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CHARACTERIZATION, REFERENCE RANGES AND THE INFLUENCE OF GENDER ON MORPHOLOGICAL PARAMETERS OF THE ENDANGERED CATALONIAN DONKEY BREED

P. Folch and J. Jordana

SUMMARY

This study characterizes morphometrically a limited-size population in danger of extinction; the Catalonian donkey breed (Spain). Sixty-nine adult individuals of both genders, forty-four jennies and 25 stallions, were characterized and analyzed for twenty-six morphological measurements and twelve corporal indices by a univariate procedure. The population showed little sexual dimorphism, since only eight of twenty-six measures and one of twelve indices showed statistically significant differences for gender effect. The analysis of correlations between measures and obtained dendrograms allowed the identification of interactions between and within the different corporal regions (head, trunk and extremities). The important morphological variability degree (coefficients of variation) shown by individuals of the Catalonian donkey breed will be of great interest to further improve the population.

Key words: Donkeys / endangered breed / morphological characters / correlation coefficient / dendrogram

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INTRODUCTION

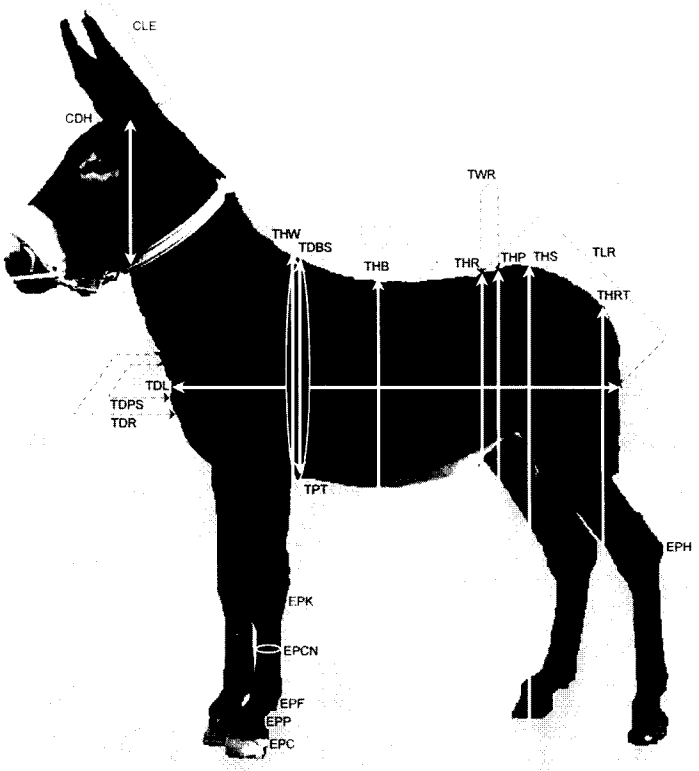
The Catalonian donkey is a local donkey breed located in several Pyrenean and pre-Pyrenean regions of the Catalonia area (Northeast Spain). The current census is very reduced, slightly surpassing one hundred individuals, a third of which, approximately, are males. These figures fit into the category of the Critical Breed (< 100 females) proposed by the FAO Expert Consultation,[1] which implies that the breed is in danger of extinction.[2]

The Catalonian donkey breed is characterized by large-sized and elongated animals with a concave profile. The coat is a black color with characteristic fadings in the muzzle, orbial zone of the eyes, belly and internal face of the extremities.[3]

The main objective of this paper is to characterize biometrically this endangered population, following the rules of action marked by the FAO Expert Consultation for the identification of possible stocks of conservation and as a basic tool for the study, maintenance and conservation of animal genetic biodiversity.[1,4]

Once established the standard type of the breed, it is necessary to analyze the degree of morphological variability of the population, so that in a near future possible objectives of selection and genetic improvement of the breed could be expounded. Thus, the existent relationship between the physical characteristics and functional aspects of animals is very well known,[5] which could be interesting concerning possible future uses of this breed.[3]

Lastly, gender effect on several morphological vari-



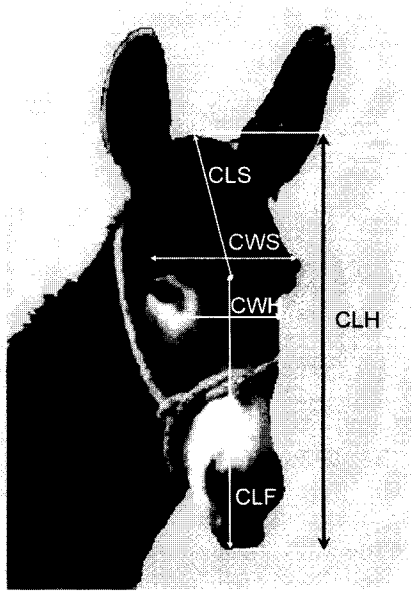


Figure **1.** (left) Morphometrical analyzed variables (codes meaning in text).

Figure **2.** (above) Morphometrical analyzed variables (head detail).

ables is analyzed, the characterization of this population possibly being able to serve as a reference point for other comparative studies within the asinus species.

MATERIAL AND METHODS

Approximately 90% of the animals having been counted, the breed population size is a total of 98 individuals, distributed in 29 foals of both genders (< 3 years old) and in 69 adults (> 3 years old), specifically: 25 stallions aged 3-13, and 44 jennies aged 3-17.

