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PREFACE

Studies related to characterization and evaluation of cattle genetic resources so far has been restricted to few well-known indigenous cattle breeds, until recently when the emphasis is given by the Bureau to explore the unique characters and utility of lesser known breeds of farm animal genetic resources of the country. Populations particularly the lesser known migratory cattle breeds have neither characterized nor evaluated in detail for their production potential. It is true that utility of such breeds may be restricted in a small region or to a certain section of the society, but the role played by these animals in providing livelihood security to landless labourers and livestock keepers is remarkable. Belahi cattle (Bos Indicus) are medium sized well-built dual purpose migratory breed of cattle from North India. Belahi animals are reared by Gujjar pastoralists from foot hills of Haryana, and nearby states like Punjab, Himachal Pradesh, Uttrakhand and Union territory of Chandigarh. Animals have good potential for producing milk under extensive system of rearing and or grazing management system. Milk of Belahi cattle can be considered at par with other indigenous milch animals from the region while male calves of Belahi cattle have a great demand in north Himalayan foot hills for their draft power and are also used in other agriculture operations. Young male calves of Belahi cattle are available at low cost and are efficaciously used to plough the agriculture fields well in hilly terrains. A pilot project was undertaken to characterize Belahi cattle both phenotypically and genetically, and also to assess the production and reproduction potential, with socio-economic utility of this breed. Such an effort may help in designing suitable breeding and conservation strategies for the breed for their overall improvement. Keeping above facts in view, it is imperative to document this valuable germplasm for its wide publicity. This manuscript is a sincere effort to compile the information generated under the ICAR-NBAGR project on characterization of Belahi cattle.

We express our gratitude to our former director, Dr. B.K. Joshi, for inspiring and persuading us to undertake the characterization and documentation project of Belahi cattle. Authors are thankful to Dr. D.K. Sadana for his support. Authors are thankful to Director ICAR-National Bureau of Animal Genetic Resources, for funding this project and publishing the bulletin. Authors hope that this research bulletin will be useful to research scholars, extension workers and scientists working in Animal Science area. In the last but not least authors are thankful to livestock keepers who are rearing and maintaining this valuable bovine germplasm.

AUTHORS

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Introduction

Animal genetic resource of India contributes substantially to the GDP as well as in providing the food security to the country. Milk and dairy products are major contributor in country's livestock economy (besides meat, egg, wool, and draught power). Milk is a source of complete food and is the only acceptable source of animal protein for the large vegetarian segment of the population in India. Cattle and buffalo are major milch animals of our country. Cattle genetic resources in India comprise of 190.90 million head which is 37.28% of the total livestock. Out of which 11.62% of indigenous cattle have been described and categorized in to 44 different populations including 39 distinct and registered cattle breeds. On the utility basis these have been classified as milch, draught or dual purpose. Among the identified breeds only 5 breeds are exclusively for dairy purpose and 8 are milk and draught purpose. Only 6% well defined indigenous milch and best dual purpose breeds exist among total indigenous cattle population. Draught power for agricultural operations and transport is primarily supplied by cattle and buffalo bullocks. Draught animal plough around 100 million of hectares of farm land in our country (Bansal and Malhotra, 2006). Bullocks still make economic sense for small and marginal farmers. These well-defined breeds are well adapted to different agro-climatic conditions of India. However, huge cattle genetic resource still remains untapped, which needs to be identified and utilized for milk production.

Indigenous cattle in India play a crucial role in the livelihood system and well-being of the traditional rural livestock keepers. It has been observed that livestock rearing is more economical for rural masses, in those parts of the country where the crops are difficult to sustain

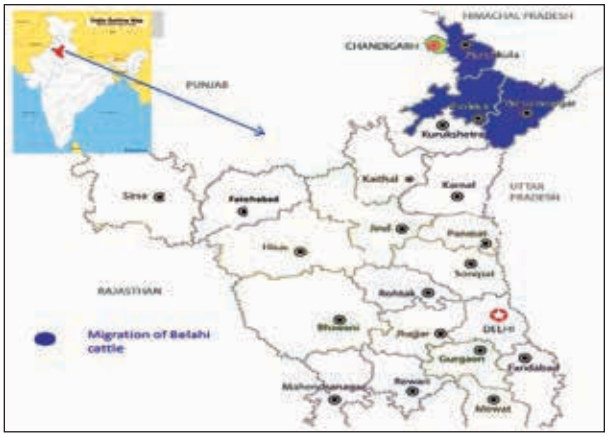
due to harsh environment and difficult geography. Moreover, with the change in climate it is expected that relevance of livestock for food will gradually increase in agriculture. At present in some areas of the country, which are inhabited by tribal and nomads, and animal rearing is the only source of earning their livelihood. Thus, livestock keeping plays an immense role in livelihood security of rural poor and which can be ensured only via. their sustainable utilization of animal genetic resources. One such rare cattle population from North Himalayan foot hills is known as Belahi. The breed derives its name based on typical colour pattern, which is a mix of reddish brown and white body colour. Different synonyms includes Gori-Belahi, Morni or desi (meaning indigenous) cattle. The animals are primarily distributed in North eastern parts of Haryana, Chandigarh, Punjab and Himachal Pradesh. Belahi cattle are dual purpose cattle breed (milk and draught power) which is kept under pastoral management system.

Pastoralist communities represent nearly six per cent of the total population in the country. Pastoral groups like Gujjars, Kinnauras, Gaddies and Bakarwal in North Himalayan and Sub-Himalayan region are well known and documented (Sharma et al, 2003), but their contribution to livestock economy is hardly ever recognized. Gujjars, from Shivalik range of Himalayas are reported to be responsible for the maintaining Belahi cattle especially in foot hills of Haryana and in its adjoining states. Both Hindus and Muslims Gujjar are raising and maintaining these cattle are called as *langarias*. These animals are reared under migratory livestock production system with extensive management / low input system. Such migratory livestock rearing is aimed to seasonal exploitation of high quality grasses and supposed to be highly efficient production system and moreover, animals defecates en-route leading to rich organic manure to the barren

fields. The livestock rearing system and their indigenous traditional knowledge of coping mechanisms of environment stress (drought and floods) and reduced diseases incidence among their indigenous breeds serves a great role in conservation of native livestock breeds needs, which needs to be explored. However, little is known regarding the contribution of pastoralists in national economy, their population size, structure, migratory route, and animal husbandry practices which these pastoralists follow. Hardly any studies have been conducted on pastoral management of cattle and their herder communities in India (Blench, 2000). No systematic program has been taken so far, to characterize and evaluate migratory Belahi cattle; on the contrary research programs are needed, as these animals seem to play an important role in sustaining livelihood security of rural pastoralists. If the economic value of Belahi cattle is to be fully exploited, then suitable management systems will have to be devised to exercise greater control over their movement and feeding habits. Not only it is one of the most important productive assets for Gujjar pastoral community, Belahi cattle serves as a critical store of wealth for their families and an insurance mechanism to cope with household related crisis.

Information related to Belahi cattle and its herders, migration route and pattern, herd size & composition, feeding and breeding, health management, milk production, collection & marketing, socio-economic status were collected and compiled through direct recording, research and interview based with the livestock keepers of Belahi Cattle from Haryana, Chandigarh, Punjab and Himachal Pradesh.

Breeding tract and location



Belahi is a dual purpose cattle breed maintained under migration system, and has been evolved more than 100 years ago by the Gujjar community. The origin of the breed is unclear however, as informed by the breeders from native tract these animals are reared in their family from several generations and Belahi cattle rearing is their sole occupation and major source of livelihood.

The native breeding tract of Belahi cattle lies in North Himalayan foot hills including Shivalik foot hills, and especially in those ranges which are extended in Haryana, Chandigarh, Punjab, Himachal Pradesh and in some parts of Uttaranchal. Niche of Belahi cattle lies in state of Haryana, which is bounded by the Union Territory of Chandigarh in the North, in the Northwest by the state of Punjab, in the Northeast by the states of Himachal Pradesh and in the East by the state of Uttarakhand, Uttar Pradesh and the union territory of Delhi. Sivalik hill ranges occupy the Northern and Northeastern fringe of Panchkula district and attain the height up to 950 m AMSL. The hills are about 500 m high with respect to the adjacent alluvial plains. These are characterized by the broad table and topography that has been carved into quite sharp slopes by numerous ephemeral streams come down to the outer slopes of the Sivaliks and spread much of gravels boulders, pebbles in the beds of these streams.

Pilot survey conducted by National Bureau of Animal Genetic Resources, Karnal revealed that Belahi animals are distributed in North Himalayan foot hill region especially northern and Northeastern parts of Haryana and its adjoining boundaries. During the study, different pastoral group were seen migrating with their animals through barren lands of Panchkula, Ambala and Yammuna Nagar districts in Haryana state (Vohra et al, 2012 & 2014). The native tract identified in the villages of Masoom pur, Rhena and Sultanpur of Raipur-Rani tehsil and Morni of Panchkula district. Shahzadpur, Kalamb, Saha, Nariangarh block of Ambala district. Chhahhrauli block of Yammuna Nagar district of Haryana. It was concluded that three districts of Haryana, spreading over 4236 square kilometer, comprises native tract of Belahi breed with its distribution between 30° 44'N to 30° 70'N Latitude and 76° 48'E to 77° 18'E Longitude. Villages having the highest population of Belahi cattle were Masoompur, Sultanpur, Rehna, Shazadpur, Saha and Khudakalan villages of these districts. However, migratory herds were also seen in the isolated pockets of Mohali, Chandigarh, Kurali, Khrar and Ropar of Punjab state, but in western Punjab, the herds were not seen / present beyond Rajpura and Patiala districts. Some migratory herds were also seen in Sundernagar, Nahan and Pota-Sahib regions in Himachal Pradesh.

Environment and climate of the native tract

Climate of Haryana is hot in the summer and markedly cold in winter; maximum temperatures in May and June may exceed 110°F (43°C), and in January, the coldest month, low temperatures may drop below the freezing point. Most of the state experiences arid to semiarid conditions; only in the northeast are conditions relatively humid. Precipitation averages about 18 inches (450 mm) annually,

most falling between July and September. Although the state has a system of canal irrigation and tube wells, there are chronic drought-prone areas, particularly in the southern and southwestern regions in the state. By contrast, the areas surrounding tributaries of the Yamuna and the Ghaggar rivers are subject to occasional floods.

