Monograph 54, 2007

Buffalo Genetic Resources of India

NAGPURI

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Published by : Director
National Bureau of Animal Genetic Resources
P.O. Box - 129, Karnal - 132001 (Haryana) India

Cover Design : Sh. Moti Ram

Printing : Intech Printers & Publishers
51-A, Model Town, Karnal - 132001
Tel. : 0184-4043541, 3292951
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PREFACE

Buffalo is the major livestock species in India for milk production. The contribution of buffaloes in the total milk production of the world is 12.3% but in India, buffaloes are contributing more than 55% of the total milk produced. A total of 97.92 million buffaloes of India are broadly classified under 10 recognized breeds along with many nondescript and lesser-known populations. Among recognized breeds of buffalo, most of them are distributed in northern, western and central parts of the country. Nagpuri is one of the most promising breeds of buffalo found in Vidarbha region of central India, contributing towards the livelihood of the small and marginal farmers and landless labourers. Also known with the synonyms of Berari, Gaorani, Purnathadi, Varhadi, Ellichpuri, Gaolavi, Arvi etc. the typical features of Nagpuri are swords like long horns. The buffaloes are known for high milk fat percentage, regularity in breeding, adaptation to hot climate and persistency in milk production. Average lactation milk yield in Nagpuri buffaloes has been recorded as 1038 kg in an average lactation length of 303 days with an average milk fat of 8.25 percent. Indiscriminate use of Murrah and Surti semen in the breeding tract is diluting Nagpuri germplasm and there is a need to formulate and execute systematic genetic improvement programme under field conditions for conservation and increasing the productivity of the Nagpuri breed.

In the literature, the information on this breed is meager. A detailed study was carried out under ICAR's Network Project on Animal Genetic Resources in collaboration with the Maharashtra Animal and Fishery Sciences University, Nagpur for phenotypic characterization of the breed. Using 25 microsatellite markers, the molecular genetic characterization of this breed has also been completed by the scientists of NBAGR, Karnal. A comprehensive review of the literature available on Nagpuri buffalo was also carried out to compile all the information in the shape of monograph to document the breed. We are hopeful that this monograph will definitely help the academician and policy planners in further development of the breed.

We express our gratitude to Director General, ICAR and DDG (AS), ICAR for encouraging and persuading us to undertake the documentation of Animal Genetic Resources of the country. We wish to plunk our heartiest thanks to Director, NBAGR, Karnal for providing direction, support and suggestions in completing the assignment. We also extend our sincere thanks to the authorities of MAFSU, Nagpur for supporting the unit on Nagpuri buffalo under Network Project. We are grateful to different divisions/ sections of the Bureau specially library, computer and photography sections for necessary inputs in compilation of information on Nagpuri buffalo.

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1. Introduction

India possesses best buffalo breeds of the world, very well adapted to local climatic conditions. With a total 10 descript breeds, buffalo population in India has recorded an increasing trend with total buffalo heads being 9.7 crores (FAO, 2004). Buffaloes in India are reared mainly for milk production however they have important contribution to our meat production and draught power as well. Most of the descript breeds in our country are confined to North or Central-Western parts. Nagpuri is one such breed distributed widely in the 'Vidarbha' region of Maharashtra. Reared mainly for fat production, Nagpuri buffaloes are the source of extra income for the farmers. The breed is well known for high fat in milk, regularity in breeding, resistance to diseases and adaptation to hot climate with low maintenance cost.

These buffaloes also known by the synonyms of Berari, Gaorani, Purnathadi, Varhadi, Ellichpuri, Gaolavi, Arvi, Shahi, Chanda, Gaolaogan, Gangauri etc., got their popularly recorded name of Nagpuri for their distribution in and around Nagpur region. History of Nagpuri buffaloes shows oldest records in the National Museum, New Delhi, wherein a seal of Siva from Indus Valley Civilization depicts a typical Nagpuri buffalo. Use of Nagpuri buffaloes for moving heavy loads to build temples 3000-4000 years ago, is also depicted on ancient stone carvings in Hyderabad. Scientifically recorded information on Nagpuri buffaloes is available through a paper presented by Kothawala at the 10th World Dairy Congress at Rome in 1934. Information on its distribution and performance has been recorded by Kaura (1952) and since 1975 the Nagpuri buffaloes have found a place in ICAR publications and F.A.O. records.

2. Distribution and breeding tract

The Nagpuri buffalo is a dual purpose breed spread in the Vidarbha region of Maharashtra (Fig. 1). The breeding tract mainly comprises of five districts Nagpur, Akola, Amravati, Wardha and Yavatmal of Mahrashtra

(Anon. 2005; Nivsarkar *et al*, 2000) Having synonym of Berari, this breed has four distinct strains- Purnathadi (Akola), Ellichpuri (Amravati), Gaulani (Wardha) and Nagpuri (Nagpur). Pandharpuri, Marathwadi and Surti are the phenotypically most closely related buffalo breeds. Typical Nagpuri buffaloes are seen in Hingna, Katol and Narkhed tehsils of Nagpur, Ellichpur, Paratwada, Daryapur and Anjangaon tehsils of Amravati District. Nagpuri animals are also seen in Arvi tehsil of Wardha and Darwha and Wani tehsils of Yavatmal districts of Vidarbha region.

Fig. 1. Breeding tract of Nagpuri buffalo

The breeding tract in five Maharashtra districts coveres an area of 41, 105 sq. km, which lies between 19° 26′ to 21° 46′ North and between 76° 37′ and 79° 98′ in East, 309 to 652 meters above mean sea level. The breeding tract of Nagpuri buffalo is predominantly dry region, with an annual rainfall of 95 cm, maximum temperature touching 44° C and mild winters with minimum temperature reaching to 14° C. The breeding tract borders Madhya Pradesh in North, Chhatisgarh in East, Andhra Pradesh in South and Marathwada region of Maharashtra in West.

