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Phenotypic differentiation of exterior traits in local Criollo Goat Population in Patagonia (Argentina)

Abstract

The Neuquén-Criollo goat is a significant genetic resource, adapted to the singular harsh environment of North Patagonia. Its present gene pool was built up from different breeds since the Spanish colonization being Angora the latest introduced. High phenotypic diversity and their geographical distribution suggest a subdivision of this goat population into four close sub-areas. As phenotypic characterization was carried out on 827 Criollo adult goats. Analyse were based on fourteen quantitative (morphostructural) and eight qualitative (morphological) variables. Correspondence analyses for qualitative and canonical discriminant analysis for quantitative traits were performed, using hair types as classification variable. Results were consistent in differentiating the four considered sub-areas. Neuquen Criollo breed could be characterized in two ecotypes: Short and Long hair goats, a mixed type area and a crossbred area fulfil the types distribution. Principal divergence factors would be isolation, natural and artificial selection, transhumance and exotic breeds introduction.

Key Words: goats, Argentina, local breed, genetic resources

Zusammenfassung

Titel der Arbeit: Phänotypische Differenzierung bei Exterieurmerkmalen der lokalen Criollo Ziegenpopulation in Patagonien (Argentinien)

Die Neuquen-Criollo Ziege ist eine bedeutende genetische Ressource, die angepasst ist an die harten Umweltbedingungen Nord-Patagoniens. Der aktuelle Genpool ist seit der spanischen Kolonisierung von verschiedenen Rassen gebildet worden, wobei die Angora-Rasse die letzte eingeführte Rasse war. Phänotypische Diversität und geographische Verteilung lassen eine Differenzierung der Population in vier angrenzenden Gebieten vermuten. Eine phänotypische Charakterisierung von 827 ausgewachsenen Criollo Ziegen wurde durchgeführt. Vierzehn quantitative (morphostrukturelle) und acht qualitative (morphologische) Merkmale wurden analysiert. Deskriptive Statistik, Korrespondenz-Analyse für qualitative und Diskriminant-Analyse, für quantitative Variable wurden mit dem „Deckhaartyp“ als Klassen-Merkmal ausgeführt. Die Ergebnisse stimmen mit der vermuteten Differenzierung in vier Gebieten überein. Die Neuquen-Criollo Ziege konnte in zwei Ecotypen: kurz- und langhaarig, charakterisiert werden. Gebiete mit gemischten Typen und mit Angora gekreuzten Typen wurden identifiziert. Die wichtigsten Differenzierungsfaktoren sind Isolierung, natürliche und künstliche Selektion, Transhumanz und Einführung von exotischen Rassen.

Schlüsselwörter: Ziegen, Argentinien, lokale Populationen, genetische Ressource

Introduction

The Neuquén-Criollo goat is an important production component for more than 2000 small breeders in Patagonia, but furthermore it is a significant genetic resource, adapted to a singular harsh environment. BARKER (1997) defines the term “breed” as a cultural entity recognized as such by the community where it is found. For a local population like the Neuquén-Criollo goat, this definition represents its identification as a unique genetic resource.

Characterization of this goat breed is the first approach to a sustainable use of its animal genetic resource. According to FAO a global strategy involves: to identify and understand a unique genetic resource in a particular region and to develop the proper use of the associated diversity (FRANKLIN, 1997).

Scarce works deal with the characterization of the genetic resources of goats. Studies on diversity and variability between native goats were performed in Asia, Europe and Africa (MENRAD, 1998; HERRERA et al., 1996; CREPALDI, et al., 2001; OSTERHOFF, 1995). Few works, however, have explored the variability within undefined goat populations as, is the case of Criollo goats in America.

