Buffalo Genetic Resources of India

NILI-RAVI

Compiled and Edited
by

P. Kathiravan, B.P. Mishra, R.S. Kataria,
D.K. Sadana, and S.P.S. Ahlawat

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

Nili-Ravi Buffalo

Monograph 59, 2007

Buffalo Genetic Resources of India

NILI-RAVI

Compiled and Edited
by
**P. Kathiravan, B.P. Mishra, R.S. Kataria,
D.K. Sadana, and S.P.S. Ahlawat**

National Bureau of Animal Genetic Resources
(Indian Council of Agricultural Research)
G.T. Road By Pass, P.O. Box No. 129, Karnal-132001 (Haryana) India

Nili-Ravi Buffalo

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

Cover Design : Dr. P. Kathiravan

Photographs : Mr. Moti Ram

Printing : Intech Printers & Publishers
51-A, Model Town, Karnal - 132001
Tel. : 0184-4043541, 3292951
E-mail : vivek.intech@gmail.com

Nili-Ravi Buffalo

CONTENTS

PREFACE

Livestock has been an integral component of traditional agriculture since time immemorial. In India, buffaloes play pivotal role in livestock production through contributions in terms of milk, meat, hide and draft power for agricultural operations. In fact, all body parts of buffaloes are used including horns and hair. Buffalo forms a part of the property, possession and profession of rural farmers. They are an easily "Convertible Currency" and a reliable living bank to serve the immediate needs of the rural masses of several communities.

India is habitat of the best riverine breeds of buffalo in the world. Among the world's best buffalo genetic resources available in India, Nili-Ravi is one, with high milk production and good fat percentage. The breeding tract of this buffalo lies in the Ferozepur, Amritsar and Gurdaspur districts of Punjab. Nili-Ravi buffalo needs immediate attention of policy makers as the population is found to be declining. There is an urgent need for conservation and genetic improvement of this breed in order to exploit its genetic potential for high milk production.

This bulletin is compilation of information on production and reproduction performance of Nili-Ravi 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 for taking initiatives in compiling and updating the information available from the literature. The authors also feel grateful to I/C Photgraphy 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.

Authors

List of Tables

List of Figures

Nili-Ravi Buffalo

1. Introduction

India is the repository of buffalo genetic resources and is a major buffalo rearing country in the world. Around 57% of the world buffalo population is found in India, which contribute more than 50% of the total milk produced in the country. Out of the 10 well defined buffalo breeds, Nili-Ravi and Murrah are considered to be the best dairy types in the Indian subcontinent. Nili-Ravi buffaloes are very similar to Murrah and have got many characteristics in common. They closely resemble each other in appearance as well as in milk production. The native breeding tract of Nili-Ravi is spread all along the Sutlej river on the Indo-Pak border. Nili-Ravi buffaloes are best suited to water logged conditions of this region. Nili and Ravi were originally two distinct breeds as they belonged to geographically isolated areas. Frequent movement of animals with improvement in communication has resulted in their blending into a single identity. For this reason, they were generally classified and shown as one breed i.e Nili-Ravi by All India cattle show committee (ICAR, 1960).

2. Origin and Breeding Tract

In early 1930s, Nili and Ravi were referred as varieties of Murrah, which differed little except in geographical location (Olver, 1938). However, Nili was shown as a breed for the first time at the first All India Cattle Show held in 1938. After the second and third cattle shows, Nili and Ravi were described separately in ICAR bulletins (1941a).

The name Nili means blue and refers to supposedly blue waters of the river Sutlej. Nili was found in the Sutlej valley and particularly in Multan and Montgomery districts (both in Pakistan) and in Ferozepur district (India). Ravi was found in the Sandal Bar area of Ravi river valley (also called as Sandal Bar breed) particularly in Lyallpur, Montgomery, Gujrat and Thang districts (all in Pakistan) and in Amritsar district (India). Nili and Ravi breeds

were almost similar in appearance except in the facial conformation. Nili had a more convex profile, more coarse hairs on head and face, and a more conspicuous double chin. The horns were finer, more tightly coiled and circular in cross section. Ravi horns were oval in cross section and the transverse rings or pits were more conspicuous.

In spite of the distinct features between these two types, due to free movement and admixture of animals, the body features had been mixed and became difficult to differentiate them on the basis of phenotypic characters. Hence these animals were officially declared as single breed i.e Nili-Ravi during All India Cattle Show (ICAR, 1960). In Pakistan too, Nili and Ravi are no longer regarded as separate breeds.

The original breeding tract of Nili-Ravi buffaloes was the central Punjab between 71° and 75° E longitude and 29.5° and 32.5° N latitude. During

Figure 1. Breeding tract of Nili-Ravi buffaloes

partition, the breeding tract got divided between India and Pakistan. Nili-Ravi is now found in Ferozepur, Amritsar and Gurdaspur districts of Indian side of Punjab. The animals are found in Jira, Ferozepur, Makhu and Fazilka tehsils of Ferozepur district and Patti and Khemkoran tehsils of Amritsar district of Punjab. The breeding tract of Nili-Ravi in India lies between 74°04′ and 75°E longitude and 30°25′ and 31°25′ N latitude. Sandy loam and loam soils are found in this area. Climate is hot and dry for most parts of the year. Summers are very hot while winters are very cold. Rainfall is restricted mainly to July and August.

3. Distribution and Population Status

The estimated population of Nili-Ravi type of buffaloes in their breeding tract (Ferozepur, Amritsar and Gurdaspur districts of Punjab) is around 0.2 million (Vij and Tantia, 2005). The three districts have almost equal numbers of these animals. Ferozepur district, which is otherwise considered as a breeding tract of Nili-Ravi, now have more than 50% buffaloes of Murrah type. Ferozepur and Amritsar districts have only 10.8% and 8.7% of Nili-Ravi type buffaloes respectively. On the contrary, Gurdaspur district not known earlier as major breeding tract of Nili-Ravi, has the highest proportion (14%) of Nili-Ravi type buffaloes. The majority of buffaloes in the breeding tract are now found to be non-descript with 72.6% in Amritsar, 68.7% in Gurdaspur and 36.1% in Ferozepur districts. The large proportion of non-descript animals shows that the breeding of buffaloes in these areas lack proper planning.

The population of Nili-Ravi buffaloes is found to be declining. The primary reason attributed for this decline is the higher market value placed on Murrah type black buffaloes. There is a definite market preference towards the Murrah type black animals and this combined with lack of quality Nili-Ravi bulls for breeding has resulted in decline of Nili-Ravi buffalo population.

4. Managemental Practices

4.1. Housing

Most of the farmers (97.6%) tie their buffaloes all the time. Animal houses though separate are found in the same premises as the residences of the farmer in most of the cases (85.6%). Animal houses are usually open (56.9%) made up of mud (48.8%) and bricks (46.5%), full walled (54.3%) with mud floor (66.4%). These are well ventilated (91%) and clean (88%). Drainage is provided in 51% of the houses (Vij and Tantia, 2005). Some of the farmers had even dug ponds in which buffaloes could wallow.

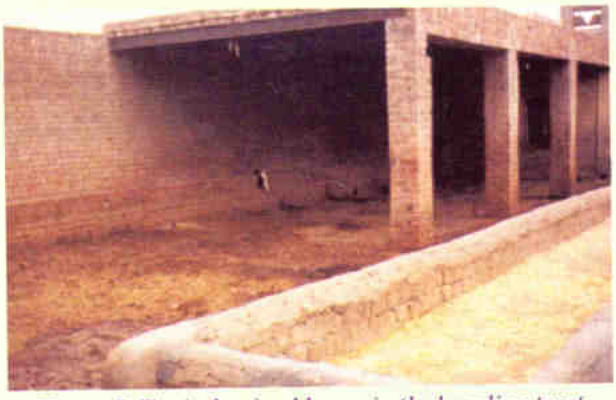

Figure 2. Typical animal house in the breeding tract

4.2. Breeding

Most of the farmers in the breeding tract of Nili-Ravi buffaloes resort to natural service rather than artificial insemination. According to Munish Kumar (2004), about 86.25% of the farmers in the breeding tract follow natural service while only 1.25% of the farmers adopt artificial insemination. About 12.5% of the farmers were following both natural and A.I methods of breeding their Nili-Ravi buffaloes. The main reason for the prevailing situation is non-availability of superior quality semen and poor conception rate with A.I. under field conditions. However, even with natural mating, the number

of breeding bulls available is not adequate and the farmers are left with no other option of either breeding with Murrah or non-descript local bulls. This is found to be one of the reasons for the declining trend of this breed.