Estimated buffalo breed composition in the breeding tract of Nagpuri showed 70.40% Nagpuri, 22.44% Murrah, 21.96% Surti and 2.97% Jaffarabadi buffaloes. A dicline of 10.20% in Nagpuri buffalo population in four districts, Nagpur, Akola, Amravati, Yavatemal of breeding tract due to influx of high yielding Murrah and Surti indicates necessity to adopt strategies for Nagpuri buffalo conservation.

Total estimated population of Nagpuri buffalo in breeding tract is approximately 2.4 to 2.6 lakhs. In four districts Nagpur, Akola, Amravati and Yavatmal, recent survey under Network Project on Animal Genetic Resources indicates age and sex wise distribution among 99872 Nagpuri animals as 42625 in milking of total 90311 females and 9561 male population. Percentage distribution of animals in the herds has been recorded to be 59.77% breeding females, 13.02% replacement females, 2.4% males and 17.63% female calves (Table 1). The animals are reared mainly by Nandagawali, Muslim-Gawali, Kunbhi (Maratha) farmers' communities. The animals are on 100% natural service with no artificial insemination practice in the area.

3. Socio-economic status of farmers

Farmers in the four districts Nagpur, Akola, Amravati and Yavatmal have average land holding of 8.01 acres with 4.38 acres irrigated land and annual income of Rs. 70,600/-. Amravati district had higher averages for these has compared to other three districts. Better socio economics status

Table 1: Age and sex wise distribution of Nagpuri buffaloes in four districts of the breeding tract*

District	Age Group											Grand Total
	Up to 1 year			1 to 3 years			3 years and above					
	M	F	Total	M	F	Total	M	F	In-milk	Breedable females	Total	
Nagpur	1733	4093	5826	1255	3670	4925	1267	5474	8193	13667	14934	25685
	(6.75)	(15.29)	(22.68)	(4.89)	(14.29)	(19.18)	(4.93)	(21.31)	(32.00)	(53.21)	(58.14)	
Akola	208	3039	3247	56	820	876	193	876	7570	8446	8639	12762
	(1.65)	(23.80)	(25.45)	(0.43)	(6.43)	(6.86)	(0.75)	(6.86)	(59.32)	(66.94)	(66.17)	
Amravati	2150	8495	10645	527	6987	7514	453	6914	21163	28077	28530	46689
	(4.60)	(18.20)	(22.80)	(1.14)	(14.96)	(16.10)	(0.97)	(14.80)	(45.33)	(60.13)	(61.10)	
Yavatmal	1021	1988	3009	562	1520	2082	136	3810	5699	9509	9645	14736
	(6.94)	(13.49)	(20.42)	(3.81)	(10.31)	(14.21)	(0.92)	(25.85)	(38.67)	(64.53)	(65.45)	
Total	**5112**	**17615**	**22727**	**2400**	**12997**	**15397**	**2049**	**17074**	**42625**	**59699**	**61748**	**99872**
	(5.12)	**(17.63)**	**(22.75)**	**(2.40)**	**(13.02)**	**15.42**	**2.05**	**(17.09)**	**(42.67)**	**(59.77)**	**(61.83)**	

**Figures in parentheses indicate percentage of animals.*
Source: Final report of MAFSU, Nagpur survey unit under Network project on Animal Genetic Resources, NBAGR, Karnal.

and better adaptability of animals to the agro-climatic conditions of Amravati district were attributed to higher Nagpuri buffalo population in this district. Most of the region is covered with dark brown to black soil and hilly region has brown soil mixed with sand. The region is well known for cotton production. Sorghum and groundnut are other major crops alongwith cultivation of wheat, maize, Bajra and Ragi. People in the region are shifting from cotton cultivation to Soyabean now. The Nagpur region is also famous for orange fruits.

4. Animal housing and feeding

Majority of farmers (84.85%) tie their animals during night only and open houses provided to most of them. About 62.82% farmers had separate houses for animals. Majority of animal houses (86.28%) were kaccha and only 13.72% pakka houses (Fig. 2). Major fodder crops include Berseem, Lucern, Cowpea, M.P. Chari, Sugarcane tops and Soyabean residues. Dub and Napier are the fodder grasses available in the area. Animals are taken

Fig. 2. Housing of Nagpuri buffaloes

for grazing in open fields and hay, karbi and wheat starw are fed along with concentrates like cotton seed hay and green fodder to stall fed animals (Fig. 3). For watering animals in herds are taken to ponds (Fig. 4) or have common watering system (Fig. 5).


Storage of dry fodder (a)


Storage of dry fodder (b)


Dry fodder and concentrate feeding (a)


Dry fodder and concentrate feeding (b)


Grazing in the field


Green fodder


Feeding of concentrate at door step


Foliage feeding

Fig. 3. Feeding practices of Nagpuri buffaloes

Fig. 4. Wallowing/ watering of Nagpuri buffalo herds during grazing

Fig. 5. Common watering at farmer's door

5. Physical and morphometric characteristics

Typical adult Nagpuri females and males are shown in Fig. 6 and Fig. 7 calves are shown in Fig. 8. Majority of Nagpuri buffaloes (82.05%) are black in colour with 17.95% brown and other colour variants (Fig. 9). White patches

Fig. 6. Typical Nagpuri adult females

Fig. 7. Typical Nagpuri adult males

Fig. 8. Nagpuri calves

Fig. 9. Coat colour varients in Nagpuri buffalo

on face, legs, and tail tips are common features. Purnathadi strain is slightly brownish with predominant white patch on the forehead. The animals have typical long sword like horn structure, varying from 50-65 cm, which are flat, heavier in males, curved and carried back on the sides of neck reaching upto shoulders. Forehead is straight, nearly plane and face long and thin, cone shaped with straight profile of medium size frontal bones (Anon. 2005).