Panchkula has 898 sq. km area and major soil type is sandy loam. The major physiography of the district can be divided in to Shiwalik, Kandi and Alluvial regions. The climate of Panchkula can be classified as subtropical monsoon, mild & dry winter, and sub-humid which is mainly dry with hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrate into the district. There are four seasons in a year. The hot weather season starts from mid of March to last week of the June followed by the southwest monsoon, which lasts up to September. The transition period from September to November forms the post monsoon season. The winter season starts late in November and remains up to first week of March. The normal annual rainfall of the district is 1057 mm, which is unevenly distributed over the area. The southwest monsoon sets in from last week of June and withdraws in end of September, contributed about 86% of annual rainfall. July and August are the wettest months. Rest 14% rainfall is received during non-monsoon period in the wake of western disturbances and thunderstorms.

Climate of Ambala over most of the year is a pronounced continental in character. It is very hot in summers and markedly cold in winters. May and June can be really hot with the temperature soaring to over 48°C,while in winter it can be as low as -1°C. Ambala has a semi-arid as well as tropical climate. Being far away from the coasts and close to the Thar desert, it does not get the full share of the Monsoon current seen mostly across central and east of the country. Around

70% rainfall is received during the month of July to September and the remaining rainfall is received during December to February. Ambala is the maximum rain-hit area in Haryana with average rainfall being 47.16 inches per annum.

District Yamunanagar area is bounded with 1756 square kilometers. Total geographical area of the district is 1756 sq. km and comprises 4% of total area of State. Large part of the District Yamunanagar comes into the Shiwalik foothills. Yamuna Nagar district is bounded by the state of Himachal Pardaesh in the north 30°17′ latitude, by the state of Utter Pardesh in the east and south east by the districts of Karnal and Kurukshetra in the south north by Ambala District in the east. Yamunanagar District located at height of 274 mt. from the sea level. The district is mainly drained by the rivers Yamuna, Markanda and its tributaries. Markanda is tributary of river Ghaggar and drains major part of the district.

Figure 2: Belahi cattle herd

Large variations in the weather is experienced by the state throughout the year and adaptability of Belahi cattle to these variations indicates that the breed is sturdy and can sustain a wide range of temperature and humidity.

Status of Belahi cattle

According to 19th livestock census report (Anonymous, 2014), there are 8.12 lakh indigenous cattle in Haryana, whereas there are 3.63 lakh and 11.65 lakh indigenous cattle available in Punjab and Himachal Pradesh, respectively. Breed wise census is not available for Belahi cattle, but large number of animals (~ 25,000) are available in the region. However, exact population of Belahi cattle is not available in the last breed wise census report, probably because of three reasons firstly, animals are kept under the migration during most part of the year, and whenever they are not migrating they stay in large herds at outskirts of villages and are not considered native to the place therefore excluded. Secondly, herds are not stationed at one particular place for long and are continuously migrating to different places on year to year bases, seeking easy availability of green grass and water supply. Thirdly, the time of conducting the census is crucial as enumerator's visits villages during day time and the livestock keepers have left their places along with their animals for grazing to far distant areas in the outskirts of villages, only to return by night time. But the situation is not same everywhere, enumerators do approach them, and animals are included for head count they are counted and listed as *Desi* animals in the Census report, due to lack of knowledge in breed recognition.

Belhai is a lesser known cattle breed of North India, as the breed lacks recognition and has never been evaluated in the past for its production and performance, possible reasons could be the migratory nature of the breed and lack of organized herd. However, based on the study conducted by the Bureau shows that Belahi could be a promising dual purpose cattle in the foot hills of North India. Moreover, Belahi cattle has its own importance among the resource limited Gujjars of the region,

who have recognized the utility of these animals as they continue to maintain and conserve this breed. In major parts of Haryana and Punjab the cattle breed of choice seems to be Sahiwal, as these animals give more milk compared to dual purpose breeds Hariana and Belahi cattle. In the recent past, Hariana cattle has lost its relevance as draught breed due to intensive mechanization in the state and subsequently the lower number of available males. In addition to above constraints, both Hariana and Sahiwal cattle in the state are losing ground to buffalo, as Murrah breed is slowly replacing the indigenous cattle for milk production. On the contrary, Belahi cattle has a definite market as a dual purpose cattle, although the market is limited to the foot hills (especially in Nahan, Sundernagar and adjoining areas) but bullocks of the Belahi cattle are preferred for ploughing and agricultural operations in the hilly terrains where mechanization is neither cost effective nor the farmers can afford mechanization.

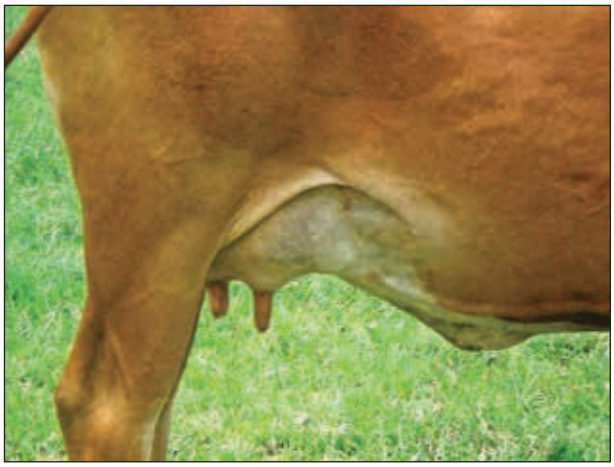
Breed characteristics

Belahi cattle have a reddish coat color with white face and dewlap and black color muzzle in majority of the animals (Vohra et al, 2012). Occasionally, there are different shades of brown coat colour can be seen. Animals were found to be unique and possess distinct phenotypic appearance, from other indigenous cattle breeds in the region which have either complete white coat colour (Hariana) or burnished red colour with dark shades at extremities (Sahiwal). Belahi is a medium statured breed with symmetrical body, tight skin, straight and broad forehead with prominent poll and slender face. The horns are medium in size and sickle shaped. Hump is more prominent in males compared to small hump in females. Tail is long and fine with majority black switch. Medium and round shaped udder properly placed udder with prominent milk vein can be seen.

Belahi animals with typical Breed Characteristic








Belahi animals with typical Breed Characteristic








Physical and morphometric traits

Physical and morphometric data on adult female cattle (N= 200) and bulls (N=32) were recorded along with their performance recording. Belahi cattle have a reddish brown and white (91.5%) coat colour, brown and white (6%) and brown (2.5%). Eyelid colour is white in 18% and black in 82% animals. A reddish patch around the eye is present in 88.3% animals. Muzzle colour is black (89.53%) and white in 10.47%. Ears have horizontal (81%) orientation and slightly dropping orientation in 19% animals, ear colour was recorded white in 47.05% and mix of white & reddish brown in 52.95% of animals. Poll is prominent in 76.47% animals. Straight forehead was seen in 94.1% and concave forehead in 5.9% of the animals. Face is lean and thin with face length & width as 43.33 ± 0.57 cm and 14.17 ± 0.28 cm respectively. Horns have Sickle shape with upwards and slightly curved inwards in orientation and were majority black (88%) in colour and brown in 12% animals with size of 25.4 ± 2.26 cm. Neck colour is primarily white colored. Medium sized dewlap is present with white colour in 70.58%, reddish brown (11.76%) and splashed (17.66%). Colour of tail switch is black in 58.73%, and white in 41.27% animals. The temperament of these animals was moderate to furious. Belahi animals are dual purpose and contribute in terms of milk, draft power and manure / dung.

The average body length, height at wither, heart girth, paunch girth, horn circumference, ear length, face length and tail length without switch in cows (200) were 116.67± 1.80 cm, 120.33 ± 4.58 cm, 157.17 ± 3.69 cm, 159.33 ± 1.65 cm, 14.20 ± 0.62 cm, 27.50 ± 0.40 cm, 43.33 ± 0.57 cm, and 93.67 ± 3.66 cm. The average body length, height at wither, heart girth, paunch girth, horn length, ear length, face length and tail length without switch in bulls (32) were 124.52 ± 1.83 cm,

131.13 ± 5.48 cm, 162.71 ± 6.30 cm, 161.85 ± 3.56 cm, 27.2 ± 3.12 cm, 28.2 ± 1.02 cm, 43.99 ± 0.91 cm, 95.31 ± 2.18 cm, respectively. The different body biometric characters under different age groups are depicted in Table 1-3.

Table 1: Biometry (in cm) of adult Belahi Cow (N=200)

Trait	Max.	Min.	Mean	Std. Error	CV %
Face Length	46	42	43.33	0.57	3.47
Face Width	15	13	14.17	0.28	5.31
Horn length	32	18	25.40	2.26	23.56
Horn circumference	16	12	14.20	0.62	11.57
Ear length	29	26	27.50	0.40	3.81
Height at withers	144	110	120.33	4.58	10.06
Body length	121	108	116.67	1.80	4.08
Chest Girth	172	146	157.17	3.69	6.21
Paunch Girth	167	156	159.33	1.65	2.74
Hip bone	38	31	34.50	1.09	8.35
Pin bone	17	14	15.00	0.41	7.30
Tail length	121	96	110.67	3.47	8.29
Tail up to switch	104	78	93.67	3.66	10.34

Table 2: Biometry (in cm) of adult Belahi Male (N=33)

Trait	Max.	Min.	Mean	Std. Error	CV %
Face Length	46	42	43.99	0.91	3.40
Face Width	15	13	14.54	0.12	5.10
Horn Length	32	18	27.20	3.12	24.16
Horn circumference	17	12	17.10	1.62	19.57
Ear Length	29	26	28.20	1.02	3.61
Height at withers	144	110	131.13	5.48	11.03
Body Length	121	108	124.52	1.83	3.99
Chest Girth	172	146	162.71	6.3	6.12
Paunch Girth	167	156	161.85	3.56	5.27
Hip bone	37	31	32.40	5.10	10.82
Pin bone	17	14	16.50	1.14	7.80
Tail length	121	96	117.70	4.72	10.92
Tail up to switch	104	78	99.01	3.21	9.83

Table 3: Biometry (in cm) of Young Belahi followers (N=68)

