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*Goat Genetic Resources of India*

# GOAT GERMPLOSM OF NAGALAND STATE



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भाकृअनुप-राष्ट्रीय पशु आनुवांशिक संसाधन ब्यूरो  
**ICAR-National Bureau of Animal Genetic Resources**

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## FOREWORD

National Bureau of Animal Genetic Resources has an important mandate of characterization of livestock populations. After characterizing and documenting the various indigenous known populations of different livestock species, we are now heading to generate information on the lesser known populations. The North Eastern Himalayan (NEH) region of India is a bowl of rich biodiversity. Therefore, we have prioritized this region to locate the undescribed livestock populations and characterize them. Goats being an important livestock genetic resource and a good supporter of economy of small and marginal farmers, need to be studied and documented to understand their genetic architecture and the management practices for their upkeep under harsh climate of North east hilly region. During last few years, we have worked and documented information on Sikkim goats. Continuing with the same zeal, the team of scientists of NBAGR and in collaboration with Nagaland University, Department of Livestock Production and Management conducted survey visits to the breeding tracts in Nagaland and generated information on Nagaland goats. The information collected/generated on different aspects of these goats has been analysed, compiled and presented in the form of this document entitled “**Goat Germplasm of Nagaland State**”. The information is supported by good photographs. I congratulate the authors for their successful endeavor and hope that the information presented in this document will be a guide to the researchers, field functionaries and policy planners who are connected with this important germplasm.



(Arjava Sharma)  
DIRECTOR



## PREFACE

Goat occupies a unique place among domestic livestock species in our agricultural system. The goat farming is preferred over cattle and buffalo because of low investment, easy management and the docile nature of the animals. The less consumption of feed, high feed conversion efficiency, low gestation period, small generation interval, high prolificacy add to its importance for preference by the small, marginal farmers. Although, goat is distributed in different parts of India and survive under varied climatic conditions but the climate and topography of North Eastern Himalayan (NEH) region is very much suited to this species. The people of NEH region are mostly non vegetarian by food habits and prefer meat rather than milk. For meat they depend on pork, chevon, chicken. Main occupation of people is agriculture followed by livestock keeping. Among livestock, keeping pig as meat animal is the first choice rather than keeping the dairy animals. Goat is mainly the meat producing animal and the demand of goat meat (chevon) is next to the pig meat (pork) in NEH region. Besides this, skin and hair are also in great demand in all the states of N.E. region. Particularly in Nagaland, the long hair obtained from goats found in Zunheboto district has been used for various purposes. Apart from long hair goats, Nagaland state has other diverse populations of goat also. The team of NBAGR scientists and Nagaland University, Department of Livestock Production and Managemen have visited Zunheboto, Kiphire, Tuensang, Phek, Dimapur districts of Nagaland and recorded information on the goats found there. The present document gives a glimpse of the phenotypic, biometric and genetic diversity existing in these goat populations.

The team express its gratitude to the Director, NBAGR for the facilities provided to carryout this work. Our sincere thanks are due to the staff of state Animal Husbandry Department and Nagaland Livestock Development Board for their cooperation. The support rendered by the farmers and goat keepers is also duly acknowledged.

**-Authors-**



### ABOUT STATE AND BREEDING TRACT

The State of Nagaland was formally inaugurated on December 1st, 1963, as the 16th State of the Indian Union. It is bounded by Assam in the West, Myanmar (Burma) on the east, Arunachal Pradesh and part of Assam on the North and Manipur in the South (Fig. 1). Rains are heavy in Nagaland. The average rainfall is between 175 cm and 250 cm. Most of the heavy rainfall is during the months from June to September. The rains during April to May is low. Strong winds blow from the north west in February and March. The climate is pleasant. The terrain is hilly, rugged and mountainous. The highest peak is Saramati in the Tuensang district, which is 3840 meters above sea level. The average



*Figure 1. Map of Nagaland State showing breeding tract*

height of the peaks is between 900 and 1200 metres. The hillsides are covered with green forests. The main rivers that flow through Nagaland are Dhansiri, Doyang, Dikhu and Jhanji. The Nagas belong to the Indo-Mongoloid family. The state is inhabited by 17 major tribes — Ao, Angami, Chang, Konyak, Lotha, Sumi, Chakhesang, Khiamniungan, Dimasa Kachari, Phom, Rengma, Sangtam, Yimchunger, Kuki, Zeme-Liangmai (Zeliang) Pochury and Rongmei as well as sub-tribes. Each tribe is unique in character with its own distinct customs, language and dress. Tribes and sub-tribes that dwell in this exotic hill state can easily be distinguished by the colorful and intricately designed costumes, jewellery and beads that they adorn. The Naga tribes practised headhunting and preserved the heads of enemies as trophies through the 19th century and as late as 1969. This practice can be seen today also in the form that the heads of hunted animals are preserved in their houses. Agriculture is the most important economic activity and the principal crops include rice, corn, millets, pulses, tobacco, oilseeds, sugarcane, potatoes, and fibres. Other significant economic activity includes forestry, tourism, insurance, real estate, and miscellaneous cottage industries. The

important handicrafts of the Nagas are woodcarving, bamboo work, pottery and blacksmithy. The traditional ceremonial attire of each tribe is in itself, an awe inspiring sight to behold. The spear decorated with multicoloured goat hair; the headgear made of finely woven bamboo interlaced with orchid stems, adorned with boar's teeth and hornbill's feathers and elephant tusk armlets, present a good piece of art.

