

Analysis of Morphofaneroptic Markers of the Caprine Population of the National University of La Plata Influence Zone (Buenos Aires Province, Argentina)

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Introduction

The goat is included within the class Mammals, order Ungulates, family Bovidae, genus *Capra*, species *Capra hircus*. There are numerous theories regarding the origin of the goat, being the most accepted Auschler theory, which includes three original types of domestic goat: *Capra prisca*, currently extinct, domesticated in the Caucasus region, *Capra aegagrus*, in Asia and *Capra falconeri* (Kashmir goat). (Bedotti, 2000)

Goat breeds can be classified in different ways according to different criteria:

For the production: Dairy, butchers, hair and hunting.
Because of its origin: European and Asian

For its distribution: Spanish, European, African and Asian.

In the National University of La Plata influence region, the main breeds studied are:

CREOLE

The Creole goat cattle, is currently considered a "genetic mosaic", being the result of numerous structured crossings based on the goats of Andalusia (White Celtibérica and Blanca Andaluza breeds) and Castilla, Cádiz, León and Extremadura (Castellana de Extremadura and Verata breeds). Argentine cattle come from the goats that the Spanish conquerors brought from Peru in the XVI century. Since then and until the introduction of Angora goats of Tibet in 1826, during the government of Rivadavia and the subsequent introduction of Toggenberg, Saanen and Anglo nubian breeds in this century, that livestock

define its structure and adapting to the environment of our country, achieving the extraordinary rusticity of the current "Creole breed". Since it has not yet been characterized phenotypically as a breed, there are specimens of different size, conformation and fur. Its prolificacy and precocity are low, being usual the occurrence of two births (single or twins) in of 14-16 months.

ANGLO NUBIAN

This dual-purpose breed comes from the crossing of English, Irish and Swiss regional goats (Saanen), with males imported from Egypt (Nubia Zaraqibe), Ethiopia, Syria, Iran and India (Jamna Pari).

In our country, the first specimens were imported from Canada to the goat hut of Villa de María del Río Seco by Córdoba province government, in 1962. This cabin had an important role in spreading the blood throughout the country.

The racial standard accepts variations of any color or combination of colors, although toasted (red), brown, black, dark (black) are predominant. The coat is short, thin and shiny. The mean height at the withers in males is 80-90 cm and in females 70-80 cm. The head is triangular shape, with or without horns, convex profile and long, drooping, wide ears, hanging close to the head. The front legs are straight and strong and the hind legs, proportionate and somewhat concave, to leave space for the udder, which must be well shaped, implanted a little forward and with good size nipples.

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SAANEN

This dairy breed is native of the Saanen Valley (Switzerland). Its fur is White, slightly creamy with some freckles on the nose, eyelids, ears and udder. Its also short, thick and thin. The body is large and long. The head is large and well-proportioned, with or without horns with straight or sub-concave profile. The ears are of medium size, raised upwards and forward. The neck must be thin and long, and the legs, robust, strong and well-trained. The udder should be well implanted, uniformly developed and globular, without division with nipples of medium thickness, uniform, rather long, pointing slightly forward. The milk yield is high; in Europe with breastfeeding periods of 240 days, total productions of up to 1,200 kilos have been recorded. (Erazo Lopez, 2012)

Materials and methods

For this study, four farms in the influence region of UNLP were taken into account, these are constituted by different biotypes according to their production: FCAYF: Population composed of Creole females, paired with Saanen, Creoles and Anglo Nubian males, with their own replacement based on the

phenotype and productive capacity (prolificacy and growth).

Uribelarrea: Population formed originally by Creole females, reproduced with Anglo Nubian males with replacement of their own females selected by phenotype corresponding to the Anglo Nubian breed standard and male reproducers bought from Anglo Nubian breed.

Tambo de Arana: Goat population composed of the Saanen breed brought from the San Luis Province, with their own replacement.

Tambo de Lobos: Population initially formed by Creole goats, with subsequent incorporation of Saanen male reproducers animals and purchase of dairy line females from Inta Catamarca and others; with internal replacement based on individual production.

Sample size

For all the populations considered, both males and females of all categories were taken into account. The number of animals sampled is specified in Table I.

Table I. Number of individuals per category sampled in each farm.