Sex	AGE	Trait	Mean	Std. Error	Min.	Max.	CV %
Female	Milk teeth	Height at wither	85.75	1.26	81.00	92.00	4.17
		Body Length	77.00	1.81	70.00	87.00	6.66
		Chest Girth	92.63	2.11	84.00	101.00	6.45
		Paunch Girth	90.00	2.14	82.00	98.00	6.72
		Face Length	29.13	0.72	26.00	32.00	6.97
		Face Width	11.13	0.52	9.00	13.00	13.10
		Horn Length	2.00	-	2.00	2.00	-
		Ear Length	18.38	0.38	17.00	20.00	5.77
		Hip Bone	19.75	0.65	17.00	23.00	9.28
		Pin Bone	8.13	0.48	6.00	10.00	16.69
		Tail Length	58.13	4.10	49.00	85.00	19.95
Female	2 teeth	Height at wither	104.20	2.56	91.00	118.00	7.78
		Body Length	97.00	2.39	86.00	110.00	7.78
		Chest Girth	120.30	3.94	97.00	140.00	10.35
		Paunch Girth	117.70	4.18	95.00	143.00	11.23
		Face Length	34.20	1.13	28.00	40.00	10.48
		Face Width	13.00	0.39	10.00	14.00	9.59
		Horn Length	3.40	0.87	2.00	6.00	57.33
		Ear Length	22.90	0.74	20.00	26.00	10.18
		Hip Bone	25.90	1.49	17.00	32.00	18.24
		Pin Bone	10.90	0.86	6.00	14.00	25.01
		Tail Length	68.00	2.09	57.00	76.00	9.71
Male	Milk teeth	Height at wither	81.33	0.99	79.00	85.00	2.98
		Body Length	72.50	1.26	68.00	76.00	4.25
		Chest Girth	85.33	2.17	75.00	90.00	6.23
		Paunch Girth	82.83	2.39	74.00	89.00	7.06
		Face Length	27.17	0.48	25.00	28.00	4.30
		Face Width	10.17	0.17	10.00	11.00	4.02
		Horn Length	1.00	-	1.00	1.00	-
		Ear Length	18.17	0.40	17.00	19.00	5.41
		Hip Bone	17.50	0.43	16.00	19.00	5.99

		Pin Bone	6.50	0.34	5.00	7.00	12.87
		Tail Length	51.00	2.25	44.00	59.00	10.81
Male	2 teeth	Height at wither	97.33	7.84	83.00	110.00	13.95
		Body Length	87.33	4.67	78.00	92.00	9.26
		Chest Girth	107.33	8.37	93.00	122.00	13.51
		Paunch Girth	102.67	6.94	91.00	115.00	11.70
		Face Length	33.33	3.18	28.00	39.00	16.52
		Face Width	12.67	1.33	10.00	14.00	18.23
		Horn Length	6.00	3.00	3.00	9.00	70.71
		Ear Length	21.00	1.53	19.00	24.00	12.60
		Hip Bone	22.33	2.60	18.00	27.00	20.19
		Pin Bone	8.33	1.20	6.00	10.00	24.98
		Tail Length	63.00	5.57	56.00	74.00	15.31

CV% = Coefficient of Variation

Husbandry and management practices

Herders and herd size

Herders of Gujjar community who rear these animals are called *langaria* (Figure 3 a,b) and they belong to Panchkula Ambala and Yammuna Nagar districts of North Haryana. Majority of the herders were illiterate (90%) and landless with average land holding <2 bigha, therefore, livestock rearing is their primary occupation. Herd men travel alone without their families and spouse. Single herd man manages multiple tasks like milking of cows, feeding, watering and overall management of animals, besides his own basic necessities like cooking, housing and even sale of milk to middle man etc. About 4-5 herders, generally relatives from the same village, pool their small herds and make a big herd (cows, bulls and followers). An average composite herd studied had the following structure: About 200 adult cattle in milk, 80 calves of less than 1 year of age, about 3 to 4 breeding bulls. A composite herd has an advantage as it leads to easier management, and works on resource and risk sharing

Figure 3a: Langaria (Belahi keepers)

principle. It was observed that generally about two third cattle remain in milk during a year, whereas about one third cattle remain dry. Such a management, not strictly but ensures continuous return through the year. Cows in 10th lactation are not uncommon, indicating that lower sale purchase of milch animals. Pastoral management of cattle in this region is different from other migratory herds coming to South West regions of Haryana, especially, Raika and Rebaris tribes of Rajasthan (Kohler and Rathore, 2000). Rebaris community have bigger migrating group, mixed with milch and dry in almost equal proportions, and men are accompanied by their women, who does cooking for them and milking of their animals. According to Sharma et al. (2003) animal husbandry practices followed were different for the different pastoral groups throughout the country but their problems are similar. Livestock is their asset and also a good source of animal protein (milk and meat), which helps them in coping with malnutrition.

Figure 3b: Langaria with animals

Feeding management

Belahi animals graze purely on grasses with little chaffed fodder and *bhusa* given prior to milking in the morning. No feeding is done during night time. Very little of feed about 0.5 kg is given to lactating and sick animals before milking, which is done twice a day. During migration Belahi animals graze on grasses, especially *Cynodon dactylon* also known as dūrvā grass and feed the tree leaves for about 6-7 hours a day along the harvested lands, waste and barren land during summer. Calves maintained on mother's milk by allowing them to suckle their dams before and after milking. During winter months (November to February), they usually return to their homelands, and there they animals are maintained on straw and *bhusa* feeding (*puralis)*. During winter season majority of the herd is dry and or pregnant with last trimester of pregnancy.

Housing management

During migration, animals herds are halted in the open fields where they graze defecate and urinate at their same resting place for days together. No animal sheds or temporary housing were constructed. The owner does not tag their animals, but do have a separate name for individual identification. It seems that livestock keepers of these migratory herds know too little about hygiene and its impact on dairy animals. However, the milking pales / utensils kept by them were clean, probably because they have to sell the milk produced in local market. The milking of animals is also done under poor hygienic conditions. During winter season in their native villages cows are housed in *pucca* (83.33%) and some house them in *kuchha* (16.67%). Majority of the animals are housed as a part of residence (86.67%) while 13.33% were housed separately. Animal house was lacking the proper drainage system in 96.66% houses, while provision for drains was observed in only 3.34% animal houses. Animals were reported to be vaccinated in majority households against diseases like HS, BQ and FMD (*Trivac*) and deworming is also practiced. These pastoralists have partial access to local veterinarians.

Bull is raised and reared along with the cows in a single herd; no special management is done for bulls. The criteria for bull calf selection are based on phenotypic characters which are true to breed and dams yield. Hundred percent natural mating is being practiced, with no artificial insemination. Prolonged use of single bull in a herd increases the chances of inbreeding, which the keepers are unable to control due to less number of bulls.

Calves are maintained on mother milk for few weeks and were not taken for grazing during their first week. Calves are kept in separate temporary enclosure with barbed wire. At around 3-4 weeks of age, calves are taken along with the herd for grazing. All the young calves born in a herd are kept under temporary housing in closed barbed enclosures with temporary roof.

Housing Management System








Housing Management System







Migratory routes

Belahi cattle are maintained as migratory herd in states of Haryana, Punjab Himachal Pradesh and in Union territory of Chandigarh. Migrations to the plains of Haryana and Punjab from Shivalik foot-hills usually starts in the month of February and continue till November (9 months) every year. Availability of bounty full green grasses attracts these animals to Haryana during the hot summers (April to June) and rainy season (July to September). Different migratory routes were identified, being followed by *langarias* in the north of Haryana (Figure 4). The first route identified was starting from Panchkula district especially villages like Raipurrani, Rehena, Masumpur, Sultanpur via Shahzadpur then they progress towards the Chhachhrauli areas of Yammuna nagar district or few may advance to Kalamb in Ambala from where they further migrate to nearby villages. Second route recognized was from Panchkula to Ambala via Narayangarh. Third route is from Panchkula in Haryana to Pontasahib in Himachal Pradesh (H.P) and animals passes through Kalaamb (Ambala), Trilokpur (H.P), Nahan (H.P). Migration towards Punjab follows a separate route, initiating from Panchkula they move towards the Union Territory of Chandigarh, from there they drift towards Mohali (Punjab) to Kharar and Roopnagar areas of Punjab, some of them diverge from Mohali towards Rajpura and may further advance to Patiala in Punjab. These routes can be considered as a broad outline of Belahi migration. Few groups may join them en-route and other may not complete the full route and travel a short distance. It was observed that their stay / halt points and distances they travel is fixed for an individual group. Vendors and milk men who collect milk from Belahi keepers are known to them and are fixed just like their halt points. In general their halt points are near the state highways, and essentially having a source

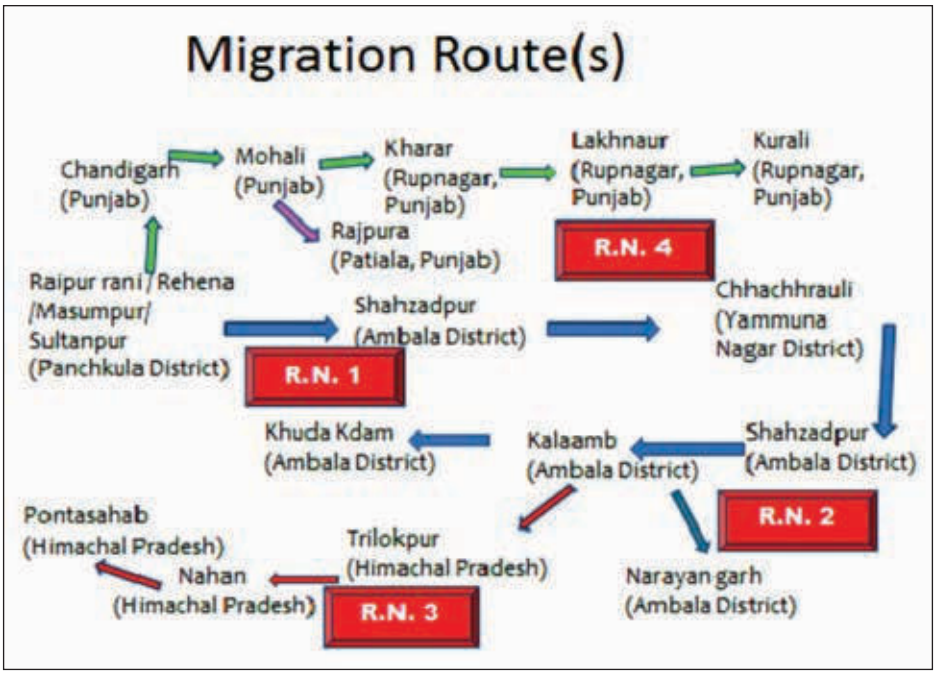


Figure 4: Migration of Belahi Cattle

of water supply to them. A particular *langaria* / group follows the one direction for 4-5 yrs and changes the halt points only under compulsions like reduction in green pastures, and or if water supply deteriorates in a particular area. Few stationary herds were also seen in their native tract.

