

Horse Genetic Resources of India

MARWARI

An Elegant Horse Breed



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National Bureau of Animal Genetic Resources

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PREFACE

Equines provide livelihood to the landless, small and marginal farmers and other sections of rural and semi-urban society through draught work and transport. The use of equines for draught purposes has special economic significance in difficult terrains in hilly, arid and semi-arid zones where motorable roads are inadequate or are still not available. Horse has been a most faithful servant in a huge variety of demanding and often grueling conditions to man. In war, sports, agriculture and even as a part of the police force, horse continues to play a vital role all over the world.

The Marwari horse breed has originated in Marwar region of the Rajasthan, where hot arid desert conditions presents a unique ecosystem. There are forelocks, poems and books in the praise of Marwari horse, nicknamed as flying horse by some authors. This is because of some peculiar features of Marwari horse like swiftness, toughness, loyalty and dauntlessness in battle. However, in recent times because of mechanization and high cost of rearing, this wonderful breed is endangered.

There is an urgent need to educate the horse owners about maintaining genetic purity without that true value of the horse can not be realized. There is an urgent need of planned developmental activities and popularization of the breed in equestrian sports and ecotourism. A open nucleus stud is required in its main breeding tract to obtain pure stallions for breeding purposes. Further it would help reducing inbreeding in the present horse population. The first step to overcome these problems is to establish the Standard Breed Characteristics.

Authors have conducted the sample surveys on Marwari breed and recorded information on breed characteristics from the livestock fairs and animal shows. The work on DNA characterization using molecular markers would be useful in diversity analysis within and between breeds. This monograph is a compilation of our results and review of other reports on the breed. We convey our sincere thanks to Col. Umed Singh, Secretary, Marwari Horse Society, Jodhpur and Ms Puja Gehlot, Marwar Horse Breeding and Research Institute Jodhpur for helping in blood sample collection. We are thankful to Sh. Moti Ram, Institute Photographer for taking photographs from different locations.

Authors

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Introduction

India is bestowed with rich domestic biodiversity, which is a culmination of years of evolution with a specific ecological and economical niche. Man has exploited animals since time immemorial basically for his own use of whom, horse deserve special place. Horse has seen rise and fall of many empires. Equines were domesticated some 10000 yrs ago and bred for war, ceremonies and riding since 400 BC, however in India; the domestication appears from Vedic era around 2000 BC. As per Hindu mythology horse came out as a winged creature from ritual flames of Yajana performed by Lord Brahma. Among the elegant equine breeds the ancient Marwari horse has a prominent place in India since medieval period. This horse enjoys an unassailable position and huge reputation for its performance and qualities such as elegance, poise, beauty, love, bravery and faithfulness to the rider.

Equines, comprising horses, mules and donkeys form an important draught and riding animal genetic resources. For centuries, the horse has been a most faithful servant in a huge variety of demanding and often gruelling conditions. Horses are popular all over the world because of their multiple utility, viz., riding, sports, racecourse and draught work. Unfortunately, during the 20th century, world is witnessing the near extinction of a number of livestock breeds and horses like other pack animals have suffered the most. According to FAO report (1995), the Marwari horse is on watch list of endangered equine species in India. India, being a signatory of Global Convention on Biological Diversity (1992), the need for conservation of the precious germplasm and Marwari horse should receive high priorities. It is a matter of great concern not only for the government institutions, but to the society as a whole because this horse is a part of our national heritage that should not vanish away from the Scene. The role of NGOs and breed societies in identification of superior germplasm, their multiplication and conservation needs greater emphases.

The information compiled in this monograph is based on our survey in the breeding tract and personal observations recorded at various livestock and horse shows, besides review of information from other published and unpublished reports.

History and Origin

History of the Marwari or Malani (synonym of beauty and strength) horse is difficult to trace with precision. Marwari horse is native to the Marwar region of India, and its origins are often linked with local folklore. According to Shri Mahant Baba Balak Dasji Maharaj, Head Priest of the Monastery at Kalabar, and a renowned breeder of Marwari horses, the history of origin of the breed can be traced back to a period, "when the ocean was churned to extract nectar for the Gods-a period when horses had wings." During the Middle Ages, the principal occupation of the Rathores of Marwar was breeding Marwari Horses. These Raiputs fielded a cavalry consisting of more than 50,000 horses under the reign of Mogul Emperor Akbar the Great. In fact, Maharana Pratap's *Chetak* horse was considered by many experts to be of Marwari breed. This horse is considered as mark of bravery and symbol of win (Fig. 1).



Source: marwarihorse.com

Fig. 1. Bronze statue

According to Maharana Mahipendra Singh of Danta, the Marwari horse has Arabian blood. The Marwari horse what we see today has a lot of similarity to Turkman and Akhiltek in conformation, colour, size, which probably influenced the indigenous Marwari gene pool.

