Sheep Genetic Resources of India

JALAUNI

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(Indian Council of Agricultural Research)
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SOME FACTS ABOUT SHEEP *

Sheep Facts and Sheep Glossary

- People started raising sheep over ten thousand years ago.
- Sheep are gregarious, precocial, defenseless creatures.
- They normally live to be about 8 years old, but can sometimes live to be as old as 20.
- Female sheep are called ewes, male sheep are called rams, and baby sheep are called lambs.
- A one-year old sheep is called a hogget, a two-year old sheep is called a two-tooth.
- Lambs typically weigh about nine pounds when they are born. Lambs can walk within minutes of being born and feed on their mother's milk, which they get through their mothers udder.
- A lamb drinks its mother's milk for about 4 months and then it eats grass, hay and grain.
- Lambs form strong bonds with their mothers. They can identify their mother by her bleat.
- Wool is water resistant and flame retardant.
- Wool retains its insulative properties when whitened, unlike cotton.
- Sheep meat is a good source of nutrients. Lamb meat comes from a sheep less than 1 year old; mutton is meat from a sheep older than 1 year. New Zealand is the country that uses sheep for meat the most.
- There are over 850 breeds of sheep in the world and over 40 in India.

Fun Facts

- Sheep are individual and unique. Each sheep can distinguish between all other sheep, they can recognize fellow flock mates even after years of separation.
- Sheep have a flight zone, which is the space they like to keep between themselves and others. The flight distance depends on the situation and on the tameness or wildness of the sheep.
- When sheep receive a haircut, it is called shearing.
- Spinning wool into thread began about 5,000 years ago. One pound of wool can make ten miles of yarn.
- An official American baseball contains 150 yards of wool yarn.
- Sheep prefer running water when they drink.
- Sheep grow two teeth a year until they have eight.
- Sheep only have lower teeth that press against an upper palette.
- Sheep have 2 digits on each foot. The hooves grow like fingernails, and need to be trimmed to maintain normal conformation.
- Sheep prefer to huddle together, if one moves the others follow.
- Race car drivers wear sheep wool-lined suits to reduce their chances of being burned in a firey crash.
- The fat from sheep also known as tallow, can be used to make both candles and soap. The tallow is cooked to purify it, and then molded into candles or further prepared into blocks of soap.
- The wool from sheep is often used to make sweaters, hats, socks, scarves and other types of clothing. Sheep's wool may also be stuffed inside quilts.
- Dolly the sheep became a scientific sensation when her birth was announced. She was born on 5 July 1996. She was the first mammal cloned from an adult cell. Mammals reproduce through a process that always involves two parent animals; one male, the other female. Cloning is the production of a new, genetically identical, individual from a single

parent animal. Many people object to cloning animals saying that it is not natural. Dolly died on 14 February 2003.

- New Zealand sheep farmers must pay a fat-tax on the methane emissions of their sheep's backsides.
- Never ask a farmer how many sheep he has, its like asking him how much money he has in the bank!

Sheep Milk - The Facts

- Did you know that sheep can be milked just like cows?
- Sheep's milk is often used to make gourmet cheeses.
- Sheep milk is three times higher in whey proteins, than cow or goat milk making the whole milk easier to digest.
- The Vitamins found in sheep's milk, mainly the B complex as well as A, D and E are all essential to good health and are most often recommended to be taken as a supplement. Why bother, when they are all in sheep milk.
- Calcium and minerals like zinc are high in sheep milk compared with other milks. Together with lactose and Vitamin D, (almost twice as much as cows milk) the calcium in sheep milk is vital in the fight against Osteoporosis.
- A cup of hot sheep milk before retiring aids a peaceful nights rest.

Why Sheep Farming?

Sheep with its multi-facet utility for wool, meat, milk, skins and manure form an important component of rural economy particularly in the arid, semi-arid and mountainous areas of the country. It provides a dependable source of income to the shepherds through sale of wool and animals. The advantages of sheep farming are :

i) Sheep do not need expensive buildings to house them and on the other hand require less labour than other kinds of livestock.

ii) The foundation stock are relatively cheap and the flock can be multiplied rapidly.

iii) Sheep are economical converters of grass into meat and wool.

iv) Sheep will eat varied kinds of plants compared to other kinds of livestock. This makes them excellent weed destroyer.

v) The structure of their lips helps them to clean grains lost at harvest time and thus convert waste feed into profitable products.

vi) Mutton is one kind of meat towards which there is no prejudice by any community in India and further development of superior breeds for mutton production will have a great scope in the developing economy of India.

vii) The unique richness of the sheep milk and its special values in human health can lead to sheep dairying alongside the cow milk industry. Hence emphasis in sheep breeding to milk besides wool and mutton would result in a unique and justified niche industry.

