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Application of varimax rotated principal component analysis in quantifying some zoometrical traits of a relict cow

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Abstract : A study was conducted to determine the interdependence among the conformation traits of 28 "Pallaresa" cows using principal component analysis. Originally 21 body linear measurements were obtained, from which eight traits are subsequently eliminated. From the principal components analysis, with raw varimax rotation of the transformation matrix, two principal components were extracted, which accounted for 65.8% of the total variance. The first principal component alone explained 51.6% of the variation, and tended to describe general size, while the second principal component had its loadings for back-sternal diameter. The two extracted principal components, which are traits related to dorsal heights and back-sternal diameter, could be considered in selection programs.

Keywords : *Blanca del Pallars*, correlation, morphometry, multivariate analysis, *Pallaresa*

Introduction

Body size and conformation are important traits in meat animals [13] and phenotypic information becomes imperative [1]. Analysis of variance and product moment correlations are widely used to characterize phenotypic and genetic relationships among traits in a breeding program [14]. However, principal component analysis is a more refined technique for analyzing data on linear body measurements and performances [6, 7]. Principal components are linear combinations of the original traits and are estimated in such a way that the first principal component can explain the largest percentage of the total phenotypic variance. This paves way for the explanation and identification of trait groups, which can allow a quantitative measure for animal conformation with fewer parameters. The resulting principal components or loading may decrease the dimension of the explanatory variables.

The "Pallaresa" or "Blanca del Pallars" breed is a native population of beef cattle found in the western regions of the Catalan Pyrenees (Catalonia, NE Spain). For a long time, these animals were raised to take advantage of their three aptitudes: work, meat and milk. Since the second half of the last century, population size decreased dramatically in favor of the "Bruna dels Pirineus" breed [4] which belongs to the Brown Alpine group.

At the present time (2011), the "Pallaresa" is on the brink of extinction, as only 49 breeding animals remain (2 bulls, 36 cows and 11 veals). The four remaining herds represent the last vestiges of the breed which can be considered as a typical example of a breed in "relic state" in Catalonia while "Bruna dels Pirineus" is widely extended in the area. Its importance as genetic and cultural heritage and its contribution in maintaining the landscape and ecosystem, as well as its unquestionable interest as a tourist attraction, make it an irreplaceable element in this area [4]. In 2001 an official recovery program was initiated.

The present investigation explores the relationships among body dimensions in the "Pallaresa" breed using Principal Component Analysis (PCA) with the view of reducing the number of body measurements required in ranking programs and also to explain the body conformation.

Materials and Methods

Twenty-eight extensively managed "Pallaresa" cows from three different farms were measured. Originally 21 metric traits were obtained on each animal following standard procedure and anatomical reference points described elsewhere [3]. The body linear measurements consisted of withers height (WH), back height (BH), rump height (RH), chest height (CH), back-sternal diameter (DL), body length (BL), thorax width (TW), shoulder width (SW), thorax girth (TG), rump width (RW), rump length (RL), cannon perimeter (CP), horn perimeter (HP), outer horn length (HoL), head length (HL) and width (HW), skull length (SkL) and width (SkW), face length (FL) and width (FW), and head depth (HD). Only adult specimens (> 24 months) were included in this study,

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because the developing skeleton undergoes large changes in size and proportions during growth. Birth data was known for all animals from official individual documentation. Morphological measurements were done with a zoometric stick, a compass and a tape measure. All measurements were recorded once and by the same person (Ignasi Sinfreu, technician of the official breeding association) to avoid between-recorder effects. No specimens had missing measurements. Ethical approval was not necessary as animals were minimally manipulated. Main statistical values of each measurement were computed. The correlation coefficients and the variance-covariance values were also determined. From the variance-covariance matrix, data for the PCA with two components were generated. Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity were computed to establish the validity of the data set (KMO's measure determines whether the common factor model is appropriate. The KMO should be greater than 0.5 for a satisfactory factor analysis to proceed; for Bartlett's test, if it is significant it means that the correlation matrix is not an identity matrix). Rotation of principal components was through the transformation of the components to approximate a simple structure. The raw varimax criterion of the orthogonal rotation method was employed for the rotation of the factor matrix (the aim of the varimax rotation is to maximize the sum of variances of a quadratic weight). Cumulative proportion of variance criterion was finally employed to determine the number of components to extract. Statistic analysis was performed using Factor ver. 7.00 [5] and PAST [2].