Present Marwari Horse

With their days as a battle horse at an end, the 20th century has seen a precipitous drop in the number of Marwari horses. Marwari horses are

thoroughbreds but have long been ignored in favour of Arabian and English thoroughbreds. Marwari horse may not fit the dictionary description of a thoroughbred “a breed of horse originating from English mares and Arab stallions”, but certainly fits into more important definition-“horse whose ancestry is fully known for several generations”. The *Mirasi* community, the traditional stable hands in royal stables, recites the ancestry of these horses in the form of poems. “So, while for the usual thoroughbreds, the family ancestry can be traced only up to four generations, the Marwari horse ancestry can be traced back to 10 generations.” Another feature of the Marwari horse breed is that the bloodline is still pure as there is no inter-breeding.

Habitat and Distribution

The Marwari horse is the original desert horse of the Marwar region in the State of Rajasthan in India. Fig.2. shows the distribution of Marwari horse



Fig. 2. Geographical distribution of Marwari horse in Rajasthan

in Marwar region comprising of Jodhpur, Barmer, Jalore, Pali and Mewar region of Udaipur and Rajsamand districts. Selective breeding by Rajput rulers to meet the needs of their cavalry resulted in the development of this resilient and elegant breed that could survive well in difficult, arid and semi-arid habitats (Fig. 3). The land in which they resettled was known as “Maru Pradesh” meaning the land of death. Marwar, a typical as the name implies, is a desolate and harsh land that require an equally rugged horse. The native Marwari Horse proved particularly well suited for the desert environment.

The ‘Malani’ region of Barmer district of Marwar, the village of Nagar, Gurha, Jasol, Sindhari, Bakhasar, Patodi, some areas of Bhinmal, Sanchore and Sayala Tehsils of Jalore district are the nucleus areas of the breed of Marwari Horse. Many famous breeders of the Marwari breed are spread all over Rajasthan and Northern Gujarat. The others who are fond of Marwari Horse have taken it to various states of the country like Punjab and even abroad to USA. Today the horses are bred for sports, as police chargers, ceremonial or marriage horses and for personal interest. A good number of Marwari Horses can be seen at fairs of Pushkar, Tilwara and at



Fig.3. Agro-ecological conditions of main breeding tract of Marwari horse

the *Marwari Horse Show* at Jodhpur, the *Chetak Horse Show* in Mewar and *Shekhawati Horse Show*.

The typical Marwar region is arid and semi arid desert that receives very little rainfall only during monsoon. As a result, the habitat has very poor vegetation cover. In the name of vegetation, there are sparsely distributed Khejri (*Prosopis cineraria*) besides some neem or babool trees. The ground has some bushes while the ground cover includes sanchrus or doob grass wherever, there is slight rain or depression of land having some collection of rain water. The water holes for animals including horses are found after miles of journey in this agro-ecosystem.

Breeding and Management

After the abolition of the princely states, the royal houses had no use and rights to keep horse cavalry units. In some cases these are kept for Polo or for display at special functions and ceremonies. *Thikanas* used to practice selective breeding of Marwari horse and provide all care to them. They used to keep a few dozen mares and about two to four good stallions, depending upon the status and income of the *Thikana*. Another set of people attached to breeding of Marwari horse was agricultural class. Earlier these people used to own one or few mares and used to take them near the *Thikanas* where free service of stallions was provided to serve the mare. Now this type of service is not available. The small owners can not afford to keep stallion, so they take the mare for breeding to any breeding male rather than for going to an established sire. This has led to the dilution of the breed.

The studs who are maintaining these horses for polo or other games, offer them balanced ration. They are looked after by well trained staff for feeding, watering and necessary exercise and training etc. The horses used for ceremonials also get due care and management. Horses kept by farmers in the villages graze in the field for most of the day time and get some concentrates at home particularly to the stallions and lactating mares.

Temperament and Behaviour

The Marwari's homing instinct helped save many a rider's life in history. They were famous for bringing back riders who became lost in the desert or injured in the wars. The Marwari breed has long been noted for having exceptional hearing sense. The smell and hearing which is very useful in the desert (Fig.4). This enables the Marwari to catch sounds from far more distance away than most other breeds, allowing both horse and rider early warning of impending danger. Marwari is an extremely sturdy horse breed, able to take thirst and heat in stride because of their thin skin. They are hardy and can sustain on the small rations available in their desert environment. Its natural tendency to perform would make it particularly suitable for dressage. It is a tough, brave and undeniably beautiful horse who has proven its ability to adapt and thrive in most diverse environmental conditions including the cold climate of USA where they have been exported recently.