How do sheep differ from goats?

People who are not familiar with livestock often confuse sheep and goats. What are some of the differences?

- Sheep generally have fleece, goats hair.
- Goats have horns, many sheep are naturally hornless.
- Sheep say baa goats say maa. Seriously, their voices are different.
- Sheep tails hang down. A goat's tail will go up (unless the goat is frightened, sick, or in distress).
- Sheep need hoof trimming much less often (maybe twice per year) than goats (once or twice monthly).
- Sheep need less copper than goats. Some mineral supplements that are great for goats can be toxic to sheep.
- Sheep are grazers, goats are browsers. That means sheep are probably better weed eaters, since they eat grasses and other plants all the way down to the ground. Goats, on the other hand, nibble here and there, sampling a variety of bushes and leaves.
- Sheep are more likely to overeat than goats.
- Sheep milk is higher in fat than goat milk. Either one can be used to make feta cheese.
- Sheep are less susceptible to external parasites, including fungi such as ringworm. Goats, especially those with longer hair, often have lice, ringworm is common.

Compiled from:

www.thebigsheep.co.uk;

http://www.danekeclublambs.com/FactsAndGlossary.html;
http://www.ahappyplanet.com/atozfolder/wool%20facts.html;
http:// lintaspersonal.org/nabard/modelbankprojects/animal_sheep.asp

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Introduction

The role of indigenous sheep breeds for the upliftment of the rural economy needs to be given greater emphasis as these breeds are able to thrive in low or no input system. Over the years, farming communities across the globe have directly or indirectly selected and improved indigenous sheep breeds to meet the needs of the harsh and adverse conditions they dwell in. Complete characterization of these indigenous breeds is imperative as they are the only remaining sources of putative alleles of economic values that might be lost due to haphazard crossbreeding and sheer negligence. Most of the ovine genetic resources in India lack either phenotypic or genetic documentation, it is therefore, germane to measure the genetic indices of all those ovine populations whose information is scanty, phenotypically as well as at the DNA level so that generated results can be utilized for planning breeding and conservation programmes.

Jalauni is one of the recognized sheep breeds of the Bundelkhand region and the animals are small to medium in size with straight nose line. The colour of the body is white with a light brown or black head in most animals. These animals are well adapted to the local agro-climatic conditions of this region and are maintained for mutton and wool. The wool quality is coarse. Jalauni sheep are reared by the *'Pal'* community which comprises of small, marginal or landless mostly illiterate farmers/labourers. A general declining trend in the Jalauni sheep population has been observed in comparison to population figure of 1977 (Sahana et al., 2004). In view of declining status of the breed due to increased crop production resulting in decrease in grazing area, there is a need for its characterization and conservation. The assessment of genetic diversity of Jalauni by measuring the morphological traits of individuals of the breed, as well as at the DNA level using molecular markers in vogue, is a first step in prioritization of this breed for conservation.

Distribution

The breed is prevalent in Jalaun, Jhansi, Lalitpur districts of Uttar Pradesh state and the Tikamgarh, Datia districts of Madhya Pradesh (Fig.1) The breeding tract of Jalauni sheep comes under the Bundelkhand Zone of Uttar Pradesh and Madhya Pradesh states (Sahana et al., 2004).

Fig. 1. Breeding tract of Jalauni sheep

Agro-climatic conditions of the region

The elevation of this area is 266 m to 560 m above mean sea level. The area is characterized by flat land with small hillocks spreading over major part of the zone. This has facilitated watershed management and construction of water tanks for irrigation. This region has a variety of soils that include clay (vertisols), clay loam (vertisol and inceptisols) and sandy loam (entisols) soils. Average annual rainfall is 900 mm to 1100 mm in this area. The temperature ranges from a minimum of 4.5°C in January to a maximum of 43°C in May. About 37% of the geographical area of this region is under cultivation and about 86% of the population, directly or indirectly dependent on agriculture, lives in villages. Forests, cultivable waste and barren land occupy more than 50% of the area, permanent pasture and other grazing lands (Fig.2) about 9% and miscellaneous tree crops and grasses about 0.7%. Wheat (*Triticum aestivum*), gram (*Cicer arietinum*) and sorghum (*Sorghum vulgare*) are the major crops; sesame (*Sesamum indicum*) and barley (*Hordeum vulga*re) are also cultivated. Ginger (*Zingiber officinale*) and betel-vine (*Piper betle*) are main commercial crops.

