



Conservation priorities of Indian goat breeds based on genetic and non-genetic parameters

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Received: 22 April 2020; Accepted: 18 August 2021

ABSTRACT

Indian goats have unique characteristics in terms of production, reproduction, disease resistance and adaptability in different agro-climatic regions of the country. Since, the country has vast goat genetic resources and different climatic regions but limited facilities including fund, there is a need for setting priority for conservation and better utilization. The microsatellite data of 1237 random DNA samples on 25 markers as well as morphological/demographic information pertaining to 27 goat breeds/populations were used to study the extinction probability and conservation priority based on different approaches. Extinction probability based on census and microsatellite data revealed same order of priority for conservation in >50% cases. Surti, Zalawadi and Gaddi were at higher risk of extinction probability (≥ 0.63) and more than half of the Indian goat breeds were having <50% extinction probability. The study will help to manage goat genetic resources of the country and to conserve suitable breeds of goat.

Keywords: Diversity, Extinction probability, Merit, Microsatellite, Utility

India ranked 2nd next to China in having 26 well defined goat breeds with 135.17 million goat population which was 16.11% of the world population and constituted 26.40% of the total country livestock population (DADF 2014, 19th India livestock census).

Conservation of all breeds is considered to be financially infeasible (Bennewitz *et al.* 2007) due to cost of conservation; moreover many breeds have similar characteristics as well as little historical and cultural significance. Therefore, prioritization is needed. If the purpose is crossbreeding or introgression, then between subpopulation, diversity should be prioritized. But if the purpose is to preserve a closed population to cope with future challenging environments or with diversified production conditions then within population, diversity should be prioritized. Both genetic diversity and non-genetic criteria are important for prioritizing breeds for conservation (Gizaw *et al.* 2008). For genetic diversity, maximization of genetic diversity through evaluation of the breed contribution to aggregate genetic diversity (contribution to between and within-breed diversity component) is important criterion for prioritizing breeds for conservation. The non-genetic criteria include threat status and breed merit. The threat status includes risk of extinction and efficiency of the breed utilization, and breed merits include economic or productive, ecological and socio-cultural values of the breed

(Ruane 2000, Gizaw 2008). Conservation is not only about endangered breeds but also about those that are not being utilized efficiently (Barker 2001). Hence, the present and future status of a breed/ population depends upon their genetic and non-genetic factors. Through this study, an effort was made to assess conservation priorities based on extinction, diversity (within and between), breed merit and combination of all of them, so that comparison of existing conditions threat, future security and management opportunities can be made and conservation and selection option(s) could be chosen.

MATERIALS AND METHODS

A total of 1237 DNA samples of 27 Indian goat breeds/populations was used for present study. The study was carried out at National Bureau of Animal Genetic Resources, Karnal during the year 2016–17. The allelic data was generated by using 25 microsatellite (<http://cabin.iasri.res.in/gomi/algorithm.html>) loci based on DNA fingerprinting of 27 goat breeds/populations. PCR products were mixed and resulting mixture was denatured by incubation to run on automated DNA sequencer of Applied Biosystems. The electropherograms were drawn through Gene Scan and used to extract DNA fragment sizing details using Genemapper software 4.0. Generated data is numeric in terms of base pair which is size of each allele along with genotype (combination of alleles at every diploid locus). The protocol followed has been described at <http://cabin.iasri.res.in/gomi/tutorial.html>.

The relative contribution of a breed to total, within and

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between-breed genetic diversity was estimated using the methods of Petit *et al.* (1998), and Caballero and Toro (2002) as implemented in Molkin ver 3.0 (Gutierrez *et al.* 2009) software.

Briefly, Petit *et al.* (1998) used the rare facted number of alleles per locus (k) to assess the contribution of the i^{th} population to the total allelic richness as $D2 = CS + CD$ where CS is the contribution to the total allelic richness due to the allelic richness of the i^{th} population and CD is the contribution due to its divergence. Positive contributions to diversity from i^{th} population using the Petit *et al.* (1998) method mean that the remaining set has a lower number of alleles than the original set; consequently, the i^{th} population would be preferred for conservation. Caballero and Toro, (2002) method partitioned the total gene diversity as in the following equation:

$$(1-f) = (1-f) + D,$$

where f , average global coancestry; f is the average coancestry between populations; $(1-f)$, GDT representing the total gene diversity; $(1-f)$, GDW representing the within population component; and D , Nei genetic distance between populations, representing the between population component. Positive contributions to diversity from a given population using Caballero and Toro method mean that the remaining dataset increases the overall diversity; consequently, the assessed population would not be preferred for conservation.