Fig. 4. Meeting ear tips in alert Marwari horse

Characterization

Very little scientific and systematic studies have been carried out on this important breed of horse like other indigenous equines. The breeding tract of the horse has been identified on the basis of their geographical location (Vijh et al., 1996). Isolated efforts have been made to describe the characteristics of the breed. With the efforts of a few Horse breeders' societies like *Chetak Horse Society*, Udaipur has organized a few horse shows at Haldighati where experts have attempted to describe the breed besides horse judging. Marwari Horse Society at Jodhpur has attempted to register the

horses, true to the breed and is maintaining some pedigree data in more or less undefined manner. The Indigenous Horse Society is responsible for setting and maintaining the breed standards. All the horses they buy, sell and breed at Marwari bloodlines are subject to their high standards. Authors have recorded the breed characteristics of Marwari horses at several horse shows at Jasdan Horse Show, Gujarat, Chetak Horse show at Haldighati and Pushkar Animal Fair, Pushkar.

Phenotypic Characterization

Horses are selected on the basis of their body colour and markings for their beauty, body size and conformation for their utility in transport, sports, sturdiness and endurance for their adaptability under the present ecosystem. For horse judging they should have ideal conformation and true to breed standards. There were no breed standards for this horse. During last few years, efforts have been made by the Marwari Horse Society to lay some breed standards, however, these need data generation of phenotypic traits that fits into the breed standards through a planned survey. We generated the information on phenotype of the Marwari horse breed at various Marwari horse shows and exhibitions. Informations were also collected from the farmer's horses in their breed tract. The detailed description of Marwari horse is as under.

Body Conformation

Balance in conformation is achieved when the head, neck, forequarters, barrel and hind quarters look as if they all belong to the same horse. In medieval times more emphasis was given on soundness, stamina, speed and courage of the horse, however, in modern times, when riding is a sport mainly for pleasure, the good looks and the beauty of the horse comes in to prominence more than ever before. The conformations of a Marwari horse has its own distinction that gives him unequal grace and balance, enabling

him to excel in sports and endurance. It is an animal, which has strong limbs with clearly defined tendons, square frame and a thin coat, which has the ability to cope with heat and cold without excessive dehydration. The Marwari have slightly less slant to their shoulder bones enabling them to more easily extract their legs from deep sand in desert ecosystem. Angle of the bone prevents Marwari horse from striding out to the fullest, thus diminishing their speed. The resulting action of legs however, makes Marwari a very comfortable horse to ride. Compact body with round rumps and muscular thighs and shoulders, make him a good all-round pleasure horse.

Colour

Colour patterns of the horse has now become very important factor and breeders try to breed for colors which are more popular and fetch best prices in the market. A wide range of colors is observed in Marwari horses (Fig. 5). The Shash Ablakh (piebald) and Lall Ablakh (skewbald) have become very popular at the expense of Bay which was the most preferred colour in medieval past. The black bhavar has always been a popular colour in Marwari horses. The most prevalent body colours are: Dark Brown (Musky or Bhawar), Bay (Kumet), Dark Bay (Telia Kumet), Chestnut (Surang), Dun (Champa), Grey (Swet), Fleabitten Grey (Kabra). *The colours mentioned in bracket are local names.*

Markings

Besides coat colour, markings also play a major role in horse identification and descriptions. Many of the horses have some white markings, normally on the head or legs, but white marks elsewhere on the body are also described while registering a particular horse. Markings may be natural or acquired. These are: star (a white marking on forehead is called a star whether it is exactly star shaped or not), stripe (a narrow white line running down the face is stripe), blaze (broad white band covering almost



Fig. 5. Coat colour diversity in Marwari horse breed

the whole of forehead between the eyes and running down to muzzle), white face (entire face is white) has been shown in fig. 6 in a Marwari horse. Snip is a small white mark between nostrils.

Skin and hair coat

Marwari horse has fine and silky hair coat. Good hair growth of forelock, mane and tail are typical features of the breed. The hair on the posterior base of the fetlock joint, inner side of ears under the jaws is often noticed in this breed. The skin is normally thick but quite soft. The mane is silky and long. Tail of the mature horse is 45-60 cm long with hair reaching down to the fetlock or sometimes even to the ground.



Fig. 6. Blaze, a type of colour marking on face of Marwari horse

Phenotypic Features

Head: The head of Marwari horse is well proportionate to the body, giving it a balanced look, smart, refined and trim in front. The head is relatively long and wide between eyes, with a medium muzzle and a shallow firm mouth.

Forehead and face: Forehead of Marwari horse is slightly concave in adults. It may be 20-22 cm wide between the eyes. However the forehead in foal below one year age may be slightly bulging above the head while attaining refinement on maturity. The face is long, flat and broad with light forehead. A mature Marwari horse may be up to 65 cm in length and 60 cm wide around the nasal bone.

