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Abstract. In order to inventory and catalog the northern Moroccan Animal Genetic Resources, goat populations have been morphologically characterized. In 145 females and 38 males raised in 61 herds we obtained 11 zoometric variables, 4 combined indices and 8 external qualitative characters following the recommendations of FAO. Descriptive statistics for quantitative variables and frequencies for qualitative were calculated considering the effect of sex and geographical location. Three zones were established based on geo-climatic characteristics and environmental influences. An ANOVA and chi-squared likelihood test was carried out using the software Statistica 8.0 for Windows. The quantitative variables showed the existence of a low sexual dimorphism in the goat population of Morocco. Global variability was considerably high among zones (coefficient of variation > 10%) in both sexes, obtaining significant differences ($p < 0.05$) between the geographic areas in 3 measurements in males and 6 in females. Two indices had also significant differences ($p < 0.05$) in females. External qualitative traits differed significantly between the 3 zones for all parameters studied except the type of hair (mostly long) and main color (dominant black) in both sexes. Eleven variations were found, although all groups predominantly presented black (25%) and brown (25%) coat. The profile was straight (94% female and 96% male) which could be due to a common origin. These results suggest that the goat population of the Northern regions of Morocco, still uncharacterized, exhibit morphological variables that differ by location, which may be due to environmental adaptation or the differences in the origins of the animals.

Keywords. Phenotypic characterization – Northern Moroccan goat – Qualitative and quantitative traits.

Approche pour la caractérisation morphologique de la population caprine du Nord du Maroc

Résumé. *Afin d'inventorier les ressources génétiques des animaux domestiques du Nord du Maroc, des caprins ont été caractérisés morphologiquement. A partir de 145 femelles et 38 males de 61 troupeaux, nous avons obtenu 11 variables zoométriques, 4 indices et 8 caractères qualitatifs externes suivant les recommandations de la FAO. Nous avons calculé des statistiques descriptives pour les variables quantitatives et des fréquences pour les qualitatives, en tenant compte de l'effet du sexe et la localisation géographique. Trois zones ont été établies en fonction les caractéristiques géo-climatiques et les influences environnementales. Un test de probabilité de et chi-carré ont été réalisés en utilisant le logiciel STATISTIC 8.0 pour Windows. Les variables quantitatives montrent le dimorphisme sexuel faible de la population caprine du Nord du Maroc. La variabilité globale est considérée élevée entre les zones (CV > 10%) pour les deux sexes, des différences significatives ($p < 0,05$) entre les zones géographiques pour 3 mesures chez les males et 6 pour les femelles ont été observées. Les caractéristiques qualitatives externes diffèrent considérablement entre les régions pour tous les paramètres étudiés sauf le type de poils (long) et la couleur principale (noir dominant) pour les deux sexes. Nous avons trouvé 11 variations, bien que tous les groupes à prédominance noire (25%) et marron (25%). Le profil est majoritaire droite (94% femelles et 96% males), ce qui pourrait être dû à une origine commune. Ces résultats suggèrent que la population caprine du Nord du Maroc, encore non caractérisée, présentent des variables morphologiques qui diffèrent selon la région, ce qui peut être due à des adaptations de l'environnement ou à la différence des origines animales.*

Mots-clés. *La caractérisation morphologique – Population caprine du Nord du Maroc – Caractères qualitatifs et quantitatifs.*

I – Introduction

Animal Genetic Resources (AnGR) are the basis of the modern agriculture, and their diversity is an important component of global biodiversity. Maintaining the genetic diversity of species requires the definition and implementation of appropriate sustainable conservation and management programs which should be based on complete information about the structure of the population. In Morocco, there are about 5.14 million goats, (occupying a 13th place on a world scale), of which 22.6% are males and 77.4% females. In northern Morocco the population reaches about 665,000 goats representing 12% of the total national population (Jout and Karimi, 2004) and it plays a very important socio-economic role for the local human population. Farms are constituted by the mixture of a limited number of breeds or by populations often heterogeneous. Phenotypic characterization is therefore an important step in a conservation program, for the identification and classification of breeds (Dossa *et al.,* 2007). The objective of this work is the morphological characterization of northern Moroccan goat populations, searching for the possible existence of distinct ecotypes.