A report on 200 Nagpuri buffaloes morphometry (Shrikhande et al., 1996) showed bulging shape forehead in 61.5% of animals with 53.5% cases having white patches. Depending upon the degree of white patches on the forehead and nasal portion the animals are locally called as "Ardh-Chandri", "Chandri", "Kapal-Chandri" and "Gal-Bhondi" etc. (Fig. 10). Legs in 59% animals were black coloured but switch of tail to be white in 81.5% of animals. Black body colour was seen in 91.5% animals with 83% having black muzzle also. Colour of eyes was black in majority of animals (88%). Ears are moderate in length with horizontal orientation in majority of animals. Buffaloes are

Fig. 10. Different head markings in Nagpuri buffalo

reported to be lighter body weight (average 363.48 kg). Average height at withers was measured to be 12.41 cm + 2.34, girth 172.61 cm + 4.12, body length 128.00 cm + 3.70. Horns are blackish-brown in color, flat, long, wide and thick at base, straight, carried backward on each side of neck upto shoulders, like a pair of swords (Fig. 11). In males horns are shorter in length

compared to females. The distance between two horns was measured to be 14.95 cm + 0.92, length of horns 63.76 cm + 4.30, circumference of horn base 16.47 cm + 1.01, length of head from muzzle to pole was found to be 51.29 cm + 4.13. Under Network project on Nagpuri buffalo various physical measurements recorded recently are shown in Tables 2 to 8 below.

Fig. 11. Typical sword like horns in Nagpuri buffalo

Table 2. Body measurements of three different age groups of Nagpuri buffalo males (Mean ± S.E.)

Traits	Upto 1 year (96)	1 to 3 years (59)	3 years and above (138)
Chest girth (cm)	87.02 +5.93	129.03 + 3.16	179.20 + 2.39
Body length (cm)	60.87 + 1.83	89.45 +3.09	133.4. + 2.39
Height at withers (cm)	73.14 + 1.51	103.23 + 2.51	124.32 + 0.88
Body weight (Kg)	84.61 + 6.07	180.21 + 9.77	396.19 + 12.76

Table 3. District-wise body measurements of adult Nagpuri buffalo male

S.N.	Characters	Districts			
		Nagpur (52)	Akola & Amravati (77)	Yavatmal (9)	Pooled (138)
1	Chest Girth(cm)	177.23+2.44	180.94+2.48	179.44+2.32	179.20+2.39
2	Body Length(cm)	129.27+1.39	131.06+3.57	139.89+2.24	133.40+2.39
3	Height at Withers(cm)	123.81+1.16	126.82+2.06	122.33+0.44	124.32+0.88

Table 4. Body measurements of three different age groups of Nagpuri buffalo female (Mean ± S.E.)

Traits	Upto 1 year (508)	1 to 3 years (374)	3 years anda bove (2142)
Chest girth (cm)	90.87 +2.38	130.92 + 2.66	175.02 + 0.53
Body length (cm)	62.80 + 1.36	89.67 + 1.49	121.21 + 0.46
Height at withers (cm)	77.74 + 1.74	103.92 + 1.43	123.67+0.32
Body weight (Kg)	91.70 + 2.07	188.52 + 6.79	349.26 + 2.01

Table 5. District-wise body measurements of adult Nagpuri buffalo female (Mean ± S.E.)

S.N.	Characters	Districts			
		Nagpur (860)	Akola & Amravati (917)	Yavatmal (365)	Pooled (2142)
1	Chest Girth (cm)	172.42+0.48	182.23+0.52	170.43+0.74	175.02+0.53
2	Body Length (cm)	119.46+0.35	121.02+0.43	123.15+0.55	121.21+0.46
3	Height at Withers (cm)	123.04+0.25	124.55+0.32	123.43+0.46	123.62+0.32
4	Body Weight (kg)	338.34+1.61	365.24+1.98	344.21+2.31	349.26+2.01

Table 6. Average morphometric measurements of adult male and female Nagpuri buffalo (Mean ± S.E.)

Traits(cm)	Male (293)			Female (3024)		
	Up to 1 yr.	1 to 3 yr	3 yrs & above	Up to 1 yr.	1to 3 yr	3 yrs & above
	(96)	(59)	(138)	(508)	(374)	(2142)
Horn length	6.29+0.27	24.45+2.76	54.83+2.96	6.86+0.53	27.99+1.68	61.55+0.48
Head length	26.69+1.08	38.16+1.27	46.98+0.68	29.08+0.85	38.58+2.59	47.96+0.31
Head width	14.03+0.48	18.05+0.67	18.29+0.69	13.90+0.28	17.70+0.38	19.81+0.15
Ear length	16.51+1.01	20.06+0.71	24.11+0.43	17.55+0.83	21.03+0.36	24.26+0.10
Tail length	31.09+0.22	39.42+1.05	54.37+1.58	32.00+0.15	41.18+0.32	50.82+0.20

Table 7. Phenotypic characteristics of Nagpuri buffalo recorded in the breeding tract

Characteristics	No. of Animals	Per-cent	Characteristics	No. of Animals	Per-cent
Coat-Colour:			**Dewlap:**		
Black	2541	82.05	Large	40	1.28
Bhura	295	9.53	Medium	393	12.69
Brown	261	8.42	Small	2664	84.02
Skin colour:			**Naval flap:**		
Black	2731	88.20	Medium	307	10.94
Bhura	273	8.80	Small	2497	89.05
Brown	93	3.00			
Muzzle:			**Penis sheath flap:**		
Black	2645	85.41	Large	18	6.11
Bhura	158	5.76	Medium	86	29.22
Brown	176	5.66	Small	189	64.67
White	98	3.17			
Eyelids:			**Basic temperament**:		
Black	2705	87.37	Docile	2694	87.00
Bhura	158	8.32	moderate	403	13.00
Brown	176	4.31			
Tail:			**Udder** :		
Black	408	13.16	**a) Shape:**		
Bhura	19	0.61	Bowl	147	8.90
Brown	10	0.31	Round	229	13.82
Tail switch	2660	85.92	Trough	869	52.46
Hoofs:			Globular	412	24.82
All Black	1970	63.62	b) **Fore udder**:		
All Bhura	681	21.99	Large	214	12.89
All Brown	27	0.89	Medium	856	51.66
Front white	91	2.89	Small	587	35.45
Rear white	326	10.52			
Rear Black	2	0.07			
Horns:			c)**Rear udder**:		
Colour –Black	2153	69.51	Large	166	10.03
Gray	355	11.47	Medium	1041	62.83
Brown	589	19.02	Upward	2435	78.62
Shape- Curved	960	31.01			
Straight	2137	68.99			

