



Phenotypic and genetic characterization of Halari donkey of Gujarat

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ABSTRACT

Halari donkey have a habitat of Halar and adjoining regions includes Jamnagar, Surendranagar and Devbhumi Dwarka districts of Gujarat. On the basis of phenotypic and molecular characterization, it got registration as a new breed of donkey with the accession number INDIA_DONKEY_0400_HALARI_05002 and considered as first donkey breed of Gujarat. A total of 269 animals includes 28 males and 241 females were examined for body measurements. Halari donkey possessed predominantly white coat colour along with grayish black muzzle, white eyelid, black hooves and white tail switch in almost 100% of males and females of Halari donkey. The ears in Halari donkey were predominantly erect in majority of population, however, laterally oriented ears were also observed. The tail setting was observed predominantly upto hock joint followed by its position beyond hock and above hock joint. The temperament is generally docile; however, nervous temperament was also rarely observed. The average face length, face width, ear length, ear width was observed as 46.86 ± 0.09 , 16.89 ± 0.20 , 28.64 ± 0.16 and 10.64 ± 0.12 cm in males while, 46.56 ± 0.04 , 19.60 ± 0.06 , 29.53 ± 0.05 and 12.36 ± 0.04 cm in females, respectively. The age at puberty, age at first service in male, age at first oestrus, oestrus cycle duration, oestrus duration, age at first heat, age at first foaling, service period, foaling interval, gestation period and lifetime number of foaling were observed as 12.95 months, 26.77 months, 13.30 months, 20.40 days, 6.72 days, 25.20 months, 36.93 months, 11.30 days, 12.15 months, 12 months and 7.83 number, respectively. Molecular characterization of 81 Halari donkey using 26 pairs of primers indicated 23 markers to be polymorphic. The observed heterozygosity (Ho) ranged from 0.0 to 0.788 for Halari donkey indicating considerable variation in the distribution of allele frequencies between loci observed in Halari donkey. Medium average number of observed alleles (5.87) in Halari donkey population with average observed heterozygosity value > 0.40 indicates less genetic variability existing in this population.

Keywords: Genetic characterization, Halari donkey, Phenotypic characterization, Polymorphism

India is blessed with huge livestock biodiversity with a total number of 220 indigenous breeds of livestock and poultry, which includes 53 for cattle, 1 for synthetic dairy cattle, 20 for buffalo, 39 for goat, 45 for sheep, 8 for horses and ponies, 9 for camel, 14 for pig, 3 for donkey, 3 for dog, 1 for yak, 20 for chicken, 3 for duck and 1 for geese (NBAGR 2024).

Gujarat ranks second after Rajasthan, in valuable genetic resources of cattle (Gir, Kankrej, Dangi and Dagri), buffalo (Mehsani Jaffrabadi, Surti, and Banni), sheep (Patanwadi, Panchali, and Marwadi), goat (Kachchhi, Surti, Zalawadi, Mehnsani, Gohilwadi, and Kahmi), horses (Kathiawari, Marwari and Kachchhi-Sindhi) and camel (Kachchhi and Kharai) as well as poultry (Ankaleshwar, Aravali and Busra) (NBAGR 2023). Several potential populations in the part of Gujarat deserve recognition. The distribution of livestock breeds in Gujarat indicates

that few regions of Gujarat are represented by the mixed population as a result of haphazard breeding practices, especially in small ruminants. Day by day, in the era of accelerated growth in India, the importance of certain livestock species is decreasing as rapid mechanization and advance instrumentation.