Farm			Number of individuals
Uribelarrea	Adults	Females	36
		Males	2
	Chevrettes	Females	44
		Males	0
Tambo de Arana	Adults	Females	22
		Males	3
Lobos	Adults	Females	48
		Males	2
FCAYF – UNLP	Adults	Females	37
		Males	5
	Kids	Females	48
		Males	50
Total			297

Methodology for Morphological and Phaneroptic characterization of herds (Qualitative Character)

The characters of qualitative type, morphological and phaneroptic, were registered in a Microsoft Excel ® database, adapting the methodology proposed by Jordana and Ribo (1991). For the morphophaneroptic characterization, ten variants related to layer color, horns and skin were selected, which correspond to the regions of the head, trunk and limbs. (Lanari,

2003)

The morphological variables considered were:
 Frontal profile: the profile of the frontonasal region of the animal is classified by direct observation or photograph. It can be: Straight, concave, subconcave, convex or subconvex.

Length of the ears: it were classified as Short when,

in the observation, they were erect, Medium if they were dropped without exceeding the line of the lower jaw, and Long, if, while falling, they surpassed the line of the lower jaw. This variable has a great importance for racial identification. The Saanen goats have short and erect ears, and the Anglo Nubians have long ears.

The phaneroptical variables considered were:

Presence of Horns: The animals were classified according to the presence or absence of the horns.

Layer color: Base coat color of the animals, which may be diluted.

Presence of Partial Albinism: Animals were classified according to the appearance or not of white spots in any part of their body.

Presence of Wattles: The wattles are appendages with elongated form that hang from the neck in the throat area, although they can be found in other nearby locations (for example in the base of the ears). They are formed by normal epidermis and dermis, with subcutaneous tissue, some muscle, nerves, blood vessels and, often, with a central cartilage. The animals were classified according to the presence or absence of these appendages.

Color of Mucous Membranes: The animals were classified from the observation of the mucous membranes of the mouth and nose. They could be classified as Depigmented (totally pink), Partially pigmented (pink parts and dark parts) and pigmented (totally dark)

Color of hooves: According to the color that was observed in their hooves, each individual was classified as with depigmented hooves (totally white), partially pigmented (white parts and dark parts) and pigmented (totally dark)

Presence of Mule Line: The Mule Line is a black or dark hair line arranged along the dorsal-lumbar line and rump. The animals were classified according to whether or not they possess this characteristic.

Presence of Beard: each individual was classified according to the presence or absence of long hairs in the ventral part of the lower jaw.

Table II contains the qualitative characteristics considered, ordered by classes and coded.

The data collection has been made by direct observation and photographic images, especially for the description of the layer color, the pigmentary distribution pattern and complementary features.

Table II. Morphofaneroptic variables by classes and their coding.

Discrete variables	Classes				
	0	1	2	3	4
MORPHOLOGY					
Frontal profile	Straight	concave	subconcave	convex	subconvex
Ear length	Short	Medium	Long		
PHANEROPTIC					
Presence of horns	Yes	No			
Layer Color	White	Brown	Black	Black and Brown	
Presence of partial albinism	Yes	No			
Presence of Wattles	Yes	No			
Color of Mucous membranes	depigmented	partially pigmented	pigmented		
Color of Hooves	depigmented	partially pigmented	pigmented		
Presence of Mule Line	Yes	No			
Presence of Beard	Yes	No			

Statistical analysis

With the classification of each one of the individuals, of all categories, and of those animals that had previous photographic record, a Microsoft Excel® database was made. The characteristics were coded with the purpose of highlighting the existing relationships between the qualitative variables and to characterize the phenotype of the animals of all subpopulations.

The Statgraphics centurion XVI.I® Program was used to perform the descriptive statistical analysis, the Chi-square tests to evaluate differences between populations and the discriminant analysis that allows observing the distribution of the populations according to their external appearance.

The females and the males were considered as different groups because of the great sexual dimorphism in this specie, and because the number of males, for productive reasons, is considerably lower than that of females in all farms.

Results

To establish the characterization of the qualitative characteristics, 297 animals, 235 females and 62 males, belonging to 4 farms, have been observed.

The results of the morphophaneroptic characterization of the Population as a whole are expressed in Table III.

Table III. Results of the morphophaneroptic characterization of the Caprine Population of the National University of La Plata influence zone.

