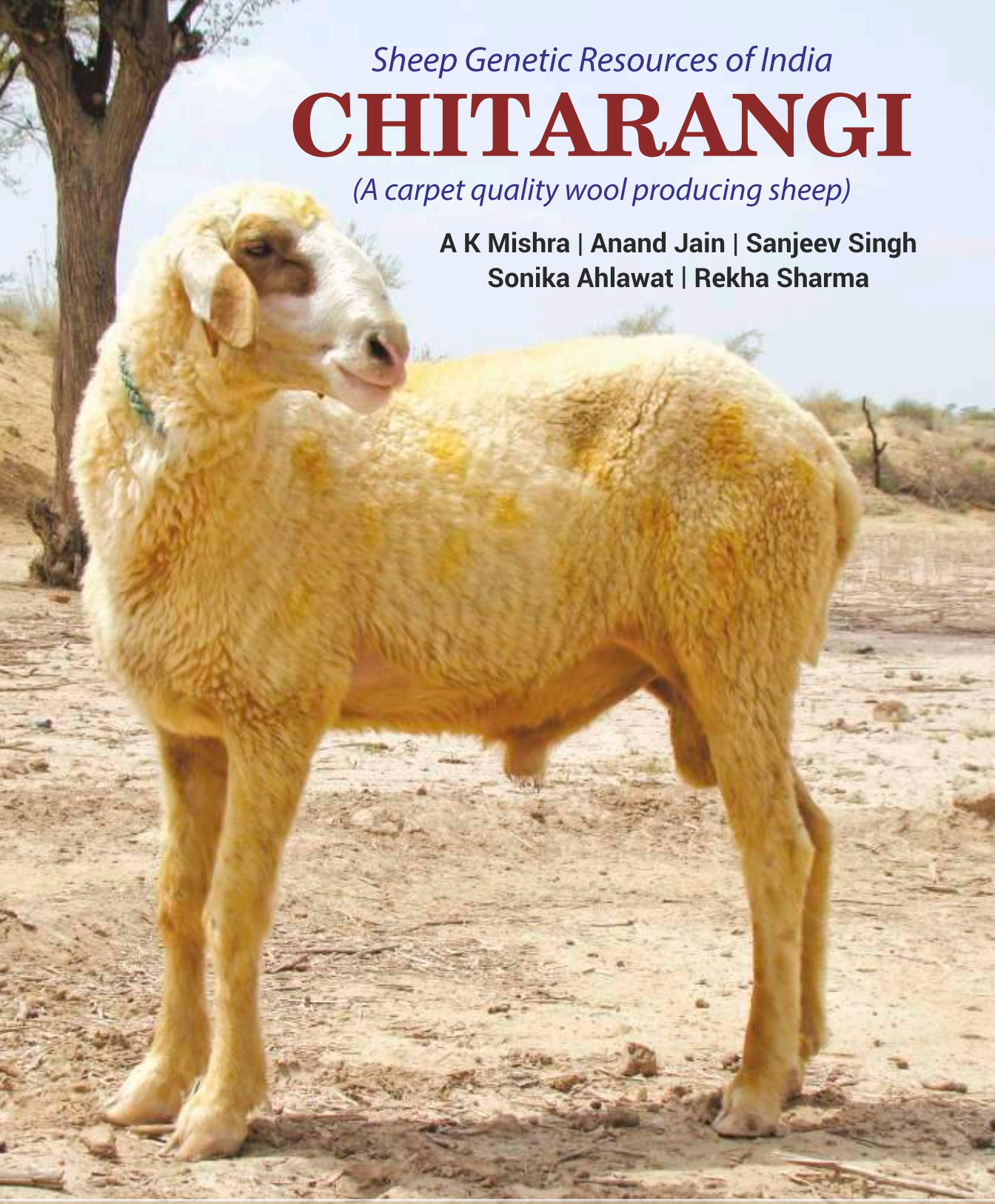
Sheep Genetic Resources of India

CHITARANGI

(A carpet quality wool producing sheep)

A K Mishra | Anand Jain | Sanjeev Singh
Sonika Ahlawat | Rekha Sharma



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PREFACE

India is blessed with large Farm Animal Genetic Resources (FAnGR) diversity, represented by 197 registered breeds of livestock and poultry species. Among livestock, small ruminants play a significant role in livelihood security and economic sustenance of large number of landless labourers, small and marginal farmers in harsh climatic areas of the country where crop farming is always a gamble due to uncertainty in rainfall and topography. India is blessed with rich sheep genetic resources that include 44 registered breeds and many other lesser known populations. According to 20th Livestock census report, our country has 74.26 million sheep which constitute 13.87% of total livestock population. The sheep population has increased by 14.13% over previous census (65.07 million). Apart from well recognised and registered breeds, there are many lesser known sheep populations in different parts of the country which need detailed study for registering them as new breeds. Chitarangi sheep is one of them, which is distributed in Rajasthan and Punjab and is being reared for carpet type wool and mutton producing ability.

The present manuscript is the compilation of information based on the survey study conducted during 2015 to 2018 under a pilot project by ICAR- NBAGR, Karnal with the aim to characterize Chitarangi sheep population. Details about its breeding tract, measurement of different body biometric traits, husbandry, management practices and their genetic characterization are presented in this monograph. Authors hope that this monograph will be useful to research scholars, scientists and policy makers working in the field of animal sciences. Moreover, determination of status and characterization of indigenous sheep genetic resources is an essential step in management of domestic animal diversity and developing strategies for their conservation.