North East hilly region of India is also a home to diverse animal genetic resources including cattle, buffalo, sheep, goat, pigs, equines, yaks, mithuns etc. The great Indian hornbill is one of the most famous birds found in the state. About one-sixth of Nagaland is covered by tropical and sub-tropical evergreen forests including palms, bamboo and rattan as well as timber and mahogany forests which serves as shelter to many of these genetic resources. The state is mostly mountainous except those areas bordering Assam valley. The goat population of India is highest in the world and has been estimated to be about 135 million (Livestock Census, 2012). The goat population of North East Hill region is about 4.37 millions where Assam is the main contributor (6169193). Goat population of Nagaland is about 99350. All these goats are non-descript maintained in difficult terrains under harsh climate. A study was conducted to generate the information on morphological, biometrical traits and management of goats of Nagaland state. The genetic profile of these goats was also compared with that of goat populations of Sikkim state.

## METHODOLOGY

To generate the information on goats, the breeding tract of long hair goats was delineated with the consultation of State Animal Husbandry Department and Livestock Development Board of Nagaland. Visits were taken to different parts of Zunheboto, Tuensang, Kiphire, Phek and plain area of Dimapur districts of Nagaland (Fig. 1) to collect information on goats. The places of visit included new Zunheboto, Satami, Aghunato, Tuzhu, Suruhato, Tokiye, Astotown, Xuivi, Lazami of Zunheboto district; Sanglao, Waoshu, Nokhu, Yempang and Vanmie of Tuensang district; Kiphire village, Kiphire town, Longthoger of Kiphire district; Meluri of Phek district; Niuland of Dimapur district. The phenotypic traits and the biometric measurements were recorded from 255 animals consisting of different age groups of both sexes from 42 flocks belonging to different farmers. The morphological features were recorded by visual observation. The measurements of biometric traits i.e. body length, height at withers, chest girth, paunch girth, face length, horn length, ear length and tail length of different age group animals were taken using standard measuring tape of 1 mm accuracy. For measuring the traits animals were allowed to stand squarely on an even ground. The body weight was recorded with the help of 125 kg weighing balance with 100 g accuracy. The owners of flocks were also interviewed to get the information on goat management and reproductive parameters like age at sexual maturity, age at first conception, age at first kidding, kidding interval, gestation length, kidding pattern etc. Some of the farmers were having their private farms established deep in the forest where they kept goats, pig, poultry, fishery etc. The animals of these farms were also covered to record the data. Data recorded were compiled and

analyzed to estimate the average measurements with standard errors. To study the genetic variability blood samples were collected aseptically from the goats of different parentage belonging to different flocks. DNA isolated from this blood was genotyped to know the genetic diversity.

### UTILITY OF GOATS

Goat is a multi utility animal. The goats are mainly reared for milk, meat, skin, fiber etc. In addition, faeces, urine etc. are used in field as organic waste for improving the soil fertility. People of the NEH region are mostly non vegetarian and therefore prefer meat than to the milk. Their preference of meat is for pork, chevon and chicken. In Nagaland, people like to consume Mithun meat also. There is a great demand for goat meat and skin in all the states of NEH region. So the goats are reared by tribal people of Nagaland mainly for meat, coarse fiber and skin.



*Figure 2. Variants of long hair goat*

### PHENOTYPIC DIVERSITY

The goats with long hair were mainly found in Zunheboto district and in some villages of Tuensang district whereas their number was very less in other districts. The geographical area covered lies between 93° 2' E to 95° 15' E longitude and 25° 6' N to 27° 4' N latitude. The long hair goats are usually found in the hilly altitude of 800 – 1800 msl and are reared mainly by Sumi tribe. The long hair obtained from these goats is having a good commercial utility in the tribal culture of Nagaland.

**Morphological Traits :** Different colour variants of long hair goats were seen during the visits to Zunheboto, Tuensang, Kiphire, Phek and Dimapur districts. These were white, black and brown





*Figure 3. Other phenotypes (short hair goats) of Nagaland goats*

with grey hair ( Fig. 2). Long hair were present in the adult males with white & black , brown and black coat. In females, the long hair were present generally on thigh region. In white and black phenotype, the black patch was present mostly in the neck and face region.

Apart from the long hair goats, other phenotypes with short hair were also seen. This included pure white, black, white with black topline, black/ brown with white facial stripes ( Fig. 3). Goats of white coat with black/brown dorsal line appeared a distinct population but the but the size of population (number of goats) was very small.

The facial features of long hair and short hair goats have been shown in (Fig. 4). The head is



*Figure 4. Facial features of long hair and short hair goats*

proportionate to the body. Nose line is straight. The ears are of medium size, erect and placed horizontally. The horns in females are shorter, pointed, directed upward and then slightly backward while that of males are thicker, longer, orienting upward and backward. The wattles and beard are present in majority of goats (Fig. 4). Muzzle is black or brown. In white goats the muzzle is pinkish. The colour of horns and hooves is grey. The belly and legs below knee joint are black (Fig. 3 and 4). The under belly is black/white. The phenotype of goats, with facial stripes, seen in Dimapur district appear similar to the Sikkim Singharey goats described by Verma *et al* (2015). The udder and teats are moderately developed. Udder is bowl shaped and teats are small and cone type. The udder in some cases were hairy (Fig. 5).



*Figure 5. Moderately developed udder and teats*

The hairy goats ( Changthangi, Chegu and Gaddi) with long white/grey hair are also available in the J&K and Himachal Pradesh states of India (Aggarwal *et al.*, 2005 and Mishra *et al.*, 2010 ) but the phenotype of Nagaland long hair goat is different.

