Sheep Genetic Resources of India

MANDYA

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Mandya sheep are small in size and are found in Southern parts of Karnataka state. 'Bandur' strain of this breed is known for its meaty conformation and excellent meat quality. Maintenance of elite rams and ewes to produce breeding stock for sale at premium price is the unique aspect of sheep husbandry in Bandur strain.

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Introduction

Karnataka is one of the states in India where sheep is an important livestock species and contributes substantially to the income of the farmers, particularly the landless labourers and the marginal farmers. Of the four recognized sheep breeds of Karnataka, Mandya is found in the southern parts of the state. 'Bannnur' and 'Bandur' are the synonyms for this breed. Generally, Bandur is used to refer a specific strain of Mandya breed, which is known for its meaty conformation and meat quality. The animals of this strain are found in a limited area in Malvalli taluka of Mandya district. The animals of Mandya breed are primarily maintained for mutton. Maintenance of elite rams and ewes to produce breeding stock for sale at premium price is the unique aspect of sheep husbandry in the Bandur strain.

Distribution, number and agro-climatic conditions

Mandya sheep prevails in Mandya district and bordering area of Mysore and Bangalore rural districts of Karnataka state. The total number of sheep in the Mandya distribution area was 0.34 million as per 2003 livestock census. There were small fluctuations in the sheep population of Mandya district from 1961 to 1977. As per 1982, 1997 and 2003 census figures, the sheep population of Mandya district registered decline in number as compared to previous census which was contrary to the trend at national level.

Most of the sheep flocks were in pure form. The Bandur strain has its distribution limited to the Malvalli taluka of Mandya district. The flocks are generally small. Average flock size was 16 comprising 1 adult male, 11 adult females and 4 young ones. Some of the farmers were observed to keep only one or two sheep.

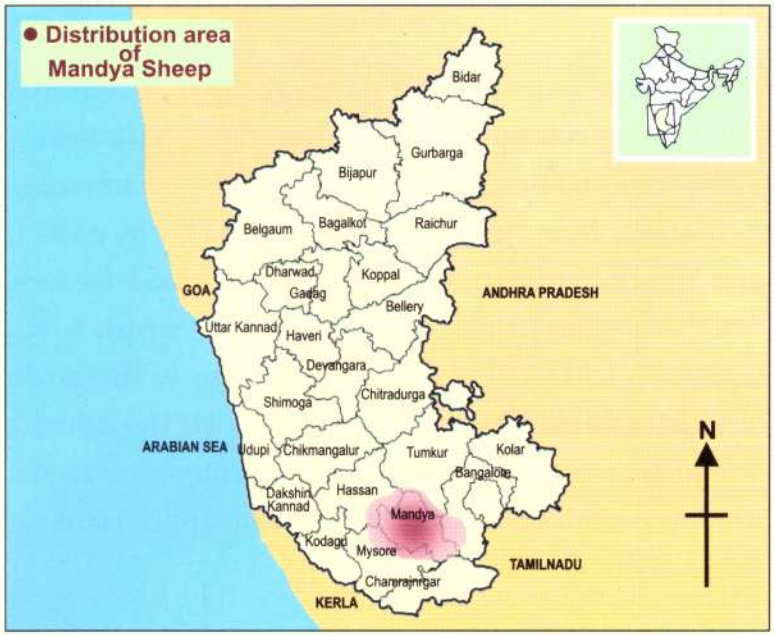

Fig 1: Distribution area of Mandya sheep

Table 1: Sheep Population (number in millions)

Year	India	Karnataka state	Mandya
1961	40.200	4.765	0.421
1966	42.015	4.748	0.396
1972	39.993	4.662	0.372
1977	40.907	4.536	0.372
1982	48.765	4.792	0.333
1987	45.703	4.727	0.341
1992	50.783	5.431	0.393
1997	56.361	8.003	0.363
2003	61.789	7.256	0.340

The climate of Karnataka is tropical with monsoon type rainfall. The maximum temperature may reach 42 °C during summer and minimum 12-13 °C during winter. The breeding tract of Mandya sheep is covered under Southern Dry Zone of Karnataka State where occurrence of drought is frequent. The average annual rainfall ranged from 671 to 887 mm.

