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Differentiating characteristics among three new goat populations from northern India

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ABSTRACT

Three non-descript goat populations, viz. Kumaoni and Garhwali of Uttarakhand hills, and Rohilkhandi of upper Ganges alluvial plain of Uttar Pradesh (India) were characterized phenotypically with standard morphometric parameters. The animals were also evaluated for their reproductive and production performance. The null hypothesis that Garhwali, Kumaoni and Rohilkhandi goat populations are same was tested using value of discriminant functions (D), Wilks' Lambda and Box's M statistics. The classification results revealed that 84.9% of all the goats were correctly classified to their own population. This could be used by livestock development agencies to take up appropriate breeding program for the improvement of native stock for future genetic conservation. The milk composition of Uttarakhand goats did not differ much due to geographic identities except for milk fat percentage. The study revealed that body height, body length, horn pattern, face length, and chest girth were the most discriminating and unique variables to separate Rohilkhandi, Kumaoni and Garhwali goat populations.

Key words: Garhwali, Goat, Kumaoni, Phenotypic, Rohilkhandi, Uttarakhand

In India, goats with their multifacet utility in the various agro-climatic conditions play an important part in rural agrarian economy. India is blessed with diverse goat populations in parallel with their diverse ecology, production systems and communities. Goats are small ruminant species with second largest population in livestock category, contributing in the production of milk after cattle and buffaloes (Sodhi 2016). Besides 34 well defined registered Indian goat breeds (http://www.nbagr.res.in), there are a large number of variants of goat population yet to be characterized, documented and registered as breed. As per 19th Livestock census, out of 135.04 million goats, more than 61% of them are yet to be characterized (Livestock Census 2012, Government of India). In Uttar Pradesh (15.58 million goats) and Uttarakhand (1.37 million goats), there are certain goat variants which need systematic characterization, evaluation and documentation. Once genetically characterized and evaluated, the population could be registered as separate breed. Systematic genetic characterization would further help livestock development agencies to take up appropriate breeding program for the improvement of native stock for future genetic conservation. Furthermore knowledge on the genetic structure of goat breeds will be beneficial to understand the role of genetic variants in resistance to various diseases. A survey on native goat breeds with special emphasis on their role as a tool of sustainability and adding value to the local economy helps to support animal biodiversity in marginal areas. The main descriptors of the economic factor include the use of local breeds, disease resistance, forage self-sufficiency, forage quality, milk quality, typical and/or traditional products, environmental labeling and direct sales. Moreover, if these populations have potential to be termed as different breed, it may further help to redefine and differentiate them at genetic level. The present investigation specifically target three population, viz. Kumaoni and Garhwali of Uttarakhand, and Rohilkhandi of Uttar Pradesh for their phenotypic characterization and genetic evaluations in their actual breeding tract. The native breeding tract of population was delineated through discussions and initial survey with State Animal Husbandry Department in the respective regions. The presence of these goat populations in Uttarakhand and Uttar Pradesh was reported earlier (Singh and Barwal 2009, Verma *et al.* 2010, Fahim *et al*. 2011, Anonymous 2012).

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MATERIALS AND METHODS

A two stage random sampling technique was performed, for each population. For Rohilkhand region, the survey was

carried out in 12 villages across 6 blocks of 3 districts, viz. Bareilly, Pilibhit and Shahjahanpur, whereas for Uttarakhand region, 29 villages were surveyed spread over 8 blocks of Almora and Pauri Garhwal districts**.** Information on feed management and breeding practices, flock size, structure and reproductive performance in the breeding tract were collected using a structured questionnaire. At least 25 goat keepers in the survey area were interviewed for each goat variant. Standard body biometric data were collected from 531 adult goats belonging to 3 populations. The standard morphological character data were analyzed using Statistical Analysis Systems version 9.1.3 (SAS 2007). Milk sample were also collected for milk composition analysis using standard procedure (ISO-IDF 2001) for different goat populations.

RESULTS AND DISCUSSION

Distribution and management of goats: Rohilkhandi goats also known as Bareilly goats are found in the Rohilkhandi region comprising Bareilly, Pilibhit and Shahjahanpur districts of Uttar Pradesh. The region is part of the upper Ganges plain, located between 28°C 30′N (Latitude) and 79°CE (longitude). The region experiences humid subtropical climate with high temperature variation. The average annual rainfall is approximately 1,714 mm, which mostly occur during the monsoon period. The crop residues and stubbles supplemented goat forage besides browsing on small tree tops in the field. The flock size of Rohilkhandi goat was small to medium (flock size >5 with 60% doe, 15% buck and 25% kid).