Ears: The length, size, direction, orientation and movement of ears are very important characteristics of this horse. The fine hair protruding from medium sized clean cut ears, which are extremely curved inward at the tip often touching each other, is the main feature of Marwari Horse. The ear length varying from 9 to 15 cm are located 90 degree axis and can rotate 180 degrees. The meeting of the tips of the ear when the animal is alert is a distinguishing feature of the breed. Any deviation in its angle or orientation is treated as disqualification from the breed.

Eyes: The eyes are clear. Deep coloured showing an intensity of reflection in this breed. Their eyes are full, luminous, prominent, fairly bulged, set widely and reflect intelligence and a placid disposition. The length and breadth of eyes in mature horse may be 7 cm and 4 cm, respectively. Long lashes, protecting eyes from sand etc in desert, covering their periphery is also a characteristic feature of the breed.

Nose: The nose is spacious, slightly Roman; the nostrils are full and sensitive, giving well-developed sense of smell to the breed which is a very important adaptation trait for desert ecosystem.

Mouth: The mouth is firm with medium sized and shallow muzzle. The jaws are well developed which imply great strength. The teeth meet when bite.

Neck: The head joins the neck at about 45 degree angles, proportionate with good musculature, the neck blends into sloping shoulders..

Shoulders: The shoulders are long and set at an angle of about 45 degree, well muscular, the slopes of shoulder blends into the withers. The horse has a long stride because of strong musculature at shoulders.

Withers: Medium high, well defined, the withers are same height or are slightly higher than croup (about 1 to 2 cm high). In this breed, the withers are relatively less prominent than other breeds, measuring up to 2-5 cm thick and 20-22 cm long, extending back beyond the top of shoulders.

Chest: Marwari horses have deep and broad chest, wide set between forelegs that blend into shoulders. The muscles inside the fore legs give the appearance of an inverted "V."

Back: The Marwari horse has short saddle back but is quite powerful. The barrel or girth is deep with well sprung ribs. The underline or belly is longer than the back and does not cut high into the flank. This feature gives the advantage of having saddle in a proper position of balanced action.

Hind Quarters: They are broad deep and heavy with good muscular. The croup is long slope gently from hip to the tail set. The hip muscles are long, extending down into stifle.

Stifle: The stifle lies well into the gaskin. . The stifle is deep when viewed from rear extends out below the hip and above the gaskin. When viewed from the rear the stifle is the widest part of Marwari horse.

Gaskin: The gaskin muscles extend down in to hock joint, both inside and out side. It is wide and shows related thickness when seen from rear in this breed.

Hock: The hock is broad, clean, strong low set and free of excess tissue. The muscling lies well into the hock joint. There is no play in the hock joint except directly forward.

Cannon: Cannon bones are short with hock and knee joints low to the ground. The cannon bones both front and rear show a perpendicular position and appear quite broad when viewed from side. The tendon, back and below the knees and hocks appear sharply separated from the bone and from each other.

Ankles: The ankles are well formed and strong to withstand shock and strain during games or walking.

Pastern: The medium length pastern denotes strength. They have a slightly forward slope about 45 degrees, viewed from either the front or rear. The legs cannons and pastern are straight.

Hoof: The hoof is oblong. Its size balances with the overall size of the individual animal and has overall same slope at the pastern. In mature Marwari horse, width of sole may be up to 18 cm and coronet up to 15 cm wide. The sole and the wall are very strong and are seldom shod except in hills or on metal roads.

Body Measurements

The standard body measurements were recorded on Marwari horses at different places, especially in the horse shows and livestock fair where identification of horses true to the breed was easier. The results have been presented in the tables 1-3 given below:

Heart Girth: The average heart girth observed in adult Marwari males and females was 169.8 ± 1.11 cm and 168.1 ± 1.95 cm, respectively at Marwari Horse show (Table 1). At Jasdan show and at Pushkar Livestock Show, these values in stallions and mares were observed to be 167 cm and 174 cm and 170.6 ± 1.44 cm and 163.4 ± 1.29 cm, respectively. At Pushkar fair, the average heart girth of Marwari horse was found to be 167.00 ± 1.58 cm with a range of 157.0 ± 4.27 - 177.4 ± 4.27 cm.

Table 1. Body confirmation biometry at Marwari Horse Show

Sr. No.	Parameters (in cm)	Stallions (n=8)	Mares (n=66)
1.	Height at withers	153.0 ± 0.93	149.1 ± 1.11
2.	Body Length	144.9 ± 1.22	146.6 ± 0.67
3.	Heart Girth	168.1 ± 1.95	169.8 ± 1.11
4.	Leg Length (fore)	99.6 ± 3.07	99.5 ± 0.56
5.	Leg Length (hind)	101.4 ± 0.98	98.0 ± 0.53
6.	Height at Knee	46.5 ± 1.02	45.3 ± 0.26
7.	Face length	60.4 ± 2.10	62.9 ± 0.52
8.	Face width	21.3 ± 0.65	19.7 ± 0.18
9.	Ear length	18.8 ± 0.37	15.4 ± 0.25
10.	Ear width	12.8 ± 0.92	8.9 ± 0.37
11.	Tail length	46.3 ± 0.92	45.5 ± 0.37