**Biometric Traits:** The body measurements indicate the skeletal growth of the animals. Body length and height at withers gives an idea about bone growth while chest girth is a measure of development of muscles, bones and fat and it has close relationship with the live weight.

The measurements on eight different biometric traits were recorded on about 200 animals belonging to different age groups and different flocks and their means are given in Table 1. The average measurements (cm.) for height at withers, body length, Chest/heart girth, paunch girth, face length, horn length, ear length and tail length in 3 months aged animals irrespective of sex, were  $32.44 \pm 0.83$ ,  $40.48 \pm 0.87$ ,  $46.96 \pm 0.99$ ,  $52.15 \pm 1.26$ ,  $11.41 \pm 0.23$ ,  $1.80 \pm 0.17$ ,  $8.81 \pm 0.31$ ,  $7.00 \pm 0.26$  respectively; for 6 months it was  $33.75 \pm 0.64$ ,  $45.77 \pm 0.66$ ,  $52.84 \pm 0.75$ ,  $58.19 \pm 1.06$ ,  $12.48 \pm 0.20$ ,  $2.90 \pm 0.35$ ,  $9.77 \pm 0.19$ ,  $7.84 \pm 0.32$  respectively; for 9 months  $41.76 \pm 0.64$ ,  $49.38 \pm 0.79$ ,  $58.00 \pm 0.78$ ,  $65.38 \pm 0.75$ ,  $13.90 \pm 0.37$ ,  $5.05 \pm 0.46$ ,  $10.55 \pm 0.41$ ,  $8.86 \pm 0.28$  respectively. The values for the same parameters for adults goats (more than 18 months) were  $46.12 \pm 0.45$ ,  $56.94 \pm 0.50$ ,  $68.49 \pm 0.66$ ,  $77.77 \pm 0.70$ ,  $15.81 \pm 0.15$ ,  $8.44 \pm 0.53$ ,  $11.64 \pm 0.18$ ,  $9.50 \pm 0.16$ . The average body weights (kg) in the age groups of 1-3 month, 4-6 month, 7-12 month and adult animals were  $7.89 \pm 0.42$ ,  $12.97 \pm 0.39$ ,  $16.62 \pm 0.26$  and  $27.69 \pm 0.73$  respectively. The values for body weight determining parameters like height, length and chest girth were generally more in male animals than their female counter parts. The difference was more prominent in adult animals in respect of height at withers, body length, chest girth and horn length.

The average measurements for different traits of Long hair goats were estimated separately also and are given Table 2. The mean values for height at withers, body length, Chest/heart girth, paunch girth, face length, horn length, ear length and tail length in adult (>18 months) male goats were  $48.43 \pm 1.52$ ,  $58.62 \pm 1.73$ ,  $71.24 \pm 2.21$ ,  $75.71 \pm 2.20$ ,  $16.19 \pm 0.45$ ,  $13.43 \pm 1.74$ ,  $10.70 \pm 0.38$ ,  $9.71 \pm 0.29$ cm respectively, whereas for females the average measurements were  $45.71 \pm 0.61$ ,  $56.35 \pm 0.81$ ,  $68.71 \pm 1.03$ ,  $77.44 \pm 1.40$ ,  $15.59 \pm 0.28$ ,  $7.79 \pm 0.71$ ,  $11.77 \pm 0.35$ ,  $9.24 \pm 0.23$ cm respectively. The overall average measurements irrespective of sex were  $46.75 \pm 0.71$ ,  $57.22 \pm 0.83$ ,

Table 1. Estimated means and SE for various biometric traits and body weight in different age groups

TRAITS	AGE GROUP											
	0 to 3 Months			4 to 6 Months			6 to 12 Months			Adults (> 18 months)		
	Females (16)	Male (22)	Overall (38)	Females (15)	Male (17)	Overall (32)	Females (9)	Male (12)	Overall (21)	Females (86)	Male (23)	Overall (109)
<b>HW(cm)</b>	30.73±1.46	33.63±0.89	32.44±0.83	37.33±1.00	37.75±0.84	33.75±0.64	42.11±1.31	41.50±0.60	41.76±0.64	45.32±0.41	48.65±1.40	46.12±0.45
<b>BL(cm)</b>	39.45±1.95	41.19±0.63	40.48±0.87	45.53±1.21	46.00±0.61	45.77±0.66	49.78±1.04	49.08±1.17	49.38±0.79	56.27±0.49	58.87±1.52	56.94±0.50
<b>CG(cm)</b>	46.09±2.21	47.56±0.75	46.96±0.99	52.87±1.09	52.81±1.08	52.84±0.75	57.22±1.39	58.58±0.91	58.00±0.78	67.52±.62	71.61±1.98	68.49±0.66
<b>PG(cm)</b>	48.55±2.20	54.63±1.19	52.15±1.26	58.53±1.45	57.88±1.59	58.19±1.06	65.33±0.97	65.42±1.12	65.38±0.75	77.81±0.75	75.70±2.07	77.77±0.70
<b>FL(cm)</b>	11.36±0.49	11.44±0.22	11.41±0.23	12.80±0.30	12.19±0.26	12.48±0.20	14.00±0.53	13.83±0.53	13.90±0.37	16.49±0.84	16.30±0.43	15.81±0.15
<b>HL(cm)</b>	1.68±0.32	1.88±0.20	1.80±0.17	2.80±0.70	3.00±0.24	2.90±0.35	4.56±0.63	5.42±0.65	5.05±0.46	7.14±0.43	13.13±1.60	8.44±0.53
<b>EL(cm)</b>	8.91±0.39	8.73±0.47	8.81±0.31	9.79±0.21	9.75±0.31	9.77±0.19	11.75±0.49	9.75±0.49	10.55±0.41	11.96±0.30	11.05±0.40	11.64±0.18
<b>TL(cm)</b>	6.82±0.44	7.13±0.31	7.00±0.26	7.27±0.33	8.38±0.52	7.84±0.32	8.78±0.46	8.92±0.36	8.86±0.28	9.48±0.19	9.65±0.34	9.50±0.16
<b>B.Wt(kg)</b>	7.31±0.77	8.32±0.47	7.89±0.42	12.87±0.63	13.06±0.50	12.97±0.39	16.67±0.44	16.58±0.34	16.62±0.26	26.39±0.64	31.87±2.14	27.69±0.73

