SHEEP GENETIC RESOURCES OF INDIA

KAJALI

(A mutton type sheep)

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PREFACE

India, a mega biodiversity country bestowed with large domestic animal diversity, represented by 151 registered breeds of livestock and poultry species. Sheep genetic resources of our country contributes about 6.5% of total world's sheep population with forty (40) recognized and registered sheep breeds along with a large portion of non-descript and less known sheep population. Our country's sheep population remains static from post-independence to late seventies, there after an erratic trend was observed. This is reflected in the 18th and 19th Livestock census, where there is a decline of 9.07 % in the total sheep population between the periods. Despite of the above facts sheep constitute an integral part of agrarian economy as they can survive on varied kinds of vegetation in comparison to other livestock species. Even though there is decline dynamics in the total sheep population, there are large proportion of ovine genetic resources distributed in different parts of the country contributing to the rural livelihood needs to be described and documented. Kajali sheep is one of them, which is distributed in Punjab, India and is being reared for mutton producing ability. Indigenous sheep play an important role in securing livelihood of a large proportion of small and marginal farmers and livestock keepers as these resources are maintained on low/zero input extensive system of management. However, intermixing of nearby breeds and introduction of exotic sheep breeds have led to decline in purebred animals of a breed. Therefore, detailed characterization of different populations is need of the hour, particularly those which are lesser known.

The present manuscript is the compilation of information based on the survey study conducted under a pilot project by ICAR- NBAGR, Karnal (2013-15) with the aim to characterize Kajali sheep population, delineating its home tract, recording of different body biometric traits, body weight, husbandry and different management practices including their genetic characterization. Information generated will serve as a stepping stone towards gaining insights of this valuable sheep genetic resource. The authors hope that this bulletin will be useful to research scholars, scientists and policy makers working in the field of Animal Sciences, ovine genetic resources in particular. Moreover, determination of status and characterization of indigenous sheep genetic resources is an essential step in planning domestic animal diversity and developing strategies for their conservation and sustainable utilization.

Authors

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1. INTRODUCTION

Sheep in India is reared mainly by the poorest and under - privileged people of society as their main or subsidiary occupation for livelihood. It is the most appropriate livestock species on account of its sustenance and multifaceted utility for meat, wool, manure, skin and milk. The sheep biodiversity in India is characterized by high degree of endemism and variations in agro-climatic conditions of the different regions (Choudary *et al*. 2014). India is endowed with wide diversity of sheep genetic resources, which forms the backbone of its rural livelihood security systems. Characterization of lesser known population of livestock species is an important task to study the domestic animal biodiversity which will help in the recognization / documentation of non-descriptive population into descriptive one.

As per the breed wise Livestock census (2007) sizable population (about 49%) of sheep in India is non-descript. There are some populations in India which deserves for registration as breed but due to lack of systematic study and information they are kept under non-descript and Kajali sheep is one of them. It is an unexplored sheep population of Punjab (India) and primarily reared for mutton production. In the recent past, mutton production has gained more importance in comparison to wool in Indian economy due to availability of synthetic wool as well as low price for wool. The mutton and chevon of Indian origin has preferential demand in domestic market as well as in International market (Kurup and Baliyan, 2012) on account of its leanness and organic nature. Hence, increasing the number of indigenous sheep population as well characterization of lesser known sheep population reared for mutton production is the need of the hour.

Reports are scant on phenotypic characters as well as management of Kajali sheep of Punjab (India), hence there is a need to characterize and document this valuable ovine germplasm. Geerling (2001) reported a “Kajeli” sheep in Rajasthan, which is kept for it’s meat producing qualities and has a white, sometimes reddish face with a black colored patch around its eyes. This breed was believed to be developed by crossbreeding a local with an exotic breed. It was not clear which local and which exotic breed was meant.

Kajeli could be equivalent to Magra. Reports are also available on Kajli sheep of Pakistan (Qureshi *et al* 2010, Qureshi 2007; Nawaz *et al* 1999; Qureshi et al 1997). A black circle around the eyes is typical character from which breed's names is derived. For the phenotypic as well as genetic characterization of Kajali sheep a pilot study was conducted in 47 villages belonging to Sangrur, Barnala, Ludhiana, Moga, Bhatinda and Ferozpur districts of Punjab, India. During survey 67 sheep flocks having population of about 2500 animals were assessed. The body biometric traits viz. body length, height at wither, chest girth, paunch girth, ear length, face length, face width, tail length and body weight were recorded from 491 adult animals (87 male and 394 females). Body weights of 221 lambs belonging to different age groups from birth to 12 months were also recorded. The body weight was recorded using spring weighing balance and biometric traits were recorded using measuring tape. The data on other physical traits viz. head profile, ear orientation, colour pattern were collected by personnel observations and interviewing sheep farmers. The information related to sheep farmers, flock size & its composition, breeding, feeding, management, health management and socio-economic status of sheep farmers etc. were collected through predesigned questionnaire developed for this purpose.

2. NATURAL HABITAT AND DISTRIBUTION

Kajali sheep, distributed in Sangrur, Barnala, Ludhiana, Moga and adjoining districts of Punjab, India (Figure 1& 2). The origin of the breed is unclear however, as informed by the sheep breeders these animals are reared in their family from several generations. The breeding tract of Kajali lies in the Northern India between $30^0$38' & $30^0$82' of North latitude and $75^0$17' &$75^0$55' east longitude. The approximate area of distribution is about 12500 sq km.

The total sheep population of Punjab is 128534 heads which is only 0.20 % of total sheep (65.069 m) population of country (Livestock census, 2012). The sheep population of Sangrur, Barnala, Ludhiana, Moga and Ferozpur districts as per 2012 census were 7968, 2640, 3563, 3478 and 32509 heads; respectively. For the production of pure bred rams, a sheep breeding farm is functioning at Mattewara, District Ludhiana, Punjab. To improve the mutton type sheep, the state Animal Husbandry department had launched

a cross breeding programme in sheep. The exotic breeds *i.e.* Corriedale and Rambouillet are used for cross breeding.

The climate of area may be classified as tropical steppe, hot and semi-arid which is mainly dry with very hot summer and cold winter except during monsoon when moist air penetrates into area. There are four seasons in a year: 1. hot weather season (mid March to last week of June); followed by 2. South west monsoon which lasts upto September; 3. the transition period from September to November forms the post-monsoon season and 4. winter season (late November to first week of March). The normal annual rainfall of the area is 500 to 700 mm, which is unevenly distributed over the area. The south west monsoon, sets from last week of June and withdraws in end of September, contributed about 78 % of annual rain fall. July and August are the wettest months. Rest 22 % of rainfall is received during non-monsoon period in the wake of western disturbances and thunder storms. The area is occupied by Indo-Gangatic alluvium and there is no surface features worth to mention except that area is plain. The soil of the zone has developed under semi-arid condition and is sandy loam to clayey with normal reaction (pH from 7.8 to 8.5). The principal crops of the area are Wheat, Paddy, Maize, Cotton and Sugarcane and among fodder crops are Bajara and Jowar.