Height at Withers: Marwari horses are generally of 15 hands high (14.3 to 16.0 hh). At Marwari Horse show, an average height at withers was recorded to be 153.0 ± 0.93 cm and 149.1 ± 1.11 cm in adult stallions and mares respectively. These measurements at Jasdan Horse show were 161 cm and 160 cm for stallions and mares, respectively (Table 2). At Pushkar Livestock Fair these values were 155.8 ± 0.54 cm and 151.4 ± 0.78 cm respectively. At Haldighati Marwari Horse show, the average height was 152.00 ± 1.56 cm with a range of 137.4 ± 3.66 to 170.0 ± 7.32 cm.

Table 2. Body measurements (cm) of Marwari horses at different livestock shows

Measurements (cm)	Jasdan Horse show, Rajkot		Pushkar Animal Fair	
	Adult Male	Adult Female	Adult Male	Adult Female
No. of observations	5	7	5	5
Body length	135	142	137.0 ± 1.23	131.6 ± 1.36
Height at withers	161	160	155.8 ± 0.54	151.4 ± 0.78
Heart girth	167	174	170.6 ± 1.44	163.4 ± 1.29
Paunch girth	172	176	161.8 ± 1.32	158.0 ± 1.25
Height at sacrum	139	132	145.8 ± 0.80	142.0 ± 0.65
Hip width	32	35	34.5 ± 0.60	33.20 ± 0.55
Ear length	17	19	18.2 ± 0.46	17.8 ± 0.54
Face length	59	60	54.0 ± 0.49	51.6 ± 0.58
Face width	22	22	21.8 ± 0.64	20.4 ± 0.60

Source: Annual Report (1996-97)

Body Length: The average body length of 146.6 ± 0.67 cm and 144.9 ± 1.22 cm was recorded in stallions and mares at Marwari Horse show. respectively. At Jasdan Show and Pushkar livestock Fair these values were 135 and 142 cm and 137.0 ± 1.23 cm and 131.6 ± 1.36 cm, respectively. At Haldighati horse show the average body length was 132.00 ± 4.80 with range of 121.8 ± 4.22 - 154.7 ± 4.88 cm (Table 3).

Table 3. Body measurements of Marwari horses from Haldighati region of Rajasthan

Measurement (cm)	Average	Range
Body length	132.00±4.80	121.8±4.22-154.7±4.88
Heart girth	167.00±1.58	157.0±4.27-177.4±4.27
Chest width	39.50. ±0.62	33.3±3.78- 45.0±7.56
Height at withers	152.00±1.56	137.4±3.66-170.0±7.32
Height at sacrum	141.60±0.54	126.8±3.60-155.0±7.20

Source: Annual Report (1994-95)

The shank is 20.5 cm in male and 20.0 cm in female. The Marwari horses had 130-140 cm long body, 152-160 cm height, 166-175 cm heart girth; 60 cm face length, 22 cm. face width, 18 cm long ears and 47 cm long tail without switch. Average Shank Measurement is 20.5 cm in male and, 20.0 cm in female.

The wide variability in the biometrical traits at different Marwari horse shows could be due to difference in age of the animals brought to the fairs. However, the differneces in the stock brought from different regions can also not be ruled out.

Genetic Characterization

In genetic analysis, various types of genetic markers such as chromosomal, biochemical and molecular markers are used.

Karyotype analysis

The chromosomal profile of the Marwari breed like other domesticated horse (*Equus caballus*) is 64. The standard karyotype of Marwari horse (Fig .7) shows chromosomal complement



Fig. 7. A Karyotype of Marwari horse

of 13 pairs of metacentric/ submetacentric chromosomes and 18 pairs of acrocentric chromosomes. The X chromosome is a large submetacentric while the Y chromosome is acrocentric. The data in table 4 shows the morphometric measurements of chromosomes of Marwari horse.

Table 4. Relative length and arm ratios of horse chromosomes

Chromosome number	Relative length	Arm ratio (Q/P)	Chromosome number	Relative length
1.	7.25±0.21	2.34±0.30	17.	3.46±0.10
2.	4.59±0.19	2.20±0.29	18.	3.21±0.08
3.	4.42±0.17	1.40±0.19	19.	3.07±0.07
4.	4.16 ±0.15	4.01±0.59	20.	2.91±0.09
5.	4.01±0.16	1.27±0.14	21.	2.73±0.05
6.	3.94±0.12	2.45±0.29	22.	2.60±0.07
7.	3.67±0.09	1.41±0.13	23.	2.43±0.05
8.	3.58±0.11	1.45±0.19	24.	2.30±0.05
9.	3.49±0.13	1.42±0.15	25.	2.15±0.06
10.	3.40±0.06	2.40±0.29	26.	1.96±0.07
11.	2.00±0.09	1.21±0.09	27.	1.73±0.08
12.	2.03±0.09	1.21±0.05	28.	1.65±0.08
13.	1.87±0.08	1.19±0.05	29.	1.51±0.06
14.	4.22±0.06	-	30.	1.33±0.11
15.	3.90±0.08	-	31.	1.16±0.14
16.	3.72±0.04	-	-	-
X	5.23±0.15	2.50±0.28	Y	1.41± 0.07