For the biometrical study, only the 69 adults have been kept in mind, and in spite of the fact that the number of animals is not too elevated, this sample could be considered as representative of the population, since it includes the near totality of the individuals utilized which are at present reproducers, individuals that form the base of the Foundational Registration of the Stud Book, starting from those which will develop the *Program of Conservation and Maintenance of Animal Genetic Resources* of the breed.

A total of 26 corporal measures, in each one of the animals of the sample, were taken; and 12 corporal indices were obtained. The anatomical references of each variable, the definition of indices, and their reference values are those described for the equine species, upon not providing reference values for asinus species.[5,6,7,8,9] The several variables were subdivided into three large groups according to corporal regions:

A) *Cephalic measures*: Head Length (CLH), Skull Length (CLS), Face Length (CLF), Head Width (CWH), Skull Width (CWS), Head Depth (CDH) and Ear Length (CLE).

B) *Trunk measures*: Withers Height (THW), Back Height (THB), Sacrum Height (THS), Rump Height (THR), Pelvis Height (THP), Root of Tail Height (THRT), Length Diameter (TDL), Back-Sternal Diameter (TDBS), Diameter between the Ribs (TDR), Point of Shoulder Diameter (TDPS), Rump Length (TLR), Rump Width (TWR) and Thoracic Perimeter (TPT).

C) *Extremities measures*: Knee Perimeter (EPK), Cannon Perimeter (EPCN), Fetlock-joint Perimeter (EPF), Pastern Perimeter (EPP), Coronet Perimeter (EPCR) and Hock Perimeter (EPH).

A measuring rule for height, width and length measures has been used, and a measuring tape for diameter and perimeter measures. All variables are shown in Figures 1 and 2.

Starting from 26 morphological variables, a total of 12 corporal indices were obtained, defined in the following manner: Body Index = (TDL x 100) / TPT, Thoracic Index = (TDR x 100) / TDBS, Metacarpo-thoracic Index = (EPCN x 100) / TPT, Skull Index = (CWS x 100) / ELS,

Table 1. Morphological measurements values in both subpopulations (males and females) of the Catalonian donkey breed.

	Corporal measurements		Mean	SD	CV	Highest	Lowest
(CLH)	Head Length	male	61.24	2.96	4.83	55	68
		female	58.25	3.83	6.58	52	66
(CLS)	Skull Length	male	27.64	2.81	10.17	21	32
		female	26.50	3.73	14.08	19	34
(CLF)	Face Length	male	40.72	5.69	13.99	27	53
		female	38.00	4.94	13.00	25	46
(CWH)	Head Width	male	25.00	1.89	7.57	21	28
		female	22.77	3.53	15.52	16	29
(CWS)	Skull Width	male	21.36	1.60	7.51	18	25
		female	19.77	1.29	6.53	17	23
(CDH)	Head Depth	male	40.44	2.87	7.10	34	45
		female	39.06	3.25	8.32	32	46
(CLE)	Ear Length	male	32.45	2.23	6.88	29	37
		female	33.81	2.61	7.73	29	40
(THW)	Withers Height	male	142.20	6.89	4.85	129	156
		female	136.29	5.95	4.36	123	148
(THB)	Back Height	male	137.44	6.64	4.83	126	152
		female	132.68	6.07	4.57	120	144
(THS)	Sacrum Height	male	143.00	6.98	4.88	127	157
		female	139.59	6.01	4.30	127	150
(THR)	Rump Height	male	139.88	6.96	4.98	125	155
		female	135.79	6.06	4.46	123	145
(THP)	Pelvis Height	male	141.80	7.73	5.45	126	157
		female	137.65	5.96	4.33	125	149
(THRT)	Root of Tail Height	male	132.60	9.43	7.11	110	155
		female	127.18	5.85	4.60	115	138
(TDL)	Length Diameter	male	145.88	7.72	5.29	132	163
		female	143.88	8.85	6.15	119	162
(TDBS)	Back-Sternal Dmtr	male	60.04	3.38	5.63	53	66
		female	59.34	3.32	5.60	52	67
(TDR)	Diameter betw Ribs	male	41.68	3.79	9.10	35	52
		female	39.45	5.03	12.76	29	50
(TDPS)	Pnt/Shoulder Dmtr	male	35.04	3.10	8.85	28	40
		female	32.40	3.34	10.31	26	40
(TLR)	Rump Length	male	45.96	2.15	4.67	42	49
		female	44.06	3.57	8.10	38	54
(TWR)	Rump Width	male	42.28	2.26	5.35	37	46
		female	43.09	3.26	7.58	37	49
(TPT)	Thoracic Perimeter	male	157.00	6.65	4.23	146	170
		female	154.70	6.12	3.95	140	169
(EPK)	Knee Perimeter	male	33.76	2.42	7.16	30	38
		female	28.95	1.52	5.26	26	33
(EPCN)	Cannon Perimeter	male	19.64	1.35	6.87	18	23
		female	17.81	1.18	6.65	15	20
(EPF)	Fetlock-jnt Perimeter	male	26.12	1.90	7.27	23	31
		female	23.20	1.95	8.44	19	28
(EPP)	Pastern Perimeter	male	19.32	1.72	8.93	16	23
		female	17.06	1.16	6.85	15	19
(EPCR)	Coronet Perimeter	male	30.44	2.77	9.10	25	36
		female	30.25	3.44	11.38	21	39
(EPH)	Hock Perimeter	male	41.12	2.31	5.63	35	45
		female	37.61	2.31	6.15	33	45

Cephalic Index = (CWH x 100) / CLH, Pelvic Index = (TWR x 100) / TLR, Pectoral Height Index = TSH / PT (Sternal Height-TSH is defined as the difference between THW and TDBS), Index 1 = (TPT / THW), Index 2 = (THW / THR), Index 3 = (TSH / THW). Index 4 = (EPCN / TSH), and Index 5 = (THW / TDL).