II – Material and methods

In 145 females and 38 males raised in 61 herds we registered 11 zoometric variables, 4 combined indices and 8 external qualitative characters following the recommendations of FAO (2012). The zoometric traits were studied measuring the bony prominences, not affected by the conformation of the animal. The traits were the following: Height at withers (HaW), Shin circumference (SC), ears length (EL), horns length (HoL), hair length (HaL), Height at rump (HaR), Rump length (RL), Height at shoulder (HS), Chest depth (ChD), Body length (BL) and Head length (HL).

The indices were reported to the height at withers, which is the best measure of development indicating environmental adaptation and is insensitive to the collection season. They were defined by: Index of proportionality (I_{PRO} = BL * 100/HaW), Index of relative chest depth (I_{ChD}= ChD * 100/HaW), Index of pelvic longitudinal (I_{PELO} = RL * 100/HaW) and Ears index (I_E = ear length * 100/HaW). Eight external qualitative characters were also obtained such as structure of hair, ear forms, horn forms, coat colors, profile, and presence of horns, wattles and beard.

Descriptive statistics for quantitative variables and frequencies for the qualitative ones were calculated. Three zones were established based on geo-climatic characteristics and environmental influences. To establish the effect of sex and geographical localization a simple ANOVA for each factor and chi-squared likelihood test was carried out using the software Statistica for Windows 8.0.

III – Results and discussion

1. Quantitative traits

The morphometric traits are similar in both sexes except the SC (Table 1). EL and HoL are higher in females and the HaL are higher in males. The body measurements were very little homogeneous according to the coefficient of variation (CV>9%) (Herrera *et al.,* 2003). There was uniformity in both sexes for HaR and the IPRO was homogenous only in males. The measures with high CV (>30%) were the length of horns and hair. The ANOVA test between sexes only showed significant differences ($p<0.05$) in SC measurements.

The global variability between geographic locations is considerably high in females (CV>10%) (Table 2). Significant differences ($p<0.05$) have been detected in 6 morphometric measurements and 2 indices. The biggest difference was observed in ear length, which is the morphological character that shows the species adaptation to temperature. The CV data was higher than that of

Table 1. Descriptive statistics and analysis of variance and differentiation between sex by morphometric measures and indices

	Female (N = 145)			Male (N = 38)			ANOVA
	Mean	SE	CV	Mean	SE	CV	F value
HaW	63.1	0.5	10.7	62.4	1.1	10.9	0.291 n.s.
SC	7.6	0.0	9.5	8.2	0.1	12.0	14.892***
HaR	66.4	0.6	8.8	66.2	1.1	8.4	0.049 n.s.
RL	15.5	0.2	14.8	15.3	0.5	17.1	0.124 n.s.
HS	40.0	0.5	12.3	40.2	1.1	14.5	0.009 n.s.
ChD	29.7	0.3	9.9	29.7	0.6	10.4	0.000 n.s.
BL	60.5	0.6	10.6	60.2	1.4	12.0	0.059 n.s.
HL	19.3	0.3	15.0	19.6	0.6	14.6	0.148 n.s.
EL	15.6	0.2	15.5	14.9	0.3	13.1	2.696 n.s.
HoL	19.9	0.7	33.7	20.8	1.6	39.8	0.308 n.s.
HaL	5.6	0.3	64.0	6.7	0.5	49.2	3.068 n.s.
I_{PRO}	93.9	1.0	10.3	95.6	1.6	8.2	0.559 n.s.
I_{ChD}	46.1	0.4	9.77	47.2	0.7	7.8	1.432 n.s.
I_{PELO}	24.0	0.3	14.8	24.3	0.8	16.3	0.124 n.s.
I_E	24.9	0.3	15.7	24.0	0.4	11.7	1.866 n.s.

n.s. = no significant (P>0.05); *P ≤ 0.05; *P ≤ 0.01; ***P ≤ 0.001; CV = Coefficient of variation; SE = Standard Error.

