Pastoral community selection and the genetic structure of a local goat breed in Patagonia

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Summary

The effect of human intervention on the structure of locally adapted breeds in America is analyzed using the case of a rural community in Patagonia (Argentina) and its goats. The Neuquen Criollo Goat is analyzed focusing on the artificial selection practiced by the local rural community and its effects on the current type's distribution. Goatherd preferences in the selection of replacements were studied by means of a survey (n= 242). The distribution of 634 females of various types was recorded and compared with selection criteria through multivariate techniques. Producers showed clear grounds for the selection of their animals, size, conformation, hair type and coat color being the criteria most frequently cited. Most producers (84%) used at least two criteria to choose their replacements. Differences of criteria and phenotypes between areas were significant, as was the correlation between Chi-squared distances matrix on both data sets (r=0.78), showing the influence of human intervention on the breed's shape. Directional selection, practiced by rural communities in marginal areas, was the main factor of microevolution in this Criollo goat population, and probably in other Criollo populations in America.

Resumen

Se analiza el efecto de la intervención del hombre sobre la estructura genética de una raza adaptada localmente, tomando como ejemplo una comunidad campesina de la Patagonia (Argentina) y sus cabras. El caso de la Cabra-Criolla-Neuquina se analiza considerando la selección artificial practicada por los campesinos y sus efectos sobre la distribución actual de ecotipos. Las preferencias de los productores fueron estudiadas mediante una encuesta (n: 242) y se registró la distribución de ecotipos de 634 hembras, comparándose ambos grupos de datos a través de técnicas multivariadas. La mayoría de los Crianceros (84%) emplean al menos dos criterios para elegir sus reemplazos. Los más frecuentes fueron: tamaño, conformación, tipo de pelo y color de capa. Se observaron diferencias significativas entre criterios de selección, así como en los fenotipos encontrados según el área de distribución. La correlación entre las matrices de disimilaridad (distancias Chi-cuadrado) fue asimismo significativa (r: 0,78) demostrando la influencia de la intervención del hombre en la modelación de esta raza. La selección dirigida, practicada por una sociedad campesina en una región marginal sería el principal factor microevolutivo en esta raza caprina Criolla y probablemente en otras poblaciones Criollas en America.

Key words: *Directional selection, Pastoral community, Genetic structure, Breed formation.*

Introduction

Although a close relationship between people living in pastoral communities and their domestic animals is recognized, there is still a dominant paradigm that livestock in developing countries has been shaped only by the environment without human intervention (Köhler-Rollefson, 2000). Particularly in America, the general model, related to the evolution of Criollo populations, indicates that after the introduction of domestic animals in the early days of colonization some five hundred years ago, the animals have occupied different environments along the continent, with natural selection driving the process of adaptation (Russell *et al*., 2000). Other microevolution factors, such as migration, genetic drift or artificial selection, were reflected to a lesser extent in the scarce studies on these groups. Criollo populations appeared to provide optimal material for improvement, because of their rusticity and their phenotypic, and assumed genetic, variability. These populations have not been properly characterized and generally have been considered as heterogeneous groups without any identity and definition.

Directional selection is a generally accepted process, as evidenced by the formation process of standard breeds in developed countries (Herrera and Rodero, 2000) but is neglected in the case of traditional populations bred by rural communities (Lauvergne *et al*., 1987) thus ignoring the symbiosis and co-evolution between people and their animals, as postulated by Negi (1998) and Blench (2000).

In America, goat populations are generally locally adapted breeds found in marginal areas. The first goats brought to this continent, from the 16th to 18th century, were most probably of Andalusian and Canarian origin (Rodero *et al*., 1992; Capote *et al*., 2004). Later a diversity of breeds were introduced, whose dispersion and cross breeding were uncontrolled (Mueller, 1993). This accepted process probably had different results not only because different breeds were introduced at different times but also because of the diverse environmental conditions and people involved in the process.