In Argentina there are more than four million goats of different breeds. Most of them belong to undefined populations and are bred in marginal areas of the country. These animals without a defined racial standard, called Criollo, originated during the Spanish conquest and colonization 400 year ago. Breeds like Angora and Tibetans were brought in 1826. Anglo Nubian goats were introduced early in the last century and promptly spread, mostly in the half north of Argentina. The diversity of the genetic pool, different environmental conditions along the country, free mating and natural and artificial selection gave place to different local populations. Recent studies have shown a high diversity in local goats of central, northwest and south of the country (DEZA et al., 2000; ZERPA et al., 2001; LANARI et al., 2000). These works may explain the diverse identity of local goats, considered until now as a unique gene pool with unknown genetic distinction.

In Patagonia, characterized for a harsh environment, poor rangeland and extreme climatic conditions, goat flocks are distributed on the north and west of this region. In north and central Neuquén small holders breed local Criollo goat mainly for meat production. This population was considered unproductive in the past and official efforts were aimed to change these animals for Angora breed, with a defined product like Mohair fibre or recently to get more productive crosses for milk or meat production. Angora goats were introduced into the region in the early XX century and afterwards through a planned program spread out since 1988. Nevertheless the Neuquén-Criollo population remains in those areas of North Neuquen, where Angora and other exotic breeds were not able to survive or produce efficiently.

The North Neuquen region, involves more than thirty thousand square kilometres with different landscapes. Important mountain systems are present (Fig. 1). Longitudinal and transversal valleys, uplands and isolated areas constitute the physical scenery where this population has evolved. Related to this, particular historical and cultural factors have characterized North Neuquen. In early times this region formed a territorial, social and economic unity with neighbouring regions of Chile and Mendoza Province that was restricted since 1930 and 1976 respectively. This isolation process altered social and economic activities in this region, including livestock production (PÉREZ CENTENO, 2001).

MUELLER (1994) reported four types of Criollo goats, according to their hair length and coat colour. In this work 86 % of 2730 Neuquen-Criollo goats showed down fibres. Long and short hair goats, 25 and 7 cm of staple length respectively were founded, with fleeces with and without a fine inner layer (down fibres). Preliminary field data showed that producers identify Criollo types, showing preferences for some of them according to location.

The hypothesis of the present study is that there are different ecotypes of Neuquén-Criollo goat breed and that they can be characterized through quantitative and qualitative traits, considering also genetic, historical, socio-cultural and geographical aspects. It belongs to a major characterization study, where genetic and productive aspects of this local breed are also considered. It is the first step to the sustainable use of the genetic resources of this goat population related to the traditional production system and natural resources in this area of the North Patagonia.

Materials and Methods

From 1997 to 2001, phenotypic information from 30 flocks distributed in North Neuquén (Patagonia, Argentina), between 36° and 39° Lat S, and 68° and 71° Long W was requested. According to existing information on population distribution (PALMILI, p.c.), the studied area was divided into 4 sub-areas: Añelo (A), Barrancas (B), Pehuenches (P) and Minas Ñorquin (MN). Table 1 describes the principal characteristic of each sub-area.

Table 1

Environmental conditions of the considered sub-areas (Umweltbedingungen in den untersuchten Gebieten)

Sub-area	Homogenous Ecological Area *	Altitude (masl)	Summer Temperature (°C)	Winter Temperature (°C)	Annual Rainfall (mm)
Añelo	“Monte”	400	21.9	5.7	106
Barrancas	“Cordillera norte”	1400	18.3	4.6	> 300
Minas-Ñorquín	“Cordillera norte”	1100	18.6	4.9	>400
Pehuenches	“Monte”	1200	19.9	4.6	135