HW-Height at withers, BL- Body length, CG- Chest girth, PG- Paunch girth, FL- Face length, HL- Horn length, EL- Ear length, TL- Tail length, B.wt- Body weight

69.67±1.06, 76.78±1.20, 15.82±0.24, 9.98±0.88, 11.35±0.27, 9.42±0.18cm respectively. The average body weight for adult males was 31.48±2.45kg and females 25.79±1.05 kg. The overall body weight was 28.22±1.26 kg.

Long hair goats were found to be similar in biometric traits to the other variants of goats existing in Nagaland state. The difference in average measurements of pooled population and long hair goat population was not significant. The biometry of long hair goats of Nagaland is also comparable with Changthangi of J&K state and Chegu of Himachal Pradesh. The reported values in Changthangi adult male for body length, heart girth, height at withers and body weight are 52.04cm, 65.20cm, 51.60 cm and 31.02 kg respectively and for adult female goats the values are 49.80, 63.00, 49.00cm and 25.72kg respectively (Acharya, 1982). The body length, height at withers and chest girth average measurements for adult chegu males are 72.9± 5.1, 66.2 ±6.70, 86.7± 7.00 cm respectively and for females 65.5±3.9, 58.1± 3.3 and 73.9± 3.80 respectively (Kaul et al.,1990). The adult body weight is 39.9± 13.4 kg in males and 27.8±10.3 kg in females.

*Table 2. Average body measurements of adult long hair goats*

TRAITS	Adults		
	Females (34)	Male (21)	Overall (55)
Body Height (cm)	45.71±0.61	48.43±1.52	46.75±0.71
Body Length(cm)	56.35±0.81	58.62±1.73	57.22±0.83
Chest Girth(cm)	68.71±1.03	71.24±2.21	69.67±1.06
Paunch Girth(cm)	77.44±1.40	75.71±2.20	76.78±1.20
Face Length(cm)	15.59±0.28	16.19±0.45	15.82±0.24
Horn Length(cm)	7.79±0.71	13.43±1.74	9.98±0.88
Ear Length(cm)	11.77±0.35	10.70±0.38	11.35±0.27
Tail Length(cm)	9.24± 0.23	9.71±0.29	9.42±0.18
Body Weight(kg)	25.79±1.05	31.48±2.45	28.22±1.26

## MANAGEMENT

Information on management practices of Nagaland goats were collected through visual observations and direct interview of farmers (Fig. 6).



Figure 6 : Interaction with Goat keepers

The information recorded from the breeding tract indicated that these goats are maintained on extensive management by small and marginal farmers. The animals are taken to hill forests in the morning and are brought back in the evening. The management practices for rearing goats in Nagaland state were found similar to that of Sikkim goats ( Verma et al., 2015, 2015a). In the night they are kept in a temporary structure. The flock size consisting of kids, adults of both sexes ranged from 2 to over 20 (Fig. 7). The number of male goats was found more in the flock.



*Figure 7 : Flocks of long hair and short hair goats*

**Goat Shelters :** Goat houses are made of mud, concrete, bamboo sticks and wooden logs with no proper arrangement of electric and water supply. Goat houses are made on the ground as well as on the platform raised from the ground at 3-4 ft level (Fig. 8) and a wooden ramp is made outside the house for entry and exit of the animals. The goat house with raised flooring help in keeping the house neat and clean as the droppings and urine do not accumulate on the floor but come down in the space below the floor of house. The raised flooring also provides good ventilation and prevents the animals from infections. Open housing system was also followed where animals are kept open within a temporary enclosure



*Figure 8. Types of goat shelter*

**Feeding:** Goat is a herbivorous animal with browsing habit. It prefers woody plants and pods with supplementation of grasses and herbage. Stall fed animals receive mixture of grasses, shrubs, weeds, thorny plants, pods, tree leaves. The whole North-East region is rich in these resources. It has been reported that plants of genus *Artocarpus*, *Bahuria*, *Caneya*, *Ficus*, *Grewia* and *Vites* are most important for providing edible leafy fodder to all the domestic livestock particularly goats in this region (Varma et al., 1982). The tribal people also use different by-products for feeding the goats. There are forest by-products e.g. banana leaves, banana stem, pine apple leaves, pine needles, wild root and tubers; crop by-products like jackfruit, tapioca leaves, pumpkin, sweet potato, squash etc. which can be fed to the goats.

In Nagaland also goats depend on local vegetation and by-products available in the jungle. There are plenty of barren and fallow pastureland with plenty of wild grasses and other vegetation which are easily accessible to the goats. Goats being the small ruminant can climb easily and browse in such difficult mountain slopes. Stall fed goats are kept on local grass, crushed maize and tree leaves ( Fig. 9). The animals love salt licking also. Some goat houses are provided with feeding mangers made of wooden crossbars. The wooden log with a rectangular cavity were also used for feeding with grains.