Utility

Belahi animals are dual purpose where females contribute in terms of milk and males contributes to draft power and manure/dung is contributed by both the sexes. The Belahi cattle has good milk potential and it was observed that average first lactation milk yield was 1071.66 ± 90.72 kg with average peak yield of 5.5 ± 0.32 kg. The bulls were used for transportation and draft power in agriculture fields. Young bull calves of Belahi cattle are sold to farmers at the rate of Rs 800-1000/- for less than a year old male, as these bulls have

market there since they are used to plough the agriculture fields of hilly terrain.

Performance of the breed

Growth traits – Body Weight

Body weights of Belahi cattle at the time of birth and pre-weaning state were recorded for both the sexes. The birth weight varied from 16 to 19 kg in Male and 14 to 17 kg in females, however, at pre-weaning stage which is around 2.5 to 3 months after calving an average weight gain of 33.75 ± 1.42 was observed in females, which is slightly more than the males of the same age group (31.6 ± 1.22). The reason probably is due to more care given to females compared to males as it is a practice prevalent to sell male calves at around one year of age. The adult body weights were estimated using Shaffer's formula (Sastry et al, 1982) using body length and chest girth. (Table 4).

Body weight (lb) = $(L \times G^2) / 300$

Where, G is heart girth and L is the body length from shoulder point to pin bone in inches.

Table 4: Body weights (kg) at different stages in Belahi Cattle

Weight at	Male			Female		
	Average	Range	N	Average	Range	N
Birth	17.6 ± 0.51	16 - 19	5	15.2 ± 0.58	14 - 17	7
Pre-Weaning	31.6 ± 1.22	20 - 44	25	33.75 ± 1.42	20 - 45	24
Adult weight	304.8 ± 1.35	213-331	32	266.74 ± 2.15	226 - 305	200

Production and reproduction performance

The milking is practiced twice a day (morning and evening). The animal is milked as and where it is standing in the field, the owner

recognizes the animal to be milked and allows calf to suckle first, the milking follows immediately after the suckling. On an average calf is allowed to suckle for 1-2 minutes. Calf suckling has an advantage in letdown of milk in females and consequently facilitates milking and considerably reduces the milking time per animal. It was noted that several of the Belahi cows gave more than 5 liters of milk / day, which is an excellent production in such extensive production system.

Milk yield

Best way of knowing the milk production potential of an animal is to record the milk yield at every milking throughout the lactation. Such an approach is limited to only few organized and institutional herds in our country. The task becomes daunting when one has to record the dairy performance in migratory herds such as Belahi cattle. Belahi animals are kept primarily for their milk producing ability under extensive system of rearing and are contributing to the livelihood security and welfare of Gujjar pastoralists residing in Panchkula, Ambala and Yamunanagar districts of Haryana. An attempt was made to estimate the dairy performance in belahi cattle through field recording. A total of 79 cattle were included in study for recording the milk performance. In first lactation, average first lactation milk yield estimated was 1071.66 ± 90.72 kg with average peak yield of 5.5 ± 0.32 kg. The first lactation milk yield varied from a minimum of 182.1 kg to a maximum of 2010.6 kg. Probable reason of a low minimum lactation yield (182.1 kg) was short truncated lactation for unknown cause. The average lactation milk yield of 1071.66 ± 90.72 in Belahi cattle is comparable to Malvi, Mewati, Deoni and Hariana breeds of cattle (Figure 6) and it is second highest among those compared after Kankrej where the lactation yield had been reported

around 1600 kg. The average daily milk yield in Belahi cattle were recorded as 3.45 ± 0.29 kg. The peak yield varied from 1.8 to 9.0 kg which indicates the milk production potential of Belahi animals and selection of superior females could lead to higher gain in herds. The phenotypic data also reveals that the animals are not selected so far, on their basis of milk production. The days to attain highest milk yield varied from as low as 8 days to 81 for first lactation and was as high as 105 days irrespective of the parity in the studied animals. The lactation length in Belahi cows varied from 133 days to 299 days with an average of 227.30 ± 12.33 days in first lactation. The overall averages of various production traits are shown in Table 5.

Milk produced is easily marketed in the nearby households and local markets en-route. The milk is sold at a remunerative prices possibly due to its good quality. The cost of milk may vary according to seasonal change but it was revealed that on an average milk is sold at an Rs 30 / kg.

Table 5: Dairy performance of Belahi cattle in different lactations (N=79)

Parameter	First Lactation			Overall		
	Average	Range	N	Average	Range	N
Daily milk yield (kg)	3.45 ± 0.29	0.59 – 6.59	23	3.25 ± 0.15	0.5 - 9.5	79
Peak milk yield (kg)	5.5 ± 0.32	1.8 - 9.0	23	5.21±0.16	1.8 - 9.5	79
Days to reach peak yield	39.34 ± 4.53	11 - 81	23	41.64 ± 2.85	8 - 105	79
Lactation length (days)	227.30 ± 12.33	133 - 299	23	231 ± 5.89	115 - 300	78
305 day Lactation milk yield (kg)	1071.66 ± 90.72	182.1 to 2010.6	22	1014.43 ± 45.46	182.1 to 2092.2	79

Milk and draft potential of Belahi animals

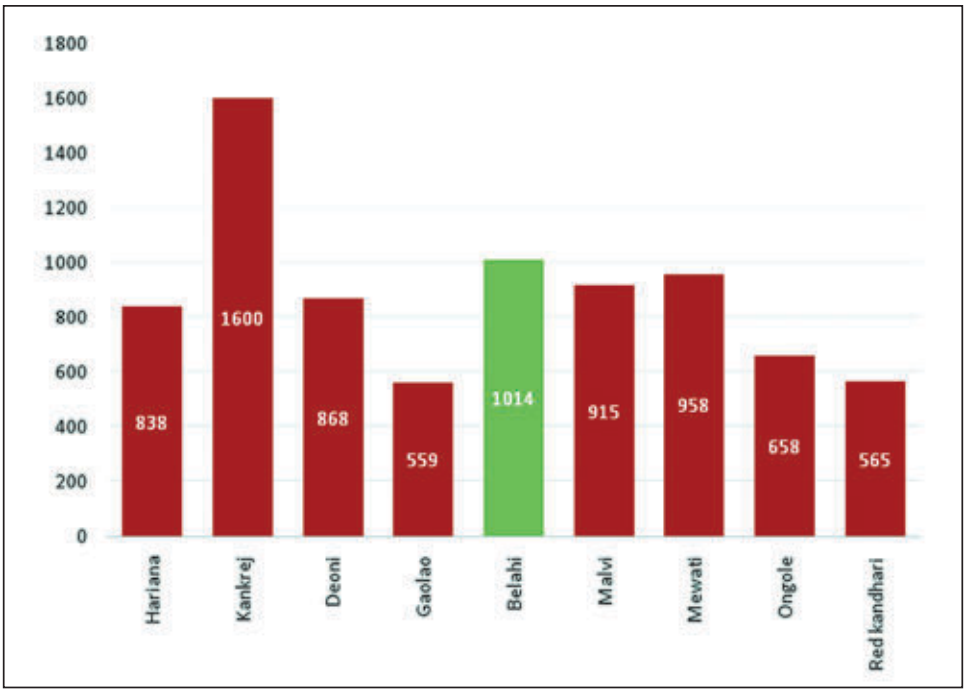


Figure 5. ***Comparison of average lactation yield of Belahi cattle with other indigenous dual purpose cattle***

Milk constituent traits

Different milk constituent traits were estimated in Belahi cattle using automatic *lactoscan* machine. The average fat percentage was 5.25 irrespective of its lactation and it varied considerably among the individual cows and it ranged from 2.37 to 7.89, this high variation could be attributed to that randomness of the milk samples collected from the field. The samples belonged to different stages of lactation and fat percentage may vary according to the stage of lactation. The average protein percentage, lactose and SNF.

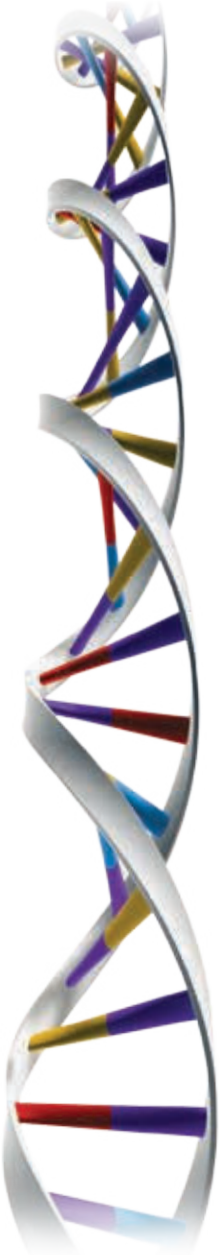
Table 6: Milk constituent traits of Belahi cattle in different lactations (N=68)

Parameter	Minimum	Maximum	Mean		Variance
			Statistic	Std. Error	
Fat %	2.37	7.89	5.25	0.18	1.97
Protein %	2.87	4.02	3.45	0.04	0.09
Lactose %	4.32	6.10	5.20	0.06	0.19
SNF %	7.80	10.98	9.39	0.10	0.63
Freezing Point	-0.63	-0.45	-0.53	0.01	0.00
Tot Solids %	10.90	18.29	14.38	0.24	3.39

Table 7: Milk constituent traits of Belahi cattle in first lactations (N=30)

Parameter	Minimum	Maximum	Mean		Variance
			Statistic	Std. Error	
Fat %	3.03	7.89	5.04	0.29	2.45
Protein %	2.87	3.90	3.33	0.05	0.07
Lactose %	4.32	5.85	5.02	0.07	0.16
SNF %	8.00	10.58	9.07	0.13	0.53
Freezing Point	-0.62	-0.45	-0.52	0.01	0.00
Tot Solids %	10.90	18.29	14.12	0.37	4.08

Genetic Characterization



Genetic characterization of Belahi cattle

Short tandem repeat microsatellite markers were used to characterize and explore the genetic variability present in Belahi cattle. A panel of 16 bovine specific neutral markers, as recommended by FAO (1998) for cattle genetic diversity studies were selected as these microsatellites were evenly distributed across different chromosomes.

Under sterile conditions, 10 ml of venous blood was collected from the jugular vein of the Belahi animals. Random blood samples from 48 adult animals of Belahi cattle from different locations in breeding tract were collected. During sampling the care was taken that no to individuals are related i.e. all the individual have different sire and dam and are unrelated as far as possible. Genomic DNA was isolated from the blood samples using phenol extraction method as described by (Sambrook and Russel, 2001). Quality of genomic DNA was judged by horizontal submarine agarose gel electrophoresis. A suitable standard DNA ladder marker was run in one of the well for comparison. Once the electrophoresis was over the gel were scored under UV Tran illuminator, DNA samples showing intact band and devoid of smearing were considered to have good quality. Purity of genomic DNA was checked by spectrophotometer. The 6 µl of genomic DNA of each sample will be dissolve in 294 µl of triple distilled water and spectrophotometer readings at OD260 and OD280 will be recorded against 300 µl double distilled water as a blank. Genomic DNA samples showing the OD ratio in the range of 1.7 to 1.9 were used further genetic analysis.