Results

Main statistic values for linear body measurements are presented in Table 1. Eight traits were subsequently eliminated because their distribution is not normal [chest height, thorax width, rump length, head width, skull length and width, face length and width]. Pearson's coefficient of correlation matrix for normally distributed measurements is shown in Table 2. Moderate to high estimates were attained for most of the variables. In the factor analysis for the extant thirteen traits, the KMO measure of sampling adequacy was 0.725. Bartlett's test of sphericity was significant (chi-square = 321.0, $p < 0.01$). The determinant of the matrix was 0.000000412510722 and so the variance of the variables can be reproduced using the other variables.

The first two components (PC1 and PC2) were selected, accounting cumulatively for 65.8% of the variance in the remnant thirteen traits (Table 3). The first principal compo-

Table 1. Main statistic values for linear body dimensions (cm) of "Pallaresa" cows (N = 28)

	Min	Max	Mean	Std. error	Variance	Stand. Dev.	Median	Skewness	Kurtosis	Geom. mean	Shapiro-Wilk W	p (normal)
WH	124	142	131.5	0.838	19.665	4.435	132.0	0.223	-0.202	131.392	0.969	0.545
BH	127	143	133.6	0.753	15.884	3.985	134.0	0.330	-0.177	133.514	0.960	0.352
RH	130	145	136.8	0.669	12.545	3.542	136.5	0.562	0.566	136.742	0.962	0.377
CH	50	65	57.6	0.647	11.735	3.426	57.0	0.567	0.749	57.475	0.928	0.056
BL	150	175	162.5	1.320	48.778	6.984	163.5	-0.135	-0.670	162.355	0.969	0.558
TW	44	60	48.4	0.765	16.386	4.048	48.0	1.149	1.212	48.202	0.888	0.006
DL	67	86	73.9	0.782	17.136	4.140	73.5	0.871	1.353	73.784	0.950	0.202
SW	36	53	45.5	0.822	18.916	4.349	46.0	-0.179	-0.316	45.278	0.973	0.669
TG	172	204	187.6	1.440	58.025	7.617	188.0	-0.075	-0.079	187.457	0.985	0.949
RL	40	55	49.9	0.721	14.544	3.814	50.0	-1.124	1.543	49.743	0.898	0.010
RW	40	55	47.0	0.816	18.628	4.316	47.0	0.146	-0.824	46.845	0.967	0.514
HL	45	56	51.5	0.523	7.665	2.769	52.0	-0.380	-0.057	51.463	0.952	0.226
HW	21	27	23.8	0.350	3.434	1.853	24.0	0.112	-1.153	23.716	0.934	0.075
HD	33	41	37.4	0.376	3.951	1.988	37.0	-0.165	0.093	37.342	0.949	0.189
SkL	13	18	15.8	0.293	2.398	1.549	16.0	-0.475	-1.044	15.674	0.889	0.006
FL	33	40	36.1	0.302	2.557	1.599	36.0	0.843	0.705	36.056	0.891	0.007
FW	10	14.5	12.8	0.177	0.877	0.936	13.0	-0.581	1.663	12.769	0.908	0.017
SkW	17	22	19.6	0.266	1.982	1.408	19.0	0.350	-0.700	19.541	0.924	0.043
HP	14.5	20.5	17.7	0.282	2.228	1.493	17.6	-0.321	-0.161	17.659	0.968	0.531
HoL	27	33.5	30.0	0.315	2.778	1.667	30.0	0.149	-0.783	29.956	0.969	0.547
CP	19	25	22.0	0.311	2.702	1.644	22.0	-0.047	-0.630	21.905	0.950	0.197

WH: withers height, BH: back height, RH: rump height, CH: chest height, BL: body length, TW: thorax width, DL: back-sternal diameter, SW: shoulder width, TG: thorax girth, RL: rump length, RW: rump width, HL: head length, HW: head width, HD: head depth, SkL: skull length, FL: face length, FW: face width, SkW: skull width, HP: horn perimeter, HoL: horn outer horn length, CP: cannon perimeter.

