

Buffalo Genetic Resources of India

JAFFARABADI



*Compiled and Edited
by*

**P. Kathiravan, B.P. Mishra, D.K. Sadana,
R.S. Kataria and Gurmej Singh**



National Bureau of Animal Genetic Resources
(Indian Council of Agricultural Research)
P.O. Box No. 129, Karnal (Haryana)



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Monograph 53, 2007

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Jaffarabadi Buffalo

PREFACE

India is habitat of the best riverine breeds of buffalo in the world. Jaffarabadi is one of the best buffalo genetic resources available in India with high milk production and fat percentage. The breeding tract of this buffalo lies in Saurashtra region of Gujarat especially areas in and around Gir forest. They form an important source of livelihood for Maldhari herdsmen in the region. Of late, efforts are being made to improve these animals genetically through progeny testing programmes. Central Institute for Research on Buffaloes (CIRB) has taken up the work under the Network Project in collaboration with Junagarh Agriculture University (Gujarat). National Bureau of Animal Genetic Resources, too has initiated an ex-situ conservation programme for this buffalo in collaboration with Bhartiya Agro-Industries Foundation (Pune). These initiatives need to be strengthened further for improvement and conservation of this breed in order to exploit its genetic potential for high milk production.

This bulletin is a compilation of information on production and reproduction performance of Jaffarabadi buffaloes along with its morphological characteristics and genetic diversity. The authors do not claim any originality as this is a compilation work. The authors thank all researchers who have worked and contributed valuable information on this breed. The authors wish to thank Dr. Gurmej Singh, Director, NBAGR whose support is immensely important in compiling and updating the information available from the literature. The authors also feel grateful to I/C Photography Unit, NBAGR and Mr. Moti Ram, for providing photographs. The authors hope and trust that the bulletin will be useful to the policy makers, researchers and students in getting glimpses of this important buffalo breed and making plans for breed improvement and conservation.

Authors

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1. Introduction

Buffalo is an important dairy animal as it produces more than 50% of the total milk in the country. India is the habitat of rich buffalo genetic diversity and Jaffarabadi is one of the best dairy type buffalo available in the country. Jaffarabadi is a heavy and massive type of river buffalo found in large numbers in Gujarat, especially in Gir forest, the well known sanctuary of Indian lion. The Gir forest reserve is a tough terrain of about 1300 square kilometers covered with open forest which abounds with diverse wildlife. The "Maldhari" herdsmen, who live in family settlements called as "Nesdas" in the forest areas own these buffaloes. Even under such difficult conditions, the Maldhari herdsmen continue to rear buffaloes which is the main source of their livelihood. However, some of the animal breeders with little landholding and professional attitude, do keep these animals in good condition and sound management.

Jaffarabadi buffaloes are good milkers and thrive well on natural grazing. These buffaloes characteristically differ from other breeds mainly in terms of production, with good genetic potential to produce more in terms of kilofat. They are very efficient in the conversion of roughages into milk with a high butter fat content. Males are good draught animals for hauling heavy loads.

2. Origin and Breeding Tract

Jaffarabadi is the heaviest of all the Indian breeds of buffaloes. It is also called as *Bhavnagri*, *Gir* or *Jaffari*. The breed is named after the town of Jaffarabad. These buffaloes are found in large numbers in this area, especially in the Gir forest area which is also inhabited by the famous Indian lion.

The main native tract of Jaffarabadi buffalo is Saurashtra region of Gujarat especially areas in and around Gir forest viz., Junagarh, Bhavagar, Jamnagar,

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Figure 1. Breeding tract of Jaffarabadi buffalo

Porbandhar, Amreli and Rajkot districts. The breeding tract lies between $20^{\circ} 5'$ and $22^{\circ} 6'$ N latitude, and between 70° and 72° E longitude. Jaffarabadi buffaloes are distributed approximately in an area of 64,339 square kilometers excluding the Kutch region.

Soil in the breeding tract is silty clay to clay and typically medium black, with high water holding capacity. It is highly calcareous and slightly alkaline with a pH range of 7.9 to 9.4. Climate in general is tropical monsoon. Rain is common during June to September and the annual rainfall ranges from 50 to 100cm. Average temperature ranges from 20° C to 36° C. Sometimes maximum temperature goes as high as 46° C and minimum as low as 11° C. Mean relative humidity is 80% during July to September and 20 to 40% during rest of the year (Anonymous, 2000).

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Figure 2. Jaffarabadi in the breeding tract

3. Distribution and Population Status

According to the Integrated Sample Survey on Livestock Population and Animal Production conducted by Animal Husbandry Department, Gujarat, around 24% of the productive buffaloes in the Gujarat state belongs to Jaffarabadi breed (Anonymous, 1995). The estimated population of Jaffarabadi buffaloes in the Saurashtra region is around 1.3 million. The estimated population under different groups in major districts of the breeding tract is given in table 1.

4. Managemental Practices

4.1 Housing

Most of the farmers provide some type of housing to the animals during day and night. Most of the animal houses are closed, kutchha and generally separate from the farmer's residence.

The percentage of the animals housed during day, night, day and night and no housing was 9.89%, 26.68%, 62.97% and 0.45% respectively. Inside the forest areas, the Maldharis keep their animals in "Nesdas" where the animal house forms a part of the farmer's house and is heavily barricaded in front to protect the animals from lions and other wild animals. Buffaloes

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Table 1 Estimated population of buffaloes in major districts of Jaffarabadi breeding tract

District	Male						Female						Total								
	Breeding		Work		Breeding & Work		Others		<1 year		1 - 3 years			In milk		Dry		Heifers		Others	
	year	<1 year	year	<1 year	year	<1 year	year	<1 year	year	<1 year	year	<1 year		year	<1 year	year	<1 year	year	<1 year	year	<1 year
Amreli	10008	988	666	154	100	32158	23067	76623	24224	4599	676	173263									
Bhavnagar	13776	3575	3696	3036	1293	48565	41651	127752	43321	9952	2380	298997									
Jamnagar	7039	1750	1060	188	204	30223	31451	96399	30271	5858	836	205279									
Junagadh	11213	2338	1119	225	324	44372	46241	135039	46531	8772	1713	297887									
Porbandar	2470	685	175	46	134	12263	12737	40674	11621	2682	217	83704									
Rajkot	10470	1549	727	471	165	41080	39756	123518	39970	10273	1235	269214									
Total	54976	10885	7443	4120	2220	208661	194903	600005	195938	42136	7057	1328344									

Source : 17th Livestock Census 2003, Dept. of Animal Husbandry, Govt. of India

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are normally allowed for wallowing. Wallowing is done during morning (31.17%), noon (56.82%) and evening (10.01%) (Anonymous, 2000).