While Chaugarkha/Kumaoni goats are mainly found in the Kumaon region (Almora and Pithoragarh districts) and hence named as Kumaoni goats, whereas Udaipuri/ Garhwali goats are found in Garhwal region (Pauri and Rishikesh districts) of Uttarakhand and hence may be termed as Garhwali goats (Fig. 1). Uttarakhand is known for the natural environment of the Himalayas, the Bhabhar and the Terai. The breeding tract of Kumaoni and Garhwali goats mostly runs through middle hill ranges of Himalayas. The area experiences summer temperatures from 15°C to 18°C; however during winter temperature even drop below the freezing point. The crop residue formed supplementary forage for the livestock. Part of the fodder need was also contributed by the lopped trees like *Bauhinia retusa* (semal), *Grewia optiva* (bhimal), *Quercus leucotrichophora* (banj), *Ougeinia oogeinensis* (saandan) etc. besides fodder grass. Flock size of Kumaoni and Garhwali goats was medium to large (flock size 7–80 with at least 56% doe, 12.5% buck and 15% kid).

Earlier Chaugarkha goats were named after Chaugarkha region (*patti*), i.e. Chitai to Dania in Almora district (Joshi 1992) and Udaipuri goats were so named after Udaipur and Ajmer *patties*, i.e. Dugadda to Yamkeshwar in Pauri district (Barwal and Singh 2010). Population of all these different variants of goats were in good number (>20,000 as per survey estimates) in their respective ecological niche. These goats were mainly reared by landless and marginal farmers. The housing system was mix of *pucca* and *kutcha* type. The goats were moved on foot to nearby area for 4–6 h grazing/day in both regions. The grazing pastures were meadows type in Uttarakhand. The concentrate feeding except for kitchen leftover was hardly practiced in the both the regions. The goats were rarely milked for domestic milk use.

Morphology and biometric characteristics: Rohilkhandi goats were mostly (>90%) black and small size animals. Kumaoni and Garhwali goats were small size animals with body colouration varying from brown to tan (60–80% animals). However, few animals having greyish white, black, fawn and mottled coat were also present. All these goat variants had convex head with small to medium size pendulous ears (10–16 cm) with tip slightly curved upward in Kumaoni, while face and ear of Garhwali goats were longer than other 2 populations. Horns were small, grayish black and curving backward in Kumaoni and Rohilkhandi but long in Garhwali goats (Fig. 1; Table 1). Wattles were absent in all the populations but animals with prominent beard were also observed in Kumaoni (9%) and Garhwali (18%) goats. Rohilkhandi goats had longer tail as compared to other populations. All three populations had hairy coat type. Based on height and body length, the goats of Uttarakhand had squared body, whereas Rohilkhand goats were of rectangular shape type.

Fig. 1. Doe and buck of different goat populations.

Table 1. Average body measurements (cm) and weight (kg) of different goat populations over age and sex

