Characteristics of Garole sheep in India

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Summary

Garole, a highly prolific breed of sheep can be characterised as real microsheep of India. Literature available in respect of its genetic potentiality for fecundity and other economic parameters is very scanty. This has peculiar characteristics such as prolificacy, resistance to foot rot disease, grazing in knee-deep water, adaptability to hot humid conditions and high mothering instinct for their neonates. Some research and development programmes have recently been initiated by Central and State Governments to study this valuable germplasm in a systematic manner. Endeavours are required to evaluate this animal in its home tract and *in-situ* conservation involving local sheep farmers is necessary for posterity.

Resumen

La raza Garole, raza ovina altamente prolífica, puede ser considerada como una auténtica *microsheep* de la India. La literatura disponible sobre el potencial genético de fecundación y otros parámetros económicos es muy escasa. Esta raza posee características particulares tales como la prolificidad, la resistencia contra el pedero, el pastoreo en agua, la adaptabilidad a condiciones de alta temperatura con humedad, así como un importante instinto materno. El Estado central y regional ha iniciado recientemente algunas investigaciones y programas de desarrollo para estudiar este importante germoplasma de forma más sistemática. Se necesitaran mayores esfuerzos para evaluar este animal en su habitat por lo que será necesario llevar a cabo posteriormente una conservación *in situ* con los ganaderos locales.

Key words*: Garole, Sheep, Prolificacy, Characteristics.*

Introduction

The Garole is found in the Sunderban area located in the 24-Parganas district of West Bengal. This animal is of short stature with a light brown coarse texture coat. Multiple birth is a common feature of this breed. Turner (1982) speculated that ancestors of Garole sheep were imported in Australia from Bengal in late 18th century and these sheep might have contributed prolificacy to the Booroola Merino sheep. Many body and fleece characteristics of Garole sheep are similar to those reported for early Bengal sheep in Australia (Piper and Bindon, 1996). Garole ewes exhibit high mothering instinct for their newly born lambs. They tend to stay with their lambs for at least the first 9-10 days in spite of going out to graze. Garole sheep are generally reared by the Haldar community in small flock sizes (5-7 sheep) and are maintained mainly upon grazing on field boundaries, fallow land and on the verges of the road (Ghalsasi and Nimbkar, 1993). Resistance to foot rot disease is a peculiar characteristic of this breed and animals can graze during the rains and even in standing water.

Habitat and Numbers

The habitat of the Bengal breed of sheep locally known as Garole is Sunderbans (Southern part of West Bengal) comprising of 13 blocks of South 24-Parganas and 6 blocks

Figure 1. Garole ram.

of North 24-Parganas district. South 24-Parganas is a coastal part of saline area agriculturally poorly developed due to poor drainage in monsoons coupled with lack of irrigation facilities during the winter and summer seasons. It is situated within 21° to 23° N latitude and 87° to 89° E longitude and spread over approximately 4 226 km^2. The delta is said to be the largest in the World (Bose and Moitra, 1995). It is the low lying region at the Ganga river, the highest elevation being 200 metres above sea level. Part of the region is in Bangladesh and it is expected that such type of animal (Garole) might also be found there. The breeding tract of this breed is tropical humid with an average rainfall of 1 750 mm per annum. Almost in every month there is some rain but its concentration lies between the months of May and October. Maximum precipitation is received during the monsoon and humidity ranges between 60 and 97 per cent. The average maximum and minimum temperatures are 36°C in summer and 13°C in the winter season.

As per livestock censuses of India, the total sheep population has increased more than twofold from 1951 (0.62 million) to 1992 (1.49 million) in West Bengal whereas, in India as a whole, it increased from 3.91 to 5.08 million during this period. The Sunderbans area, where Garole sheep are found, has a sheep population of around 0.16 million as per the survey conducted by Birla Technology Institute and Agricultural Finance Corporation of West Bengal (Singh and Bohra, 1996). However, the population status of this breed and trend of population structure over the passage of time is not exactly known and there is hardly any reference available on these parameters.

Morphological Characteristics

By and large, Garole sheep have a light brownish coat colour. Very few sheep with completely black or white coat colour or black / white spot on the body can also be found. The fleece is open and very coarse.. Usually farmers do not shear their animals and utilise them for meat purpose only. Males are horned and females are polled. The Garole has a compact and square body with a small head, medium ears and a short thin tail. The fleece cover on the coat is not dense but covers almost the whole body and the greater part of the legs. Photographs of the animals of this breed are presented in figure 1 through to 6.

It is a small sized animal with a relatively low body weight in comparison to medium and heavy breeds of sheep. The average adult body weight in males and females being 14.43 and 14.14 kg, respectively. The Udder is fairly well developed and twins can easily be sustained on milk available from the ewe. Some managemental manipulations are required to feed triplets and quadruplets.

Body measurements

A total of 46 adult sheep (14 males and 32 females) belonging to different farmers' flocks were measured. The average body measurements are depicted in table 1. Height at withers and body length were more in males in comparison to contemporary females where the opposite situation was observed in case of heart and paunch (belly) girth. The distance between eye and tail length was also on the higher side in males than in females.

Figure 2. Garole ewe.

The average ear length was 6.75 and 7.36 cm for males and females respectively. On the basis of shape and length, ears of Garole sheep can be further classified into three distinct categories viz. rudimentary (<4 cm) medium, (4-8 cm) and long (>8 cm). The percent of sheep measured having rudimentary, medium and long ears were 13.04, 58.70 and 28.26 respectively. The present results lie in within the range reported by Ghalsasi and Nimbkar (1993) for length, height and heart girth. Similar measurements for adult animals were reported by Bose and Moitra (1995).

Table 1. Body measurements of Garole sheep.

Parameters (cm)	Male	Female
Height at withers	50.71±0.788 (14)	45.34±0.369 (32)
Body length	49.46±0.904 (14)	47.84±0.578 (32)
Heart girth	58.79±0.927 (14)	60.11±0.627 (32)
Paunch / Belly girth	56.50±1.148 (14)	62.65±0.696 (32)
Eyes	9.79±0.255 (14)	8.06±0.092 (32)
Ear	6.75±0.620 (14)	7.36±0.431 (32)
Tail	11.04±0.334 (14)	10.20±0.347 (32)

Within parenthesis are number of observations.

Figure 3. Garole ewe with twins.

Table 2. Production characteristics of Garole sheep.

Traits	Number of observations	Averages (kg)
Birth weight	96	0.82±0.03
3-month weight	34	5.29±0.20
6-month weight	20	7.47±0.31
12-month weight	8	11.54±0.63
Adult body weight		
Male	14	14.43±0.62
Female	31	14.14±0.32
Wool yield	42	0.18±0.02

Reproduction and breeding

Garole, although a highly prolific sheep is not well known to common masses. Literature available with regard to its genetic merit for multiple births is very meagre. These sheep breed all year round in their home tract with no pronounced breeding season, however, maximum lambing takes place between December to February and August to September. The age at first service is 7 to 9 months and age at first lambing is 12 to 14 months. Gestation period is 150 days and lambing interval is 8 months (Bose and Moitra, 1995).

A total of sixty lambings were recorded at the Central Sheep and Wool Research Institute, Avikanagar from May, 1997 to August, 1998. During the said period, the percentage of ewes giving birth to single lambs, twins, triplets and quadruplets were 40, 53.33, 5.0 and 1.67 respectively. The average number of lambs born per ewe was 1.68.

By and large similar observations on multiple births have been reported by Bose and Moitra (1995) and Singh and Bohra (1996), however, Ghalsasi and Nimbkar (1993)

Figure 4. Garole ewe with triplets.

Figure 5. Garole ewe with quadruplets.

reported somewhat higher figures for multiple births than those in the present findings.

Production characteristics

Being a small sized animal, the body weights at different ages and adult weight of Garole sheep are comparatively lower than the medium and heavy breeds of sheep. The observations on production characteristics of Garole sheep were collected at the Institute farm and are summarised in table 2. A small flock of Garole sheep was procured from its home tract in March, 1997 and is being maintained for full study on this valuable germplasm. Farmers, in general, do not shear their animals and are ignorant about the use of wool. The average adult annual wool yield of 42 animals procured from Sunderban area was 179 gms as per the shearing done at the Institute in April, 98. The wool is for rough carpet use. The average fibre diameter, medullation, staple length and crimp/cm were 67.82 µ, 75.17 %, 5.09 cm and 2.08 respectively (Singh and Bohra, 1996).

Research and Development

This breed has been lacking national attention and no genuine and systematic attempts have been made for its improvement, in spite of certain peculiar characteristics viz. prolificacy, knee-deep water grazing habit, resistance to foot rot disease and adaptability to hot humid conditions. Considering the importance of multiple births in sheep breeding, Garole sheep have recently been introduced into the Mutton Project at the Central Sheep and Wool Research Institute, Avikanagar. Efforts are simultaneously being made to ensure that body weights are not adversely affected. A

Figure 6. Flock of Garole sheep.

total of 64 Garole sheep (15 males and 49 females) were procured in March, 1997 from the Sunderbans area with the objective of studying this germplasm thoroughly and introducing prolific genes into relatively less prolific breeds of sheep. In years to come, Garole crossbreds will be evaluated in terms of multiple births and net economic returns. Around 50 animals of this breed are being maintained at KVK, Nimpith and State Livestock Farm, Kalyani for research and development purposes (Singh and Bohra, 1996).