All this information was filed in a data base (Microsoft ACCESS 2.0) for its later utilization.

Reference ranges were calculated by use of standard deviation (SD) about the mean, and the highest and lowest values in the sample for each variable as a measure of location. Also, the coefficient of variation (CV) has been obtained as a unitless measure of relative variability (the ratio or the standard deviation to the mean expressed as a percentage).

Correlation coefficients (Pearson's product-moment) between the variables have been calculated. Probability values of < 0.05 were considered significant. In order to

Table **2.** Corporal Indices values in both subpopulations (males and females) of the Catalonian donkey breed

Corporal Indices		Mean	SD	CV	Highest	Lowest
Body Index	male	92.97	4.41	4.74	81.43	99.37
	female	93.03	5.04	5.41	81.50	105.88
Thoracic Index	male	69.58	6.88	9.88	57.37	83.63
	female	66.56	8.41	12.64	52.72	85.18
Metacarpo-thoracic Index	male	12.50	0.61	4.93	11.32	13.77
	female	11.52	0.73	6.41	9.86	12.85
Skull Index	male	78.04	9.95	12.75	64.51	100.00
	female	76.15	12.55	16.47	56.66	109.52
Cephalic Index	male	40.85	2.83	6.94	33.87	45.16
	female	39.01	4.93	12.64	26.66	45.61
Pelvic Index	male	92.13	5.69	6.18	77.08	104.65
	female	98.06	7.10	7.24	86.04	117.07
Pectoral Height Index	male	0.52	0.02	4.86	0.47	0.56
	female	0.49	0.00	5.77	0.44	0.56
Index I	male	1.10	0.04	4.18	1.02	1.21
	female	1.13	0.04	3.64	1.04	1.23
Index 2	male	1.01	0.01	1.41	0.90	1.04
	female	1.00	0.01	1.71	0.95	1.05
Index 3	male	0.57	0.01	2.02	0.55	0.60
	female	0.56	0.01	3.30	0.52	0.60
Index 4	male	0.23	0.01	4.84	0.21	0.26
	female	0.23	0.01	7.09	0.18	0.26
Index 5	male	0.97	0.04	4.58	0.88	1.07
	female	0.94	0.04	5.05	0.85	1.07

view the existent relationships between variables of a graphic form (dendrogram), the method of cluster analysis using the UPGMA algorithm[10] was applied to the correlation coefficient values by using the PHYLIP computer package.[11]

Both genders have been considered independently since there is a possible sexual dimorphism for some of the measures. Statistical differences for this factor of variation were analyzed by the ANOVA test. Computations were performed using a statistical software program.[12]

RESULTS AND DISCUSSION

Reference corporal measurements of male and female Catalonian donkeys are shown in Table 1, and corporal indices are shown in Table 2.

Large differences between genders for the studied parameters were not observed, since only 8 of 26 corporal measures and 1 of 12 corporal indices analyzed showed significant differences: EPCN, EPK, EPP, CWS ($P< 0.001$); THRT ($P< 0.01$); THR, TLR, CWH, Index 3 > ($P < 0.05$), which would indicate that the population shows little sexual dimorphism. The greatest differences between genders are reported, above all, in the cephalic level (CWH, CWS), height from posterior third (THR, TLR, THRT) and extremities perimeters (EPCN, EPK, EPP), always showing males more elevated values than females, such as other authors confirm in several saddle-horse breeds.[5,8,13,14] In view of these results it could be interpreted that females are, in general, of a finer and more slender physical appearance than males.

A. Cephalic measures

Two of seven cephalic variables showed significant differences between genders, CWS ($P<0.001$) and CWH ($P< 0.05$). Males had a wider skull and head than females did, in a similar way to that found by other authors in saddle-horse breeds.[5,13]

Cephalic variables showed, in general, as much in males as in females, an elevated coefficient of variation (CV). These results would indicate, in principle, that a high degree of morphological variability for these characters in the population exists although interpretation of results should be taken with caution, since when in vivo measuring was carried out, several environmental factors could exist that influence in measurements, the temperamental state of the individual, mainly with the subsequent difficulty in the precise localization of anatomical reference points.

B. Trunk measures

Upon analyzing "summit line" measures, which define animal height, one could observe that they are those that show a lower variation coefficient in both genders. This is important, since it is these measures that fundamentally define the animal profile, and this could be, in the future, a preferential selection objective. From analysis of height variables shown in Table 1, it can be observed that males, as an average, possess greater stature than females although the obtained values were not statistically significant, except for THR ($P< 0.05$)and THRT ($P < 0.01$); rump length (TLR) also showed significant differences between

genders ($P < 0.05$), all these values being higher in males than in females.

Some thoracic measures (TDR and TDPS) have a relatively high coefficient of variation as much in males as in females (CV > 8.8), the females also showing higher values than males (CV > 10). The two diameters (TDR and TDPS) behave in a similar form although TDPS shows a slightly smaller variability degree. In a general way, we suppose that some of these variability values could be overestimated, mainly those measures in which it is difficult to determine the anatomical reference points, depending on physiological (pregnancy or not), nutritional (fatty and muscular tissue) or temperamental states of the animal. Nevertheless, elevated coefficients of variation for variable TDR (CV > 10) have also been described in the PRE equine breed (*Pura Raza Español -Spanish Pure Breed-*).[13] The greatest variability degree that shows female subpopulation with regard to male subpopulation for these thoracic variables could argue partly as a consequence of the different management system that exists between both genders, since the great majority of females are breeding in a free pasture regime while males are accustomed to always being stabled. The effect of the environmental factor of exercise or the absence of it, could be responsible for the different degree of variability shown by both subpopulations. This important phenotypic variability (partially genetic) shown in the Catalonian donkey breed will be of great interest in a near future when possible objectives of genetic improvement in the breed begin to be expounded.