Fig. 2. Grazing Land

Population

The total Jalauni population according to a survey conducted by the U.P. Government in 1973-74 was 31968, whereas the total sheep population in the Jalauni distribution area, according to the 1972 census, was 0.179 m, of which 0.026 m were adult rams and 0.103 m were adult ewes (Acharya , 1982). Sahana et al., 2004 reported a declining trend of 0.04 % per annum over the years from 1977 to 1997 in the total sheep population in Uttar Pradesh and Madhya Pradesh states. A similar trend was observed in the distribution area of Jalauni sheep except Jhansi district where sheep population increased during this period. The decline in sheep population may be attributed to farmers moving towards crop agriculture and large animals.

Breed characteristics

Jalauni sheep are small to medium in size with straight nose line. The colour of the body is white with a light brown or black head in most animals. Generally about 5% animals, although as high as 50% in Lalitpur district, are completely black in colour. The sheep of Lalitpur district are comparatively smaller in size and have a compact body. Both males (Fig. 2) and females (Fig. 3) are polled and the face is devoid of wool. The ears are large, flat and drooping and the tail is medium in size and thin. The fleece is generally white, coarse, short-stapled and open, the belly and legs are devoid of wool. (Acharya, 1982; Sahana et al., 2004)

The body weights and body measurements of Jalauni sheep are presented in Table 1 for farmers' flocks and Table 2 for Jalauni sheep maintained at the Indian Grassland and Fodder Research Institute (IGFRI) Jhansi farm.

Fig. 3. Jalauni Ram

Fig. 4. Jalauni Ewe

Table 1. Body weight and body biometry of Jalauni sheep in the farmers flocks (Sahana et al., 2004)

Trait	Adult male		Adult female	
	Mean ± SE	Range	Mean + SE	Range
Body weight (kg)	35.5±2.1 (24)	25-51	27.2±0.7 (92)	16-36
Body length (cm)	71.5±1.3 (39)	53-82	63.2±0.5 (162)	50-78
Height at wither (cm)	71.9±1.2 (39)	60-81	63.3±0.4 (162)	55-76
Chest girth (cm)	82.0±2.3 (39)	64-93	74.6±0.6 (162)	60-89
Ear length (cm)	17.0±0.6 (38)	9-18	16.1±0.2 (159)	8-21
Tail length (cm)	27.0±0.2 (24)	13-32	24.6±0.6 (106)	12-33

Number of animals in brackets, SE = Standard error

Table 2. Body weight and body biometry of Jalauni sheep at IGFRI, Jhansi Farm (Sahana et al., 2004)

Trait	Male (12-24 months)		Female (12-24 months)	
	Mean ± SE	Range	Mean ± SE	Range
Body weight (kg)	25.0 ± 1.9 (8)	16-31	20.9 ± 0.8 (31)	14-29
Body length (cm)	65.3 ± 1.0 (8)	62-71	63.5 ± 1.1 (31)	52-74
Height at wither (cm)	63.3 ± 1.3 (8)	58-69	61.9 ± 0.7 (31)	51-69
Chest girth (cm)	77.9 ± 2.4 (8)	69-89	76.8 ± 1.3 (31)	64-85
Ear length (cm)	16.6 ± 0.5 (8)	15-19	16.2 ± 0.6 (31)	11-19
Tail length (cm)	25.5 ± 1.2 (8)	17-31	27.9 ± 0.8 (31)	20-38

Number of animals in brackets SE= Standard Error

Management practices

Majority of the farmers house their sheep during night but some keep them in the open. Usually other livestock like cattle, buffaloes, goats are kept in the same house separated by some sort of barrier. A part of the farmers' house is used to shelter the sheep and other livestock in most cases. (Fig. 5) . Jalauni sheep are maintained on grazing. (Fig. 6, 7). The animals are allowed to graze from about 9-10 a.m. till sunset. No supplementary feed is provided to the animals. The lambs are kept in the house for about 15 days after birth and thereafter join the flock for grazing. The flock size ranges