Age	3 months		6 months		12 months		Adult	
Trait	Male	Female	Male	Female	Male	Female	Male	Female
				Rohilkhandi goats				
N	7	10	13	23	14	20	22	61
Ht	47.0±3.0	49.1±2.0	53.5±1.2	53.0±0.7	58.7±1.2	55.8±0.9	66.4±1.4	61.9±0.6
BL	41.0±2.0	41.3±2.1	44.2±1.0	46.4±0.8	50.6±1.1	50.6±0.9	57.1±1.1	55.3±0.6
CG	45.5±1.5	49.1±2.5	51.5±1.2	52.5±0.8	58.6±1.5	58.2±0.9	68.4±1.4	65.1±0.7
PG	48.5±2.5	48.1±2.5	50.5±1.4	52.4±0.9	59.1±1.2	61.4±1.3	68.6±1.6	68.1±0.8
FL	11.5±1.5	10.1±0.4	9.9±0.9	11.0±0.2	11.7±0.3	12.3±0.2	13.6±0.3	13.2±0.2
HL	0.2±0.1	0.4±0.2	0.3±0.0	0.4±0.1	0.5±0.1	0.6±0.1	4.7±1.1	3.7±0.6
EL	12.0±2.0	12.2±1.6	14.0±0.4	14.2±0.6	14.4±0.5	15.2±0.4	16.2±0.4	15.5±0.4
TL	9.0±0.0	6.8±1.6	11.2±0.5	10.4±1.6	11.5±0.3	10.9±0.5	14.1±0.4	12.1±0.2
WT	9.5±0.5	8.0±0.9	12.0±0.7	12.6±0.4	16.2±0.8	17.0±0.7	26.0±1.6	23.6±0.8
				Kumaoni goats				
N	7	12	10	12	6	11	18	82
Ht	45.28±1.6	45.16±1.4	48.90±0.8	48.75±0.8	53.16±1.3	53.0±1.2	58.33±1.4	57.88±0.4
BL	43.0±1.6	44.50±1.9	51.30±1.2	49.0±1.3	54.17±1.2	52.18±1.0	58.16±0.9	61.0±0.6
CG	48.14±1.5	48.83±1.9	54.20±1.2	53.33±1.4	56.83±3.3	57.27±1.5	64.22±1.4	65.45±0.6
PG	50.71±1.3	53.41±2.0	54.80±1.5	55.67±1.7	60.50±2.1	64.27±2.2	63.61±4.0	72.12±0.8
FL	10.42±0.3	10.75±0.4	11.80±0.4	11.25±0.3	11.83±0.0	12.09±0.2	13.33±0.3	13.61±0.1
HL	2.42±0.4	2.25±0.4	4.8±1.4	3.67±0.5	7.67±0.9	5.09±0.4	9.44±0.6	7.63±0.3
EL	10.29±0.4	10.91±0.4	11.20±0.4	11.92±0.4	11.0±0.8	11.81±0.3	13.0±0.4	12.79±0.1
TL	7.57±1.1	8.50±0.4	9.30±0.3	9.25±0.3	9.16±0.7	10.0±0.3	10.89±0.5	10.50±0.1
WT	9.79±1.0	11.42±1.2	14.50±0.9	13.96±0.9	18.50±1.6	17.73±0.9	25.69±1.7	27.42±0.7
				Garhwali goats				
N	14	22	18	22	12	16	55	200
Ht	48.23±1.2	48.50±1.0	56.94±1.4	57.09±1.5	59.58±1.6	58.81±1.2	66.53±0.7	63.58±0.3
BL	48.36±1.8	45.95±1.0	53.17±3.1	55.09±1.6	60.0±1.5	57.87±1.3	66.49±0.9	63.71±0.5
CG	50.43±1.4	51.18±1.2	59.55±1.3	58.09±1.6	63.91±1.4	61.37±1.2	71.32±0.8	69.64±0.5
PG	53.07±1.8	52.45±1.5	60.28±1.3	60.31±2.0	65.5±1.4	63.06±1.5	73.07±0.9	72.44±0.5
FL	11.57±0.3	11.59±0.3	14.11±0.4	13.36±0.4	14.17±0.3	14.12±0.3	16.89±0.4	15.70±0.1
HL	3.79±0.5	3.22±0.4	6.78±0.5	7.0±0.9	10.5±0.8	6.75±0.5	14.60±0.6	11.76±0.2
EL	11.92±0.3	12.31±0.3	12.67±0.3	12.82±0.3	12.50±0.3	13.25±0.3	13.76±0.3	13.59±0.2
TL	9.57±0.3	9.09±0.3	10.55±0.4	10.09±0.3	10.53±0.4	10.25±0.4	12.07±0.3	11.11±0.1
WT	14.18±2.2	11.98±0.9	17.67±1.7	18.98±1.7	22.96±1.3	20.22±1.0	31.61±1.2	28.52±0.5

N, Number of individuals; Ht, body height; BL, body length; CG, chest girth; PG, paunch girth; FL, face length; HL, horn length; EL, ear length; TL, tail length; WT, body weight.

A perusal of morphometric characteristics revealed that colour and facial characteristics reasonably distinguish these 3 goat populations. In animals of similar colour, facial characteristics, horn pattern, face length as well as body size of the animals could help to distinguish different variants. These goat strains are distinguishable from other well defined breed like Jamunapari, Barbari, Beetal and Gaddi based on body colour, size and facial characteristics. Jamunapari and Beetal are large size (>75 cm) dairy breeds of goat having white and black colour, respectively. The distinguishing character of Jamunapari is a highly convex nose line with a tuft of hair, giving a parrot mouth like appearance. The ears are very long (>20 cm), flat and drooping. While Barbari and Gaddi are small size goats but can be distinguished by their colour pattern and coat type from the goats under study. Barbari goats are mostly white with brown spots on its body, with typical ears (short, tubular, almost double), with the slit opening in front, erect, directed upward and outward (Acharya 1982). Gaddi is a woolly goat breed with white and lustrous coat. Hence, based on morphology and body biometry, these goat variants in Uttarakhand and Rohilkhand region had the potential to be recognized as separate breeds of the region.