C. Extremities measures

As for variables that define the extremities of the animal, it was observed that it is in this corporal region where sexual dimorphism becomes more patent, in a similar way to that which is described in equine populations of PRE,[13] since three of six variables, EPC, EPK and EPP, showed highly significant differences ($P < 0.001$). All the perimeters showed superior figures in males, the coefficients of variation being elevated, although quite similar between genders.

D. Corporal indices

The described corporal indices were proposed, designed and utilized based upon the saddle horse classification.[13,15,16,17,18–22] Given that measurements and proportions from this asinus breed are so stylized, and in the absence of previous studies on the topic, it was decided to make use of them as well as of their reference values,[6,7,8,9] always interpreting the results keeping in mind that it is about a breed of asses. The ANOVA test only showed significant differences between genders for Index 3 ($P < 0.05$).

The Body Index (BI) gives one an estimate of the proportions of the breed and allows the classification of the animals as longilinear (BI≥90), mesolinear (BI≥84 and ≤89) or brevilinear (BI≤83). The obtained values (BI > 92) permitted the classification of our animals as longilinear. This morphology was confirmed as well by the Thoracic Index (TI < 70), which indicates the compact degree of the thoracic chest and it also permits classifying individuals as longilinear (TI≤ 83), mesolinear (TI≥84 and ≤89) or brevilinear (TI≥90), showing that these animals are slim and slender. According to other authors, females are somewhat wider than males due, mainly, to their reproductive function.[23,24]

The Metacarpo-Thoracic Index, indicates what the animal format is like, that is to say, it shows us the existent relationship between the mass of individuals and the members that sustain it, allowing one to define three types of animals: hypermetric, eumetric and elipometric. The results obtained allowed the classification of the animals as of the hypermetric format, since in both genders its value was superior to 11, the reference value given for horse breeds.[8]

The Skull Index as well as the Cephalic Index indicate whether the head proportions are harmonious, giving us an idea of the compactness of the same, that is to say, they indicate whether longitudinal diameters prevail on transverses or vice versa, and it allows classification of individuals as brachycephalic (Index > 100) or as dolichocephalic (Index < 100), in this case verifying that it is about animals of the dolichocephalic type.

The Pelvic Index (PI) gives us an idea of the structure of the rump, and is very related with the THRT variable that indicates the tail insertion point (up, middle or down), characteristic that has permitted the typifying of a lot of equine breeds.[6] A very proportionate rump shows a width approximately equal to its longitude ($PI \approx 100$), which we could define as horizontal; if the obtained values are < 100, it is a convex line rump, and if they are superior, concaviline. In this study, it is about animals with a convex rump and a low tail insertion -THRT- (Index values < 100), which allow one to define the pelvis as convexiline.

Index 1 relates thoracic perimeter (TPT) with withers height (THW), and according to Lesbre[17] one should distrust such an animal of work aptitude, for its direct relationship with resistance to fatigue, when its TPT does not exceed the THW by at least 1/8, that is to say, when the ratio between both variables is not ≥ 1.125. For the results shown in Table 2, it could be observed that males have an Index 1 slightly inferior to the referred value (Index 1 = 1.10), which would indicate that its thoracic chest would be proportionally smaller, in relationship to the height that they reach, than ideally desirable for an animal of work aptitude. On the other hand, females transcend this index (Index 1 = 1.13), although obtained values in the two subpopulations were not significantly different. Depending on which is the orientation of the future economic perspectives of the breed that the *Association of Fomenta-*

Table **3.** Morphological correlation matrix among male corporal measures of the Catalonian donkey breed.