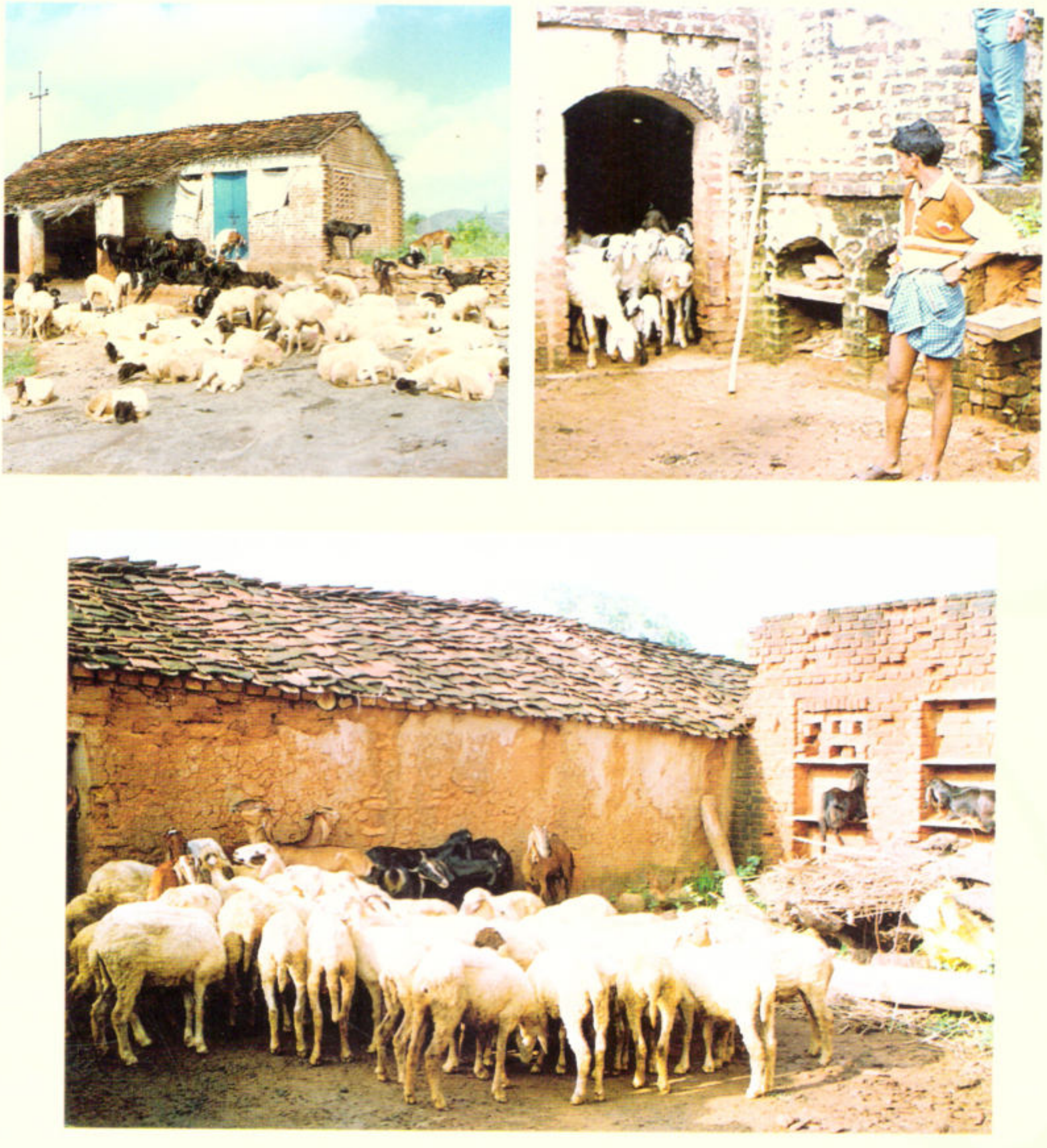

Fig. 5. Housing of Jalauni sheep

from 3 to 150 (Fig. 8). Tail docking is generally practiced for hygiene and improved appearance of the animal.

Fig. 6. Jalauni sheep alongwith goats being taken for grazing

Fig. 7. Grazing Jalauni sheep

Fig.8. A Typical Jalauni Flock

Reproductive performance

Breeding is by natural mating. Usually one breeding ram is maintained per flock. Some large flocks with more than 50 animals maintain more than one adult male. Other male animals are generally sold at 8-12 months for meat purposes. Average age at sexual maturity is one year for both males and females. Average age at first lambing was 1.5 to 2 years and lambing interval one year. An ewe, on an average, delivers 7-9 lambs in its lifetime. Lambing takes place throughout the year with the October and November seeing the highest number of births with twining a rarity.

Health management

Vaccination against common diseases is not practiced by majority of the farmers. Any veterinary treatment is also not provided to diseased animals due to lack of awareness, poor financial status and inaccessibility of veterinary hospitals. Parasitic infection and pneumonia were reported as major diseases in the area. Lamb mortality, with an average of 15-20% and as high as 50%, was reported as the major health problem. Pneumonia was reported to be the main reason for lamb mortality in winter season and diarrhoea in other seasons. Abortion was reported in 1-2% of cases.