*Fig 9. Browsing and stall feeding*

#### **PERFORMANCE:**

Breeding in these goats is through natural mating. The litter size varies from 1 to 4 ( Fig.10), however, tetraplets were seen rarely. The first kidding generally delivers singlet, however, the litter size increases in subsequent kidding. Twinning was recorded in more than 50% cases. In long hair goat the average litter size is  $1.12 \pm 0.10$ . Age at first service in males is around one year whereas the age at first kidding varies from 15 to 18 months. The average gestation period like other goat breeds is about 150 days. Since these goats are reared mainly for meat purpose, the milk yield is very less ( 0.3 to 0.5 liter per day). The milk is not drawn but left for kids. The udder and teats are not well developed. The mean age at puberty , age at first kidding and inter kidding period has been reported as  $225 \pm 3.14$  (days) ,  $390 \pm 3.67$  (days) and  $270 \pm 4.39$  (days) respectively by Zaman et al (2015).





*Figure 10. Singlet, twin, triplet and quadruplets*

#### **UTILITY OF GOAT HAIR:**

An adult goat can yield fiber ranging from 187 to 207 gm with mean  $197.33 \pm 1.22$  gm. The fiber length ranges from 10 to 18 cm with mean  $15.55 \pm 1.27$  cm whereas fiber diameter ranges from 210 to 250 micron with mean  $225.56 \pm 16.35$  micron ( Sheetal , 2016). Goat hair obtained from the Nagaland goats has commercial utility for the tribal people. It is used for beautification purpose in garments, ornaments and weaponry. The hair are processed locally and dyed using organic colour extracted from plants/flowers. Different articles of in garments, jewellery and weaponry having use of goat hair is depicted in figure 11 .

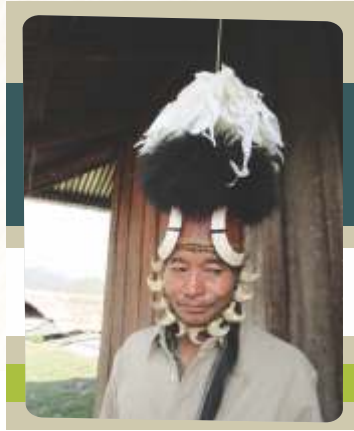
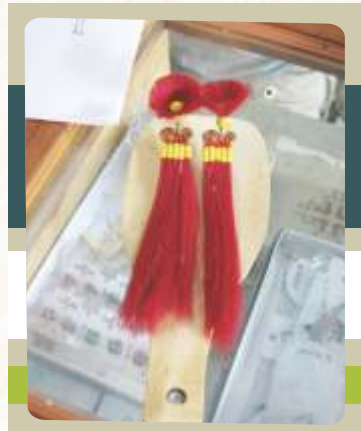
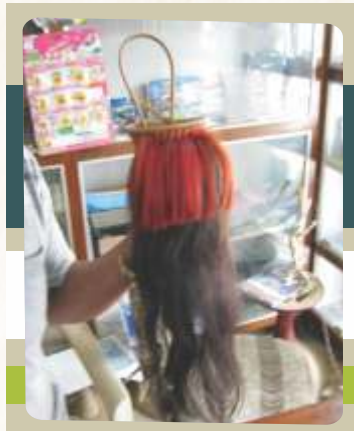
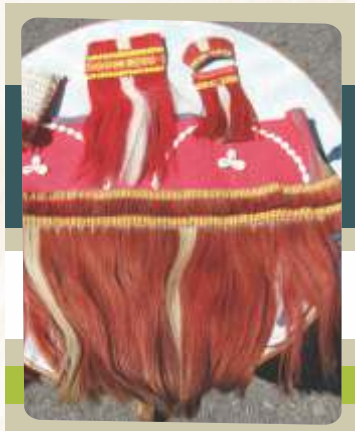


Figure 11 : Use of goat hair in different articles

**GENETIC DIVERSITY:**

An assessment of genetic variability in domestic goats is a first step towards conservation of genetic resources for maintaining breeding options. Loss/dilution of a breed due to any reason results in the loss of genetic variability from the gene pool. It is important to know the genetic variability existing in a particular breed/population. Good amount of genetic variability helps the population to survive and perform better under varied climatic conditions. Microsatellite markers which are co-dominant in nature have been used as good tools to analyze the genetic variation existing in various livestock species. The Nagaland goats have been characterized genetically and their genetic diversity is compared with Singharey and Sikkim Black goats of Sikkim state

More than fifty blood samples were collected from genetically different ( of different parentage) animals from different villages of Zunheboto and Tuensang districts of Nagaland (Figure 12). DNA was isolated by standardized phenol-chloroform method using protocol of Sambrook et al (1989). The quality of DNA was checked by agarose gel electrophoresis and quantity was assessed by spectrophotometry. The DNA samples were appropriately diluted (10-50 times) for obtaining a final concentration of approximate 50 ng/ $\mu$ l in MiliQ water, for further use. A battery of 23 microsatellite markers (Table 3) based on the guidelines of ISAG (International Society for Animal Genetics) and FAO's (Food and Agriculture Organization) DADIS (Domestic Animal Diversity Information System) program was utilized to generate allelic data. Each forward primer was tagged on the 5' end with one dye out of four dyes (FAM-Blue, VIC-Green, NED-Yellow, PET-Red) as supplied by Applied Biosystems, UK.