	CLH	CLS	CLF	CWH	CWS	CDH	CLE	THW	THB	THS	THR	THP	THRT	TDL	TDBS	TDR	TDPS	TLR	TWR	TPT	EPK	EPCN	EPF	EPP	EPCR	EPH
CLH	1.00																									
CLS	0.28	1.00																								
CLF	0.46a-	0.43a	1.00																							
CWH	0.43a	0.57b	0.00	1.00																						
CWS	0.25	0.17	-0.01	0.54b	1.00																					
CDH	053b	0.40a	0.10	0.40b	0.22	1.00																				
CLE	0.12	0.11	-0.23	0.37	0.41	0.50a	1.00																			
THW	0.68c	0.06	0.35	0.10	0.09	0 59c	-0.02	1.00																		
THB	0.68c	0.23	0.23	0.26	0.21	0.65c	0.12	0.94c	1.00																	
THS	0.72c	0.09	0.44a	0.25	0.17	0.51b	-0.07	0.93c	0.93c	1.00																
THR	0,72c	0.14	0.32	0.21	0.18	0.60c	-0.02	0.95c	0.97c	0.96c	1.00															
THP	0.73c	0.09	0.42a	0.23	0.22	0.55b	0.01	0.95c	0.96c	0.97c	0.98c	1.00														
THRT	0.33	0.04	0.18	-0.02	0.06	0.42a	0.00	0.64b	0.61c	0.53b	0.58b	0.55b	1.00													
TDL	0.27	0.11	0.06	0.09	0.31	0.48a	0.27	0.60b	0.59c	0.45a	0.53b	0.55b	0.49a	1.00												
TDBS	0.62c	0.15	0.21	0.26	0.18	0.63c	0.27	0.87c	0.83c	0.78c	0.80c	0.82c	0.65b	0.60b	1.00											
TDR	0.49a	0.04	0.44a	0.45a	0.40	-0.10	-0.28	0.24	0.19	0.42a	0.32	0.37	-0.05	-0.10	0.15	1.00										
TDPS	0.21	0.00	0.01	0.13	0.22	0.41a	0.04	0.46a	0.37	0.35	0.38	0.42a	0.30	0.58b	0.49b	0.27	1.00									
TLR	0.37	-0.27	0.47a	-0.07	-0.10	-0.02	-0.20	0.50a	0.44a	0.57b	0.49a	0.5lb	0.28	0.13	0.36	0.24	0.12	1.00								
TWR	0.12	0.14	-0.32	0.19	0.07	0.15	-0.10	0.04	0.01	0.03	0.04	-0.02	0.04	-0.05	0.05	0.18	0.24	0.25	1.00							
TPT	0.58b	-0.08	0.62c	0.32	0.21	0.31	0.10	0.58b	0.53b	0.62c	0.55b	0.66c	0.39	0.49b	0.58b	0.47b	0.61c	0.50b	0.01	1.00						
EPK	0.60b	0.02	0.34	0.21	0.42a	0.59b	0.16	0.85c	0.84c	0.83c	0.84c	0.86c	0.48a	0.60b	0.81c	0.22	0.33	0.31	-0.14	0.52b	1.00					
EPCN	0.55b	0.21	0.50b	0.04	0.31	0.36a	0.15	0.75c	0.65c	0.71c	0.66c	0.74c	0.39	0.57b	0.65c	0.32	0.49a	0.48a	-0.22	0.67c	0.66c	1.00				
EPF	0.71c	0.07	0.45b	0.32	0.43a	0.53b	0.19	0.75c	0.72c	0.74c	0.72c	0.78c	0.30	0.45a	0.64c	0.45a	0.50b	0.34a	-0.02	0.65c	0.78c	0.81c	1.00			
EPP	0.57b	-0 01	0.58b	0.24	0.39	0.39	0.08	0.71c	0.68c	0.73c	0.71c	0.78c	0.36	0.55b	0.66c	0.39a	0.41a	0.31	-0.33	0.70c	0.82c	0.83c	0.78c	1.00		
EPCR	0.13	-0.23	0.40b	0.25	0.33	0.13	0.23	0.42a	0.45a	0.48a	0.43a	0.5lb	0.28	0.31	0.40a	0.31	0.41a	0.28	-0.25	0.55b	0.43b	0.47b	0.5lb	0.54b	1.00	
EPH	0.56b	-0.12	0.17	0.30	0.32	0.52b	0.22	0.67c	0.72c	0.62c	0.70c	0.73c	0.33	0.66c	0.61c	0.25	0.57b	0.01	-0.24	0.55b	0.77c	0.61c	0.68c	0.72c	0.42a	1.00

a (P<0.05); b(P<0.01); c(P<0.001)

tion of the Catalonian Donkey Breed (AFRAC) believe most convenient (work, agro-tourism, sport,...), it perhaps would be interesting to select breeding animals for their resistance and capacity of work again, like those that historically gave worldwide fame to this breed.[25]

Index 2 relates withers height (TWH) with rump height (THR), so that an animal is considered as very proportionate if the two measurements should be equal, that is to say, the value of Index 2 should be the same or similar to 1. Higher values indicate that it is about animals with an anterior region more elevated than the posterior, transferring the center of gravity to posterior extremities in this manner and, therefore, overloading them. From analysis of obtained values in our population we could conclude that these animals are very well proportioned (values of 1.01 and 1.00, for males and females, respectively), although they show a slight and recognized tendency (Table 1) that the anterior third is slightly more elevated than the posterior.[26]

Index 3 relates sternal height (TSH) with withers height (TWH), and according to Oom,[9] the value of this index should not transcend the 0.50-0.55 interval. The obtained average values for this breed, for males (Index 3 = 0.57) as well as for females (Index 3 =0.56) transcend this value slightly, signifying that back-sternal diameter (TDBS) would be proportionally minor in relationship to the reached height (TWH), that is to say, they would be animals with slightly lengthened extremities, also named "distanced from land." The conclusions of this index, as for the proportionality of individuals, are very similar to those obtained for Index 2.

Index 4 relates cannon perimeter (EPCN) with sternal height (TSH). In saddle-horse breeds and according to Menezes,[20] for each centimeter of cannon perimeter

(EPCN) 4 cm of sternal height (TSH) should correspond; that is to say, Index 4 should have a value close to 0.25. In our case, and as a characteristic feature of the asinus species, it was observed that the EPCN is smaller than in horses, in females as well as in males.[5,9,13] This makes the value of this index smaller than the described values by the above author, and we should thus consider it as much of an indicator of osseous feebleness of extremities.

Index 5 relates withers height (THW) with length diameter of the individual (TDL). Ideally, a very proportionate animal should show an index value equal to 1, at which these indiduals would describe a perfect square. Several authors[13] grant great importance to this index for ethnic classification, so that mesolinear animals would describe a square (Index 5 = 1) brevilinear animals would deviate in favor of THW (Index 5 > 1), and longilinear animals in favor of TDL (Index 5 < 1). In our population, the value of this index, much in males (0.97) as in females (0.94), was lower than one unit, indicating that they adjust to a longilinear format pattern, such as the Body and Thoracic Indices confirmed.