Authors

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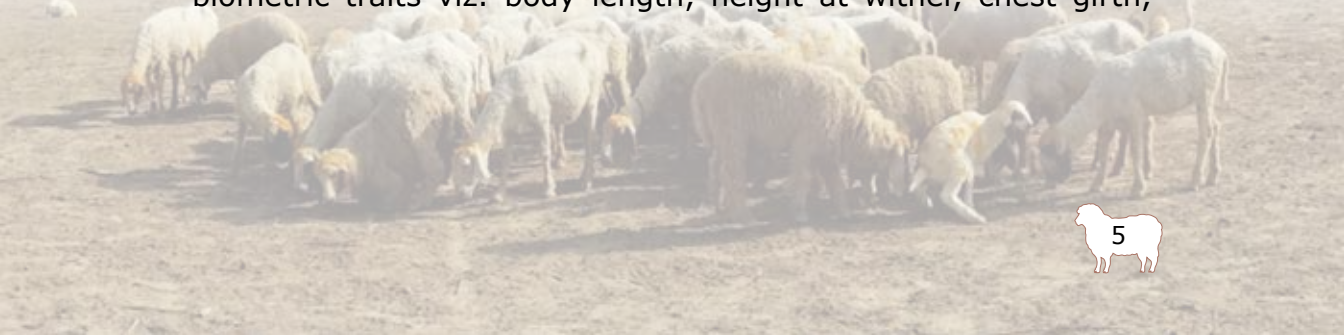
INTRODUCTION

Sheep rearing is an important enterprise from temperate to tropical ecology of India characterized by sparse vegetation, marginal land and a high incidence of poverty. Sheep are reared mainly by the poorest people in the lower strata of society and serve either as the main or supplementary source of income in this category. Perhaps, it is the most appropriate species of livestock for utilization of available scanty vegetation owing to their multi faceted utility (wool, meat, skin, milk and manure) and constitute an important part of the rural economy. Our country is endowed with wide diversity of sheep genetic resources, which form the backbone of its rural livelihood security systems. The characterization of lesser known populations of livestock species is an important task to study the domestic animal biodiversity and is an area of immense priority for ICAR-NBAGR, Karnal. This will help in the recognition of non-descript populations into descript breeds. As per breed wise Livestock census report (2013), a sizable proportion of Indian sheep is non-descript (41.08%). There are some populations in India which deserve to be registered as breeds. However, due to lack of systematic study, they are classified as non-descript and Chitarangi sheep is one of them (Mishra *et al*. 2020). Since there is scanty information available on Chitarangi sheep, there is a need to characterize and document this valuable sheep genetic resource of India.

For phenotypic as well as genetic characterization of Chitarangi sheep, a pilot study was conducted in 20 villages of Fazilka, Muktasar (Punjab) and Sri Ganganagar (Rajasthan) districts. A total of 56 sheep flocks having a population of about 5000 animals were surveyed from April 2015 to March 2018. 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 371 adult animals (72 males and 299 females). Body weights of 205 lambs belonging to different age groups from birth to 12 months were also recorded. The body weight was recorded using a spring weighing balance and biometric traits were recorded using measuring steel tape after ensuring that the animal stands squarely on an even ground. The data on other physical traits viz. head profile, ear orientation, colour pattern, production performance, reproduction traits and management practices were collected by personal observations and interviewing the sheep farmers using a questionnaire developed for this purpose.