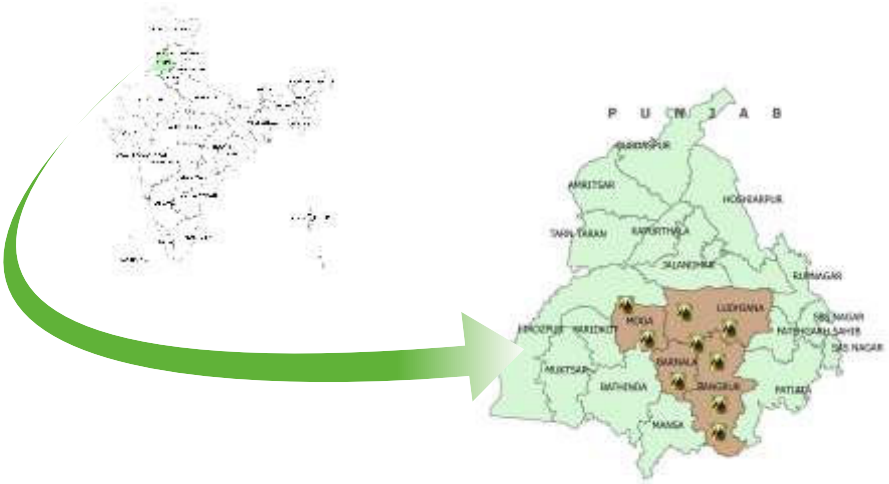


Figure 1. Distribution of Kajali sheep

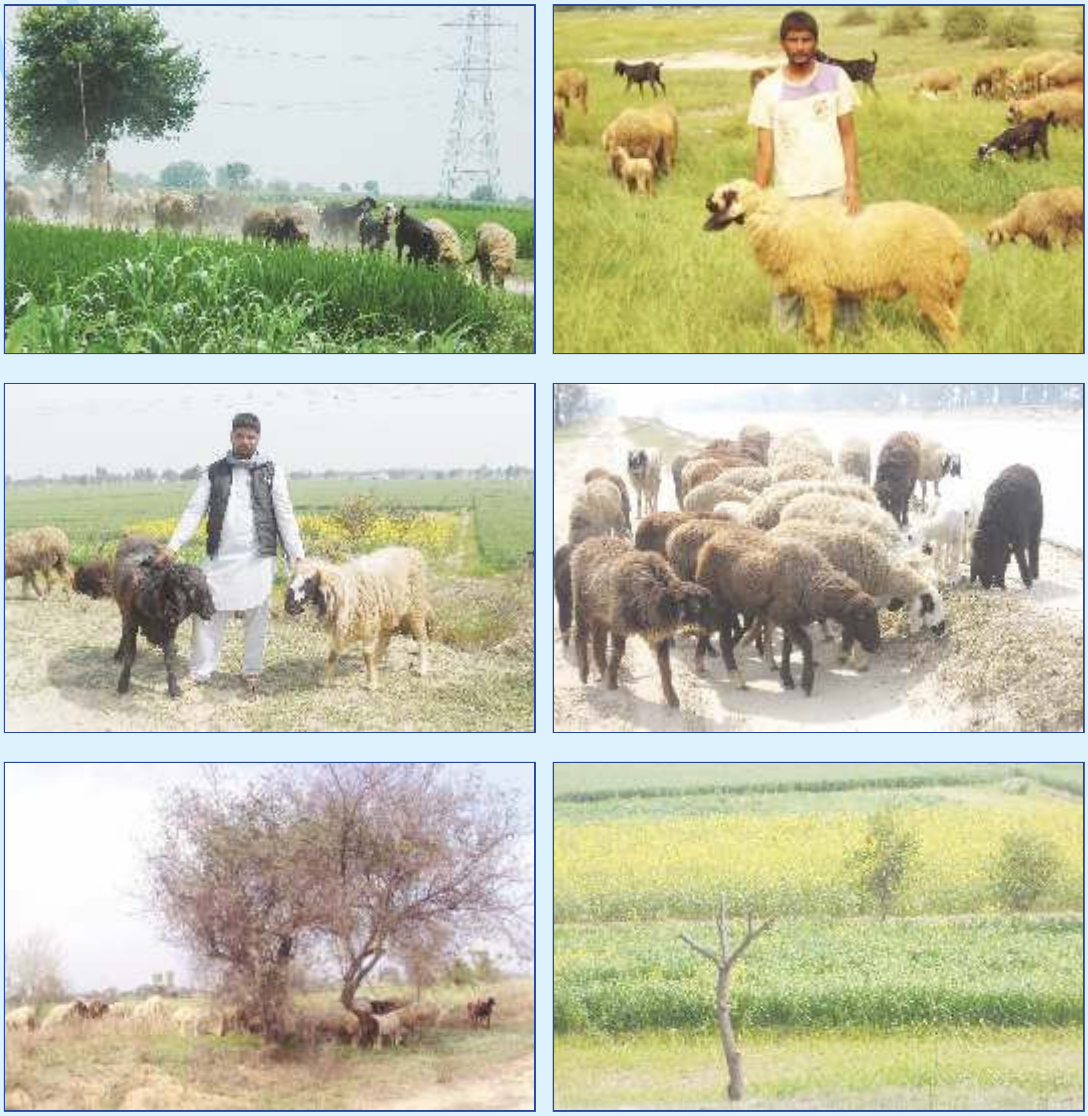


Figure 2. Natural habitat of Kajali sheep

3. BREED CHARACTERISTICS

Kajali sheep has two colour variants distinguishable based on the coat colour of the animals. The colour variants are 1, White (Chitti) Kajali, 2 Black (Kali) Kajali. White / Chitti Kajali animals are with complete white coat and with black or dark brown

circle/patch around the eyes & in face and ears. The black / dark brown colour pattern is varying in degree even covering up to 95% face and ear. Black Kajali animals are with complete black or mixture of black- brown or brown body coat with about 41.57% (6 to 55 cm) tail covered with white coat. Out of the total animals surveyed 54.99 % (1444) and 45.01% (1182) are of Black and White Kajali type, respectively.

Kajali sheep is large in size with well-built body having Roman nose, long, flat and pendulous or leafy ears and long tail touching to ground. Out of total animals studied 64.57 % were of Roman nose and rest was off slightly convex type. The udder is medium sized and having medium teats. Both sexes are polled however in some males horn was also noticed. The unique phenotypic appearance especially colour pattern on face, colour patches around the eye, roman nose, ear size & shape and tail length are distinct and distinguishing phenotypic characteristic (Figure 3, 4 and 5) of this breed. Twining is reported to be 5 to 10 % by majority of farmers (38.71%). 33.87% sheep farmers reported that twining varies from 0 to 5 % and 3.23 % reported even more than 20% multiple births. Few triplets were also noticed.

Figure 3. Kajali (White/Chitti) sheep with typical characteristics

Figure 3. Kajali (White/Chitti) sheep with typical characteristics

Figure 4. Kajali (Black/Kali) sheep with typical characteristics

Figure 5. Physical characteristics of Kajali sheep

Biometry and Body Weight

The average body weight and biometry of adult Kajali sheep, frequency distribution of body weight and average body weight of lambs are given in tables 1, 2 and 3. The body weight of adult males and females were 56.98 ± 1.02 and 43.23 ± 0.36 kg, respectively, which varies from 30 to 76 kg in males and 26 to 67 kg in females. The overall body length, height at withers, chest girth, ear length and tail length of adult males were 79.92 ± 0 .71, 78.84 ± 0.51, 89.89 ± 0.58, 21.47 ± 0.20 and 60.71± 1.02 cm respectively and corresponding figures for adult females were 72.69 ± 0.71, 72.18 ± 0.17, 83.02 ± 0.27, 21.30 ± 0.09 and 54.78 ± 0.37 cm, respectively. The diameter of tail at base was 14.80 ± 0.66 (13 to 17) cm and ear width was 10.85± 0.19 (9 to 16) cm. The frequency distribution of adult body weight (Table 2) shows that the body weight of majority of males (39.08 %) were ranges between 50 to 60 kg and in ewes from 40 to 50 kg (51.38 %). The perusal of Table 2 also reveals that 72.41% adult males weigh more than 50 kg and 51.38 % adult females weigh from 40 to 50 kg. The lamb's body weight shows increasing trend with advancement of age. The 3 to 6 months body weight of male lambs is very important for marketing. The body biometry and adult body weight observed in Kajali sheep under present study reflects that this sheep is quite large in size and also one of the heaviest sheep of the country.

Table 1. Body weight (kg) and biometry (cm) of adult Kajali sheep

Traits	Body weight	Body length	Height at wither	Chest girth	Paunch girth	Ear length	Face length	Face width	Tail length
Overall	...	73.97 ± 0.28 (491)	73.36 ±0.20 (491)	84.23 ±0.27 (491)	85.81 ± 0.35 (491)	21.33 ± 0.08 (488)	22.05 ± 0.07 (491)	10.90 ± 0.07 (491)	55.83 ± 0.37 (490)
Sex	**	**	**	**	**	NS	**	**	**
Male	56.98 ±1.02 (87)	79.92 ± 0.71 (87)	78.84 ± 0.51 (87)	89.89 ±0.58 (87)	91.34 ± 0.75 (87)	21.47 ± 0.20 (87)	23.77 ± 0.16 (87)	12.07 ± 0.16 (87)	60.71 ±1.02 (87)
Female	43.23 ± 0.36 (399)	72.69 ± 0.71 (404)	72.18 ± 0.17 (404)	83.02 ± 0.27 (404)	84.62 ± 0.75 (404)	21.30 ± 0.09 (401)	21.68 ± 0.07 (404)	10.65 ± 0.07 (404)	54.78 ± 0.37 (403)
Range									
M	30-76	66-98	69-90	76-103	76-112	17-26	19-27	9-16	35-79
F	26-67	58-86	62-88	68-103	58-107	15-27	12-29	8-14	31-80

** Significant at p< 0.01; figures within parentheses are number of observations

Table 2. Frequency distribution of body wt.