Table 2. Coefficients of correlation among body measurements of "Pallaresa" cows (N=28)

	WH	BH	RH	BL	DL	SW	TG	RW	HL	HD	HP	HoL
BH	0.9526*											
RH	0.8884*	0.9535*										
BL	0.5602*	0.5854*	0.5734*									
DL	0.6827*	0.6212*	0.5515*	-0.0288								
SW	0.3076	0.1544	0.0947	0.3593	0.1161							
TG	0.7544*	0.7225*	0.7009*	0.7320*	0.3251	0.3832*						
RW	0.4461*	0.3626	0.3179	0.6616*	-0.1324	0.3995*	0.5310*					
HL	0.4314*	0.5418*	0.6013*	0.4606*	0.0924	-0.1083	0.3703	0.2803				
HD	0.6298*	0.7139*	0.6805*	0.5909*	0.2483	0.2236	0.5462*	0.3566	0.5458*			
HP	0.6205*	0.6048*	0.6334*	0.2039	0.5104*	0.2416	0.5297*	0.1045	0.1449	0.3440		
HoL	0.3883*	0.5101*	0.5929*	0.3086	0.1691	0.0613	0.4448*	0.2497	0.4615*	0.3018	0.5686*	
CP	0.6323*	0.5798*	0.5266*	0.5661*	0.2606	0.4557*	0.7441*	0.5430*	0.3705	0.6051*	0.3323	0.3244

*$p < 0.05$.

Table 3. Eigenvalues and communalities after unrotated matrix of each morphological trait of "Pallaresa" cows

Trait	PC1	PC2	Communality
WH	-0.923		0.885
BH	-0.933		0.931
RH	-0.913		0.909
BL	-0.725	0.513	0.789
DL	-0.491	-0.670	0.690
SW	-0.354	0.424	0.305
TG	-0.860		0.771
RW	-0.544	0.655	0.726
HL	-0.581		0.339
HD	-0.758		0.585
HP	-0.637	-0.434	0.594
HoL	-0.582		0.370
CP	-0.755	0.310	0.667
Eigenvalue	6.712	1.847	
% variance	51.63	14.21	

Loadings lower than absolute 0.300 are omitted.

nent (PC1) accounted for 51.6% of the total variance and clearly distinguished dorsal heights. The second PC (PC2) summarized 14.2% of the variation, and showed a differentiation pattern with back-sternal diameter.

The communalities (0.305~0.931) observed indicated that a good amount of variance has been accounted for by the component solution. For withers height, back height and rump height, it means that about 88.5%, 93.1% and 90.9% respectively of their variance has been captured by the two PC together. All traits presented coefficients > 0.300 and showed a negative relative contribution of each trait to the PC1 (Table 3). Being of the same sign, the PC1 seemed to be explaining the body size of the cow.

Discussion

Shoulder width, rump width and horn perimeter were the more variable parameters but in general all traits showed low variance. This could be attributed to a low degree of environmental effects and the same condition of all animals. The obtained metric traits were in general slightly minor than those obtained by Jordana *et al.* [4], although no statistical test has been applied to compare them. Probably the differences are due to a simple individual variation.

The result of PCA is slightly lower to those obtained by other authors. Pundir *et al.* [8] studied Kankrej cows using 18 measurements and these explained 66.0% of total variation. Salako [10] who studied Uda sheep using seven measurements and these explained 67.7% of the total variation.