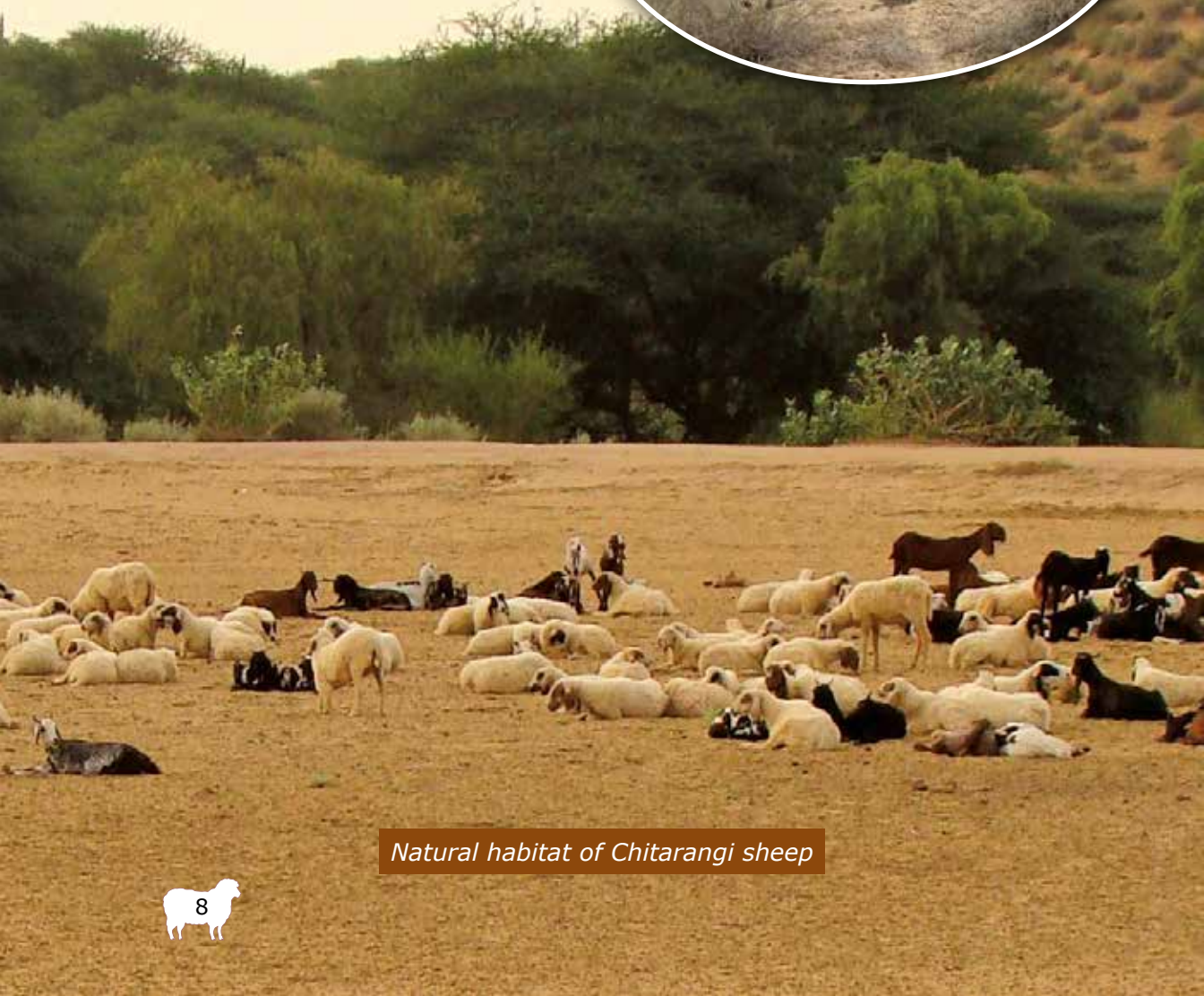
NATURAL HABITAT AND DISTRIBUTION

Chitarangi is a fine carpet quality fleece producing sheep inhabiting Fazilka and Muktsar districts of Punjab, Sri Ganganagar districts of Rajasthan and the adjoining areas. The origin of breed is unclear, however, the sheep keepers informed that Chitarangi sheep is reared in their family since 2 to 3 generations. The sheep farmers of Fazilka and Muktsar districts of Punjab informed that they migrated from Shamaki village of Ghadasana Mandi tehsil of Sri Ganganagar district of Rajasthan, that's why they called it "Shamaki Wali". Sri Ganganagar district is situated in the north – western part of India between 28.4 to 30.6 latitude and 72.2 to 75.3 longitude and at 168 to 227 meters height above the mean sea level. Sri Ganganagar district is a plain region of the vast Thar Desert land. It has sandy soil in the west dotted with 4-5 metre high sand dunes. The northern part of the district is mostly covered with forest. The region experiences high climatic variation throughout the year. It is an arid region with very low rainfall. The summer season extends from April to June, rainy season from July to mid-September, post-monsoon season from mid-September to October and winter season from November to March. The temperature fluctuates from as low as 0.0°C to as

high as 49.0° C. As a result, there are biting cold waves in winter and sizzling heat waves in summer. Dust storms during summer and frosty winter nights with ground fog are some of the typical features of the weather in the region. The average annual rainfall of the district is 20.70 cm and is relatively low in western part as compared to eastern part of the zone. The mean rainfall in the zone is 32.6 cm, of which 75 per cent is received during the months of July to September. January is the coldest and June is the hottest month of the year. The economy of the area is based on agriculture; its main crops are wheat, mustard and cotton. Other crops are guar, bajra, sugarcane and grams.

Distribution area of Chitarangi sheep

Shamaki Village, Ghadasana mandi
Tehsil (Sri Ganganagar)



Natural habitat of Chitarangi sheep

BREED CHARACTERISTICS

Chitarangi means attractive colour pattern

Chitarangi animals are medium to large in size and famous for carpet quality wool production. "Shamakiwali", a more prevalent synonym for this sheep among the farmers, is derived from Shamaki village of Ghadsana mandi tehsil of Sri Ganganagar district. It is also known as *Ratani* sheep. The coat colour and face is white with tan color patches around eyes, muzzle and distal end of the ear pinna. Light brown, chocolaty and black color patches are also seen in flocks. Ears are large in size and leafy. Serrations of different shape and depth are available on distal end of ear pinna in all the animals, which is a characteristic feature of this breed. The length of ear pinna ranges from 12 to 24 cm. Both the sexes are polled, however, horns were observed in few males. Tail is medium in length and thin. The tail length is 22.19±0.17 cm (Table 1). The udder is medium sized and developed with medium teats. Majority of farmers reported that twinning varied from 1 to 2%. Fleece is of good carpet quality and not very dense. The fibre diameter (micron), modulation percentage and staple length (cm) were 42.22±0.10, 56.60±4.22 and 5.90±0.32, respectively.

Body biometry and body weight

The average body weight and biometry of adult Chitarangi sheep and average body weight of lambs are given in Tables 1, 2 and 3, respectively. The average body weight of adult males and females were 56.27 ± 1.28 and 46.16 ± 0.50 kg, respectively. The overall body length (BL), height at wither, chest girth (CG), paunch girth (PG), face length (FL), face width (FW), ear length (EL) and tail length (TL) were 72.54± 0.24, 73.70 ± 0.22, 86.52 ± 0.31, 88.66 ± 0.38, 20.25 ± 0.07, 9.48 ± 0.04, 18.03 ± 0.09 and 22.19 ± 0.17 cm, respectively. There is significant difference between males and females for all the biometric traits under study. The body weight of Chitarangi sheep is higher than that reported for Magra sheep (Anonymous 2013), a contemporary carpet type sheep breed of North- western India. Body weight of lambs in the


Chitarangi female
Chitarangi male

Physical traits of Chitarangi sheep

age groups of 1-3, 3-6 and 9-12 months ranged between 5-17, 10-36, 15-45 and 22-51 kg, respectively. The study also revealed that 68.05% adult males weighed more than 50 kg and 70.03% females weighed from 40 to 60 kg. The body biometry and adult body weight observed in Chitarangi sheep under the present study reflect that animals of Chitarangi are quite large in size.

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

Traits	N	BW	BL	Height	CG	PG	FL	FW	EL	TL
Overall	371	48.13 ± 0.51	72.54 ±0.24	73.70 ± 0.22	86.52 ±0.31	88.66 ±0.38	20.25 ±0.07	9.48 ±0.04	18.03 ±0.09	22.19 ±0.17
Sex		**	**	**	**	**	**	**	**	**
Male	72	56.27 ±1.28	76.65 ±0.56	78.78 ± 0.47	90.60 ±0.73	92.03 ±0.91	21.78 ±0.17	10.26 ±0.10	18.63 ±0.20	23.63 ±0.41
Female	299	46.16 ±0.50	71.56 ±0.28	72.47 ± 0.19	85.54 ±0.32	87.85 ±0.40	19.88 ±0.59	9.29 ±0.04	17.89 ±0.10	21.84 ±0.18
Range										
Male		39-95	68-90	71-88	78-107	79-109	18-25	8-12	14-23	12-32
Female		26-74	59-87	64-89	68-99	73-107	17-23	7-16	12-24	12-32