Ref.: according to BRAN, 2002

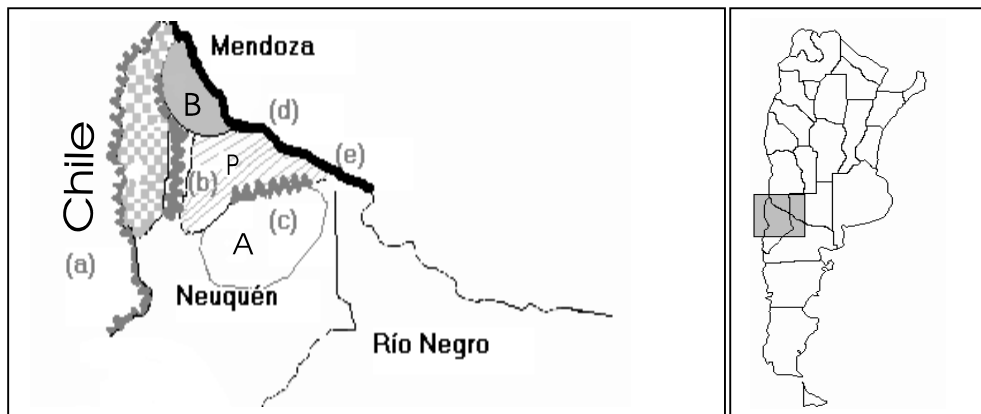


Fig. 1: Map of regional distribution of the Neuquen-Criollo goat population in the North of Patagonia (Landkarte der regionalen Verteilung der Neuquen-Criollo Ziegenpopulation in Nordpatagonien)

Hair type was used as a classification variable. Four types were considered: Long hair with down (L-D), Long hair without down (L-W), Short hair with down (S-D) and Short hair without down (S-W).

Data from 827 Criollo goats, older than 3 years, were recorded. Variables were classified by their assumed genetic determination pattern (polygenic or oligogenic), in quantitative (10) and qualitative (8) traits. Moreover four body ratios were calculated after AGRAZ GARCÍA (1981) (Table 2). Variables with a great environmental influence, as liveweight (LW) and body score (BS) were taken as reference. Information was clustered by sub-area and hair type. Descriptive statistics were obtained for quantitative (n, mean, sd) and qualitative traits (frequency).

Table 2

Analysed traits (Analysierte Merkmale)

Quantitative traits	Qualitative traits (class levels)	Ratios
RL: Rump length (cm)	HT: Hair type (4)	HR: Head ratio: HW/HL
RW: Rump width (cm)	CC: Coat colour (4)	RR: Rump ratio: RW/RL
TD: Thorax depth (cm)	W: Wattles (2)	BR: Body ratio: (BL/TP)
TP: Thoracic Perimeter (cm)	G: Goatee (2)	WLR: Weight-Length ratio
SW: Shoulder point width (cm)	CP: Cranial Profile (2)	
HL: Head length (cm)	EP: Ear position (3)	
HW: Head width (cm)	ES: Ear size (2)	
BL: Body length (cm)	HS: Horn shape (5)	
WH: Withers height (cm)		
SC: Shin circumference (cm)		

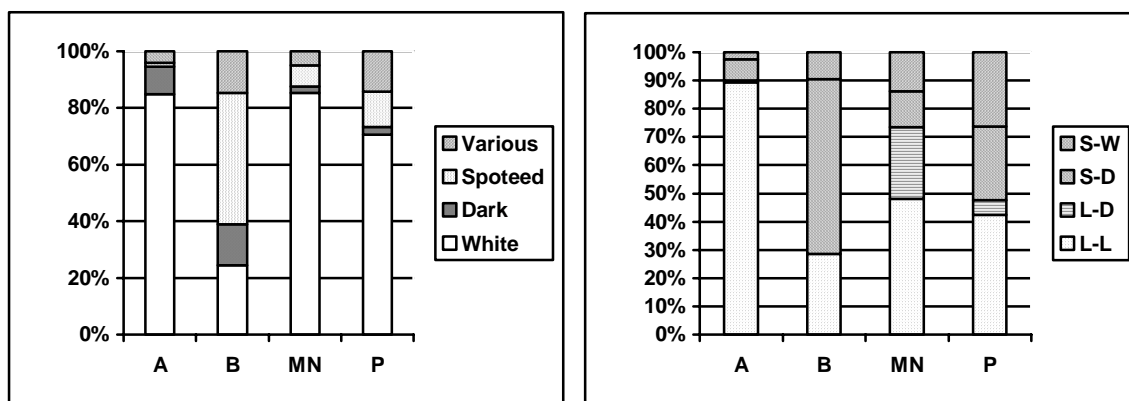
Qualitative traits association were studied through correspondence analysis (LEBART et al., 1995). A graphical representation of the relationship of variables was obtained. To examine the association between sub-area and qualitative traits, corresponding sub-area were included in the analysis as a supplementary variable.