Characteristics	No. of Animals	Per-cent	Characteristics	No. of Animals	Per-cent
Orientation/ Pointing tip-			d) **Teat shape:**		
			Cylindrical	317	19.15
Small	450	27.14	Funnel	50	3.05
Downward	83	2.68	Conical	1290	77.80
Backward	579	18.70	e) **Teat tip**:		
Ear:			Pointed	515	31.09
Horizontal	2485	80.25	Round	1109	66.90
Dropping	612	19.75	Flat	33	02.21
Body:			f) **Milk vein**:		
Hump-Small	3097	100	Large	87	5.28
			Medium	1309	78.97
			Small	261	15.75

Table 8. Body weight and body measurements in Nagpuri buffaloes-review

Trait	Data size	Mean	Reference	Remarks
Birth weight	1028 calves (1945-69)	28.55±0.27 kg	Ambalkar *et al* (1981a)	No significant effect of sex, parity or month of calving.
Body weight	200 adult female buffaloes from 20 villages	363.5 kg	Shrikhande *et al* (1996)	Most buffaloes had a convex forehead, black body and legs, and a white end of the tail.
Withers height	200	121.3 cm	Shrikhande *et al* (1996)	
Body length	200	128.0 cm	Shrikhande *et al* (1996)	
Horn length	200	63.8 cm	Shrikhande *et al* (1996)	
Horn length	70	58.41 cm	Ali *et al* (1994)	
Horn breadth	70	21.08 cm	Ali *et al* (1994)	
Head length	70	47.08 cm	Ali *et al* (1994)	
Height	70	127.8 cm	Ali *et al* (1994)	
Head breadth	70	20.97	Ali *et al* (1994)	
Distance between pin bone and hip	70	38.71 cm	Ali *et al* (1994)	
Heart girth	70	186.80 cm	Ali *et al* (1994)	
Body length	70	124.0 cm	Ali *et al* (1994)	

6. Production and reproduction traits

6.1 Production traits

The detailed production and reproduction performances of Nagpuri buffaloes based on recently collected field data are given in Tables 9 and 10.

Table 9. District-wise production traits recorded in Nagpuri buffalo in breeding tract

S.N.	Productive Traits	District			
		Nagpur (687)	Akola (980)	Yavatmal (247)	Avg.(1914)
1.	Daily milk yield (Kg)	5.02+0.24	4.80+0.22	5.65+2.47	5.15+0.23
2	Peak milk yield (Kg)	7.28+0.19	6.60+0.20	7.65+0.35	7.14+0.25
3	Lactation length (Days)	298.49+9.53	314.90+10.81	306.49+16.68	303.26+16.80
4	Lactation milk yield (Kg)	1066.07+42.28	882.30+33.03	1167.10+43.39	1038.49+39.56
5	Fat %	8.13+0.19	8.41+0.33	8.10+0.16	8.21+0.19
6	Dry period (Days)	109.16+9.58	131.14+6.63	128.36+5.96	122.78+7.34

Table 10. Lactation-wise milk production traits in Nagpuri buffalo (Mean ± S.E.)

Lactation O/N	DMY (Kg)	PMY (Kg)	LMY (Kg)	LL (Days)	DP (Days)	Fat %
Lact. 1 (190)	5.19±0.04	6.46±0.28	859.84±29.19	279.43±24.07	120.80±6.91	8.33±0.23
Lact. 2 (376)	5.38±0.07	7.12±0.24	1065.09±52.28	309.78±9.02	118.92±5.76	8.21±0.26
Lact. 3 (538)	5.47±0.09	7.60±0.29	1087.45±35.20	305.12±7.55	116.17±4.42	8.30±0.29
Lact. 4 (360)	5.33±0.11	7.35±0.18	1057.19±40.82	308.07±8.41	120.77±5.79	8.62±0.26
Lact. 5 (209)	5.29±0.27	7.45±0.24	1079.15±57.46	303.68±10.63	113.66±5.22	8.10±0.32
Lact. 6 (136)	5.33±0.33	7.15±0.24	1064.82±53.91	313.79±12.19	116.99±6.66	8.10±0.29
Lact. 7 & above (105)	5.54±0.30	7.04±0.37	1057.23±66.83	330.47±15.75	138.42±12.19	8.10±0.32
Overall (1914)	5.36±0.31	7.17±0.26	1038.68±	268.19±12.51	120.82±6.72	8.25±0.28

DMY-Daily Milk Yield; PMY-Peak Milk Yield; LMY-Lactation Milk Yield; LL-Lactation Length; DP-Dry Period.

Their udder is medium in size mostly trough shaped and milk veins are medium to well developed (Fig. 12). Shrikhande et al. (1998), reported

Fig. 12. Fore and rear udder with prominant milk veins

average lactation yield of Nagpuri buffalo based on 200 animals' record to be 1036.24 litres in agreement with earlier report of Khire et al. (1977), who reported average lactational yield of 1043.19 litres. Under village conditions this performance of Nagpuri buffalo is far better than all India average buffalo milk yield of 500-700 litres. Average lactation length recorded by Shrikhande and coworkers (1998) was 242.68 days with peak yield period of 90 days. Baglane et al. (2005) analyzed productive performance of 410 lactation records of Purnathadi strain of Nagpuri buffalo recently under farm conditions. The lactation length ranged between 261 to 355 days with an average of 299.55+1.03 days. The average milk yield in the present study was found to be 930.26+7.25 kg with a wide range between 615 to 1455 kg. The average dry period was 189.54+2.09 days with a range between 134 to 302 days. Nagpuri buffaloes are known for their longivity and animals upto 32 years of age with 23 calvings have been recorded (Fig. 13). Production traits in Nagpuri buffaloes have been reviewed in Table 11.