**Significant at p≤ 0.01; figures within parentheses are number of observations;Source: Mishra *et al* (2020)

Table 2. Frequency distribution of body weight

Group	Male	Female
<40 kg	2.78% (2)	25.25%(475)
40-50 kg	29.17% (21)	45.45% (135)
50-60 kg	36.11% (26)	24.58%(73)
>60 kg	31.94 (23)	4.71% (14)

Table 3. Body weight of Chitarangi lambs (kg)

Age	1-3 months	3-6 months	6-9 months	9-12 months
Overall	19.53 ± 0.56 (89)	26.99± 0.90 (66)	28.71 ±0.75 (21)	35.00 ±1.39 (24)
Sex	*	**	NS	**
Male	20.29 ± 0.72 (49)	29.16 ± 1.26 (41)	28.00 ± 1.39 (7)	38.36 ±1.75 (11)
Female	18.61 ± 0.85 (40)	23.44 ± 0.75 (25)	29.07 ± 0.90 (14	32.15± 1.80 (13)
Range	10-36	15- 45	24-35	22-51

** Significant at p≤ 0.01; *Significant at p≤ 0.05; figures within parentheses are number of observations

SOCIO-ECONOMIC STATUS OF SHEEP FARMERS

Majority of the sheep farmers are landless poor belonging to communities such as Majabi sikh, SC, Meghwal, Kumhar, Nayak, Jat and Muslim. Average family size was 7.66 with 2.26 males, 1.9 females and 3.43 children. The overall literacy rate was 21.43% and the average number of family members involved in sheep rearing was 1.86. About 53.57% famers were having 05 bigha to 5 acre agricultural land. Farmers reported rearing this sheep since last 40-50 years.

Flock size

The flocks of Chitarangi are large in size with average of 93.37 animals. The flocks consisted of 91.19 Chitarangi animals and 2.18 other sheep (mainly Magra). Chitarangi sheep flocks comprised of 2.80 rams, 64.98 ewes and 23.41 lambs. Out of the surveyed flocks, 83.93% were pure Chitarangi flocks.

Chitarangi flocks

Sheep farmers




HUSBANDRY PRACTICES

Breeding management

The ewes are bred through natural service and the rams per flock were observed to be 1.89 with a ram-ewe ratio of 1:34.33. Only Chitarangi rams were being used for breeding of the ewes in all the surveyed flocks. The rams are either selected from their own flock or exchanged with the other breeders. The farmers selected their rams based on body conformation, size and color pattern. The age at first mating in rams was about 10-15 months as reported by majority of sheep breeders (Table 4). The ram is used in a flock for 2 to 3 years and farmers kept breeding rams in the flock 24 hours a day. The females start breeding at about 10 to 12 months of age. The age at first lambing is 17 to 18 months as reported by 71.43% of farmers (Table 4). The main lambing season is January to March and minor from August to October with an average of 80 to 90% of annual lambing. The breeding life of ewes was 7 to 8 years. Twinning was reported to be 1 to 2% by majority of farmers (56.36%). About 38.18% sheep farmers reported that twinning ranged from 2 to 10% and 5.45% reported even more than 10%. One triplet was also observed during the survey.

Feeding management

Table 4. Breeding practices adapted by farmers

Particulars	Items	Sheep farmers
Age at first breeding: Males (months)	10 – 15	76.79%; Majority 12 months (44.64%)
	15 – 24	23.21%
Age at first lambing (months)	≤ 17	5.36%
	17-18	71.43%
	> 18 to 28	23.21%
Lambing (%)	70- 80	30.91%
	80-90	51.79%
	>90	18.18%
Twinning (%)	1-2	56.36%
	2 to 10	38.18%
	>10	5.45%

Feeding practices

The Chitarangi sheep are primarily maintained on grazing, however, 55.36% farmers provided concentrate especially during scarcity period, breeding season, pregnancy and to lambs. Some farmers (7.14%) offered concentrate round the year. About 87.5% farmers also provided fodder to sheep during scarcity period (from January to March when wheat crops are in field) and in rainy season. The major fodder was Gwar bhusa. The sheep farmers grazed their sheep for 8-10 hours in a day from 7-8 AM to 6-7 PM. The distance covered by majority of sheep farmers (55.36%) for grazing was 8 to 10 Km. In the native tract, majority of farmers grow wheat which has resulted in non-availability of local grazing land, especially during Rabi season, which is main reason for the sheep farmers to walk long distance in search of grazing area. The sheep graze on natural pastures, road sides and canal sides. The feeding on tree lopping is quite common in native area.

Housing Management

Housing management

The majority (89.29%) of farmers kept sheep in open area fenced with local material. Some farmers constructed separate houses with Katcha and Pucca type roofs.

Table 5. Feeding and housing management practices adopted by Chitarangi sheep farmers

Particulars	Items	% of sheep farmers
Grazing : Distance travelled (Km)	< 8	25.00
	8 to 10	55.36
	>10 (upto 35)	19.64
Grazing hours (hrs) Time: 7 or 8 AM to 6 or 7 PM	≤ 8	5.36
	8 to 10	78.57
	>10	16.07
Housing pattern		
Nature of Housing	Separate	76.79
	Part of owners house	23.21
Type of Housing	Open	89.29
	Closed	10.71

Within parentheses are number of respondents.

Health management

Chitarangi sheep being native is well adapted to arid region of Rajasthan and thus, there is no problem of survivability. Majority of sheep farmers vaccinate their animals against Food and mouth disease (FMD), Peste des petits ruminants (PPR), Sheep pox, Haemorrhagic septicaemia and Enterotoxemia (ET). The most prevalent diseases noticed were FMD, Gid, lameness, pox and pneumonia (Lambs). Majority of sheep farmers reported that mortality ranges from 5 to 10% in lambs and less than 5% in adults.