Figure 3. Housing of Jaffarabadi buffaloes nearby farmer's residence

4.2 Feeding

As Jaffarabadi buffaloes are massive, they are heavy grazers. They are maintained on normal pastures throughout the year. The commonly available fodder trees in the breeding tract are *Samanca saman*, *Acacia nilotica*, *Prosopis juliflora*, *Ficus bengalensis*, etc. The major native fodder grasses available are *Cyanodon*, *Dicanthium*, *Aristida*, *Eleuopus* and *Desmodium*.

The buffaloes are normally fed concentrate mixture during pregnancy and lactation. The mixture contains groundnut cake, cottonseed, cottonseed cake and compound (pelleted) feed. The main green fodder fed to Jaffarabadi animals are maize, sorghum, groundnut fodder, sugarcane tops and lucerne, whereas dry fodder comprises sorghum and maize stalks, groundnut husk, groundnut hulls, wheat straw, wheat bhusa, etc. About 44.12 and 45.45% farmers grow green fodder in winter and summer seasons respectively. Only 11.78% farmers provide chaffed fodder to the animals. Most of the farmers (62.55%) fed cake as supplement along with fodder and only 15.19% provided concentrate mixture to the lactating animals. Before feeding, the

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concentrate is soaked by majority of the farmers (80.8%) and is fed during milking time.



Figure 4. Jaffarabadi buffaloes grazing in a field

4.3 Breeding

Most of the farmers in the breeding tract of Jaffarabadi buffaloes resort to natural service rather than artificial insemination. Natural service is followed in 88.33% of the cases and only 11.66% of the farmers are adopting artificial insemination. However, the availability of breeding bulls in the tract is found to be inadequate as they comprise only 1.4% of the breedable female population.

5. Physical Characteristics

The adult Jaffarabadi buffaloes have massive body with big head and bulging forehead making it to appear like a baby elephant. Few animals may have white spots on forehead. The usual colour of the animals is black but few animals having grey colour or white spots on forehead, feet and tail switch are also seen. The latter types of buffaloes are called “Nav Chandra” and are considered lucky by the Maldharis. The horns are inclined to droop on each side of the neck and then turn up at the tips, the curls being not as tight as in the Murrah breed. The horns usually emerge out by compressing

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Figure 5. Jaffarabadi bull

the head, go downward sideways, upwards, inward and finally forming a ring like structure. It makes eyes to look small, termed as sturdy eye, and especially in males, sometimes it leads to blindness. Ears are long and horizontal. Head and neck are massive. Navel flap and penis sheath are medium in size.

Udder is well developed. Pendulous and round udders are found in almost equal proportions. Forequarter is slightly larger than the hindquarter. Teats are mostly funnel shaped and have pointed tips. Quite a large number of buffaloes have cylindrical teats. Milk vein is medium in size. Jaffarabadi buffaloes are of docile temperament.



Figure 6. Jaffarabadi cow

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6. Morphological Traits

6.1 Body measurements

Various morphological traits of Jaffarabadi buffaloes like body length, heart girth, height at withers, face length, horn size and ear length are given in Table 2.

Table 2 Various body measurements of Jaffarabadi buffaloes

Trait	Sex	Cockrill (1974)	Anonymous (2000)
Body length (cm)	Male	167.6	127.7
	Female	160.0	132.6
Heart girth (cm)	Male	190.5	207.7
	Female	187.9	203.0
Height at withers (cm)	Male	142.2	126.1
	Female	139.7	129.1
Face length (cm)	Male	-	58.0
	Female	-	48.4
Horn size (cm)	Male	-	48.4
	Female	-	45.3
Ear length (cm)	Male	-	25.5
	Female	-	23.8

6.2 Muzzle dermatoglyph patterns

Singh and Patel (2001) studied various muzzle measurements and muzzle characteristics in different age groups of Jaffarabadi buffaloes (Table 3). They also tried to predict the age of Jaffarabadi buffaloes based on muzzle dermatoglyph patterns and found that there was parallel increase in various muzzle measurements to age of buffaloes, while with muzzle characteristics, the correlations were negative and significant. The regression

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equation showed significant value of R^2 (77.6%) to predict the age by various muzzle measurements and muzzle characteristics in Jaffarabadi buffaloes.

Table 3 Muzzle dermatoglyph pattern in Jaffarabadi buffaloes

Age group	Mean muzzle measurements (cm)				Mean muzzle characteristics (Nos.)		
	Basal length	Upper length	Central length	Distance between nostrils	Beads	Clustered beads	Total converted beads
0-5.9	5.19	4.78	4.74	2.39	63.38	11.00	96.50
6-11.9	5.87	5.59	5.72	3.07	45.56	6.33	60.72
12-23.9	6.52	5.88	6.87	3.83	48.33	1.00	52.50
24-35.9	7.39	6.58	7.35	4.06	38.25	4.63	47.31
36-59.9	7.94	7.18	8.05	4.45	30.13	3.33	40.97
6-above	9.59	9.12	9.21	5.33	22.21	1.21	25.07
Lactating	9.54	8.93	9.25	5.30	23.75	1.06	26.25

Source : Singh and Patel (2001)

7. Performance Traits of Jaffarabadi Buffaloes

7.1 Body weight and growth rate

The average body weight at birth, 3, 6 and 12 months in Jaffarabadi buffaloes were 29.3, 71.0, 102.0 and 142.5 kg respectively (Anonymous, 2000).