Belahi cattle was genotyped using 16 microsatellite markers. The details of the primers are presented in Table 8. Forward primer of each microsatellite marker was 5′-labelled with FAM (Blue), VIC (Green), NED (Yellow) or PET (Red) fluorescence tags in order to perform

Table 8: List of 16 microsatellite loci and primer sequences with fluorescent tag

Locus	Primer Sequences (5'-3')	Fluorescent Dye	Allele size	Annealing temp. (°C)	Chromosome
BM1824	GAGCAAGGTGTTTTTCCAATC CATTCTCCAACTGCTTCCTTG	VIC	176-197	55-60	1
HEL1	CAACAGCTATTTAACAAGGA AGGCTACAGTCCATGGGATT	PET	99-119	54-57	15
ILSTS006	TGTCTGTATTTCTGCTGTGG ACACGGAAGCGATCTAAACG	FAM	283-295	55	7
ILSTS005	GGAAGCAATGAAATCTATAGCC TGTTCTGTGAGTTTGTAAGC	NED	188-214	58	7
ILSTS011	GCTTGCTACATGGAAAGTGC CTAAAATGCAGAGCCCTACC	NED	269-283	58	14
INRA063	ATTTGCACAAGCTAAATCTAACC AAACCACAGAAATGCTTGGAAG	PET	154-168	56	18
INRA035	ATCCTTTGCAGCCTCCACATTG TTGTGCTTTATGACACTATCCG	FAM	120-140	58	16
INRA005	CAATCTGCATGAAGTATAAATAT CTTCAGGCATACCCTACACC	FAM	119-123	54.7	10
MM8	CCCAAGGACAGAAAAGACT CTCAAGATAAGACCACACC	NED	116-140	58	2
MM12	CAAGACAGGTGTTTCAATCT ATCGACTCTGGGGATGATGT	PET	101-145	50-55	9
CSSM66	ACACAAATCCTTTCTGCCAGCTGA AATTTAATGCACTGAGGAGCTTGG	FAM	171-209	55-65	14
CSRM60	AAGATGTGATCCAAGAGAGAGGCA AGGACCAGATCGTGAAAGGCATAG	PET	79-115	55-65	10
CSSM033	CACTGTGAATGCATGTGTGTGAGC CCCATGATAAGAGTGCAGATGACT	NED	154-175	65	17
CSSM008	CTTGGTGTTACTAGCCCTGGG GATATATTTGCCAGAGATTCTGCA	VIC	179-193	55	-
TGLA122	CCCTCCTCCAGGTAAATCAGC AATCACATGGCAAATAAGTACATAC	PET	136-184	55-58	21
TGLA227	CGAATTCCAAATCTGTTAATTTGCT ACAGACAGAAACTCAATGAAAGCA	PET	75-105	55-56	18

fragment length analysis of the PCR products with automated DNA sequencer (ABI 3100). For accurate sizing, primers producing fragment size >75bp were preferred. The microsatellite loci with

overlapping size range were labeled with different dyes to facilitate multiplexing. Each PCR was carried out in 15 µl reaction volume consisting of 200μM of each dNTP, 5pM of each primer, 1.5mM $MgCl_2$ and 1.2U Taq polymerase (Invitrogen, CA). Amplification was performed using MASTERCYCLER EP (Eppendorf, Germany) with an initial denaturation at 95˚C for 2 min followed by 30 cycles of 94˚C for 60 sec, respective annealing temperature (50-65°C) for 60 sec and 72˚C for 60 sec, with a final extension for 10 min at 72˚C. After completion of PCR cycle, amplification was confirmed by running a small aliquot of PCR product on 2% agarose gel. To maximize the throughput, products amplified by different primers with different dyes were pooled for one capillary injection. For fragment sizing, GeneScan-500 LIZ™ Size Standard (Applied Biosystems) was used as the internal standard. Internal lane size standard was run with every sample for accurate sizing. The samples were loaded on to ABI PRISM 3100 DNA Analyzer for genotyping using 36 cm array. For calculation of the molecular weight (size) of different alleles/ DNA fragments, GeneScan software was used.

Different measurements of within breed genetic variations were estimated using POPGENE 1.32. Observed and expected heterozygosity estimates were computed after Nei (1973) as executed in POPGENE 1.32 software (Yeh et al, 1999). Allele frequencies were utilized for assessing Polymorphic Information Content (PIC) values as per Botstein et al. (1980). The PIC values was estimated as per formula given below

$$PIC = 1 - \sum_{i=1}^{k} X_i^2 - \sum_{i=1}^{k-1} \sum_{j=i+1}^{k} 2X_i^2 X_j^2$$

Where Xi and Xj are the frequencies of ith and j^{th} alleles and K is number of alleles.

Hardy-Weinberg equilibrium

Departure of from Hardy-Weinberg equilibrium was derived using the exact test of POPGENE 1.32. Heterogeneity of the deviations from Hardy-Weinberg equilibrium among the microsatellite loci was investigated by considering the microsatellite loci was investigated by considering the deviations as correlation coefficient and tested accordingly. Heterozygosity deficiencies were calculated as $F_{IS} = (H_o - H_e) / H_e$ where H_o and H_e are the observed and expected frequencies of heterozygotes, respectively.

All the 16 loci amplified successfully and produced unambiguous alleles from which individual genotypes were assessed. The various genetic variability measures were estimated as shown in Table 9. There were total of 149 alleles observed with the mean number of observed alleles 9.31 ± 3.11, which varied from 5 (BM1824 and ILSTS11) to 15 (Hel1). The microsatellite loci studied showed 5 or more alleles indicating that all the 16 loci are polymorphic enough to be used as marker to study the genetic diversity of Belahi Cattle. The estimate of gene diversity was 0.72 ± 0.15 (mean expected heterozygosity) in Belahi Cattle. The effective number of alleles (Ne) was distinctly less than the observed values across all loci and varied from 1.47 (TG227) to 7.53 (CSSM33). The observed and expected heterozygosity varied from 0.303 (TG227) to 0.875 (TGLA122) and 0.323 (TG227) to 0.876 (CSSM), respectively. The mean observed heterozygosity values, though lower than the expected values, exhibited failure of significant differences suggesting random mating in Belahi Cattle.

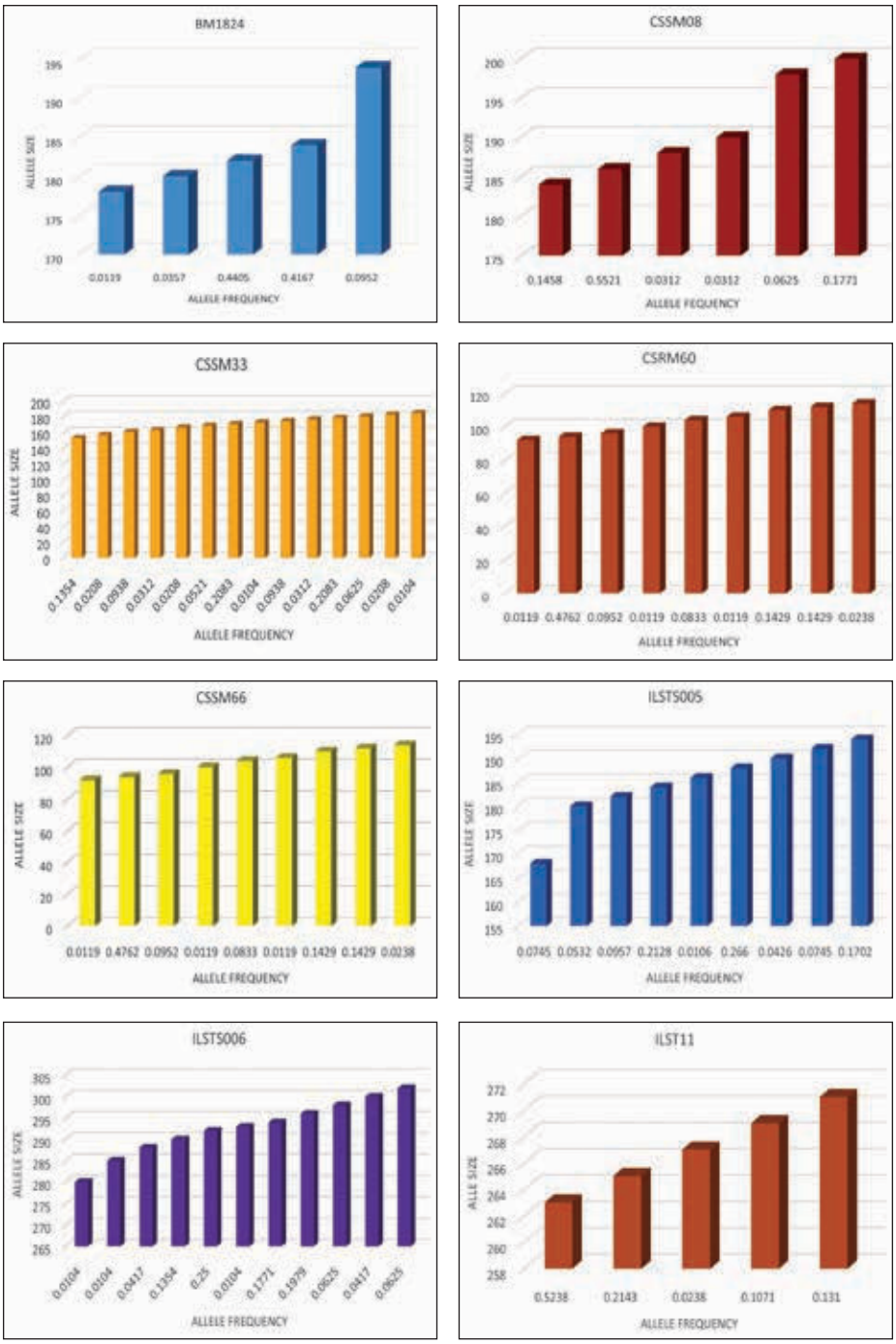
Table 9: Various diversity indices and size range at each micro satellite locus in Belahi Cattle