Variable	Class	%
Frontal profile	Straight	37
	concave	0
	subconcave	30
	Convex	14
	Subconvex	19
Ear length	Short	35
	Medium	27

	Long	38
Presence of horns	Yes	97
	No	3
Layer Color	White	27
	Brown	35
	Black	15
	Black and Brown	23
Presence of partial albinism	Yes	56
	No	44
Presence of Wattles	Yes	30
	No	70
Color of Mucous membranes	Depigmented	22
	Partially Pigmented	30
	Pigmented	48
Color of Hooves	Depigmented	28
	Partially Pigmented	24
	Pigmented	48
Presence of Mule Line	Yes	21
	No	79
Presence of Beard	Yes	33
	No	67

When performing the Chi-square test, no significant differences were found in any of the morphophaneroptic characters between the different categories because these are expressed from birth or first days of life and are maintained throughout the animal's life. But significant differences were found among the subpopulations. The results are expressed in Table IV.

Table IV. Values and significance of the Chi-Square Test for the qualitative characters among the four goat populations.

Variable	Subpopulation				X2 Value	P
	FCAyF	Lobos	Tambo Arana	Uribelarrea		
Frontal profile	a	b	c	d	136,733	<0,0001
Ear length	a	b	c	d	94,626	<0,0001
Presence of horns	a	a	a	a	5,36	ns
Layer Color	a	b	c	c	166,53	<0,0001
Presence of partial albinism	a	b	c	d	80,311	<0,0001
Presence of Wattles	a	b	ab	ab	12,139	<0,01
Color of Mucous membranes	a	a	b	c	50,869	<0,0001
Color of Hooves	a	b	c	d	87,926	<0,0001
Presence of Mule Line	a	a	b	b	15,393	<0,001
Presence of Beard	a	b	a	c	51,547	<0,0001

Different letters indicate significant differences between populations

The particular analysis of each subpopulation yields the following results:

Frontal Profile: Of the possible variations of the profile (straight, concave, convex, subconcave and subconvex), it has been found that 75% of the adult females of FCAyF have straight profile, 20% subconcave and 5% subconvex; in the adult females of Lobos, 64.58% have a subconcave frontonasal profile, 18.75% have a straight frontonasal profile, 14.58% have a subconvex profile and the rest convex; in the subpopulation of adult females from Uribelarrea, 35% have a convex profile, 33,75% have a subconvex profile and the rest have a straight profile, none of them have a concave or subconcave profile; finally, in Tambo de Arana all adult females have a sub-concave profile.

As for the males, all the animals of Uribelarrea and Tambo de Arana have a convex frontonasal profile, but in Lobos there is a male with a subconcave profile and one with a subconvex profile and in FCAyF two of the male goats have a convex profile and only one has a straight profile.

Ear length: for this character 46.34% of the FCAyF females with short ears and 41.46% with long ears were found, while the Medium Ear variant was the least number of individuals (17,07%); in the Arana population all the females have short ears, corresponding to the phenotype of the Saanen breed; also in the Lobos farm, most of the females have short ears (50%), although those with medium ears are 37.5% of the population and the females with long ears are the minority, being only 12.5% of the total; the Uribelarrea's Farm is the one with the most variability exhibits for this character, being 68.75%

of female animals with long ears, 26.25% of medium ears and a small number of short-eared animals (5%).

All the males of Uribelarrea have long ears, all the males of Lobos and Tambo de Arana have short ears and in FCAyF there are two males with short ears and one with long ears. None present medium ears.

Horns Presence: This is the only character that is not significantly different between populations, the Arana, Lobos and Uribelarrea farms have all animals with horns, both males and females, while in the FCAyF population 96.47% of the females and all the males present horns.

Layer color: This character is significantly different between subpopulations. The Arana's subpopulation, having all the individuals with Saanen phenotype, presents all white animals; in Lobos Farm, most of the animals are White (75%), but there are 10.4% of Brown and 10.4% of Brown and black and only 4.2% of Black Goats, all of the males are white; Uribelarrea's Farm, that presents a Nubian phenotype, has the majority of colored goats, as the breed standard allows, being the White coat a minority of 2.5%, the majority of the goats, 42.5%, possess black and brown coat color, 31.25% black coats and 23.75% brown coat, one male is black and the other black and brown, while in the subpopulation of FCAyF the coat with the largest representation is brown, with 56% of the individuals, followed by white, with 23%, then brown and black, with 17% and finally the black coat color is expressed in only 4% of the animals, two of the adult males are white and one is black and brown. All these colors, in almost all subpopulations can be combined with the

appearance of partial albinism, giving rise to the appearance of goats of two or three colors.