In order to determine the degree of phenotypic similarity or divergence among sub-areas canonical discriminant analysis was performed (TOMASSONE et al., 1988). Previously variables with more discriminant power were selected. A dendrogram using UPGMA cluster analysis was constructed from Mahalanobis distance. Statistical analyses were performed with the statistical package SAS/STAT (SAS INSTITUTE, 1990).

Results

Descriptive analysis

Different frequency in hair type and coat colour by sub area was verified (Fig. 2). Barrancas showed high frequency for S-D goats (61.9 %) with heterogeneous coat colours (75.6 %) while Añelo has mostly white (84.9%) L-D (89.4%) goats. Although in Minas Ñorquín and Pehuenches all types are present, L-D goats prevailed (over 40 %). Presence of down is most frequent, showing Añelo and Barrancas more than 90 % of individuals with down. In Minas Ñorquín 39.2 % of the sampled individuals presented fleeces without down and in Pehuenches 33% (Table 3).



(a)

(b)

Fig. 2: Coat colour and hair type distribution for Neuquen-Criollo Goat, according to sub-area (Verteilung der Haarfarbe und des Haartyps der Neuquen-Criollo Ziege je Gebiet)

Descriptive analysis of quantitative traits is shown in Table 4. Few means presented differences among sub areas, showing Barrancas and Minas Ñorquín extremes values in TP (85.3 cm vs. 69.9 cm), WH (65,0 cm vs. 62.5 cm). Calculated proportions were similar, only BR showed differences between origin, where Minas-Ñorquín goats were *long linear* and other sub-areas had *meso linear* individuals.

Correspondence analyse of qualitative traits

Variables that contributed to identify differences among sampled population were: hair type, coat colour, cranial profile and horn shape. Categories contributed different to inertia to total chi-square: mainly S-D hair (23.4 %) and spotted coat (16.6 %) contributed to first dimension, S-W hair (19.5 %) and absent horns (18.8 %) to second dimension. A bidimensional graph represents association among categories of qualitative traits. Two first dimensions show clear relationship between S-D goats with coloured coats and Barrancas sub-area. On the left are associated L-D white goats, with spiral horns from Añelo and- Minas-Ñorquín that presents an approximation to L-W goats. Near the centre, Pehuenches area shows association with straight profile, arc or various types of horns and S-W hair goats (Fig. 3). It is to remark that among sub areas Pehuenches showed negligible quality of representation.

Discriminant analyses of quantitative traits

Stepwise procedure allowed the selection of the most discriminat variables: shin circumference, shoulder width point, withers height, thorax depth, thorax perimeter, head width and head length. Analysis showed that the 2 first canonical variables represented a cumulative 82 % of total variation. Variables HW and SC were the most discriminative in canonical correspondence with the ordinate axis (CAN1) and again SC and HL with coordinate axis (CAN2). Phenogram representing Mahalanobis distances shows two closer sub-areas (Minas Ñorquín and Pehuenches), joined to them Barrancas and Añelo clearly separated from them (Fig. 4).