Marker	N_a	N_e	Obs_H_o	Exp_H_o	Obs_H_e	Exp_H_e	Nei's H_e
INRA35	9	4.65	0.213	0.207	0.787	0.793	0.785
ILSTS05	9	5.88	0.234	0.161	0.766	0.839	0.830
INRA05	9	3.88	0.292	0.250	0.708	0.750	0.742
INRA63	6	2.77	0.333	0.354	0.667	0.646	0.639
BM1824	5	2.64	0.310	0.371	0.691	0.629	0.622
ILSTS11	5	2.86	0.238	0.342	0.762	0.658	0.651
CSRM60	9	3.51	0.191	0.286	0.810	0.724	0.715
CSSM66	12	6.85	0.208	0.137	0.792	0.863	0.854
TGLA122	11	7.47	0.125	0.125	0.875	0.875	0.866
MM12	10	3.18	0.500	0.308	0.500	0.693	0.685
CSSM33	14	7.53	0.146	0.124	0.854	0.876	0.867
MM8	6	1.96	0.625	0.504	0.375	0.496	0.491
ILST6	11	6.14	0.208	0.154	0.792	0.846	0.837
CSSM8	6	2.75	0.458	0.357	0.542	0.643	0.637
TG227	12	1.47	0.688	0.677	0.313	0.323	0.319
HEL1	15	6.68	0.208	0.141	0.792	0.859	0.850
Mean	9.31	4.39	0.31	0.28	0.69	0.72	0.71
St. dv	3.11	2.06	0.17	0.15	0.17	0.15	0.15

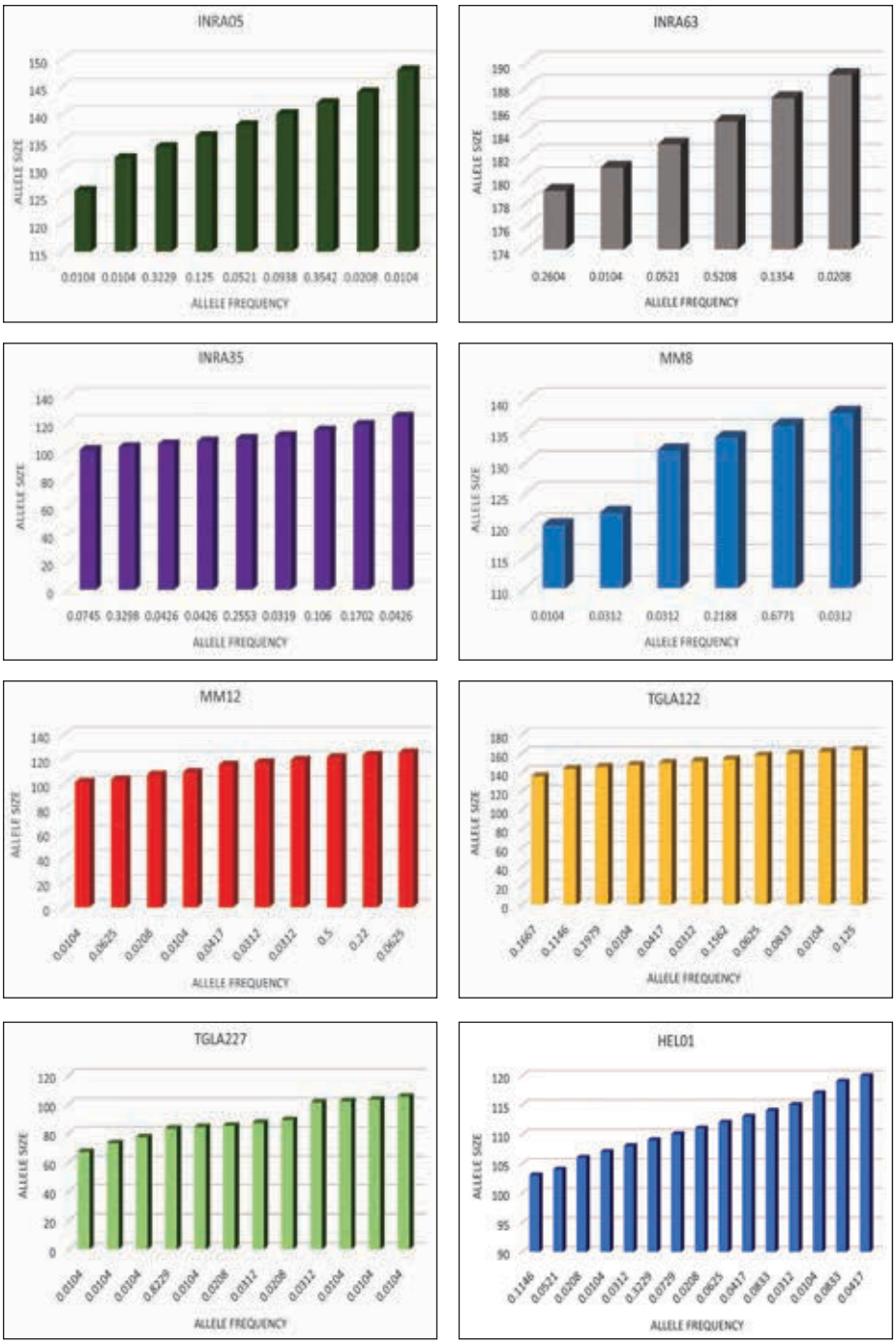
N_a: Observed number of alleles; **N_e**: effective number of alleles; **Obs_H_o**: observed homozygosity; **Exp_H_o**: expected homozygosity; **Obs_He**: observed heterozygosity; **Exp_H_e**: expected heterozygosity.

Polymorphism information content

Polymorphism information content values varied from 0.319 (TG227) to 0.872 (CSSM33) and about 87.5% of the markers were observed to be highly informative (PIC>0.50) and the remaining 12.5% were also reasonably informative (0.50>PIC>0.31) this indicates the high utility of these markers for biodiversity analysis in native Indian cattle breed. The estimate of genetic variability counts reported earlier in other native cattle breeds (Mukesh et al, 2004; Sodhi et al, 2005; Pandey et al, 2006).



Frequency of alleles observed at different microsatellite loci in Belahi cattle



Frequency of alleles observed at different microsatellite loci in Belahi cattle

Within population inbreeding estimates (F_{is}) for Belahi cattle is depicted in Table 10. The estimate ranged between -0.1712 to 0.2357 with an average F_{is} value 0.0337. Thus on an average deficiency of 3.37% of heterozygotes existed in Belahi cattle, which indicates that Belahi cattle has considerable genetic variability with very low inbreeding, the probable reason could be its migratory nature. All the 16 markers except INRA35, INRA63, BM1824, ILSTS11, CSRM60 and TGLA122 contributed to this observed heterozygote shortage. Heterozygote deficiency analysis revealed deviations from Hardy-Weinberg Equilibrium ($p<0.01$) at 7 out of 16 loci in Belahi cattle. It is difficult to envisage the exact basis of this departure.

Table 10: Various diversity indices and size range at each micro satellite locus in Belahi Cattle

Marker	Na	Ne	Nei's He	I*	Fis	PIC	Chi Value	df
INRA35	9	4.65	0.785	1.771	-0.0029	0.785	60.169**	36
ILSTS05	9	5.88	0.830	1.933	0.0772	0.830	81.935**	36
INRA05	9	3.88	0.742	1.592	0.0428	0.742	33.241	36
INRA63	6	2.77	0.639	1.243	-0.0428	0.639	11.309	15
BM1824	5	2.64	0.622	1.122	-0.1103	0.622	50934	10
ILSTS11	5	2.86	0.651	1.263	-0.1712	0.651	12.816	10
CSRM60	9	3.51	0.715	1.588	-0.1315	0.715	30.04	36
CSSM66	12	6.85	0.854	2.099	0.0729	0.854	70.687	66
TGLA122	11	7.47	0.866	2.134	-0.0103	0.866	41.767	55
MM12	10	3.18	0.685	1.556	0.2704	0.685	102.098**	45
CSSM33	14	7.53	0.867	2.249	0.0150	0.872	96.434	91
MM8	6	1.96	0.491	0.969	0.2357	0.491	64.793**	15
ILST6	11	6.14	0.837	1.999	0.0542	0.826	127.552**	55
CSSM8	6	2.75	0.637	1.305	0.1493	0.637	21.245	15
TG227	12	1.47	0.319	0.871	0.0211	0.319	110.641**	66
HEL1	15	6.68	0.850	2.283	0.0689	0.860	143.705**	105
Mean	9.31	4.39	0.71	1.62	0.0337	-	-	-
stdv	3.11	2.06	0.15	0.46	0.1197	-	-	-

N_a: Observed number of alleles; N_e: effective number of alleles; **Nei's He**: Nei's heterozygosity; **PIC**: Polymorphism Information Content, **I***: Shanon's Index, F_{is}: within population inbreeding estimate; **Chi value**: Hardy Weinberg equilibrium; ** means significant at 1% level of significance; **df:** degree of freedom of H-W test.

Bottleneck analysis

Bottle neck hypothesis was explored in Belahi cattle population. According to the hypothesis if the population that has experienced the recent reduction, effective population size exhibit a correlation in reduction of allele numbers and gene diversity. However, the allele number is reduced faster than the gene diversity. Therefore, in a population experiencing bottleneck, the observed gene diversity is higher than the expected gene diversity. Three different tests, viz., sign rank, standardized differences and Wilcoxon tests under all the 3 models (Cornuet et al, 1996) of microsatellite evolution (IAM, SMM and TPM) were employed to investigate whether Belahi cattle populations has undergone recent bottleneck. These values were significant and thereby null hypothesis of mutation drift equilibrium was rejected. Our findings were similar to those reported by Deepika and Kumar, 2012 who reported absence of recent genetic bottleneck in grey coloured cattle breeds (Hariana, Nagori, Mewati, Tharparkar and Kankrej) of India. Thus, Belahi cattle revealed moderate genetic diversity within population although the population is deviating from mutation drift equilibrium (except IAM), there was no significant heterozygosity excess indicating the absence of genetic bottleneck in the recent past.

Another powerful test of qualitative graphical method based on mode-shift distortion was also utilized to visualize the allele frequency spectra as an indicator for genetic bottleneck. No mode shift (Luikart and Cornuet, 1997) was detected in the frequency distribution of alleles and the alleles with the lowest frequencies (0.01 to 0.1) were found to be most abundant (Figure 6). The results indicated the absence of any recent bottlenecks in Belahi cattle.

