineral mixture.

The goat houses are made of bamboos and planks at the height of about 2–4 ft from ground so that urine and feaces drops through the floor on the ground. This helps in proper cleaning of house. Separate compartments are made to keep the different category of animals. No proper electricity supply is provided in these houses. Because of its design and material of construction the houses are well ventilated. Feeding mangers are provided on the outer side of the walls of house.

Performance: Malabari goats show early maturity and conceive at an age of 8 to10 months. When goats are kept together the heat symptoms are exhibited by most of the goats together in the flock. The male starts breeding at an age of 9–12 months. The average age at first kidding has been reported as 365.22days (CIRG 2005–06) whereas inter kidding interval is 258 days. The breed is having a good prolificacy i.e. 50% twinning, 25% triplets and 5% quadruplets. Multiple birth percentage has been reported more than 60% at AICRP centers for Malabari goats. There is no specific breeding and kidding season in Malabari goats. The milk yield varies from 0.5 to 1.5 liters/day. The milk is mostly used for feeding the kids. The kids are weaned at the age of 3 months. The milk is sold @ Rs10–15/liter. For medicinal purposes the milk is purchased by the company at still higher price. One year males are sold @ Rs 100/kg live body weight whereas female kids with more than 10 kg of body weight are sold @ Rs 200/kg live body weight. Adult goats are sold at a price ranging from Rs 6000 to 7000 depending upon the litter size of the goat.

Breeding: Crossbreeding Malabari goats with South African boers led to the decline of pure Malabari goats initially (Bablu 2002) but with the timely realization the use of boers on Malabari goats was stopped and this type of crossbreeding was restricted to local nondescript goats only. Malabari bucks have been provided to the farmers under AICRP hence pure breeding is practiced. Since the breed is of non-migratory nature hence chances of crossbreeding are minimized. For upgrading the milk potential of Malabari goats Jamunapari bucks have also been used. The breeding efficiency on the basis of does tupped has been reported as 144.90 with a kidding rate of 1.43 (CIRG 2005–06). Due to the shortage of good Malabari bucks AI was used to maintain the purity of the breed and success rate was over 40% (Ramavarman, The Hindu, dated 16.11.07). A pilot project of AI among Malabari goats was launched in Palakkad district in 2006 and extended to other areas of the state. Kerala is probably the first state to launch AI among goats at such a wide scale. Some NGOs are also active in propagating this breed with the objective of conserving and popularizing goat rearing as an income generating activity. Government goat farm, Attapaddy; District livestock farm, Kudappanakkunnu, Thiruvananthpuram; Jersey farm, Vithura, Thiruvananthpuram; Buffalo breeding farm, Kuriottumala, Kollam and State Government farms at Kommeri in Kerala

Fig. 3. Malabari breeding buck.

state promoted the goat farming by maintaining the separate units of goats. Under the scheme "Kudumb Sree" a group of ladies make a cooperative and rear the goats. Financial assistance is provided by the government for purchasing and rearing the animals. The veterinary officer of the area helps these self employed groups in getting the funds and rearing the animals.

Population status: As per the 17th quiquennial livestock census conducted in 2003 the population of goats in Kerala state was 12.22 lakh. According to rough estimate, nearly 10% of the goat population of the state belonged to Malabari variety (Ramavarman 2007). Attapaddy goats another breed studied recently (ICAR–NBAGR Network project report 2003, Aggarwal *et al*. 2006) are nearing 10 000 only.

Genetic variability: Various measures of genetic variation in terms of allele number, poly information contents, Nei's values and heterozygosity are presented in the Table 2. The F–statistics estimates, Genetic diversity and Allelic richness are presented in Table 3. The number of alleles observed across the studied microsatellite loci varied from 4 (ILSTS008, OarJMP29 and ILSTS065) to 26 (ILSTS058) with an overall mean of 10.36. The effective number of alleles was less than the observed number and varied from 1.18 (OarJMP29) to 13.33 (OarFCB304). The total number of alleles observed and the minimum number of alleles at a locus demonstrated that all microsatellite loci were sufficiently polymorphic and markers used were appropriate since the number of alleles resolved for each marker was either equal or more than the required number of alleles (at least 4 alleles) recommended for microsatellite markers to be used in the estimation of genetic distance (Barker 1994). The PIC values varied from 0.147 (OarJMP29) to 0.891 (ILSTS058) with a mean of 0.658 indicating high polymorphism across the loci. The average observed heterozygosity varied from 0.033 (ETH224) to 0.979 (ILSTS082) whereas expected heterozygosity ranged from 0.152 (OarJMP29) to 0.925 (OarFCB304) with mean of 0.689 (Table 2).

The gene diversity across the studied loci for Malabari breed of goat varied from 0.153 (OarJMP29) to 0.927 (OarFCB304). The allelic richness across the studied loci varied from 3.61 (ILST008) to 20.96 (OarFCB304). This reflected the sufficient number of the alleles per locus in the population independent of the sample size and thus can be used for comparing the different populations. The positive values of the F_{IS} ranged from 0.028 (ILSTS002) to 0.924 (ETH 225). Higher genetic diversity observed in this study might be due to the large effective number of alleles. The

Table 2. Number of alleles, PIC and Heterozygosities at diiferent microsatellite loci.