Table 2. Descriptive statistics and differentiation between three geographical zones by morphometric measurements and indices in female

	Zone 1 (N = 37)			Zone 2 (N = 47)			Zone 3 (N = 61)			ANOVA
	Mean	SE	CV	Mean	SE	CV	Mean	SE	CV	F value
HaW	62.9	1.4	14.2	60.6	0.9	10.2	65.1	0.6	7.5	6.113**
SC	7.6	0.1	9.2	7.5	0.1	11.5	7.7	0.0	7.9	1.621 n.s.
HaR	68.5	1.0	8.2	64.7	1.5	9.2	65.8	0.8	8.6	2.848 n.s.
RL	15.2	0.4	13.7	14.3	0.5	15.0	16.1	0.3	14.5	3.927*
HS	42.2	0.8	10.1	38.6	1.3	13.1	39.2	0.7	12.7	4.083*
ChD	30.2	0.6	11.5	28.0	0.7	11.2	29.9	0.3	7.8	3.307*
BL	61.6	1.2	10.4	57.5	2.0	13.5	60.9	0.8	9.4	2.152n.s.
HL	19.4	0.4	11.6	18.7	0.91	17.5	19.4	0.5	16.5	0.306 n.s.
EL	15.7	0.4	16.4	14.32	0.3	16.0	16.6	0.2	11.5	14.165***
HoL	20.5	1.1	29.8	18.7	1.3	40.8	20.7	1.1	29.7	0.857n.s.
HaL	4.7	0.4	60.1	5.1	0.5	72.5	6.5	0.4	57.0	3.774*
I_{PRO}	95.8	2.2	12.5	92.6	2.2	9.4	93.2	1.2	8.7	0.811n.s.
I_{ChD}	47.0	1.1	13.3	45.3	1.1	10.0	45.8	0.4	6.3	0.890 n.s.
I_{PELO}	23.6	0.7	17.4	23.1	0.6	10.9	24.6	0.5	14.2	1.288 n.s.
I_E	25.4	0.8	19.4	23.6	0.5	15.0	25.6	0.4	12.7	3.834*

n.s. = no significant (P>0.05), * P≤ 0.05; * P ≤ 0.01; *** P ≤ 0.001; CV = Coefficient of variation; SE = Standard Error.

Spanish goats obtained by Herrera *et al.* (1996). This high CV indicated the large differences between herds or the existence of disorganized crossing (Chacón *et al.,* 2011). These results could be a consequence of adaptive or selective processes, or the great geographical distribution (55,120 km^2). Furthermore, Northern Moroccan goats could have suffered different crossbreeding

with Moroccan breeds and even Spanish breeds such as the Murciana-Granadina and Malagueña (Tadlaoui Ouafi *et al.,* 2002). A low variability was reported in Spanish goat breeds by Herrera *et al.* (1996), due to the limited geographical distribution (1,850 km^2), hence inbreeding increased. The large variation shown by the high CV is a result of absence of selection. Possibly these body parts are affected more by the environment than others (Mavule *et al.,* 2012). The goats from Zone 2 were the smallest and thus clearly separated from the largest goats in Zone 3. Whilst, the animals of Zone 1 showed the intermediate values in the majority of morphometric measurements, suggesting that this zone may be considered as a great crossbred zone (Dossa *et al.,* 2007).