Curiously, both Yakubu & Ayoade [13] in rabbit as Shahin *et al.* [12] in buffalo obtained positive loadings on all body measurements. The variables associated with withers height, back height and rump height had the highest loadings (component-variate correlations), followed by thoracic girth. It corroborates the submission of Pundir *et al.* [8], Salako [10], Shahin & Hassan [11] and Yakubu & Ayoade [13], between others, for whom the PC1 can be considered as a generalized size factor. Similarly, Ruales-España & Perdomo [9] extracted eight principal components from 31 original traits and concluded that these could be of great importance in the determination of body attributes of criole Romosinuano cow. Size can be synonymous with body mass as traits correlated with live weight, such thoracic girth, present a high communality (0.771). Moreover, as it has been seen, high relationship appeared between thoracic girth and withers height, back height and rump height, this could imply that selection for any of these traits will lead to improvement in the other. More importantly, any of these body dimensions could serve as a predictor of body mass. Thus body weight can be estimated by size. Because this multicollinearity of interdependent explanatory variables, it could lead to erroneous inferences if only thoracic girth was used as predictor. The PC2 had its loading for back-sternal diameter.

So, the use of orthogonal characters (PC1 and PC2) derived from the PCA can be more reliable in predicting body size compared to the use of the original body measurements. These first two PC could be exploited in the evaluation and comparison of animals and thus provide an opportunity to select the animals based on a small group of traits rather than on isolated traits. Our results suggest that the present PCA provided a means for a reduction in the number of biometric traits to be recorded in “Pallaresa” cows [withers height, back height, rump height and thoracic girth] which could be used in ranking programs as a mean to explain the body conformation.

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References

1. **Ali AKA, Al-Enazi M, Hayes E, Al-Saidy M.** Phenotypic factor and image analysis of type traits of Holstein cows in the Masstock Saudi herds. J King Saud Univ Agric Sci 1995, **7**, 143-161.
2. **Hammer Ø, Harper DAT, Ryan PD.** PAST: Paleontological statistics software package for education and data analysis. Palaeontol Electronica 2001, **4**, art. 4.
3. **Herrera M, Luque M.** Morfoestructura y sistemas para el futuro en la valoración morfológica. In: Sañudo C (ed.). Valoración morfológica de los animales domésticos. pp. 83-102, Ministerio de Medio Ambiente y Medio Rural y Marino, Madrid, 2009.
4. **Jordana J, Ferrando A, Marmi J, Avellanet R, Aranguren-Méndez JA, Goyache F.** Molecular, genealogical and morphometric characterisation of the *Pallaresa*, a Pyrenean relic cattle breed: Insights for conservation. Livest Sci 2010, **132**, 65-72.
5. **Lorenzo-Seva U, Ferrando PJ.** FACTOR: a computer program to fit the exploratory factor analysis model. Behav Res Methods 2006, **38**, 88-91.
6. **Miserani MG, McManus C, Santos SA, Silva JA, Mariante AS, Abreu UGP, Mazza MC, Sereno JRB.** Variance analyses for biometric measures of the Pantaneiro horse in Brazil. Arch Zootec 2002, **51**, 113-120.
7. **Posta J, Komlósi I, Mihók S.** Principal component analysis of performance test traits in Hungarian sporthorse mares. Arch Tierz 2007, **50**, 125-135.
8. **Pundir RK, Singh PK, Singh KP, Dangi PS.** Factor analysis of biometric traits of Kankrej cows to explain body conformation. Asia Australas J Anim Sci 2011, **24**, 449-456.
9. **Ruales-España FR, Perdomo CM.** Uso del análisis de componentes principales para construir un índice tipo producción en ganado Romosinuano (Bos taurus). Rev Colomb Cienc Pecu 2007, **20**, 124-128.
10. **Salako AE.** Principal component factor analysis of the morphostructure of immature Uda sheep. Int J Morphol 2006, **24**, 571-574.
11. **Shahin KA, Hassan NS.** Sources of shared variance among body shape characters at marketing age in new zealand white and Egyptian rabbit breeds. Ann Zootech 2000, **49**, 435-445.
12. **Shahin KA, Soliman AM, Moukhtar AE.** Sources of shared variability for the Egyptian buffalo body shape (conformation). Livest Prod Sci 1993, **36**, 323-334.
13. **Yakubu A, Ayoade JA.** Application of principal component factor analysis in quantifying size and morphological indices of domestic rabbits. Int J Morphol 2009, **27**, 1013-1017.
14. **Yakubu A, Salako AE, Abdullah AR.** Varimax rotated principal component factor analysis of the zoometrical traits of Uda Sheep. Arch Zootec 2011, **60**, 813-816.