Group	Male	Female
<40 kg	4.60 % (4)	35.34 % (141)
40-50 kg	22.99 % (20)	51.38 % (205)
50-60 kg	39.08 % (34)	11.78 % (47)
>60 kg	33.33 % (29)	1.50 % (6)

Table 3. Body weight of Kajali lambs (kg)

Age	Birth wt	0-1 Months	1-3 Months	3-6 Months	6-12 Months
Overall	3.92 ± 0.43 (9)	9.52 ± 0.48 (62)	18.12 ± 0.49 (73)	23.93 ± 0.61 (65)	32.04 ± 1.19 (12)
Sex	NS	NS	NS	**	NS
Male	4.30 ± 0.74(4)	9.37 ± 0.57 (36)	19.60 ± 0.99 (20)	26.47 ± 1.56 (18)	33.58 ± 1.80 (6)
Female	3.62 ± 0.52 (5)	9.72± 0.83 (26)	17.56 ± 0.54 (53)	22.96 ± 0.54 (47)	30.50 ± 1.44 (6)

** Significant at p< 0.01; figures within parentheses are number of observations

4. SOCIO- ECONOMIC STATUS OF SHEEP FARMERS

Kajali sheep framers belongs to Jamidar, Majabi sikh, Nai sikh, Jat sikh, Ramdasi sikh, Bajigar, SC, Shansi Muslim, Gujjar mislim etc. and are generally poor and underprivileged people of the society (Figure 6). Average family size was 7.10 with 4.05 male and 3.05 female. Overall literacy rate was 17.24 and rest (82.76%) were illiterate, however 51.72% families educating their children. The majority (84.13%) of sheep farmers were landless and rest (15.87%) were having 3 bigha to 12 acres of land. The average family members involved in sheep rearing was 1.98. Apart from low income group, most of the sheep farmers (87.72%) of the area are having toilet facility and they are more aware of cleanliness. Out of 44 respondent, 3(6.82%) had got training in Agri. and Animal Husbandry activity by different Govt. and non-Govt. organizations. The 96.49% (55/57) farmers having electricity connection and 8.20% (5/61) having 4 wheelers viz. car, truck and tractor. None of the farmers are employed but 19.61% (10/51) farmers family engaged in contract type of farming on others agricultural land.