Fig. 13. Thirty- two years old Nagpuri buffalo in 23rd calving

Table 11. Production traits in Nagpuri buffaloes- review

Trait	Data size	Mean	Reference	Remarks
Lactation milk yield	200 buffalo cows Gauli strain of Nagpuri	1243 litres	Kolte and Sodekar (1996)	
Lactation milk yield	53 (1958-76)	1049.66 ±14.80 kg	Khire *et al* (1983)	Increased from the 1st to 5th lactation, and then declined. Parity had a significant effect on lactation milk yield.
Lactation milk yield	Over 20 yr on 348 lactations of 76 buffaloes	1060.20 ±16.93 kg	Belorkar *et al* (1977)	
First lactation yield	76	926 litres	Khire *et al* (1977)	
Lactation duration	200	270.5 days	Kolte and Sodekar (1996)	
Lactation length	76	297.85 ±3.12 days	Khire *et al* (1983)	No significant effect of parity on the trait.
Lactation length	Over 20 yr on 348 lactations of 76 buffaloes	279.56 ±3.13 days	Belorkar *et al* (1977)	
First lactation length	76	295 days	Khire *et al* (1977)	
Dry period	374 pregnancies of 76 females during 1956-1975	129.07 days	Kadu (1978)	
Dry period	Over 20 yr on 348 lactations of 76 buffaloes	129.07 ±4.85 days	Belorkar *et al* (1977)	
Producing ability	76	1043 litres (range 782-1518)	Khire *et al* (1977)	Herd av. nr/[1 + (n-1)r].(cow's own average-herd average); where n is number of lactation completed and r is repeatability of lactation yield.

6.2 Repeatability of economic traits

Ambalkar *et al* (1981b) analyzed the data on 210 females at 3 government farms and reported the pooled repeatability estimates for lactation milk yield, lactation length and calving interval to be 0.43, 0.41 and 0.43 respectively. Khire *et al* (1983) reported the repeatability of lactation milk yield as 0.64.

6.3 Reproduction traits

The study of reproductive performance in Nagpuri buffaloes indicated heifers attaining puberty at an average age of 48 months, whereas age at first calving was recorded to be 55 months.Various reproductive performance records of Nagpuri buffalo in collected under Network project, are shown in Table 12 and reviewed in Table 13.

Table 12. District-wise reproductive performance in Nagpuri buffalo in breeding tract

S.N.	Reproduction Traits		District			
			Nagpur (871)	Akola/ Amravati (934)	Yavatmal (216)	Overall (2021)
1.	Age at first Oestrus (Months)	Mean	45.27	44.90	41.87	44.73
		S.E.	+0.32	+0.21	+0.45	+0.17
2.	Oestrus cycle duration (Days)	Mean	21.07	21.01	21.02	21.02
		S.E	+0.16	+0.01	+0.0	+0.06
3	Oestrus duration (Hours)	Mean	16.93	18.84	20.30	18.17
		S.E.	+0.24	+0.26	+0.97	+0.19
4	Age at first mating(Months)	Mean	47.32	45.75	42.97	46.12
		S.E.	+0.31	+0.18	+0.48	+0.16
5	Age at first calving(Months)	Mean	58.38	56.61	53.89	57.08
		S.E.	+0.31	+0.20	+0.64	+0.17
6	Interval from calving to first conception (Days)	Mean	107.66	118.55	137.64	115.90
		S.E.	+1.36	+1.35	+5.98	+1.08
7	No. of services per conceptions	Mean	1.86	2.46	1.77	2.13
		S.E.	+0.02	+0.02	+0.06	+0.01
8	Calving interval (Days)	Mean	418.18	428.28	449.30	426.44
		S.E.	+1.36	+0.02	+5.75	+0.81
9	Gestation period (Days)	Mean	310.52	309.72	310.09	310.10
		S.E.	+0.05	+0.33	+0.06	+0.15

Table 13. Reproduction traits in Nagpuri buffaloes- review

Trait	Data size	Mean	Genetic parameter	Reference
Age at puberty	200	42 months		Kolte and Sodekar (1996)
Age at 1st conception	374 pregnancies of 76 females during 1956-1975	44.31 months		Kadu (1978)
Gestation period	200	309.7 days		Kolte and Sodekar (1996)
Gestation period	139	304.96 ±0.62 days	Male calves being carried an average of 1.89 days less than females, but the effect of sex of calf was not significant.	Ambalkar (1980a)
Age at 1st calving		1634 days		Khire *et al* (1977)
Age at 1st calving	200	55 months		Kolte and Sodekar (1996)
Number of services/ conception	374 pregnancies of 76 females during 1956-1975	1.31	r = 0.59	Kadu (1978)
Services required/ conception	60	1.2		Pargaonkar and Kaikini (1977)
Service period	374 pregnancies of 76 females during 1956-1975	96.49 days	r = 0.14	Kadu (1978)
Service period	348	97.51 ±4.84 days	Significantly correlated with dry period (0.22) and lactation milk yield (0.40)	Belorkar *et al* (1977)
Service period	684 calvings	139.54 ±9.64 days	Effect of season of calving was significant.	Ambalkar (1980b)

Trait	Data size	Mean	Genetic parameter	Reference
Service period	Over 20 yr on 348 lactations of 76 buffaloes	97.51 ±4.84 days		Belorkar *et al* (1977)
Overall service period	76	97 days	Significantly correlated with Breeding Efficiency (-0.37)	Khire *et al* (1977)
1st service period	76	133 days	Significantly correlated with Breeding Efficiency (-0.34)	Khire *et al* (1977)
Service period	60	68.38 days (range 34-435)	Buffaloes calving in the normal season manifested postpartum heat earlier than females calving out of season.	Pargaonkar and Kaikini (1977)
Interval from calving to the next oestrus	200	106 days		Kolte and Sodekar (1996)
Correlation between duration of uterine involution and the service period	60	0.42		Pargaonkar and Kaikini (1977)
oestrous cycle duration	200	19-21 days		Kolte and Sodekar (1996)
Breeding efficiency as 100 [365 (n-1)]/D n is total number of calvings and D is day from 1st to last calving.	76	89.68% (range 59.9-100.0).	h^2=0.38	Khire *et al* (1977)
Breeding Efficiency	374 pregnancies of 76 females during 1956-1975		h^2= 0.38	Kadu (1978)