The other genetic and non-genetic criteria like extinction probability based on effective population size, geographical distribution, crossbreeding, existing conservation program and organized farm, adaptation and uniqueness/special traits of the breed (production/reproduction) were also included. The effective population size (N_e) based on census was estimated using formula of Wright (1931) while based on STR (short tandem repeat) data, NeLD was computed from genotypic data using Ne Estimator 2.01 software based on linkage disequilibrium (Hill 1981, Waples 2006). This method was implemented in LDNe program (Waples and Do 2008), which corrects for biases resulting from the presence of a wide range of sample sizes and rare alleles, and was developed by Waples (2006). And finally, the extinction probability of each breed was computed by summing of all seven variables and the sum was rescaled to a value between 0.1 and 0.9 using the following equation as suggested by Reist-Marti *et al.* (2003):

$$Z_i = 0.8/1.2 \times \sum Z_{ia} + 0.1,$$

where Z_i , extinction probability of i^{th} breed and Z_{ia} , sum of extinction probability of all the variables ($a=1-7$).

The breed merit estimation was based on scored value of current economic, ecological and socio-cultural merits of breeds as suggested by Ruane (2000); which was assessed on the basis of review of available literature, some field observations and discussion with scientists and farmers. Average breed merit (W) for each breed was subsequently calculated by averaging the scores over all merits

(economic, ecological and cultural merits). Economic merit of breeds was scored based on its relative contributions to milk and meat production; growth, wool and skin production; reproductive traits like prolificacy, twinning and kidding percentage; feeding (grazing and stall); impact on livelihood (based on religious and earn); quality of product; domestic and export use of product by giving score of each category as 0.20, 0.10, 0.15, 0.05, 0.10, 0.10, 0.10, respectively. Ecological values reflect adaptive characters of the breeds. A high score (0.10) or medium score (0.05) was assigned to breeds that inhabit in extreme and moderate climate. Cultural values were defined by the degree of the traditional association of a community to a particular goat breed and contribution of the breed to socio-cultural functions and rituals. Accordingly, scores from 0.10 (very high) to 0.05 (low) were given.

Finally, a conceptual framework for a maximum utility through a weighted summation of measures of neutral diversity and breed merits as suggested by Simianer *et al.* (2003) was developed. A simplified approach to rank breeds on their total utility as used in Gizaw *et al.* (2008) was adopted to provide a working ranking of breeds. Total utility of breed i (u_i) can be estimated as:

$$u_i = 2(z_i \times D_i) + W_i$$

where z_i , extinction probability; D_i , partial contribution of breed i to global diversity; W_i , current merit of breed i . The conservation potential ($z_i \times D_i$) is the possible increase in expected diversity if an endangered breed i was made completely safe.

RESULTS AND DISCUSSION

The breed-wise extinction probability has been presented in Table 1. The average estimated extinction probability based on STR and other variables over all breeds was 0.43. Surti had highest extinction probability (0.70) followed by Zalawadi and Gaddi (0.63) whereas Black Bengal and Sangamneri had the lowest. The extinction probability of half of the breeds was below the average value and only six breeds (Ganjam, Jharkhand Black, Marwari, Narayanpatna, Kalahandi and Rohilkhandi) had higher than 50% extinction probability while Attapady, Changthangi and Jamunapari had just 50%. The similar values of extinction probability were also estimated in different cattle breeds with average extinction probability of 0.48 with Sheko (0.77), Highland zebu (0.70), and Kapsiki (0.67) having the highest, and Nguni (0.20), Afrikaner (0.30), and Mashona (0.32) having the lowest (Reist-Marti *et al.* 2003). They also estimated half of the extinction probabilities in the range of 0.40 and 0.50, and one-third higher than 50%.

However, Gizaw *et al.* (2008) reported highest extinction probability of 0.90 in one sheep breed but for the rest breeds, it ranged from 0.10 to 0.50. Pinnet Tamina (2009) reported extinction probability of chicken breeds in range of 0.15 to 0.76.