Socio-economic conditions of the farmers and management practices

Most of the sheep farmers were of low-income group. The average family size was 8 with marginally higher number of males than females. The literacy rate was about 33%. Female members play an important role in animal management including grazing of flocks independently in the fields. The sheep are taken out for grazing at about 10 o'clock in the morning and brought back at sunset. The sheep are grazed on the roadsides, barren land and in the harvested fields. The flocks cover a distance of about 5-6 km in a day for grazing. Most of the flocks are stationary. The flocks are supplemented with horse gram husk, jowar, wheat, ragi, peepal leaves, neem leaves, acacia etc. during the lean period only. Stall feeding of small flocks is a routine.

Fig 2 : A Bandur flock graged by females

The animals are housed at night. In daytime the small flocks, when not sent for grazing or after return from grazing, are kept and fed near the house in shadow or in an enclosure made for housing of sheep. Generally, the house is either a closed type or a fenced enclosure with a shed in it. The sheep house is either a part of the owner's dwelling or adjacent to it. The elite Bandur animals are kept under a close watch.

Fig 3: A Bandur flock

The farmers vaccinate their sheep against entrotoxaemia. The average mortality rate was about 5 per cent. Post mortem findings of 778 Nellore, 633 Nellore synthetic, 771 Mandya and 690 Mandya synthetic sheep revealed pneumonia (34.85%) and enteritis (27.26%) as most important causes of death under farm management conditions, but there were no breed differences; the mortality was highest in spring (41.47%) and in adult sheep (66.83%) as compared with lambs below one year of age (Prasad *et al.*, 1992). Analysis of data of bluetongue outbreaks revealed that most outbreaks occurred during the south-west monsoon period (June-September), the animals aged 6-12 months were the most susceptible and morbidity incidence of 6.6% in Mandya breed was comparable to 5.9% in Nellore but was much lower as compared to 23.5% in Dorset and its crosses (Sreenivasulu and Rao, 1999).

Breed characteristics

The animals are small in size. Coat color is white with light brown face usually extending upto neck; some of the animals may be completely white. Almost all the animals have wattles. Neck is stout and strong. Bandur animals have compact and low set body, small legs and appear typical

reverse -U shaped from the rear. Animals of this strain have typical meaty conformation and are valued for meat quality with intra-muscular fat giving a marbling effect to the mutton. The ears are medium long and drooping but alert. Average ear length was 13.0±0.08 cm.

Fig 4: A Bandur ram

Fig 5: A Bandure ewe

Nose line is slightly roman. Both the sexes are polled. Males may rarely have scurs or rudimentary/ small horns. Tail is short and thin with an average length of 10.0 ± 0.05 cm. Fleece is extremely coarse, open and hairy. Face belly and legs are devoid of wool.

Table 2: Body biometry and weight of Mandya sheep

Body characteristic	Adult male		Adult female	
	Average ± SE	Range	Average ± SE	Range
Body weight (kg)	36.8 ± 1.08 (56)	9.0 - 60.0	26.7 ± 0.21 (447)	11.0 - 38.0
Body length (cm)	68.3 ± 0.51 (54)	57.0 - 76.0	60.6 ± 0.17 (483)	51.0 - 72.0
Height at wither (cm)	62.3 ± 0.60 (54)	52.0 - 72.0	54.6 ± 0.20 (483)	44.0 - 72.0
Chest girth (cm)	79.2 ± 0.73 (54)	65.0 - 89.0	69.6 ± 0.23 (483)	47.0 - 85.0
Chest breadth (cm)	24.3 ± 1.36 (54)	18.0 - 95.0	19.1 ± 0.10 (483)	14.0 - 30.0

Genetic structure and diversity

Karyotype analysis of 2 male and 4 female Mandya sheep revealed the diploid chromosome number as 54. Three pairs of autosomes were submetacentrics and 23 pairs acrocentrics, X-chromosome was the largest acrocentric and Y-chromosome a small metacentric (Umrikar and Narayankhedkar, 1997)

The genetic characterization of Mandya sheep was undertaken by using microsatellite markers. Amongst various genetic markers, microsatellite marker system is preferred for evaluation of biodiversity owing to their abundance in mammalian genome, high polymorphism and amenability for automation.