Within sub-areas, distances among hair types showed different magnitude. In Añelo, as just mentioned, predominate L-D goats (89.4 %). Other types are poorly represented. In Barrancas, where no L-W goats were registered, L-D and S-D are closer (0.57) while S-W diverges from L-D (1.77) more than from S-D (1.26) significantly. In Pehuenches, all types were present, but only between S-W and L-D or S-D distance are significant (1.42 and 1.66 respectively). Minas-Ñorquín showed significant distance between L-W against all others types, (1.7 vs. L-D 1.17 vs. S-D and 2.09 vs. S-W); S-W diverges from the other types too (6.4 vs. L-D, 4.44 vs. S-D).

Discussion

Neuquen-Criollo goat population showed a great heterogeneity, whose current structure could be understood taking into consideration its territorial distribution and the historical and cultural context. According to historical regional development, it could be suggest that isolation from neighbours was the main factor that defined this population. The region, formerly a transit and open area, was transformed by successive restrictions in a confined territory. Principal isolation cause was the interruption of traditionally livestock exchange with Chile. The additional restriction of flock movements as a consequence of sanitary barrier with the northern Province

Mendoza increased the isolation (PÉREZ CENTENO, 2001; BENDINI et al., 1994). It could be suggested, that in south Mendoza and Chile local goat populations could have the same original gene pool and consequently evolved to similar phenotypes.

Table 3
Qualitative traits frequency, according to sub-area (Qualitative Merkmalshäufigkeit je Gebiet)

Variables	Class Level	Total n: 827	Sub-Area			
			A n: 199	B n: 213	MN n: 184	P n: 230
Hair type	L-D	0.52	0.88	0.29	0.48	0.42
	L-W	0.07	0.04	0.00	0.25	0.06
	S-D	0.28	0.06	0.62	0.13	0.26
	S-W	0.13	0.02	0.09	0.14	0.26
Coat colour	white	0.65	0.85	0.24	0.85	0.71
	dark	0.07	0.10	0.14	0.02	0.03
	spotted	0.18	0.01	0.47	0.08	0.12
	various	0.10	0.04	0.15	0.05	0.14
Wattles	1) Absence	0.94	0.89	0.98	0.91	0.96
	2) presence	0.06	0.11	0.02	0.09	0.04
Goatee	1) absence	0.18	0.02	0.15	0.18	0.35
	2) presence	0.82	0.98	0.85	0.82	0.64
Cranial Profile	1) Convexe	0.05	0.05	0.12	0.01	0.02
	2) rectilinear	0.95	0.95	0.88	0.99	0.97
Ear position	1) horizontal	0.37	0.54	0.16	0.45	0.35
	2) slightly drooping	0.50	0.45	0.62	0.47	0.44
	3) drooping	0.13	0.01	0.22	0.08	0.20
Ear size	1) long,	0.28	0.41	0.25	0.17	0.29
	2) middle length	0.72	0.59	0.75	0.83	0.71
Horn shape	1) absence,	0.06	0.14	0.02	0.06	0.03
	2) spiral,	0.07	0.10	0.10	0.08	0.02
	3) rectilinear,	0.06	0.02	0.15	0.03	0.04
	4) arch,	0.64	0.73	0.59	0.56	0.67
	5) arch and spiral	0.17	0.01	0.14	0.27	0.24

Area: A: Añelo, B: Barrancas, MN: Minas-Norquín, P: Pehuénches. LD: long hair with down, SD: short hair with down, LW: long hair without down, SW: short hair without down. Bold letter for larger frequency

Table 4
Quantitative traits statistics, according to sub-area (Quantitative Merkmalsstatistiken je Gebiet)