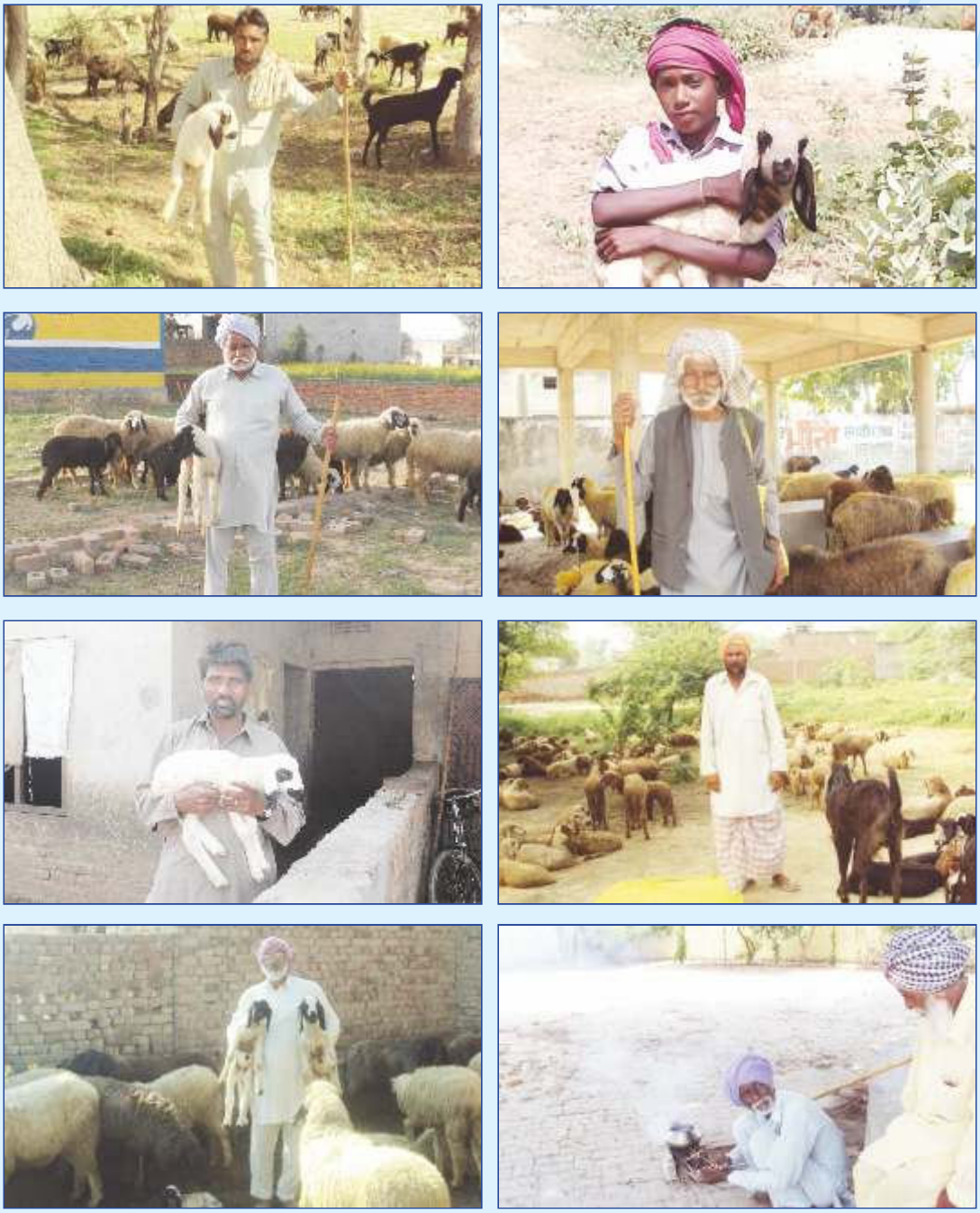


Figure 6. Kajali sheep famers

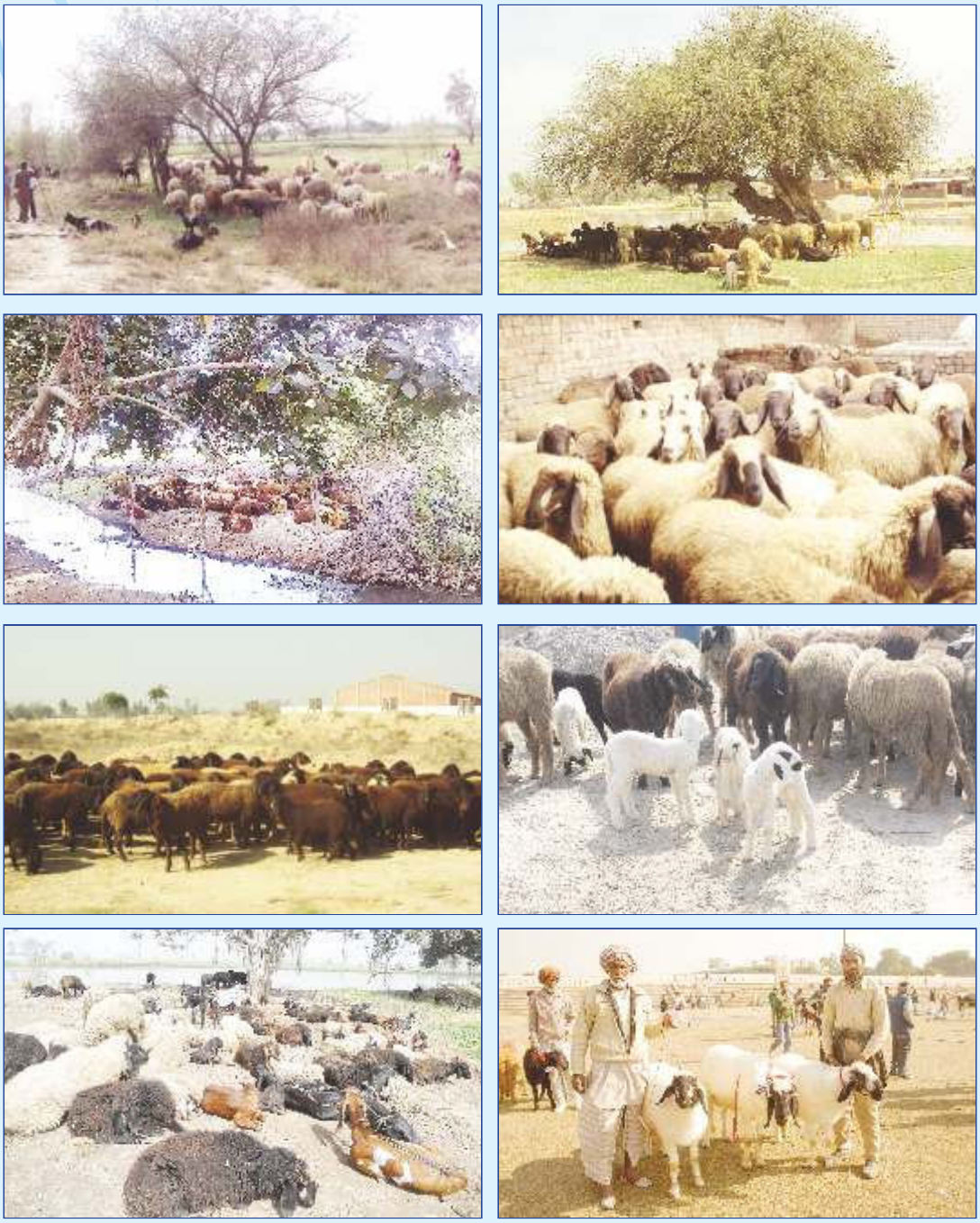


Figure 7. Kajali flocks

Flock size

The average flock Size is 56.45 (range: 5 -150). The flocks consist of 50.94 Kajali and 5.51 other sheep breeds (Munjal and non-descript). The Kajali sheep flocks (Figure 7) comprising 1.97 male, 36.06 female and 12.91 lambs. Among total surveyed flocks 55.22% (37/67) are of pure Kajali flock. Besides rearing of sheep 61.19% sheep farmers reared goat, 1.49% buffalo, 22.39% goat & buffalo, 8.96% cattle, goat & buffalo and 1.49% cattle & buffalo. Some farmers also kept equines as pack animal.

5. HUSBANDRY PRACTICES

Breeding and reproduction

The ewes are bred through natural service, the rams per flock was observed to be 1.88 with a ram-ewe ratio of 1:30.02. In all the studied flocks only Kajali ram is being used for breeding purpose. The rams are either selected from their own flock or exchanged with the other breeders; the farmers select their rams based on body conformation specific to Kajali sheep and also on body weight and growth rate of ram lambs. The females show sexual maturity at about 10 to 12 months of age (Table 4). The age at first mating in rams was about 12-15 months as reported by 66.10% sheep breeders and 69.09% of farmers reported about 12-18 months as age at first breeding in females. The main lambing season is January to March and minor is from August to October with an average of 80 to 90 percentage of annual lambing. The breeding life of ewes is reported to be 7 to 8 years by 62.75% sheep farmers. The litter size is single but 38.71% farmers reported that twining varied from 5 to 10 % in their flock.

Feeding Practices

Kajali sheep are primarily maintained on grazing however, 8.12% of farmers provide concentrate especially during breeding season, to pregnant ewes and lambs. The animals are allowed for grazing for about 8-10 hrs in a day (10 or 11 AM to 6 PM), the

distance covered by majority of sheep farmers (53.45%) to graze their animals was ranged from 5 to 10 km per day (Table 5). In Punjab the farmers follow intensive agriculture with multiple cropping in a year, resulted in non-availability of local or community grazing land, which is main reason for the sheep farmers to walk long distance in search of grazing material. The 67.21% (41/61) farmers provide fodder to sheep during scarcity period. 9.84 % (4/61) farmers offer fodder in feeding trough. The feeding troughs are either made up of bricks or of wood or plastic gunny bags (Figure 8) and were generally constructed 1 to 2 feet above the ground level.

Table 4. Breeding practices followed by Kajali sheep farmers

Particulars		Items	Sheep farmers
Age at first Breeding:	Males	<12 months	16.95 % (10)
		12-15 months	66.10 % (39)
		>15 months	16.95 % (10)
	Females	<12 months	29.09 % (16)
		12-18 months	69.09 % (38)
		>18 months	1.81 % (1)
Tupping		<80 %	0.00 %
		80-90%	57.78 % (26)
		>90 %	42.22 % (19)
Age at first lambing		< 17 months	36.00 % (18)
		17-20 months	58.00 % (29)
		>20 months	6.00 % (3)
Age at puberty		< 10 months	24.49 % (12)
		10-12 months	61.22 % (30)
		>12 months	14.29 % (7)
Weight at puberty		<25 kg	12.82 % (5)
		25-30 kg	76.92 % (30)
		>30 kg	10.26 % (4)
Breeding life		<7 years	17.65 % (9)
		7-8 years	62.75 % (32)
		>8 (up to 12 years)	19.61 % (10)

Figures within parentheses are number of respondents.

Table 5. Feeding and Housing management practices followed by Kajali sheep farmers

Particulars	Items	% of sheep farmers
Grazing : Distance travelled	< 5 km	6.90 % (4)
	5 to 10 km	53.45 % (31)
	>10 km	39.66 % (23)
Grazing hours	< 8 hrs	31.03 % (18)
	8 to 10 hrs	65.52 % (38)
	>10 hrs	3.45 % (2)
Housing pattern		
Housing	Pucca	46.77 %(29)
	Kutcha	53.23 % (33)
	Separate	57.89 % (33)
	Part of owners house	42.11 % (24)

Figures within parentheses are number of respondents

Figure 8. Feeding management

Housing Management

Majority of sheep farmers provide housing (Fig 9) particularly during night hours. About 46.77% of sheep farmers have pucca housing and 53.23% provide kutcha housing to their sheep. About 57.89% farmers constructed separate house for sheep. Out of total surveyed flocks 2.98 % farmers provide water to animals at house. The waterers are either pucca type or of metal type.

Figure 9. Housing management system

Health Management

The majority (85.25%) of sheep farmers vaccinate their animals against FMD, sheep pox, Haemorrhagic septicaemia and Enterotoxemia. Drenching of anthelmintics was practiced against internal parasites. The major diseases noticed were FMD, HS, PPR, Gid, Lameness, Pox and Pneumonia. The mortality is reported to be < 5% (Table 6) in adult and <10% in lambs by majority of sheep farmers.

Table 6. Mortality pattern in Kajali sheep

Particulars	Items	Sheep farmers
Lamb Mortality	<10%	50.00 % (21)
	10-15 %	14.28 % (6)
	15-20 %	16.67 % (7)
	>20 %	19.05 % (8)
Adult mortality	<5 %	85.71 % (30)
	5-10 %	11.43 % (4)
	>10 %	2.89 % (1)

Figures within parentheses are number of respondents.

Animal Products and Production Management

The sheep are generally shorn twice a year during the month of February- March and August – September. Majority (64.44%) of farmers reported that average greasy wool production ranges from 800 to 1000 g per shearing (Table7). The cost of black wool was reported as ₹15 to 20 and white wool was as ₹20 to 40 per kg by 82.14% farmers however, 16.07% farmers sold white wool even more than ₹40 per kg.

The marketing age of male lambs was reported as 3 to 6 months by 60% sheep farmers and the cost of surplus lambs was reported as ₹ 2500 to 4000 by 75% farmers (Table 8). The cost of adult/old aged rams and ewes varied from ₹ 2000 to 3000 as reported by majority (52.18%) of farmers. The cost of surplus animals were depends upon condition of individual animal. Almost all the farmers sold their animals to traders or butcher. The daily milk yield was reported as 200 to 300 ml with lactation length of 90 to 120 days, but milking is not practiced by the sheep farmers.

Table 7. Wool production pattern and their cost

Particulars	Items	Sheep farmers
Wool production (g)	<800	24.44 %(11)
	800 to 1000	64.44 % (29)
	>1000	11.11 % (7)
Wool cost Black wool (₹)	15 to 20	100 %
White wool (₹)	<20	1.76 % (1)
	20 to 40	82.14 % (46)
	>40	16.07 % (9)

Figures within parentheses are number of respondents.

Table 8. Marketing & disposal age and cost of live animals

Particulars	Items	Sheep farmers
Marketing age (month)	3 - 4	60 % (33)
	4-6	38.18 %(21)
	>6	1.81% (1)
Lamb cost at marketing age (₹)	< 2500	36.11 % (13)
	2500 to 4000	38.89 % (14)
	>4000	25.00 (9)
Adult cost/culled animals cost (₹)	< 2000	15.22 % (7)
	2000 – 3000	36.96 % (17)
	3000-5000	26.09 % (12)
	> 5000	10 % (21.74)
Disposal age (Years)	7	18.18 % (8)
	7-8	34.09 %(15)
	8-10	40.91 % (18)
	>10	6.82 % (3)
Life time lambs produced	8	27.66 % (13)
	8-10	34.04 %(16)
	10-12	25.53 %(12)
	>12	12.27 % (6)

Figures within parentheses are number of respondents.

