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RESEARCH ARTICLE

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Two clear different wool phenotypes in White Majorcan ovine breed

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ABSTRACT

This study characterised two different phenotypes of the White Majorcan ovine breed, a local indigenous breed restricted to Balearic Islands. For this purpose, 20 different adult animals from phenotype "rasa" (short wooled) and "ble" (long wooled) were studied. Each sample was analysed for wool yield, fibre diameter (finesse), fibre curvature, % medullation, % kemp, F30 (percentage of fibres with a diameter < 30 µ), length of short and long fibres, and crimp, as well as wool weight, body weight and wool yield. Two phenotypes were clearly differentiated and significantly different, except for body weight, which would correspond to the "lowland" and "highland" strains described by some authors. According to the bibliography, the long wooled phenotype, which is probably the highland strain, could be considered as the oldest.

Keywords: "Blanca Mallorquina" sheep: long fibres; short fibres

INTRODUCTION

The way in which sheep interact with their environment varies between individuals. Wool traits could be used to examine these differences. Differences in the level of long staple variation in fibre diameter have been observed between individual sheep and sire groups, selection lines and bloodlines. This suggests that some sheep may be genetically predisposed to produce a certain type of wool. For example, non-medullated fine wool provides inner insulating, and thermal protection of the breed's wool should be viewed as prevalent above mechanical protection, which would be provided by medullated and coarse fibres (>35 µm) [1].

It is said that there may have been sheep on the Balearic Islands for hundreds of years. Greeks (9th and 8th centuries BC) identified Majorca with the name "Melousa", which is a toponym for "sheep land" [2]. In the 14th century textile exportations are well documented [2]. During the 18th and 19th centuries, imports from the Iberian Peninsula are also documented [2].Therefore, ovine livestock has been an important traditional source of wealth on the island of Majorca. The White Majorcan ("Blanca Mallorquina") is indigenous to the island of Majorca, being the most widespread sheep breed on the Balearic Islands (FEAGAS) (http://feagas.com/images/stories/portal/actividades/biodiversidad/2011-2012/resultados/OVINO.pdf). Males present a wither height of 73 cm and weigh 60 kg on average (FAO) (http://dad.fao.org/). The breed is included as a "breed of special protection" and in the updated official catalogue of livestock breeds in Spain. It is an ancient breed, presenting great hardiness and a high capacity to adapt to difficult media with environmental conditions of drought and high temperatures. Since 1996, a breeders association ("Associació de Ramaders de l'Ovella de Raça Mallorquina") has existed with the goal of defending and improving the breed. In 2001, the genealogical book was officially recognized by the Balearic Government. The race is distributed throughout the territory of the island of Majorca, although its largest concentration is located in the southeast [3]. Breed raising is mainly for meat production, wool currently bringing residual income to farmers. Animals are shorn every 12 months. According to the FEAGAS (http://feagas.com/images/stories/portal/actividades/biodiversidad/2011-2012/resultados/OVINO.pdf),

there are an estimated 12,258 pedigree bred animals, 275 rams and 11,983 ewes, distributed in 103 Majorcan farms (2012). More general details of the breed are provided in http://www.racesautoctones.com/index.php?id=6 (accessed on May 23rd 2015) and http://feagas.com/images/stories/portal/actividades/biodiversidad/2011-2012/resultados/OVINO.pdf (accessed on May 30th 2015). This breed is related to the sheep of the Mediterranean islands, such as the Majorcan Red - with which it shares Majorca-, Menorquina, Formentera and Eivissenca [4], all four living on the Balearic Islands, Corsican, Sardinian and Sicilian sheep (http://dad.fao.org/ [5], among others. Sadly, ancient detailed references are scarce. For instance, the classical book by Aparicio [6] on Spanish breeds does not consider it. A classical monography by Esteban [7] devotes rigorous information to the breed.

This study aims to examine wool traits in two distinctive phenotypes of the White Majorcan sheep bred: "ble" (long wooled) and "rasa" (short wooled). Two different strains are insinuated by Anguera [2] and Sánchez & Sánchez [5], and clearly stated as "llano" (lowland) and "montaña" (highland) strains in Esteban [7], differentiated mainly by fibre traits.