Trait	Data size	Mean	Genetic parameter	Reference
Calving season	374 pregnancies of 76 females during 1956-1975	Monsoon-27.8 Autumn- 59.9 Winter- 11.2 Summer-1.1		Kadu (1978)
Calving interval	51	432.72 days (range 350-721) Significantly longer for females calving beyond normal season than in normal season (625 Vs 377.2 days)	No significant effect on subsequent lactation length or milk yield.	Pargaonkar and Kaikini (1977)
Calving interval	76	403.00 ±5.97 days	No significant effect of the parity on trait.	Khire *et al* (1983)
Calving interval	200	468.2 days		Kolte and Sodekar (1996)

Intercalving period was found to be 17 months and average gestation period was 305 days with average postpartum estrus period of 105 days. Ambulkar et al. (2005), gathered information on Berari (Nagpuri) buffalo under farm conditions and reported age at first calving ranging between 1295 to 2187 days with an average of 1682.64+30.65 days. Average gestation period was recorded to be 306.21+0.10 days which was 305.59 days for male births and 307.04 days for female births. The intercalving period was 490.64+3.16 days. The average breeding efficiency was 74.52+0.24 percent, which was comparable to Murrah.

Kaikini (1984) observed that out of the 365 females (32.25%) in oestrus, the distribution in summer, monsoon and winter was 7.52, 20.23 and 4.60% respectively., while the distribution of females in anoestrus was 2.92, 1.51 and 0.17%.

From two year study on a herd of 51 Nagpuri buffaloes, Pargaonkar and Kaikini (1974) reported that the time taken for complete uterine

involution averaged 10.73±0.35 days for the non-gravid and 23.57±0.96 days for the gravid horn. 84.53% of calvings were during Aug.-Oct., and the interval to post-partum oestrus averaged 55.10 days. The time taken for uterine involution was correlated with the interval to post-partum oestrus (0.66) and with the service period (0.42).

Kadu *et al* (1978) observed that horn of pregnancy had a significant effect on calf birth weight in Nagpuri buffaloes (141 births); calves from the right horn averaged 26.95 kg vs. 29.29 kg for calves from the left horn.

Kaikini *et al* (1976) reported pathological termination occurring in 8.35% of animals in 359 Nagpuri buffaloes. The respective overall incidences of embryonic mortality, abortion, stillbirth, dystocia and retention of placenta were 0.56, 1.95, 2.79, 1.11 and 1.95% respectively. No case of prolapse was recorded in Nagpuri buffaloes.

Chede *et al* (1992) found plasma average levels of progesterone and oestradiol-17-beta as 2.68±0.75 ng/ml and 14.98±1.74 pg/ml, respectively in the mid-luteal phase, and 0.15±0.13 ng/ml and 41.02±11.11 pg/ml at oestrus in cycling Nagpuri buffaloes.

Raut and Kadu (1988) monitored 52 oestruses in 40 Berari (Nagpuri) buffalo cows and 92.31% were ovulatory, and the interval from the onset of oestrus to ovulation averaged 14.76±0.36 h, the highest frequency of ovulation (45.84%) occurring 15-18 h after the onset of oestrus. Parity had no significant effect on the interval from oestrus to ovulation, but the interval was shorter in winter than in the monsoon period (15.75±0.44 vs. 16.37±0.27 h). As the interval from time of service to ovulation increased, the CR decreased, but was maintained at 60.00 to 71.43% for an interval of 16 to 28 h. The time of day of ovulation had no significant effect on fertility.

Raut and Kadu (1989) studied 52 oestrous periods in 40 Nagpuri buffaloes. In 8 of the 48 periods that were ovulatory, ovulation occurred within 9-12 h after the end of oestrus, 16 within 12-15 h, 22 within 15-18 h, 1 within 18-21 h and one >21 h after oestrus. On average, ovulation occurred 14.76±0.36 h after the end of oestrus in buffaloes of parity -3, 15.35±0.39 h after oestrus for parities 4 and 5, and 14.70±0.76 h after oestrus for parities 6 and 7. Ovulation occurred 16.37±0.27 h after oestrus in the monsoon season, 15.75±0.44 h in summer and 14.97±0.44 h in winter. Discharge of cervical

mucus was observed in 47 (90.38%) of 52 cases of oestrus (73.08, 15.38 and 1.91% in winter, summer and monsoon respectively). Consistency was either thin in early oestrus, becoming thick later, or was thick throughout oestrus (80.77 and 5.77% of females respectively). The pH averaged 8.07±0.09, ranging from 7.6 to 8.6.

7. Biochemical/blood group polymorphism

Biochemical polymorphism studies based on starch-gel electrophoresis of blood samples from up to 1746 buffaloes of 7 breeds (Bhadawari, Marathawada, Murrah, Nagpuri, Nili-Ravi, Pandharpuri and Surti) reported two Hb types, A1 and A2, present in 99% of the samples. There were 2 rare variant types: in one, the Hb concentration in the A2 electrophoretic band was only about half the normal value, and in the other there was a 3rd band, N. Three transferrin types were found, each with 3 bands. Type K was the most common, followed by D; type N occurred only in Nili and Surti samples. There were 2 types of albumin (AlbF and AlbS). The latter was very common. Amylase occurred in 3 forms, AmA, AmB and AmC, of which the first was the most common. Ceruloplasmin was monomorphic. Codominant alleles were involved in the inheritance of transferrin, albumin and amylase types. Blood groups were studied in 1734 animals of 6 breeds using 22 typing reagents. All 22 antigenic factors were present in all populations studied, though their frequencies varied between breeds and between herds within breeds. The blood group and biochemical polymorphism data obtained were used as the basis for analyses of the genetic relationships between the 7 breeds.

Joshi *et al* (1980) studied gene frequencies at 11 loci (Tf, albumin, amylase and the A, B, F, L, Q, O, S and B blood-group systems) in Marathwada, Murrah, Nagpuri, Nili, Pandharpuri and Surti buffaloes. Eight Murrah populations from different geo-climatic regions were involved. Meteorological data were collected for the location of each breed or population. The gene frequencies indicated a close genetic relationship between breeds from adjacent locations compared with breeds from distant

locations. The Nili appeared genetically close to the Murrah, and the Nagpuri, Pandharpuri and Marathwada breeds appeared closely related. The Surti remained a distinct population.