Amplifications were conducted in a 25  $\mu$ l reaction volume consisting of 2.5  $\mu$ l of 10X PCR buffer, 0.5  $\mu$ l dNTP (200  $\mu$ M), 50nM KCl, 10nM Tris-HCl (pH 9.0), 0.1% Triton X-100, 2.0 mM MgCl<sub>2</sub>, 5  $\mu$ l of each primer (10 pmol) and 0.25  $\mu$ l of Taq polymerase (Sigma) using touch down protocol. The standard PCR conditions were initial denaturation at 95° C for 1 min., 3 cycles of 95° C for 45 sec. and 60° C for 1 min., 3 cycles of 95° C for 45 sec., 57° C for 1 min, 3 cycles of 95° C for 45 sec, 54° C for 1 min, 3 cycles of 95° C for 45 sec., 51° C for 1 min, 20 cycles of 95° C for 45 sec., 48° C for 1 min, final extension at 72° C for 5 min. At the end, 5.0  $\mu$ l stop dye (95% formamide, 0.25% bromophenol blue and 0.25% xylene cynol) was added to stop the reaction. 6.0  $\mu$ l of PCR product was electrophoresed on 2% agarose gel and visualized over UV light after ethidium bromide staining to detect the amplification. Out of 23 microsatellite primers amplification was noticed in the 21 primers. The PCR products were mixed in the ratio of 1:1.5:2:2 of FAM, VIC, NED and PET labeled primers respectively. 0.5  $\mu$ l of this mixture (PCR multiplex) was combined with 0.3  $\mu$ l LIZ 500 as internal lane standard and 9.20  $\mu$ l formamide per sample. The mixture was denatured by incubating at 95° C for 5 min. The denatured samples were run on automatic DNA sequencer (ABI 3100 Avant). The electropherograms drawn through Gene Scan were used to extract DNA fragment sizing details using Gene Mapper software version 3.0.

Observed and expected heterozygosity, allele numbers were calculated using Pop Gene software, version 1.32 (Yeh et al., 1999). F statistics were determined using F-stat (Goudet, 2002) with jackknifing procedure. Tests for deviation from Hardy Weinberg equilibrium were conducted.



*Figure 12. Blood sampling from long hair goat*

Genetic variation between breeds was measured by genetic distance (Nei et al., 1983). Genetic diversity in terms of allelic number, heterozygosity, information index, poly information contents and inbreeding estimates are given in Table 4.

All the 23 loci investigated were polymorphic in nature as more than 90% of the loci exhibited minimum two or more alleles. The total number of alleles observed across these microsatellite loci was 116. Among the loci the number of alleles observed varied from 2 (OarJMP29) to 9 (ILSTS058) with an overall mean of  $5.043 \pm 0.380$ . Effective number of alleles ranged from 1.048 (OarJMP29) to 5.414 (ILSTS058) with mean  $2.576 \pm 0.285$ . Interestingly, private alleles were also found in these goat populations and the frequency of private alleles was up to 89.80% (allele size 157 at locus ILSTS34) in Long Hair Nagaland Goat. Singharey had relatively more private alleles but with comparatively lower frequency. Low frequency private alleles in Long Hair Nagaland goat were at the ILSTS019 locus (16.7%), ILSTS058 (20.9%), and locus ILSTS082 allele 120 (17.0%) whereas,

high frequency alleles were at ILSTS34 (89.8%), RM088 allele (89.50%). An allelic pattern exhibited by Sikkim Black (SB), Singharey(SS) and Long Hair Nagaland Goat (LHNG) is shown in Fig. 13.

*Table 3. Microsatellite markers, their sequences, type of repeat, size range and dye*

Locus	Primer sequence	Type of Repeat	Size range	Dye	*Chr. No.	**Acc. No.
IETH225	gatcaccttgccactatttct acatgacagccaagctgctact	VIC	(CA)18	146-160	14	Z14043
ILSTS044	agtcacccaaaagtaactgg acatgttgattccaagtgc	NED	(GT)20	145-177	Ann	L37259
ILSTS008	gaatcattgatttctgggg tagcagtgagtgaggtggc	FAM	(CA)12	167-195	14	L23483
OarHH64	cgttcctcactatggaaagtatatatgc cactctattgtaagaattgaaatgagagc	PET	--	120-138	4	212a
ILSTS059	gctgaacaatgtagatgttcagg gggacaatactgcttagatgctgc	FAM	(CA)4(GT)2	105-135	13	L37266
ILSTS065	gctgcaaaagattgaacacc aactattacaggaggctccc	PET	(CA)22	105-135	24	L37269
OarJMP29	gtatacacgtggacacgcctttgtac gaagtggaagattcagaggggaag	NED	(CA)21	120-140	Ann	U30893
ILSTS033	tattagagtgctcagtgcc atgcagacagtttagaggg	PET	(CA)12	151-187	12	L37213
OarFCB48	gagttagtacaaggatgacaagaggcac gactctagaggatcgcaagaaccag	VIC	(CT)10	149-181	17	M82875
OMHC1	atctggtgggctacagtcctag gcaatgctttctaattctgaggaa	NED	--	179-209	Not reported	228a
ILSTS005	ggaagcaatgaaatctatagcc tgttctgtgagttgtaagc	VIC	(nn)39	174-190	10	L23481
ILSTS019	aaggacacctatgtagaagc actttggaccctgtagtgcc	FAM	(GT)10	142-162	Ann	L23492
ILSTS058	gccttactaccatttcagc catcctgactttggctgtgg	PET	(GT)15	136-188	17	L37225
ILSTS087	agcagacatgatgactcagc ctgccttttcttgagagc	NED	(CA)14	142-164	Ann	L37279
ILSTS029	tgtttgatggaacacagcc tggatttagaccagggtgg	PET	(CA)19	141-191	3	L37252
ILSTS049	caattttctgtctctcccc gctgaatctgtcaaacagg	NED	(CA)26	160-184	11	L37261
ILSTS30	ctgcagttctgcatatgtgg cttagacaacaggggtttgg	FAM	(CA)13	159-179	2	L37212
ILSTS34	aagggtctaagtccaactggc gacctggttttagcagagagc	VIC	(GT)29	153-185	5	L37254
ILSTS022	agtctgaaggcctgagaacc cttacagtccttgggggtgc	PET	(GT)21	186-202	Ann	L37208
RM088	gatcctcttctgggaaaaagagac cctgttgaagtgaaccttcagaa	FAM	(CA)14	109-147	4	U10392
RM4	cagcaaaaatcagcaaacct ccacctgggaaggccttta	NED	(CA)13	105-127	15	U32910
ILSTS082	ttcgttctcatagtgctgg agaggattacaccaatcacc	PET	(GT)17	100-136	2	L37236
OarAE129	aatccagtggtgaaagactaatccag gtagatcaagatatagaatattttcaacacc	FAM	(CA)14	131-175	7	L11051