Table 6. Mortality pattern in Chitarangi sheep

Particulars	Mortality (%)	Sheep farmers
Lamb Mortality	<5	8.93%
	5-10	58.93%
	10-20	21.43%
	>20	10.71%
Adult mortality	<5	85.71%
	> 5	14.28%

Production management

Wool production and wool quality: The sheep are generally shorn thrice a year in the months of February- March, June- July and October-November. Majority of farmers reported average annual greasy wool production ranging from 1.5 to 2 Kg. The sale price of February- March clip wool was higher (₹80 to 230) followed by June-July (₹30-140) and October-November clip (₹20-100). The fleece color of February-March clip is white and that from other clips is canary yellow. The fleece of Chitarangi is of good carpet quality.

The fibre diameter, medulation and staple length were 42.22 ± 0.10 μ, 56.60 ± 4.22% and 5.90 ± 0.32 cm, respectively.

Type of wool

Wool shearing

Table 7. Wool production of Chitarangi sheep

Particulars	Items	Sheep farmers
Wool production (Kg)	< 1	5.36%
	1 to 2.5	92.86%
	>2.5	01.79%

Marketing age: Marketing age of male lambs was reported as 6 months by 66.07% of sheep farmers and the price of surplus lambs was reported as ₹3000 to 6000 by 55.36% farmers. The price of adult/old aged ewes varied from ₹2000 to 5000. The price of surplus animals depended upon condition of individual animal. Almost all the farmers sold their animals to traders or butchers. However, the price of breeding ewes ranged from ₹6000 to 30000 and price of breeding rams was reported upto ₹50000.

Milk yield: 250 to 500 ml with lactation period of 90 to 120 days. Milking is not practiced.

Sheep manure: Majority of farmers use manure in their own field. However some farmers sold @ of ₹500 to 2000 per trolly.

Disposal age of ewes: Majority of the farmers disposed off old aged ewes (>8 years), however, some of farmers kept them till their death.

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

Particulars	Items	Sheep farmers
Marketing age (months)	4 – 6	16.07%
	6	66.07%
	>6	17.86%
Lamb cost at marketing age (₹)	≤ 3000	25.00%
	3000 to 6000	55.36%
	> 6000 to 12000	19.64%
Adult cost/culled animals cost (₹)	Ewes (old age)	2000-5000
	Ewes : rearing	6000-30000
	Males rearing	30000 to 50000
Disposal age (years)	6- 7	12.96%
	7-8	38.89%
	> 8 to till death	48.15%

GENETIC CHARACTERIZATION

DNA isolation and PCR amplification

Blood samples were collected from 48 unrelated Chitarangi animals from their distribution area. The genomic DNA was isolated using standard phenol/ chloroform/ isoamyl alcohol extraction method (Sambrook *et al*. 1989). Genetic diversity was assayed using a set of 24 microsatellite markers, out of which 20 were taken from MoDAD list of FAO, recommended for ovines (Bradley *et al*. 1997). The remaining four markers

(CSRD247, HSC, MAF214 and OarCP49) were taken from the panel of markers for parentage verification tested at the 2001/02 ISAG comparison test (Di Stasio, 2001). The forward primer for each marker was fluorescently labelled with FAM, NED, VIC or PET dye. Amplification of the loci was performed in a 25µl final reaction volume containing at least 100 ng of genomic DNA, 5pM of each primer, 1.5mM $MgCl_2$, 200µM dNTPs, 0.5U *Taq* DNA polymerase and 1x*Taq* buffer. A common touch down PCR programme, as suggested under MoDAD project (FAO 1996) without an extension step was used for the amplification of all the twenty four markers. PCR amplification consisted of 3 cycles of 45 sec at 95˚C, 1 min at 60˚C; 3 cycles of 45 sec at 95˚C, 1 min at 57˚C; 3 cycles of 45 sec at 95˚C, 1 min at 54˚C; 3 cycles of 45 sec at 95˚C, 1 min at 51˚C and 20 cycles of 45 sec at 95˚C, 1 min at 48˚C. The amplified products were resolved on 2% agarose gel and genotyped on an automated DNA sequencer using LIZ 500 as internal lane standard (ABI PRISM). The raw data files were extracted by Gene Mapper software version 3. Popgen3.2 (Yeh *et al*. 1999) and GenAlEx6.5 softwares (Peakall and Smouse, 2005) were used for the genetic diversity analysis. Polymorphism Information Content (PIC) of the microsatellite loci was estimated according to Botstein *et al*. (1980). Bottleneck events were estimated following two different approaches. The first was based on the heterozygosity excess consisting of sign test, standardized differences test and a Wilcoxon sign-rank test. The probability distribution was established using 1000 simulations under three models: infinite allele (IAM), stepwise mutation (SMM) and two-phase mutation model (TPM). The test was conducted using Bottleneck 1.2.01 software (Piry *et al*. 1999). The second was based on graphical representation of mode-shift equilibrium.

The maternal lineages of Chitarangi sheep were identified by exploring the mitochondrial DNA diversity in 15 samples. A 1246 bp fragment spanning part of the control region, the tRNA-Phe and

12S rRNA was amplified using F-AACTGCTTGACCGTACATAGTA and R- AAGGGTATAAAGCACCGCC primers (Meadows *et al*. 2005). The amplified products were purified and sequenced in both forward and reverse directions using ABI Prism Big Dye Terminator 3.1 chemistry and ABI 3100 Automated DNA Sequencer (Applied Biosystems, USA). Multiple alignments of the mtDNA sequences of Chitarangi sheep were performed with MEGA 7.0 (Kumar *et al*. 2016) after alignment to a minimum of 1041 bp. All positions containing gaps and missing data were eliminated from the dataset. DNA SPv6 (Rozas *et al*., 2017) was used to analyse the polymorphic sites, number of haplotypes (h), nucleotide diversity (π) and haplotype diversity (Hd). Median joining network was generated using the Network 5.0.0.3 software (http://www.fluxus-engineering.com) to explore relationship among the observed haplotypes.