Based on livestock breed survey data, the extinction probability was found to be highest in Attapady (0.70)

Table 1. Breed-wise extinction probability of Indian goat

Breed	Extinction probability	
	Based on census	Based on STR
Black Bengal	0.10	0.23
Ganjam	0.50	0.57
Gohilwadi	0.57	0.43
Jharkhand Black	–	0.57
Attapady	0.70	0.50
Changthangi	0.50	0.50
Kutchi	0.63	0.43
Mehsana	0.50	0.30
Sirohi	0.10	0.43
Malabari	0.43	0.37
Jamunapari	0.23	0.50
Jakhrana	0.37	0.37
Surti	0.37	0.70
Gaddi	0.43	0.63
Marwari	0.37	0.57
Barbari	0.17	0.43
Beetal	0.23	0.30
Kanni-Adu	0.37	0.37
Sangamneri	0.50	0.23
Osmanabadi	0.23	0.37
Zalawadi	0.57	0.63
Chegu	0.37	0.43
Berari	0.43	–
Konkan Kanyal	0.63	–
Narayapatna	–	0.57
Raighar	–	0.37
Kalahandi	–	0.57
Rohilkhandi	–	0.57
Malkangiri	–	0.37
Average	0.40	0.43
ST.DEV.	0.17	0.13

followed by Kutchi and Konkankanyal (0.63) and Zalawari (0.57) goats while lowest in Black Bengal and Sirohi (0.10). The extinction probability for rest of the goat breeds was ≤ 0.50 .

Thus, the microsatellite and breed survey data both revealed that Attapady, Kutchi and Zalawadi were relatively at higher risk of extinction probability and more than half of the Indian goat breeds were having $< 50\%$ extinction probability. 50% of the breeds having $\geq 50\%$ extinction probability were the same as identified by both types of data.

Prioritization of breeds based on their contribution to the genetic diversity: Glowatzki-Mullis *et al.* (2008) reported that both Weitzman, and Caballero and Toro approaches do measure between population diversity and are almost identical while Boettcher *et al.* (2010) advocated that coancestry method of diversity analysis is technically sound. On the other hand, Ramadan *et al.* (2012) suggested that the different methods to measure breed contribution to aggregate genetic diversity are important criteria for deciding conservation options.

Therefore, here we have used Caballero and Toro (2002) and Petit *et al.* (1998) approaches to estimate breed

contribution to diversity and both approaches were compared. The relative contribution of breed to within and between and to the total genetic diversity of breeds has been presented in Table 2. Except in few cases, almost all negative values estimated by Caballero and Toro method are comparable with positive values of Petit *et al.* (1998) method, so both methods indicated the same order of conservation priority. Zalawadi was at the top priority followed by Kutchi, Sirohi, Narayanpatna, Kanni-Adu, Ganjam and Chegu which contributed 0.73, 0.68, 0.66, 0.44, 0.41, 0.25 and 0.22 to the total genetic diversity, respectively. Therefore, their extinction will lead to loss in population diversity. On the other hand, Gaddi, Malabari, Marwari, Black Bengal, Jamunapari, Surti, Beetal were at least priority because their extinction was not likely to affect total diversity of the population as it was compensated by prioritized breeds. The similar concept was also advocated in chicken by Ramadan *et al.* (2012), and Tadano and Kataoka (2014).

If aim is to preserve within diversity, then, KanniAdu, Kutchi, Sirohi and Narayanpatna were more suited breeds/populations as they can cope more with future challenges. But, if aim is to preserve between diversity, then, Zalawadi, Changthangi, Sirohi and Kutchi were more suited breeds. The contribution of these breeds will help to preserve the unique alleles between different breeds of goat in the country. But when we combine other criteria, the order of ranking may be different. The same statement was also advocated by Ramadan *et al.* (2012) for Egyptian chickens.

Prioritization of breeds based on their merit: The breed merit of each goat breed/population based on sum of score value of production, reproduction, product quality, ecological and socio-cultural impact was estimated and presented in Table 3. The score of breed merit ranged from 0.40 (Kalahandi and Rohilkhandi) to 0.90 (Malabari, Jakhrana) across the breeds under study. The higher score revealed better production, reproduction, and adaptability of the breed, and vice-versa.

Prioritization of breed based on their utility: The total utility of each breed under the study was estimated based on product of their total genetic diversity and extinction probability which is weighted by their merit (Table 4) using the theme of prioritization as maximum diversity, extinction probability and utility for prioritization of breeds for conservation.

Assuming a cut-off utility score of 0.95, Zalawadi, Sirohi, Changthangi, Kutchi, Narayanpatna, Ganjam and Kanni-Adu goat breeds were at top priority for conservation as they had greater contribution to the diversity, extinction probability and merit. These seven breeds on conservation priority constituted just 25% of the total breeds covered in this study. On the other hand, Jamunapari, Gaddi, Surti, Attapady and Marwari breeds were at least priority even they had greater extinction probability and merit but least contribution to the diversity.