Fifty blood samples were taken randomly from genetically unrelated animals of Mandya sheep from its breeding tract. Genomic DNA was isolated and purified using the standard phenol chloroform extraction protocol. Nineteen ovine specific microsatellite markers (Table 3) selected from the list proposed by International Society of Animal Genetics (ISAG) were amplified using PCR touchdown programme as suggested under MoDAD project (FAO.1996). The PCR products were resolved on a 6% denaturing polyacrylamide gel. The resolved bands of DNA (alleles) were visualized by silver staining (Bassam *et al.*, 1991). The genotypes were scored manually and allele size was calculated using INCHWORM programme. Genotype of each individual animal was recorded for each of the loci under consideration from the silver stained gels. Allelic frequencies were used to calculate polymorphic information content (PIC) values following Botstein *et al.* (1980). The bottleneck hypothesis was investigated using BOTTLENECK programme (Cornuit and Luikart, 1996).

Table 3: Allele frequency at various loci in Mandya sheep

Locus /Allele	A	B	C	D	E	F	G	H	I
BM827	0.0116	0.4070	0.4186	0.1395	0.0233				
BM6526	0.2609	0.1739	0.0326	0.0870	0.4457				
BM8125	0.0217	0.8478	0.0217	0.1087					
HUJ616	0.0222	0.0222	0.1000	0.0556	0.6667	0.1333			
ILSTS002	0.0789	0.0395	0.5132	0.1184	0.1842	0.0526	0.0132		
ILST005	0.0326	0.0435	0.3261	0.2609	0.1522	0.1739	0.0109		
OarAE129	0.0513	0.8077	0.1410						
OarCP32	0.3256	0.4767	0.1977						
OarFCB48	0.4022	0.0326	0.1848	0.0652	0.2391	0.0543	0.0217		
OarFCB128	0.0233	0.0465	0.2558	0.4651	0.2093				
OarHH35	0.0125	0.1750	0.1625	0.2250	0.3875	0.0375			
OarHH41	0.0326	0.1957	0.5000	0.0543	0.2174				
OarHH47	0.0250	0.1500	0.1250	0.2625	0.0625	0.0750	0.1000	0.0625	0.1375
OarHH64	0.7826	0.0326	0.1196	0.0652					
OarJMP8	0.2174	0.1196	0.4348	0.1196	0.0761	0.0326			
OarJMP29	0.0109	0.0652	0.4565	0.1848	0.0217	0.2283	0.0326		
OarVH72	0.0789	0.1447	0.3947	0.2500	0.0263	0.1053			
OMHC1	0.0111	0.1000	0.2000	0.1556	0.1222	0.0778	0.0444	0.2889	
RM4	0.0375	0.1000	0.1750	0.3750	0.2750	0.0375			

Various measures of within breed genetic variability viz. allele frequencies, observed number of alleles, effective number of alleles, observed heterozygosity, expected heterozygosity and within breed heterozygosity deficit were estimated using POPGENE 1.31 (Yeh *et al.*, 1999) to assess the variability at DNA level. All the loci were effective in detecting polymorphism in the investigated breed of sheep as is evident from allelic frequencies (Table 3) of used markers which reflected that the population has retained

the presence of several alleles although at low frequency. A total of 109 alleles were detected across the 19 analyzed loci. The average number of observed alleles per locus was 5.74±0.17. Locus OarHH47 showed the highest number of alleles (na=9) and locus OarAE129 and OarCP32 the lowest (na=3). The effective number of alleles (ne) was less than the observed number of alleles at all the loci. The values for effective number of alleles (ne) ranged from 1.37 (BM8125) to 6.67 (OarHH47) with a mean of 3.33±0.14. Comparison of effective number of alleles (ne) with observed (na) indicated the predominance of certain alleles at each locus.