Genetic diversity analysis

Different measures of within breed genetic variations viz. actual number of alleles (N_a), effective number of alleles (Ne), observed heterozygosity (H_o) and expected heterozygosity (He) along with polymorphism information content (PIC) of different microsatellite loci and within population inbreeding estimates (F_{IS}) are given in Table 9. The microsatellite loci amplified were observed to be polymorphic in the investigated Chitarangi sheep population. All the markers were found to be highly informative with an average PIC value of 0.71. This indicated the usefulness of the markers for genetic diversity analysis. A total of 237 distinct alleles were identified across the 24 markers in Chitarangi sheep. The observed number of alleles ranged from 4 (OarAE129) to 16 (CSSM31) with a mean of 9.875±0.641. Effective number of alleles were lower than the observed number of alleles and ranged from 1.612 (CSSM47) to 8.828 (CSSM31) with a mean value of 4.171±0.371. The non-significant differences ($P > 0.05$) between the average observed heterozygosity values (0.636) and

the average expected heterozygosity values (0.712) suggested random mating in Chitarangi population and the population to be at Hardy-Weinberg equilibrium.

The estimates of allele diversity (mean number of observed alleles) and gene diversity (mean expected heterozygosity) implied the presence of substantial amount of genetic variability in this population. The mean F_{IS} (within population inbreeding estimates) value was 0.096 which indicated deficiency (9.6%) in the number of heterozygotes in Chitarangi sheep population. The observed positive F_{IS} in the investigated population might be due to the use of fewer rams for the breeding purpose. 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 for deficit of heterozygotes is difficult to predict due to non availability of pedigree information in the field conditions. The positive F_{IS} value for Chitarangi sheep is comparable to those reported previously for most of Indian sheep breeds viz. Magra, Nali, Malpura, Jalauni, Kajali and Deccani (Arora *et al.* 2011a, Arora *et al*. 2011b, Arora *et al.* 2011c, Singh *et al.* 2017).

The genetic characterization of Chitarangi sheep by using microsatellite markers revealed substantial amount of genetic variability in this sheep population. This variability can be utilized for the selection of animals for increasing their body weight. This will increase the meat productivity of the Chitarangi sheep. Thus, higher meat production will fetch more income to the small and marginal farmers rearing this sheep.

Bottleneck analysis

Bottleneck hypothesis was explored in Chitarangi sheep. According to this hypothesis, if the population has experienced recent reduction, effective population size exhibit a correlation with reduction of allele numbers and gene diversity.

Table 9. Genetic variability measures in Chitarangi sheep across different microsatellite markers. (Mishra *et al*. 2020)

S. No.	Locus	Na	Ne	Ho	He	Fis	PIC
1	BM757	6	2.543	0.542	0.607	0.107	0.607
2	BM8125	6	1.868	0.521	0.465	-0.121	0.465
3	BM827	8	3.651	0.609	0.726	0.162	0.726
4	OarCP	13	5.640	0.771	0.823	0.063	0.823
5	OarHH47	11	4.768	0.705	0.790	0.108	0.79
6	CSSM47	8	1.612	0.489	0.380	-0.288	0.380
7	MAF0214	10	3.046	0.618	0.672	0.080	0.671
8	OarCP20	10	2.454	0.532	0.593	0.102	0.593
9	OarHH41	10	4.249	0.717	0.765	0.062	0.765
10	OarVH72	6	3.064	0.660	0.674	0.021	0.674
11	BM6526	14	4.581	0.756	0.782	0.033	0.782
12	OaCP34	6	3.082	0.563	0.676	0.167	0.676
13	OarAE129	4	2.344	0.362	0.573	0.369	0.573
14	OarFCB128	11	4.617	0.688	0.783	0.122	0.783
15	HSC	11	4.904	0.674	0.796	0.153	0.796
16	OarHH35	13	5.543	0.574	0.820	0.299	0.820
17	OarHH64	7	3.027	0.432	0.670	0.355	0.670
18	OarJMP29	11	4.235	0.750	0.764	0.018	0.764
19	OarJMP8	10	5.290	0.854	0.811	-0.053	0.820
20	BM1314	13	4.299	0.521	0.767	0.321	0.767
21	BM6506	7	2.182	0.563	0.542	-0.038	0.542
22	CSRD247	13	7.143	0.822	0.860	0.044	0.86
23	CSSM31	16	8.828	0.896	0.887	-0.010	0.887
24	OarFCB48	13	7.131	0.659	0.860	0.233	0.860
Mean		9.875	4.171	0.636	0.712	0.096	0.712
SE		0.641	0.371	0.027	0.027	0.031	0.027

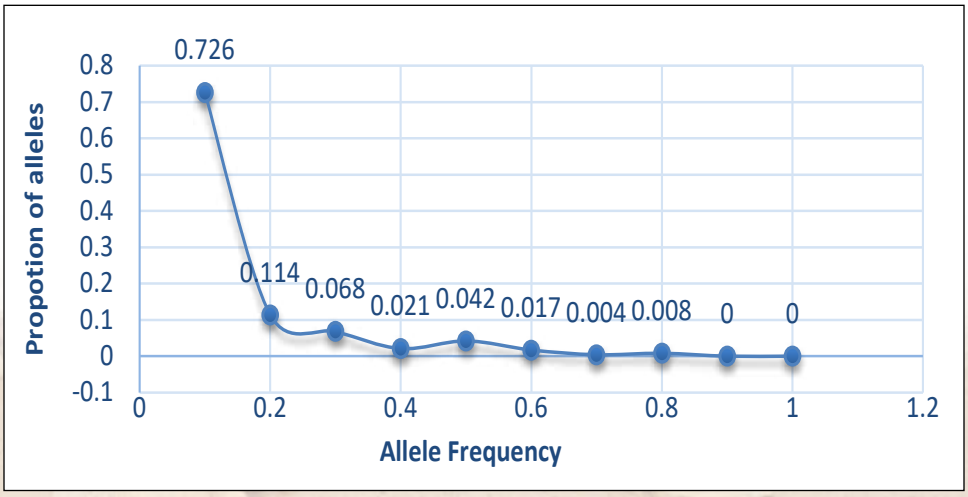
Na: Observed number of alleles; Ne: Effective number of alleles [Kimura and Crow (1964)]
Expected heterozygosity was calculated by Levene (1949).