Donkey is one of the forgotten and ignored species of livestock as a result of mechanization and modernization of India. For many centuries, donkey has been used as beast of burden in many cultures. Donkeys and mules are still essential for transportation of heavy load in hilly terrain but now a days, it is losing its importance. As a consequence, not only individual breeds but also whole species is endangered. Despite of being good for transportation of heavy load during migration, Donkey is one of the most neglected species of livestock and hence, unlike other domestic livestock it is least explored for any scientific studies. In India, we have only one recognized donkey breed (Spiti breed of Himachal Pradesh). During a field survey, a population of domestic ass with uniform phenotypic characters but distinctly different from already described breed was located in Halar and adjoining regions

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(Jamnagar, Surendranagar and Devbhumi Dwarka districts) locally known as “Halari donkey”. The name of Halari is derived from Jam Sri Halaji Jadeja who is supposed to be the 9th-generation grandfather of Jam Sri Rawalji Lakhaji Jadeja (who is the founder of the region and the first king to reign in the region). Currently, Halar region is in Jamnagar district of Gujarat. Traditionally, this area is known amongst local peoples as Halar Pradesh. Halar is the arid and dry region, the landscape is undulating, scrub and thorn forests abound in this ecosystem. Mainly Bharwad and Rabari Communities keep livestock in this region.

Government of Gujarat has initiated a project on identification and characterization of lesser-known livestock breeds. A non-descript population of donkey reared by Bharwad, Rabari and Kumbhar community adjoining to Halar region of Gujarat was identified having uniform phenotypic distinct characters. The animals are taller in size as compared to non-descript donkey population of Gujarat. This population is described as Halari by state AH department and was suggested to be investigated for phenotypic characterization and eventual registration as new breed of donkey. Hence, present study was carried out for phenotypic and molecular characterization of this population in collaboration with Sahjeevan Trust, Bhuj and Department of Animal Genetics and Breeding, Veterinary College, AAU (now under Kamdhenu University), Anand. On the basis of phenotypic and molecular characterization of Halari donkey, we applied for recognition and registration as a new donkey breed and got registration with the accession number INDIA_DONKEY_0400_HALARI_05002, as first donkey breed of Gujarat in 2018 (NBAGR 2018).

MATERIALS AND METHODS

Phenotypic characterization: Information on various management practices opted by the Halari donkey owners in the Halar region and performance traits was generated by interviewing the owners from villages of 6 tehsils of Jamnagar (Dhrol, Jamjodhpur, Jamnagar, Jodiya, Kalavad and Lalpur) and 4 tehsils of Devbhumi Dwarka (Dwarka, Bhanvad, Khambhaliya and Kalyanpur) using a structured questionnaire. Owners were interviewed to know the habitat, status, management, utility, average stud size, composition of stud and performance of the donkey. Owners were also interviewed for utility, sale and purchase of animals, feeding, breeding, prevalent diseases and performance of the Halari donkey in the area. Morphological traits were recorded with the help of measuring tape and were classified according to age group of the animal. Details of the observations containing physical and morphological traits were recorded in the prescribed format provided by National Bureau of Animal Genetics Resources (NBAGR), Karnal for evaluation of breed of Horse and Donkey under field conditions. Different morphological observations were recorded on males (28) and females (241) of Halari donkey by multiple visits to the area. The morphological observations include colour of body coat, muzzle, eyelids,

tail switch, hooves etc.

Performance traits like body weights at different ages, age at puberty, age at first service, oestrus duration, age at first covering, age at first foaling, service period, foaling interval, gestation period, number of foaling during entire lifetime and draft performance were collected by conversation with the owners from the surveyed villages. Physical characteristics were recorded on animals of different age and sex during the survey. Thirty-three different body measurements and physical characteristics were recorded on 269 animals of different age and sex.

Body weight of animals from birth to one year of age (28), one to three years of age (12) and adults (above 3 years of age) (28) were derived from body measurements using standard formula. The measurements of different body parts in males, females and heifers include chest girth, body length, height at withers, face length, tail length, ear length, height etc. Data were statistically analysed for descriptive measures viz., mean, standard error, range (Nininahazwe *et al.* 2017).