Figure 10. Wool shearing

6. GENETIC CHARACTERIZATION

Blood collection and DNA isolation

Blood samples were collected from 42 unrelated animals (rams and ewes) of Kajali sheep in its breeding tract. The genomic DNA from the blood samples was isolated using a standard phenol/chloroform/isoamyl alcohol extraction method (Sambrook *et al.* 1989).

PCR amplification

Set of 24 microsatellite markers based on the list of MoDAD (FAO) reported by Bradley *et al.* (1997) and Di Stasio (2001) were utilized to generate data on DNA samples of the Kajali sheep. The details of microsatellite markers, primer sequences, size range, gene bank accession number and chromosomal location is given in Table 9. The forward primer for each marker was fluorescently labeled with FAM, NED, VIC or PET dye. Amplification of the loci (multiplexed) was performed in a 25µl final reaction volume containing at least 100 ng of genomic DNA, 5 pico moles / µl of each primer, 1.5mM $MgCl_2$, 200µM dNTPs, 0.5 U Taq *DNA polymerase* and 1x Taq buffer. A common touch down PCR programme as suggested under MoDAD project (FAO, 1996) without extension step was used for the amplification of all the twenty four markers. PCR amplification consisted of 3 cycles of 45 sec at 95^{0}C, 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 95^{0}C, 1 min at 48^0 C. The amplified products were resolved on 2% agarose gel.

Genotyping of the PCR products

PCR products were genotyped on an automated DNA sequencer using LIZ 500 as internal lane standard (ABI PRISM). Gene Mapper software version 3 was used to extract raw data. Popgen 3.2 (Yeh *et al*. 1999) and GenAlEx6.5 (Peakall and Smouse, 2005) softwares were used for the genetic diversity analysis. Polymorphism Information Content (PIC) of the microsatellite loci was estimated according to Botstein *et al*. (1980).

Table 9. Details of microsatellite markers used in the study of sheep.

Locus	Primer sequence	Size range (bp)	Genebank accession no.	Chromosome no.
BM6506	F -gCA CgT ggT AAA gAg ATg gC R - AgC AAC TTg AgC ATg gCA C	191-199	G18455	1
OarCP20	F -gAT CCC CTg gAg gAg gAA ACg g R - ggC ATT TCA Tgg CTT Tag CAg g	72-88	U15699	21
OarFCB48	F -gAg TTA gTA CAA ggA TgA CAA gAg gCA C R - gAC TCT AgA ggA TCg CAA AgA ACC Ag	146-152	M82875	17
OarVH72	F -CTC Tag Agg ATC Tgg AAT gCA AAg CTC R - ggC CTC TCA Agg ggC AAg AGC Agg	121-133	L12548	25
OarHH47	F -TTT ATT gAC AAA CTC TCT TCC TAA CTC CAC C R - gTA gTT ATT TAA AAA AAT ATC ATA CCT CTT AAg g	124-144	L12557	18
BM757	F - Tgg AAA CAA TgT AAA CCT ggg R - TTg AgC CAC CAA ggA ACC	172-186	G18473	9
BM1314	F -TTC CTC CTC TTC TCT CCA AAC R - ATC TCA AAC gCC AgT gTg g	141-167	G18455	22
BM8125	F -CTC TAT CTg Tgg AAA Agg Tgg g R - ggg ggT Tag ACT TCA ACA TAC g	109-119	G18475	17
OarHH35	F -AAT TgC ATT CAg TAT CTT TAA CAT CTg gC R - ATg AAA ATA TAA AgA gAA TgA ACC ACA Cgg	107-137	L12554	4
OarHH64	F -CgT TCC CTC ACT ATg gAA AgT TAT ATA TgC R - CAC TCT ATT gTA AgA ATT TgA ATg AgA gC	127-135	L12558	4
OarJMP8	F -Cgg gAT gAT CTT CTg TCC AAA TAT gC R - CAT TTg CTT Tgg CTT CAg AAC CAg Ag	115-139	U35059	6
OarJMP29	F -gTA TAC ACg Tgg ACA CCg CTT TgT AC R - gAA gTg gCA AgA TTC AgA ggg gAA g	109-143	U30893	24
BM827	F -ggg CTg gTC gTA TgC TgA g R - gTT ggA CTT gCT gAA gTg ACC	210-218	U06763	3
OarHH41	F -TCC ACA ggC TTA AAT CTA TAT AgC AAC C R - CCA gCT AAA gAT AAA AgA TgA TgT ggg Ag	120-140	L12555	10
CSSM31	F -CCA AgT TTA gTA CTT gTA AgT AgA R - gAC TCT CTA gCA CTT TAT CTg TgT	146-180	U03838	23
CSSM47	F -TCT CTg TCT CTA TCA CTA TAT ggC R - CTg ggC ACC TgA AAC TAT CAT CAT	148-152	U03821	2
CSRD0247	F -ggA CTT gCC AgA ACT CTg CAA T R - CAC TgT ggT TTg TAT TAg TCA gg	211-239	EU009450	14
MAF0214	F -AAT gCA ggA gAT CTg Agg CAg ggA Cg R - ggg TgA TCT TAg ggA ggT TTT ggA gg	185-229	M88160	16
OarCP0049	F -CAg ACA Cgg CTT AgC AAC TAA ACg C R - gTg ggg ATg AAT ATT CCT TCA TAA gg	83-139	U15702	17
BM6526	F -CAT gCC AAA CAA TAT CCA gC R - TgA Agg Tag AgA gCA AgC AgC	191-199	G18454	26
OarCP34	F - gCT gAA CAA TgT gAT ATg TTC Agg R - ggg ACA ATA CTg TCT Tag ATg CTg C	112-126	U15699	3
INRA0063	F -gAC CAC AAA ggg ATT TgC ACA AgC R - AAA CCA CAg AAA TgC TTg gAA g	173-199	X71507	14
OarAE129	F -AAT CCA gTg TgT gAA AgA CTA ATC CAg R - gTA gAT CAA gAT ATA gAA TAT TTT TCA ACA CC	133-159	L11051	5
OarFCB128	F -CAg CTg AgC AAC TAA gAC ATA CAT gCg R - ATT AAA GCA TCT TCT CTT TAT TTC CTC GC	106-130	L01532	2

Table 10. Genetic variability measures in Kajali sheep across different microsatellite markers.

Locus	Na	Ne	Heterozygosity Observed/	Expected	PIC	FIS
BM757	4.00	1.912	0.444	0.477	0.408	0.068
BM8125	3.00	1.949	0.432	0.487	0.381	0.112
OarHH47	9.00	5.935	0.727	0.831	0.808	0.125
BM6526	8.00	2.557	0.610	0.609	0.587	-0.001
OarCP34	5.00	3.219	0.650	0.689	0.646	0.057
CSRD0247	6.00	3.269	0.575	0.694	0.644	0.172
MAF0214	5.00	2.058	0.500	0.514	0.473	0.027
OarCP0049	9.00	5.787	0.756	0.827	0.805	0.086
OarHH35	7.00	3.378	0.613	0.704	0.666	0.129
OarHH64	7.00	1.817	0.192	0.450	0.430	0.572
OarJMP8	6.00	2.604	0.138	0.616	0.555	0.776
OarFCB48	4.00	2.510	0.000	0.602	0.548	1.000
OarCP20	15.00	8.733	0.762	0.885	0.957	0.140
CSSM31	9.00	2.524	0.424	0.604	0.578	0.297
OarVH72	12.00	8.036	0.800	0.876	0.729	0.086
CSSM47	13.00	9.475	0.765	0.894	0.885	0.145
OarFCB128	6.00	2.274	0.500	0.560	0.535	0.107
INRA0063	12.00	3.717	0.500	0.731	0.708	0.316
Mean	7.778	3.986	0.522	0.669	0.63	0.234
SD	0.803	0.588	0.054	0.035	0.04	0.065

Na = Observed number of alleles, Ne = Effective number of alleles [Kimura and Crow (1964)]
Expected heterozygosity was calculated by Levene (1949)

Genetic Diversity Analysis

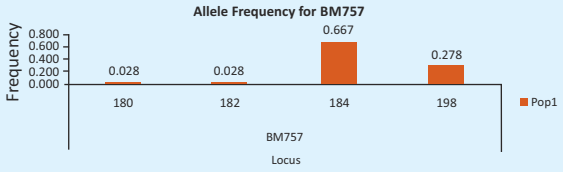
Different measurements of within breed genetic variations viz. observed and effective number of alleles (Ne) observed (Ho) and expected heterozygosity (He) along with polymorphism information content (PIC) of different microsatellite loci and within population inbreeding estimates (FIS) are given in Table 10. The microsatellite loci amplified were observed to be polymorphic in the investigated Kajali sheep population. All the markers were found to be highly informative with average PIC value of 0.63. This indicates that these markers are quite useful for genetic diversity analysis. The allele frequencies across all the loci ranged from 0.012 to 0.731 (Figure 11). A total of 140 distinct alleles were identified across the 18 markers in Kajali sheep. The observed no.