Figure 3. Nili- Ravi bull

4.3. Feeding

Most of the farmers grow fodder for feeding their animals and on an average a farmer had 0.5 ha of land under fodder production. Mostly the animals are stall-fed and are sent for grazing rarely. The green fodders that are available in this area are berseem, jowar, bajra and maize and these are found to be available throughout the year. Nili-Ravi buffaloes are fed in their breeding tract by stall feeding – 85%, grazing – 1.25% and both – 13.75% (Munish Kumar, 2004).

5. Physical Characteristics

Nili-Ravi buffaloes are of large size and have deep and low set frames. Head is elongated, bulging at top and is depressed between eyes. Muzzle is fine but with wide nostrils. Double chin is conspicuous. Horns are small, tightly curled and circular in cross section. The neck is long and thin in females while it is thick and powerful in the male. The chest is deep and well developed; the brisket is broad, but not excessive. There is no dewlap

and the umbilical fold is small. The legs are comparatively short, with good bones. The barrel is long, deep and capacious and the ribs are well sprung (Cockrill, 1974).

Figure 4. White markings on the face with typical horn pattern

The female is wedge shaped with relatively narrow forequarters and wide, roomy hindquarters. The male has a massive front and lighter rear. The back is wide and straight between the prominent withers and the slightly sloping rump. The hindquarters are strongly developed and slightly higher than the forequarters, with broad, strong loins and hip bones being distinctly apart. The pin bones are prominent and well set apart. The flank is fine and hollow. Thighs and buttocks are flat and broad but more muscular in the male. The twist is arched in the female, less so in the male. Hocks are strong and straight in the male, slightly bent in the female. The tail is well set, broad at the base and ends at the fetlock or just below it with a big tuft of hair which may trail on the ground. The udder is well developed, extending far forward and backward. Its skin is thin, pliable and soft to touch and the hair is coarse and scanty. The teats are long, even and squarely placed; milk veins are prominent, long and tortuous. Skin and hair are normally black-brown; fawn and grey animals are not uncommon. They are usually "wall-

eyed" and have white markings on forehead, face, muzzle, legs and tail. The most desired character of the female is the possession of these five white markings known as *"Panch Kalyani"*. Animals typically have white moustache. The survey by Vij and Tantia (2005) has revealed that their morphological characteristics have undergone some changes over the years. The true Nili-Ravi animals with all five white markings are rarely available. Most of the Nili-Ravi type buffaloes now available in the field have white markings on the forehead and hind limbs and some animals have wall eyes.

6. Morphometric Characteristics

Various morphological traits of Nili-Ravi buffaloes like body length, height at withers, heart girth, birth weight and adult weight are given in Table 1.

Table 1. Morphological characteristics of Nili-Ravi buffaloes

Characteristics	Sex	ICAR (1941b)		Sarwar and Ishaq (1957)		Nivsarkar *et al.* (2000)	Taneja, (2004)
		Nili	Ravi	Nili	Ravi	Nili-Ravi	Nili-Ravi
Body Length	Male	159.0	155.0	157.5	154.9	160.0	-
(cm)	Female	149.0	150.0	147.3	149.8	165.4	-
Height at	Male	137.0	133.0	132.2	132.1	140.0	140.0
Withers (cm)	Female	136.0	127.0	127.0	127.0	134.2	134.0
Heart Girth	Male	226.0	224.0	-	-	230.0	-
(cm)	Female	225.0	215.0	-	-	207.7	-
Birth Weight	Male	-	-	-	-	35.01	37.0
(Kg)	Female	-	-	-	-	34.5	34.0
Adult weight	Male	600.0	-	-	-	567.0	543.0
(kg)	Female	450.0	-	-	-	454.0	483.0

Figure 5. Nili-Ravi cow

7. Performance Traits in Nili-Ravi Buffaloes

7.1. Body weight and growth rate

The mean values of body weights at birth, 6,9,12,18,24 months and at first calving along with the heritability estimates as reported by various workers are presented in Table 2. The average daily gain in body weight was found to increase from birth to 6 months. However, it went on declining thereafter up to age at first calving (Sharma and Basu, 1984). In terms of

Table 2. Average body weight and heritability estimates at different ages

Stage	Sharma and Basu (1984)		Singh (2003)	
	Mean ± S.E (Kg)	h^2	Mean ± S.E (Kg)	h^2
At birth	29.97 ± 1.03	0.36 ± 0.22	29.53 ± 0.10	0.37 ± 0.08
3 months	84.33 ± 3.10	0.42 ± 0.24	-	-
6 months	139.50 ± 4.84	0.31 ± 0.21	144.07 ± 0.87	0.20 ± 0.05
9 months	185.86 ± 6.65	0.21 ± 0.19	-	-
12 months	243.25 ± 9.12	0.51 ± 0.26	231.73 ± 1.52	0.29 ± 0.07
18 months	-	-	309.97 ± 1.76	0.36 ± 0.08
24 months	395.22 ± 15.85	0.31 ± 0.21	380.66 ± 2.00	0.20 ± 0.05
At first calving	531.06 ± 21.74	0.23 ± 0.19	516.30 ± 2.38	0.17 ± 0.04

Figure 6. Nili-Ravi calf

body weight, on an average, Nili-Ravi animals gained 406.1 g daily from birth to first calving.

7.2. Age at first calving

The average age at first calving reported by various workers are presented in Table 3. It varied from 1137.48 days to 1596 days.

Table 3. Mean Age at First Calving in Nili-Ravi buffaloes

AFC (days)	No. of observations	References
1596 ± 18	-	Amble *et al.* (1958)
1248 ± 35.7	22	Amble *et al.* (1970)
1224	27	Singh and Singh (1977)
1259.72 ± 12.66	425	Reddy (1980)
1411.11 ± 9.7	-	Ahmad *et al.* (1983)
1137.48 ± 34.37	-	Singh *et al.* (1986)
1476	-	Ahmad *et al.* (1992)
1464 ± 270	-	Khan *et al.* (1997)
1282.75 ± 10.14	423	Naqvi and Shami (1999)
1359	-	Nivsarkar *et al.* (2000)
1387 ± 22	89	Chawla *et al.* (2003)
1350	-	Taneja (2004)
1427.10	-	Munish Kumar (2004)
1234.5 ± 16.5	59	Anonymous (2004)

7.3. Milk yield

7.3.1. First lactation milk yield

The mean first lactation milk yields reported by various workers are presented in Table 4. It varied from 1483 kg to 2013 kg. Amble *et al.* (1970) observed that the Nili buffaloes were better producers than Murrah and graded Murrah buffaloes. It was also substantiated by Patro and Bhat (1979a), who reported the averages of first lactation yield in Murrah, Murrah grades, Nili and Nili grades to be 1575.80 ± 36.58, 1609.80 ± 24.05, 1649.90 ± 41.34 and 1638.50 ± 30.75 kg respectively. The average yield for all lactations in Nili-Ravi has been reported by various workers as: 1560.90 kg (Chaudhury and Shaw, 1965); 1820 kg (Nivsarkar *et al.* 2000) and 1850 kg (Taneja, 2004).