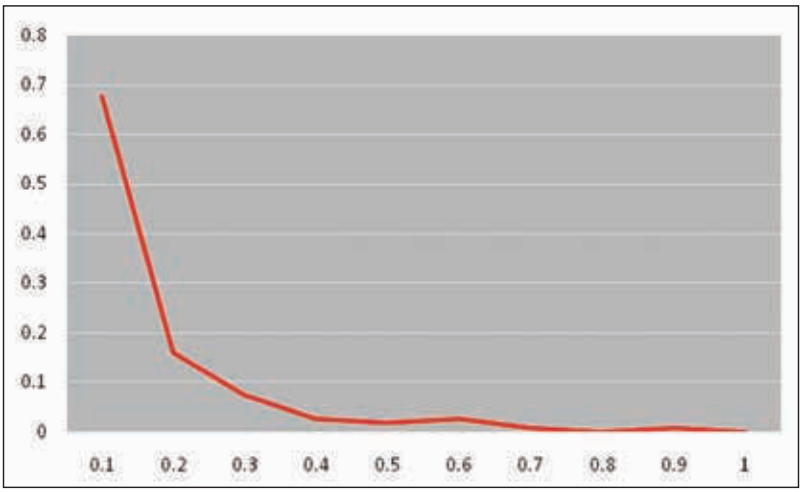


Figure 6: Mode shift test for bottleneck analysis in Belahi cattle

Between breed diversity analysis

The multi locus data generated for Belahi cattle was compared with similar data on Sahiwal, Gir, Tharparkar, Rathi, Nagori, Mewati and Kankrej breeds of cattle. Population differentiation was examined by fixation indices FIT, FIS, and FST using the methods of Weir and Cockerham (1984) for each of the 16 analyzed loci. Mean estimates of F-statistics over loci were: F (FIT) = 0.1985 (total inbreeding estimate), f (FIS) = 0.0506 (within-population-inbreeding estimate), θ (FST) = 0.1558 (population differentiation). The global deficit of heterozygotes across population (FIT) amounted to 19.85% ($p<0.05$). An overall significant deficit of heterozygotes (FIS) of 5.1% ($P<0.05$) occurred across the analyzed loci. From bootstrap analysis, the true value of FIS-statistic, with a 95% confidence interval, ranged from -0.09 (CSRM60) to 0.253 (TGLA227). Except for four loci (CSSM08, CSRM60, ILSTS011, and HEL1), all other loci contributed significantly to the heterozygote deficit within population (FIS). Three loci TGLA227, MM12 and ILST006, contributed maximally for the observed deficit

(Table 11.) while all other loci except CSSM08, CSRM60, ILSTS011, and HEL1, significantly affected the global heterozygote deficit (FIT). The value of breed differentiation obtained in our study was similar to those reported for other indigenous and exotic cattle breeds. For example, 11.3% in Hariana, Deoni and Sahiwal (Mukesh et al. 2004), 11.2% in seven European cattle (Mac-Hugh et al. 1998), 9% in Swiss cattle (Schmid et al. 1999), 10.7% in 20 North European cattle breeds (Kantanen et al. 2000).

Table 11: Global F-Statistics (within population and between population inbreeding estimate, and measurement of population differentiation) and Gene Flow for each microsatellite locus in different milch and dual utility cattle breeds.

Marker	Sample Size	FIS	FIT	FST	Nm*
BM1824	684	0.0396	0.1356	0.0999	2.2516
CSSM08	576	-0.0136	0.2760	0.2857	0.6250
CSSM33	592	0.0312	0.2104	0.1849	1.1019
CSRM60	672	-0.0962	0.0736	0.1549	1.3640
CSSM66	674	0.0201	0.0803	0.0614	3.8210
ILSTS005	670	0.0191	0.1442	0.1276	1.7098
ILST06	684	0.1868	0.2620	0.0925	2.4524
ILSTS11	664	-0.0026	0.2357	0.2377	0.8016
INRA05	680	0.0308	0.0892	0.0603	3.8978
INRA63	664	0.0633	0.2173	0.1644	1.2707
INRA35	662	0.0353	0.1085	0.0759	3.0429
MM8	666	0.0932	0.1380	0.0494	4.8120
MM12	680	0.1136	0.2253	0.1260	1.7337
TGLA122	680	0.0608	0.1293	0.0729	3.1775
TGLA227	620	0.2532	0.4031	0.2008	0.9950
HEL1	422	-0.0014	0.5078	0.5085	0.2416
Mean	643	0.0506	0.1985	0.1558	1.3542

F_{is}: within population inbreeding estimate; **F_{it}**: between population inbreeding estimate; **F_{st}**: measurement of population differentiation; Nm: Gene flow estimated from Fst = 0.25(1-Fst)/Fst

The genetic differentiation values (FST) per locus varied from 0.05 (MM8) to 0.51 (HEL1) with an average of 0.156 across all the

loci. All the microsatellite loci ($P<0.05$) significantly contributed to this differentiation. The FST values implied that overall genetic differentiation among breeds was moderate, but significantly different from zero. Average FST value indicated that 15.6% of the total genetic variation corresponded to breed differences while the remaining 84.4% corresponded to differentiation among individuals. The effective number of migrants (Nm) was estimated as 1.35 pointing to moderate gene flow and continuity among different cattle breeds. Our results were not in agreement with Deepika and Kumar (2012) where they reported lower F Statistic (F_{ST} = 0.07; F_{IS} = 0.03; F_{ST} = 0.07) and higher gene flow (Nm = 4.06) in ten breeds of grey colour indigenous cattle of India, which could be due to admixture of Hariana cattle with other grey colour indigenous cattle, while it is not in Belahi cattle.

Nei's Genetic distance and Phylogenetic relationships

The Nei's genetic distances among eight different milch cattle are presented in Table 12. The least distance (0.06) was found between Mewati with Kankrej cattle. The highest (0.90) genetic distance was observed between Mewati and Belahi cattle. The distance among the milch breeds (Sahiwal, Gir, and Tharparkar) varied from 0.40 (Gir and Sahiwal) to 0.51 (Tharparkar and Sahiwal) whereas the distance among the dual purpose breed (Kankrej, Mewati, Rathi and Belahi) varied between 0.36 (Rathi and Belahi) to 0.90 (Belahi and Mewati). The distance between dual purpose cattle breeds was higher than that from milch breeds of cattle studied.

The Nei's genetic distances were used to prepare genogram tree to delineate phylogenetic relationship among populations are presented in Figure 7. Kankrej and Mewati breeds showed closest relationship. Similarly, Tharparkar and Rathi grouped together

in one cluster. Belahi cattle was clubbed with Sahiwal breed in a separate cluster. Sahiwal is good milch cattle and its genetic closeness to Belahi cattle indicates the milk potential of this rare migratory cattle of North India. Probable reason for this similarity, could be nearby geographical locations of these two breeds. Moreover, the stake holders of both Belahi and Sahiwal breeds of cattle are same (Gujjars) and during the course of time Belahi sub group must have been separated or migrated towards foot hills, leading to huge difference in climate. Genetic divergence time and drift needs to be studied for these breeds.

Table 12: Nei's genetic identity and genetic distance estimates among different milch and dual purpose cattle breeds

	Tharparkar	Rathi	Kankrej	Gir	Nagori	Mewati	Sahiwal	Belahi
Tharparkar		0.7661	0.6758	0.6353	0.6097	0.6498	0.5979	0.5315
Rathi	0.2664		0.6878	0.7319	0.5841	0.6865	0.7002	0.6962
Kankrej	0.3918	0.3742		0.7588	0.8594	0.9354	0.5049	0.4097
Gir	0.4536	0.3122	0.2761		0.7303	0.7221	0.6661	0.6000
Nagori	0.4948	0.5377	0.1515	0.3142		0.8779	0.4917	0.4150
Mewati	0.4311	0.3761	0.0668	0.3255	0.1303		0.4987	0.4043
Sahiwal	0.5143	0.3564	0.6834	0.4064	0.7098	0.7367		0.6312
Belahi	0.6321	0.3621	0.8924	0.5109	0.8796	0.9056	0.4602	

Nei's genetic identity (above diagonal) and genetic distance (below diagonal)

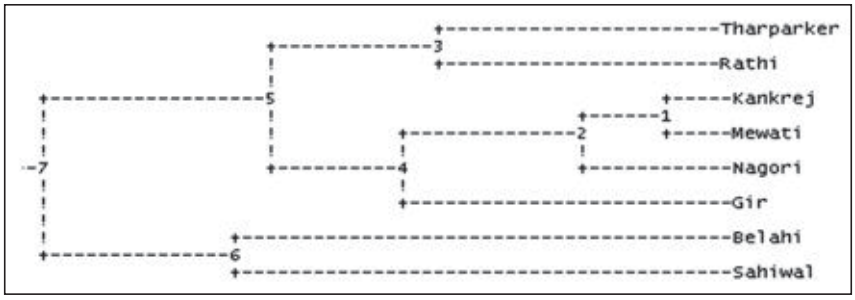


Figure 7: Genogram showing the different clusters of milch and dual purpose cattle

CONCLUSION

The information generated under the pilot project has established the Belahi cattle as unique and distinct bovine germplasm. Indian council of agricultural research, New Delhi has recognized and registered as 38th cattle breed of the country. Belahi cattle are potential dual purpose breed of Haryana state, which is migratory in nature unlike the Hariana cattle breed. These animals seem to play a vital role in the livelihood of pastoralists form North Haryana. Majority of the herders solely depend upon Belahi rearing and do not possess much of farming land therefore, livestock rearing is their prime occupation. Shrinkage of grazing pasture land is a serious problem for these migratory pastoral groups. Providing adequate drinking water to their animals is becoming difficult day by day due to fast drying up of ponds and cannels in the region. Though land owners appreciated the dung provided by these herds during their halt in harvested fields, which they used as manure / fertilizer, but in recent years this relationship has become unbalanced, due to the availability of chemical fertilizers which has made manure to some extent redundant, therefore, now baron lands are being preferred by these migratory pastoralists. Marketing of milk is not much of a problem as the local milkmen daily collect their produce and sell in local markets nearby which are having a good demand for indigenous milk, but all of these pastoralists are underpaid by the middlemen / vendors. Some of the major problems identified among the Gujjar pastoral group / Belahi keepers in their order of priority are listed below:

a. Inadequate knowledge among the animal keepers regarding value addition of the livestock products organized marketing of animals as well as their products.

b. Declining pastures and lack of water storage and water harvesting facilities leading to limited access of water

c. Lack of organization support like cooperatives, self-help group, breeder's society etc.

d. Lack of credit facilitating institutions, since nationalized banks does not include livestock to access the credit worth of pastoralists in the region.