Breeds like Pattanwadi and Sonadi of the North-Western region can be considered for improvement in having multiple births by introducing Garole blood into such breeds of sheep. It is expected that relatively higher milk yield available in these breeds will help the farmers to sustain twin / triplet lambs expectedly born out of Garole x Pattanwadi, Garole x Sonadi or other similar breed combinations.

Acknowledgement

Authors are thankful to Shri A.K. Prasad, T-2 of AG&B Division for collecting some valuable information and typing this manuscript meticulously.

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Traditional goats and fat-tailed Sabi sheep in semi-arid north eastern Zimbabwe

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Summary

Characterisations are given of the little-known Sabi sheep and the local population of the Small East African goat in two areas in NE Zimbabwe. The southern area had been more affected by drought in 1991-92. For sheep (both areas combined; n = 28 in 10 flocks) the mean declared age of breeding females and the median age at first parturition were surprisingly high (6.1 years and 4 years respectively). Breeding female goats in the southern area were younger (4.9 vs. 6.4 years), and their age at first kidding was lower (3 years vs. 5 years), than in the north (n = 122 in 25 flocks total). These advanced ages could be an after-effect of the drought. Juvenile mortality and the proportions of young that were ultimately marketed were similar to what has been found elsewhere in semi-arid Africa. Breeding females were found to be smaller than their counterparts in semi-arid areas in West Africa with mean withers heights of 56.5 cm (n = 112 goats) and 60.4 cm (n = 36 sheep). Conditions in this area appear difficult for small ruminants and the populations sampled may be well adapted to marginal environments and thus worthy of conservation.

Resumé

Il manque encore de l'information sur les petits ruminants du secteur traditionnel de Zimbabwe. Des données zootechniques étaient recueillies sur les moutons Sabi (races à queue grasse) et sur les chèvres de race Small East African (variant de Zimbabwe), sous gestion traditionnelle dans deux aires du nord-est de Zimbabwe. Les tailles des échantillons étaient de 28 brébis en dix troupeaux, et de 122 chèvres, en 25 troupeaux. Les deux aires étaient séparées par 20 - 30 km de broussailles presque dépopulées. Dans les deux aires combinés, les brébis étaient assez âgées (6,1 ans), et l'âge du premier vêlage (4 ans) était bien avancé. Dans l'aire du sud, plus affecté par les sécheresses, les chèvres étaient moins âgées (4,9 cf 6,4 ans au nord) avec un âge au premier vêlage moins avancé (3 cf. 5 ans). Ces âges avancés étaient peut-être une conséquence de la sécheresse. Les taux de mortalité et de commercialisation des jeunes étaient de même ordre que ceux déjà observées en Afrique semi-aride. Les ovins et les caprins sont de moindre taille que leurs équivalents des zones semi-arides d'Afrique occidental (hauteurs au garrot, 56,5 cm; n = 112 chèvres; 60,4 cm; n = 36 brébis).

Key words: *Sabi sheep, Small East African goat, Productivity, Traditional management, Semi-arid Africa.*

Introduction

In the traditional livestock sector in Zimbabwe, goats are better characterised than sheep (Sikosana, 1992, 1996) but field data are lacking on both species. Mason (1988) did not describe any distinct breeds of goat in Zimbabwe, though variants of the Small East African goat were noted. The Sabi sheep, a fat-tailed breed, was briefly described by Ward (1959, 1983). Sikosana (1996) described

Figure 1. Ewes and lambs, Sabi sheep in Rwenya, Zimbabwe.

it as the only indigenous breed of sheep in Zimbabwe, and as being an ‘endangered breed in need of conservation’.

In the present study, metrical data were gathered in order to characterise these animals, and an assessment was made of performance in two study areas separated by a corridor, 20-30 km wide, of effectively uninhabited bush.

Methods

The study areas, denoted RS and RN, are located to the south and north respectively of the Rwenya Wildlife Management Area (Hall, 1998). Annual rainfall is highly variable, usually 450 - 600 mm; there can be severe dry spells with a drought in 1991-92 (IIED, 1992; R.M. Blench, in preparation). The holdings of goats and sheep of 31 owners, 28 of whom also owned the cattle described by Hall (1998) were visited, all were within 2 km of a dirt track. Numbers of parous female sheep (ewes) and goats were noted.

Livestock owners were asked about the breeding history of each female, and the fates of all offspring. Reproductive rate was defined as the number of pregnancies per breeding female per year since the start of her breeding career.

Tape measures were used to measure ewes and female goats and notes were made of incisor teeth, coat colour and of presence or absence of horns, and of wattles (fleshy,

Table 1. Dentition (number of adult incisors) of parous female goats.

	Juvenile only	1 pair	2 pairs	3 pairs	4 pairs
Goats RS	1	0	5	8	40
Goats RN	2	2	6	20	38

Table 2. Fates of progeny of goats.

	RS	%	RN	%	chi^2
Total live births	160		178		
Died before 6 months	25	15.6	31	17.4	0.16
Died after 6 months	24	15.0	7	3.9	11.19
Kept in herd	84	52.5	110	61.9	1.26
Transferred	27	16.9	30	16.8	0
Totals		100.0		100.0	12.61 $p < 0.01$

paired appendages hanging from the throat of some sheep and goats; also called tassels) and beard in the case of goats.

Statistical analysis was mainly by t-tests, Wilcoxon-Mann-Whitney tests (both 2-tailed) and X^2 tests, the latter with d.f. = 1 unless otherwise stated.

Figure 2. Ewes and lambs, Sabi sheep in Rwenya, Zimbabwe.

Results

Holdings of breeding female goats ranged from two to eleven in both RS (n = 10, mean 5.6±0.99), and in RN (n = 15, mean 4.6±0.70); these did not differ significantly. For sheep, as sample sizes were small, data from areas RS and RN were combined. Holdings of breeding female sheep ranged from two to eight (n = 8, mean 4.5±0.78). Only Sabi sheep were encountered. Case histories were obtained for 28 sheep and for 122 goats (68 in RN and 54 in RS).

Goats

Reproductive histories

The mean declared age of parous females in RS was 4.9±0.29 years and in RN, 6.4±0.24 years, which is highly significantly greater. Median age at first parturition followed the same pattern, being 3 years (range 1 - 7) in RS and 5

Table 3. Mean (SEM) body dimensions (cm) of goats (n = 122) and sheep (n = 36), RS and RN combined.

	goats	sheep
Heart girth	67.1 (0.39)	69.4 (0.84)
Withers height	56.5 (1.35)	60.4 (0.66)

years (range 2-9) in RN ($p < 0.001$). In RS, 13 goats were primiparous (24%) and in RN a nonsignificantly different proportion, 22 (32%) . In RS, 8 primiparae had full adult incisor dentition but in RN, only 5 animals had ($p < 0.05$).

The incisor dentition of the goats is reported in table 1. A significantly lower proportion of the parous goats from RN had full adult dentition (38 out of 68 compared with 40 out of 54 in RS; $p < 0.05$).

The goats in RS had had 99 litters and those in RN, 124, i.e. means of 1.8±0.13 and 1.8±0.15 litters per female respectively (ns). Only two sets of triplets had been born, both in RN. Proportions of multiple births were 36 / 99 in RS, and a significantly lower proportion, 29 / 124 ($X^2 = 4.49$, $p < 0.05$) in RN.

Mean litter size did not differ between RS and RN, being 1.25±0.03 for the areas combined.

Fates of offspring

These are considered in table 2. The main difference between the areas was in deaths after 6 months of age. Classifying kids according to litter size, in RS, of the 72 twins born 16 (22.2%) died and of the 86 singles, 9 (10.4%) died ($p<0.05$). In RN, of the 60 twins and triplets born, 12 (20.0%) died and of the 113 singles, 19 (16.8%) died (NS).

Metrical data

There were no differences in body size between the goats of RS and those of RN so the data from all 122 goats were pooled (Table 3).

Figure 3. Sabi ram, Zimbabwe

Figure 4. Sabi ram, Zimbabwe

Qualitative data

In RS, 37 female goats possessed horns, and 23 a beard. In RN, 62 had horns and 21 a beard. One goat in each area had wattles. Beards therefore were equally frequent in RS and RN (ns) while horns were more frequent in RN ($p<0.001$). The most common coat colour was black (24 in each area) while light brown was much more frequent (19 goats) in RN than in RS (one goat only). Other colours observed were white, tan, grey, cream, red-brown and combinations of these.

Sheep

Reproductive histories

The mean age of the 28 parous sheep was 6.1±0.39 years; median age at first parturition was 4 (range 1 - 8) years. Four sheep were primiparous, three of them having 4 pairs of adult incisors. Considering all 28 sheep, 11 had two pairs of adult incisors, 15 had 4 pairs and the other two had one and three pairs respectively.