Table 4. Average First lactation milk yield in Nili-Ravi buffaloes

First lactation milk yield (kg)	No. of observations	References
1661.50 ± 100.72	12	Amble *et al.* (1958)
1858.20 ± 106.34	18	Amble *et al.* (1970)
1878.60 ± 29.01	44	Singh and Singh (1977)
1649.90 ± 41.34	-	Patro and Bhat (1979b)
1706.53 ± 29.97	389	Reddy (1980)
1701.13 ± 51.836	-	Singh *et al.* (1986)
1629.80	-	Singh and Yadav (1986)
2013 ± 597	-	Khan *et al.* (1997)
1833.36 ± 16.56	652	Naqvi and Shami (1999)
1483	-	Nivsarkar *et al.* (2000)
1879 ± 47	89	Chawla *et al.* (2003)

7.3.2. Average daily milk yield

Amble *et al.* (1970) reported the average yield per day of first lactation length as 5.50 ± 0.34 and 6.10±0.22 kg in Nili buffaloes at two farms. The

estimates, however, were based on only 12 and 18 buffaloes respectively. Singh and Singh (1977) reported it as 6.04 kg based on 99 Nili buffaloes while Munish Kumar (2004) reported an average of 8.45 ± 0.32 kg. Naqvi and Shami (1999) reported an average daily milk yield of 6.72 ± 0.03 kg and 6.60 ± 0.21 kg in early and late maturing Nili-Ravi buffaloes respectively.

7.3.3. Peak yield

The average peak yield of two groups of elite Nili-Ravi buffaloes in different lactations are given in Table 5 (Chawla *et al.* 2003). The yield increased up to third lactation, reached its maximum and declined afterwards in Nili-Ravi animals. The peak yield of elite Nili-Ravi buffaloes was higher than Surti, Mehsana and Jafarabadi buffaloes (Anonymous, 2002).

Table 5. Peak yield in two groups of elite Nili-Ravi buffaloes

Lactation No.	Group I*	Group II**
1	10.8 ± 0.4	8.6 ± 0.4
2	13.8 ± 0.8	11.2 ± 0.6
3	16.3 ± 1.0	12.6 ± 1.6
4 & above	15.6 ± 1.2	11.7 ± 0.5

* Group I : Buffaloes producing more than 2300 kg in 1st lactation and more than 2500 kg in 2nd and later lactations in 300 days

** Group II : Buffaloes producing less than 2300 kg in 1st lactation and less than 2500 kg in 2nd and later lactations in 300 days

7.4. Lactation length

The average first lactation lengths of Nili-Ravi buffaloes reported by different workers are presented in Table 6. It varied from 277.77 to 355.94 days.

Table 6. Average first lactation length in Nili-Ravi buffaloes

First lactation Length(days)	No. of observations	References
304.90 ± 1.036	12	Amble *et al.* (1958)
305.80 ± 15.81	18	Amble *et al.* (1970)
310.70	44	Singh and Singh (1977)
306.13 ± 4.41	390	Reddy (1980)
355.94 ± 7.5	-	Singh *et al.* (1986)
285	-	Khan *et al.* (1992)
277.77 ± 2.02	652	Naqvi and Shami (1999)
294	-	Nivsarkar *et al.* (2000)
298	-	Taneja (2004)

7.5. Calving interval

The mean first calving interval reported by various workers is presented in Table 7. It varied from 443.03 to 579.99 days.

Table 7. Mean first calving interval in Nili-Ravi buffaloes

First Calving Interval (days)	No. of observations	References
461.60 ± 18.76	20	Amble *et al.* (1958)
444.90 ± 21.31	10	Amble *et al.* (1970)
508.39 ± 10.10	368	Reddy (1980)
520.50 ± 2.58	-	Singh *et al.* (1986)
490	-	Nivsarkar *et al.* (2000)
579.99 ± 12.90	-	Taneja (2004)
443.03 ± 49.31	78	Anonymous (2004)

7.6. Dry period

The average first dry period reported by various authors is presented in Table 8. It varied from 98.20 to 202.26 days.

Table 8. Average first dry period in Nili-Ravi buffaloes

First Dry Period (days)	No. of Observations	References
98.20	-	Chaudhury and Shaw (1965)
202.26 ± 8.00	368	Reddy (1980)
126.50 ± 6.33	-	Singh *et al.* (1986)
306.39 ± 8.78	592	Naqvi and Shami (1999)
151	-	Nivsarkar *et al.* (2000)
136.29 ± 26.67	78	Anonymous (2004)

7.7. Service period

The average first service period reported by various authors are presented in Table 9. It varied from 138.37 to 280.96 days.

Table 9. Average first service period in Nili-Ravi buffaloes

First Service Period (days)	No. of Observations	References
200.78 ± 10.32	340	Reddy (1980)
221.53 ± 4.57	-	Ahmad *et al.* (1983)
280.96 ± 9.32	617	Naqvi and Shami (1999)
202	-	Nivsarkar *et al.* (2000)
138.37 ± 9.00	78	Anonymous (2004)

7.8. Herd life and causes of culling in Nili-Ravi buffaloes

The average herd life of elite Nili-Ravi buffaloes was 145 ± 4.7 months. Five major causes of disposal, frequency and average herd life in months are given in Table 10 (Chawla *et al.* 2003). The frequency of buffaloes

disposed due to mastitis and infertility was 28.05 and 29.27% respectively. It was also found that every 6th buffalo was culled due to old age among total elite buffaloes. Buffaloes culled due to other reasons such as weakness, poor health, lameness, low production, etc. were found to constitute 18.29%.

Table 10. Causes of culling in elite Nili-Ravi buffaloes

S.No	Causes of culling	Avg. herd life in months	Frequency of buffaloes
1	Old age	206.0 ± 11.2	15.85
2	Mastitis	150.3 ± 7.4	28.05
3	Infertility	125.5 ± 6.8	29.27
4	Death	134.5 ± 13.2	8.54
5	Others	121.6 ± 5.4	18.29

Source : Chawla *et al.* (2003)

7.9. Heritability estimates in Nili-Ravi buffaloes

The heritability estimates of different production traits in Nili-Ravi buffaloes as reported by various workers are presented in Table 11.

Table 11. Heritability estimates of production traits in Nili-Ravi buffaloes

Traits	Reddy (1980)	Singh *et al.* (1987)	Singh and Yadav (1986)	Singh and Yadav (1989)	Manoharan *et al.* (2002)
AFC	0.14 ± 0.11	0.36 ± 0.15	0.25 ± 0.06	-	0.003±0.01
WFC	0.08 ± 0.12	-	0.24 ± 0.06	-	-
FLMY	0.08 ± 0.10	0.14 ± 0.19	-	-	0.10 ± 0.01
Y/LL	0.09 ± 0.10	-	-	0.01 ± 0.00	-
Y/C.I	0.31 ± 0.17	-	-	0.13 ± 0.00	0.11 ± 0.06
FLL	0.13 ± 0.11	0.26 ± 0.19	-	-	0.07 ± 0.14
FDP	0.02 ± 0.08	0.25 ± 0.05	-	-	-
FCI	0.10 ± 0.11	0.18 ± 0.06	0.06 ±0.04	-	0.04 ± 0.05
BE	0.22 ± 0.15	-	-	-	-

Figure 7. Nili-Ravi Cow with a calf

8. Genetic Characterization of Nili-Ravi Buffaloes

8.1. Characterization of Nili-Ravi buffaloes using microsatellite DNA markers

Microsatellite genotyping of Nili-Ravi buffaloes was carried out using microsatellite markers in the Buffalo Genomics Lab., DNA Fingerprinting Unit at NBAGR, Karnal. Heterologus bovine specific microsatellite markers already evaluated for buffalo diversity analysis were used for genotyping of Nili-Ravi buffaloes. A total of 25 microsatellite markers were used for the analysis. Across the 25 microsatellite loci studied, a total of 132 alleles were identified (Table 12). The allelic frequencies at different loci are presented

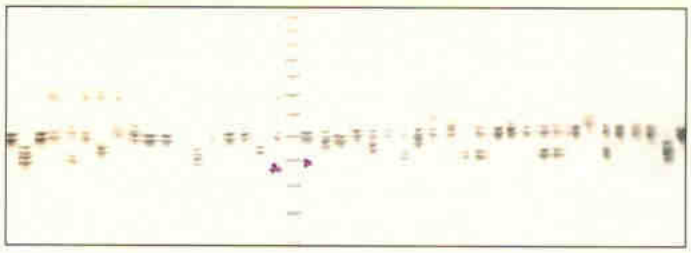

Figure 8. Microsatellite Polymorphism at ILSTS 052 locus in Nili-Ravi buffaloes

Table 12. Microsatellite loci analyzed, annealing temperature, observed and effective number of alleles in Nili-Ravi buffaloes