MATERIALS AND METHODS

Animals

The data for this study were obtained from 20 adult animals, aged at least two years, from 14 different Majorcan flocks. Ten animals were of phenotype "ble" (long wooled) and ten of "rasa" (short wooled), to which we will refer as "phenotypes". They were managed extensively, sometimes with supplementary feeding. Only those animals considered as pure breed and of apparent good health were used for this study. Field data collection was performed during sheep shearing between the months of April and July 2014. Ethical approval was not required as sampling did not represent any harm to animals.

Wool samples

Fleece samples were manually pulled from the shoulder region and kept in thick paper bags for further analysis. Each fleece was subsequently subjected to objective measurements of fibre diameter (*finesse*), fibre curvature, % medullation, F30, % *kemp*, length of long and short fibres, and crimp. Fibre diameter was measured by lanometer (OFDA 100); a total of 252,000 measurements were taken. The proportion of each type, expressed as a percentage of the total fibre number, was calculated. F30 was calculated as the percentage of fibres with a diameter < 30 µ. An overall mean for each animal was calculated as the average of each measurement. Elasticity and breaking strength were not studied. Wool analyses were performed at the Wool Testing Authority Europe Ltd (Wales). Length of short and long fibres and crimp were evaluated under microscope by the second author (JS) on 30 fibres per animal. Crude wool weight and body weight were obtained by JS, to the nearest 0.01 kg. Wool yield (%) for each animal was calculated as the proportion of crude wool weight, relative to body weight. Descriptive statistics were performed. The NPMANOVA (Non-Parametric-Multivariate-ANalysis-Of-Variance, also known as PERMANOVA) allowed us to detect differences between phenotypes for all traits. NPMANOVA is a non-parametric test of significant difference between two or more groups, based on any Mahalanobis measure [8]. The Bonferroni-p correction was performed. Finally, for the reduction of data, a Principal Component Analysis was then carried out, from the correlation matrix. The Jolliffe cut-off value may indicate the number of significant principal components [9]. Components with eigenvalues smaller than this value may be considered insignificant, but too much weight should not be given to this criterion. Univariate comparisons were undertaken with the Mann-Whitney U test.

Statistical analysis

Data were analysed using PAST [10]. Significance level was established at 5%.

RESULTS AND DISCUSSION

Descriptive statistics (range, mean and coefficient of variation) for both phenotype and for each trait studied are shown in Table 1. NPMANOVA showed significant differences between phenotypes ($p<0.001$). Results for the first nine Principal Components (PCs) appear in Table 2. Jolliffe cut-off was 0.7 and three first PCs explained 85.4%. All traits except body weight were discriminative traits in Principal Component 1, which explained 57% of the total variance observed (Figure 1) and allowed a clear separation between the two groups (Figure 2). Body weight was similar for both phenotypes (U=46.5, $p=0.820$), as well as kemp (U=41.5, $p=0.476$), and the rest of the traits studied were different between them. Wool yield appeared to be higher in long wooled animals (4.7 *versus* 3.3%, respectively).

Figure 1. Loadings for traits studied: fibre diameter (Diam), fibre curvature (Curv), % medullation (Med), F30 (percentage of fibres with a diameter < 30 µ), % *kemp*, wool weight (WW), body weight (BW), length of long (Long) and short (Short) fibres, and crimp (Crimp). This shows to what extent the different original variables (given along the x axis) enter into Principal Component 1, which explained 57% of the total variance observed.BW as the less discriminative traits.