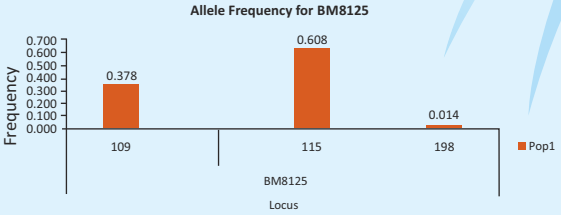
of alleles ranged from 3 (BM8125) to 15 (OarCP20) with a mean of 7.778. Effective number of alleles was lower than the observed number of alleles and ranged from 1.817 (OarHH64) to 9.475 (CSSM47) with a mean value of 3.986. The average observed heterozygosity values (0.522) compared to the average expected heterozygosity values (0.669) did not show significant differences ($P > 0.05$) which suggested random mating in Kajali population. The estimates of allele diversity (mean no of observed alleles) and gene diversity (mean expected heterozygosity) implied the presence of substantial amount of genetic variability in the Kajali sheep population.

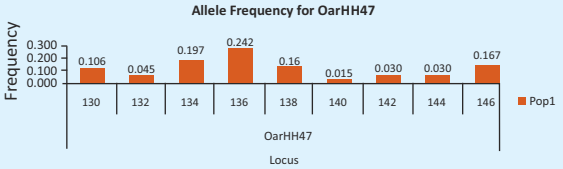
The mean FIS (within population inbreeding estimates) is 0.234 which indicated deficiency in the number of heterozygotes in Kajali sheep. The observed positive FIS in the investigated sheep population might be due to the non-random mating and use of fewer rams for the breeding purpose. However, the high gene diversity estimates observed in the present study does not support inbreeding. The existence of population substructure (Wahlund effect) due to sampling from different flocks in different villages of the distribution area appears to be the most probable explanation. The most appropriate or exact reason of deficit of heterozygotes is difficult to predict due to non availability of pedigree information in the field conditions. The positive FIS value for Kajali sheep is comparable to those reported previously for most Indian sheep breeds (Arora *et al*. 2011).

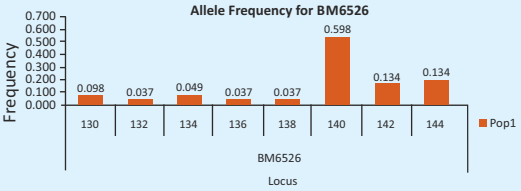
Phylogenetic Analysis

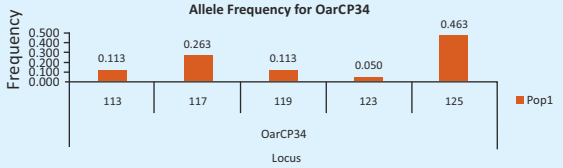
Microsatellite allele frequency data of nineteen (19) sheep breeds/populations of our country were used to calculate genetic distance estimates and phylogenetic tree (Fig. 12) was constructed using Nei et al. (1983), an Unweighted Pair Group Method with Arithmetic Mean Algorithm (UPGMA). The study revealed that Garole, the prolific sheep clusters in a separate node, the Kajali sheep under study clustered in same node with Munjal sheep (bootstrap value of 22%), another lesser known mutton type sheep distributed in near vicinity of the breeding tract of Kajali sheep. Kajali and Munjal sheep are phenotypically distinct from each other.

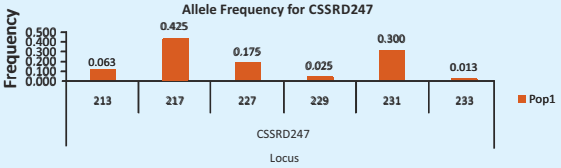

Allele Frequency for BM757
Frequency
0.800
0.600
0.400
0.200
0.000
0.028
0.028
0.667
0.278
180
182
184
198
Pop1
BM757
Locus

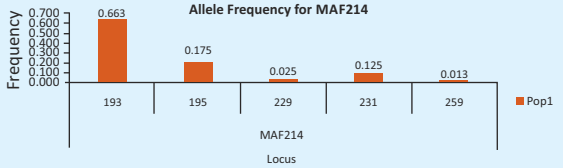

Allele Frequency for BM8125
Frequency
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.378
0.608
0.014
109
115
198
Pop1
BM8125
Locus

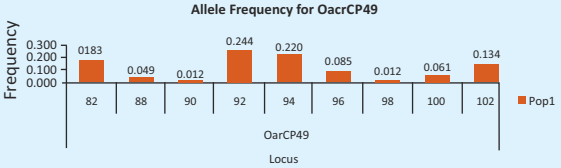

Allele Frequency for OarHH47
Frequency
0.300
0.200
0.100
0.000
0.106
0.045
0.197
0.242
0.16
0.015
0.030
0.030
0.167
130
132
134
136
138
140
142
144
146
Pop1
OarHH47
Locus

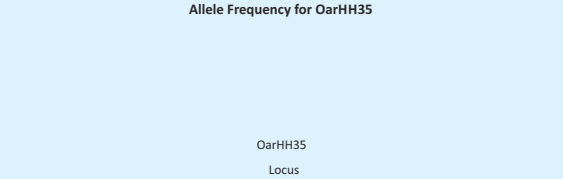

Allele Frequency for BM6526
Frequency
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.098
0.037
0.049
0.037
0.037
0.598
0.134
0.134
130
132
134
136
138
140
142
144
Pop1
BM6526
Locus

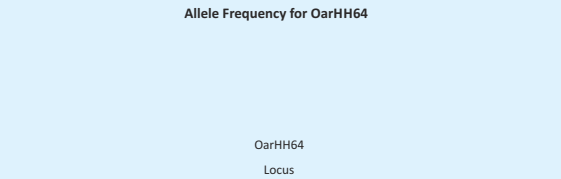

Allele Frequency for OarCP34
Frequency
0.500
0.400
0.300
0.200
0.100
0.000
0.113
0.263
0.113
0.050
0.463
113
117
119
123
125
Pop1
OarCP34
Locus


Allele Frequency for CSSRD247
Frequency
0.500
0.400
0.300
0.200
0.100
0.000
0.063
0.425
0.175
0.025
0.300
0.013
213
217
227
229
231
233
Pop1
CSSRD247
Locus


Allele Frequency for MAF214
Frequency
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.663
0.175
0.025
0.125
0.013
193
195
229
231
259
Pop1
MAF214
Locus


Allele Frequency for OacrCP49
Frequency
0.300
0.200
0.100
0.000
0183
0.049
0.012
0.244
0.220
0.085
0.012
0.061
0.134
82
88
90
92
94
96
98
100
102
Pop1
OarCP49
Locus