There had been 70 litters, i.e. 2.5±0.19 litters per female, or 0.87±0.05 litters per year of parity. Six litters were twins, so mean litter size was 1.1±0.03.

Fates of offspring. Of the 75 lambs born, 11 died before the age of 6 months and two afterwards (17.6%); 9 (12.2%) were later transferred and 53 (71.6%) retained in the flock.

Metrical data

These are given in table 3 for both areas combined.

Qualitative data

Twenty four female sheep (67%) had horns and none had wattles. All male sheep had horns. The most common colour pattern was brown and white (16), followed by black and white (10), brown (9) and black (1) (Figure 1 to 4).

Four adult male sheep were measured: means were heart girth 75.7, withers height 65.0, body length 62.3, ear 11.3 cm. Tail length and the circumference of the tail at the proximal end averaged 39.8 and 27 cm respectively.

Discussion

This study presents a characterisation of two almost undocumented breeds, in an area which appears only marginal for livestock production. No assessment can be made of nation-wide numerical status; the Small East African goat is probably as plentiful within Zimbabwe (Sandford, 1982) as elsewhere (there are 2 million breeding females in Uganda alone: Mbuza, 1995) (Figure 5). Sabi sheep are less well known, but a nationwide survey would be highly desirable. The Rwenya populations of both breeds may perhaps be regarded, because of the rigours of the environment, as locally adapted types.

Sizes of herds of goats and flocks of sheep (mean number of breeding females 5.4 and 4.5 respectively) were towards the lower end of the range reported by Wilson (1988) for other semi-arid areas in Africa where sedentary management is practised. These small group sizes could be due to some combination of environmental rigour, and of a rather low priority being attached to small ruminants. The market prices of adult male goats and sheep were only 5%, and 8% respectively, of that of an ox (Hall, 1998 and unpublished data). In northern Ghana also in 1997, a male goat commanded 9%, and an adult sheep 13%, of the price of an ox (S.J.G. Hall, unpublished).

In Rwenya breeding females were surprisingly old (mean age of goats 5.7, of sheep 6.1 years) and median ages at first parturition (goats 3 or 5 years, sheep 4 years) remarkably high. Females had had very few litters. Elsewhere in Zimbabwe, Sandford (1982) found mean age at first parturition to be 24 months for goats, which he considered "rather high"; in northern Nigeria it was 12.3 months (RIM, 1990, p. 167). Similarly, median age at first lambing of 4 years for sheep is also high. The only pre-existing data for Sabi sheep cannot be compared as they came from fully managed flocks; 15 months (Ward, 1959) and 23 months (Sikosana, 1996). In Nigerian sheep mean age at first lambing is between 12.3 and 19.3 months (RIM, 1990, p. 201).

Sixteen of the 39 primiparous sheep and goats had four pairs of adult incisors, consistent with late onset of breeding. Elsewhere in Africa this adult dentition is achieved at around 3 years in sheep and perhaps earlier in goats (Wilson and Durkin, 1984).

Probably most breeding sheep and goats present in 1997 in RN and RS were born just after the 1991-92 drought and their puberty could have been delayed and lifetime fertility reduced by poor environmental conditions (I'Anson *et al*., 1991). That access to food may influence puberty in traditional flocks and herds was suggested by RIM (1990, pp. 167-175, 200-208), who found that sheep and goats kept under less strict sedentary husbandry systems, thus having better access to feed, started breeding at a younger age.

The 1991-92 drought had worse effects in RS than in RN, for cattle (Hall, 1998) and for the small ruminants. The lower mean age of goats in RS suggests the loss of a cohort, and the higher proportion of primiparae in RS with four pairs of adult incisors suggests a retardation of puberty of goats that were born soon after the drought.

These sheep and goats clearly inhabit a marginal environment to which they may well have specific adaptations; this could justify conservation efforts as well as making them the appropriate genotypes for any livestock development programme.

Prolificacy and juvenile survival

Prolificacy of the goats, with multiple births accounting for about 25% of litters, is similar to that reported for Small East African goats elsewhere in Zimbabwe (twinning rate

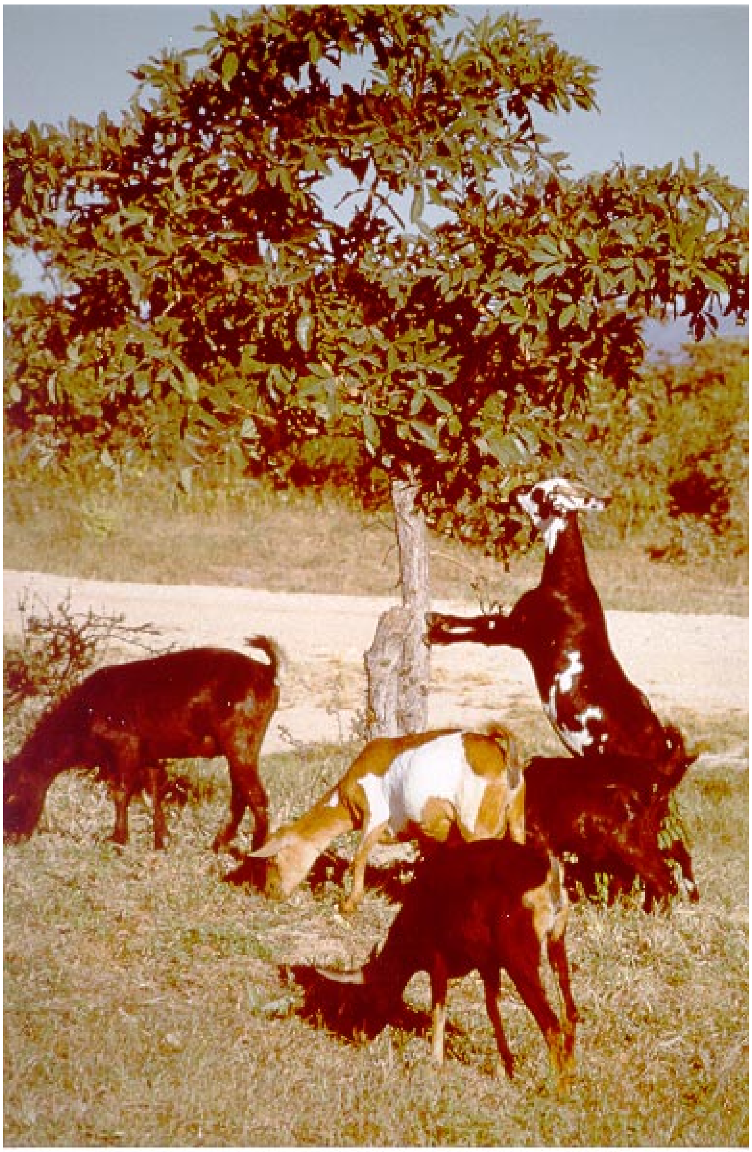

Figure 5. Small East African goats, Zimbabwe

30-32%) by Sikosana (1992), while their mean litter size (1.3) is in the middle of the African range (Wilson and Durkin, 1988). In the present study at 19.3% estimated juvenile mortality rate is less severe than the 30-50% estimated by Sikosana (1992, 1996).

Prolificacy of the sheep, with 9% of litters being multiple births and a mean litter size of 1.08, is similar to that of Sabi sheep in a managed flock (Sikosana, 1996) and also to other African findings (Wilson and Light, 1986). Overall, juvenile mortality of sheep (14.9%) was similar to that reported by Ward (1959) and by Sikosana (1996) for Sabi sheep (i.e. 17.9 and 14% respectively) and is towards the lower end of the range observed elsewhere in semi-arid Africa (range 12.6-30.2%; Wilson *et al*., 1985).

Phenotypic characterisation

This is the first report on the body measurements of the Zimbabwe population of Small East African goats. Compared with nearby populations they are rather smaller than Malawian goats (heart girth 69.4, body length 63.5 cm, body weight 23.9 kg: Ayoade, 1981) and also smaller (withers height 56.5 cm) than those of southern Zimbabwe (withers height 70 cm: Sikosana, 1992).

Mason (1988) states wattles to be 'common' elsewhere in this breed, as does Sikosana (1992), but in the present study only two out of 112 goats had them. On the basis of these quantitative and qualitative differences, the goats described here may be a distinctive variant of the Small East African goat.

The goats of RS and RN differ in the high frequency of the polled characteristic in the former and of the light brown coat colour in the latter, so the two areas could be reproductively isolated, supporting the speculation of Sikosana (1992) that local populations are inbred.

In body length, the goats and sheep measured here are similar to the breeds of northern, semi-arid Nigeria which are respectively 58.1 and 59.7 cm long. However, the Zimbabwe animals are much shorter at the withers (goats 56.5, sheep 60.4 cm, cf. Nigerian goats, 64.3, sheep 72.5 cm: Hall, 1991). The association in West Africa of long-legged sheep and goats with semi-arid regions, and of their short-legged conspecifics with humid zones, is well known (Bouchel and Lauvergne, 1996) so it is perhaps surprising to find relatively short-legged sheep and goats in semi-arid Zimbabwe. Perhaps the populations are of only recent establishment and these adaptations have not yet become fixed, but this seems unlikely since the Rwenya area has clearly been settled since well before colonial times (R.M. Blench, in preparation). Alternatively, long legs may only be an adaptation to semi-arid conditions under transhumant systems, where ability to trek long distances is important.