In a population at mutation-drift equilibrium, there is approximately an equal probability that a locus shows a gene diversity excess or a gene diversity deficit. If allele number reduces faster than the gene diversity in a population, it is experiencing bottleneck. The observed gene diversity is higher than the expected gene diversity which is computed from the observed number of alleles, under the assumption of a constant-size (equilibrium) population (Luikart *et al*. 1998). Three different tests, viz. sign rank, standardized differences and Wilcoxon tests under all the 3 models of microsatellite evolution (IAM, SMM and TPM) were employed to investigate whether Chitarangi sheep has undergone recent bottleneck (Table 10). The populations exhibiting significant excess in heterozygosity are considered to have experienced a recent genetic bottleneck. In this study, the heterozygosity excess was not significant under any of the models (IAM, TPM and SMM) using Wilcoxon rank test. Under strict SMM, the heterozygosity excess resulting from population size expansion is either undetectable or heterozygosity deficiency is found (Maruyama and Fuesrt, 1984). The heterozygosity excess is usually lower under the SMM model than IAM and even heterozygosity deficiency (negative values) may occur in SMM (Cornuet and Luikart 1996). This is in agreement with our finding (Table 10) in which negative T2 value (-13.60) was obtained indicating that the population may be expanding with no recent bottleneck. Moreover, the Wilcoxon test, which is considered to be more reliable than the sign test and standardized differences test, showed no significant results for population bottleneck under all the three models i.e. IAM, TPM and SMM. In addition, the mode shift analysis (Luikart and Cornuet 1997) resulted in a typical L-shaped curve indicating the absence of bottleneck. Thus, both the mode shift analysis and mutation drift equilibrium tests showed no recent reduction in the population size of this sheep population.

Table 10. Different test for mutation drift equilibrium in the 24 microsatellite loci in Chitarangi Sheep

Test	Parameters	IAM	TPM	SMM
Sign Test	Observed no. of loci with He excess Expected no. of loci with He excess p-value	17 14.36 0.19	7* 14.21 0.003	0* 14.06 0.00*
Standardized difference test	T2 value p-value	0.524 0.300	-4.241* 0.00001	-13.60* 0.000
Wilcoxon sign rank test	p-value (two tail test for He excess and deficiency)	0.172	0.998	1.000

* means P<0.05 (Mishra *et al*. 2020)



Mode Shift analysis in Chitarangi sheep

Mitochondrial DNA diversity

A 1246 bp fragment of mitochondrial DNA spanning part of the control region, tRNA-Phe coding region and 12S rRNA gene was amplified and sequenced in 15 samples of Chitarangi sheep. Upon sequence alignment, 9 haplotypes could be identified in Chitarangi sheep. These novel sequences were submitted to GenBank and accession numbers were obtained (MN073924-MN073932). The haplotype diversity and nucleotide diversity values were 0.848 and 0.002, respectively. These indices were higher than the values reported by Arora *et al*. (2013) in 19 sheep breeds from 3

agro-ecological zones of India, but lower than the values reported by Singh *et al*. (2013) involving 12 breeds from four agro-climatic regions of India. The relationship between Chitarangi sheep and known ovine haplogroups across the globe (Haplogroups A to E) was assessed by constructing a Median Joining network (Meadows *et al*. 2011). The mitochondrial diversity analysis revealed that majority of the Chitarangi sheep haplotypes grouped with haplogroup A and only 2 haplotypes clustered with haplogroup B.

MAJOR PROBLEMS FACED BY SHEEP FARMERS

» Shrinking of grazing land
» High price of feed and fodder
» In native area, brick makers uses Gwar bhusa as fuel for ripening of bricks
» Lack of financial support and costly medicines

INDIGENOUS TECHNICAL KNOWLEDGE (ITK'S)

Sheep keepers have indigenous knowledge to treat and manage their flocks, which have been 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 persistent use of them since time immemorial. During the efforts to characterize Chitarangi sheep and while recording the management practices followed by sheep farmers, information regarding some ITK's was also collected which are summarized below:

- For pneumonia/cold: Hot iron branding on ear and face

Hot iron branding

- For cold: Methidaana + alum (1 spoon each)
- For cold: Gud + Ajvain;kakadha
- For blockage of urine : Vinegar of Jamun @ 5 ml per animal
- Honey for power
- For indigestion: Black salt or black salt + Ajwain + Kali jiri + Alum (5 g per animal) or Chotee elaichi + Alum + Lahori salt + badi elaichi + kali jiri + Ajwin + Sonth (5 g/ animal)
- For cold/pneumonia: Ajwain + Gud + Saunf (after boiling)

CONCLUSION AND RECOMMENDATIONS

- The study reveals that the Chitarangi sheep is a carpet wool type sheep which is phenotypically different from other sheep breeds of the region. The unique phenotypic appearance especially white coat color and face with tan color patches around eyes, muzzle & distal end of the ear pinna and serrations of different shape and depth on distal end of ear pinna easily distinguish this valuable germplasm from other extant sheep breeds of the region.
- The farmers prefer this sheep because of its large size, better growth rate and wool quality. It is well adapted to the arid and semi-arid region of Rajasthan and Punjab (India).
- The Chitarangi sheep population needs to be improved and propagated by using elite breeding rams. There is sufficient potential in this breed for improvement in the body weight as well as carpet type wool trait by selective breeding.
- Since sheep farming is dependent on grazing, community pastures should be developed.
- In native tract of Chitarangi sheep, the brick makers use Gwar bhusa, a quality fodder crop for sheep as a fuel for ripening of bricks. Hence, there is an urgent need to stop the use of Gwar bhusa as a fuel for brick industry.
- Chitarangi should be recognized and registered as a distinct breed at the national level.