Molecular characterization: Blood samples were collected from total 81 randomly non-related Halari donkeys from breeding tract of these animals. DNA was extracted from whole blood samples by John's method (John *et al.* 1990). The quality and quantity of DNA were checked by Nano drop ND-1000 Spectrophotometer V3.5 (Nano drop Technologies, Inc. USA) and agarose gel electrophoresis. The concentration was determined and samples were diluted uniformly to approximate 30 ng/μL final concentrations with nuclease free water for further use. Three μL template DNA was used for 25μL PCR reaction. For agarose gel electrophoresis, 0.8 % agarose in 0.5X TBE (Tris 45 mM, Boric acid 45 mM, EDTA 1 mM) buffer (pH 8.0) was used. After quality and quantity evaluation, PCR amplification of DNA samples, using 26 microsatellite markers was carried out in two multiplex panels. Samples were genotyped by capillary electrophoresis on automated DNA sequencer (ABI PRISM 3500 Genetic Analyzer) using GSLiz500 as size standard. Further analysis of the samples was done using Genemapper 4.1 version. The detailed information regarding primers pairs with respective to their panel information, annealing temperature and amplified allele base pairs are given in below Table 1. The data on genotypic frequencies were subjected to statistical analysis using the population genetics software GenAIEx 6.41 (<http://biology.anu.edu.au/GenAIEx/Welcome.html>).

RESULTS AND DISCUSSION

The Halari donkey is considered as a pride of Halar region of Gujarat state for landless-community people including labours, who depend on day to day earning through local work. For such community, Halari donkey is also considered as a golden pack animal. The utility of Halari donkey varies from area to area and from community to community. Bharwad and Rabari pastorals mainly use this donkey as pack animal to carry luggage during migration with small ruminants. Kumbhar (potter) community also

Table 1. Microsatellite markers used for characterization of Halari donkey

Marker	Chromo	Primer Sequence	5' Labelling with Fluorochrom	Amplicon size range (bp)
<i>Panel I (17 primers with annealing Temp. 60°C)</i>				
VHL20	30	F- CAAGTCCTCTTACTTGAAGACTAG R- AACTCAGGGAGAATCTTCCTCAG	FAM	82-102
HTG04	9	F- CTATCTCAGTCTTCATTGCAGGAC R- CTCCCTCCCTCCCTCTGTTCTC	FAM	116-138
AHT04	24	F- AACCGCCTGAGCAAGGAAGT R- CCCAGAGAGTTTACCCT	FAM	140-166
HMS07	1	F- CAGGAAACTCATGTTGATACCATC R- TGTTGTTGAAACATACCTTGACTGT	FAM	167-187
HTG06	15	F- CCTGCTTGGAGGCTGTGATAAGAT R- GTTCACTGAATGTCAAATTCTGCT	HEX	73-103
AHT05	8	F- ACGGACACATCCCTGCCTGC R- GCAGGCTAAGGGGGCTCAGC	HEX	126-146
HMS06	4	F- GAAGCTGCCAGTATTCAACCATTG R- CTCCATCTTGTGAAGTGTAACCTCA	HEX	154-170
ASB23	3	F- GAGGTTTGTAAATTGGAATG R- GAGAAGTCATTTTAAACACCT	HEX	176-212
ASB02	15	F- CCTTCCGTAGTTTAAAGCTTCTG R- CACAACCTGAGTTCTCTGATAGG	HEX	237-269
HTG10	21	F- CAATTCCCGCCCCACCCCGGCA R- TTTTATTCTGATCTGTCACATT	NED	83-111
HTG07	4	F- CCTGAAGCAGAACATCCCTCCTTG R- ATAAAGTGCTGGGCAGAGCTGCT	NED	114-128
HMS03	9	F- CCAACTCTTTGTACATAACAAGA R- CCATCCTCACTTTTCACTTTGTT	NED	146-170
HMS02	10	F- ACGGTGGCAACTGCCAAGGAAG R- CTTCGAGTCGAATGTGTATTAATG	NED	216-238
ASB17	2	F- GAGGGCGGTACCTTTGTACC R- ACCAGTCAGGATCTCCACCG	PAT	104-116
LEX03	X	F- ACATCTAACCAGTGCTGAGACT R- AAGAAGTAGAACCTACAACCTAGG	PAT	137-161
HMS01	15	F- CATCACTCTTCATGTCTGCTTGG R- TTGACATAAATGCTTATCCTATGGC	PAT	166-178
CA425	28	F- AGCTGCCTCGTTAATTCA R- CTCATGTCCGCTTGCTC	PAT	224-248
<i>Panel II (9 primers with annealing Temp. 58°C)</i>				
NVHEQ21	20	F- CCAGAACCTGGACTGAACAGTGTC R- GAATGTGCTTGATGCAGAAGAAGG	FAM	151-159
NVHEQ29	4	F- GAGATTTTGCCCCAAAGTTA R- CTCTTCTTTCTTCCCCAGGTCT	FAM	91-103
NVHEQ05	20	F- CGCATGTGCTTCCCCTCAC R- CCTCTTTCCACGCAATCACTCTA	HEX	151-161
NVHEQ100	1	F- CCAAAGCAGAACATGTGAAGTT R- TGGCATAGATGTTAGCTAAGTGA	HEX	185-199
NVHEQ11	19	F- GGCCCCACCCACTAAATATCACTG R- CGGGGTCTTGGAATTTATGAAGG	HEX	120-130
NVHEQ70	3	F- GCTGGTCAAGTCACACTGTG R- AACCTCACCCCAAGTTGTAT	NED	189-203
HTG14	22	F- CCAGTCTAAGTTTGTTGGCTAGAA R- CAAAGGTGAGTGATGGATGGAAGC	NED	129-137
NVHEQ82	3	F- TGTGGCAGCATCCCACAAAC R- CCTCCATTTTGTGCGTTAGCG	PAT	123-137
NVHEQ40	11	F- TGGCATCTGAATGGAGAATG R- GATTATGATGCTACAGGGGAAAG	PAT	146-154