Presence of Partial Albinism: The presence of this character adds variability to the external appearance of the animals, allowing a better individual identification, in the case of Tambo de Arana, it was not possible to determine whether this character was expressed or not by the simple fact that Saanen Goats phenotype are all white therefore the phenomenon of epistasis is observed, in the other subpopulations, it is possible to observe, obtaining 18.75% of goats with presence of Partial Albinism in Tambo de Lobos, 84.81% of presence in Uribelarrea and 57% in FCAyF. As for the adult males, partial albinism is not observed in the subpopulations of Lobos and Tambo de Arana because the animals are white in their layer coat, but there is partial albinism in the two males of Uribelarrea, corresponding to the Anglo Nubian breed standard and only one adult of FCAyF shows this character.

Presence of Wattles: The appearance of these appendages of skin is found in all populations, although in different frequency. The subpopulation that has the highest number of animals with wattles is that of FCAyF, reaching 43%; the subpopulation of Uribelarrea has 23.75% of animals with this characteristic, the Tambo de Arana 27.27% and in Lobos they are only found in 16.6% of the subpopulation.

Of the males, only one in Tambo de Arana and two of FCAyF have them.

Color of Mucous Membranes: This character is closely related to the breed standard, in general, the goats whose layer color is totally white, usually have mucous membranes and hooves depigmented as well, although the pigment has a function of protection against UV lightning. The subpopulations where Saanen phenotype is predominant, such as Lobos, FCAyF and Tambo de Arana, have a greater number of animals with depigmented mucous membranes (39.58%, 35.18% and 27.27% respectively) and partially pigmented (43.75 %, 20.37% and 72.72% respectively) with a minority of goats with pigmented mucosa; however, in Uribelarrea, where the broodstock is Anglo Nubian, most of the animals have pigmented mucosa (61.25%) or partially pigmented mucosa (26.25%). As for males, in Uribelarrea farm all have pigmented mucous membranes, while in FCAyF one male has pigment and two do not, in Tambo de Arana two males have partially pigmented mucous and one depigmented and in Lobos one has depigmented mucous membrane and one partially pigmented mucous membrane.

Color of hooves: In this case something similar happens to the color of the mucous membranes. In the Uribelarrea subpopulation, 74% of the goats have colored hooves, while 22% have partially pigmented hooves and very few depigmented hooves. In FCAyF and Lobos there is greater variation, with the majority of the hooves being depigmented (48% and 46% respectively). some partially pigmented (20% and 35% respectively) and others have pigmented hooves (32% and 19% respectively). In the subpopulation of Tambo de Arana, there are no animals with totally pigmented hooves, most of them (90%) are depigmented and the rest partially pigmented.

As for the males, in Uribelarrea all have pigmented hooves, while in FCAyF two males have pigment and one does not, in Tambo de Arana two males have partially pigmented hooves and one depigmented and in Lobos one has depigmented hooves and one partially pigmented.

Presence of Mule Line: This character is quite influenced by the layer color, since it does not appear in totally white animals and there is no possibility of watch it in totally black individuals. Therefore, in the subpopulation of Tambo de Arana it was not observed in any case, in Lobos it was only observed in 4% of the population and where it was most found was in FCAyF with 29% and Uribelarrea with 21% of cases. It was not observed in any male.

