



# Inbreeding depression and environmental effect on milk traits of the Murciano-Granadina goat breed



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## ABSTRACT

The extent of inbreeding as well as environmental factors such as parity order, age at kidding and contemporary group (herd-year-season) was evaluated for their effects on the total production of milk, fat, protein and dry extract in Murciano-Granadina goats in Spain. The pedigrees of 11,926 females were traced to calculate the inbreeding coefficient for each animal. The lactations of these 22,832 females were analysed, standardised to 210 days of lactation, and information on the whole milk, fat, protein and dry extract production was recorded. The least squares method was used, and fixed effects in the model included parity order, the age of goat at kidding and contemporary group, and the inbreeding rate as a continuous variable, considering linear and quadratic effects. Based on this model, only 1.18% of the animals presented inbreeding, and the average population was of low magnitude (0.24%). However, among inbred animals, the average was considered high (20.31%). The total average of milk, fat, protein and dry extract production is within the range considered normal for the breed. The variables of parity order, the age of goat at kidding and contemporary group, exerted a statistically significant influence on the milk production and composition traits. Inbreeding had a quadratic effect on total milk production with a minimum point at 10.59% of inbreeding. Inbreeding had a positive linear correlation with total fat and dry extract yield. There was no statistically significant effect of inbreeding on total protein production. In general, the inbreeding levels in the Murciano-Granadina goat population did not negatively affect milk traits in the evaluated period.

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## 1. Introduction

The Murciano-Granadina goat breed is the most cosmopolitan of Spain, and it can be found in several countries in Europe, Africa and South America (Camacho-Vallejo et al., 2009). In 2012, the Murciano-Granadina goat breed consisted of a population of 111,939 animals scattered throughout various regions of Spain, including Murcia, Andalucía, Valencian Community, Castilla-La Mancha, Catalonia, Balearic Islands and Extremadura (MAGRAMA, 2013). Breed improvement programmes have contributed to increased productivity, profitability and quality of milk, based on the artificial selection of animals that show increased production efficiency and product quality. According to Camacho-Vallejo et al. (2009), these animals produce approximately 200 kg of milk in 150 days at first lactation, reaching 550 kg from the second lactation

onwards, with lactations that can last 240 days. In Spain, the milk of Murciano-Granadina goats produces a fine cheese that when paired with matured red wine is very appreciated by consumers.

Artificial selection programmes for productive uniformity within the Murciano-Granadina breed have contributed to the use of a limited number of animals with superior productive traits in reproduction, most often from the same family and/or lineage. This produces an artificial founder effect that has led to increased inbreeding and loss of genetic variability within the population. The genetic gain to a population is greater when there is high genetic variability, and increased inbreeding can result in homozygosity for both beneficial and deleterious alleles. In the case of beneficial homozygous alleles, inbreeding would be an advantage since it would result in (1) homozygosity for dominant alleles, which are imposed by successive generations (prepotency), (2) homogeneity of the flock and (3) breeding pattern. However, homozygosity for deleterious recessive alleles can lead to inbreeding depression resulting in reproductive and adaptive problems and generally reduced biological fitness in a given population. Such population bottlenecks are reflected mainly in commercial flocks that depend

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**Table 1**  
Average number of records for each class effect considered in the model.

Effects	Values <sup>a</sup>
Average number of records to parity order	2076 (8992–6)
Average number of records to age at kidding	2283 (7110–17)
Average number of records to kidding year	2076 (5383–115)
Average number of records to kidding season	5708 (8198–2739)

<sup>a</sup> In parenthesis are maximum and minimum values.

on low-cost production, and they affect the average performance of inbred animals and result in reduced milk quality and production. However, few studies have been conducted with the purpose of investigating this effect of inbreeding on milk traits in goats. Sajjad Khan et al. (2007) concluded that inbreeding affected growth and reproductive traits discreetly in the Beetal goat breed in Pakistan. However, these researchers suggested the use of planned matings to prevent further inbreeding and avoid any potential deleterious effects. According to Dario and Bufano (2003), inbreeding in the local Altamura Italian sheep breed resulted in decreased lactation length and a significant loss in milk productivity throughout lactation.

Environmental factors such as age of goat at kidding, parity order, season, and flock are also responsible for changes in important traits such as milk yield and composition (Soares Filho et al., 2001; Pimenta Filho et al., 2004; Peralta-Lailson et al., 2005; Paz et al., 2007; Montaldo et al., 2010; Goetsch et al., 2011; Irano et al., 2012; Ishag et al., 2012; Mucha et al., 2014; Selvaggi and Dario, 2015). Therefore, selective breeding practices should be closely observed for improvements in the production system adopted. This study aimed to assess inbreeding effects and the influence of environmental factors on total milk production and milk constituents of Murciano-Granadina populations belonging to the National Breed Association of Murciano-Granadina Goat Breed (CAPRIGRAN) of Spain.