Production performance: Garhwali goats were heavier and taller than Rohilkhandi and Kumaoni goats at different ages ($P<0.05$). Garhwali goats had larger chest and paunch girth as well as longer body than Kumaoni and Rohilkhandi goats. However, Rohilkhandi and Kumaoni goats did not differ significantly in terms of body weight. The differences in the body weight and height among the populations were more prominent at early stages compared to adulthood. Males were heavier and taller than females at different ages across the populations (Table 1; Fig. 1).

The estimates for different biometrical traits of Kumaoni/Chaugarkha are comparable with the estimates reported by Singh and Barwal (2009) except for height at withers and body length. However, the body weights, height and length of Garhwali/Udaipuri goats reported earlier (Barwal and

Singh 2010) were lower than the present estimates. The body weights at different ages and corresponding biometrical estimates of different traits in our study were higher than those reported by Fahim *et al*. (2013). The differences in our and earlier reports for different traits may be due to sampling locations, timing and sample size.

Reproductive performance: The reproductive performance of all the 3 populations was almost same except for litter size of Rohilkhandi goats. Twining percentage was more (20–30%) in Rohilkhandi goats. The reproductive performance of Rohilkhandi goats is in agreement with Fahim *et al.* (2012) who reported least squares means for age at first heat, mating and kidding, and gestation length of Rohilkhandi goats under farm condition as 282.23, 362.14, 543.17 and 149.7 days, respectively. Males and females of these populations sexually matured around 12 months of age. The summer (March to April) and winter (October to November) breeding seasons were practiced in breeding tract of these goats.

Milk yield and quality attributes: The milk composition of Kumaoni and Garhwali goats did not differ much. The observed fat percentage was lower in the milk of Garhwali goats compared to that of Kumaoni and Rohilkhandi goats. Observed estimates of fat and SNF % for Rohilkhandi goats were lower than those reported for this population under farm condition (Upadhyay *et al*. 2013). The protein and lactose percentage were lower in the milk of Rohilkhandi goats compared to Kumaoni and Garhwali (Table 2). This indicates that milk of Rohilkhandi was less sweet with lower lactose content than that of other goats, which may be due to environmental condition of the different geographical locations. The milk yield in the field conditions varied from 300 to 500 ml/day among these goats. The average daily milk

Table 2. Average milk composition of different goat populations

Variable	Kumaoni	Garhwali	Rohilkhandi
Fat (%)	4.45±0.13	3.51±0.14	4.44±0.27
Protein (%)	6.18±0.16	5.90±0.15	3.9±0.17
Lactose (%)	7.66±0.12	6.71±0.15	5.64±0.25
SNF (%)	11.20±0.18	10.72±0.17	9.87±0.39

yield (657 ml) of Rohilkhandi goats under farm condition was almost in agreement with farmer's observation.

Classification of goat populations: The null hypothesis that Garwali, Kumaoni and Rohilkhandi goat populations are same was tested using value of discriminant functions (D), Wilks' Lambda and Box's M statistics (Table 3). The Wilks' Lambda and Box's M was significant, which showed significance of the discriminant functions and hence indicated group differences among the goats, which was further supported by correct assignment of goats to its own group. Wilks' lambda indicated that discriminant function 1 and 2 were significant (P<0.000). The significance of the discriminant functions tested with the minimization of Wilks' lambda (lambda = 0.199 and 0.614) and chi square

Table 3. Tests of equality of group means in three goat populations

	Wilks' Lambda	F	df1	df2	Sig.
Body height	0.676	126.277	2	528	–
Body length	0.686	120.816	2	528	–
Chest girth	0.755	85.786	2	528	–
Paunch girth	0.864	41.588	2	528	–
Face length	0.659	136.881	2	528	–
Horn length	0.496	268.052	2	528	–
Ear length	0.794	68.308	2	528	–
Tail length	0.941	16.414	2	528	–
Body weight	0.786	71.956	2	528	–

(846.726, P<0.01, and 256.010, P<0.05) for discriminant functions 1 and 2, respectively, revealed that the models were efficient with greater power of function 1 to differentiate the groups. The tests of equality of group means indicated higher F value of horn and face length followed by body height (Table 3) and thereby relative importance of these characteristics in differentiation of these goat populations. Yakubu *et al*. (2010) also indicated the power of these characteristics in discriminating West African Dwarf and Red Sokoto goats. The first canonical variable accounted for 76.8% of the total variation in populations (Table 4). First 2 canonical variables were able to clearly differentiate these 3 populations (Fig. 2). Higher loadings of horn and face length; and body height re-emphasized the power to discriminate and classify these different goat populations.