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Breed Descriptor for Chitarangi Sheep

I. GENERAL DESCRIPTION

1.	Name of the breed	-	CHITARANGI
2.	Synonyms	-	Shamaki wali, Ratani
3.	Background for such a name / origin	-	CHITARANGI for attractive colour pattern, Shamakiwali for village name of Sri Ganganagar district of Rajasthan from where the breed is considered to have originated, Ratani for red or tan colour spots on face.
4.	Since when the breed is known	-	Since times immemorial
5.	Strains (or within breed types)	-	nil
6.	Most closely related breeds (in appearance)	-	Magra of Rajasthan
7.	a. Native tract of distribution in terms of longitude	-	Fazilika of Punjab: 30.3730^{0}N, 74.1240^{0}E, Sri Ganganagar 29.4019^{0}N, 73.5594^{0}E
	b. Approximate area of distribution (sq km)	-	approx. 14267
	c. Place (s)		State: Rajasthan, Punjab; District: Sri Ganganagar, Bikaner; Fazilka, Muktsar
8.	Estimated population	-	
	a. Year of estimation		2017
	b. Population		15000 to 20000
	c. Source / Reference		Mishra *et al* (2017)
9.	a. Communities responsible for developing the breed	-	Muslims/ SC/ Majahabisikh
	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		91.19
			Composition: Rams 2.80 Ewes 64.98 Lambs 23.41
11.	Utility of the breed [Fibre (Apparel/ Carpet/Coarse)/ Meat/ Milk/ Skin/ Fur (lamb skins)/ Pelt/ Transport/ Manure/Others (specify)]		- Carpet wool and mutton
12.	Any other information		: Its wool is of good carpet quality

II. PHYSICAL CHARACTERS

1.	Colour	-	The coat colour and face is white with tan colour patches around eyes, muzzle and on ear. The light brown, chocolaty and black colour patches were also seen in flocks.

	Distinctive colour markings, if any		Tan colour patches around eyes, muzzle and on ear, Serrations of different shape and depth are available on distal end of ear pinna
2.	Head profile (straight/slightly convex/convex)	–	Slightly convex
3.	Ears		
	a. Orientation (erect/pendulous/ horizontal)	-	Pendulous
	b. Shape	-	Flat
	c. Length (cm)		18.03±0.09cm
4.	Wattles (present/absent)	-	Absent
5.	Horns	-	Absent: animals are polled
	a. Number		
	b. Colour		
	c. Shape		
	d. Orientation		
	e. Size (small < 15/ medium 1525 /large > 25 cm.)		
6.	Coat		
	a. Type (hair/wool)	-	Woolly
	b. Length (12 month fleece) (short <5/medium 5 to 10 /long >10 cm)		5.90±0.32 cm (medium)
	c. Lustre (lustrous/nonlustrous)	-	Lustrous
	d. Crimp/curl(straight/ low crimp = <4/ high crimp = >4 cm.)		NA
	e. Fineness (fibre diameter) (fine < 21 /medium 22 to 26 coarse >26 microns)		42.22 ± 0.10µ
	f. Wool cover (covered/bare)		
	• Head	-	Bare
	• Face	-	Bare
	• Belly	-	Partially covered
	• Legs	-	Half-covered
7.	Beard (present/absent)	-	Absent
8.	Tail		
	a. Type	-	Thin
	b. Shape	-	Cylindrical
	c. Length (short/medium/long)	-	Medium: 22.19±0.17 cm
9.	Any other information	-	Serrated distal end of ear pinna is a characteristic feature of this sheep.

III. PERFORMANCE

1. Body Weight (Kg)

Weight at	Male			Female		
	Average	Range	N	Average	Range	N
Birth	3.25 ± 0.75		2	3.00		1
1 - 3 months	20.29 ± 0.72		49	18.61 ± 0.85		40
3-6 months	29.16 ± 1.26		41	23.44 ± 0.75		25
9-12 months	38.36 ± 1.75		11	29.07 ± 0.90		13
Adult weight	56.27 ± 1.28	39 - 95	72	46.16 ± 0.50	26-74	299

2. Body measurements (cm)

Body measurement	Male			Female		
	Average	Range	N	Average	Range	N
Chest-girth	90.60 ± 0.73	78-107	72	85.54 ± 0.32	68-99	299
Body length	76.65 ± 0.56	68-90	72	71.56 ± 0.28	59-87	299
Height at withers	78.78 ± 0.47	71-88	72	72.47 ± 0.19	64-89	299

3. Carcass characters Not available

4. Dairy performance NA; Chitarangi sheep is not reared for milk production

	Average	Range	N
Daily milk yield (g)		200-500 ml	
Total lactation milk yield (kg)			
Lactation length (days)		90-120 days	
Fat%			
SNF%			

5. Reproduction

	Average	Range	N*
Age at first mating in males (months)		10–15 months	56
Age at first mating in females (months)		12-13 months	56
Age at first Oestrus (days)			
Oestrus cycle duration (days)			
Age at first lambing (months)		17-18 months	56
Lambing interval (months)			

	Average	Range	N*
Service period (days)			
Gestation length (days)			
Litter size	Mostly Single; 56.36% farmers reported twining from 1 to 2% and 38.18% reported 2 to 10% in their flock.		
Lifetime lamb production		5- 8 lambs	47
Lambing rate (%)	80-90%	70-100%	56
*N: indicates number of flocks			

6. Wool production (true wool/heterotypes/hair/kemps): true wool and heterotypesl
   a. Age at shearing (months): 1st 6 monthly; 3 times in year in the months of February-March, June-July and October-November,
   b. Fleece colour White

Trait	Average	Range	N
Greasy fleece weight (Kg)		1.0 to 2.5	56*
Clean fleece weight (Kg)			
Staple length (cm)	5.90 ± 0.32	3.9-12.9	30
Fibre diameter (μ)	42.22 ± 0.10	27.89-50.91	30
Medullation%	56.60 ± 4.22	17-96	30
* indicates number of flocks			

7. Pelt production Skin of the slaughtered or dead animals may be used.
8. Any other information specific to the breed: *It is one of the best carpet wool type sheep of the country.*

Source:

- Based on Institute Research project "Characterization of Chitarangi and Dumba sheep in their native tract".
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