In the present study the Neuquen Criollo goat of north Patagonia, is taken as a case study to analyze the effect of human activities on its phenotypic and genetic structure. This breed has been recently defined based on phenotypic and genetic characteristics (Table 1). Its holders identify one breed, Criollo Goat, and two types, Criollo Pelada and Criollo Chilluda (Figure 2a and 2b). Type differentiation can be explained according to a geographical pattern (Lanari *et al*., 2003). Nevertheless, these differences may not be the consequence of adaptational advantages or simply of geographical isolation as other factors could produce the observed divergence. Therefore the aim of this study was to discern how human intervention, cultural practices and other factors affected the formation of this local breed.

Materials and Methods

A survey was carried out in the north of Neuquén Province, Argentina (Figure 1). The region is home to some 1 500 "*Crianceros*" and 340 000 Neuquen Criollo goats (INDEC 2002). According to previous studies (Lanari *et al*., 2003), the region was divided into four areas: Pehuenches (P), Barrancas (B), Añelo (A) and Minas-Ñorquín (W). "*Crianceros*" can be described as goat herds which belong to rural communities of indigenous and local origin who practice an extensive subsistence farming system with transhumance. Goats have an important role in the life of the community and most associated practices have their roots in the Mapuche and Tehuelche culture (Figure 3).

Table 1. Phenotypic and genetic characteristics of Neuquén Criollo goat.

Phenotypic trait		Genotype locus	Allele	Frequency
Fleece	Fleece with inner layer of Cashmere fiber	Hemoglobin	A	0.571
			B	0.373
Hair type	Short and Long hair types		D	0.056
Cranial profile	Straight	Malic Enzyme	A	0.156
Coat color	Mixed		B	0.574
Ear tonicity	Horizontal or slightly drooping ears		C	0.270
Ear length	Medium length	Alkaline Phosphatase	0	0.834
			F	0.166
Wattles	Mostly absent	Albumin	A	0.323
			B	0.535
			V	0.143
Horn shape	Aegrarus and mixed	X Protein	0	0.090
			1	0.288
			2	0.622
Body weight	Females: 39 kg	Nucleoside Phosphorylase	H	0.450
	Males: 63 kg		L	0.550
Withers height	Females: 64 cm			
	Males: 72 cm			
Shin circumference	Females: 8.6 cm			
	Males: 11 cm			
Body length	Females: 72 cm			
	Males: 84 cm			

From: Lanari, 2004.

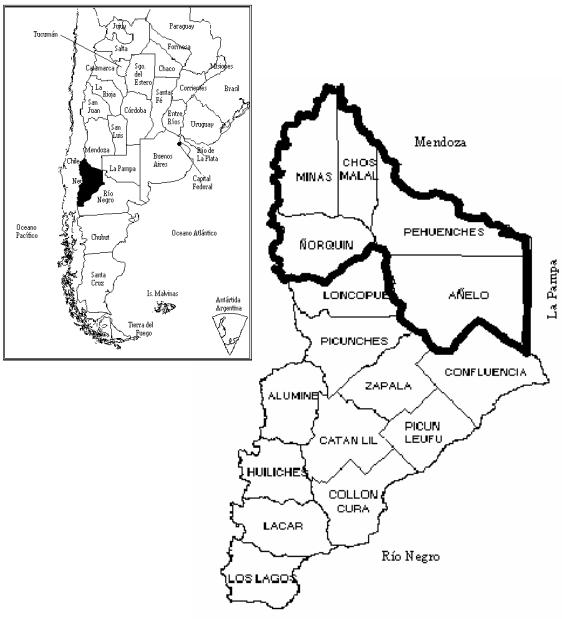

Figure 1. Neuquen Criollo Goat distribution area.

A total of 242 "*Crianceros*" were interviewed during November and December 2002. They were asked about their preferences in relation to the selection of bucks, the replacement of females and types of births in their flocks. Questions were designed to identify the importance that was given to morphological and productive traits.