Allele Frequency for OarHH35
OarHH35
Locus


Allele Frequency for OarHH64
OarHH64
Locus

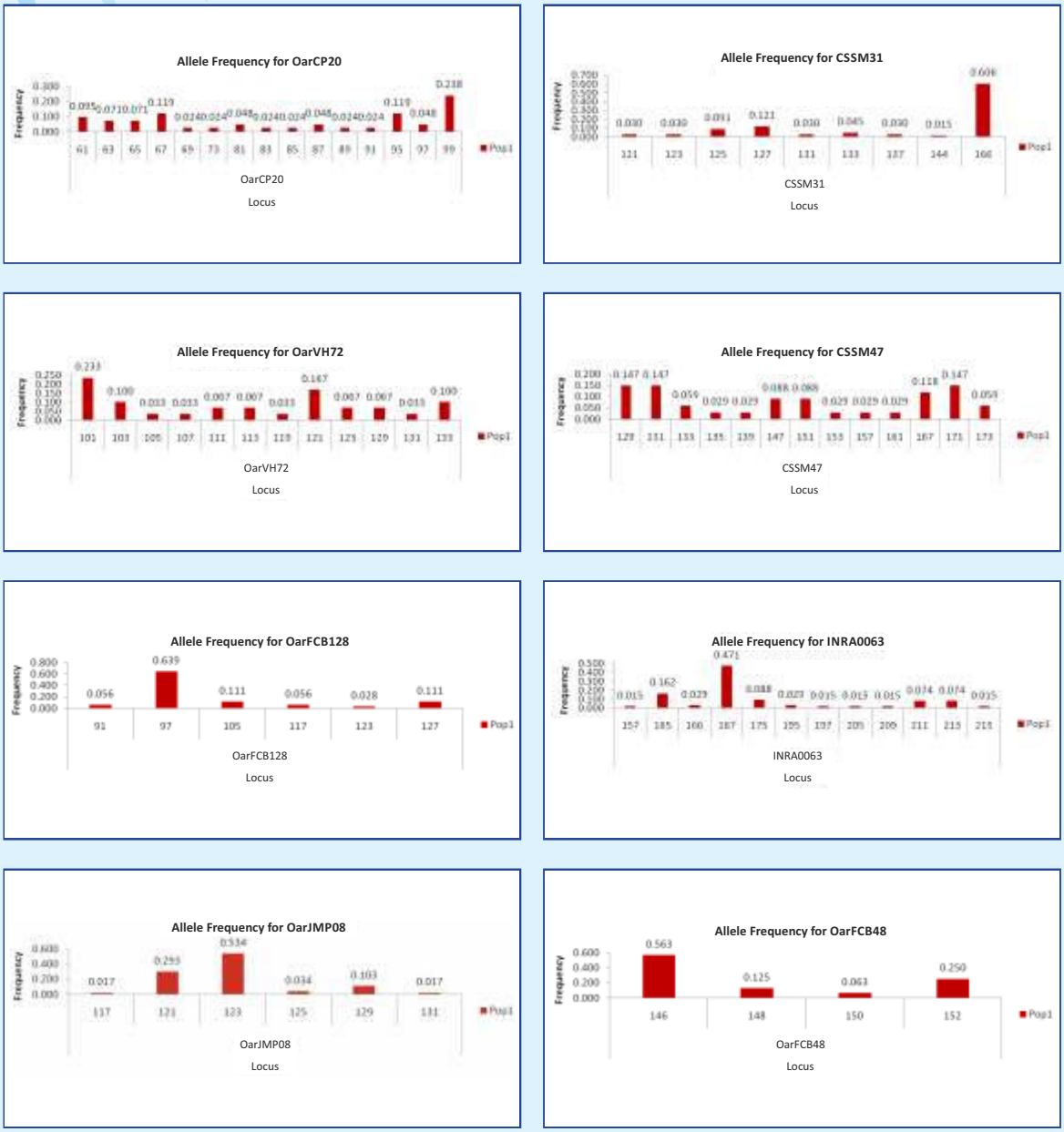


Figure 11. Allele frequencies distribution at different microsatelite loci in Kajali sheep

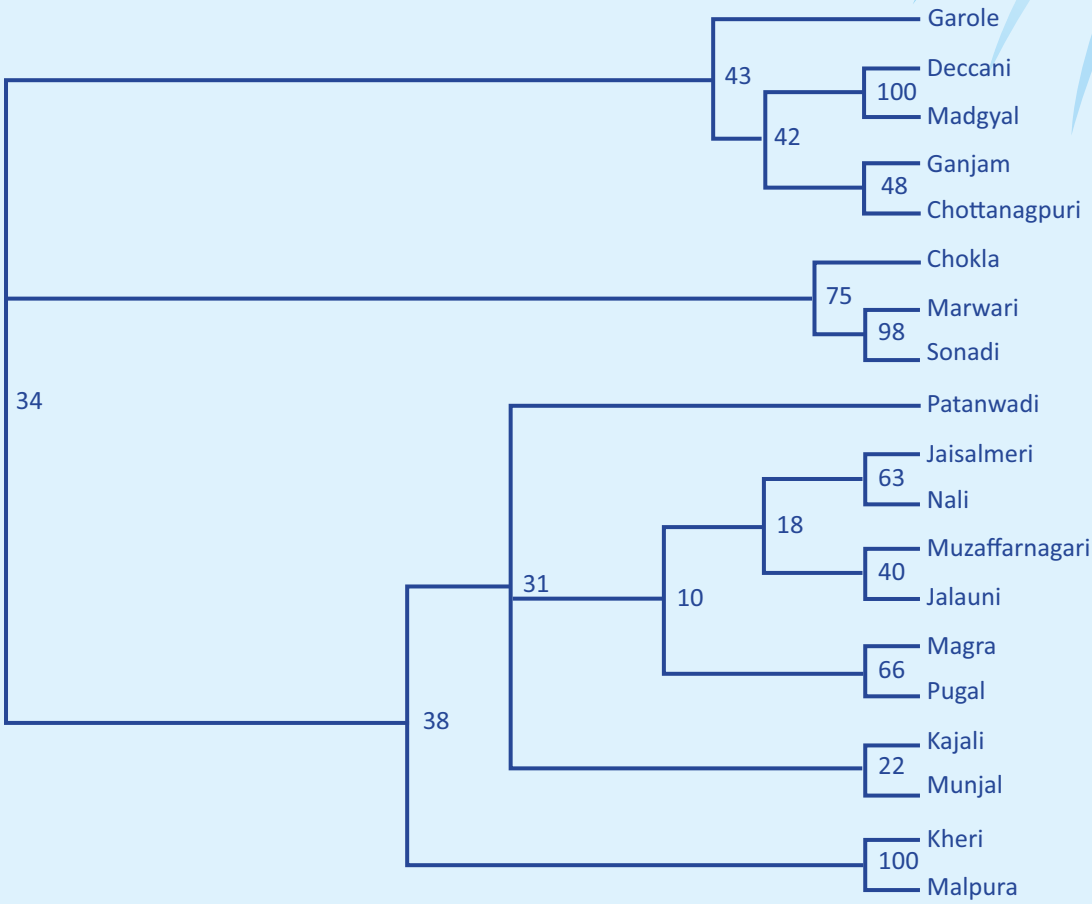


Figure 12. Phylogenetic analysis of different sheep breeds of India based on microsatellite allele frequency data.

7. MAJOR PROBLEMS/ CONSTRAINTS IDENTIFIED AMONG KAJALI SHEEP FARMERS

- Shrinkage of grazing land is identified as major problem, as the sheep and goat farming is totally depends on grazing and browsing.
- High price of feed and fodder
- Poor market facility for meat and wool
- Lack of financial support
- Costly medicines

- Few farmers reported heavy mortality as a constraint.
- Lack of training in the field of animal husbandry

8. INDIGENOUS TECHNICAL KNOWLEDGE (ITK'S) PRACTICED BY KAJALI SHEEP FARMERS

Sheep keepers have indigenous knowledge to treat and manage their flocks, which are passed on to them by their forefathers. Though the exact mechanism and physiology of these substances is not known however, the practical experience has led to persist use of them since time immemorial and they are still relevant. During the efforts to characterize Kajali Sheep and while recording the management practices followed by Kajali sheep farmers information regarding some ITK's was also collected which are summarized below:

For treating bloat/ acidity; one farmer use sweet (meetha) soda. The amount of sweet soda was taken as per need. One farmer offer meetha soda in case of overfeeding of wheat grain. Some farmers also give Deshi alcohol/whisky (90-100 ml/animal) to treat bloat condition. One farmer informs that he kept tobacco in his mouth and with milk he blows these two items from his mouth to mouth of sheep. Some farmers give 4-5 gm tobacco/ animal to treat acidity/bloat/anorexia. One farmer informed that grind: Kaddu + Ajwaine + Kali jiri + Methi + Kala namak + Kudtumma (locally available); and give one teaspoon (TSP) /day/animal for treating bloat/indigestion. One farmer informed that smell of kerosene oil also improve bloat condition of sheep.

For treating weakness and anorexia; One farmer informed that after mixing; Ajwain + Saunf+ Sendha (Lahore) salt + Aak + Black pepper (Kali mirch) + lassi; ferment all these for a day, and after that he gave @ 2 teaspoon per day and this will improve the health of animal. To treat toxicity one farmer informed that he provided 250 ml lassi with two TSP ghee and this improved the condition of animal. One farmer, use mustard oil as laxative for 15 days old lamb. For treating diarrhoea one farmer use turmeric + milk. One farmer uses 200 warm milk + 15 gm deshi ghee for shedding of placenta.