Correlations

Correlation coefficients among 26 morphological variables included in this study, differentiated by genders, are shown in Tables 3 and 4. The great majority of values were shown to be positive, except for some exceptions in that they were negative, more in males than in females, although none of them was statistically different from zero (except CLF vs CLF, in the male subpopulation, r= -0.43; P< 0.05).

From the analysis of obtained results, we have been able to observe, in global form, that a higher correlation degree among morphometric variables in the female than in the male subpopulation exists, in a similar way to that reported by other authors in several equine populations.[5,9,13] Likewise, at the corporal region level (head, trunk and extremities), the intra-region correlations were significantly higher for trunk and extremities than for cephalic measurements, in males

Table **4.** Morphological correlation matrix among female corporal measures of the Catalonian donkey breed.

	CLH	CLS	CLF	CWH	CWS	CDH	CLE	THW	THB	THS	THR	THP	THRT	TDL	TDBS	TDR	TDPS	TLR	TWR	TPT	EPK	EPCN	EPF	EPP	EPCR	EPH
CLH	1.00																									
CLS	0 56c	1.00																								
CLF	0 30a	0.01	1.00																							
CWH	0.66c	0.53c	-0.10	1.00																						
CWS	0.42b	0.22	0.36b	0.18	1.00																					
CDH	0.65c	0 43b	0.26a	0.62c	0.29	1.00																				
CLE	0.34b	0.01	0.00	0 14	0 12	0.02	1.00																			
THW	0.35b	0.08	0.56c	0.08	0.52c	0.40b	0.18	1.00																		
THB	0.50c	0.23	0.54c	0.27	0.57c	0.54c	0.15	0.93c	1.00																	
THS	0.44b	0.17	0.65c	0.12	0.40b	0.44b	0.13	0.90c	0.90c	1.00																
THR	0.46b	0.22	0.59c	0.21	0.46b	0.50c	0.13	0.92c	0.94c	0.93c	1.00															
THP	0.44b	0.20	0.63c	0 14	0.43b	0.43b	0.13	0.91c	0.90c	0.96c	0.97c	1.00														
THRT	0.52c	0.28	0.47b	0.27	0.47b	0.48c	0.17	0.85c	0.87c	0.86c	0.85c	0.84c	1.00													
TDL	0.25	0.01	0.32b	0.03	0.47b	0.34a	0.42a	0.65c	0.58c	0.55c	0.54c	0.5lc	0.54c	1.00												
TDBS	0.58c	0.49c	0.29	0.40b	0.49c	0.51c	0.34a	0.68c	0.67c	0.60c	0.61c	0.61c	0.62c	0.66c	1.00											
TDR	0.57c	0.50c	0.35a	0.50c	0.08	0.37a	-0.14	0.18	0.28	0.33a	0.32a	0.36b	0.18	-0.15	0.30a	1.00										
TDPS	0.69c	0.65c	0.12	0.57c	0.42b	0.49c	0.27	0.27	0.32b	0.30a	0.31a	0.32b	0.32b	0.26	0.65c	0.55c	1.00									
TLR	0.32a	0.53c	0.24	064c	0.29	0.59c	-0.02	0.32a	0.42b	0.37a	0.42b	0.39b	0.35a	0.16	0.58c	0.72c	0.65c	1.00								
TWR	0.63c	0.43b	0.20	0.22	0.35a	0.43b	0.08	0.48c	0.50c	0.42b	0.46b	0.45b	0.40b	0.31a	0.59c	0.33a	0.55c	0.59c	1.00							
TPT	0.25	0.20	0.39b	0.00	0.33a	0.40b	0.00	0.65c	0.59c	0.62c	0.59c	0.59c	0.48c	0.55c	0.63c	0.25	0.41b	0.39b	049c	1.00						
EPK	0.51c	0.21	0.56c	0.22	0.50c	0.48c	0.45b	0.76c	0.76c	0.74c	0.75c	0.75c	0.64c	0.70c	0.70c	0.28	0.47b	0.40b	0.48c	0.52c	1.00					
EPCN	0.46b	0.14	0.50c	0 09	0.40b	0.30a	0.61c	0.65c	0.62c	0.63c	0.59c	0.62c	0.56c	0.64c	0.68c	0.17	0.39b	0.26a	0.35b	0.43b	0.81c	1.00				
EPF	0.51b	0.31	0.43b	0.36a	0.47b	0.48c	0.39b	0.66c	0.64c	0.57c	0.63c	0.63c	0.59c	0.56c	0.77c	0.28	0.48c	0.42b	0.39b	0.45b	0.81c	0.75c	1.00			
EPP	0.34a	0.12	0.47b	0.14	0.38a	0.42b	0.26	0.64c	0.61c	0.65c	0.63c	0.65c	0.56c	0.52c	0.60c	0.16	0.36b	0.20	0.37b	0.51c	0.73c	0.76c	0.74c	1.00		
EPCR	0. 15	-0.05	0.47b	-0.07	0.38a	0.18	0.43b	0.61c	0.55c	0.5lc	0.52c	0.52c	0.50c	0.44c	0.42b	-0.14	0.16	-0.01	0.24	0.40b	0.61c	0.69c	0.55c	0.60c	1.00	
EPH	0 .19	-0.06	0.42b	0.00	0.26	0.27b	0.15	0.66c	0.62c	0.65c	0.63c	0.65c	0.57c	0.38a	0.42b	0..19	0.20	0.29	0.31a	0.44b	0.60c	0.56c	0.57c	0.49c	0.54c	1. 00