Data on morphological traits such as hair type (HT) and coat color (CC) from 634 adult female goats was taken from a previous survey (Lanari *et al*., 2000). Liveweight corrected for Body Condition Score (CLW) was taken as size indicator. The correction on Body Condition Score allows us to ignore the effect of fattening level. Two types of hair were considered: long hair (L) and short hair (S), both types having a down layer of

Figure 2a. Types of Neuquén Criollo goat: Criollo Pelada .

Figure 2b. Types of Neuquén Criollo goat: Criollo Chilluda.

cashmere fibers. Detailed descriptions of the region and hair types were presented in Lanari *et al*. (2003).

Descriptive analyses and Chi-square test were carried out to compare answers, as well as phenotypes in the different areas. Both sets of records were analyzed by multivariate techniques. Correspondence analysis was performed taking all variables, the answers and phenotypic traits as attributes of each area. In this procedure, Area was considered the principal classificatory variable and was included as a supplementary variable in the analysis (SAS, 1989). Then Chi-squared distances between areas were calculated based on the frequencies of each category and were separated for the inquiry and for phenotypic traits. Two additive trees (neighbour-joining) were obtained and the distance matrix compared. The SAS/STAT package was applied for the statistical analyses (Figure 5).

Table 2. Selection criteria used for the selection of "Crianceros", according to areas.

	Area			
	A	B	P	W
Buck preference- 1st choice	n=25	n=27	n=97	n=45
Size	0.48	0.15	0.42	0.56
Age	0	0.52	0.13	0.04
Hair type	0.52	0.26	0.41	0.29
Coat colour	0	0.04	0	0.07
Horns	0	0	0.04	0.02
Conformation	0	0.04	0	0.02
Buck preference- 2nd choice	n=25	n=24	n=71	n=35
Size	0.40	0.04	0.27	0.14
Age	0.16	0.08	0.24	0.37
Hair type	0.36	0.08	0.23	0.29
Coat colour	0.08	0.04	0.03	0.06
Horns	0	0.04	0.13	0.09
Conformation	0	0.71	0.11	0.06
Female goat preference- 1st choice	n=25	n=23	n=77	n=51
Size	0.08	0.52	0.69	0.76
Hair type	0.80	0	0.09	0.07
Coat colour	0	0.04	0	0
Horns	0	0.09	0.03	0.13
Conformation	0.08	0.22	0	0.02
Mothering ability	0.04	0.13	0.19	0.02
Female goat preference- 2nd.choice	n=25	n=20	n=60	n=36
Size	0.04	0.05	0.18	0.14
Hair type	0.16	0.25	0.25	0.39
Coat colour	0.16	0.35	0.03	0.14
Horns	0	0	0.10	0.06
Conformation	0.60	0.20	0.07	0.19
Mothering ability	0.04	0.15	0.37	0.08

Ref: A: Añelo, B; Barrancas, P: Pehuenches, W: Minas-Ñorquin.
n: number of effective answers to corresponding question.
Numbers in the cells indicate frequencies of answers.

Table 3. Preferences of Neuquen Criollo breeders by area.

	Area			
	A	B	P	W
Buck preference	n=15	n=73	n=97	n=46
Big	0.07	0.08	0.40	0.50
Big & Compact	0.40	0.69	0.44	0.17
Angular	0	0	0	0.02
Small	0	0	0.01	0
Compact	0.53	0.23	0.16	0.31
Female goat preference	n=25	n=72	n=97	n=46
Big	0.08	0.06	0.54	0.61
Big & Compact	0.12	0.75	0.38	0.24
Angular	0	0	0	0.02
Small	0	0	0	0
Compact	0.80	0.19	0.08	0.13
Buck hair length preference	n=15	n=74	n=97	n=46
Short	0	0.81	0.14	0.22
Long	0.87	0.19	0.79	0.61
Indifferent	0.13	0	0.06	0.17
Females hair length preference	n=25	n=74	n=97	n=46
Short	0	0.80	0.11	0.20
Long	1.00	0.19	0.78	0.59
Indifferent	0	0.01	0.10	0.21
Buck coat colour preference	n=15	n=74	n=97	n=46
White	0.87	0.13	0.85	0.70
Coloured	0	0.84	0.05	0.17
Indifferent	0.13	0.03	0.10	0.13
Female goat coat colour preference	n=25	n=74	n=97	n=46
White	0.16	0.14	0.72	0.65
Coloured	0	0.82	0.03	0.02
Indifferent	0.84	0.04	0.25	0.33
Type of birth	n=25	n=74	n=97	n=46
Single	0.04	0.88	0.78	0.57
Multiple	0.96	0.12	0.22	0.43