use this animal for pottery work in Dwarka, Jamnagar region and as pack/ donkey cart to lift mud and bricks in brickmaking factory (brick kiln). Bharwad pastoralists maintain Halari donkey herd with few elite jacks for breeding sell young foals and surplus donkey in Vautha donkey fair, an annual donkey fair organized in Vautha village of Dholka Taluka of Ahmedabad District. Buyers come from different regions of Gujarat and other states to buy Halari donkey to use this animal in construction work.

Feeding and rearing practice for Halari donkey: Majority of Halari donkey owners of Jamnagar and Devbhumi Dwarka surrounding district are pastoralist and they follow extensive pattern for donkey rearing and management. In whole Jamnagar and Dwarka district, grazing is the only source of fodder availability to the Halari donkey and stall feeding is almost absent. Water is available from the natural water resources (Pond/lake) in grazing land or water trough of village. Generally pastoral women take care of Halari donkeys- they handle donkeys to arrange their luggage on the back of donkey, once they remove the luggage, they leave them to graze, and once they need to move other location again, they found the donkeys at work back. Halari donkey is mostly used for pack animal by Bharwad and Rabari pastoralists during migration with their goat population and they also graze along with goat.

Pastoralist have good relations with local farmers of Saurashtra. The farmers mainly cultivate cotton, groundnut, toor dal etc. After harvesting of crops, goats graze on crop residues. There is sharing mechanism, the pastoralist family members offer labor work to farmer to harvest their crops and farmers allow them to graze their animals in the farm. Pastoralists of Jamnagar and Devbhumi Dwarka districts regularly migrate to other districts. They start to migration during late November and travel across several districts till June. They reach to their native tract after first rain. When pastoralist return home, Halari donkeys are left for grazing in the village surrounding area till next migration starts post monsoon.