Figure 7. Jaffarabadi calf

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In a study on 12 Jaffarabadi buffaloes under feedlot, average daily gain, dry matter intake, dry matter intake per 100 kg body weight, feed conversion and gain efficiency were 1.11 ± 0.051 kg, 8.38 ± 0.214 kg, 2.19 ± 0.051 kg, 6.26 ± 0.14 and 0.132 ± 0.004 respectively. The animals were fed with corn silage (60.1%), corn (31.3%) and cotton seed meal (8.7%) in this study (Nogueira *et al.*, 2002).

7.2 Production and reproduction traits

Jaffarabadi buffaloes are good milkers with high butter fat content.

Table 4. Performance traits of Jaffarabadi buffaloes

Trait	Patel <i>et al.</i> (1996)*	Nivsarkar <i>et al.</i> (2000)	Dutta <i>et al.</i> (2003)	Taneja (2004)	Sethi and Kala (2005)	Gajbhiye <i>et al.</i> (2007)
Overall lactation milk yield (kg)	-	2238.7 ± 74.87 (70)	2641	2336	-	1752 ± 74.8 (742)
First lactation milk yield (kg)	1686.75 ± 47.64 (110)	2151.3 ± 130.53 (29)	-	-	1794 ± 142 (39)	1689 ± 62.2 (742)
Daily milk yield (kg)	-	-	8.80	-	-	-
Lactation length (days)	364.64 ± 8.42 (110)	305.1 ± 9.61 (70)	-	289	-	340 ± 8.54
Dry Period (days)	152.26 ± 10.51 (110)	144.9 ± 8.4 (57)	-	-	179.6 ± 10.1 (33)	-
Fat content (%)	-	7.68 ± 0.04 (2060)	7.73	8.5	-	-
Age at first calving(days)	-	1361.7 (715)	1635.30 ± 1.2	1530	1410 ± 51 (15)	-
Service period (days)	218.45 ± 12.10 (110)	93.4 ± 0.69 (715)	-	-	155 ± 18.1 (33)	-
Calving interval (days)	521.90 ± 11.84 (110)	440.30 ± 14.32 (54)	415	440	165.8 ± 18.0 (33)	-
No. of services per conception	2.00 ± 0.11 (110)	1.5 (715)	-	-	-	-

* Under field conditions

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The animals are mainly kept for production of ghee which is the principal source of income for Maldhari herdsman. The mean values of various production and reproduction traits as reported by different workers are presented in Table 4. The total milk yield per lactation normally exceeds 2000 kg with an average daily milk yield of 6 to 10 kg.

7.3 Seminal attributes and fertility of Jaffarabadi bulls

Shelke and Dhama (2002) studied the seminal attributes of sexually mature Jaffarabadi breeding bulls and the mean physiological values of seminal characteristics, cold shock resistance and freezability as reported by them are presented in Table 5. Under field conditions, the age at training for mounting is about 3.30 ± 0.06 years and that of first service is 3.80 ± 0.07 years. The fertility of Jaffarabadi bulls through artificial insemination in the farmers herd was between 46 to 56.5%, while it was 78.78% in the farm managed herd (Dutta *et al.* 2003).

Table 5. Seminal attributes of Jaffarabadi bulls

Seminal attributes	Mean \pm S.E (N=45)
Ejaculate volume (ml)	5.09 \pm 0.18
Density score (0-5)	2.72 \pm 0.13
Initial pH	6.66 \pm 0.02
Mass Activity (Score 0-5)	2.23 \pm 0.15
Initial motility (%)	59.44 \pm 3.05
Sperm count / ml (in millions)	1209.56 \pm 53.48
Sperm count / ejaculate (in millions)	6075.18 \pm 324.71
Live sperm (%)	82.60 \pm 1.52
Abnormal sperm (%)	22.18 \pm 3.11
Crenellation score (0-3)	2.03 \pm 0.11
Cold shock resistant sperm (%)	36.40 \pm 1.23
Pre-freeze motility (%)	41.65 \pm 3.30
Post-thaw motility (%)	28.22 \pm 2.82

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Figure 8. Herd of Jaffarabadi buffaloes

8. Genetic Characterization of Jaffarabadi Buffaloes

8.1 Biochemical genetic studies

Biochemical genetic studies on Jaffarabadi buffaloes was conducted in the Core laboratory, Gujarat Agricultural University, Anand. The study was undertaken on 70 animals of Jaffarabadi buffaloes and typing was done for haemoglobin, transferrin and albumin proteins. All the animals typed for haemoglobin were A1A2 and DD for transferrin. 17 animals typed as FF, 44 FS and 9 SS for albumin giving a gene frequency of 0.557 ± 0.042 for F allele and 0.443 ± 0.056 for S allele.

8.2 Characterization of Jaffarabadi buffaloes using microsatellite DNA markers

Genotyping of Jaffarabadi buffaloes were carried out using microsatellite markers in the Buffalo Genomics Lab., DNA Fingerprinting Unit at NBAGR, Karnal (Annual Report, NBAGR, 2002).

Heterologous bovine specific microsatellite markers already evaluated for buffalo diversity analysis were used for genotyping of Jaffarabadi buffaloes. Twenty five microsatellite markers were analyzed in 45 to 48 unrelated genomic DNA samples. PCR amplification was carried out using

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Figure 9. Stacks of fodder

microsatellite markers viz. CSRM 060, ILSTS 026, HEL 013, ILSTS 030, ILSTS 033, ILSTS 017, ILSTS 019, ILSTS 045, ILSTS 034, ILSTS 058, ILSTS 056, ILSTS068, CSSM 066, ILSTS 036, ILSTS 095, ILSTS 029, ILSTS 028, ILSTS 025, ILSTS 052, ILSTS 031, ILSTS 073, ILSTS 060, BM 1818, ILSTS 061, ILSTS 008. To assess the existence of polymorphism at each locus, PCR amplified product was resolved on 6% denaturing Urea-PAGE and alleles were visualized by silver staining. Number of alleles and size range was estimated for each marker manually.