Utility

Jalauni sheep are maintained for mutton and wool production. The wool quality is coarse. Shearing is practiced three times in a year in the months of October - November, March-April and June-July. Average wool production is 150-200 g/shearing with an annual production ranging between 400 and 750 g. However, higher greasy fleece weight of 900g with average fibre diameter of 41.1±0.19 and 70% medullation has also been reported (Acharya, 1982). Males are sold for slaughter at an age of 9-12 months with an average body weight of 16-20 kg (Table-3) Ewes are milked for 107 to 128 days and produce 300 to 350 g milk per day (Acharya, 1982).

Table 3. Average body weights (in kg). (Sahana et al 2004)

Age in months	Male	Female
> 3 to 6	9.9 (11)	9.2 (9)
>6 to 9	12.3 (8)	11.8 (14)
>9 to 12	15.6 (12)	15.3 (38)
>12 to 24	24.0 (17)	20.3 (45)

Number of animals in brackets

Microsatellite based characterization

To achieve the genetic characterization of Jalauni sheep microsatellite markers were chosen due to their high levels of polymorphism, ubiquitous nature, codominant inheritance, ease and accuracy of typing.

Sample collection and DNA extraction

The blood samples of 50 unrelated animals of Jalauni breed were collected randomly from several villages in the breeding tract of the sheep.

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Animals for genotyping were chosen in order to ensure that they were representative of the Jalauni breed as per their phenotypic characteristics. Attempts were made to avoid sampling of related animals. DNA was extracted from the white blood cells using standard phenol/chloroform/ isoamyl alcohol extraction protocol (Sambrook et al., 1989).

Genotyping

Twenty five microsatellites from the list of MoDAD (FAO ,Table 4) by Bradley et al. (1997) were genotyped on 50 DNA samples of Jalauni breed. Amplifications for the loci was performed in a 25µl final reaction volume containing at least 100ng of genomic DNA, 50ng of each primer, 1.5mM $MgCl_2$, 200µM dNTPs, 0.5U Taq polymerase and 1x buffer. The thermal touchdown profile for PCR was as follows: 3 cycles of 45 sec at 95^0C, 1 min at 60^0 C; 3 cycles of 45 sec at 95^0 C, 1 min at 57^0 C; 3 cycles of 45 sec at 95^0 C, 1 min at 54^0 C; 3 cycles of 45 sec at 95^0 C, 1 min at 51^0 C and 20 cycles of 45 sec at 92^0 C, 1 min at 48^0 C. Amplification was confirmed on 2% agarose gel and the products were size separated on 6% denaturing polyacryamide gel and visualized by silver staining (Bassam et al., 1991). Estimation of allele size was done by running a 10bp DNA molecular weight marker along with the PCR products. Genotyping was done manually from the silver stained gels.

Computation and statistical analysis

Genetic variation was quantified by calculating observed (Na) and effective number of alleles (Ne), observed and expected heterozygosity (Ho and He) and within breed heterozygotes deficiency (F_{IS}) following the POPGENE version 1.31 program (Yeh et al. 1999). The polymorphism information content (PIC) of microsatellite loci was estimated using the formula given by Botstein et al. (1980). The test for deviations from the Hardy Weinberg Equilibrium was performed with version 3.2a of the GENEPOP software package (Raymond and Russet, 1995). The recent bottleneck effect was inferred for the population using mode shift analysis under the assumption of Two phase microsatellite mutation model (TPM), implemented in the programme BOTTLENECK ver 1.2.02 (Cornuet and Luikart, 1996).

Intrabreed genetic variability

Microsatellite profiles for 25 loci located on 19 chromosomes were recorded for 50 animals of Jalauni sheep. Allele frequencies ranged from 0.022 to 0.863 (Fig. 9).

Table 5 summarizes allele number (observed, effective) and heterozygosity (observed, expected) estimates computed across the 25 loci. In total 148 alleles were detected across 25 microsatellite loci that were typed and the actual number of observed alleles at each locus ranged from 2 (BM8125) to a maximum of 9 (CSSM31, OMHC1 and TGLA137) in this breed. Apart from the loci BM8125 where only two alleles were detected, a fairly high degree of genetic variation was observed within the breed in terms of number of alleles per locus (>2). The mean number of alleles was 5.92 across these loci. The effective number of alleles, being lower than the observed number of alleles ranged between 1.3 (OarCP20) to 6.3 (TGLA137).