Khanna *et al* (1979) reported that 22 blood-typing reagents were produced in buffaloes. The J antigenic factor was present in the serum and erythrocytes. The distribution of 22 blood-group factors has been tabulated for 34 Marathwada, 1343 Murrah, 74 Nagpuri, 110 Nili-Ravi, 37 Pandharpuri and 136 Surti buffaloes. Frequencies varied among breeds, but no factor was exclusive to a single breed.

8. Genetic characterization

8.1 Cytogenetic characterization

As in other river buffaloes, Nagpuri buffalo also possesses 2n diploid chromosome number 50 with 24 pairs of autosomes and a pair of sex chromosome. as studied in Purnathadi strain. Cytogenetic architecture of Purnathadi buffalo was more or less similar to Berari buffalo (Fuke *et al*, 2003). Of the 24 pairs of autosomes, 11 pairs were recorded to be metacentric and 13 pairs as sub-metacentric. 'X' chromosome was longest and 'Y' chromosome was the smallest metacentric in size. Centromeric indices in Purnathadi were estimated to be slightly lower than those reported in Murrah and Paralakhemundi buffaloes.

8.2 Molecular genetic characterization

8.2.1 Microsatellite marker based characterization

Work has been carried out at National Bureau of Animal Genetic Resources, Karnal to characterize Nagpuri buffalo using microsatellite markers already identified for the genetic characterization of buffalo using heterologous cattle microsatellite primers. Study was based on PCR amplification of 25 microsatellite markers of 45 to 50 random DNA samples, of Nagpuri buffaloes and products were resolved in Urea-PAGE gels followed by silver staining (Fig. 14 and 15).

Alleles scored manually and data analyzed using 'POPGEN' software. The heterozygosity and other values recorded are given in Table 14, which shows effective and observed number of alleles at each locus. Moderate

Table 14. Number of alleles (Observed-no, Effective-ne), heterozygosity (Observed –Ho, Expected-He) and polymorphism information content (PIC) in Nagpuri buffalo.

Locus	no	ne	Ho	He (Nei*)	PIC
CSRM60	7.0000	2.3878	0.2683	0.5812	0.5560
ILSTS026	5.0000	1.9811	0.5122	0.4952	0.4224
HEL13	8.0000	4.8151	0.6977	0.7923	0.7696
ILSTS030	4.0000	2.2184	0.4884	0.5492	0.4849
ILSTS033	5.0000	2.6153	0.4762	0.6176	0.5439
ILSTS017	5.0000	3.1150	0.5909	0.6790	0.6259
ILSTS019	3.0000	**1.1163**	**0.0652**	**0.1042**	**0.1014**
ILSTS045	5.0000	1.4842	0.2857	0.3262	0.3021
ILSTS034	4.0000	1.3985	0.2340	0.2850	0.2727
ILSTS058	8.0000	**6.1073**	0.3409	**0.8363**	0.8153
ILSTS056	6.0000	1.4016	0.3191	0.2866	0.2763
ILSTS089	6.0000	4.6316	**0.7500**	0.7841	0.7517
CSSM66	4.0000	2.5901	0.6098	0.6139	0.5527
ILSTS036	6.0000	3.4037	0.4043	0.7062	0.6571
ILSTS095	5.0000	2.5658	0.3571	0.6103	0.5750
ILSTS029	5.0000	1.5722	0.3778	0.3640	0.3469
ILSTS028	6.0000	4.5353	0.7111	0.7795	0.7455
ILSTS052	7.0000	4.6633	0.5814	0.7856	0.7545
ILSTS031	4.0000	1.8856	0.3333	0.4697	0.4326
BM1818	9.0000	3.2156	0.4103	0.6890	0.6565
ILSTS068	**11.0000**	5.9822	0.6585	0.8328	**0.8329**
ILSTS060	6.0000	4.2983	0.2973	0.7673	0.7304
ILSTS061	11.0000	6.0719	0.5897	0.8353	0.8260
ILSTS073	**2.0000**	1.8772	0.3256	0.4673	0.3581
ILSTS025	5.0000	2.8868	0.4884	0.6536	0.6103
Mean	**5.8800**	**3.1528**	**0.4469**	**0.5965**	**0.5600**

Fig. 14. Urea PAGE gel analysis of Nagpuri DNA samples at microsatellite locus ILSTS030.

Fig. 15. Urea PAGE gel analysis of Nagpuri DNA samples at microsatellite locus ILSTS025.

levels of genetic variability depicted by range of Nei's expected heterozygosity values from 0.1042 (ILSTS019) to 0.8363 (ILSTS058) suggested effectiveness of these microsatellite loci for measurement of within breed genetic variability in Nagpuri buffalo. PIC estimates varied between 0.1014 (ILSTS019) and 0.8329 (ILSTS068). Quantification of Nagpuri breed structure reflected by average diversity measures viz. mean number of alleles (5.88), observed heterozygosity average (0.4469), mean expected heterozygosity (Nei's 0.5965) and mean PIC estimate (0.5600) implied a moderate amount of within breed genetic variability. The analysis of data for allele frequency distribution (mode shift indicator) showed a normal L shaped distribution; likelihood of that Nagpuri population has not experienced a recent reduction of their effective population size (Fig. 16).

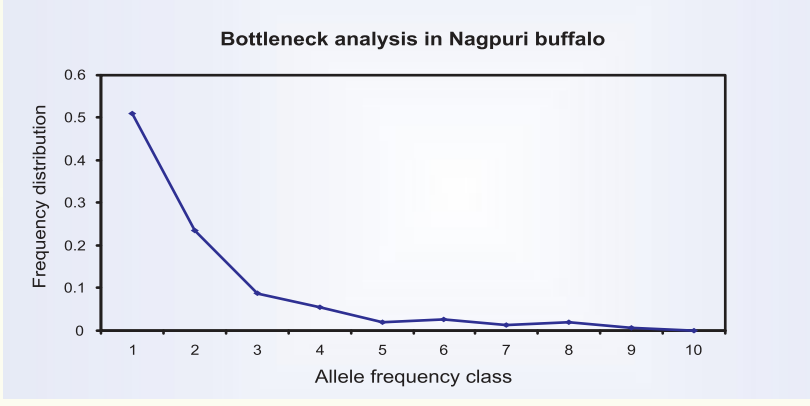

Fig. 16. Bottle neck analysis in Nagpuri buffalo.