(P<0.05); b(P<0.01); c(P<0.001)

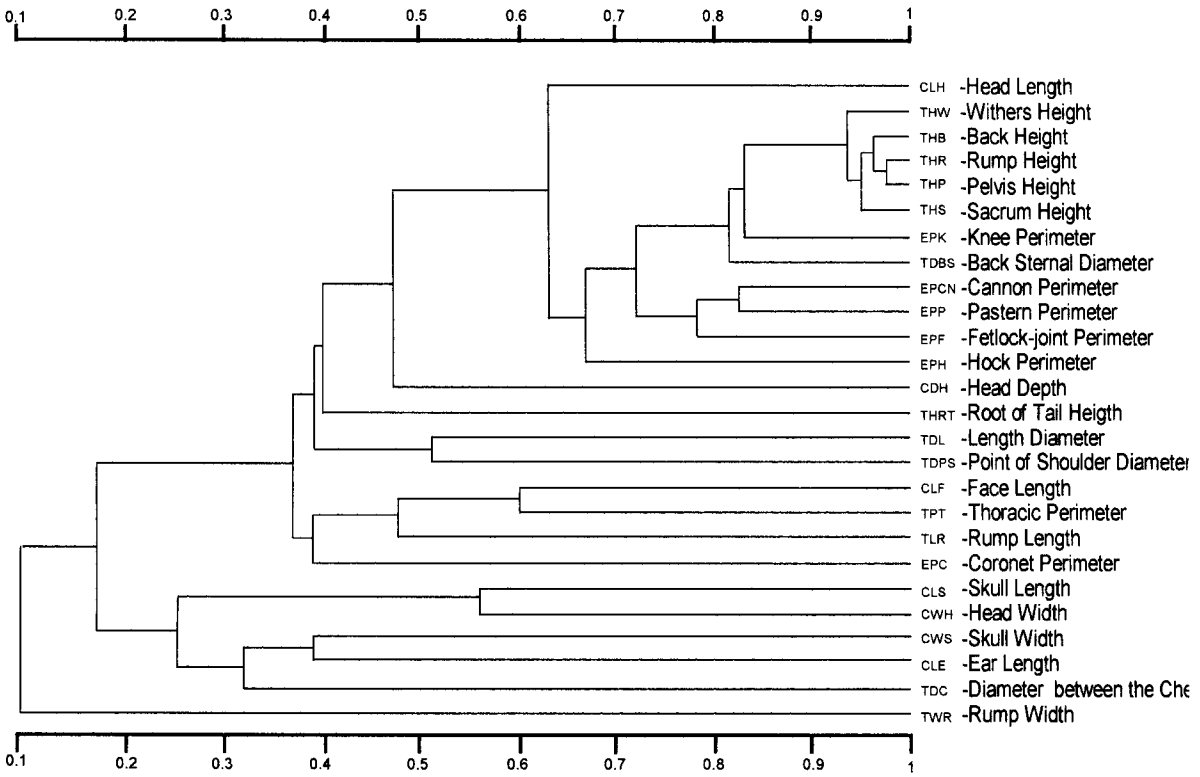


Figure **3.** Dendrogram obtained by PHYLIP analysis using the UPGMA method from morphological correlation data in the male subpopulation of the Catalonian donkey breed (Scale makes reference to morphological correlation degree).

as well as in females. As for the inter-region correlations, globally, a close correlation between trunk and extremities was observed, this relationship being very variable when the cephalic region was compared with the other two, as regards the gender level and the individual cephalic variable level.

A. Cephalic measures

It has already been commented that this corporal region is the one which shows a higher degree of independence among its variables, as much in males as in females. Only head length (CLH), and in the female subpopulation, showed significant correlations with all the other cephalic variables. Important differences due to gender in this region also exist, which makes being able to give a whole interpretation of the existent relationships among these measurements very difficult.

The existent correlations among the morphometric variables of the other corporal regions (trunk and extremities) were also greatly variable, with regards to gender level as well as to individual measures level. As more outstanding data, we could point out: absence of correlation (with some few exceptions) of ear length (CLE) with the remainder of corporal measures, manifested more in males than in females. Absence of correlation between skull width (CWS) and the remainder of variables in the male subpopulation, in a similar way as that found by other authors in PRE populations[5]; on the contrary, CWS showed, in the female subpopulation, a close correlation with almost all the other corporal variables. Significant correlations showed in head length (CLH) and head depth (CDH), in males as well as in females, with regard to a great majority of variables. Skull length (CLS) and head width (CWH) only showed correlation with the measurements of diameters, and this just in the female subpopulation. Finally, face length (CLF) showed significant correlations with the measurements of extremities block, as much in males as in females, and in the female subpopulation also with all the measurements of height.

B. Trunk and extremities measures

These variables maintain a high and significant degree of correlation, in males and females, as much in intra as well as in inter-regions. Nevertheless, the closest relationships ($P < 0.001$) are seen between the measurements of height, between the measurements of perimeters (including thoracic perimeter, TPT), and between heights vs perimeters, as much in males as in females.