Livestock marketing in the Rwenya area mainly concentrates on cattle (Sandford, 1982). Yet sheep and goats are highly likely to have a role in the economic development of the region, provided marketing arrangements can be improved, in which case the local breeds are presumably the appropriate ones to use. Thriving local populations would serve not only for in situ conservation but also as a means to sustainable livestock development.

Acknowledgements

This work was funded by the Department for International Development under the programme "Partnerships and policies for improved natural resource management". The assistance of Dr. David Mazambani, Mr. George Whitney and particularly of Mr. Felix Bowa of EDIT Resource Centre, Zimbabwe is gratefully acknowledged.

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Relaciones genéticas entre razas ibéricas de caballos utilizando caracteres morfológicos (prototipos raciales)

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Resumen

A partir del estudio cualitativo y cuantitativo de 46 caracteres morfológicos, obtenidos a partir de recopilaciones bibliográficas, se analizan las relaciones existentes entre 17 poblaciones equinas de la Península Ibérica (14 razas españolas y 3 portuguesas).

Los resultados obtenidos permiten clasificar a las diferentes razas en sus correspondientes troncos ancestrales: *Equus ferus gmelini, Equus ferus przewalski* y *Equus ferus solutreensis*, integrándose los representantes de los dos primeros grupos en el llamado Tronco Tarpánico.

El promedio de distancia morfológica entre razas, medida como MCD (Mean Character Difference, o promedio de diferencias entre caracteres), tomó un valor de 0,51± 0,11. El análisis cuantitativo de los datos indica que el grupo que forman los poneys ibéricos es morfológicamente muy semejante, a diferencia de lo que ocurre con los grupos de los caballos de silla y los de tiro.

Se analizan las relaciones y se discuten las causas de la variabilidad morfológica entre grupos.

Summary

Starting from the qualitative and quantitative examination of 46 morphological characters, obtained from bibliographical recompilation, the relationships existing between 17 equine populations of the Iberian Peninsula (14 Spanish and 3 Portuguese breeds), were analysed.

The results obtained allow the different breeds to be classified in their corresponding ancestral trunks: *Equus ferus gmelini*, *Equus ferus przewalski* and *Equus ferus solutreensis*, integrating the representatives of the first two groups into the so called Tarpanic Trunk.

The average morphological distance between breeds, measured as MCD (Mean Character Difference), had a value of 0.51 ± 0.11. The quantitative analysis of data indicated that the group formed by the Iberian ponies is morphologically very similar, in contrast to that which occurs with the groups of the riding and carriage horses.

The relationships are analysed, and the causes of the morphological variability between groups are discussed.

Key words: *Iberian horse breeds, Morphological characters, Genetic relationships, Dendrogram.*

Introducción

Para estudiar las relaciones genéticas existentes entre diferentes especies, razas o poblaciones, el material más apropiado debería ser el análisis de la variabilidad de genes neutros estructurales, con una elevada tasa de polimorfismo y sin ninguna relación con respecto a la eficacia biológica de los individuos, cuyos alelos hubieran aparecido en la población por mutación y se hubieran mantenido o perdido por deriva. Este material sería, por ejemplo, los llamados polimorfismos bioquímicos, y más especialmente los marcadores de ADN, minisatélites y microsatélites (Bruford y Wayne, 1993; Bowcock *et al*., 1994).

Existen diferentes estudios llevados a cabo en la especie equina utilizando marcadores genéticos (Bowling y Clark, 1985; Rognoni *et al*., 1996; Behara *et al*., 1998). No obstante, el análisis, mediante métodos de taxonomía numérica (Sneath y Sokal, 1973), de diversos caracteres morfológicos, podría proveer de información adicional que suplementara estas investigaciones, y en algunos casos podría ayudar a contrastar algunas de las hipótesis mantenidas por otros autores, postuladas a partir de diferentes fuentes de información: históricas, arqueológicas, bioquímicas, etc., (Altarriba *et al*., 1979; Lauvergne *et al*., 1988; Jordana *et al*.,1992, 1993).

La importancia de los caracteres morfológicos en la reconstrucción de las relaciones genéticas en razas de caballos, quedó patente en el trabajo llevado a cabo por Jordana *et al.* (1995) en un total de 22 poblaciones equinas mundiales a partir del análisis de 30 caracteres morfológicos, puntualizando, sin embargo, que los resultados obtenidos intentan tan solo mostrar el grado de relación y semblanza morfológica entre razas actuales de caballos, el cual puede ser o no un indicador de la verdadera historia evolutiva de las poblaciones. Debemos considerar que los caracteres morfológicos han estado sujetos, durante un largo período de tiempo, a la selección natural y artificial, así como al hecho de que ha existido migración génica entre alguna de estas poblaciones, siendo por tanto estas fuerzas evolutivas las que habrían tenido un mayor peso en el proceso de diferenciación racial.

El principal objetivo de este artículo es estudiar las relaciones existentes entre todas las razas equinas de la Península Ibérica (España y Portugal), a partir del análisis cualitativo y cuantitativo de datos morfológicos, utilizando métodos estadísticos (SAS, 1989) y programas computacionales diseñados específicamente para tal tipo de análisis (Swofford, 1993).

Material y Métodos

Razas estudiadas

Se analizaron un total de 17 poblaciones equinas Ibéricas. Cinco razas de aptitud silla: Andaluza (AND), Catalana (CAT), Lusitana (LUS), Mallorquina (MAL) y Menorquina (MEN); ocho razas de poneys: Asturcón (AST), Gallego (GAL), Garrano (GAR), Jaca Navarra (JAN), Jaca Soriana (JAS), Losino (LOS), Pottoka (POT) y Sorraia (SOR), y cuatro razas de tiro: Aragonesa (ARA), Bretón Cerdà (BRC), Bretón Empordanès (BRE) y Burguete (BUR). También se incluyó en este estudio la Raza Asnal Catalana (RAC) como población *outgroup*. La localización geográfica se muestra en la figura 1. Algunas razas de caballos se muestran en las figuras de 4 a 12.

Caracteres y análisis

Tomando como referencia un individuo ideal, representativo de cada una de las 17 poblaciones equinas y de la raza asnal catalana, se analizaron un total de 46 caracteres morfológicos. El estado de cada uno de los caracteres, para cada raza, se estableció a partir de datos bibliográficos de diferentes estudios morfológicos de la raza en cuestión; Andaluza (Aparicio *et al.*, 1986), Aragonesa y Bretón Empordanès (Homedes, 1967; Sierra, 1987), Asturcón (García-Dory, 1980), Bretón Cerdà (Torres, *et al*., 1983; Parés y Parés, 1991), Burguete (Gil y Martínez, 1958; Dévimeux, 1988), Catalana (Moyano, 1908), Gallego (Iglesia, 1983; Santamarina, *et al*., 1992), Garrano, Sorraia y Lusitana (Oom, 1992), Jaca Navarra (Donezar, 1951), Jaca Soriana y Losino (Ferreras, 1935a), Mallorquina (Payeras y Pons, 1991), Menorquina (Sánchez-Belda, 1987), Pottoka (Ferreras, 1935b; Maguregi *et al*., 1992) y la Raza Asnal Catalana (Jordana y Folch, 1996).