Fig.8 shows a idiogram of Marwari horse breed. The first pair is the largest chromosome and subsequently the change is very gradual. Since no polymorphism has been reported in chromosomal profile of horses, so is not considered a suitable marker for breed characterization.

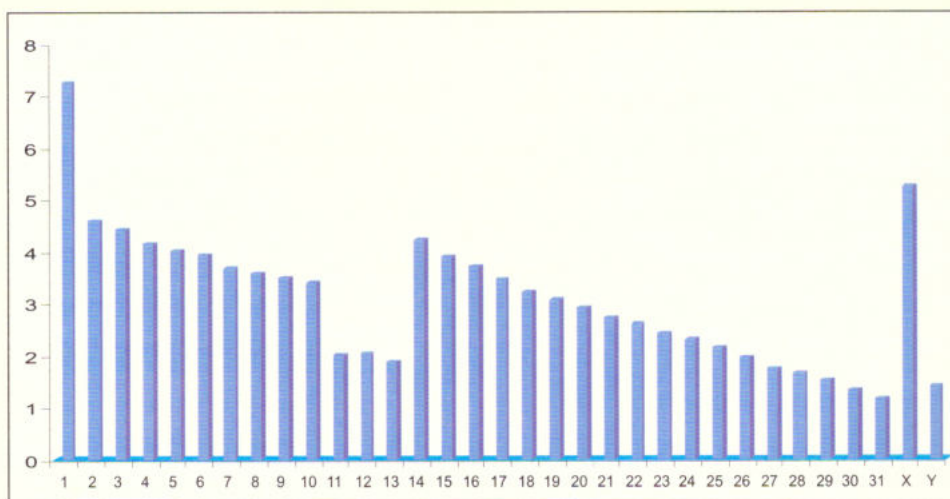


Fig.8. An idiogram of Marwari horse chromosomes

DNA Fingerprints

In a breed conservation/improvement programme, the genetic characterization of local breeds is a major pre-requisite. The polymorphic microsatellite DNA markers have proved to be markers of choice for the analysis of genetic variability within and between the populations. This study was undertaken to genetically characterize Marwari horses using polymerase chain reaction (PCR) based microsatellite DNA analysis, in order to know the present status of available genetic variability of these horses.

The allele frequencies, observed effective number of alleles, observed/expected heterozygosity were calculated using POPGENE computer package (Yeh *et al.*, 1999). The polymorphism information content (PIC) was also calculated at each locus. The PCR product size range varied between 84 to 100 bp at locus HTG6 to 238-248 at locus UCDEQ425. The total number of alleles varied between three (NVHEQ54 and NVHEQ79) to nine (AHT 4). Except the above mentioned two loci the number of alleles at all other loci was four or more than four.

The mean observed and expected heterozygosity was 0.58 ± 0.08 and 0.77 ± 0.07 , respectively. The mean observed heterozygosity is lower than the expected values. The observed heterozygosity values and total number of alleles observed at studied loci are lower than these values reported in literature for other horse breeds (Bjornstad *et al.*, 2000; Canon *et al.*, 2000). The lower heterozygosity values reflect that the level of genetic diversity is less in Marwari horses and to certain extent it also reflects the state of inbreeding. This may be attributed to the dwindling population of Marwari horses.

The PIC values ranged between 0.53 at locus NVHEQ54 to 0.84 at loci AHT4 and HMS2, which reflected the suitability of these markers for such genetic characterization studies of Indian horses. The less number of alleles and lower heterozygosity values shown by Marwari horses compared to other horse breeds points to the falling genetic variability levels in Marwari horses, probably due to limited population of these horses and even lesser number of available studs. In view of this, immediate attention is required for conservation of this unique breed.

The Marwari horses were studied to find out whether any recent genetic bottlenecks have occurred in them, using data generated at twenty five microsatellite loci with three quantitative tests of Cornuet and Luikart (1996). The results are given in Table 5. The sample size was 42 or 84 haploid genomes. The expected number of loci with heterozygosity excess was 14.93, 14.69 and 14.81 for IAM, TPM and SMM, respectively, in the finite sample size and assuming mutation drift equilibrium. The number of loci actually observed with heterozygosity excess has been 25 for all the three mutation models. These values are significant using Sign Rank test and thus null hypothesis of mutation drift equilibrium is rejected in all three mutation models suggesting that Marwari horses have undergone recent genetic bottleneck.