Ref.: A: Añelo, B; Barrancas, P: Pehuenches, W: Minas-Ñorquin.
n: number of effective answers to corresponding question.
Numbers in the cells indicate frequencies of answers.

Results

Goatherds expressed clear criteria for selecting replacements. Most of them mentioned two criteria (84%) and a negligible proportion showed indifference. There was an agreement on considering size or conformation in males and females. In males, hair type and age were other important options while in females, size, hair type and conformation were the most frequent criteria cited (Table 2).

In response to the question about preferences in hair type and coat color, 'Crianceros' answered differently according to area (Table 3). These differences among areas were significant ($P<0.01$).

Figure 3. "Crianceros" and their goats in North Neuquén (Patagonia, Argentina).

Table 4. Morphological traits frequency and liveweight by area.

	Area			
Phenotype	A (n= 196)	B (n= 154)	P (n= 122)	W (n= 157)
Long hair	0.89	0.29	0.73	0.48
Short hair	0.11	0.71	0.27	0.52
White	0.85	0.24	0.85	0.71
Colored	0.15	0.76	0.15	0.29
Horn presence	0.86	0.99	0.94	0.97
Horn absence	0.14	0.01	0.16	0.03
Corrected liveweight * (kg ± stderr)	39.0 ± 0.41	40.6 ± 0.43	40.9 ±0.79	38.7 ±0.40
CV of CLW* (%)	14.8 %	13.2 %	21.2 %	13.0 %

Ref.: A: Añelo, B; Barrancas, P: Pehuenches, W: Minas-Ñorquin.
n: number of animals.
Numbers in the cells indicate frequencies of answers.
*CLW: Liveweight corrected after Body Condition Score of 2.5. CV: Coefficient of Variation

The answers to birth-type preferences were clearly different. Only "*Crianceros*" from area A preferred twins, in W preferences were balanced and the others preferred single births.

Phenotype distribution, particularly HT and CC, indicated a clear distinction by area (Table 4).

Liveweights showed no significant difference from area to area. Variation (CV) was greater in area P, over 20 %, and about 13% in the rest.

Table 5. Coordinates from correspondence analysis

	Producer's preferences		Phenotypes distribution	
Traits	DIM1	DIM2	DIM1	DIM2
White coat	0.277	-0.87	-0.640	0.453
Colored coat	-1.41	0.508	1.05	0.739
Long hair	0.568	-0.396	-0.69	0.488
Short hair	-1.21	0.397	0.96	-0.679
Areas (supplementary variables)				
Añelo (A)	1.210	0.844	-0.68	0.154
Barrancas (B)	-1.19	0.377	0.876	0.150
Pehuenches (P)	0.362	-0.482	-0.406	-0.158
Minas –Ñorquín (W)	0.468	0.023	0.154	-0.281

Ref: DIM1: first dimension or abscises; DIM2: second dimension, or ordinates.

Legend.: A: Añelo, B: Barrancas, P: Pehuenches, W: Minas-Ñorquín. HT1: long hair, HT2: short hair, CC1: white coat, CC2: colored coat.