Breeding practice for Halari donkey: Halari donkey breeders usually keep four to five females and one or two breeding male/jack and breed them selectively. Jack is selected very carefully on the basis of physical characters like pure white coat, excellent height, body length with well-built body size and good scrotal circumference for breeding and raised. Purity of the breed is maintained by the breeder through selective breeding and avoiding crossing other local non-descript donkey breed as far as possible. Through selective breeding they produce good Halari donkey which they sell to local donkey trader or in Vautha Donkey fair earning good price. But the pure breed population in the native tract is very less and almost on verge of extinction.

Physical characteristics of Halari donkey: White coat was the most prominent colour along with grayish black muzzle, white eyelid, black hooves and white tail switch in almost 100% of males and females of Halari donkey.

The forehead of Halari donkey was convex in majority of population in both sexes, followed by concave and rare straight/flat, while the nasal bone was observed as concave in majority of population followed by convex and rarely straight/flat.

The ears in Halari donkey were erect in majority of population, however, laterally oriented ears were also observed. The eyes were found to black in almost population. The back was majorly concave, followed by straight and convex, while the tail setting in majority of Halari donkey was found to be upto hock joint followed by also beyond hock and above hock joint. The temperament of Halari donkey is generally docile, however, rarely nervous temperament was also observed.

The birth weight of Halari donkey was found to be 15 to 20 kg in both sexes. The average body weight in adult male donkey was observed as 143 kg with highest adult weight as 251.8 kg, while, in adult females it was 138.3 kg with highest adult weight as 235 kg.

An average face length, face width, ear length, ear width were observed as 46.86, 16.89, 28.64, 10.64 cm in males and 46.56, 19.60, 59.53, 12.36 cm in females, respectively. The height at wither, body length, heart girth, tail length, height at croup was observed as 108.04, 116.71, 119.39, 38.07 and 112.04 cm in males, and, 107.25, 114.60, 119.03, 35.75 and 111.88 cm in females, respectively. Height at wither, body length, heart girth, tail length and height at croup reported in the present study were higher than that reported by Pal *et al.* (2013). Other important physical characters for male and female Halari donkey with their measurement are presented in Table 2. The reproduction traits were measured through interview and cross questionnaire to owners. The age at puberty in male, age at first service in male, age at first oestrus, oestrus cycle duration, oestrus duration, age at first covering, age at first foaling, service period, foaling interval, gestation period and lifetime number of foaling was observed as 12.95 months, 26.77 months, 13.30 months, 20.40 days, 6.72 days, 25.20 months, 36.93 months, 11.30 days, 12.15 months, 12 months and 7.83 number, respectively.

As Halari donkey is used as pack animals, the average load carrying capacity was observed as 100 kg, with an average work duration of 4.63 hrs. per day and average distance covered in a day up to 11.0 km. Majority of Halari donkey have medium work capacity but approximately 10 percent of total animals also have hard work capacity include more load carrying capacity up to long distance during the migration. The present finding is in accordance with load carrying capacity of donkey of south western Bihar as reported by Gupta *et al.* (2017). However, Halari donkey have more load carrying capacity for short distance.

The donkey milk exhibits organoleptic characteristics and a chemical composition comparable to human milk (Guo *et al.* 2007). In terms of its high lactose and low protein content and even lower level of fat percentage, donkey milk is most comparable to human milk (Garhwal *et al.* 2022). Gross composition of Halari donkey milk was characterized