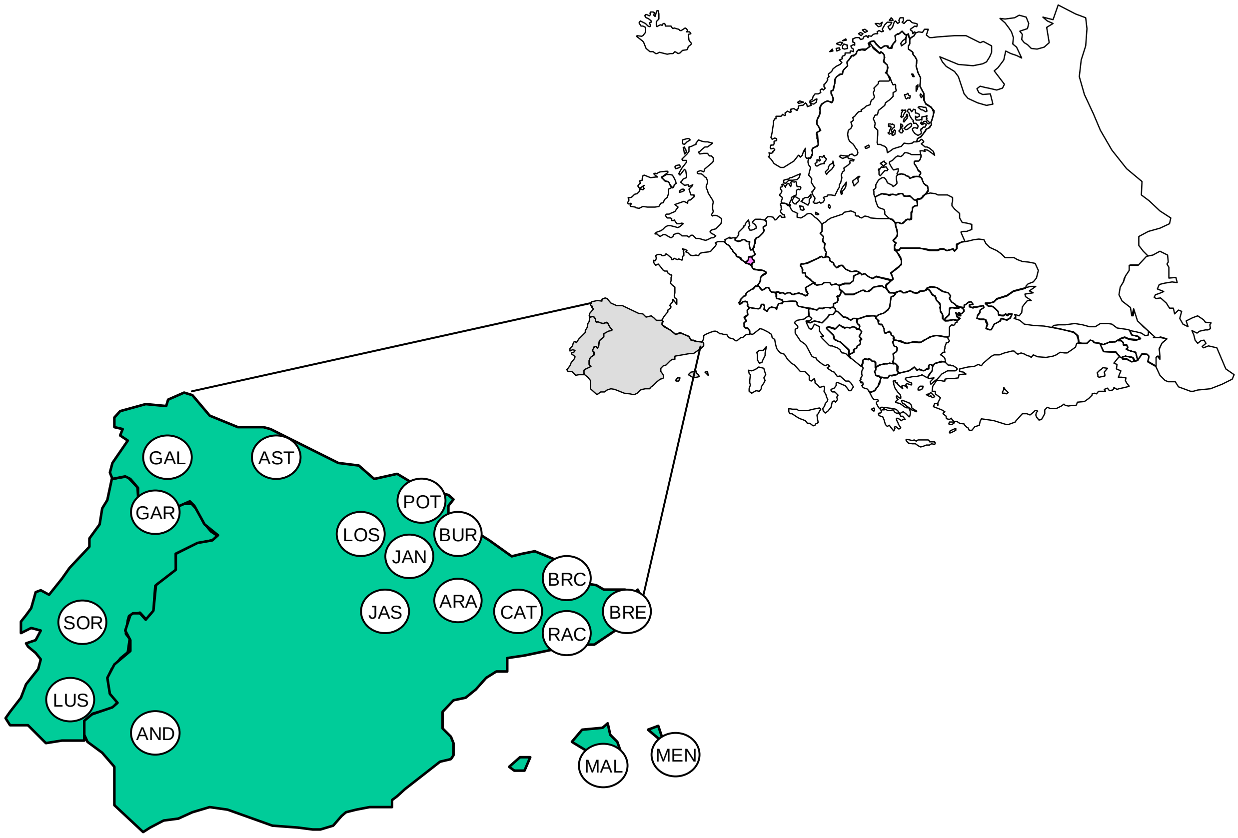


Figura 1. Principal localización geográfica de las razas equinas ibéricas.

Para cada estado de los diferentes caracteres se asignó un orden numérico de forma arbitraria. Estos números no representan ninguna ponderación específica. El número de estados para cada carácter se estableció dependiendo del número de clases fenotípicamente distinguibles. Los caracteres utilizados y el estado de los mismos se muestran en la tabla 1. La matriz original de semejanzas morfológicas se muestra en la tabla 2.

El programa PAUP (Swofford, 1993) se utilizó para realizar el análisis cualitativo de los datos a partir de los caracteres discretos mostrados en la tabla 2. Este análisis se basa en el principio de la parsimonia, es decir, el árbol generado (dendrograma) sería aquel que requiriera el menor número posible de pasos o transiciones del estado del carácter, sumados a través de todas las ramas. El método utilizado fue el de la parsimonia de Fitch (Fitch, 1971). Para darle una dirección evolutiva, los árboles resultantes fueron rotados utilizando el método del *outgroup* (Farris, 1972) con la Raza Asnal Catalana. El programa PAUP nos permite, asimismo, calcular la confianza que nos merece la topología, mediante un análisis *bootstrap* (Efron, 1979) adaptado a la inferencia de filogenias (Felsenstein, 1985). Se realizaron cien replicaciones *bootstrap*, y el árbol de consenso se obtuvo basándonos en el método *majority-rule* (Margush and McMorris, 1981) producido por el algoritmo *global-branch-swapping* (Hendy and Penny, 1982). Para el análisis cuantitativo, los datos cualitativos fueron transformados y procesados en forma de una matriz de distancias. Se calculó el promedio de diferencias entre caracteres o distancia MCD (Mean Character Difference) propuesta por Cain y Harrison (1958), la cual varía de 0 a 1, y se utilizó como una medida de parecido taxonómico. Los cálculos se llevaron a cabo utilizando el paquete estadístico SAS (1989).

Tabla 1. Caracteres y estados de los mismos, utilizados en la construcción de la matriz de semejanzas morfológicas.

(A) Perfil cefálico 0. Subcóncavo 1. Rectilíneo 2. Subconvexo 3. Rectilíneo o Subconvexo 4. Convexo	*(B) Tamaño corporal* 0. Elipométrico 1. Eumétrico 2. Subhipermétrico 3. Hipermétrico
(C) Proporción long/anchura 0. Brevilíneo 1. Mesolíneo 2. Sublongilíneo 3. Longilíneo	*(D) Alzada a la cruz* 0. < 140 cm. 1. 141 - 148 cm. 2. 149 - 154 cm. 3. 155 - 160 cm. 4. 161 - 170 cm.
(E) Perímetro torácico 0. < 160 cm. 1. 161 - 170 cm. 2. 171 - 185 cm. 3. 186 - 190 cm.	*(F) Peso vivo en machos* 0. < 200 Kg 1. 200 - 450 Kg 2. 450 - 500 Kg 3. 500 - 650 Kg 4. 650 – 1 000 Kg
(G) Proporción cabeza/cuerpo 0. Pequeña 1. Proporcionada 2. Grande	*(H) Anchura de la cabeza* 0. Estrecha 1. Media 2. Ancha
(I) Tamaño de la frente 0. Reducida 1. Mediana 2. Grande	*(J) Perfil frontal* 0. Cóncavo 1. Recto 2. Subconvexo 3. Subcóncavo 4. Convexo
(K) Longitud de la cara 0. Acortada 1. Mediana 2. Alargada	*(L) Perfil de la cara hasta la parte inferior de los supranasales* 0. Cóncavo 1. Recto 2. Convexo
(M) Perfil de la cara desde la parte inferior de los supranasales 0. Cóncavo 1. Recto 2. Convexo	*(N) Tamaño de las orejas en relación a la cabeza* 0. Largas 1. Medianas 2. Pequeñas
(O) Orbitas 0. Salientes 1. De prominencia media 2. No salientes	*(P) Apófisis cigomáticas* 0. Poco manifiestas 1. Bien manifiestas

(To be continued...)

(...To be continued)

(Q) Supranasales 0. Estrechos 1. Anchos	*(R) Ollares* 0. Pequeños 1. Grandes
(S) Labios 0. Finos 1. Gruesos	*(T) Perfil del cuello* 0. Ligeramente arqueado 1. Arqueado 2. Recto 3. Hundido
(U) Forma del cuello 0. Piramidal 1. Masivo 2. Cervuno	*(V) Longitud del cuello* 0. Corto 1. Medio 2. Largo
(W) Anchura del cuello 0. Delgado y estrecho 1. Medio 2. Ancho	*(X) Cruz* 0. Poco prominente 1. Manifiesta
(Y) Longitud de la espalda 0. Corta 1. Media 2. Larga	*(Z) Costillar* 0. Plano 1. Con suave arqueamiento 2. Cilíndrico
(A) Conformación del pecho 0. Medio 1. Ancho 2. Muy ancho	*(B) Profundidad del pecho* 0. Poco profundo 1. Intermedio 2. Profundo
(C) Longitud del dorso 0. Reducida 1. Mediana 2. Alargada	*(D) Línea dorsal* 0. Ligeramente ensillada 1. Recta
(E) Longitud del lomo 0. Reducida 1. Larga	*(F) Línea del lomo* 0. Ligeramente ensillada 1. Recta
(G) Grupa 0. Horizontal 1. Ligeramente inclinada 2. Inclinada 3. Inclinada y doble 4. Muy inclinada	*(H) Nacimiento de la cola* 0. Bajo 1. Medio 2. Alto
(I) Extremidades 0. Finas y delgadas 1. Fuertes y robustas	*(J) Cascos* 0. Pequeños y altos 1. Medianos 2. Grandes y anchos

(To be continued...)

(...To be continued)

(K) Color de la capa 0. Ratonera 1. Negra 2. Torda 3. Castaña 4. Alazana y castaña 5. Negra y castaña 6. Torda y castaña	*(L) Marcas blancas* 0. Ausentes 1. Presentes o no en la cabeza, pero siempre de forma muy discreta. 2. Presentes en cabeza y extremidades. 3. Presentes o no en la cabeza y extremidades, pero siempre de forma muy discreta.
(M) Raya de mulo 0. Ausente 1. Presente	*(N) Banda crucial* 0. Ausente 1. Presente
(O) Cebraduras 0. Ausentes 1. Presentes	*(P) Piel* 0. Fina 1. Gruesa
(Q) Crines 0. Cola y crin cortas 1. Cola y crin largas y escasas cernejas 2. Cola y crin largas y abundantes cernejas	*(R) Crin* 0. Enhiesta y corta 1. Caída
(S) Aptitud fisiológico-mecánica 0. Poney 1. Silla 2. Tiro ligero 3. Tiro pesado 4. Vive en estado salvaje	*(T) Biotipología constitucional* 0. Hipermetabólico u oxidativo 1. Metabólico u ortosténico 2. Muscular o masivo.