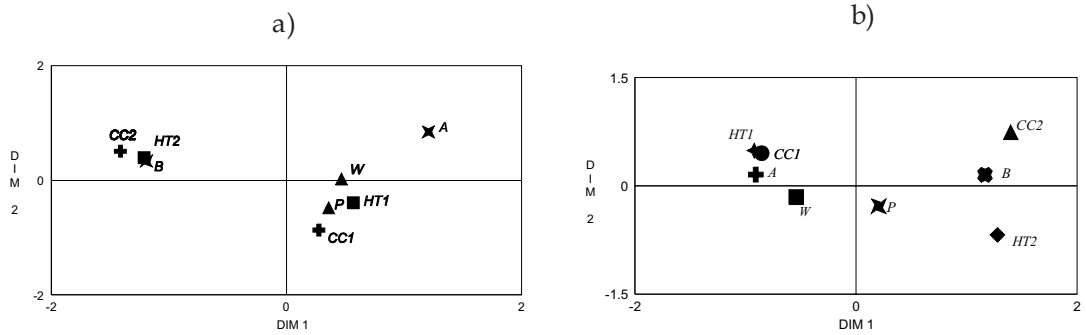

Figure 4. Graphical representation of correspondence analysis of preference of "Crianceros" (a) and phenotypes distribution (b)

Correspondence analysis allows for examining the association between different attributes. In this analysis two dimensions (DIM1 and DIM2) were taken into account. Similar values in both dimensions indicate an association among traits and Areas (Table 5).

The graphical representation of Table 5 shows the relationship between area (supplementary variable), morphological attributes and the selection criteria of the "*Crianceros*" (Figure 4a, b). Both graphs show a clear association between colored CC, short HT and B area.

Additive trees (neighbour-joining) represent Chi-squared distances between areas based on "*Crianceros*" selection criteria and on observed phenotypes (Figure 5a, b). Both dissimilarity matrixes show a significant correlation (r) of 0.78.

Discussion

In the present study, it is demonstrated that the pastoral community of Neuquen (Patagonia, Argentina) practices directional selection on their goats, which may explain an important part of their currently observed phenotypic differences (Table 3 and 4). According to Palermo (1988) directional selection was also practiced by the ancient

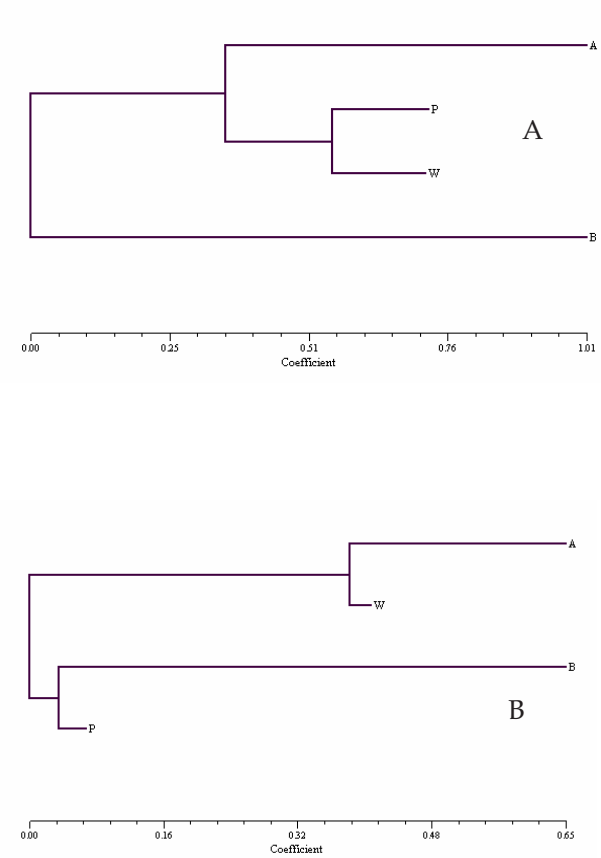

Figure 5. Additive tree representing Chi-square distances among areas; A) based on "Crianceros" preferences and B) based on phenotype.

tribes in the same region of North Patagonia, who introduced the European domestic animals to their culture.