## 2. Material and methods

The inbreeding and environment effects (age of goat at kidding, parity order and contemporary group) were analysed for total milk production (TMP), fat (TFP), protein (TPP) and total dry extract (TDEP) standardised at 210 days of lactation. Data referring to genealogical information and production traits of Murciano-Granadina goats belonging to 41 different flocks were obtained from the National Association of Breeders of Murciano-Granadina Goat Breed (CAPRIGRAN).

The database to estimate individual inbreeding contained only females who had father and mother information and complete lactations, totalling 11,926 females. These females had their genealogical trees traced with information from up to five previous generations, and the database contained 18,212 animals of which 17,390 were females and 822 males born between the years 1987 and 2005. The individual inbreeding coefficients were estimated based on the method proposed by Wright (1923), by the R software (2012), using the package PEDIGREE.

Another database was prepared with 22,832 lactations of 11,926 females from 1996 to 2006, which also included parity order information (1–11), kidding year (1996–2006), kidding season (spring, summer, fall and winter), age at kidding (1–10 years) (Table 1), flock (1–41) and the inbreeding coefficients of each animal. Only data up to 2006 were available for the study, because the CAPRIGRAN was being restructured, which made it difficult access data from subsequent years. The database contained some effects with a few records of milk production to cover the largest number of lactations and estimate results with greater accuracy.

**Table 2**  
Population genetic parameter estimated for the Murciano-Granadina goat breed.

Variables	Values <sup>a</sup>
Total number of animals	11,926
Flocks number	41
Average number of animals for flock	290.88 (16–1282)
Number of inbred animals	141
Inbred animals (%)	1.18
Average <i>F</i> of total population (%)	0.24
Average <i>F</i> of inbred population (%)	20.31
<i>F</i> range (%)	0.00–37.50
Average of total milk production (kg)	333.23
Average of total fat production (kg)	16.35
Average of total protein production (kg)	11.42
Average of total dry extract production (kg)	45.28

<sup>a</sup> In parenthesis are maximum and minimum values.

For better control of the environmental effects, contemporary groups were performed considering kidding year, kidding season and flock. Contemporary groups with less than four records were excluded from the database. Statistical analyses were performed by the least squares method using the SAS software (2002), by PROC GLM and PROC REG procedures. A model was used that included contemporary group (herd-year-season), the age of goat at kidding and parity order as fixed effects, and individual inbreeding as covariate, with linear and quadratic effects. There was no significant effect of interaction between variables, therefore, these effects were removed from the model as follows:

$$y_{ijkl} = \mu + PO_i + AK_j + CG_k + b_1(FI) + b_2(FI^2) + e_{ijkl};$$

where  $y_{ijkl}$  is the vector of dependent traits (TMP, TFP, TPP and TDEP);  $\mu$  is the general constant of observations;  $PO_i$  is the effect of parity order  $i$  ( $i = 1$  to 11);  $AK_j$  is the effect of age  $j$  at kidding ( $j = 1$  to 10);  $CG_k$  is the effect of contemporary groups  $k$  ( $k = 1$  to 640);  $b_1$  is the linear regression coefficient;  $b_2$  is the quadratic regression coefficient;  $FI$  is the effect of inbreeding coefficient  $I$  of goat;  $e_{ijkl}$  represents errors associated with each observation.

All the inbreeding levels were used, including the level zero, to check differences in production according to these different levels.

## 3. Results

The number of inbred animals as well as the average inbreeding coefficient of the population was low. However, there were a significant number of individuals with high inbreeding levels (Table 2). The averages of TMP, TFP, PP and TDEP of the studied Murciano-Granadina goat population were within the breed standard. The variables parity order (PO), age at kidding (AK) and contemporary groups (CG) significantly influenced the milk production and composition values (Table 3).

There was a significant inbreeding effect on total milk production (TMP), fat (TFP) and dry extract (TDEP) but not on total protein production (TPP) (Table 3). There was a quadratic effect of the inbreeding on the TMP with a minimum value when the inbreeding reached 10.59%, resulting in a depression of milk yield until that level (Fig. 1). This was followed by an increment in TMP with increased inbreeding levels. The TFP and TDEP traits were affected positively by the linear effects of inbreeding (Fig. 2), with little impact on those traits. This suggests that some favourable alleles were expressed as reported by Carvalho et al. (2004).

## 4. Discussion

Both the number of inbred animals and the average population inbreeding values was low in the Murciano-Granadina goat population. This may favourably reflect the mating management

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