Resultados y Discusión

Análisis cualitativo

El dendrograma resultante de la aplicación del método de la parsimonia de Fitch a los caracteres morfológicos (tabla 2) se muestra en la figura 2. La raza asnal Catalana se utilizó como población *outgroup*. Para la construcción del dendrograma el método de la parsimonia de Fitch necesitó 215 pasos o transiciones (longitud total del árbol) para reordenar los caracteres y obtener el árbol de máxima parsimonia. El índice de consistencia (una medida de la homoplasia) fue de 0,456. Las distancias de rama y de internodos son proporcionales al número de cambios requeridos en el estado del carácter.

Los caballos domésticos actuales podrían ser descendientes de tres tipos fundamentales: el *Equus ferus gmelini*, el *Equus ferus przewalski*, y el *Equus ferus stenonis, robustus o solutreensis.* No obstante, Sotillo y Serrano (1985) y Groves (1986) postulan que el caballo de Przewalski (*Equus przewalski*) podría ser la variante sud-oriental del Tarpan

Tabla 2. Matriz de semejanzas morfológicas.

C/R[a]	RAC[b]	AND	ARA	AST	BRE	BRC	BUR	CAT	GAL	GAR	JAN	JAS	LOS	LUS	MAL	MEN	POT	SOR
A	0	2	4	1	0	2	1	1	1	1	1	1	1	2	2	3	1	2
B	2	1	2	0	3	2	2	1	0	0	0	0	0	1	1	1	0	0
C	3	0	1	1	0	1	1	3	1	1	1	1	1	1	2	1	0	1
D	1	3	3	0	4	2	1	2	0	0	0	0	0	3	2	4	0	0
E	0	2	4	0	4	3	2	1	0	0	0	0	0	2	2	2	1	0
F	1	2	4	1	4	3	3	1	1	0	0	0	1	3	2	2	1	0
G	2	1	2	1	2	1	2	2	2	2	2	0	0	1	2	2	1	0
H	2	0	2	0	1	1	2	0	0	0	1	1	0	1	2	1	0	0
I	2	2	2	2	2	2	2	0	2	2	2	1	2	0	2	1	2	2
J	1	4	2	3	1	1	1	1	2	1	1	1	1	4	2	1	0	4
K	2	2	2	2	2	2	0	1	2	2	2	2	2	2	2	2	2	2
L	1	2	2	2	1	1	1	1	2	2	2	2	2	2	1	1	2	2
M	1	2	2	1	0	1	1	2	1	1	1	1	1	2	2	1	1	1
N	0	1	0	2	0	2	2	2	2	2	2	2	2	1	2	1	2	2
O	0	0	2	1	1	0	1	0	1	0	0	0	0	0	0	1	0	1
P	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q	1	0	0	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1
R	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1
S	0	1	0	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1
T	2	1	1	3	2	1	0	2	3	2	3	2	2	0	2	0	3	3
U	0	1	1	2	1	1	1	1	0	2	2	2	2	0	0	1	2	2
V	2	1	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	1
W	2	1	0	0	2	2	1	0	0	1	0	1	1	1	1	2	0	0
X	0	1	1	1	0	0	0	1	1	0	0	1	1	1	1	0	1	1
Y	2	2	0	0	0	1	1	2	2	2	2	2	0	2	2	2	2	2
Z	1	1	2	1	2	2	1	1	0	1	1	1	1	1	1	1	1	0

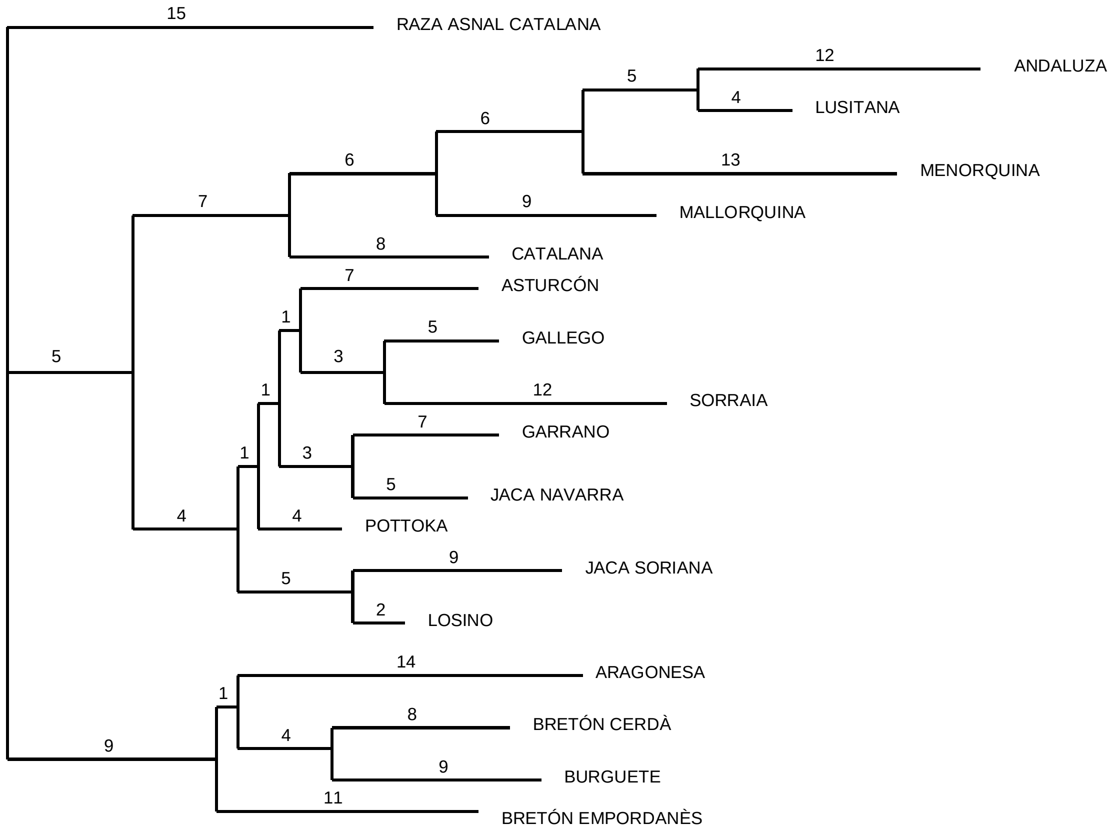
(To be continued...)

(...To be continued)

C/R[a]	RAC[b]	AND	ARA	AST	BRE	BRC	BUR	CAT	GAL	GAR	JAN	JAS	LOS	LUS	MAL	MEN	POT	SOR
A	1	1	1	1	2	2	1	0	1	1	1	1	1	0	1	0	1	0
B	1	2	2	1	2	2	2	1	0	1	1	2	1	1	1	0	1	0
C	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
D	1	0	1	0	1	1	0	1	0	1	1	1	0	1	0	1	1	1
E	1	0	0	1	0	0	0	1	1	0	1	0	0	0	1	1	0	0
F	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G	0	2	2	2	3	2	3	1	2	0	4	2	2	1	2	1	2	1
H	0	0	0	0	0	1	1	2	0	1	0	1	0	0	0	0	0	0
I	1	0	1	0	1	1	1	1	0	0	0	0	1	1	0	1	1	0
J	0	1	2	0	2	2	2	1	0	0	0	0	0	1	2	1	0	1
K	1	2	2	1	5	4	3	5	5	3	3	6	5	6	1	1	5	0
L	2	2	0	0	3	2	0	3	2	2	0	1	1	3	0	3	0	2
M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
P	0	1	0	1	1	1	1	1	1	1	0	0	0	1	1	0	1	1
Q	0	2	2	1	2	2	2	1	0	1	1	2	1	1	1	2	1	1
R	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S	2	1	3	0	3	3	3	2	0	4	0	0	0	1	1	1	0	0
T	0	1	2	1	2	2	2	1	1	1	2	1	1	1	1	1	1	1

[a] C / R = Caracteres / Razas
[b] Ver texto para los códigos

Figura 2. Análisis cualitativo de los datos morfológicos (Tabla 2). Dendrograma producido mediante el análisis PAUP, resultante de la aplicación del método de la parsimonia de Fitch. Las distancias de rama e internodos son proporcionales al número de cambios requeridos en el estado del carácter. El árbol fue rotado utilizando la raza asnal Catalana como población outgroup.



(*Equus gmelini*), y que habría sido introducido en Africa y Europa a través de Egipto y el Estrecho de Gibraltar (España), integrándose todos sus descendientes en el llamado Tronco Tarpánico. Los resultados obtenidos en el estudio de las razas equinas de la Península Ibérica y los obtenidos por Jordana *et al.* (1995) en un total de 22 razas equinas mundiales, en las que se incluía el Tarpan y el Przewalski, confirmarían esta hipótesis.

En este árbol podemos observar dos grandes grupos perfectamente definidos. Uno de ellos formado por trece razas: Andaluza, Lusitana, Menorquina, Mallorquina, Catalana, Asturcón, Gallego, Sorraia, Garrano, Jaca Navarra, Pottoka, Jaca Soriana y Losino (grupo A), que se corresponderían con los descendientes del Tronco Tarpánico. El otro gran grupo, que se corresponde con los descendientes del Tronco Solutrensis, incluye cuatro razas: Aragonesa, Bretón Cerdà, Burguete y Bretón Empordanès (grupo B).