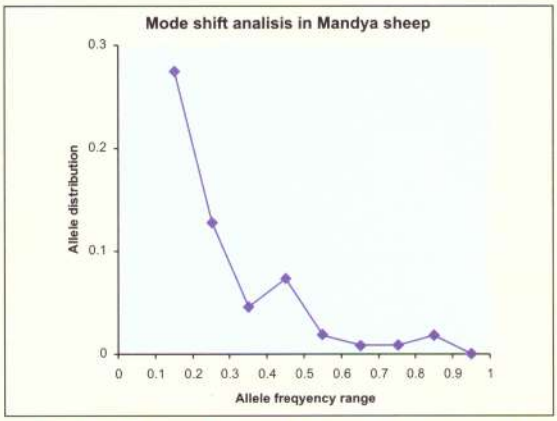

Fig 6 : Normal L shaped curve indicating no mode shift in Mandya sheep

The observed (Ho) heterozygosity ranged from 0.08 (OarAE129) to 0.83 (OarHH35) while the expected heterozygosity (He) ranged from 0.27 (BM8125)to 0.86 (OarHH47). The mean values of observed and expected heterozygosity were 0.55±0.02 and 0.65±0.02 respectively. The mean value of observed heterozygosity was lower than that for expected heterozygosity. This situation was also true for loci taken individually except two loci (OarJMP29 and OarHH35) where observed heterozygosity was more than the expected heterozygosity. The PIC values varied from 0.26 (BM8125) to 0.84 (OarHH47) with an average of 0.63±0.04. Since microsatellites having PIC values higher than 0.5 are considered highly informative, therefore, 85% of the markers were highly informative (PIC>0.50) while the remaining 15% were reasonably informative (0.50>PIC>0.25) which further indicated high suitability of used markers for genetic diversity analysis. The high average estimates of allele diversity (mean number of observed alleles per locus, 5.74) and gene diversity (mean expected heterozygosity, 0.65)

displayed by the panel of 19 microsatellites implied the presence of substantial amount of genetic variability in the investigated sheep breed. These findings were in accordance with those of other domestic sheep breeds investigated earlier (Sodhi *et al.*, 2003, 2005; Arora and Bhatia, 2004, 2005; Bhatia *et al.*, 2005).

The observed genotypic frequencies were significantly different from the expected frequencies for 12 loci under Chi-square test and for 11 loci under G-square test indicating that the genotypic frequencies were not under Hardy-Weinberg equilibrium at these loci.

Wright's (1978) fixation index (F_{IS}) (Table 4) revealed the population to be heterozygote deficit at 15 loci and heterozygote excess at two loci (OarJMP29 and OarHH35). At two loci the population was neither heterozygote deficit nor heterozygote excess. The F_{IS} values ranged from -0.15 to 0.76 for various loci. The heterozygote deficiency in the population may be explained on account of consanguineous mating or close linkage of some of these microsatellite loci with the economic traits for which selection is being practiced.

The population was investigated using BOTTLENECK programme (Cornuet and Luikart, 1996) under the assumption that all loci fit TPM mutation-drift equilibrium. The expected number of loci with heterozygosity excess was 11.22. The observed number of loci with heterozygosity excess (13) did not differ significantly from the expected value as revealed by the Sign test. Similarly, the Standardized Difference, Wilcoxon and Sign tests also revealed the deviation from the mutation-drift equilibrium to be non-significant ($P<0.05$). The normal L-shaped curve indicated no mode shift in the population. Thus, the BOOTLENECK investigation revealed the population at mutation-drift equilibrium and has not suffered any bottleneck in the recent past.