RECOMMENDATIONS

a. A detailed study on evaluation of Belahi cattle should be done, may be under network project on animal genetic resources.

b. Belahi cattle are mainly found under migration in foot hills of Haryana and Punjab and in adjacent parts of these states, these animals are often deprived of the benefits from state govt. agencies. There should be more coordination between the livestock keepers and state agencies involved in genetic improvement of the breeds in the states having considerable number of these animals.

c. Livestock keepers should be made aware about the utility and quality of Belahi cattle breed.

d. An improvement program in the shape of ONBS is required immediately in the breeding tract.

e. Belahi cattle should be included in census as separate breed, so as to know the time trend of their population and their reasons thereof.

f. A breed society must be formed for Belahi Cattle by involving their stakeholders in the respective breeding tract.

BREED DESCRIPTOR

Accession No. INDIA_CATTLE_0532_BELAHI_03038

I. GENERAL DESCRIPTION

1	Name of the Population	Belahi
2	Synonyms	Morni, Desi
3	Background of such name (Belahi)	Based on body colour pattern (as reported by livestock keepers)
4	Since when the population is known	Not known, but kept by their forefathers
5	a. Species name b. Strains (or within breed types)	*Bos indicus* -
6	Most closely related breeds (in appearance)	-
7	Native tract distribution in terms of a. Latitude & longitude b. Approximate area of distribution c. Places (State & Districts)	Latitude 30° 44' N to 30° 70' N Longitude 76° 48' E to 77° 18' E 4236 square kilometers Haryana – Panchkula, Naraiangarh, Ambala, Yamuna Nagar Districts
8	Estimated population a. Year of estimation b. Population c. Source / Reference	 2012-13 25 000 – 35 000 NBAGR Survey /Pilot Project
9	a. Communities responsible for developing a breed b. Description of community (Farmers/ Nomads/ isolated/ tribals)	Who developed is not clear But Gujjars (both Muslim and Hindu) Known as *Langarias,* are at present maintaining the breed for generations. Nomads and tribal
10	Herd Book / Register established (Yes / No)	No
11	Herd: Average size Composition:	Breeding females = 71.20. % Replacement females (1-3yrs), replacement males (1-3yrs) and calves (in %) = 27.22% estimated jointly as followers < 2 yrs of age Breeding bulls = 1.58 Bullocks = not estimated
12	Utility of the breed (Milk/meat/draught/manure/other specify)	Milk, Draught and Manure
13	Basic temperament of the breed (docile/ moderate/ tractable/ wild)	Moderate

14. Feed

a.	Major fodder trees	-
b.	Major native fodder grass	*Cynodon dactylon* also known as dūrvā grass
c.	Cultivated legume fodder and monocot grass	Berseem
d.	Cultivated tubers	-
e.	Source of dry fodder	Wheat Straw Paddy Straw
f.	Seed and grain feed	Khal; Chokar
g.	Cakes and other concentrates	-
h.	Any reported deficiency of minerals in water	-
i.	Any reported minerals in harmful quantity and source	-
j.	Practice of feeding i) Grazing ii) Individual/Group feeding	Grazing for about 6-7 hrs a day

15. Housing

Only during the day	No
Only at night	Yes
Day and night	-
None	-
Type of housing	• During migration = Housed in Open • During winter months when not migrating (native villages) animals are housed in pucca (83.33%) and in kuchha (16.67%). • Part of residence = 86.67%; • Housed separately = 13.33%. • Animal house was lacking the proper drainage system

16. Mating method

Natural service (%)	100%
Artificial insemination (%)	Nil

17. Any other information:

Literacy rate: Majority of the adult herders were illiterate (85 to 90%)

Average land holding capacity: Landless or with average land holding <2 bighas

The Belahi animals are migratory in nature and are maintained on low input cost
(Migration starts in February - March and ends in October – November, every year)

II. PHYSICAL CHARACTERS

1.	Colour	Male	Female
a.	Coat colour	Reddish Brown & Grey (90%) Others (10%)	Reddish Brown and white (91.5%) Brown and white (6.0%) Brown (2.5%)
b.	Skin	Reddish Brown and white	Reddish Brown and white
c.	Muzzle	Black (90%) White (10%)	Black (89.53%) White (10.47%)
d.	Eyelids	Black (80%) White (20%)	White (18%) Black (82%) Brown patch around the eye (88.3%)
e.	Tail Switch	Black (90%) White (10%)	Black (58.73%) White (41.27%)
f.	Hooves	Black (70%) Grey (30%)	Black (60%) Grey (40%)

2.	Horns	Male	Female
a.	Colour	Black	Black (88%) Brown & Grey (12%)
b.	Size	27.2 ± 3.12 cms	25.4 ± 2.26 cms
c.	Shape (Straight/curved)	Curved (Sickle shaped)	Curved (Sickle shaped)
d.	Orientation	Curved Upwards and Inwards	Curved Upwards and Inwards

3.	Ears	Male	Female
a.	Length	28.2 ± 1.02 cms	24.4 ± 0.4 cms
b.	Orientation (horizontal/drooping)	Horizontal	Horizontal

4.	Head	Male	Female
a.	Forehead (Convex/concave/straight)	Straight	Straight
b.	General description	Broad head with poll prominent	

5.	Body	Male	Female
a.	Hump (large/medium/small)	Medium	Small
b.	Dewlap (large/medium/small)	Medium	Small
		Colour of the Dewlap is variable: a. White (70.58%) b. Reddish Brown (11.76%) c. Splashed (17.66%)	
c.	Naval flap (large/medium/small)	Medium	-
d.	Penis sheath flap (large/medium/small)	Medium	-

6.	Udder	
a.	Shape (bowl/round/trough/pendulous)	Round (90%); Bowl (10%)
b.	Udder size (large/medium/small)	Medium
c.	Teat shape (cylindrical/funnel/pear)	Cylindrical
d.	Teat tip (pointed/round/flap)	Round (96%); Pointed (4%)
e.	Milk vein (Prominent / not prominent)	Prominent

7. Any other information

Belahi is a medium sized animals raised primarily for milk and has a uniform but distinct body colour pattern having reddish brown body and white face and extremities and different degrees of white colour on ventral part of body.

III. PERFORMANCE

1. Body Weight (kg)

Weight at	Male			Female		
	Average	Range	N	Average	Range	N
Birth	17.6 ± 0.51	16 – 19	5	15.2 ± 0.58	14 - 17	7
Pre-Weaning	31.6 ± 1.22	20 - 44	25	33.75 ± 1.42	20 - 45	24
12 months	Not available					
24 months	Not available					
First mating	Not available					
First calving	Not available					
Adult weight*	304.8 ± 1.35	213-331	32	266.74 ± 2.15	226 - 305	200

*Estimated weight

2. Body measurements (in cm)

Parameter	Male			Female		
	Average	Range	N	Average	Range	N
Chest girth	162.71 ± 6.30	147-169	32	157.17 ± 3.69	146-172	200
Body length	124.52 ± 1.83	106-120	32	116.67 ± 1.80	108-121	200
Height at withers	131.13 ± 5.48	112-138	32	120.33 ± 4.58	110-144	200

3. Dairy performance

Parameter	First Lactation			Overall		
	Average	Range	N	Average	Range	N
Daily milk yield (kg)	3.45±0.29	0.59 – 6.59	23	3.25±0.15	0.5 - 9.5	79
Peak milk yield (kg)	5.5±0.32	1.8 - 9.0	23	5.21±0.16	1.8 - 9.5	79
Days to reach peak yield	39.34±4.53	11 - 81	23	41.64 ± 2.85	8 - 105	79
Lactation length (days)	227.30 ± 12.33	133 - 299	23	231 ± 5.89	115 - 300	78
305 day Lactation milk yield (kg)	1071.66 ± 90.72	182.1 to 2010.6	22	1014.43 ± 45.46	182.1 to 2092.2	79
Fat %	5.04	3.03 - 7.89	30	5.25	2.37 - 7.89	68
Protein %	3.33	2.87 - 3.90	30	3.45	2.87 - 4.02	68
Lactose	5.02	4.32 - 5.85	30	5.20	4.32 - 6.10	68
SNF %	9.073	8.0 - 10.58	30	9.39	7.80 - 10.98	68
Dry period (days)	201.72 ± 7.73	97-256	22	195.29 ± 3.83	97 - 256	62

4. Reproduction

a.	Males	Average	Range
(i)	Age at first ejaculation (months)	No attempt has been made so far, to collect the semen from males. Therefore, no systematic record is available	
(ii)	Age at first mating (months)	3.5 yrs	3 to 4 yrs

b.	Females	Average	Range
(i)	Age at first oestrus (month)	Farmers practise 100%	-
(ii)	Oestrous cycle duration (days)	natural breeding / mating	-
(iii)	Oestrus duration (hrs)	in their herds, however a	-
(iv)	Age at first mating (months)	broad range is available	21 - 36 month
(v)	Age at first calving (months)	based on information	30 - 46 month
(vi)	Service period (days)	collected through survey	60 - 146 days
(vii)	Calving interval (days)	and interview	365 - 456 days
(viii)	Gestation length (days)		268 - 300
(ix)	No of services per conception	A.I. is not practised where as 100% natural mating	–

5. Draught performance

a.	Purpose (ploughing, threshing, power etc.)	Ploughing and power	
b.	Physiological parameters	Before work	After work
	Rectal temperature (°F)	101 ± 0.5	–
	Respiration rate /min	19 - 22	–
	Pulse rate /min	55 - 60	–
c.	Fatigue Score		
	Frothing	After 3 to 3.5 hrs of continuous work	
	Leg in-coordination	–	
	Excitement		
	Inhibition of progressive movement		
	Tongue protrusion		
d.	Draught Power (HP)	–	
e.	Average duration of work per day (hrs)	5-6 hrs	

6. Drought tolerance (Excellent/ Very Good/ Good/ Average/ Low) Good

7. Heat tolerance (Excellent/ Very Good/ Good/ Average/ Low) Very Good

8. Any other information specific to the breed:

The animals are feed on grazing with very low input system on routine basis, however additional supplement / concentrate is given to high yielder and sick animals. The animals are less succeptible to summer / winter stress and parasitic dieseases as compared to crossbred animals. Farmers in Himachal Pradesh prefer bullocks

of this medium built breed for ploughing and other agricultrual operations. Belahi animals does not share their breeding tract with other 37 breeds reported and infact has different and non overlapping breeding tract in foot hills of shivalik and Haryana. Moreover, Belahi animals play a significant role in the rural livelihood of the Gujjar's / nomads in the region by providing milk, manure and through sale purchase of these animals.

Source of information

NBAGR funded research project "Characterization of Gojri Buffalo and Belahi Cattle populations under migration in Foot Hills and Sub-Himalayan Regions of Northern India"

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