En el Tronco Tarpánico es posible, a su vez, diferenciar dos subgrupos: el A1, que se corresponde con los poneys ligeros, es decir, Asturcón, Gallego, Sorraia, Garrano, Jaca Navarra, Pottoka, Jaca Soriana y Losino, descendientes directos del *Equus gmelini*. Las otras cinco razas, Andaluza, Lusitana,

Figura 3. Arbol de consenso y porcentaje de replicaciones bootstrap obtenido a partir de los datos morfológicos utilizando el programa PAUP.

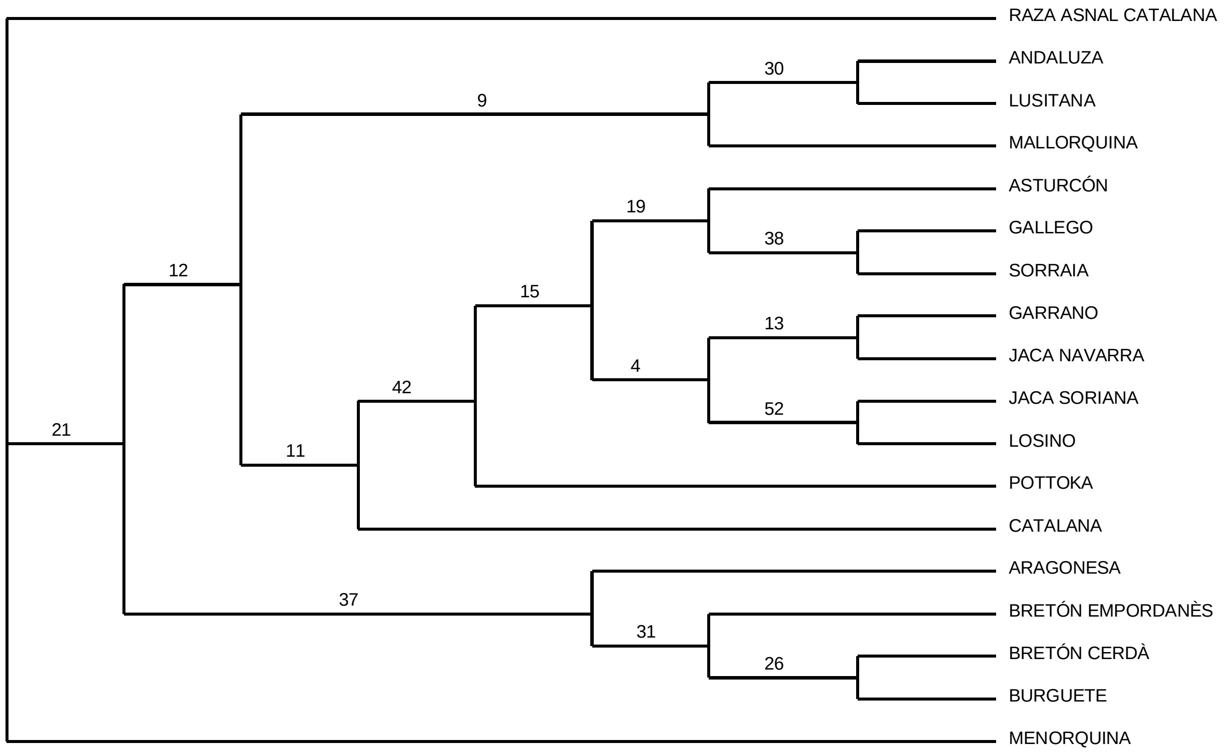


Figura 4. Caballo de raza Andaluza.

Figura 5. Caballo Breton.

Menorquina, Mallorquina y Catalana formarían el subgrupo A2, y se corresponderían con los representantes del *Equus przewalski*.

La figura 3 representa el árbol de consenso obtenido después de cien replicaciones *bootstrap*; los valores en el árbol indican el porcentaje de replicaciones obtenidas después del análisis, es decir, la amplitud del intervalo de confianza. Ambos dendrogramas, el más parsimonioso y el de consenso son muy similares, manteniéndose los tres grupos anteriormente descritos, con la excepción de la raza Menorquina, que forma una tricotomía no resuelta con la raza asnal Catalana y las demás razas equinas. No obstante, los bajos niveles de significación indicarían que existe poca confianza con esta ordenación.

Es sorprendente que los niveles de significación del análisis *bootstrap* obtenidos en este estudio sean substancialmente menores que los obtenidos por Jordana *et al.* (1995). En los dos trabajos las diferentes razas se adscriben perfectamente en sus respectivos troncos ancestrales, confirmándose la estrecha relación existente entre los individuos de los troncos *Equus gmelini* y *Equus przewalski*, conformando el Tronco Tarpánico y confirmando la hipótesis de Sotillo y Serrano (1985) y Groves (1986); sin embargo, el nivel de confianza es substancialmente diferente. Creemos que esto puede ser debido, principalmente, a que el área geográfica de las 17 poblaciones analizadas en este estudio es muy restringida (España y Portugal), y por tanto, las posibilidades de migraciones génicas entre razas habrían sido mayores, en comparación con las otras razas de distribución mundial más amplia. Esto podría comportar una mayor homogeneidad en los caracteres morfológicos analizados, con lo cual la ordenación de las diferentes razas en sus respectivos troncos ancestrales tendría un menor nivel de confianza, indicándonos

Tabla 3. Matriz de distancias morfológicas (MCD) entre las razas equinas ibéricas.

Razas	AND	ARA	AST	BRE	BRC	BUR	CAT	GAL	GAR	JAN	JAS	LOS	LUS	MAL	MEN	POT	SOR
Andaluza (AND)	****																
Aragonesa (ARA)	0.50	****															
Asturcón (AST)	0.50	0.63	****														
Bretón Empordà (BRE)	0.61	0.48	0.63	****													
Bretón Cerdà (BRC)	0.54	0.50	0.61	0.37	****												
Burguete (BUR)	0.59	0.52	0.54	0.43	0.33	****											
Catalana (CAT)	0.57	0.67	0.57	0.59	0.59	0.59	****										
Galllego (GAL)	0.52	0.61	0.22	0.63	0.59	0.54	0.52	****									
Garrano (GAR)	0.54	0.70	0.37	0.61	0.50	0.46	0.50	0.37	****								
Jaca Navarra (JAN)	0.63	0.59	0.28	0.59	0.52	0.48	0.52	0.33	0.24	****							
Jaca Soriana (JAS)	0.52	0.61	0.39	0.61	0.52	0.54	0.61	0.43	0.30	0.33	****						
Losino (LOS)	0.54	0.57	0.26	0.61	0.57	0.52	0.50	0.33	0.30	0.33	0.24	****					
Lusitana (LUS)	0.33	0.59	0.59	0.67	0.57	0.61	0.41	0.61	0.54	0.57	0.57	0.54	****				
Mallorquina (MAL)	0.41	0.59	0.48	0.65	0.61	0.54	0.46	0.46	0.52	0.52	0.61	0.52	0.46	****			
Menorquina (MEN)	0.52	0.63	0.65	0.52	0.61	0.59	0.52	0.65	0.67	0.59	0.57	0.65	0.43	0.57	****		
Pottoka (POT)	0.48	0.59	0.22	0.59	0.52	0.54	0.41	0.28	0.33	0.28	0.39	0.24	0.48	0.50	0.70	****	
Sorraia (SOR)	0.54	0.74	0.37	0.67	0.63	0.70	0.61	0.35	0.39	0.43	0.46	0.48	0.54	0.63	0.65	0.41	****

Figura 6. Caballo de raza Gallega.

asimismo, que razas de diferentes troncos habrían podido intervenir en la formación y mejora de otras.

Análisis cuantitativo

Los valores de la distancia MCD entre las razas ibéricas de caballos se muestran en la tabla 3. El promedio de distancia entre razas toma un valor de 0,51 ± 0,12, con valores extremos de 0,22 entre los pares Asturcón-Gallego y Asturcón-Pottoka, y de 0,74 para el par Aragonesa-Sorraia.

Este valor medio de MCD entre las razas ibéricas fue ligeramente inferior al obtenido por Jordana *et al.* (1995) con 22 razas equinas mundiales (MCD = 0,57 ± 0,17), aunque las diferencias no fueron estadísticamente significativas (F = 2,12; no significativa).

Cuando se analiza la variabilidad morfológica intragrupo, mediante el cálculo de los correspondientes MCDs, se obtienen los siguientes valores promedio para cada uno de los grupos: MCD = 0,33 ± 0,07 para el grupo A1 (*Equus gmelini*), MCD = 0,47 ± 0,08 para el grupo A2 (*Equus przewalski*), y MCD = 0,44 ± 0,08 para el grupo B (*Equus solutreensis*). El test de la F para contrastar la heterogeneidad de las medias mediante el método de Student-Newman-Keuls (SAS, 1989), indicó que únicamente existen diferencias significantes entre el grupo A1 y los otros dos, A2 y B (F = 14,24; P < 0.001). Este resultado indicaría que las razas descendientes de *Equus gmelini* (poneys ligeros) tendrían una mayor relación de semblanza morfológica que los representantes de los otros troncos ancestrales, corroborando la estrecha relación observada en el dendrograma de la figura 2 (bajos valores de distancia de rama e internodo, los cuales son proporcionales al número de cambios requeridos en el estado del carácter). El relativamente elevado valor (42%) del análisis *bootstrap* (Figure 3), cuando es comparado con los otros valores, también confirmaría este elevado nivel de semejanza morfológica.