To treat Swollen of stomach of child due to eating of soil (in human): One farmer informs that provide Sheep milk to children, will improve the condition.

The above information is based on information collected from sheep farmers however all above information needs validation before their application. The readers are requested to consult nearby Veterinary doctors for treatment of their animals.

9. CONCLUSION AND RECOMMENDATIONS

- Kajali sheep are found to be large in size with well-built body having Roman nose, long and pendulous ears and characteristic long tail touching to ground. The unique phenotypic appearance especially colour pattern on face, roman nose, ear size & shape and tail length are able to distinguish this valuable germplasm from other extant sheep breeds of region.
- The study reveals that Kajali is one of the heaviest sheep breed of India and farmers preferred it because of its fast growth rate and good mutton quality. It is well adapted to the geographical area of Punjab (India).
- Kajali sheep population need to be propagated using elite rams at large scale and systematic breeding plans needs to be developed for faster genetic gains. Based on pilot study there seems to be a sufficient potential in this breed to be used as an improver sheep breed for higher weight gain and for improving mutton production through selective breeding.
- Since, sheep farming is dependent on grazing hence, community pastures should be developed.
- A detailed study on evaluation of Kajali sheep should be done through ICAR-NBAGR Network Project on animal genetic resources.
- Kajali sheep should be recognised and registered as a distinct sheep breed at National level.

10. ACKNOWLEDGEMENTS

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measurements of their animals and also for collection of blood samples. Our sincere thanks to Director, Animal Husbandry, Govt. of Punjab (India) and Deputy Directors of Sangrur, Barnala, Ludhiana and Moga districts. The special thanks are to Dr Reena Arora , Principal Scientist, ICAR- NBAGR, Karnal for phylogenetic analysis, Dr. Avnish Kumar, Principal Scientist for providing map and to Dr Inderjeet Ganguly, Senior Scientist for help in genetic characterization. The help provided by Shri Shubash Chander and Shri Moti Ram, Technical officers of the Institute are duly acknowledged. We sincerely thank to Dr. V K Gupta retired Dy. Director, Dr. Sukh Charanjit Singh SVO, Sangrur, Dr. Malprit Singh CVO, Jagraon, Dr. Karan Jeet Singh VO Badrokha, Dr. Yagvinder Sindhu VO, Dr. Vinay Kumar Jindal, VO, Dr. Lakhbir VO, Dr. Prit Mahendra VO, Dr. Aman Deep Singh VO, Dr. Kamal Jeet Singh VO Jagroan, Shri Manjit Singh Vet. Inspector, Shri Umesh Goyal Vet. Inspector, AH department, Government of Punjab and others who directly or indirectly support the survey work for characterization of Kajali sheep.

BREED DESCRIPTOR FOR KAJALI SHEEP

I. GENERAL DESCRIPTION

1. Name of the breed	-	**KAJALI**
2. Synonyms	-	Kali Kajali & Chitti Kajali
3. Background for such a name / origin	-	Collyrium or based on black circle around the eyes
4. Since when the breed is known	-	Times immemorial
5. Strains (or within breed types)	-	Kali Kajali (completely black coat or black brown or brown animals) & Chitti Kajali (White animals with black or dark brown circle around the eyes and in the face with varying degree)
6. Most closely related breeds (in appearance)	-	Kajli of Pakistan
7. a. Native tract of distribution in terms of longitude and latitude	-	Sangrur- 30°12'N - 75°53'E, Barnala- 30°38'N - 75°54'E Ludhiana- 30°55'N - 75°55'E and Moga- 30°82'N - 75°17'E
b. Approximate area of distribution (sq km) :	12500	

c. Place(s)	State	District
	Punjab	Sangrur, Barnala, Ludhiana, Moga and nearby districts

8. Estimated population	
a. Year of estimation	2015
b. Population	6000 to 8000
c. Source / Reference	Mishra et al. (2015)
9. a. Communities responsible for developing the breed	Nomads / SC
b. Description of community (Farmers/nomads/isolated/tribals)	The farmers belong to under privileged peoples of the society. Most of the farmers doing sheep farming generation after generation.
10 Flock: Average size	50.94
Composition:	Ewes- 36.06 Rams-1.97 Lambs 12.91
11. Utility of the breed	Primarily for mutton along with wool and manure purpose
12.Any other information	The growth rate of Kajali sheep is better than other sheep of the area.

II. PHYSICAL CHARACTERS

1. Colour	Two types /colour variants distinguished primarily on the basis of colour viz., 1. White (Chitti) Kajali - with black or dark brown circle around the eyes and in the face with varying degree, and 2. Black (Kali) Kajali- with complete black or black- brown or brown body with about 41.57 % white tail (varied from 6 to 55 cm).
Distinctive colour markings, if any	41.57% white coloured tail in animals having black coat colour
2. Head profile (straight/slightly convex/convex)	64.57 % (64.57) of animals surveyed had Roman nose and rest were having slightly convex type.
3. Ears	
a. Orientation	Pendulous
b. Shape	flat
c. Length (cm)	21.33 ± 0.08 cm

4. Wattles (present/absent) - Absent
5. Horns - Absent
   a. Number
   b. Colour
   c. Shape
   d. Orientation
   e. Size (small < 15/ medium 15 25 /large > 25 cm.)
6. Coat
   a. Type (hair/wool) - Woolly
   b. Length (12 month fleece) (short <5/medium 5 10/long >10 cm) - NA
   c. Lustre (lustrous/non lustrous) NA
   d. Crimp / curl (straight/low crimp = < 4 / high crimp = > 4 cm.) NA
   e. Fineness (fibre diameter)(fine < 21 /medium 22 - 26 coarse >26 micrometers)
   f. Wool cover (covered/bare)
- Head - Bare
- Face - Bare
- Belly - Covered
- Legs - Half-covered
7. Beard (present/absent) - Absent
8. Tail
   a. Type - Thick and Long
   b. Shape - Round
   c. Length (short/medium/long) - long touching up to the ground (55.83 ± 0.37 cm)
9. Any other information

III. PERFORMANCE

1. Body Weight (kg)

Weight at	Male			Female		
	Average	Range	N	Average	Range	N
Birth	4.30 ± 0.74		4	3.62 ± 0.52		5
1 - 3 months	19.60 ± 0.99		20	17.56 ± 0.54		53
3-6 months	26.47 ± 1.56		18	22.96 ± 0.54		47
6-12 months	33.58 ± 1.80		6	30.50 ± 1.44		6
First Lambing						
Adult weight	56.98±1.02	30-76	87	43.23 ± 0.36	26-67	399

2. Body measurements(cm)

Body measurement	Male			Female		
	Average	Range	N	Average	Range	N
Chest-girth	89.89 ±058	76-103	87	83.02 ± 0.27	68-103	404
Body length	79.92 ± 0.71	66-98	87	72.69 ± 0.71	58-86	404
Height at withers	78.84 ± 0.51	69-90	87	72.18 ± 0.17	62-88	404

3. Carcass characters Not available
4. Dairy performance Kajali sheep is not reared for milk production

Daily milk yield (g)	Average	Range	N
Total lactation milk yield (kg)		200 to 300 ml (as informed by the farmers)	
Lactation length (days)		90-120 days	
Fat %			
SNF %			

5. Reproduction

Daily milk yield (g)	Average	Range	N
Age at first mating in males (months)		12-15 months	39
Age at first mating in females (months)		12-18 months	38
Age at first Oestrus (days)		10-12 months	30
Oestrus cycle duration(days)			
Age at first lambing (months)		17-23 months	32
Lambing interval (months)			
Service period (days)			
Gestation length (days)	150		39
Litter size	Mostly Single; 38.71 % farmers reported twining from 5 to		
10 % in their flock.			
Lifetime lamb production		8- 10 lambs	16
Lambing rate (%)			

6. Wool production (true wool/heterotypes/hair/kemps): Wool
a. Age at shearing (months) :
b. Fleece colour-White and Black/ dark brown

Trait	Average	Range	N
Greasy fleece weight (kg)	0.8-1.0 kg	29	
Clean fleece weight (kg)			
Staple length			
Fibre diameter			
Medullation %			

7. Pelt production Nil
8. Any other information specific to the breed : It is one of the heaviest sheep of the country

SOURCE:

1. Annual Report 2014-2015, ICAR – National Bureau of Animal Genetic Resources, Karnal, Haryana - 132 00, pp: 17-18.
2. Mishra A K. 2014. Identification of two color variants of Kajali sheep of Punjab, NBAGR News letter, April to September 2014, pp: 3
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