Assignment of an individual goat to its own group: The classification results revealed that 84.9% of all the goats were correctly classified into 3 different populations. On cross validation, almost 84.2% of individuals were classified to their own groups (Table 5). The Garhwali goats were

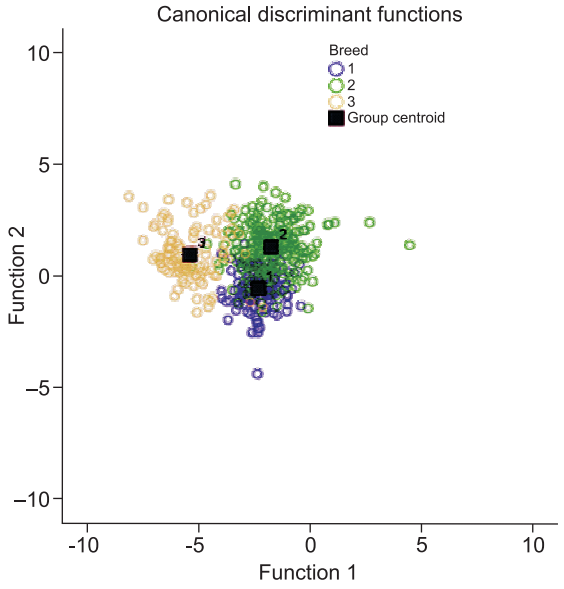

Fig. 2. Canonical discriminant functions depicting differentiation of goats. 1, Kumaoni goat; 2, Garhwali goat; 3, Rohilkhandi goat.

Table 4. Total sample standardized canonical discriminant function coefficients, eigenvalue, total variance and canonical correlation

Trait	Canonical Function 1	Canonical Function 2
Body height	–0.465	1.041
Body length	0.452	–0.091
Chest girth	–0.275	0.546
Paunch girth	–0.055	–0.646
Face length	0.503	–0.149
Horn length	0.760	0.112
Ear length	–0.444	0.188
Tail length	–0.351	–0.301
Body weight	0.076	–0.014
Eigenvalue	2.087	0.630
% of variance	76.8	23.2
Canonical correlation	0.822	0.622

Table 5. Classification of different goat populations with predicted and cross validated group membership

	Breed	Predicted Group Membership			Total
		1	2	3	
		Original			
Count	1	111	34	1	146
	2	24	237	7	268
	3	5	9	103	117
%	1	76.0	23.3	.7	100.0
	2	9.0	88.4	2.6	100.0
	3	4.3	7.7	88.0	100.0
		[a]Cross-validated			
Count	1	110	35	1	146
	2	25	236	7	268
	3	5	11	101	117
%	1	75.3	24.0	.7	100.0
	2	9.3	88.1	2.6	100.0
	3	4.3	9.4	86.3	100.0

[a]In cross validation, each case was classified by the functions derived from all cases other than that case; Goat populations (1, Kumaoni; 2, Garhwali; 3, Rohilkhandi).

classified with better accuracy as compared to Rohilkhandi and Kumaoni goats. In similar investigations, the discriminant analysis was used to correctly classify (70–99.7%) several goat populations into their source populations (Yakubu *et al.* 2010, Dossa *et al*. 2007, Traore *et al*. 2008). The present classification function is the first tool available to differentiate among Rohilkhandi, Kumaoni and Garhwali goats under field conditions.

The study revealed that body height, body length, horn length, face length and chest girth were the most discriminating variables to separate out studied population of Rohilkhandi, Kumaoni and Garhwali goats. This is important because the potential capacity of populations to adapt and evolve as independent biological entities in different environmental conditions is restricted by the exchange of individuals between populations. The function provides important and informative variables (breed markers) that could be used to assign these goats into distinct populations, thereby reducing the errors of selection in future breeding programs. The present findings would definitely aid in field assessment, management and conservation practices. These would further help in the selection of phenotypically pure local genetic resources for sale/ purchase and for future conservation and improvement programs. Local breeds are the major component of animal farm biodiversity, due to their excellent adaptation to specific environmental conditions. Therefore, every effort to add value to local breeds is important, especially as a contribution to the prospects of their conservation through sustainable use. However, an investigation on the genetic characterization of these goat populations using molecular markers like microsatellite and SNP markers will complement the results obtained from morphometric differentiation.

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