Variable	Sub-Area				
	Total n: 827	A n: 199	B n: 213	MN n: 185	P n: 230
	mean \pm sd	mean \pm sd	mean \pm sd	mean \pm sd	mean \pm sd
Body Score	2.26 \pm 0.71	2.20 \pm 0.6	2.42 \pm 0.7	2.32 \pm 0.7	2.13 \pm 0.7
Liveweight (kg)	39.1 \pm 6.7	38.6 \pm 6.1	41.1 \pm 7.0	37.9 \pm 5.1	38.9 \pm 7.8
Rump length (cm)	21.7 \pm 1.1	21.8 \pm 1.1	21.7 \pm 1.1	21.7 \pm 1.0	21.8 \pm 1.3
Rump width (cm)	15.4 \pm 1.1	15.7 \pm 0.9	15.5 \pm 1.4	15.2 \pm 1.1	15.2 \pm 1.1
Thorax depth (cm)	30.5 \pm 1.8	31.1 \pm 1.8	30.5 \pm 1.8	30.5 \pm 1.7	30.1 \pm 1.9
Thoracic Perimeter (cm)	81.1 \pm 7.8	81.9 \pm 5.2	85.3 \pm 10.7	69.9 \pm 5.2	79.6 \pm 7.9
Shoulder width (cm)	18.0 \pm 1.8	17.5 \pm 1.5	18.9 \pm 1.9	18.2 \pm 1.6	17.6 \pm 1.5
Head length (cm)	23.3 \pm 1.4	23.8 \pm 1.4	23.5 \pm 1.2	23.1 \pm 1.6	22.9 \pm 1.2
Head width (cm)	12.6 \pm 0.6	12.9 \pm 0.6	12.5 \pm 0.5	12.7 \pm 0.6	12.4 \pm 0.7
Body length (cm)	72.3 \pm 4.7	71.3 \pm 4.6	72.1 \pm 4.9	72.3 \pm 4.6	72.8 \pm 4.9
Withers height (cm)	64.1 \pm 3.3	64.5 \pm 3.8	65.0 \pm 2.9	62.5 \pm 3.1	64.3 \pm 2.9
Shin circumference (cm)	8.6 \pm 0.7	8.4 \pm 0.5	9.0 \pm 0.7	8.5 \pm 0.8	8.4 \pm 0.6
Weight/length ratio	0.61 \pm 0.05	0.60 \pm 0.09	0.63 \pm 0.1	0.61 \pm 0.08	0.60 \pm 0.11
Body ratio	0.89 \pm 0.08	0.87 \pm 0.06	0.88 \pm 0.08	0.99 \pm 0.07	0.91 \pm 0.07
Head ratio	0.54 \pm 0.03	0.55 \pm 0.03	0.54 \pm 0.03	0.55 \pm 0.04	0.55 \pm 0.03
Rump ratio	0.71 \pm 0.05	0.71 \pm 0.05	0.71 \pm 0.05	0.70 \pm 0.05	0.70 \pm 0.04

Ref.: A: Añelo, B: Barrancas, MN: Minas-Norquín, P: Pehuénches. Head ratio: head width/head length, Rump ratio: Rump width/ rump length, Body ratio: Body length/Thorax perimeter.