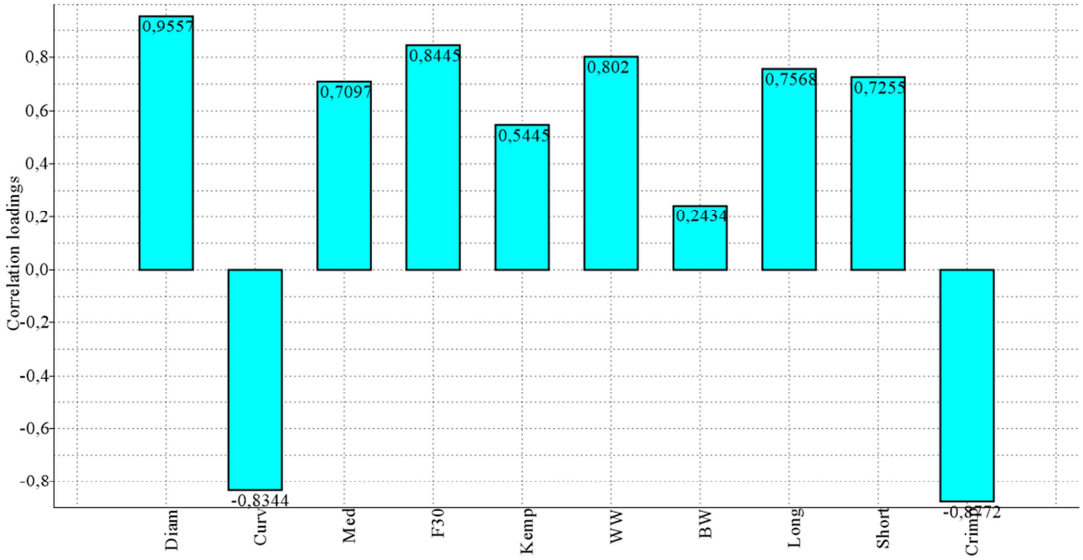

Figure 2. Principal Component Analysis for Principal Component 1 (56.9% of the variance observed) and Principal Component 2 (16.0%). Squares correspond to long wooled animals, and crosses to short fibre ones.

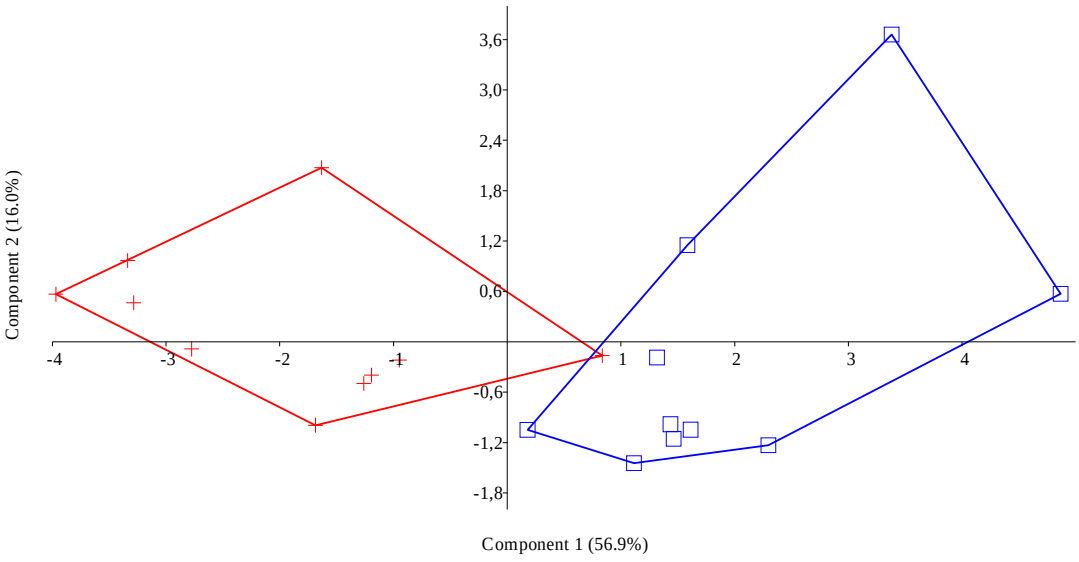

Table 1. Mean values (range, mean and CV) for the raw traits measured for both phenotypes of the White Majorcan sheep breed: "ble" (long wooled, n=10) and "rasa" (short wooled, n=10). Only body weight and kemp were similar for both phenotypes and the rest of the traits.