Table 5. Microsatellite loci amplified in Marwari horse genomic DNA

Microsatellite locus	Primer sequence	Annealing temperature (°C)
HTG4	ctatctcagttgattgcaggac, ctccctccctccctctgtctc	55
HTG6	cctgctggaggctgtgataagat, gttcactgaatgtcaaattctgct	55
HTG7	cctgaagcagaacatccctccttg, ataaagtgctggcagagctgct	5b
HTG8	caggccgtagatgactaccaatga, tttcagagttaattggtatcaca	55
HTG10	caattcccgcacccccggca, tttttattctgatctgtcaca ttt	55
HTG14	ccagctaaagttgttgctagaa, caaaggtgagtggatggaagc	60
HTG15	tcttgatggcagagccaggattg, aatgtcaccatgcccacatgact	55
AHT4	aaccgctgagcaaggaagt, cccagagagttaccct	60
AHT5	acggacacatccctgctgc, gcaggctaaggggctcagc	60
HMS2	acggtggcaactgccaaggaag, ctgacagtcgaatgtgtattaatg	58
HMS3	ccaactctgtgcacataacaaga, ccatcctcactttttcactttgtt	60
HMS6	gaagctgccagattcaaccattg, ctccatctgtgaagtgaactca	60
HMS7	caggaactatgttgataccatc, tgtgtgaaacataccttgactgt	60
VHL20	caagtccttacttgaagactag, aactcaggagaatcttctcag	60
LEX20	ggaataggtgggggtctgtt, aggttactagccaagtgactgc	55
NVHEQ5	cgcatgtgctcccctcac, cctcttccacgcaatcactcta	60
NVHEQ11	ggccccaccactaaatcactg, cggggtcttggaaattatgaagg	60
NVHEQ18	ggaggagacagtggccccagtc, gctgagctctccatcccatcg	60
NVHEQ29	gagatttgcccaaaggta, ctctcttcttccccaggctt	60
NVHEQ40	tggcatctgaatggagaatg, gattatgatgctacaggggaaag	60
NVHEQ100	ccaaagcagaacatgtgaagtt, tggcatagatgttagctaagtga	59
NVHEQ21	ccagaacctggactgaacagtgc, gaatgtgcttgatgcagaagaagg	60
NVHEQ54	agatgtccacctctcgctg, cggggcttttaggaggaac	58
NVHEQ79	atgcctgtgctgagatgg, gcaaattgcctctgtatcacac	60
UCDEQ425	agctgcctcgtaattca, ctcatgtccgctgtctc	55

(Behl *et al.*, 2004 a,b)

Table 6 - Effective number of alleles, observed and expected heterozygosity and polymorphism information content (PIC) in Marwari horses (2n=84)

Microsatellite locus	PCR-product size range (bp)	Observed no. of alleles	Effective no. of alleles	Observed heterozygosity	Expected heterozygosity	PIC
HTG4	131-137	4	3.16	0.55	0.69	0.66
HTG6	84-100.	5	3.02	0.57	0.68	0.67
HTG7	116-126	4	3.54	0.48	0.73	0.71
HTG8	176-190	7	5.62	0.69	0.83	0.82
HTG10	94-114	5	3.69	0.48	0.74	0.71
HTG14	127-137	4	3.22	0.55	0.70	0.67
IITG15	128-146	7	6.06	0.67	0.85	0.83
AHT4	142-164	9	6.37	0.64	0.85	0.84
AHT5	130-138	4	3.58	0.48	0.73	0.70
HMS2	218-236	8	6.23	0.67	0.85	0.84
HMS3	151-169	8	5.38	0.71	0.82	0.81
HMS6	159-167	4	3.94	0.45	0.76	0.73
HMS7	168-182	7	5.80	0.67	0.84	0.82
VHL20	95-109	6	5.33	0.62	0.82	0.81
LEX20	196-208	5	4.22	0.64	0.77	0.75
NVHEQS	149-159	6	4.22	0.67	0.77	0.76
NVHEQ11	122-130	5	4.56	0.52	0.79	0.77
NVHEQ18	118-132	7	5.22	0.69	0.81	0.79
NVHEQ29	93-103	6	4.92	0.62	0.81	0.79
NVHEQ40	146-156	5	4.43	0.55	0.78	0.76
NVHEQ100	189-203	7	5.58	0.60	0.83	0.82
NVHEQ21	153-161	5	4.03	0.50	0.76	0.74
NVHEQ54	178-186	3	2.31	0.45	0.57	0.53
NVHEQ79	132-136	3	2.82	0.50	0.65	0.62
UCDEQ425	238-248	6	5.11	0.55	0.81	0.80