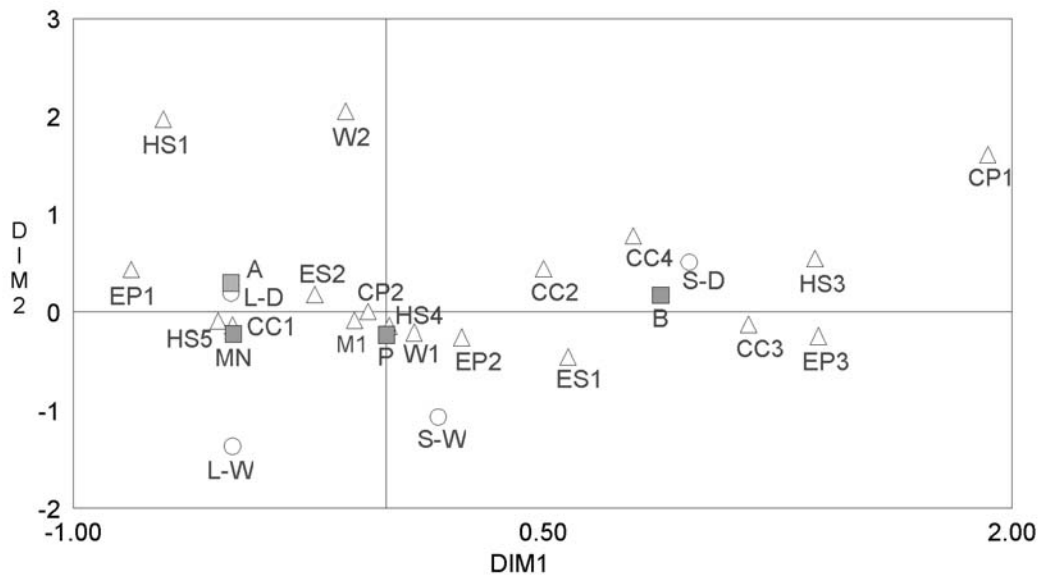


Fig. 3: Association among qualitative traits categories, resulting from correspondence analysis (Beziehungen zwischen qualitativen Merkmalsklassen nach der Korrespondenzanalyse)

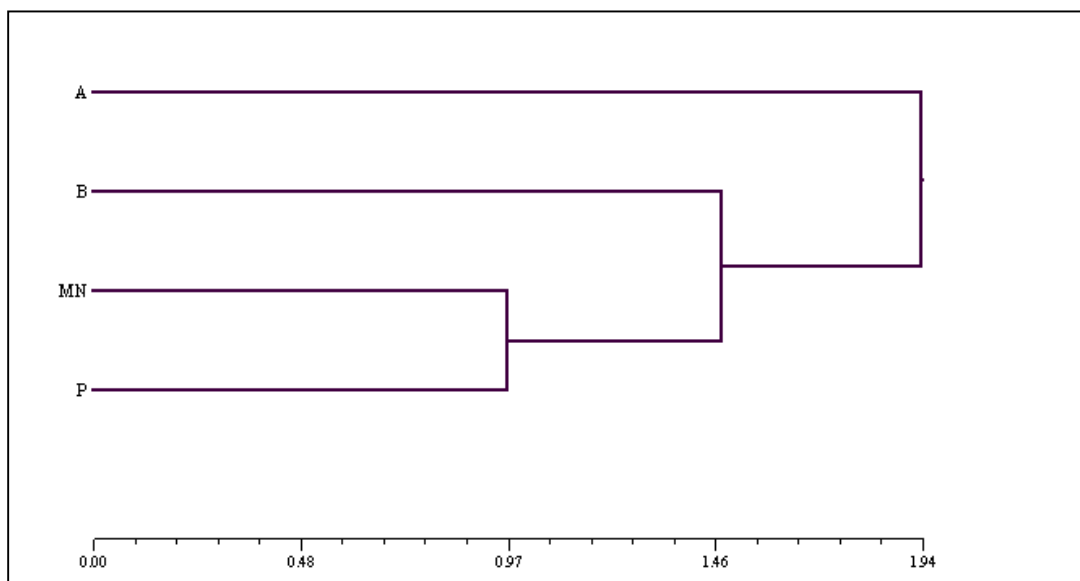


Fig. 4: Representation of Mahalanobis distance among sub-areas (Mahalanobis Distanzen zwischen den Gebieten)

NUEVO (1983) describes five types of goats in the population of the neighbouring Provinces. This author founded that short hair individuals evidence some Anglo Nubian influence. However, in our study were found 88.2 % of S-D goats, with straight cranial profile and 61.9 % with slightly drooping ears that differed clearly from the Anglo Nubian breed, with typical convex CP and drooping ears. S-D goats should have probably other origin.

According to AGRAZ GARCÍA (1981) Criollo populations would have lost size and efficiency in respect to their original ancestors. Among these breeds, only Angora goats were pure reared in similar production systems. It was found that Neuquen-Criollo goats presented higher values in size traits (WH, BL, LW) than Angora (LANARI, et al., 2000). On the other hand, in the present work smaller individuals were found in the crossbred area, located in Minas-Ñorquin.