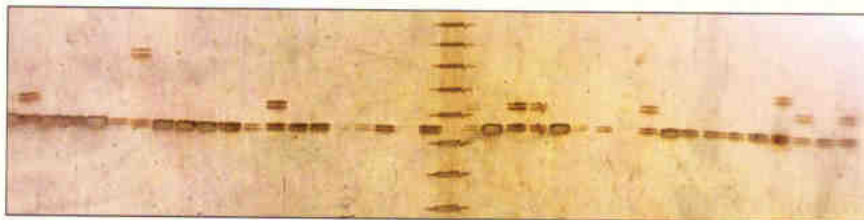


Figure 10. a. Microsatellite polymorphism at ILSTS 056 locus



Figure 10. b. Microsatellite polymorphism at ILSTS 026 locus

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Across the 25 microsatellite loci studied, a total of 119 alleles were observed (Table 6). The observed number of alleles varied between 2 (ILSTS 017 and ILSTS 073) to 8 (ILSTS 029) with overall mean number of alleles per

Table 6. Microsatellite loci analyzed, annealing temperature, observed and effective number of alleles and Information index on Jaffarabadi buffaloes

Locus	Annealing Temperature	N	Observed number of alleles*	Effective number of alleles*	Shanon's Information Index
CSRM 060	55	44	6	4.17	1.53
ILSTS 026	55	40	4	1.69	0.78
HEL 013	55	40	7	6.07	1.86
ILSTS 030	55	32	5	2.31	1.08
ILSTS 033	55	38	4	1.78	0.83
ILSTS 017	55	38	2	1.33	0.41
ILSTS 019	55	30	4	1.23	0.41
ILSTS 045	55	41	3	2.35	0.88
ILSTS 034	55	35	3	2.46	0.97
ILSTS 058	55	39	5	3.57	1.38
ILSTS 056	55	38	4	1.42	0.58
ILSTS 068	55	38	6	5.19	1.71
CSSM 066	55	35	5	3.20	1.32
ILSTS 036	55	39	6	3.18	1.35
ILSTS 095	55	41	4	1.88	0.92
ILSTS 029	55	38	8	6.39	1.94
ILSTS 028	55	42	5	3.14	1.22
ILSTS 025	55	40	5	3.20	1.35
ILSTS 052	55	37	7	3.27	1.41
ILSTS 031	55	36	3	1.50	0.56
ILSTS 073	55	42	2	1.99	0.69
ILSTS 060	55	38	4	3.06	1.78
BM 1818	55	38	5	2.63	1.19
ILSTS 061	55	40	7	3.48	1.49
ILSTS 008	55	36	5	4.44	1.54
Mean	-	-	4.76	2.99	1.14

*Crow and Kimura (1964)

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Table 7. Summary of heterozygosity and polymorphism information content at 25 different microsatellite loci in Jaffarabadi buffaloes

Locus	N	Heterozygosity			PIC	F _{IS}
		Ho	He	Nei's He		
CSRM 060	44	0.682	0.769	0.760	0.722	0.103
ILSTS 026	40	0.475	0.414	0.409	0.377	-0.161
HEL 013	40	0.775	0.846	0.835	0.814	0.072
ILSTS 030	32	0.750	0.577	0.568	0.516	-0.321
ILSTS 033	38	0.158	0.444	0.438	0.398	0.640
ILSTS 017	38	0.290	0.251	0.248	0.217	-0.169
ILSTS 019	30	0.200	0.188	0.185	0.177	-0.081
ILSTS 045	41	0.805	0.562	0.555	0.455	-0.145
ILSTS 034	35	0.829	0.602	0.593	0.507	-0.397
ILSTS 058	39	0.692	0.730	0.720	0.673	0.039
ILSTS 056	38	0.316	0.299	0.295	0.270	-0.071
ILSTS 068	38	0.553	0.818	0.808	0.780	0.316
CSSM 066	35	0.286	0.698	0.688	0.643	0.585
ILSTS 036	39	0.692	0.695	0.686	0.631	-0.010
ILSTS 095	41	0.390	0.475	0.469	0.438	0.168
ILSTS 029	38	0.868	0.855	0.844	0.824	-0.030
ILSTS 028	42	0.542	0.690	0.681	0.617	0.336
ILSTS 025	40	0.450	0.697	0.688	0.645	0.346
ILSTS 052	37	0.892	0.703	0.694	0.647	-0.285
ILSTS 031	36	0.417	0.340	0.335	0.288	-0.243
ILSTS 073	42	0.071	0.503	0.497	0.374	0.856
ILSTS 060	38	0.421	0.682	0.673	0.606	0.374
BM 1818	38	0.579	0.628	0.620	0.572	0.066
ILSTS 061	40	0.750	0.722	0.713	0.678	-0.053
ILSTS 008	36	0.611	0.786	0.775	0.737	0.211
Mean	-	0.536	0.599	0.591	0.544	0.086

* Ho = Observed Heterozygosity

*He = Expected Heterozygosity

* Nei He = Nei's Expected Heterozygosity

PIC = Polymorphism Information

F_{IS} = Within population inbreeding estimate

Content

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locus as 4.76. The mean effective number of alleles was lower than the mean observed number of alleles (2.99). The effective number of alleles ranged between 1.23 (ILSTS 019) to 6.39 (ILSTS 029). The effective number of allele (n_e) for all the loci was less than the observed number of alleles (n_o).