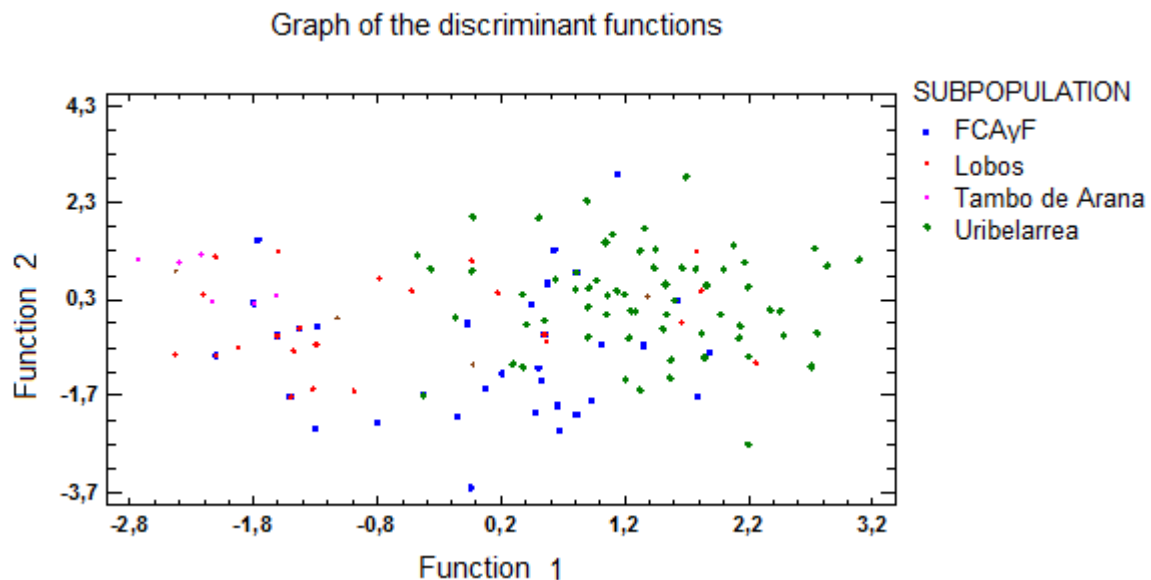
Presence of Beard: All the animals of Tambo de Arana present Beard, in the rest of the subpopulations it is a character of less frequent appearance, 40% of the goats of FCAyF express it, 33% of the animals Lobos and only 18% in Uribelarrea. All males express this character except for one of Uribelarrea's farm.

Also, from the coding assigned to each of the morphofanerotic variables for all the females of all the subpopulations, a discriminant analysis was carried out, whose result indicated that the first discriminant function explains 77% of the variance, the second explains the 18% and the third the remaining variation, all were significant ($p < 0.001$, $p < 0.001$ and $p = 0.0005$ respectively). 70% of the cases were correctly assigned. The graph of the functions (Figure 1) allowed to observe the grouping of the goat subpopulations of Arana and Uribelarrea around their respective centroids, and the greater dispersion of the animals of Lobos and FCAyF, which shows their greater morphofanerotic variability. In this graph you can see the different goat phenotypes differentiated from the observation of their phenotype, as well as their morphology. On the one hand, the subpopulation of Tambo de Arana, composed of animals of the Saanen phenotype (dairy

biotype) and the population of Uribelarra, composed of phenotypically Anglo Nubian animals (dairy biotype) around their own centroids, and on the other hand, the subpopulations of Lobos, conformed by Saanen and others breeds (milk biotype) and FCAyF composed by creole animals with Anglo Nubian and Saanen reproducers (double purpose animals) with a

much larger dispersion around their centroids.

Figure 1. Graph of the discriminant functions obtained from the coding of the variants for each of the morphophaneroptic characters of the females of each subpopulation under study.



Discussions and Conclusion

After analyzing all the results, it is concluded that each subpopulation has a particular racial composition that differentiates it from the rest, even though they share some morphophaneroptic characteristics. This could be explained in part by the composition of each population, which originally shared a creole breed founding population, but, over the years were selected by phenotypic and biotype aspect and reproduced with particular breeds. That results in differentiated subpopulations, apt to fulfill specific purposes.

Among the morphophaneroptic variables analyzed, some less informative can be distinguished than others, for example, all goats, of all populations, have horns, therefore, this feature does not provide much information for the purposes of discrimination of subpopulations, on the other hand, other variables, such as the frontonasal Profile, the length of the Ears and the Color of the Hooves have significantly different values in each group, which indicates that the racial component is different.

Although the study of morphophaneroptic characters is useful for evaluating the composition of subpopulations within a set, it is not a tool with great discriminatory power because, as the graph shows, there is a grouping of animals due to their external characteristics, but it is not independent enough to

achieve assigning an animal to a subpopulation with only this data.

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