DEZA et al. (2000) and ZERPA et al. (2001) distinguished another Criollo population in Central and North Argentina respectively. These authors referred to the actual influence of exotic breeds, mainly Anglo Nubian and Saanen. This genetic dilution process apparently did not affected to a big extent the Neuquén Criollo population. Harsh environmental conditions could have limited exotic influence. Angora introduction in north Neuquén was not successful because of its poor adaptation to range conditions of this region. In a less extent were introduced Anglo Nubian bucks but for this breed climatic conditions are intolerable and they do not survive in extensive production systems. Therefore a natural selection pressure through local extreme and harsh environmental conditions would have a positive effect on preservation of the genetic identity of this rustically local goat.

To determine racial origin head profile would be the most important trait (HERRERA et al., 1996). In this study about 90 % of sampled goats showed straight profile, thereafter Neuquen-Criollo goats would belong to Asiatic stem. Moreover hair types suggest European or Asiatic origin. An important fleece characteristic is the presence of a fine inner layer, or down fibre, typical for traditional goat populations from central Asia (MENRAD, 1998). This fibre is also associated to wild animals and would have an important role on adaptation to regional climatic conditions. The present study not only confirmed the proportion reported by MUELLER (1994) but also allowed discrimination into sub-areas. Individuals without down were found particularly in Minas-Ñorquin, strongly influenced by Angora goats.

Results of descriptive, correspondence and discriminate analysis, showed consistency about diversity distribution within this population, following a geographical pattern. There are two areas, Barrancas and Añelo, where defined S-D and L-D types were present. Mixed situation was observed in Pehuenches area, where all hair types are present and negligible differentiation among hair types within sub-area could be found. Minas-Norquín has showed also all types but furthermore some rare types, L-W and S-W, representing more than 20 and 10 % of sampled goats respectively. Particularly S-D goats from Barrancas were separated from the others types and areas.

Variables that contribute to differentiate groups among Neuquen-Criollo were similar to those found by HERRERA et al. (1996) working on Andalusian breeds and CREPALDI et al. (2001), working on goat populations from the Lombardy Alps.

Graphical representation of correspondence analysis shows closeness between central-western and southeast areas, Minas-Ñorquin and Añelo, while after discriminant analyse both central sub-areas were closer. By qualitative traits, coat colour would have played an important role in associating both sub-areas that presented more frequency in white goats.

Causes of differentiation could be, environmental conditions of each sub-area, cultural and economic factors. CAPOTE et al. (1992) have differentiated the Canary Goats Group, in defined ecotypes, from determined locations with extreme ecological differences. Even if climatic and rangeland conditions of north Neuquén are not so

severe different as in the Canary Island, there are local situations that could decide the preference or selection of a type. Different environments, described in Table 1, determine climatic variables like snowfall, extreme temperatures and aridity. After preliminary data producers of Barrancas selected S-D coloured goats. This option would be related with usual snowfall in this area. Breeders of others sub-areas preferred white coats. Probably remains the association with Angora, from early times when all goats used to be shorn.

Transhumance is cited as a dynamic factor of gene exchange (DRAGANESCU, 1997; MENRAD, 1998). Since this is a usual practice of this production system (BENDINI et al., 1994; LANARI et al., 2000) its possible consequences was further analysed.

Another important factor of significance in evolution would be the introduction of Angora breed particularly in the west area (M-Ñ), where it is common to find white goats with Angora like fleeces. On the other hand crossbred individuals show coarser fibres, with high kemp proportions, that represents a contamination for Mohair fibre. Crossbreeding has had in this case a negative effect to breeds, losing Neuquen-Criollo its rusticity and Angora its fleece quality.

Principal factors in the differentiation process would be: isolation, natural and artificial selection, transhumance and the recent introduction of Angora breed. Moreover differentiation by qualitative and quantitative traits found in the present work has to be confirmed by current studies supported on genetic markers.

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