The average PIC value across 25 loci was estimated to be 0.544 and ranged between 0.177 (ILSTS 019) and to 0.824 (ILSTS 029) (Table 7). According to Botstein et al. (1980), polymorphic markers were classified as highly informative which had a PIC value greater than 0.5, reasonably informative with a PIC value ranging between 0.25 and 0.50 and slightly informative if the PIC value was below 0.25. Seventeen of the 25 loci had PIC values more than 0.5 suggesting that they are highly informative for buffalo diversity analysis. Six loci were found to be reasonably informative and only two were less informative in Jaffarabadi buffalo population. Observed heterozygosity varied between 0.071 (ILSTS 073) to 0.892 (ISLSTS 052) and the mean observed heterozygosity (0.536) was less than average expected heterozygosity (0.599) (Table 7). Nei's average expected heterozygosity ranged between 0.185 (ILSTS 019) and 0.844 (ILSTS 029) with a mean of 0.591.

The test for H-W equilibrium (HWE) showed that several of the loci except eight deviated significantly (Table 8). Departure from HWE is mostly due to heterozygote deficiency which may result from one or more of the following reasons: presence of null alleles, small sample size and Wahlund effect i.e presence of fewer heterozygotes in a population than predicted on account of population sub-division. Jaffarabadi buffalo population was found to have a heterozygote deficiency of 8.6%. The test for BOTTLENECK was performed using allele frequency data (Figure 11 a-g) and it did not show any significant reduction of effective population size in the recent past. The allele frequency spectrum visualized by the qualitative graphical method of Cornuet and Luikart (1996) is shown in Figure 12. The distribution

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followed the normal L-shaped form suggesting that the breed did not encounter genetic bottleneck in the recent past.

Table 8. Test for Hardy-Weinberg equilibrium at 25 microsatellite loci in Jaffarabadi buffaloes

Locus	DF	Chi Square	P-value
CSRM 060	15	54.20	0.000
ILSTS 026	6	10.10	0.121
HEL 013	21	69.84	0.000
ILSTS 030	10	41.29	0.000
ILSTS 033	6	53.20	0.000
ILSTS 017	1	0.98	0.323
ILSTS 019	6	0.304	0.999
ILSTS 045	3	11.16	0.011
ILSTS 034	3	12.83	0.005
ILSTS 058	10	25.14	0.005
ILSTS 056	6	3.14	0.791
ILSTS 068	15	60.25	0.000
CSSM 066	10	50.29	0.000
ILSTS 036	15	84.60	0.000
ILSTS 095	6	43.42	0.000
ILSTS 029	28	87.35	0.000
ILSTS 028	10	18.20	0.052
ILSTS 025	10	107.07	0.000
ILSTS 052	21	63.07	0.000
ILSTS 031	3	2.30	0.512
ILSTS 073	1	31.69	0.000
ILSTS 060	6	37.88	0.000
BM 1818	10	7.15	0.711
ILSTS 061	21	20.24	0.506
ILSTS 008	10	25.57	0.004

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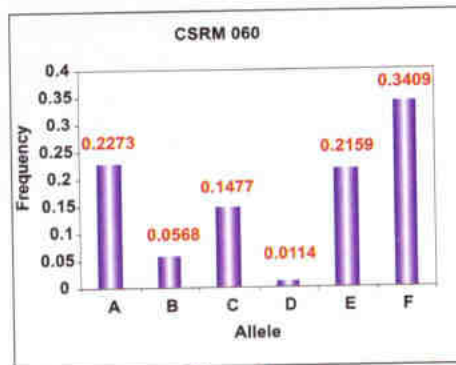


Figure 11 a

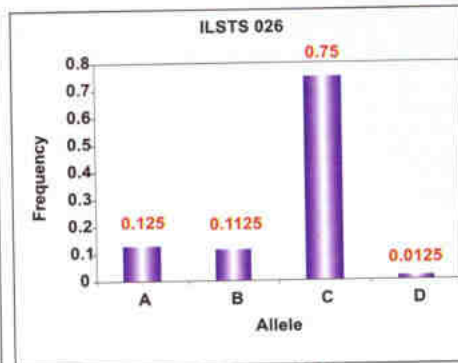


Figure 11 b

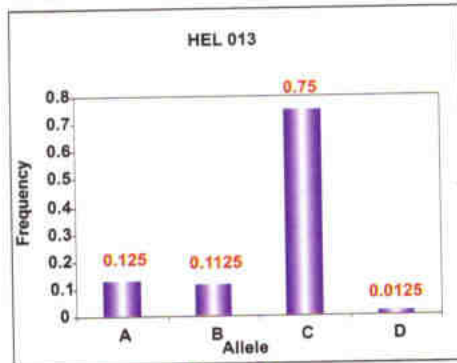


Figure 11 c

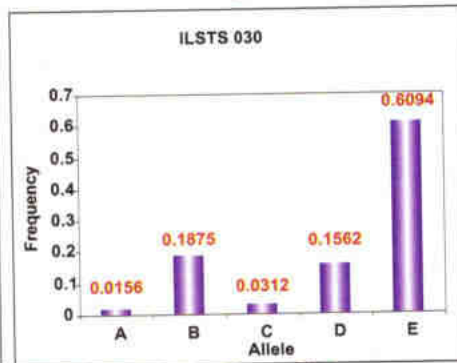


Figure 11 d

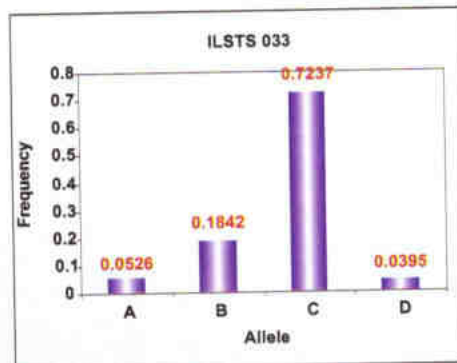


Figure 11 e

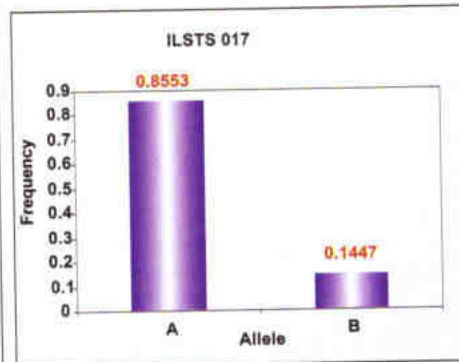


Figure 11 f

Figure 11 (a-f) Allelic frequencies at different microsatellite loci in Jaffarabadi buffaloes