8.2.2 Microsatellite markers based comparative analysis

Genotypic data across the 20 microsatellite markers has been analysed to estimate the genetic variability among four buffalo breeds Nagpuri, Pandharpuri, Surti and Mehsana of central/western India (Fig. 17).

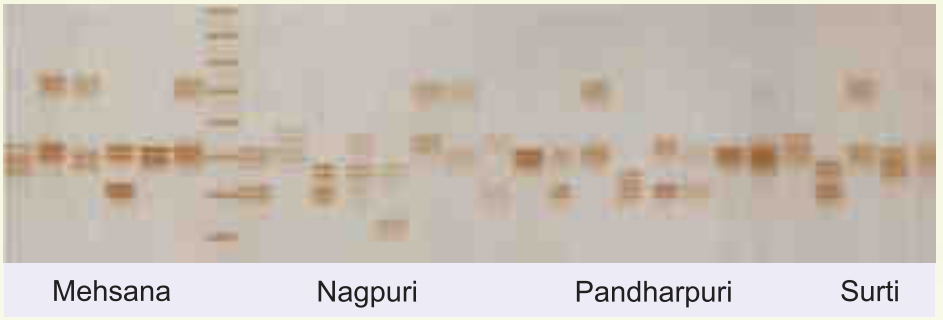

Fig. 17. Comparative gel analysis of four buffalo breeds at Locus ILSTS052

Total numbers of alleles observed in Nagpuri ranged between 2 (ILSTS073 locus) to 8 (ILSTS058 and HEL132 loci) with mean of 5.3, for Pandharpuri also it ranged between 2 (ILSTS073 and ILSTS031 loci) and 8 (HEL132 locus) with a mean of 4.6. For Surti buffalo range was between 2 (ILSTS073 locus) and 10 (ILSTS058) with a mean of 5.4 and for Mehsana it ranged between 2 (ILSTS073) to 7 (for ILSTS058 and 5 other loci) with mean of 5.2. The mean effective number of alleles for Nagpuri, Pandharpuri, Surti and Mehsana were 3.0, 2.7, 3.1 and 3.3 respectively (Fig. 18).

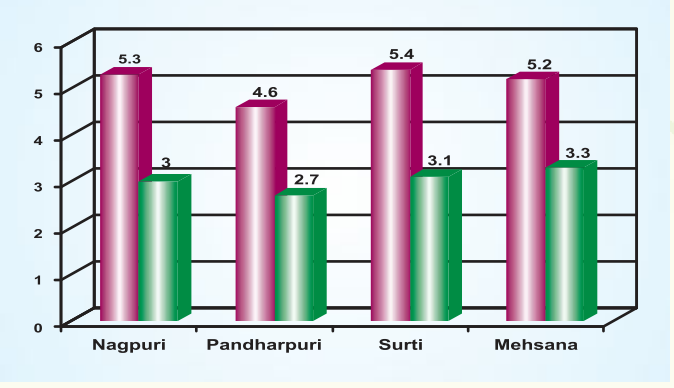

Fig. 18. Average allelic diversity across four buffalo breeds.

Mean observed heterozygosity for these four populations was 0.46, 0.40, 0.49 and 0.50 whereas mean Nei's expected heterozygosity across 20 loci was 0.58, 0.55, 0.62 and 0.65 respectively (Fig. 19).

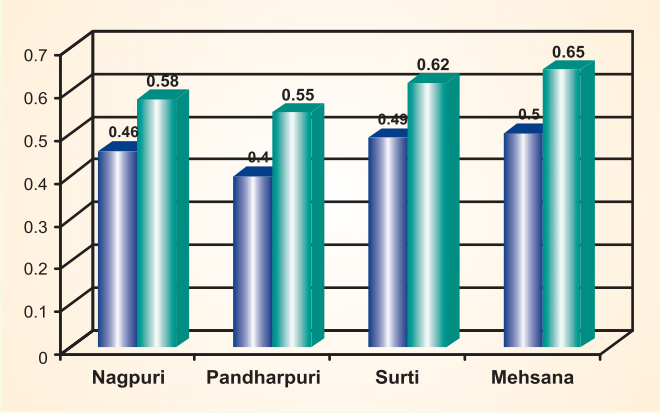

Fig. 19. Average heterozygosity values in four breeds of buffalo.

Comparative analysis of Nagpuri buffalo with Pandharpuri, Surti and Mehsana to establish between breed genetic variability in terms of genetic distances revealed Nagpuri buffalo having divergence of 0.2353 from Pandharpuri, 0.2811 from Surti and 0.4756 from Mehsana. Dendrogram based on Nei's genetic distance also showed placement of Nagpuri closest to Pandharpuri and most distant from Mehsana.

9. Conclusion

Though sizable population of this important breed of buffalo exists in its native tract of Vidarbha region, but it has shown marginal decline due to introduction of Murrah and Surti semen in the breeding tract. As majority of farmers whose livelihood is dependent on buffalo rearing to a great extent, want to retain this buffalo therefore state government should take following immediate steps for its conservation :

- Cross breeding should be stopped immediately and semen of only Nagpuri buffalo should be made available to the farmers.
- Large-scale propagation of elite germ plasm through MOET and embryo transfer programme should be encouraged.

- There is a need to establish a breed society for Nagpuri buffalo to look after the farmers' interest to encourage rearing of this breed in its breeding tract.
- Registration of elite animals of farmers through establishment of Herd Registration Society is required.
- Facilities for collection & storage of Nagpuri buffalo semen should be strengthened.
- To encourage Nagpuri buffalo rearing, farmers keeping elite animals should be given incentives and movement of elite animals from breeding tract should be checked.

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