The number of alleles observed at a locus is an indication of genetic variability at that locus having direct impact on differentiation of breeds within a species (Buchanan et al., 1994) and the mean allele number provides a reasonable indicator of the levels of variability present assuming that the population is in mutation drift equilibrium (MacHugh et al., 1998). The mean allele number (5.92) reflected high genetic variability in Jalauni sheep. The average number of alleles found in the investigated breed was, however, lower than that of several Spanish sheep breeds (Arranz et al., 1998). Nevertheless, due to a different marker set used in this study, a direct comparison could not be made. The number of genotypes per locus varied from 3 (BM8125) to 17 (OMHC1). The high genotypic values could be

Fig. 9. Allele frequencies distribution at 25 microsatellite loci

Table 4.The primer sequences and chromosomal localization of the used microsatellites

S.No	Microsatellite Marker	Primer Sequences(5'-3')	Chromosomal Location
1	BM757	TGGAAACAATGTAAACCTGGG TTGAGCCACCAAGGAACC	9
2	BM827	GGGCTGGTCGTATGCTGAG GTTGGACTTGCTGAAGTGACC	3
3	BM1314	TTCCTCCTCTTCTCTCCAAAC ATCTCAAACGCCAGTGTGG	22
4	BM6506	GCACGTGGTAAAGAGATGGC AGCAACTTGAGCATGGCAC	1
5	BM6526	CATGCCAAACAATATCCAGC TGAAGGTAGAGAGCAAGCAGC	26
6	BM8125	CTCTATCTGTGGAAAAGGTGGG GGGGGTTAGACTTCAACATACG	17
7	CSSM31	CCAAGTTTAGTACTTGTAAGTAGA GACTCTCTAGCACTTTATCTGTGT	23
8	CSSM47	TCTCTGTCTCTATCACTATATGGC CTGGGCACCTGAAACTATCATCAT	2
9	HUJ616	TTCAAACTACACATTGACAGGG GGACCTTTGGCAATGGAAGG	13
10	OarAE129	ATCCAGTGTGTGAAAGACTAATCCAG GTAGATCAAGATATAGAATATTTTTCAACACC	5
11	OarCP20	GATCCCCTGGAGGAGGAAACGG GGCATTTCATGGCTTTAGCAGG	21
12	OarCP34	GCTGAACAATGTGATATGTTCAGG GGGACAATACTGTCTTAGATGCTGC	3
13	OarFCB48	GAGTTAGTACAAGGATGACAAGAGGCAC GACTCTAGAGGATCGCAAAGAACCAG	17
14	OarFCB128	CAGCTGAGCAACTAAGACATACATGCG ATTAAAGCATCTTCTCTTTATTTCCTCGC	2

15	OarHH35	ATTGCATTCAGTATCTTTAACATCTGGC ATGAAAATATAAAGAGAATGAACCACACGG	4
16	OarHH41	TCCACAGGCTTAAATCTATATAGCAACC CCAGCTAAAGATAAAAGATGATGTGGGAG	10
17	OarHH47	TATTGACAAACTCTCTTCCTAACTCCACC GTAGTTATTTAAAAAAATATCATACCTCTTAAGG	18
18	OarHH64	GTTCCCTCACTATGGAAAGTTATATATGC CACTCTATTGTAAGAATTTGAATGAGAGC	4
19	OarJMP8	CGGGATGATCTTCTGTCCAAATATGC CATTTGCTTTGGCTTCAGAACCAGAG	6
20	OarJMP29	GTATACACGTGGACACCGCTTTGTAC GAAGTGGCAAGATTCAGAGGGGAAG	24
21	OarVH72	CTCTAGAGGATCTGGAATGCAAAGCTC GGCCTCTCAAGGGGCAAGAGCAGG	25
22	OMHC1	ATCTGGTGGGCTACAGTCCATG GCAATGCTTTCTAAATTCTGAGGAA	20
23	RM004	CAGCAAAATATCAGCAAACCT CCACCTGGGAAGGCCTTTA	15
24	TGLA137	GTTGACTTGTTAATCACTGACAGCC CCTTAGACACACGTGAAGTCCAC	5
25	TGLA377	GACTGTCATTATCTTCCAGCGGAG GATCTCTGGTTGAAATGGCCAGCAG	2

attributed to the high number of alleles in Jalauni sheep, which also suggested the existence of heterozygous genotypes in this population.