Figura 7. Caballo de raza Jaca Navarra.

Los ligeros poneys ibéricos, que se localizan mayoritariamente en las regiones septentrionales de España y Portugal, y cuyos orígenes se remontan a los antiguos poneys celtas traídos a la Península Ibérica durante las sucesivas invasiones (Dévimeux, 1988; Santamarina *et al.*, 1992) habrían sufrido pocas introgresiones génicas de razas foráneas durante su formación y posterior evolución y mejora, lo cual redundaría en un mayor grado de parecido morfológico. En cambio, en las razas que conforman los grupos de los caballos de silla (grupo A2) y los de tiro (grupo B), la aportación génica de otras razas foráneas habría sido manifiesta, hipótesis apoyada por las informaciones históricas que se tienen al respecto, con lo que los valores MCD intragrupo serían superiores y estadísticamente significativos cuando se comparan con el grupo de los poneys.

Así, por ejemplo, en la formación y posterior evolución del caballo Andaluz, habrían influido sobre las primitivas poblaciones de caballos ibéricos, razas tales como el Berberisco y el Arabe, así como poblaciones de caballos númidas y germánicos (Aparicio, 1960; Bongianni, 1987). En las otras razas ibéricas de silla, también habrían influido, principalmente, las razas Berberisca y Arabe, aunque en cada caso particular ha podido haber influencia de otras razas equinas mundiales, como, por ejemplo, en la raza Mallorquina, donde la influencia de caballos de la Italia Central y Meridional (raza Napolitana y caballos negros de la Corte Vaticana) ha sido importante (Dévimeux, 1988).

También en las razas de tiro (grupo B), la aportación genética foránea ha sido muy importante. Basta citar la referencia que sobre ellas hacen Sotillo y Serrano (1985), cuando señalan que España no poseía caballos de tiro hasta prácticamente el siglo pasado, en el que, sobre la base de yeguas de silla del norte de España actuaron, principalmente, razas pesadas francesas. Las principales influencias sobre el Bretón Empordanès y el Bretón Cerdà han sido debidas al Bretón Postier francés, aunque la población de Bretón Cerdà también ha recibido un cierto aporte genético de razas

Figura 8. Caballo de raza Menorquina.

Figura 9. Caballo Pottoka.

Figura 10. Caballo de raza Mallorquina.

tales como el Ardenés, Boloñés y Percherón (Parés y Vilaró, 1994). El caballo de Burguete se originó a partir del cruce entre sementales Bretón Postier y yeguas locales próximas a la Jaca Navarra y al Pottoka. En cuanto a la raza Aragonesa, el mayor aporte genético provino de la raza francesa Percherón, aunque otras razas tales como el Ardenés, Boloñés, Normando y Bretón también contribuyeron en su mejora (Sotillo and Serrano, 1985; Sierra, 1987). Por último, sólo comentar que en muchas de las razas europeas de tiro, y también en las españolas (*Equus solutreensis*), las razas Arabe y Andaluza (*Equus przewalski*), principalmente, han contribuido de forma notable en su mejora (Hartley, 1981; Baudoin, 1991), con lo que, lógicamente, la variabilidad morfológica intragrupo (medida como MCD) se vería aumentada.

Asimismo, la intensidad de selección (selección artificial) llevada a cabo sobre diferentes caracteres de interés (morfológicos, funcionales, etc.,) también habría sido substancialmente diferente para los tres grupos, siendo casi nula para el grupo de los poneys (grupo A1) y de una importancia relativa para los representantes de las razas de silla y tiro (grupos A2 y B, respectivamente). Elevadas intensidades de selección para diferentes caracteres en las diferentes razas, podrían contribuir al incremento del grado de variabilidad morfológica entre las razas dentro del grupo (grupos A1 y B), y a reducir dicho nivel de variabilidad (mayor parecido morfológico) cuando las diferentes poblaciones (grupo de los poneys, A2) no se ven afectadas por la selección artificial de los caracteres en estudio.

Conclusiones

Como principales conclusiones de este estudio podemos señalar la confirmación, al menos desde el punto de vista morfológico, de la hipótesis propuesta por Sotillo y Serrano (1985) y Groves (1986), de que el caballo de Przewalski (*Equus przewalski*) podría ser la variante sud-oriental del Tarpán (*Equus*

Figura 11. Caballo Burguete.

gmelini), integrándose todos sus descendientes en el llamado Tronco Tarpánico, conclusión también expresada por Jordana *et al.* (1995); no obstante, debería ser verificada a través del análisis de marcadores moleculares. Asimismo, se comprueba que el grupo que forman los poneys ibéricos es morfológicamente muy semejante, a diferencia de lo que ocurre con las razas de silla y las de tiro, posiblemente debido a un mayor aislamiento genético, a una casi nula selección artificial para los caracteres morfológicos, y a una elevada movilidad de reproductores intra-grupo, conclusión que también tendría que ser contrastada a través del análisis de marcadores genéticos.

Agradecimientos

Los autores quieren mostrar su agradecimiento a los amigos y colegas que nos han ayudado en la recopilación del material gráfico para este manuscrito: Isidro Sierra (raza Aragonesa), Fernando Muñoz (razas Burguete y Menorquina), Luciano Sánchez (raza Gallega), Maria do Mar Oom (razas Garrano y Sorraia), Rui Morais (raza Lusitana; http://www.cite.pt/fvhorses/), Ricardo de Juana (raza Losino), Xavier Such (razas Jaca Navarra y Pottoka), y Centro Excursionista de Catalunya (raza Catalana). La raza Bretón Empordanès se obtuvo del libro “Els Concursos de Bestiar” (Rosell i Vilà, 1922). Las restantes fotos son propiedad de los autores.

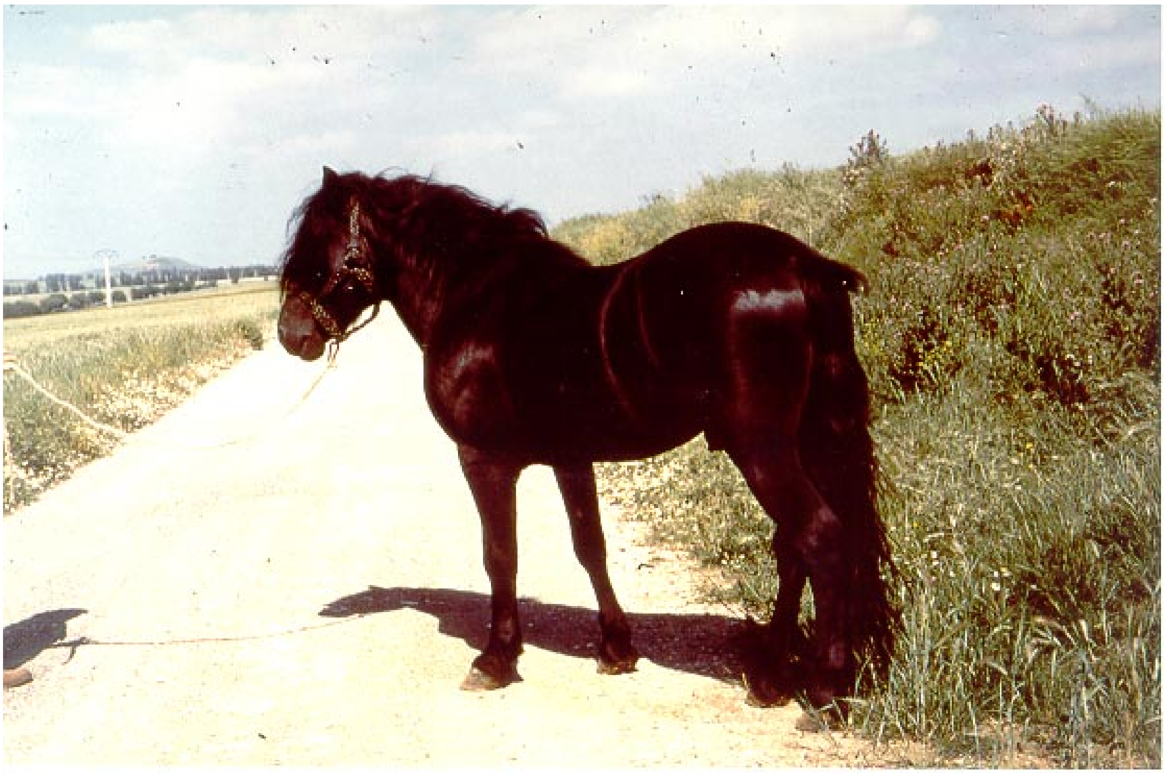


Figura 12. Caballo Losino.

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