Table 3. Frequencies and differences between sex ([a]) and between the three zones ([b]) for qualitative phenotypic traits

		All zones		Zone 1		Zone 2		Zone 3		X^2 p-value		
Characters	**Description**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M vs F[a]**	**M[b]**	**F[b]**
Hairs structure	Very-long	76	81	63	76	79	91	82	75	0.09	0.60	0.08
	Razed	0	5	0	3	0	4	0	7			
	Long	24	15	38	22	21	4	18	18			
Ear forms	Drooping	47	41	63	27	21	15	82	70	0.45	0.00	0.00
	Erected	47	52	25	62	79	83	9	21			
	Pedunculate.c	0	1	0	3	0	0	0	2			
	Drooping.c	5	3	13	0	0	0	9	7			
	Pedunculated	0	3	0	8	0	2	0	0			
Horn forms	Ibex	45	12	50	16	53	15	27	7	0.00	0.19	0.00
	Markhar	11	43	13	43	11	55	9	34			
	Intermediate	34	39	13	24	26	30	64	54			
Coat color	Blackd	29	26	50	32	16	19	36	26	0.32	0.44	0.32
	Brown + White	11	12	0	8	11	13	18	15			
	White	8	7	13	5	11	6	0	8			
	Brown.d	26	32	25	38	32	28	18	31			
	Chamois	3	8	0	5	0	13	9	5			
	Black + White	16	10	13	8	16	9	18	11			
	Brown + Black	3	3	0	0	5	4	0	3			
	Br + Wh + Bl	5	1	0	0	11	4	0	0			
Profile	Straight	95	94	100	92	100	100	82	92	0.44	0.07	0.08
	Concave	0	2	0	5	0	0	0	2			
	Convex	5	3	0	3	0	0	18	7			
Presence of horns	No	34	39	13	24	26	30	64	54	0.61	0.04	0.00
	Yes	66	61	88	76	74	70	36	46			
Presences of wattles	No	61	70	88	81	42	51	73	79	0.25	0.04	0.01
	Yes	39	30	13	19	58	49	27	21			
Presence of beard	No	34	37	50	35	32	55	27	25	0.73	0.56	0.03
	Yes	66	63	50	65	68	45	73	75			

F = females; M = males; c = curled; d = dominant; Br + Wh + Bl = Brown + White + Black. n.s. = no significant (P>0.05); *P ≤ 0.05; *P ≤ 0.01; ***P ≤ 0.001; CV = Coefficient of variation; SE = Standard Error.

2. Qualitative traits

Table 3 showed the frequency of qualitative traits in both sexes. Hair length was mostly very-long. Ears were generally drooping and erected. Horn forms were ibex in females (72%) and *markhar* or intermediate in males (66.7 and 26.7%). The variability is evident in the coat color; 11 variations were found, although all groups predominantly presented black (25%) and brown (25%) coat. The profile was straight (>80%) and the horns were present in 60% of the animals. The profile is the most important characteristic to determine the breed origin (Herrera *et al.,* 1996). The profile was straight (94% female and 96% male) which could be due to a common origin. According to Leng *et al.* (2010), the high presence of wattles (29.3% in females and 44% in males) can be due to the selection of this trait but may also be due to adaptation. There were no significant differences ($p>0.05$) between sexes for qualitative traits.

External qualitative traits differed significantly between the 3 zones for all parameters studied except the type of hair (mostly long) and main color (dominant black) in both sexes. Dossa *et al.* (2007) found differences in the frequency of qualitative traits between goats of different vegetation zones but in our case it was not existent. The qualitative trait frequencies were different in both sexes (females of Zone 2 were more associated with the presence of horns and wattles, erected ears and ibex horns while males of the same location were more associated with the presence of wattles and beard, erected ears but *markhar* horns). The other two geographical zones had more similar qualitative traits. These results could also be explained by the same causes proposed for the variation of the quantitative traits.

IV – Conclusions

The analysis of quantitative variables shows a low sexual dimorphism in the goat population of Northern Morocco. Results for qualitative variables support the initial hypothesis regarding the existence of different ecotypes within this population. These results suggest that the goat population of Northern Morocco, still uncharacterized, exhibits values of morphological variables that differ among locations, possibly due to environmental adaptation to different climatic conditions or to differences in the origins of the animals. The goat population of the Northern regions of Morocco shows some morphologic resemblance to Spanish breeds. A study of production traits and the genetic characterization of Northern Moroccan goats will be necessary to complete this research.

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