Respondents have demonstrated the use of clear criteria to choose their replacements. The selections seem to be based on hair type and coat color, which is demonstrated by the significant correlation between selection criteria and observed phenotypes (r= 0.78). Major genes determine both traits (Lauvergne, *et al*., 1987). Less distinction is shown by the selection on size. Corrected Liveweight (CLW) by area presented a high Coefficient of Variation, particularly in area P, where CLW showed a great dispersion that suggested a strong environmental effect at work on this trait (Table 4).

Birth type is contradictorily evaluated. People from A, and to a lesser extent from W, look for twins but B and P "*Crianceros*" prefer singles. Field data of kids born in this region have shown high prolificacy particularly in B and P areas (Lanari, 2004). People want the opposite of what they have, preferring a lower level of prolificacy probably due to the husbandry difficulties associated with raising multiple births. High prolificacy would be an undesirable attribute under harsh environmental conditions (Bradford and Berger, 1988). In spite of the fact that these goats are able to rear twins even in this situation, their kids do not reach slaughter weight within a desirable timeframe. On the other hand, some "*Crianceros*" probably unconsciously select for twins, because they remain in the flock while singles are sold for slaughter.

Hair and coat color preferences have possibly been influenced by production and environmental factors. Mainly in areas W, A and less so in P, people sheared their goats in the past (Campbell and Alvarez, 1978), but this tradition was not so strong in area B. In spite of the fact that a white colored fleece is related to this shearing tradition, nowadays Neuquen Criollo goats are not shorn because their fibers do not fulfill market requirements. Acharya *et al*. (1995) suggest that white and longhair goats are more adapted to heat and high radiation. This fact seems to be an additional advantage of longhaired white goats, present in areas A and P which have an arid, continental climate. On the other hand typical Criollo hair, with an inner layer, provides important thermal protection. That is why "*Crianceros*" cull animals that show poor adaptation to cold weather; such is the case of the Anglo-Nubian goats.

The preference for colored coats in area B in the north was based on two practical points. First, colored goats are easier to find under the snow and second, color helps with the identification of kid and mother in the pen. Area B presents harder winter conditions, the snow is more persistent and twins more common (Lanari, 2004).

Artificial selection oriented to production traits and economic goals has been considered important for the creation of standard breeds in the last 200 years. The most important difference between conventional and pastoralists' selection is the relationship between the animals and the environment and the period of time involved to achieve breeding goals. Conventional selection considers individual efficiency of domestic animals in first place while the environment (husbandry, feed and health management) is modified to achieve the maximal expression of individual potential and economic success in the short term. Community selection takes the animal as a component within the environment. It means that the animals must essentially have the ability to survive and produce in a given, generally marginal, situation. As noted by Köhler-Rollefson (2000) "such populations are raised under conditions close to those obtained in the wild; therefore the breeds kept by them are most likely to retain those traits that are of greatest interest from the genetic resource angle". In this case the productive as well as the economic vision exist as a long term goal, and imply the sustainability of the whole system.

The present study emphasizes the importance of the pastoral community that bred and therefore shaped this population. In the Neuquen Criollo goat, the harsh environment has played an important role in avoiding the introduction of exotic breeds and has acted over the centuries as a force of natural selection. Isolation from nearby populations as a result of political and sanitary barriers could have accentuated the process. Other local breeds in America such as Chiapas-sheep (Pérezgrovas and Castro, 2000) and Navaho-Churro sheep (Sponenberg, 2000) are examples as well of similar developmental processes. Köhler-Rollefson (1997) proposed selection practiced by pastoral communities as a part of the breed formation process. In America this process probably took place and has been preserved only in isolated areas, where the environment includes extreme climatic conditions, either tropical or cold, and where local pastoral societies exist. In those cases the original introduced livestock in America became local breeds with a defined cultural identity.

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