Locus	Annealing Temperature	Observed number of alleles*	Effective number of alleles*
CSRM 060	55	7	4.35
ILSTS 026	55	5	3.05
HEL 013	55	7	4.33
ILSTS 030	55	4	2.68
ILSTS 033	55	6	3.21
ILSTS 017	55	5	3.28
ILSTS 019	55	3	1.66
ILSTS 045	55	5	3.01
ILSTS 034	55	4	2.54
ILSTS 058	55	7	4.80
ILSTS 056	55	5	1.58
ILSTS 068	58	5	4.51
CSSM 066	55	6	5.26
ILSTS 036	55	5	4.03
ILSTS 095	58	5	2.42
ILSTS 029	55	4	1.34
ILSTS 028	55	7	4.78
ILSTS 025	55	5	2.49
ILSTS 052	55	10	3.67
ILSTS 031	60	4	1.61
ILSTS 073	55	2	1.51
ILSTS 060	63	4	3.22
BM 1818	55	5	1.58
ILSTS 061	55	7	4.35
ILSTS 008	55	5	3.84
Mean	-	5.28	3.16

* Kimura and Crow (1964)

in Figure 10 (a-y). The observed number of alleles varied between 2 (ILSTS 073) to 10 (ILSTS 052) with overall mean number of alleles per locus as 5.28. The mean effective number of alleles (3.16) was lower than the mean observed number of alleles. The effective number of alleles ranged between 1.34 (ILSTS 029) to 5.26 (CSSM 066). 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 0.585 and ranged between 0.242 (ILSTS 029) and to 0.783 (CSSM 066). According to Botstein et al. (1980), polymorphic markers were classified as highly informative with a PIC value ranging between 0.25 and 0.50 and slightly informative if the PIC value was below 0.25. Nineteen of the 25 loci had PIC values more than 0.5 suggesting that they are highly informative for population genetic analysis. Five loci were found to be reasonably informative and only one was less informative in Nili-Ravi buffalo population.

Observed heterozygosity varied between 0.174 (ILSTS 029) to 0.891 (ISLSTS 061) and the mean observed heterozygosity was less than average expected heterozygosity (0.633) (Table 13). Nei's average expected heterozygosity ranged between 0.255 (ILSTS 029) and 0.810 (CSSM 066). The test for Hardy-Weinberg equilibrium (HWE) showed that 16 of the 25 loci deviated significantly (Table 14).

Departure from HWE is mostly due to heterozygote deficiency which may result from one or more of the following reasons: (i) presence of null alleles (ii) small sample size and (iii) Wahlund effect i.e presence of fewer heterozygotes in a population than predicted on account of population subdivision. In farm animal species, the prevalence of sire lines selected for economic traits lead to increased consanguinity. Such a breeding system

Table 13. Summary of heterozygosity, polymorphism information content and F_{IS} at 25 different microsatellite loci in Nili-Ravi buffaloes

Locus	No. of Observations	Heterozygosity			PIC	F_{IS}
		Ho*	He*	Nei's He		
CSRM 060	29	0.448	0.783	0.770	0.740	0.418
ILSTS 026	36	0.583	0.682	0.672	0.614	0.132
HEL 013	44	0.841	0.778	0.769	0.738	-0.093
ILSTS 030	45	0.378	0.634	0.627	0.554	0.397
ILSTS 033	46	0.326	0.696	0.689	0.635	0.526
ILSTS 017	46	0.587	0.703	0.695	0.647	0.116
ILSTS 019	46	0.456	0.401	0.396	0.350	-0.152
ILSTS 045	47	0.617	0.675	0.668	0.607	0.076
ILSTS 034	46	0.739	0.614	0.607	0.551	-0.218
ILSTS 058	45	0.511	0.801	0.792	0.763	0.355
ILSTS 056	47	0.426	0.373	0.369	0.354	-0.154
ILSTS 068	47	0.362	0.787	0.778	0.744	0.535
CSSM 066	47	0.851	0.819	0.810	0.783	-0.050
ILSTS 036	42	0.571	0.761	0.752	0.710	0.240
ILSTS 095	46	0.239	0.593	0.587	0.509	0.593
ILSTS 029	46	0.174	0.257	0.255	0.242	0.317
ILSTS 028	46	0.522	0.810	0.710	0.762	0.340
ILSTS 025	33	0.364	0.608	0.598	0.560	0.392
ILSTS 052	47	0.596	0.736	0.728	0.707	0.181
ILSTS 031	46	0.326	0.385	0.380	0.352	0.143
ILSTS 073	44	0.432	0.343	0.339	0.281	-0.275
ILSTS 060	40	0.725	0.698	0.689	0.632	-0.052
BM 1818	45	0.178	0.370	0.366	0.351	0.514
ILSTS 061	46	0.891	0.779	0.770	0.740	-0.157
ILSTS 008	46	0.500	0.748	0.740	0.699	0.324
Mean	-	0.506	0.633	0.625	0.585	0.178

* Ho = Observed Heterozygosity
* He = Expected Heterozygosity
* Nei He = Nei's Expected Heterozygosity
PIC = Polymorphism Information Content
F_{IS} = Wright's Inbreeding Coefficient

produces reduced heterozygosity within a sub-population in a breed. In Nili-Ravi buffaloes, lesser availability of breeding bulls in the tract and intensive grading up with Murrah bulls might have contributed to increased consanguinity. This is further supported by the estimated mean value of F_{IS} in the population which was positive and equal to 0.178. Thus, the shortage of breeding bulls in the population and confinement of these buffaloes to a small geographical area could be the possible reasons for the deficiency of heterozygotes.

The test for BOTTLENECK 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 9. The distribution followed the normal L-shaped form suggesting that the breed did not encounter genetic bottleneck in the recent past.

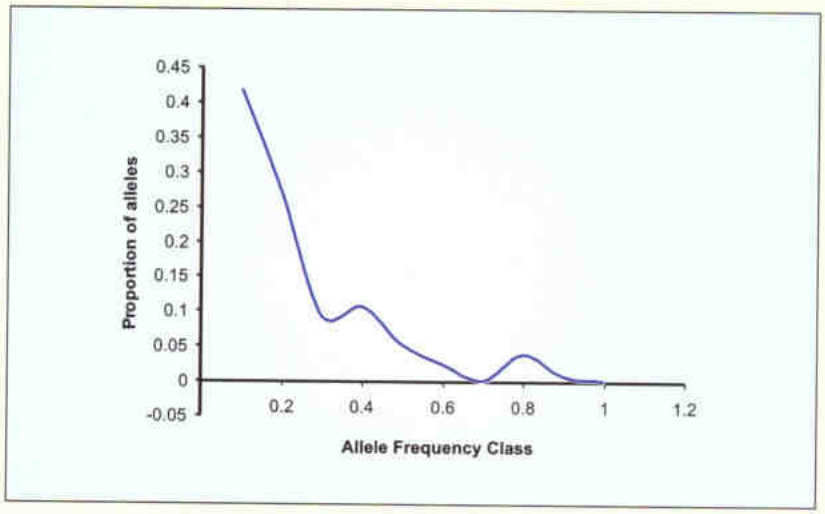

Figure 9. Mode Shift Indicator of bottleneck.