The polymorphic information content is a parameter indicative of the degree of informativeness of a marker. In the present study polymorphism information content (PIC) revealed a high average of 0.64 with a range of 0.24 (OarCP20) to 0.82 (TGLA137) (Fig. 10). The high mean PIC value displayed by panel of 25 microsatellites in Jalauni supported suitability of the used set of markers for genetic diversity analysis in Indian sheep too

Table 5. Genetic diversity indices across 25 microsatellite markers in Jalauni sheep

Locus	Na	Ne	Ho	He
BM757	4	3.818	0.666	0.738
BM827	7	4.400	0.727	0.772
BM1314	5	1.656	0.368	0.396
BM6506	3	2.523	0.550	0.603
BM6526	6	4.420	0.363	0.773
BM8125	2	1.856	0.611	0.461
CSSM31	9	3.904	0.913	0.743
CSSM47	4	1.927	0.434	0.481
HUJ616	7	3.408	0.636	0.706
OMHC1	9	5.845	0.739	0.828
OarAE129	3	2.046	0.400	0.511
OarCP20	4	1.329	0.272	0.248
OarCP34	6	4.198	0.565	0.761
OarFCB48	7	5.617	0.714	0.822
OarFCB128	7	4.587	0.588	0.782
OarHH35	8	5.013	0.789	0.800
OarHH41	7	5.348	0.818	0.813
OarHH47	6	3.072	0.263	0.674
OarHH64	6	4.033	0.363	0.752
OarJMP8	7	4.830	0.625	0.793
OarJMP29	7	2.881	0.454	0.652
OarVH72	5	3.405	0.526	0.706
RM4	6	4.007	0.869	0.750
TGLA137	9	6.345	0.952	0.842
TGLA377	4	2.399	0.521	0.583
Mean	5.92	3.715	0.589	0.681

Na-Observed allele number; Ne- Effective allele number; Ho- Observed heterozygosity; He-Expected heterozygosity

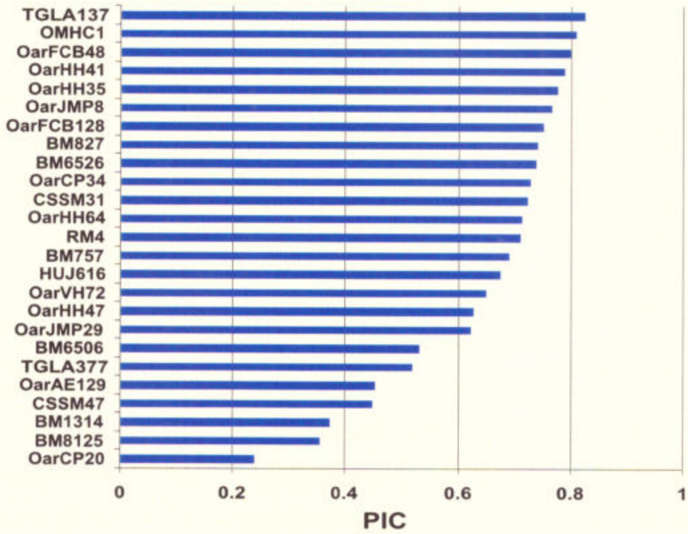

Fig. 10. PIC values across 25 microsatellite markers in Jalauni Sheep

(Botstein et al., 1980). Similar results were obtained from the same set of markers in earlier reported breeds of sheep by the authors (Sodhi et al., 2003; Arora and Bhatia, 2004, 2006; Mukesh et al., 2006). Following the criteria of Botstein et al. (1980), in the present study 80% markers were highly informative (PIC >0.5), 16% reasonably informative (0.25<PIC<0.5) and 4% were slightly informative (PIC<0.25), which also suggested high utility of these markers for population assignment (MacHugh et al., 1998) and genome mapping (Kayang et al., 2002) studies in addition to genetic diversity analysis.

The Jalauni breed showed significant (P<0.05) deviation from Hardy-Weinberg equilibrium at six loci. This deviation might represent sub-structure present in the form of localized heterozygote deficiencies. Departure from HW proportions is also suggestive of localized inbreeding, selection or the presence of null alleles. It was not possible to estimate the extent of null alleles as no pedigree records were available for analysis and blood samples were collected from unrelated animals only. However, there did not appear to be significant deviations from equilibrium across all loci within this population, subsequent analyses were therefore, carried out on the basis that Hardy-Weinberg equilibrium prevailed in the investigated sheep (Marshall et al., 1999).

The observed heterozygosity ranged from 0.263 (OarHH47) to 0.952 (TGLA137). The expected heterozygosity per locus varied from 0.248 (OarCP20) to 0.842 (TGLA137) in Jalauni sheep. The mean values of observed heterozygosity and expected heterozygosity (gene diversity) were 0.589 and 0.681 respectively. The results showed that Jalauni sheep breed possessed a considerable amount of genetic diversity. The observed heterozygosity (Ho) and expected heterozygosity averages of Jalauni were consistent with those reported for other domestic sheep breeds (Saitbekova et al., 2001; Sodhi et al., 2003; Arora and Bhatia 2004). The expected heterozygosity values were, however, much higher than wild Mouflon sheep (He=0.45) probably due to close captive relatedness in this wild sheep flock (Saitbekova et al., 2001). The mean observed heterozygosity value though lower than the mean expected value was not significantly different from expected (ANOVA, ($p>0.05$), which suggested that the investigated population maintains a random mating structure.