Table 2. Physical characters of adult male and female Halari donkey

Parameter (in cm)	Male (N=28)		Female (N=241)	
	Average	Range	Average	Range
Face Length	46.86 $\pm$ 0.09	39 – 53	46.56 $\pm$ 0.04	22 – 56
Face Width	16.89 $\pm$ 0.20	10 – 24	19.60 $\pm$ 0.06	10 – 32
Ear Length	28.64 $\pm$ 0.16	19 – 38	29.53 $\pm$ 0.05	17 – 39
Ear Width	10.64 $\pm$ 0.12	7 – 15	12.36 $\pm$ 0.04	7 – 18
Neck length	54.11 $\pm$ 0.26	35 – 71	51.32 $\pm$ 0.10	31 – 80
Neck Circumference (TL)	54.43 $\pm$ 0.18	40 – 70	56.41 $\pm$ 0.09	25 – 87
Neck circumference (MP)	65.96 $\pm$ 0.23	39 – 81	67.19 $\pm$ 0.09	21 – 92
Chest width	26.75 $\pm$ 0.13	21 – 34	27.32 $\pm$ 0.04	17 – 42
Height at Withers	108.04 $\pm$ 0.19	78 – 130	107.25 $\pm$ 0.06	70 – 129
Body Length	116.71 $\pm$ 0.20	89 – 151	114.60 $\pm$ 0.07	72 – 152
Heart Girth	119.39 $\pm$ 0.23	83 – 153	119.03 $\pm$ 0.08	75 – 152
Paunch Girth	146.25 $\pm$ 0.33	92 – 189	150.29 $\pm$ 0.12	80– 193
Distance b/w Withers to Croup	70.86 $\pm$ 0.27	27 – 83	71.73 $\pm$ 0.07	37– 82
Distance b/w Croup to Dock	27.54 $\pm$ 0.35	21 – 68	26.92 $\pm$ 0.05	16 – 41
Tail Length	38.07 $\pm$ 0.18	30 – 59	35.75 $\pm$ 0.07	20 – 70
Tail Length up to Switch	49.86 $\pm$ 0.29	12 – 68	46.37 $\pm$ 0.07	33 – 67
Height at Croup	112.04 $\pm$ 0.18	88 – 134	111.88 $\pm$ 0.06	73– 136
Fore arm Length	33.07 $\pm$ 0.14	25 – 43	34.95 $\pm$ 0.05	19 – 45
Fore arm circumference	24.14 $\pm$ 0.11	15 – 29	25.95 $\pm$ 0.05	15 – 37
Canon Length	23.79 $\pm$ 0.15	18 – 34	24.01 $\pm$ 0.05	13– 34
Canon circumference	16.25 $\pm$ 0.09	11 – 21	17.21 $\pm$ 0.04	10 – 28
Pastern Length	11.04 $\pm$ 0.15	7 – 19	12.37 $\pm$ 0.06	8 – 26
Pastern Circumference	15.79 $\pm$ 0.08	13 – 22	16.91 $\pm$ 0.04	10 – 24
Hoof Length	7.29 $\pm$ 0.10	5 – 10	8.11 $\pm$ 0.04	4 – 11
Hoof Circumference	26.14 $\pm$ 0.13	20 – 34	27.98 $\pm$ 0.05	10 – 38
Gaskin Length	37.57 $\pm$ 0.18	21 – 45	38.14 $\pm$ 0.04	23 – 49
Gaskin Circumference	27.64 $\pm$ 0.09	22 – 33	28.12 $\pm$ 0.04	15 – 36
Cannon Length	28.39 $\pm$ 0.15	20 – 37	27.47 $\pm$ 0.05	15– 39
Cannon Circumference	16.32 $\pm$ 0.11	10 – 23	17.12 $\pm$ 0.04	10 – 26
Pastern Length	10.89 $\pm$ 0.10	8 – 14	12.03 $\pm$ 0.04	7 – 26
Pastern Circumference	16.07 $\pm$ 0.07	12 – 19	16.76 $\pm$ 0.03	12 – 26
Hoof Length	7.75 $\pm$ 0.11	5 – 11	8.17 $\pm$ 0.04	4 – 11
Hoof Circumference	26.96 $\pm$ 0.19	19 – 34	27.90 $\pm$ 0.05	15 – 39

by very low-fat content (0.86 $\pm$ 0.04%) and high amounts of lactose (5.75 $\pm$ 0.15%). Total solids and solids not fat (SNF) accounted for 9.61 $\pm$ 0.08% and 8.81 $\pm$ 0.14%, respectively. Low protein content (2.03 $\pm$ 0.03%) was recorded in Halari donkey milk, with fair amounts of carbohydrate content (6.23 $\pm$ 0.19%) (Garhwal *et al.* 2023).