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

Table 14. Test for Hardy-Weinberg equilibrium at different microsatellite loci in Nili-Ravi buffaloes

Locus	DF	Chi Square	P-value
CSRM 060	21	102.90	0.000
ILSTS 026	10	12.90	0.230
HEL 013	21	23.70	0.308
ILSTS 030	6	38.29	0.000
ILSTS 033	15	54.72	0.000
ILSTS 017	10	21.11	0.020
ILSTS 019	3	2.29	0.515
ILSTS 045	10	9.30	0.504
ILSTS 034	6	7.71	0.260
ILSTS 058	21	81.60	0.000
ILSTS 056	10	3.24	0.975
ILSTS 068	10	61.92	0.000
CSSM 066	15	28.95	0.016
ILSTS 036	10	46.32	0.000
ILSTS 095	10	44.84	0.000
ILSTS 029	6	22.64	0.001
ILSTS 028	21	55.45	0.000
ILSTS 025	10	79.19	0.000
ILSTS 052	45	114.20	0.000
ILSTS 031	6	24.45	0.000
ILSTS 073	1	3.13	0.077
ILSTS 060	6	9.99	0.125
BM 1818	10	56.79	0.000
ILSTS 061	21	18.96	0.588
ILSTS 008	10	35.83	0.000

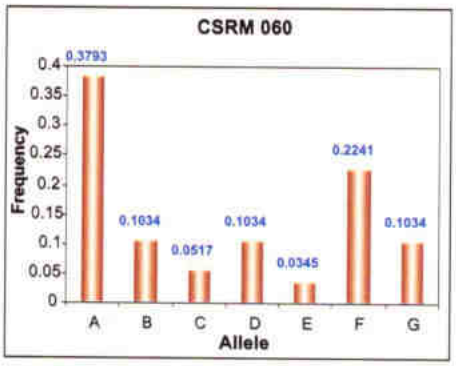

Figure 10 (a)

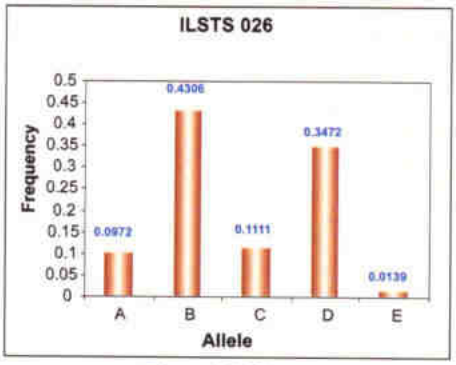

Figure 10 (b)

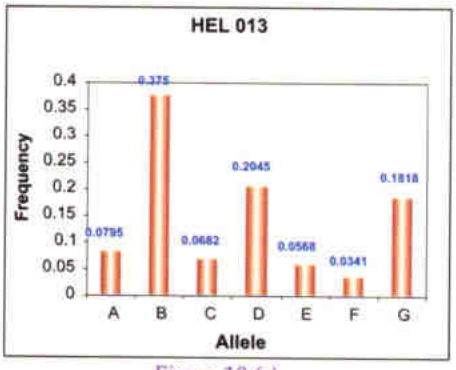

Figure 10 (c)

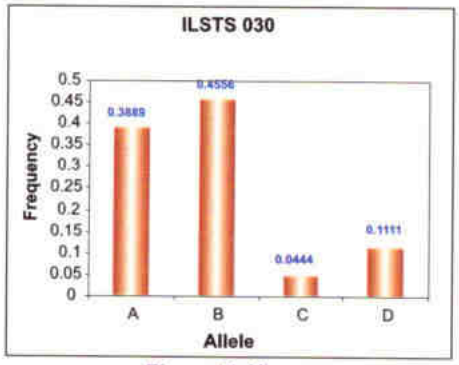

Figure 10 (d)

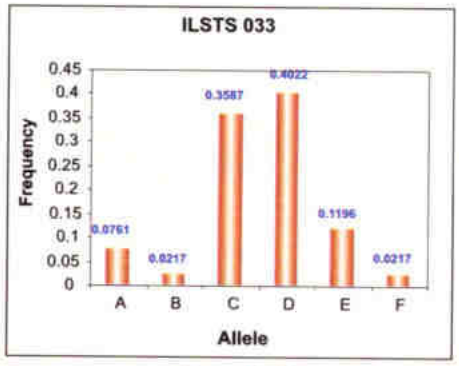

Figure 10 (e)

Figure 10. (a-e) Allelic frequencies at different microsatellite loci in Nili-Ravi buffaloes

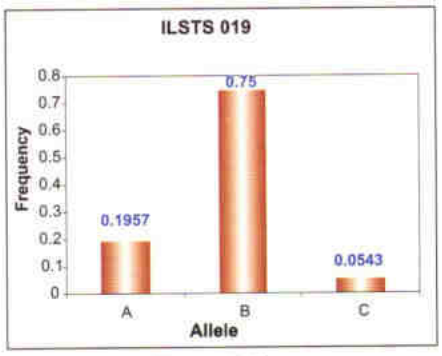

Figure 10 (f)

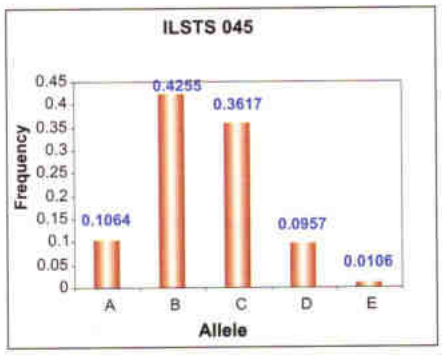

Figure 10 (g)

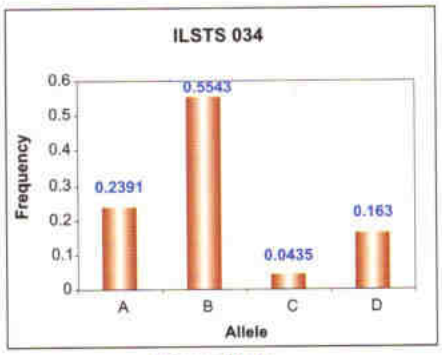

Figure 10 (h)

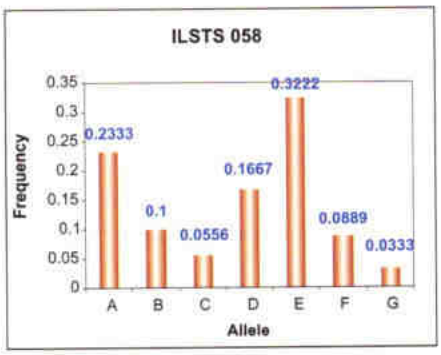

Figure 10 (i)

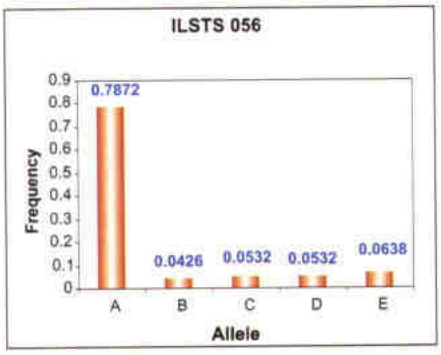

Figure 10 (j)

Figure 10. (f-j) Allelic frequencies at different microsatellite loci in Nili-Ravi buffaloes

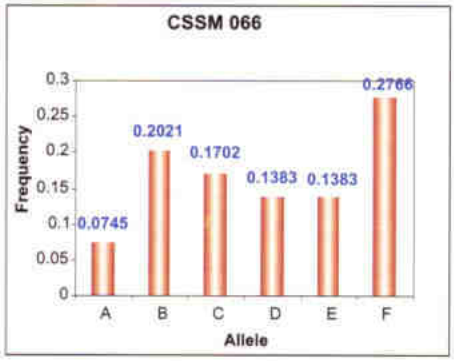

Figure 10 (k)

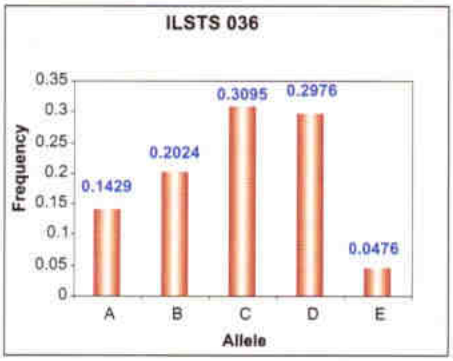

Figure 10 (l)

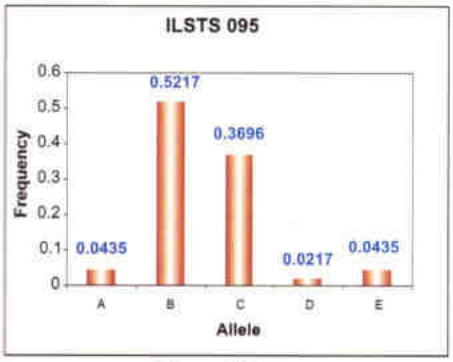

Figure 10 (m)