"Rasa" (short wooled")	Ø (µ)	Curvature	% Medullation	F30	*Kemp*	Wool weight (kg)	BW (kg)	Wool yielding (%)	Length long fibres (cm)	Length short fibres (cm)	Crimp
Min	23.8	45.8	1.51	17.6	0.0	0.8	40.3	1.7	6.3	4.0	3.2
Max	34.0	93.8	3.8	62.2	0.2	2.8	58.0	5.5	9.3	6.4	8.5
Mean ±DSt	29.0 ±8.5	64.9 ±14.1	2.4 ±0.6	39.8	0.04	1.5 ±0.5	47.0 ±5.9	3.3 ±1.0	8.2	5.1	7.2 ±1.6
CV (%)	11.2	21.7	27.9	38.3	-	37.1	12.6	31.2	12.4	16.9	22.5
"Ble" (long wooled)											
Min	31.4	36.1	2.8	46.9	0.0	1.7	37.6	3.4	14.2	6.1	2.5
Max	41.7	63.7	14.4	77.5	0.6	3.8	55.3	7.6	20.2	10.4	4.6
Mean ±DSt	35.2 ±13.5	50.2 ±7.3	5.7 ±3.4	56.8	0.13	2.2 ±0.6	47.1 ±5.0	4.7 ±1.2	16.5	8.4	3.1 ±0.7
CV (%)	7.4	14.7	59.9	15.7	-	29.8	10.7	26.5	10.4	16.4	25.1

Ø: diameter; DSt: Standard Deviation; CV: coefficient of variation; BW: Body Weight

Table 2.Results for the first 9 Principal Components (PC). Three first PCs explained 85.4% of the total variation observed. Jolliffe cut-off was 0.7.

PC	Eigenvalue	% variance	% explained variance
1	**5.694**	**56.940**	**56.940**
2	**1.601**	**16.014**	**72.954**
3	**1.248**	**12.479**	**85.433**
4	0.679	6.788	92.221
5	0.332	3.321	95.541
6	0.226	2.262	97.803
7	0.106	1.056	98.860
8	0.077	0.773	99.633
9	0.027	0.268	99.901

CONCLUSION

Are these two different phenotypes a remembrance of different influences on the breed? We must go to historical sources. Relatively recent imports from SE Peninsular breeds are documented in the 19th century [7], but with different intensities across the Island [5]. During the 20th century, influences of Segureña, Manchega and Lacaune breeds are described [7], all being entrefine wool breeds. Probably the reason for these imports was the fall in the price of wool and an increase in the significance of meat production. Old shepherds remember imports from what they call "Alicante" during the 1960s-70s. It would seem logical to suppose that these foreign influences would be bigger in lowland ("pla") areas than in hilly areas ("serra"). Thus, highland animals would remain purer, conserving the original type. Indeed, the same oral source indicates that wool from mountain areas was of higher quality but also largely more resistant to great temperature fluctuations (long wool sheep are best adapted to cool, high rainfall areas with abundant forage), thus supporting the thesis that the original type was the long wooled one. Moreover, long fibres were traditionally more appreciated in Majorcan trade. This makes sense as, for instance, long fleeces tend to become lustrous with a loose crimp (waviness), being more highly valued by niche marketers and hand spinners. Sadly, as many animals have been moved between farms, it is not possible to classify the animals sampled according to their primary origin (highland and lowland). Sánchez & Sánchez [5] cite an "isolated branch" and another "crossed and melted branch" as two different local breeds that would actually appear to be a totally mixed and heterogeneous population, and Payeras & Pons [11] state that the long wooled type would be the oldest one. The two strains, lowland ("llano") and highland ("montaña"), of Esteban [7] would also corroborate the existence of two phenotypes.

The genetic basis of wool-related phenotypic variation in White Majorcan sheep remains unknown, so knowledge of causal genetic variation has rarely been incorporated into future genetic studies. Moreover, although the current description of the breed unifies the different strains, it seems reasonable to pay more attention to the different wool structures in order to define the "purity" of the breed.

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