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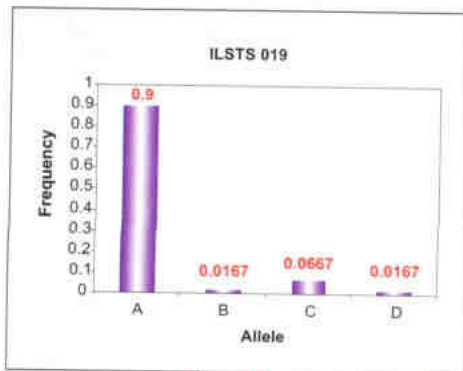


Figure 11 g

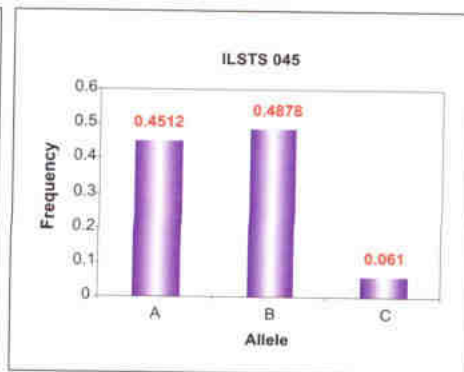


Figure 11 h

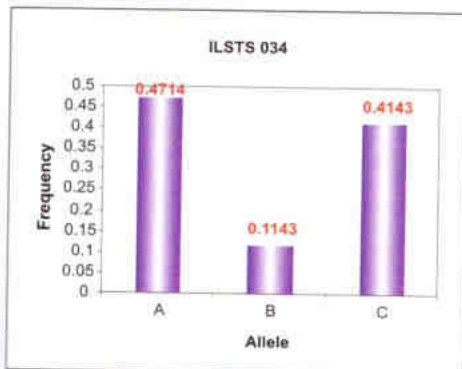


Figure 11 i

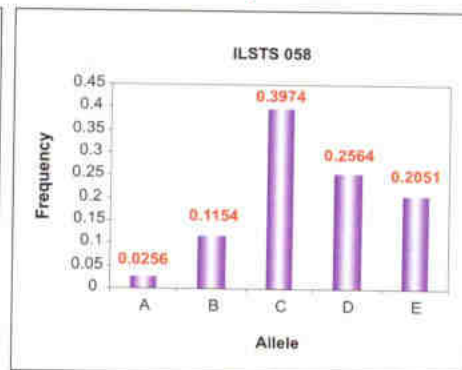


Figure 11 j

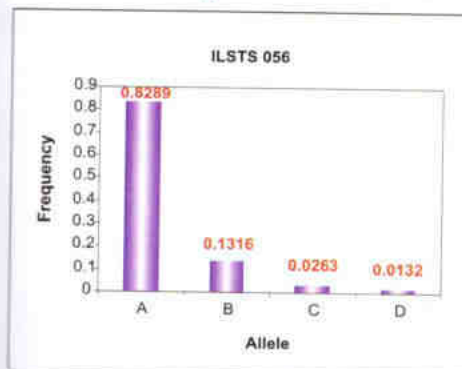


Figure 11 k

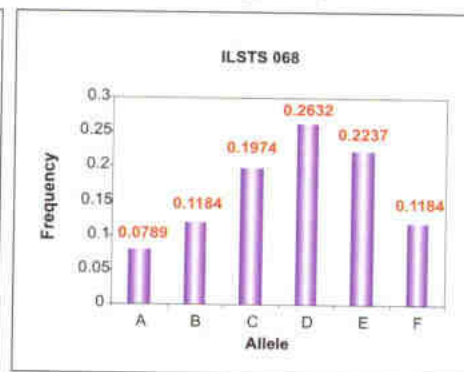


Figure 11 l

Figure 11 (g-l) Allelic frequencies at different microsatellite loci in Jaffarabadi buffaloes