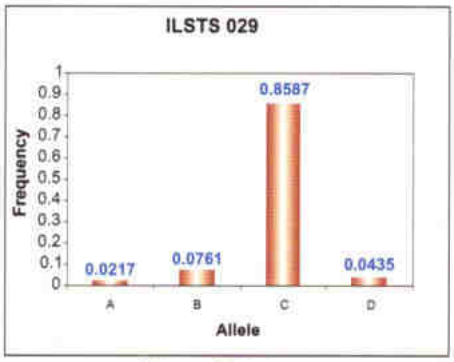

Figure 10 (n)

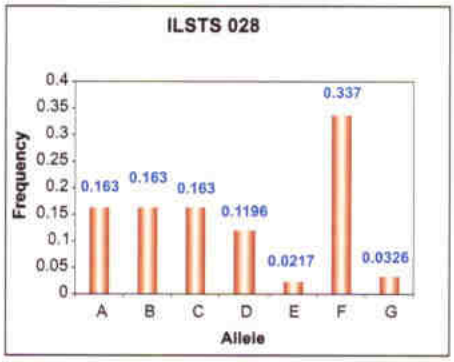

Figure 10 (o)

Figure 10. (k-o) Allelic frequencies at different microsatellite loci in Nili-Ravi buffaloes

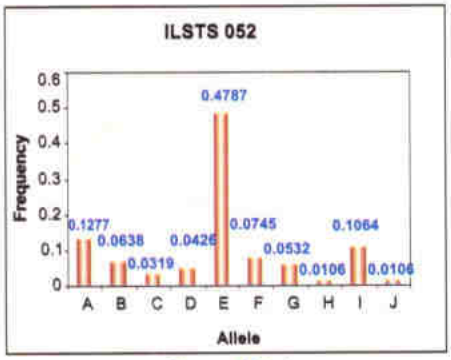

Figure 10 (p)

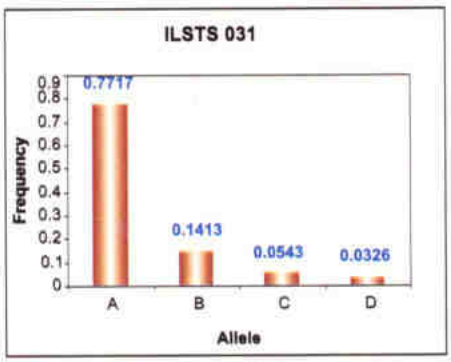

Figure 10 (q)

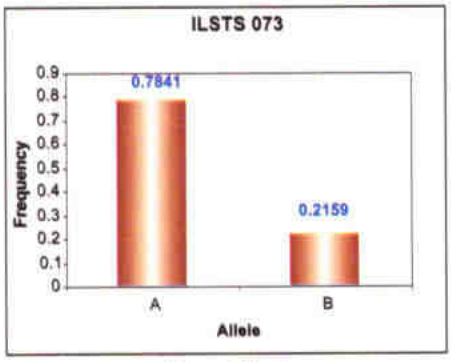

Figure 10 (r)

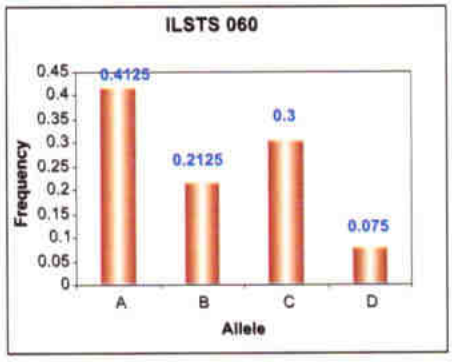

Figure 10 (s)

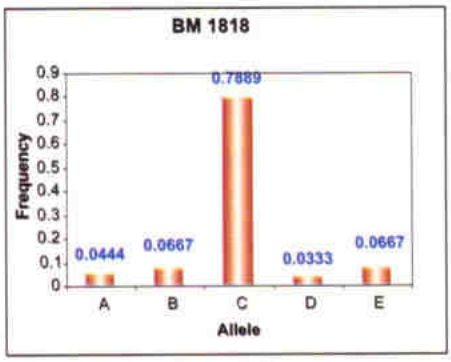

Figure 10 (t)

Figure 10. (p-t) Allelic frequencies at different microsatellite loci in Nili-Ravi buffaloes

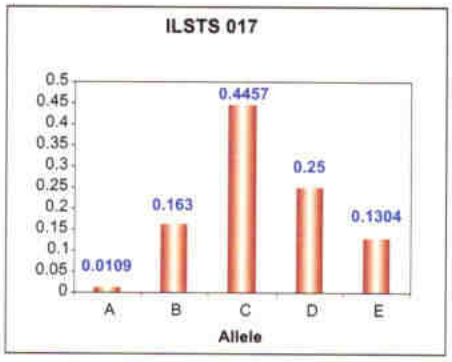

Figure 10 (u)

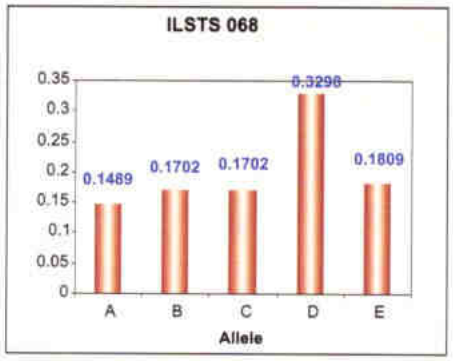

Figure 10 (v)

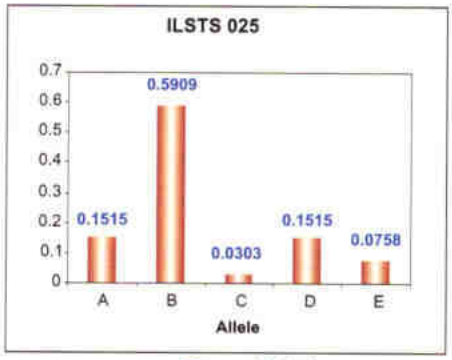

Figure 10 (w)

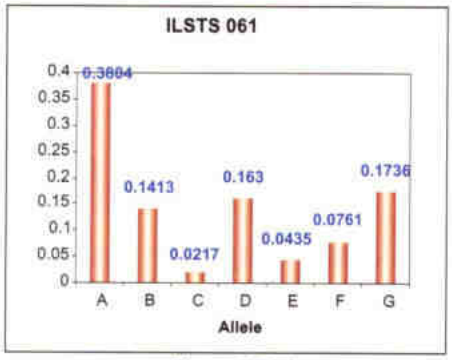

Figure 10 (x)

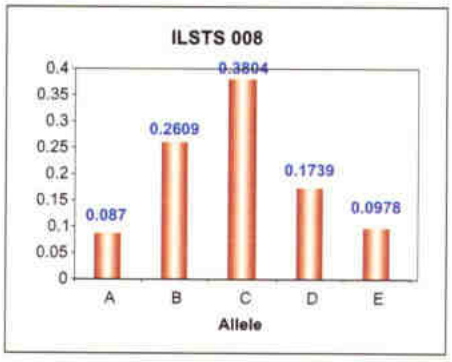

Figure 10 (y)

Figure 10. (u-y) Allelic frequencies at different microsatellite loci in Nili-Ravi buffaloes

8.2. Study on Genetic Relatedness and Diversity

8.2.1. PCR-RAPD technique

The PCR-RAPD technique was utilized to assess the differences in the genetic composition of Nili-Ravi and Murrah buffalo breeds. A total of 50 random primers were screened to detect relatedness and diversity between the two breeds. Out of 50 random primers screened, 26 (52%) revealed polymorphism between Nili-Ravi and Murrah buffaloes and a total of 263 bands were generated using 26 primers with a range of 3 (OPG 06 and B4) to 26 (OPJ 04). Average band sharing within Nili-Ravi and Murrah buffaloes was 0.783 and 0.730 respectively, whereas between breed band sharing value was 0.686. The Nei's (1972) standard genetic distance of 0.119 between Nili-Ravi and Murrah clearly revealed a close genetic relatedness between these two North Indian buffalo breeds (Sodhi et al. 2006).