Overall, it was concluded that microsatellite panel can be used effectively for assessing genetic variation and

Table 2. Relative contribution of 27 breeds/populations to within, between and total genetic diversity based on Caballero and Toro (2002) and Petit *et al.* (1998) methods

Breed	Caballero and Toro's method			Petit <i>et al.</i> method		
	Within breed (%)	Between breed (%)	Total (%)	Within breed (%)	Between breed (%)	Total (%)
B.Bengal	-0.56	0.65	0.09	-0.07	-0.08	-0.15
Ganjam	-0.80	0.70	-0.10	-0.04	0.29	0.25
Gohilwadi	-0.62	0.61	-0.02	-0.17	0.03	-0.14
Jh.Black	-0.89	0.78	-0.11	-0.12	0.11	-0.01
Attapady	-0.98	0.93	-0.05	-0.05	-0.08	-0.13
Changthangi	-0.77	0.71	-0.07	-0.11	0.72	0.62
Kutchi	-1.11	0.93	-0.18	0.28	0.39	0.68
Mehsana	-1.02	0.89	-0.12	0.15	-0.14	0.01
Sirohi	-1.08	0.78	-0.30	0.21	0.45	0.66
Malabari	-0.63	0.73	0.10	-0.10	-0.17	-0.27
Jamunapari	-0.90	0.92	0.02	-0.07	-0.20	-0.26
Jakhrana	-0.80	0.85	0.06	-0.02	-0.27	-0.29
Surti	-0.82	0.98	0.16	0.05	-0.28	-0.22
Gaddi	-0.86	1.03	0.17	-0.03	-0.27	-0.30
Marwari	-0.81	0.89	0.08	0.14	-0.45	-0.31
Barbari	-0.89	0.89	0.00	0.01	-0.22	-0.21
Beetal	-1.03	1.05	0.02	0.08	-0.24	-0.16
Kanni-Adu	-1.16	1.03	-0.13	0.38	0.03	0.41
Sangamneri	-0.89	1.01	0.12	-0.23	0.18	-0.05
Osmanabadi	-0.68	1.03	0.35	0.00	0.00	0.00
Zalawadi	-1.36	0.88	-0.48	-0.17	0.89	0.73
Chegu	-1.05	0.95	-0.10	0.20	0.02	0.22
Narayanpatna	-1.06	0.96	-0.09	0.21	0.23	0.44
Raighar	-0.68	0.64	-0.04	-0.19	0.37	0.18
Kalahandi	-0.79	0.75	-0.03	-0.20	0.29	0.09
Rohilkhandi	-0.91	0.89	-0.02	0.07	0.07	0.14
Malkangiri	-0.82	0.79	-0.03	-0.24	0.24	0.01

Table 3. Breed-wise total score (merit) and its different components

Breed	Prod-milk and meat (0.20)	Growth / wool/skin (0.10)	Repro. prolif, twin, kidding (0.15)	Feeding (0.05)	Impact on livelihood (0.10)	Prod. quality (0.10)	Export/ import (0.10)	Score (0.80)	Adaptability (extreme/ moderate) (0.10)	Cultural/ social (0.10)	Total score (1.0)
B.Bengal	0.05	0.05	0.15	0.05	0.10	0.10	0.10	0.60	0.05	0.05	0.70
Ganjam	0.10	0.10	0.15	0.05	0.10	0.10	0.10	0.70	0.10	0.05	0.85
Gohilwadi	0.20	0.05	0.05	0.05	0.10	0.05	0.05	0.55	0.10	0.10	0.75
Jh.Black	0.10	—	0.05	0.05	0.05	0.05	0.05	0.35	0.05	0.05	0.45
Attapady	0.10	—	—	—	0.10	0.05	0.05	0.30	0.05	0.10	0.45
Changthangi	0.10	0.05	—	0.05	0.10	0.10	0.10	0.50	0.10	0.10	0.70
Kutchi	0.20	0.05	0.05	—	0.10	0.05	0.05	0.50	0.10	0.05	0.65
Mehsana	0.20	0.05	0.10	0.05	0.10	0.05	0.05	0.60	0.05	0.10	0.75
Sirohi	0.20	0.05	0.10	0.05	0.10	0.10	0.10	0.70	0.05	0.10	0.85
Malabari	0.20	0.10	0.15	0.05	0.10	0.10	0.10	0.80	0.05	0.05	0.90
Jamunapari	0.15	0.05	—	—	0.05	0.05	0.05	0.35	0.05	0.05	0.45
Jakhrana	0.20	0.05	0.15	0.05	0.10	0.10	0.05	0.70	0.10	0.10	0.90
Surti	0.20	—	0.05	0.05	0.05	0.05	0.05	0.45	0.05	0.05	0.55
Gaddi	0.10	0.05	—	0.05	0.10	0.05	0.05	0.40	0.10	0.10	0.60
Marwari	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.10	0.10	0.70
Barbari	0.20	—	0.10	0.05	0.10	0.10	0.05	0.60	0.10	0.05	0.75
Beetal	0.20	0.05	0.10	0.05	0.10	0.05	0.05	0.60	0.05	0.10	0.75
Kanni-Adu	0.10	0.05	0.10	0.05	0.10	0.05	0.05	0.50	0.10	0.05	0.65
Sangamneri	0.20	0.05	0.10	0.05	0.10	0.10	0.05	0.65	0.05	0.05	0.75
Osmanabadi	0.20	—	0.10	0.05	0.10	0.05	0.05	0.55	0.05	0.05	0.65
Zalawadi	0.20	—	0.10	0.05	0.10	0.05	0.05	0.55	0.05	0.05	0.65