Jaffarabadi Buffalo

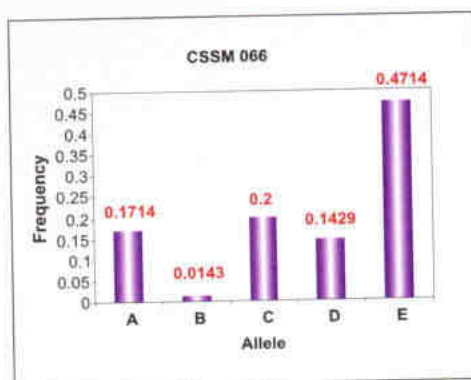


Figure 11 m

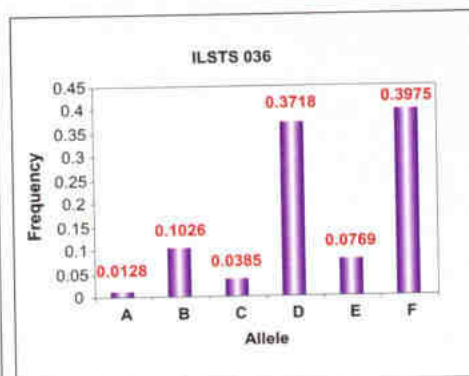


Figure 11 n

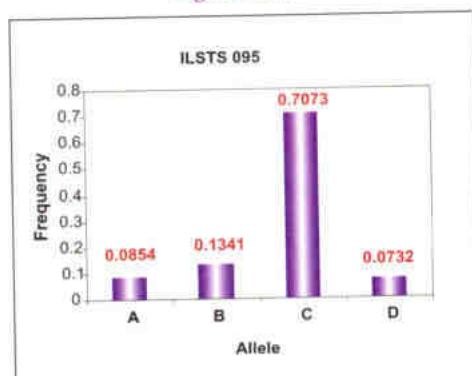


Figure 11 o

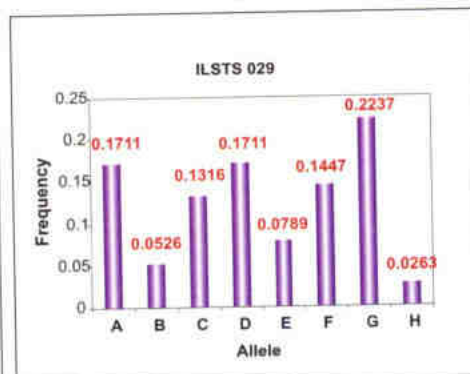


Figure 11 p

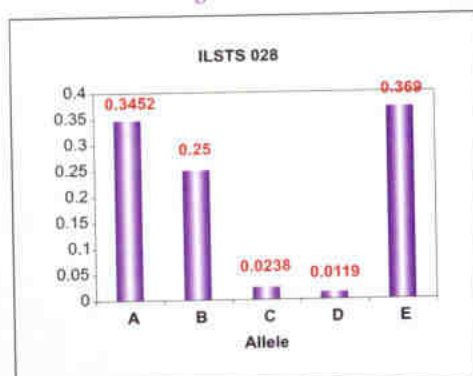


Figure 11 q

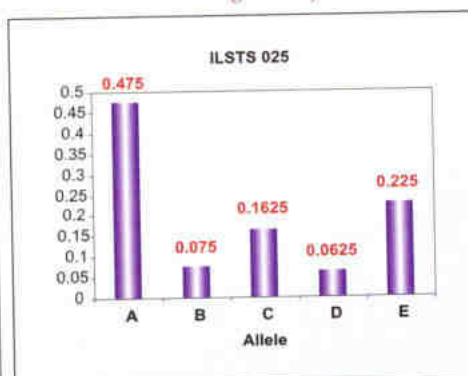


Figure 11 r

Figure 11 (m-r) Allelic frequencies at different microsatellite loci in Jaffarabadi buffaloes

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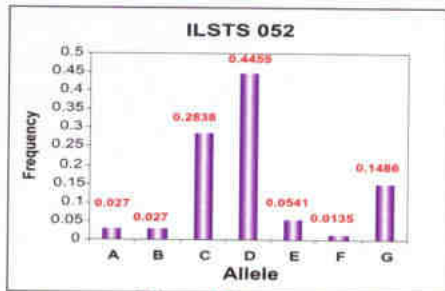


Figure 11 s

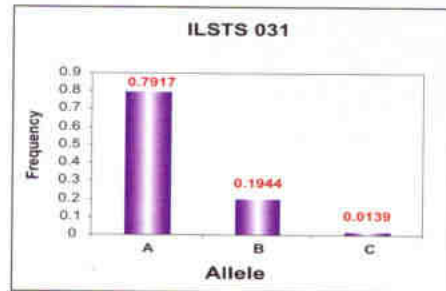


Figure 11 t

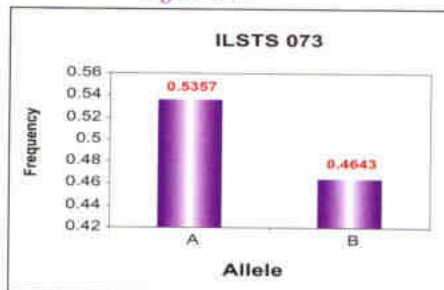


Figure 11 u

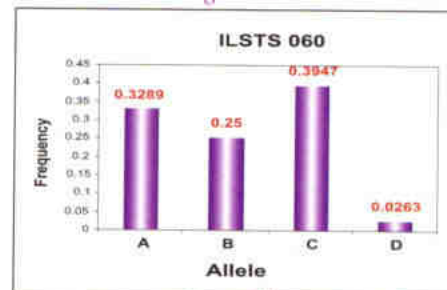


Figure 11 v

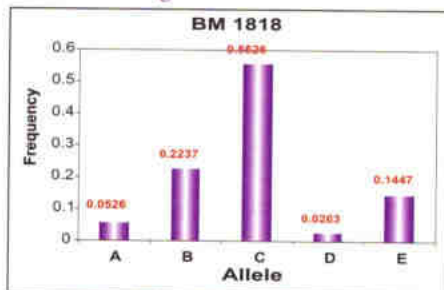


Figure 11 w

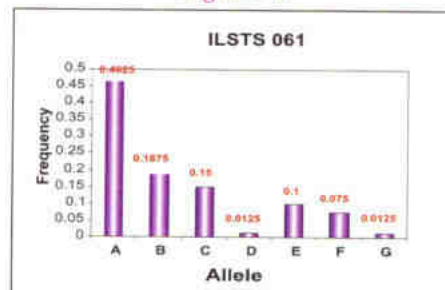


Figure 11 x

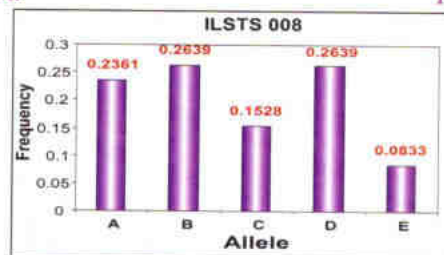


Figure 11 y

Figure 11 (s-y) Allelic frequencies at different microsatellite loci in Jaffarabadi buffaloes

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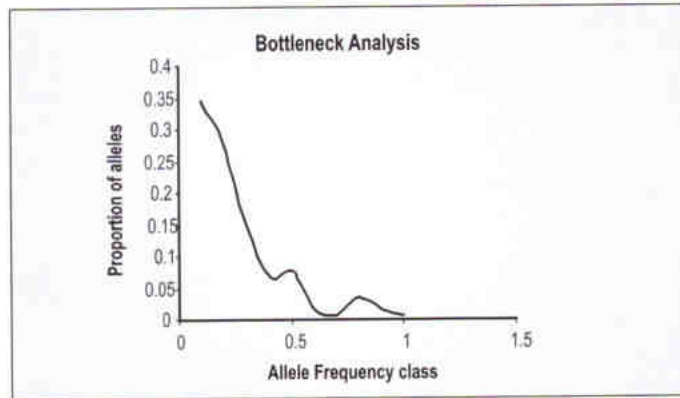


Figure .12. Mode Shift Indicator of Bottleneck.