Molecular characterization of Halari donkey: PCR amplification for multiplex microsatellite study was carried out for total 81 Halari donkey samples using 26 pairs of primers. Fragment run of all samples in 2 panels system were completed in ABI genetic analyzer 3500 system. The representative electropherogram of allele differentiation of microsatellite study is presented in Fig. 1.

Out of 26 microsatellites markers, successful amplifications were observed for 23 markers in Halari donkey populations with a total of 140 alleles. All 23 markers were found to be polymorphic. The number of alleles per locus amongst the polymorphic markers ranged

from 2 (markers VHL20, HMS06 and NVHEQ21) to 13 (marker HTG14) in Halari donkey indicating considerable variation in the distribution of allele frequencies between loci observed in population. Similarly, Kim *et al.* (2021) reported 5.87 observed number of alleles per locus in Korean donkey. Statistical analysis for different parameters of genetic variability in Halari donkey population is presented in Table 3. The mean number of observed alleles was quite high as compared to effective number of alleles (6.087 Vs. 2.557) in Halari populations.

The observed heterozygosity (Ho) ranges from 0.0 (NVHEQ21, NVHEQ 100) to 0.788 (HTG10) for Halari donkey indicating considerable variation in the distribution of allele frequencies between loci. The average observed and expected heterozygosities were 0.459 and 0.503, respectively indicating there were presence of less genetic variability in population, while, low Ho and He also reported by Kim *et al.* (2021) in Korean donkey. Polymorphic

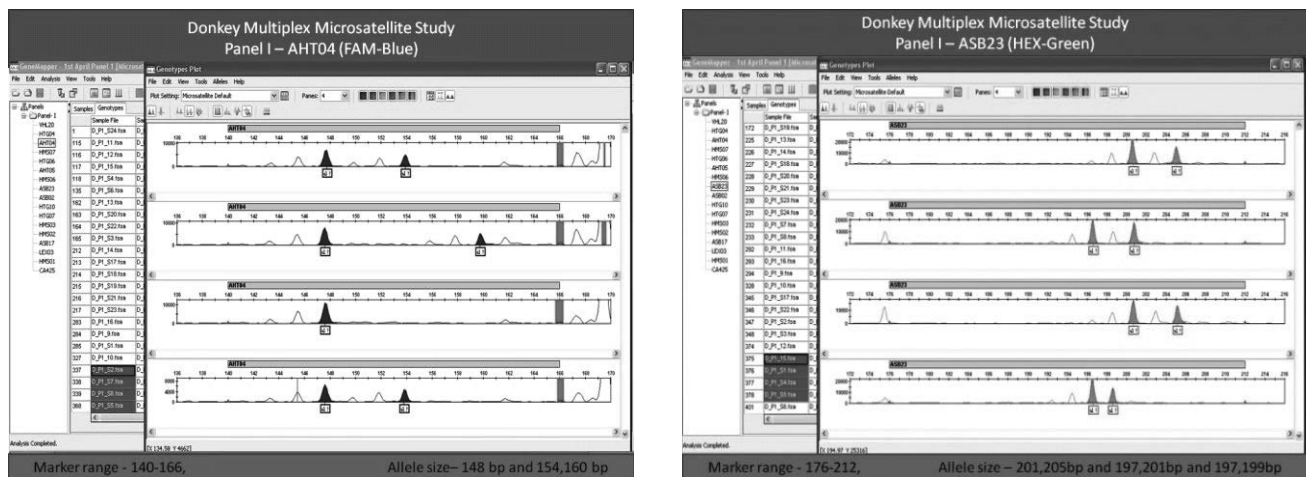


Fig. 1. Electropherogram for allelic differentiation of donkey microsatellite study

Table 3. Heterozygosity and polymorphism parameters for various microsatellite markers in Halari Donkey