8.2.2. Microsatellite data

Based on the allele frequency data for 12 microsatellite loci, the genetic identity and distances among four buffalo breeds Nili-Ravi, Murrah, Jaffarabadi and Mehsana was estimated as per standard genetic distance method of Nei (1972). Nei's genetic distance was found to be 0.146 between Nili-Ravi and Murrah while it was 0.359 and 0.209 with Jaffarabadi and Mehsana respectively. It was observed that Nili-Ravi and Murrah breeds were closely related and shared one node while Mehsana was placed separately relative to this node. Jaffarabadi was observed to be distinctly different and placed separately. The molecular genotyping data indicated the genetic relationship of these four buffalo breeds in the expected line of their origin, history and geographical distribution.

9. Crossbreeding of Nili-Ravi Buffaloes in India

In the late 1960s, military farms in India started grading Murrah buffalo cows by crossing them with Nili buffalo bulls. The Nili grades had the Nili inheritance of around 75 percent.

The results of this experimental crossbreeding showed that the body weights of Nili grades were intermediate between the parental breeds from birth to first calving, though the differences were not significant (Table 15).

Table 15. Body weight and first lactation performance of Nili, Nili grade and Murrah buffaloes

Trait	Nili	Nili Grade	Murrah	Reference
Birth Weight (kg)	30.51	29.92	29.42	Johari (1976)
Body weight at 6 months (kg)	141.71	131.58	127.10	-do-
Body weight at year (kg)	219.25	205.59	212.59	-do-
Body weight at 2 years (kg)	354.87	338.63	326.05	-do-
Body weight at calving (kg)	533.61	508.18	461.91	-do-
Age at first calving (months)	42.85	42.65	42.39	Johari and Bhat (1979)
300 days milk yield (kg)	1596.00	1596.50	1532.10	Patro and Bhat (1979a)
Lactation length (days)	298.60	299.10	291.70	-do-
Service period (days)	179.09	176.88	160.64	Johari and Bhat (1979)
Calving interval (days)	487.20	484.32	474.62	-do-

Similarly, the differences in first lactation performances were also not significant. The production performance of Nili grades was identical to Nili pure breeds but higher than the Murrah. In reproductive performaces, Nili grades were close to Nili pure breds but inferior to Murrah. These studies clearly indicate that basically, there being no difference between Murrah and Nili breeds, crossbreeding between these two breeds cannot achieve more than what can be gained by selection.

10. Genetic Improvement and Conservation Efforts

The Central Institute for Research on Buffaloes (CIRB), Hisar, Haryana established a herd at its sub-campus, Nabha to genetically improve and conserve this important breed. The performance of the herd has improved progressively since its inception. Under the Network Programme on Buffalo Improvement, progeny testing of breeding bulls has been undertaken in this herd. The testing of first set of Nili-Ravi bulls have been completed under this project and at present, second set of bulls is being used on breedable females of the farm. The CIRB sub-campus Nabha is assisting the maintenance and conservation of Nili-Ravi buffaloes along with its breed improvement by dissemination of quality semen from selected Nili-Ravi bulls through progeny testing programme.

In this programme, a total of 33 bulls have so far been sent from CIRB sub-campus, Nabha to semen bank, Nabha for semen collection and processing. A total of 5.77 lakh doses of semen have been produced, out of which 84.36% have been distributed to Gurdaspur, Amritsar and Ferozepur districts with a frequency of 0.211, 0.521 and 0.154 respectively (Patil et al., 2004). Apart from this an ex situ conservation programme by deep freezing of semen from Nili-Ravi bulls is also undertaken by semen bank, Nabha in collaboration with National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana. The programme involves procurement of 20 to 25 unrelated

young bulls and collection of about 2000 doses of semen per bull, which will be cryoconserved and stored for posterity at National Gene Bank of NBAGR, Karnal

Figure 11. Nili-Ravi buffaloes wallowing in a pond

11. Nili-Ravi in Pakistan

Nili-Ravi buffaloes are found mainly in Lahore, Sheikhupura, Faisalabad, Sahiwal, Multan and Bahawal Nagar districts in Punjab Province of Pakistan.

Figure 12. Nili-Ravi Calves

However due to it's good dairy qualities, it is now found all over the country. Nili-Ravi buffaloes are popular in Pakistan not only as milch animals, but also for their meat and draft capabilities. They are very important for ploughing paddy fields, transporting farm materials to market, and lifting water from wells. In order to improve the Nili-Ravi buffaloes in Pakistan, a progeny testing program is in operation since 1981 in Punjab province and this has been further strengthened under National Coordinated Buffalo Research Program (NCBRP).

12. Movement of Nili-Ravi Germplasm Outside Indian Subcontinent

Nili-Ravi buffaloes, by virtue of their better dairy characteristics, have good demand in different parts of the globe. Among the buffalo breeds imported by various countries from India, Nili-Ravi seems to be the most preferred one after Murrah.

In China, the crossbreeding of local animals with Nili-Ravi has resulted in significant improvement in milk production in comparison to the local buffaloes. On an average, about two to three fold increase in lactation milk yield of crossbreds over local buffaloes was noticed. (Table 16)

Table 16. Performance of Nili-Ravi and its crosses in China

Genetic Group	Lactation milk yield (kg)	Lactation length (days)
Local	441±212	236
Nili-Ravi	1873±690	261
½ Nili-Ravi X ½ Local	1500±100	297
Triple crosses (Local X Murrah X Nili-Ravi)	1981±0.00	285

Source: (Xiao, 1988)

In Philippines, a massive programme was launched in 1993 to improve native swamp buffalo locally known as Carabao and to develop it as an efficient producer of meat, milk and draft. This programme aimed to generate crossbreds by crossing the native buffalo with either Murrah or Nili-Ravi. The results have shown that Murrah and Nili-Ravi F_1 grades were heavier by about 40% at birth than the natives (Chopra and Punia, 2005)

Nili-Ravi animals were taken to European countries like Italy, Hungary, Romania, Greece and Yugoslavia during 10th century A.D. along with the pilgrims and crusaders (Table 17). Also, the migrant Indian population took these animals to Trinidad Island when they settled there. Nili-Ravi buffaloes had been exported to other countries like Brazil, Bulgaria and Bangladesh. Apart from these, frozen semen of Nili-Ravi bulls had also been exported to different countries as part of germplasm exchange programme.

Table 17. Movement of Nili-Ravi germplasm to other countries

Country	Year	No. and type of animals/semen doses	Mode of Movement of animals/germplasm
Brazil	1895	Variable no. of animals	Through purchase and shipment
Trinidad	1903-1906	Variable no. of animals	Along with migrants
Phillipines	1947	85 animals	Through purchase and shipment
Bulgaria	1979	1000 doses of frozen semen	Through germplasm exchange
European countries	1000 A.D	Variable no. of animals	Along with pilgrims and crusaders from the holy land

Source: Nivsarkar *et al.* (2000)

13. Breeding Farms

1. Buffalo Breeding Centre, NDDB, Nekarikallu, Andhra Pradesh
2. Central Institute for Research on Buffaloes, Nabha Campus, Punjab
3. Government of Punjab, Mattewara
4. Military Dairy Farm, Ferozepur, Punjab
5. Punjab Agricultural University, Ludhiana, Punjab
6. Punjab State Co-operative Milk Producers Federation, Bhattian, Punjab

Figure 13. Nili-Ravi animals under loose housing

14. Contact Agencies

Central Institute for Research on Buffaloes, Hisar, Haryana

Department of Animal Husbandry, Punjab

15. Conclusions

The population of Nili-Ravi buffaloes is declining. There is a definite market preference towards the Murrah type black animals in the breeding tract. The farmers resort to grading up of Nili-Ravi with Murrah semen, which is easily available in veterinary dispensaries and A.I. centres.

Moreover, majority of the farmers are not aware of the fact that Nili-Ravi and Murrah are two distinct breeds and this factor also contributes to the mixing of these two breeds, which result in the production of non-descript animals. This trend needs to be checked to prevent the erosion of this gene pool in India. There is an urgent need to provide semen of typical Nili-Ravi bulls in the breeding tract so as to produce progeny true to its characteristics and propagate the breed. Also simultaneous genetic improvement programmes need to be implemented. Efforts have to be made by the state government at the grass-root level to conserve this breed through awareness campaigns.