Table 4 : Measure of genetic variation in Bandur sheep

Locus	Sample Size	Na	ne	I	Obs _Het	Exp _Het	PIC	Fis
BM827	86	5	2.77	1.14	0.60	0.65	0.60	0.05
BM6526	92	5	3.27	1.34	0.65	0.70	0.67	0.06
BM8125	92	4	1.37	0.55	0.26	0.27	0.26	0.03
HUJ616	90	6	2.10	1.10	0.47	0.53	0.51	0.11
ILSTS002	76	7	3.11	1.45	0.55	0.69	0.66	0.18
ILST005	92	7	4.33	1.60	0.52	0.78	0.75	0.32
OarAE129	78	3	1.48	0.60	0.08	0.33	0.31	0.76
OarCP32	86	3	2.69	1.04	0.63	0.64	0.59	0.00
OarFCB48	92	7	3.82	1.55	0.67	0.75	0.72	0.09
OarFCB128	86	5	3.05	1.26	0.67	0.68	0.64	0.00
OarHH35	80	6	3.86	1.48	0.83	0.75	0.72	-0.11
OarHH41	92	5	2.95	1.27	0.39	0.67	0.64	0.41
OarHH47	80	9	6.67	2.03	0.63	0.86	0.84	0.26
OarHH64	92	4	1.58	0.74	0.33	0.37	0.36	0.11
OarJMP8	92	6	3.68	1.51	0.41	0.74	0.71	0.43
OarJMP29	92	7	3.33	1.43	0.80	0.71	0.68	-0.15
OarVH72	76	6	3.89	1.53	0.63	0.75	0.72	0.15
OMHC1	90	8	5.53	1.84	0.62	0.83	0.81	0.24
RM4	80	6	3.85	1.50	0.65	0.75	0.72	0.12
Mean	87	5.74	3.33	1.31	0.55	0.65		
SE		0.17	0.14	0.09	0.02	0.02		

na : Observed number of alleles
ne : effective number of alleles [Kimura and Crow (1964)]
I : Shannon's Information index [Lewontin (1972)]
PIC : polymorphic information content
Fis : is the Wright's (1978) fixation index, a measure of heterozygote deficiency or excess

Reproduction and body weights

Most of the Mandya flocks were purebred. Males are selected on the basis of size and conformation. In Bandur sheep the desirable traits for selection of ewes and rams are roman nose, medium sized head, white patch on the poll, long body with medium height, short and strong legs particularly the hind legs and presence of wattles. Typical Bandur rams and ewes are selected

Fig 7: A lactating ewe

Table 5: Reproductive performance of Bandur/Mandya ewes under farm management conditions

Trait	Value	Reference
Age at 1st lambing	977.54 days	Readdy and Rai (1985)
Age at 1st lambing	895.9 days	Gupta and Reddy (1986)
Age at 1st lambing	645.4±26.1	Ravi *et al.* (1988)
Gestation length	149.6 days	Gupta and Reddy (1986)
Lambing interval	378.4 days	Gupta and Reddy (1986)
Lambing interval	284.2±9.2 days	Ravi *et al.* (1988)
Service period	233.8 days	Gupta and Reddy (1986)

and maintained with great effort and care. They are used to produce breeding stock and are tagged with a premium price. November to December is the main lambing season. Lambing rate was about 70% with an average lambing interval of about 14-15 months. In certain cases the lambing interval was reported as low as 8 months. An ewe produced 6-7 lambs in its lifetime. Kale and Raman (1994) reported 0.31% twinning and 2.52% stillbirths and abortions combined together in Mandya sheep under farm management conditions.

Fig 8 : A Bandur ewe with its twins

Body weight of Bandur lambs at various important ages under farm management conditions are given in Table 6. The average body weights reported by various workers under farm management conditions at birth, 3 months and 6 months of age ranged between 2.1-2.21 kg, 9.55-11.7 kg and 14.2-16.0 kg respectively whereas the average body weight at 12 months of age was 22.13 kg.