Table 4. Locus wise genetic diversity in long hair goats

Locus	Allelic Number		Hetrozygosity		I	FIS	PIC
	Na	Ne	Ho	He			
ETH225	3.000	1.246	0.043	0.198	0.398	0.780	0.175
ILSTS044	7.000	1.628	0.167	0.386	0.915	0.568	0.376
ILSTS008	3.000	2.340	0.176	0.573	0.926	0.692	0.481
OarHH64	8.000	4.620	0.522	0.784	1.701	0.334	0.752
ILSTS059	4.000	2.066	0.536	0.516	0.965	-0.038	0.473
ILSTS065	4.000	2.048	0.188	0.512	0.939	0.634	0.461
OarJMP29	2.000	1.048	0.047	0.045	0.110	-0.024	0.044
ILSTS033	6.000	1.409	0.279	0.290	0.655	0.039	0.278
OarFCB48	5.000	4.068	0.372	0.754	1.504	0.507	0.717
OMHC1	7.000	5.011	0.786	0.800	1.769	0.018	0.775
ILSTS005	6.000	2.219	0.476	0.549	1.157	0.133	0.518
ILSTS019	6.000	4.037	0.395	0.752	1.461	0.474	0.708
ILSTS058	9.000	5.414	0.512	0.815	1.811	0.372	0.789
ILSTS087	6.000	3.734	0.523	0.732	1.462	0.286	0.687
ILSTS029	6.000	4.082	0.650	0.755	1.560	0.139	0.721
ILSTS049	6.000	2.232	0.432	0.552	0.972	0.218	0.462
ILSTS30	3.000	1.282	0.135	0.220	0.448	0.386	0.208
ILSTS34	3.000	1.232	0.205	0.188	0.395	-0.086	0.182
ILSTS022	4.000	1.211	0.256	0.174	0.410	-0.467	0.171
RM088	3.000	1.234	0.209	0.190	0.372	-0.104	0.175
RM4	4.000	2.251	0.227	0.556	0.957	0.591	0.476
ILSTS082	5.000	2.913	0.455	0.657	1.281	0.308	0.615
OarAE129	6.000	1.910	0.390	0.477	1.020	0.181	0.453
Mean	5.043	2.576	0.347	0.499	1.008	0.258	0.465
S.E.	0.380	0.285	0.040	0.050	0.105	0.064	0.048

The average observed heterozygosity within the population ranged from 0.043 (ETH225) to 0.786 (OMHC1) with an average of  $0.347 \pm 0.040$ , whereas expected heterozygosity ranged from 0.045 (OarLMP29) to 0.815 (ILSTS058) with an average of  $0.499 \pm 0.050$ . The expected heterozygosity was significantly higher than observed heterozygosity at most of loci except ILSTS059, OarJMP29, ILSTS34, ILSTS022 and RM088 where heterozygotic deficiency was noticed. The loci with higher expected heterozygosities showed positive deviation from Hardy Weinberg equilibrium. Shannon's information index which measures the level of genetic diversity was sufficiently high with a mean of  $1.008 \pm 0.105$  and ranged from 0.110 (OarJMP29) to 1.811 (ILSTS058). This indicated that these

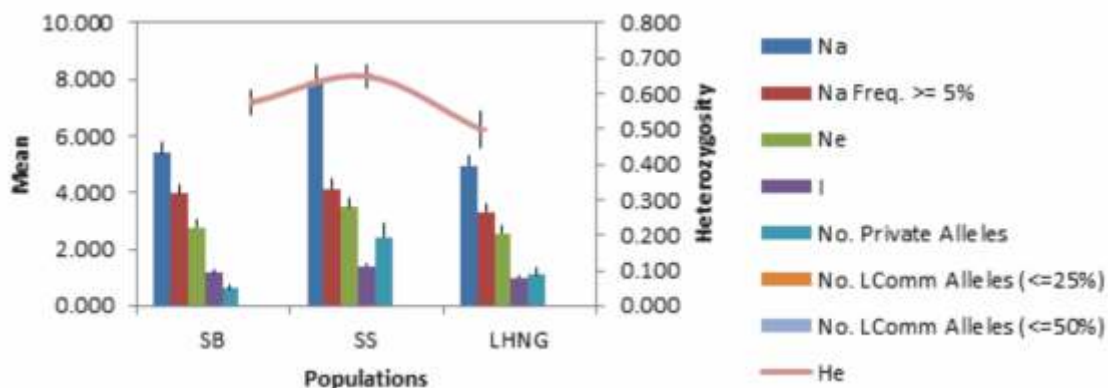


Figure 13 Allelic pattern in Sikkim Black (SB), Singharey (SS) and Nagaland long hair goats (LHNG)