16. References

Ahmad, N., M.Irfan, R.A. Chaudhry and W. Ahmed (1983). Reproductive efficiency of Nili-Ravi buffaloes in Pakistan. Indian J. Anim. Sci., 53 (10) : 1066-1068.

Ahmad, Z., P.G. Berger and M.H. Healey (1992). Estimated culling probabilities, age distribution and expected herd life in Nili-Ravi buffalo. J. Dairy Sci., 75 : 1715-1724.

Amble, V.N., K.S. Krishnan and P.N. Soni (1958). Age at first calving and calving interval for some Indian herds of cattle. Indian J. Vet. Sci., 28 : 83-92.

Amble, V.N., R. Gopalan, J.C. Malhotra and P.C. Mehrotra (1970). Some vital statistics and genetic parameters of Indian buffaloes at military dairy farms. Indian J. Ani. Sci., 40 : 377-388.

Anonymous (2002). Annual Report on Network Project on Buffaloes. Central Institute for Research on Buffaloes, Hisar, Haryana.

Anonymous (2004). Annual Report, Central Institute for Research on Buffaloes, Hisar, Haryana.

Botstein D., White R. L., Skolnick M. and Davis R. W. (1980). Construction of a genetic linkage map in man using restriction fragment length polymorphisms. *Am. J. Hum. Genet.* **32**, 314–331.

Chaudhury, I.A. and A.O. Shaw (1965). Production traits of Pakistani buffaloes. Pakistan J. Sci., 17 : 252-258, Cited in Anim. Breed. Abstr., 35 :3381.

Chawla, D.S., M.C. Kamboj and G. Singh (2003). Production performance and herd life of elite Nili-Ravi buffaloes. Indian Buffalo J., 1(1) : 21-26.

Chopra, S.C. and B.S. Punia (2005). Role of Indian buffaloes in the genetic improvement programmes worldwide. In Proceedings of VIII National Conference on Animal Genetics and Breeding, Central Institute for Research on Goats, Makhdom, U.P., India.

Cockrill, W.R. (1974). The Husbandry and Health of the domestic buffalo, FAO Publications, Rome.

Cornuet J. M. and Luikart G. (1996). Description and power analysis of two tests for detecting recent population bottlenecks from allele frequency data. *Genetics* 144, 2001–2014.

ICAR (1941a). A brief survey of some of the important breeds of cattle in India, Part III. Prize winners at the 2nd and 3rd All India Cattle Shows, Delhi. Miscellaneous Bulletin No. 46

ICAR (1941b). Definition of characteristics of Dhanni and Khillari cattle and Nili-Ravi and Surti buffaloes, Delhi. Miscellaneous Bulletin No.47

ICAR (1960). Definitions of the characteristics of cattle and buffalo breeds in India, New Delhi. Bulletin No 86.

Johari, D.C (1976). Body weights at various ages of Nili, Nili grade and Murrah females. Indian Vet J. 53 : 943.

Johari, D.C and Bhat, P.N. (1979). First lactation performances of Nili, Nili grade and Murrah buffaloes. Indian J. Anim. Sci., 49 : 1 & 984.

Khan, M.S., G.E.Shook, A.A. Asghar, M.A. Chaudhary and R.E. Mc Dowell (1997). Genetic parameters of milk yield and adjustment for age at calving in Nili-Ravi buffaloes. Asian-Aus. J. Anim. Sci., 10 (5) : 505-509.

Kimura M. and Crow J. F. (1964) The number of alleles that can be maintained in a finite population. *Genetics* **49**, 725–738.

Manoharan, T.K., W. Vandpitte and G. Mohiuddin (2002). Heritability estimates for various performance traits of NIli-Ravi buffaloes. In Proceedings of 7th World Congress on Genetics Applied to Livestock Production, Montpellier, France.

Munish Kumar (2004). Studies on managemental practices of Nili-Ravi buffalo in Ferozepur district of Punjab. M.V.Sc. Thesis submitted to National Dairy Research Institute, Deemed University, Karnal, Haryana.

Naqvi, A.N. and S.A. Shami (1999). Comparative performance of early and late maturing Nili-Ravi buffalo heifers. Asian Aus. J. Anim. Sci., 12 (3) : 336-340.

Nivsarkar, A.E., P.K.Vij and M.S. Tantia (2000). Animal Genetic Resources of India : Cattle and Buffalo. Directorate of Information and Publications of Agriculture, ICAR, New Delhi.

Olver, A. (1938). A brief survey of some of the important breeds of cattle in India, Delhi. Imperial Council of Agricultural Research, Miscellaneous Bulletin No. 17.

Patil,N.V., G. Singh, S.N. Kala, M.L.Singh and T.P. Singh (2004). Feedback to contribution in conservation of purebred Nili-Ravi buffaloes at its native tract. In Proceedings of National Symposium on Livestock BioDiversity vis-à-vis Resource exploitation-An Introspection, NBAGR, Karnal, Haryana, pp.116.

Patro, B.N. and P.N. Bhat (1979a). Inheritance of production traits in buffaloes. Indian J. Ani. Sci., 49 (1) : 10-14.

Patro, B.N. and P.N. Bhat (1979b). Effect of some non-genetic factors on production traits in Indian buffaloes. Indian J. Ani. Sci., 49 (2) : 91-98.

Reddy, C.E. and V.K. Taneja (1984). A note on factors influencing the first lactation traits of Nili-Ravi buffaloes. Indian J. Dairy Sci., 37 (1) : 36-39.

Reddy,C.E. (1980) Genetic analysis of breeding records of buffaloes. Ph.D Thesis submitted to Kurukshetra University, Kurukshetra, Haryana.

Sarwar, S.M. and S.M. Ishaq (1957). Breeds of livestock, Lahore Animal Husbandry Bulletin No.8.

Sharma, A. and S.B. Basu (1984). Genetic architecture of Nili-Ravi buffaloes – I *Growth. Indian Vet. J., 61 (3) : 227-232.*

Singh, C.V. (2003). Factors affecting body weight, production and reproduction traits in Nili-Ravi buffaloes. Pantnagar J. Res., 1 : 65-69.

Singh, C.V. , R.V. Singh and S.P. Singh (1989). Different aspects of milk production efficiency in Nili-Ravi buffaloes. Indian J. Ani. Sci., 59 (9) : 1161-1164.

Singh, C.V. and M.C. Yadav (1986). Estimation of genetic and non-genetic parameters affecting reproductive traits in Indian buffaloes. Asian J. Dairy Res., 5 (3) : 171-174.

Singh, C.V. and M.C. Yadav (1989). Non-genetic variation in part lactation and 300 days milk yield of Nili-Ravi buffaloes. Indian J. Ani. Sci., 57 (9) : 1005-1007.

Singh, C.V., R.V. Singh and Y.P. Singh (1987). Effect of some non-genetic factors on economic traits in Nili-Ravi buffaloes. Indian J. Ani. Sci., 57 (8) : 891-894.

Singh, H.P. and R. Singh (1977). Statistical studies of some economic traits of Indian buffaloes. Indian Vet. J., 54 : 823-833.

Sodhi, M., M. Mukesh, A. Anand, S. Bhatia and B.P. Mishra (2006). Assessment of genetic variability in two North Indian buffalo breeds using Random Amplified Polymorphic DNA (RAPD) markers. Asian. Aust. J. Anim. Sci., 19 : 1234-1239.

Taneja (2004). http://dad.fao.org/cgi-dad/$cgi_dad.dll/BreedEdit

Vij, P.K. and M.S.Tantia (2005). Status of Nili-Ravi buffaloes in India. Animal Genetic Rsources Information, 37 : 75-81.

Xiao (1988). Crossbreeding in buffaloes. In Proceedings of II World Buffalo Congress, New Delhi, India.

Published by : Director, NBAGR

For enquiries, please contact :

DIRECTOR, NATIONAL BUREAU OF ANIMAL GENETIC RESOURCES

(Indian Council of Agricultural Research)

P.O. Box. No. 129, G.T. Road By-Pass, Near Vasant Vihar, KARNAL - 132001 (Haryana)

Tel. : 0184-2267918 Fax : 0184-2267654 E-mail : director@nbagr.ernet.in