Length diameter (TDL) and back-sternal diameter (TDBS), as well as thoracic perimeter (TPT), also were closely correlated with height variables and with extremities perimeters ($P < 0.001$)), confirming the obtained results with the Body, Thoracic and Metacarpo-thoracic Indices, which indicated that animals were of longilinear

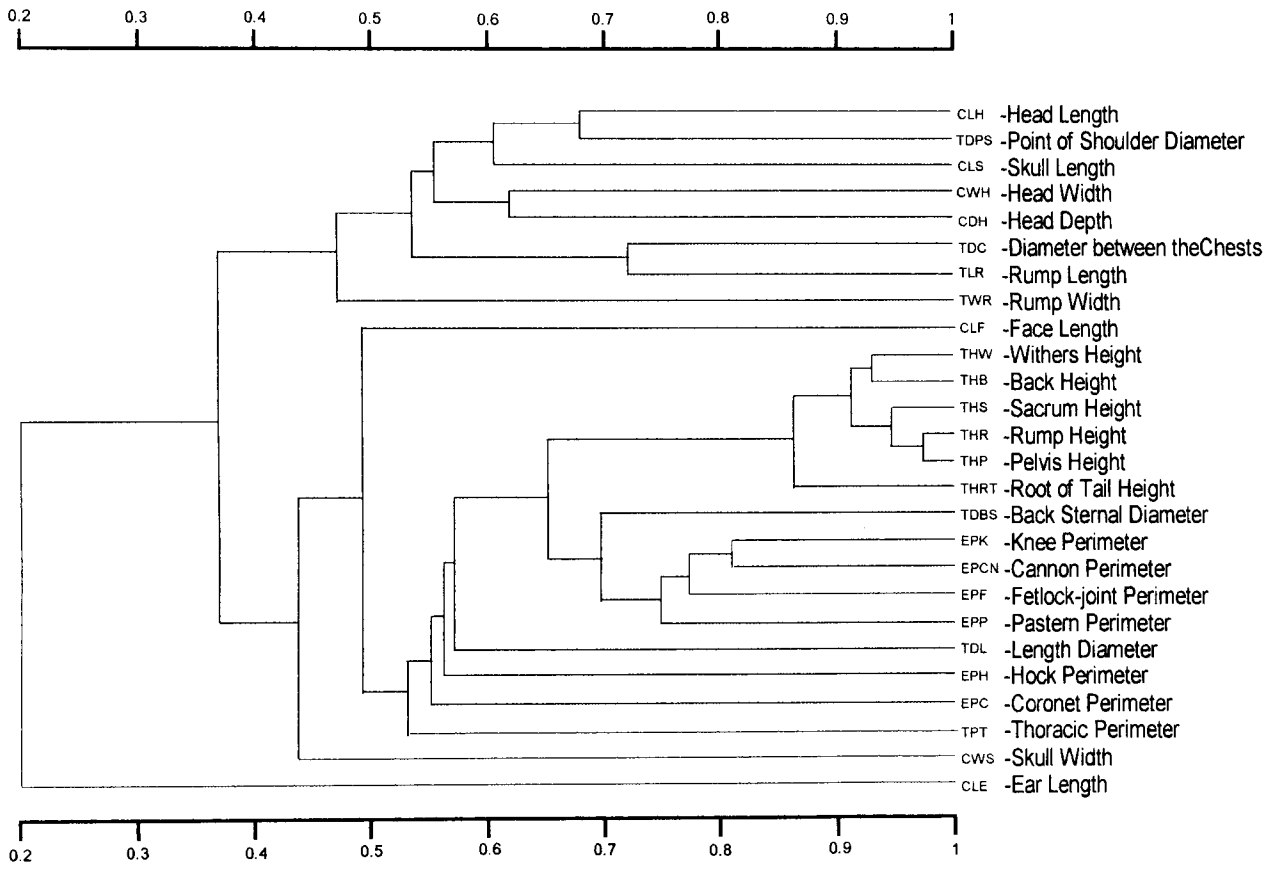


Figure **4.** Dendrogram from correlation data in the female subpopulation.

appearance and hypermetric format.

Rump length (TLR) and rump width (TWR) showed null correlation with the remainder of variables in the case of males (with the exception of TLR with the variables of height ($P < 0.01$), of a contrary form to that which happens in the case of females, where significant correlations with the great majority of variables, included the cephalic, showed.

CONCLUSIONS

Dendrograms obtained applying the UPGMA method for correlation coefficients, were slightly different for male (Figure 3) and female (Figure 4) subpopulations, as was expected, and confirmed the results and interpretations carried out previously.

As more relevant conclusions, we could point out the intra-region, existent close relationship, between cephalic, trunk and extremities variables, more apparent in the female than in the male subpopulation, although in this last one, the weak relationship of many variables could perhaps be attributed to the reduced sample size (n=25 males).

The cluster that forms the variables of height with the perimeters of the extremities in the two dendrograms confirm the close relationship that exists between these measurements.

As for the measurements of thoracic diameters, it was observed that length (TDL) and back-sternal (TDBS) diameters kept a closer relationship with height variables and perimeters; on the other hand, diameter between the ribs (TDR) and point-of-shoulder diameter (TDPS) showed a closer relationship with cephalic measures, although this last, in the male subpopulation, was more akin to extremities and trunk variables than to cephalics.

The rump variables, rump length (TLR) and rump width (TWR), formed a well defined cluster with cephalic measures in the case of females, behaving in an independent form in the male subpopulation, although rump length (TLR) to a greatly minor degree than rump width (TWR).

Lastly, with regard to the cephalic variable ear length (CLE), it could be concluded that it does not show any relationship with the remaining, studied morphological measures.

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