Locus	N	Na	Ne	I	Ho	He	uHe	PIC	F _{IS}	HW
VHL20	79	2	1.543	0.537	0.380	0.352	0.354	0.29	-0.079	NS
HTG04	77	6	1.905	0.825	0.494	0.475	0.478	0.399	-0.039	NS
AHT04	80	8	2.632	1.290	0.625	0.620	0.624	0.575	-0.008	NS
HMS07	80	3	1.038	0.105	0.038	0.037	0.037	0.037	-0.015	NS
HTG06	80	3	1.065	0.160	0.013	0.061	0.061	0.06	0.795	NS
AHT05	76	8	3.719	1.487	0.671	0.731	0.736	0.686	0.082	NS
HMS06	80	2	1.536	0.533	0.175	0.349	0.351	0.288	0.498	NS
ASB23	80	5	2.822	1.196	0.738	0.646	0.650	0.583	-0.142	NS
ASB02	80	3	1.267	0.389	0.238	0.211	0.212	0.191	-0.127	NS
HTG10	80	6	3.117	1.284	0.788	0.679	0.683	0.624	-0.159	**
HTG07	80	4	2.751	1.145	0.513	0.636	0.640	0.571	0.195	NS
HMS03	79	5	2.051	0.858	0.696	0.512	0.516	0.425	-0.358	*
HMS02	77	10	4.018	1.604	0.701	0.751	0.756	0.712	0.066	NS
LEX03	79	9	4.932	1.782	0.582	0.797	0.802	0.769	0.270	NS
CA425	78	12	4.539	1.774	0.782	0.780	0.785	0.748	-0.003	NS
NVHEQ21	79	2	1.026	0.068	0.000	0.025	0.025	0.025	1.000	NS
NVHEQ05	76	9	3.368	1.497	0.684	0.703	0.708	0.661	0.027	NS
NVHEQ100	68	3	1.304	0.437	0.000	0.233	0.235	0.212	1.000	NS
NVHEQ11	76	5	1.314	0.530	0.211	0.239	0.240	0.228	0.119	NS
NVHEQ70	76	9	2.762	1.324	0.658	0.638	0.642	0.589	-0.031	NS
HTG14	76	13	3.992	1.707	0.618	0.749	0.754	0.715	0.175	NS
NVHEQ82	77	5	2.950	1.280	0.610	0.661	0.665	0.617	0.077	NS
NVHEQ40	75	8	3.157	1.494	0.347	0.683	0.688	0.648	0.493	***
Mean		6.087	2.557	1.013	0.459	0.503	0.506	0.463	0.167	
SE		0.625	0.229	0.108	0.053	0.049	0.050		0.069	

Na: No. of alleles, Ne: No. of effective alleles, I: Shannon's Information Index, Ho: Observed heterozygosity, He: Expected heterozygosity and μ He: Unbiased expected heterozygosity, PIC: Polymorphism Information Content and F_{IS}: Fixation Index, HW: Hardy Weinberg Equilibrium, NS: not significant, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

information content (PIC) for Halari donkey ranged from 0.025 (NEHEQ21) to 0.769 (LEX03) with an average of 0.463. More than 0.4 polymorphism information content (PIC) values indicated that most of the markers used in the study were sufficiently informative and hence, suitable for diversity studies. Only three microsatellite markers showed significant deviation from Hardy-Weinberg equilibrium

for Halari donkey population. The within-population inbreeding estimate (F_{IS}) ranged between -0.003 (CA425) and 1.00 (NVHEQ21, NVHEQ100) with average of 0.167 for Halari donkey indicates mild inbreeding is present in Halari donkey population.

In the present study, genetic characterization of Halari donkey population was done using 23 polymorphic

microsatellite markers. Medium average number of observed alleles (6.087) in Halari donkey population with average observed heterozygosity value > 0.40 indicated less genetic variability existing in Halari donkey population. As the loss of genetic variation in the population results into a population cannot evolve in response to changing environmental variation, there is an increased risk of extinction. Hence, Halari donkey needs a special attention for its conservation as a valuable genetic resource.

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