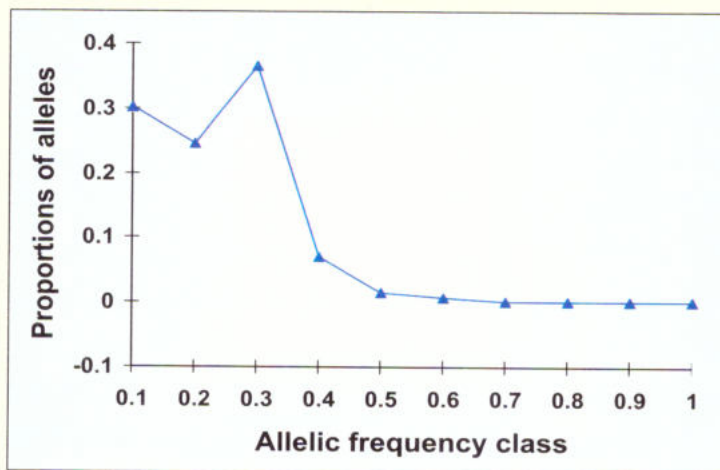


Fig:9. Graphic representation of proportion of alleles and their distribution in Marwari horses at twenty five microsatellite loci.

In standardized differences test, the static T_z values for Marwari horses are equal to 7.570, 6.654 and 5.213 for IAM, TPM and SMM models, respectively. All these values are greater than 1.645 (value from table of normal distribution) and thus reject the null hypothesis of mutation drift equilibrium inferring thereby that the population has recently undergone genetic bottleneck (Fig. 9).

A mode shift was observed in Marwari horses. The shift mode test can detect the recent bottleneck up to 40-80 generations while the quantitative test of Cornuet and Luikart (1996) can detect bottleneck up to 250 generations and is thus more sensitive.

Present Status

With global mechanization, the equine draught power and farming process, throughout the world has been reduced to a great extent. In India the horses were mainly bred and held by state rulers for use in the army, sport and pleasure. However, ponies and donkeys maintained for livelihood of the poor. During the last five decades the equine population as a whole

has drastically reduced in India, with slight increase in mule population. Traditional breeds of horses in the country are slowly disappearing due to multiple reasons, viz. lack of support, reduction in land-holding, lack of knowledge and mechanization. However, the main reason remains as integration of states and abolition of Jagirdari that gave a severe blow to horse industry.

Today the breed is once again achieving eminence after over a century of twilight status due to the Imperial presence of the British and further, the new Indian democracy. They have also crossed continents and have been kept on the Island of Chappaquiddick, MASS, USA. Together they form the largest nucleus of this breed. It is the first time that the Marwari horses are exported to advanced country like USA. Marwari horses have been fascinating the foreigners due to their activity, alertness and smartness. There is a lot of potential in export of animal of this breed. However, some diseases prevalent in horses and other equines in the country need to be controlled for boosting the export of these horses of rare quality. Currently there are six horses in the USA with several more due later in the coming years. We anticipate exporting a maximum of 10 a year for the foreseeable future. (Horsemarwari.com)

Role of Breed Societies

The Marwari breed horses are near extinction due to indiscriminate crossing because of lack of stallions true to breed specifically in the native area. During one survey by the Marwari Horse Association, out of the total population of 23,314 horses in the home tract, number of purebred Marwari horses has been estimated to be around 3000 (about 13%). No efforts have been taken for conservation of the breed getting extinct, except the sole efforts made by recently formed Marwari Horse Breed Association under the patronage of Ex Maharaja of Jodhpur. Though, this breed of horses have declined in relation to overall reduction of horse population, cross breeding between Kathiawari and Marwari horses has also played a major role, especially in Gujarat and border areas of Rajasthan.



Fig.10. A Marwari horse show at Haldighati in Rajasthan

The society is doing very good work for the characterization and conservation of this magnificent breed of horses. They are not only registering the pure bred horses with full pedigree records but also monitor the movement of the horses within and outside the breeding tract. Further the society organizes the horse shows to popularize the breed as well as gives incentives to the Marwari horse breeders. Fig. 10. shows the exhibition of true to Marwari breed horses at Haldighati, organized by Chetak Horse Society, Udaipur. They also help the breeders in marketing the horses and now farmers are getting remunerative price of their horses and their number is improving. There is another Society, Indigenous Horse Society of India on Marwari Horse breed located at Jaipur and have helped in exporting the Marwari horse to USA.

Conservation Efforts

Marwari horse breeding and Research Institute, an NGO, has recently been initiated by grant from Department of Animal Husbandry and Dairying, Government of India. National Research centre on Equine, Bikaner Station, is also now making efforts to conserve this breed in its home tract. Breeding services from good quality Marwari stallion is also provided to the farmers.

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