(Table 3. *Concluded*)

Breed	Prod-milk and meat (0.20)	Growth / wool/skin (0.10)	Repro. prolif, twin, kidding (0.15)	Feeding (0.05)	Impact on livelihood (0.10)	Prod. quality (0.10)	Export/ import (0.10)	Score (0.80)	Adaptability (extreme/ moderate) (0.10)	Cultural/ social (0.10)	Total score (1.0)
Chegu	0.10	0.10	0.10	0.05	0.10	0.10	0.05	0.60	0.10	0.05	0.75
Narayanpatna	0.20	–	0.10	0.05	0.05	0.05	0.05	0.50	0.10	0.05	0.65
Raighar	0.10	–	0.10	0.05	0.10	0.10	0.05	0.50	0.05	0.10	0.65
Kalahandi	0.10		0.05	–	0.05	0.05	0.05	0.30	0.05	0.05	0.40
Rohilkhandi	0.10	–	0.05	–	0.05	0.05	0.05	0.30	0.05	0.05	0.40
Malkangiri	0.10	0.05	0.10	0.05	0.10	0.10	0.05	0.55	0.10	0.10	0.75

Table 4. Utility of different breeds based on diversity, extinction probability and merit, and their ranking

Breed	According to Petit <i>et al.</i>			Breed utility	Cons. priority rank
	Cont. to Aggr. Div. (%)	Ext. prob.	Breed merit		
B.Bengal	–0.15	0.23	0.70	0.63	17
Ganjam	0.25	0.57	0.85	1.14	6
Gohilwadi	–0.14	0.43	0.75	0.63	16
Jh.Black	–0.01	0.57	0.45	0.44	21
Attapady	–0.13	0.50	0.45	0.32	23
Changthangi	0.62	0.50	0.70	1.32	3
Kutchi	0.68	0.43	0.65	1.23	4
Mehsana	0.01	0.30	0.75	0.76	11
Sirohi	0.66	0.43	0.85	1.42	2
Malabari	–0.27	0.37	0.90	0.70	13
Jamunapari	–0.26	0.50	0.45	0.19	26
Jakhrana	–0.29	0.37	0.90	0.69	14
Surti	–0.22	0.70	0.55	0.24	24
Gaddi	–0.30	0.63	0.60	0.22	25
Marwari	–0.31	0.57	0.70	0.35	22
Barbari	–0.21	0.43	0.75	0.57	18
Beetal	–0.16	0.30	0.75	0.65	15
Kanni-Adu	0.41	0.37	0.65	0.95	7
Sangamneri	–0.05	0.23	0.75	0.73	12
Osmanabadi	0.00	0.37	0.65	0.65	15
Zalawadi	0.73	0.63	0.65	1.56	1
Chegu	0.22	0.43	0.75	0.94	8
Narayanpatna	0.44	0.57	0.65	1.15	5
Raighar	0.18	0.37	0.65	0.79	9
Kalahandi	0.09	0.57	0.40	0.51	20
Rohilkhandi	0.14	0.57	0.40	0.55	19
Malkangiri	0.01	0.37	0.75	0.76	10

setting conservation priority for Indian goat breeds. In addition to genetic diversity, we need to consider threat status, breed merit and their utility that enable us to make a balance between conserving diversity as an insurance against future uncertainties and current sustainable utilization.

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