markers can be used for diversity estimation studies across goat populations of Nagaland. Within population the inbreeding estimates (FIS) were calculated for all the 23 loci to know the extent of inbreeding in the population. FIS varied from 0.018 (OMHC1) to 0.780 (ETH225) with average  $0.258 \pm 0.064$  (Table 4). Only 5 loci (ILSTS059, OarJMP29, ILSTS34, ILSTS022, RM088) revealed negative F values indicating the absence of inbreeding at these loci. About 26% of the inbreeding was noticed in LHNG which resulted in moderate level of homozygosity in the population. It is higher than Singharey and Sikkim Black. Polymorphic Information Contents, estimated for the microsatellite markers used for the genotyping of LHNG goats, ranged from 0.044 (OarJMP29) to 0.789 (ILSTS058) with an average  $0.465 \pm 0.048$ .

To detect any reduction in effective population size of Long Hair Nagaland Goat, three different tests i.e. sign test, standardized difference test and Wilcoxon sign-rank test were employed under different mutation models of microsatellite evolution i.e. infinite allele model, step-wise mutation model and two-phase model. Expected number of loci heterozygosity excess under sign test were 12.81, 13.31 and 13.52 under IAM, TPM and SMM respectively. As indicated in Table 5, the deviation was negative under TPM ( $T_2 = -2.153$ ) and SMM ( $T_2 = -6.386$ ) but positive under IAM ( $T_2 = 0.357$ ). Wilcoxon rank test revealed that estimated values are higher than 0.05 for IAM, TPM and SMM thus all the three models rejected null hypothesis favouring heterozygotic deficiency.

The L-shaped mode-shift curve as shown in Fig. 14 indicates that LHNG population is non-bottlenecked and has not shown any reduction in the effective population size in the recent past and thus remained at mutation drift equilibrium

As revealed by the genetic distances (0.636) given in Table 6 long hair goats of Nagaland is genetically distant from Singharey (0.636) and Sikkim Black goats of Sikkim and hence need separate programme for their management and genetic improvement. There is a need to establish a separate goat farm for their conservation.

Table 5: Population bottle neck analysis in Long Hair Nagaland Goat

Tests		Model used		
		I.A.M.	T.P.M.	S.M.M.
Sign test (No. of loci with hetrozygosity excess)	Exp	12.81	13.21	13.52
	Obs	12	10	7*
Standardized differences test	P- value	0.44431	0.12625	0.00553
	T2 value	0.357	-2.153*	-6.386*
Wilcoxon test (one tail for H excess)	P- value	0.36071	0.01568	0.00000
	P- value	0.26012	0.91033	0.99627

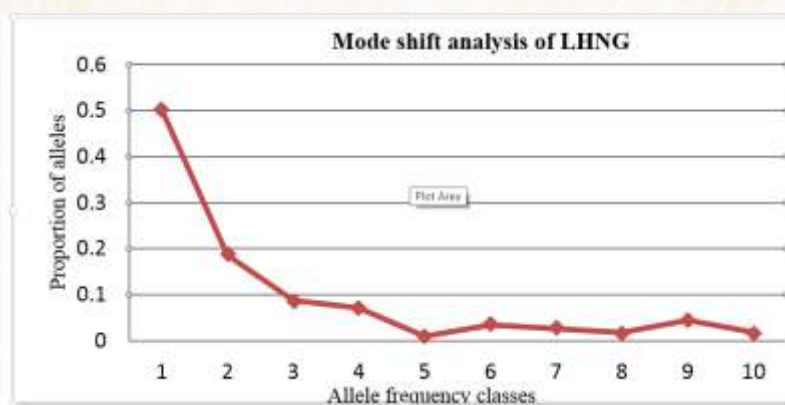


Figure 14. L-shaped mode shift curve

Table 6: Nei's Genetic Distance

	Singharey	Sikkim Black	Nagaland long hair goat (NLHG)
Singharey	0.000		
Sikkim Black	0.122	0.000	
Nagaland long hair goat	0.636	0.636	0.000

### CONCLUSION AND RECOMMENDATIONS:

The goat germplasm of Nagaland state has good amount of phenotypic, biometric and genetic diversity. Different variants of Nagaland goats appeared to be different from other goat populations (Assam Hill, Assam local, Bengal type and Sikkim goats) of N.E. region. The long hair goats, in particular, is phenotypically and genetically different from other variants of Nagaland goats and appear to form a distinct goat population. Therefore, this population in view of its diversity and importance in tribal culture of the state needs to be improved and propagated further. There can be a separate goat farm in the breeding tract where long hair goat can be maintained. This farm can prepare the breeding bucks and distribute them in the field to maintain the genetic purity of long hair goat germplasm. The increase in population size and genetic improvement of long hair goats will also improve the livelihood of goat keepers.



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*Project team with goat keepers in the breeding tract*



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