Fig 9 : Bandur lambs grazing in the field

Table 6: Body weight of Mandya/Bandur lambs under farm management conditions

Trait	Value	Reference
Birth weight	2.10 kg	Charyulu and Munirathnam (1984)
Birth weight	2.21 kg	Readdy and Rai (1985)
Birth weight (male)	2.2±0.06 kg	Ravi *et al.* (1988)
Birth weight (female)	2.1±0.05	Ravi *et al.* (1988)
3 months weight	9.55 kg	Charyulu and Munirathnam (1984)
3 months weight	10.11 kg	Readdy and Rai (1985)
3 months weight (female)	11.2±1.4	Ravi *et al.* (1988)
3 months weight (male)	11.7±0.8 kg	Ravi *et al.* (1988)
6 months weight	14.89 kg	Charyulu and Munirathnam (1984)
6 months weight	14.24±0.17 kg	Reddy and Rai (1987)
6 months weight (female)	16.0±0.56 kg	Ravi *et al.* (1988)
6 months weight (male)	15.6±1.4 kg	Ravi *et al.* (1988)
12 months weight	22.13±0.26 kg	Reddy and Rai (1987)

Readdy and Rai (1985) compared the performance of Mandya and its halfbreds with Dorset and Suffolk and reported the crossbreds to be significantly superior to Mandya in body weight at various ages and age at first lambing. The improvement ranged from 11.54 to 28.05%. Similarly, a comparison of body weights in Mandya and its halfbreds revealed average body weight at 6 and 12 moths of age to be higher in crossbreds as compared to corresponding weights in Mandya (Reddy and Rai, 1987).

A number of experiments have been undertaken by various research workers to study the carcass traits in this sheep. Reddy and Reddy (1985) reported average live weight, carcass weight dressing percentage and the percentage of bone in the carcass as 17.08 kg, 8.34 kg, 48 % and 19 % in Mandya lambs slaughtered at 180 days of age. Prasad *et al.* (1991 a) reported average

liveweight at 180 days of age under feed lot conditions as 18.05 kg with feed conversion efficiency of 13.5%. The carcass weight, dressing percentage based on empty body weight and percentage of bone in the carcass averaged 8.18 kg, 56.8% and 20.7% respectively at 180 days of age (Prasad *et al.*, 1991 b).

Mahendrakar *et al.* (1988) compared carcass traits, non-carcass components and quality characteristics of meat from Mandya ram lambs on intensive fattening (concentrate feeding) with those reared on range feeding upto 10-11 months of age. The fattened lambs reached 22.7 kg liveweight as compared to a significantly lower liveweight of 14.5 kg for range-fed lambs. The studies indicated higher growth potential, dressing yield, meat yield and meat:bone ratios in Bandur sheep under stallfed conditions as compared with those maintained under range grazing system. The yield of less valuable parts such as skin, head and blood as a proportion of liveweight was lower for fattened sheep. Increased intramuscular fat content due to fattening of lambs did not affect the water holding capacity, cooking loss or thermal shortening of muscles. The lower shear force values for muscles from fattened sheep indicated that fattening produced tenderer muscles than those from range-fed sheep.

Utility conservation and improvement

The animals of Mandya breed are primarily maintained for mutton, the sheep droppings enhance the soil fertility, but there is hardly any income from the wool. Bandur is probably the only sheep breed in India having a meaty conformation. The selected elite Bandur animals are used to produce the breeding stock for sale. This is a unique situation of income from sheep in India. The surplus male lambs are sold at an age of 3-5 months for Rs 800-1500/- per lamb in a weekly market called 'SANDY'. The average cost of an ewe lamb was Rs 2000-3000 at an age of about 18 months. The cost of elite

Bandur rams and ewes was reported to be as high as Rs 15000/- in some exceptional cases. The animals are generally sheared twice a year in the months of January-February and July-August. Average greasy wool production was about 400-450 g per annum in two clips. Average shearing charges were the sheared wool plus Rs 5/- per sheep. Bandur sheep provides gainful employment to the rural females for their livelihood.

Fig 10: Stall feeding of elite Bandur sheep

The population size, trend over the years and the practice of selective breeding in Mandya flocks suggested a normal status of the breed. However, the Bandur strain needs imposing attention for its conservation, improvement and expansion. Bandur Sheep Development Scheme is already in operation and doing some work. Bandur sheep are being maintained at Bandur Sheep Breeding Farm, Dhangur, Malvalli in Mandya district. A large-scale programme need to be launched to improve the farmers' flocks of Bandur sheep. The farm should act as an 'Open Nucleus' so that there is continuous exchange of elite animals with the farmers' flocks associated with improvement.

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