Locus	Sample size	Observed number of alleles	Effective number of alleles	Poly information contents	Heterozygosity		
					Observed	Expected	Nei
ILST008	46	4	1.43	0.275	0.239	0.303	0.729
ILSTS059	44	11	5.32	0.779	0.682	0.812	0.364
ETH224	30	7	1.76	0.411	0.033	0.432	0.624
ILST043	46	7	2.16	0.492	0.391	0.536	0.550
ILSTS002	48	8	6.10	0.804	0.813	0.836	0.350
OarFCB304	46	25	13.33	0.910	0.783	0.925	0.295
OarFCB48	46	10	4.50	0.736	0.717	0.778	0.387
OarHH64	43	13	7.81	0.848	0.674	0.872	0.327
OarJMP29	44	4	1.18	0.147	0.114	0.152	0.856
ILSTS005	47	6	1.83	0.420	0.277	0.454	0.608
ILSTS019	45	10	5.10	0.768	0.688	0.804	0.369
OMHC1	46	16	10.20	0.884	0.809	0.902	0.309
ILSTS087	47	10	5.78	0.796	0.333	0.827	0.355
ILSTS30	45	9	4.50	0.744	0.543	0.778	0.385
ILSTS34	46	8	3.72	0.682	0.468	0.731	0.418
ILSTS033	47	15	4.83	0.762	0.652	0.793	0.375
ILSTS049	46	8	3.18	0.636	0.391	0.686	0.447
ILSTS065	46	4	1.59	0.344	0.375	0.373	0.671
ILSTS058	48	26	10.99	0.891	0.674	0.909	0.305
ILSTS029	41	14	2.94	0.638	0.439	0.660	0.458
RM088	48	11	3.56	0.716	0.875	0.719	0.402
ILSTS022	47	5	1.74	0.363	0.043	0.426	0.638
OARE129	48	15	7.46	0.843	0.792	0.866	0.330
ILSTS082	48	15	7.35	0.841	0.979	0.864	0.331
RM4	46	8	4.35	0.726	0.391	0.770	0.392
Mean	–	10.36	3.22	0.6582	–	0.6895	–

Table 3. Genetic diversity, allelic richness and F statistics of Malabari goats

Locus	Sample Size	Gene diversity	Allelic richness	F_{is}	P–value	Proportion of alleles showing smaller F_{is} than the observed
ILST008	46	0.303	3.61	0.212	0.054	0.982
ILSTS059	44	0.813	10.50	0.162	0.020	0.998
ETH225	30	0.439	7.00	0.924	0.002	1.000
ILST044	46	0.537	6.37	0.272	0.008	1.000
ILSTS002	48	0.836	7.62	0.028	0.444	0.724
OarFCB304	46	0.927	20.96	0.156	0.002	1.000
OarFCB48	46	0.778	8.48	0.078	0.196	0.878
OarHH64	43	0.875	12.08	0.229	0.002	1.000
OarJMP29	44	0.153	3.77	0.256	0.064	0.986
ILSTS005	47	0.456	5.49	0.394	0.002	1.000
ILSTS019	45	0.806	8.39	0.147	0.032	0.992
OMHC1	46	0.903	14.39	0.105	0.032	1.990
ILSTS087	47	0.833	9.51	0.600	0.002	1.000
ILSTS30	45	0.781	8.74	0.304	0.002	1.000
ILSTS34	46	0.734	7.50	0.363	0.002	1.000
ILSTS033	47	0.795	12.84	0.180	0.006	1.000
ILSTS049	46	0.689	7.07	0.432	0.002	1.000
ILSTS065	46	0.373	3.86	–0.005	0.592	0.634
ILSTS058	48	0.911	20.79	0.260	0.002	1.000
ILSTS029	41	0.663	12.66	0.337	0.002	1.000
RM048	48	0.748	9.63	–0.170	0.998	0.012
ILSTS022	47	0.430	4.15	0.901	0.002	1.000
OARE129	48	0.867	13.02	0.087	0.090	0.962
ILSTS082	48	0.863	13.02	–0.135	1.000	0.008
RM4	46	0.774	7.18	0.495	0.002	1.000
	Mean				0.238	0.002

observed heterozygosity was lower than the expected heterozygosity for all the loci. The heterozygotic deficiency at these loci may be due to population subdivision owing to genetic drift, selection against heterozygotes or inbreeding. However, differentiation among these factors is difficult (Christiansen *et al.* 1974) but a reason observed here is that inbreeding which presumably resulted from the unplanned and indiscriminate mating prevailing in the breeding tract, led to the small effective population size. Due to the non–availability of sufficient number of breeding bucks same few bucks are used for the whole village and also in the nearby villages.

The mode shift analysis generated a L–shaped distribution curve (Fig. 4) indicating that the population has not undergone any bottle neck in the recent past. The shift mode test can detect the recent bottleneck up to 40 – 80 generations while the quantitative test of Cornuet and Luikart (1996) can detect bottleneck up to 250 generations. In case of existence of any bottleneck event the rare alleles are lost more often than the commonly occurring alleles and consequently there is a reduction in the population size. Allele loss does not occur at the extremes of allele size distribution so the range in allele size remains unaffected. With the assumption that all loci fit the 3 different mutation models the values obtained for expected number of alleles and probabilities support the absence of any bottleneck in the population.

Fig. 4. L-Shaped curve showing absence of bottleneck.

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