Normal L-shaped curve of distribution of allelic proportions in different allele frequency classes indicating absence of recent bottleneck in Jaffarabadi buffaloes

8.3 Study on genetic relatedness and diversity

Based on the allele frequency data of different microsatellite loci, the genetic identity and distances among four buffalo breeds Jaffarabadi, Mehsana Murrah and Nili-Ravi was estimated as per standard genetic distance method of Nei (1972) (Table 9). The dendrogram based on Nei's (1972) genetic distance was constructed using UPGMA method modified from NEIGHBOR procedure. It was observed that Jaffarabadi was distinctly different and placed separately from other three breeds. Murrah and Nili-Ravi breeds were closely related and shared one node while Mehsana was placed separately relative to this node.

Table 9. Genetic Identity and Distance among four buffalo breeds

	Jaffarabadi	Mehsana	Murrah	Nili-Ravi
Jaffarabadi	***	0.7344	0.7666	0.6984
Mehsana	0.3087	***	0.7808	0.8111
Murrah	0.2658	0.2475	***	0.8639
Nili-Ravi	0.3589	0.2094	0.1463	***

Nei's Genetic Identity (above diagonal) and Genetic Distance (below diagonal)

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Satish Kumar *et al.* (2006), who studied the genetic variation at 27 microsatellite loci in eight Indian buffalo breeds, also derived similar conclusions. The neighbour-joining tree constructed from chord distance matrix, and the Multi Dimensional Scaling display of pairwise F_{ST} values revealed four distinct clusters, with Jaffarabadi, Toda and Pandharpuri representing three different clusters respectively and the fourth cluster representing an admixture of the remaining five breeds (Murrah, Mehsana, Surti, Bhadawari and Nagpuri). Thus, it is very clear from these studies at DNA level that Jaffarabadi buffaloes are distinctly different from all other breeds of Indian buffaloes.



Figure 13. Women in the forefront of maintaining Jaffarabadi buffaloes

9. Genetic Improvement and Conservation Efforts

In order to harvest the production potential of buffaloes to the fullest extent, it is important to evaluate the sires under field conditions. With this aim, a Network Project on Jaffarabadi buffalo was initiated in 2003-04 by Central Institute for Research on Buffaloes, Hisar in collaboration with Junagarh Agriculture University, Gujarat. A field progeny testing programme for genetic improvement and conservation of Jaffarabadi buffalo is actively under progress with Cattle Breeding Farm, Junagarh as the

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nucleus herd. Over 1200 Jaffarabadi buffaloes have been identified and about 300 of them have been registered. The testing of first set of five bulls is presently under progress (Gajbhiye *et al.* 2005).

Regarding conservation of Jaffarabadi buffaloes, National Bureau of Animal Genetic Resources, Karnal has initiated an *ex situ* conservation programme under Network Project on Animal Genetic Resources in collaboration with Bharatiya Agro-Industries Foundation (BAIF), Pune.

10. Jaffarabadi in other Countries

As Jaffarabadi is one of the heavy milkers among the Indian riverine buffaloes, a good number of animals have been exported to different parts of the world. It is the third most preferred buffalo breed after Murrah and Nili-Ravi. Among the countries, Brazil has imported large number of Jaffarabadi buffaloes from India for its crossbreeding and genetic improvement programmes of native buffaloes. The details of the countries to which Jaffarabadi buffaloes/germplasm have moved is given in Table 10.

Table 10. Movement of Jaffarabadi to other countries

Country	Year	Mode of Movement of Animals/Germplasm
Bulgaria	1970	As germplasm exchange
Italy	Between 475 and 900 A.D	As germplasm exchange
European countries like Hungary, Romania, former Yugoslavia, Greece	1000A.D.	Along with pilgrims and crusaders
Brazil	1895	Through purchase and shipment
Trinidad	1903-1906	Along with migrants

Nivsarkar *et al.* (2000)

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11. Jaffarabadi Buffalo Breeding Farms

1. Buffalo breeding Centre, National Dairy Development Board, Nekarikallu, Andhra Pradesh.
2. Cattle Breeding Farm, Gujarat Agricultural University, Junagarh, Gujarat.
3. Akshar Purushottam Mandir Gaushala, Gondal, Gujarat.
4. Sabarmati Ashram Gaushala, Bidaj, Gujarat.
5. BAIF Development Rsearch Foundation, Urulikanchan, Pune, Maharashtra.

12. Contact Agencies

1. Gujarat Agricultural University, Junagarh, Gujarat.
2. Department of Animal Husbandry, Govt. of Gujarat.

13. Conclusions

Jaffarabadi buffaloes are massive and heavy animals having good genetic potential for milk and fat production. Studies on genetic architecture of these animals have revealed that they are unique and distinct from other buffalo breeds of the country. The population of Jaffarabadi buffaloes has been estimated to be around 1.3 million and there is no imminent threat to the breed in the near future. However, the genetic potential of these animals have not been exploited fully and steps in this direction have been initiated. The Network Project on genetic improvement of Jaffarabadi buffaloes by CIRB, Hisar and Network Project on conservation of Jaffarabadi buffaloes by NBAGR, Karnal have to be strengthened further for sustainable maintenance of this precious germplasm of the country.

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Glimpses of Jaffarabadi buffalo

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