The average within population inbreeding estimate (F_{IS}) was observed to be 0.123 ranging from -0.324 (BM8125) to 0.610 (OarHH47). The positive F_{IS} value observed was not significant ($p>0.05$). The high heterozygote deficiency / within population inbreeding (F_{IS}) estimates (12.9%) across the investigated population may be explained by a Wahlund effect if population subdivision is occurring. Further the heterozygote deficiency may be affected by sampling individuals from geographically isolated herds for the same population. Other reasons/factors could be segregation of non amplifying (null) alleles or inbreeding. In the absence of detailed past information about this breed it is difficult to identify precisely which past demographic factors influenced the current genetic structure of this breed. Nevertheless, we cannot deny the effect of relatedness of few samples otherwise deemed unrelated during collection in view of absence of pedigreed data under field conditions.

Sahana et al. (2004) reported a declining trend of 0.04 % per annum over the years from 1977 to 1997 in the Jalauni sheep, except in Jhansi district where sheep population increased during this period. The bottleneck analysis was, therefore, performed to assess whether decrease in population had also led to decrease in genetic diversity. The typical L-like distribution of the allele frequencies obtained in the Mode shift test (Fig. 11) strongly indicated that a recent bottleneck was very unlikely. This finding clearly suggested absence of a recent reduction in the effective population size or a genetic decline. Hence it can be inferred that the occurrence of demographic decline probably did not result in a genetic bottleneck (Luikart et al., 1998) in Jalauni sheep. The absence of genetic bottleneck in the experimental population is consistent with the results of similar studies on sheep breeds of same agro ecological region of India (Bhatia and Arora 2007).

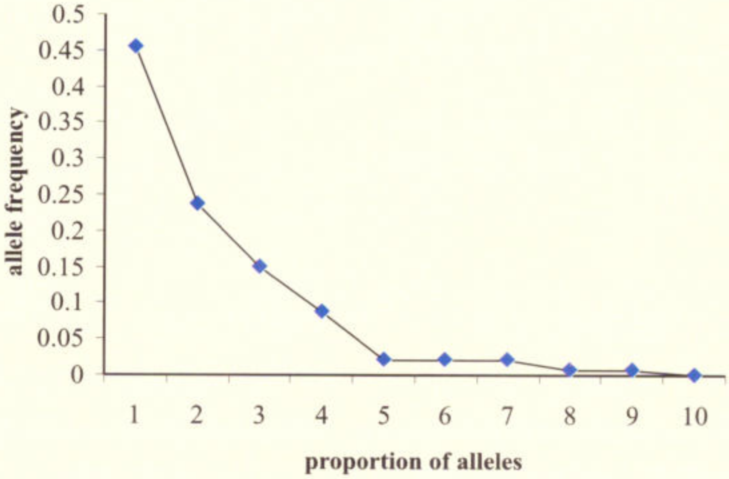

Figure 11 Normal L-shaped curve depicting no mode shift in Jalauni sheep

Conclusions

1. The result of genetic differentiation for many generations has been the conservation of different genes and therefore, Jalauni sheep has its own unique value.
2. A substantial amount of genetic diversity in the Jalauni sheep suggested that currently there is no danger of any loss of genetic variation at the nuclear loci level in this sheep population.
3. Breed improvement programmes through selective breeding need to be undertaken in the area.
4. Efforts are needed for strengthening of disease control mechanism. Veterinary treatments and vaccination of sheep are also not accessible or affordable to the farmers. It requires proper extension services and timely vaccination of animals as well as prompt deworming which can minimize high lamb mortality. There is an urgent need to develop basic facilities to support the farmers in the vaccination of their sheep.
5. Farmers need to be educated in better feeding, health care practices, hygienic management, suitable genetic management and upkeep of their sheep in order to reduce losses.
6. Sheep farmers do not receive any support, financial or otherwise, from government or other developmental agencies working in that area. There is a special need to strengthen financing with a different rate of interest.
7. Suitable strengthening of local markets for animal products.
8. The state Veterinary and Agriculture Universities, National Institutes of ICAR, Educational Institutions, Religious Trusts and organizations associated or having interest in historical preservation, conservation and breeding of livestock including small ruminants should be aided

by the government to encourage maintaining small groups of animals in their natural habitat or intended management systems.

Taking into account these appropriate suggestive measures and the availability of a vast grazing area in the breeding tract, it appears Jalauni sheep rearing can be made more profitable in the region.

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