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Characterization of the lactation curve in Murciano-Granadina dairy goats

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ABSTRACT

The lactation curve of Murciano-Granadina goats was studied by using records collected between 2004 and 2010 under its Official Dairy Recording program, which includes three milking control programs (Granada, Almeria and Cordoba). A total of 518,557 test-day records corresponding to 69,330 lactations by 38,039 does in 130 herds were included in the analyses. Different mathematical models were fitted, and average curves for region of production, parity, kidding season and type of kidding were estimated. A quadratic spline function gave the best fitting performance and provided a good description of the Murciano-Granadina lactation curve. All the factors studied affected both the scale of the lactation curve and its shape, with more distinct curves in first lactations, goats kidding in the summer and those producing singletons. When compared with later parities, first-parity does had a lower initial level of production, later and lower peak yield, and a smaller decline in milk production after the peak. Goats kidding in the Summer had a steep increase in milk yield up to the peak, which occurred earlier and with a higher yield than in other seasons, but seasonal effects differed slightly among regions. The lactation curve was flatter and with a later peak in goats producing single kids, and a steeper increase in yield up to the peak was observed as the number of kids increased.

1. Introduction

The lactation curve is the mathematical representation of the physiological response of milk production throughout the milking period (Masselin et al., 1987). The study of lactation curves has several practical applications in the dairy industry, both for breeding and management purposes. The prediction of future records of lactating animals allows an early evaluation of selection candidates in progeny test programs, and the assessment of total milk yield and knowledge of lactation curve traits, including production peak and persistency of lactation, is essential for a proper estimation of animal requirements for diet formulation. Furthermore, the analysis of lactation curves also allows the early detection of animals to be culled for low production or with sub-clinical pathologies (Dematawewa et al., 2007). In these circumstances, a crucial point is the choice of a suitable mathematical function able to efficiently describe the evolution of milk yield throughout lactation. An appropriate choice should be based on data coming from different populations and herds, and the effects of different environmental factors on function parameters should be evaluated (Wood, 1980).

The pattern of milk yield throughout the lactation in dairy species is usually characterized by two different phases, i.e., the ascending phase, from parturition to peak production; and the descending phase, from this maximum point until drying-off, with the slope during this phase representing the persistency of lactation (Masselin et al., 1987). The lactation curve has been deeply studied in dairy

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cattle (Pollot, 2000), and several mathematical models have been proposed to describe it (Wood, 1967; Wilmink, 1987; Cappio-Borlino et al., 1995; Serchand et al., 1995; Vargas et al., 2000). There are fewer references regarding lactation curves in dairy goats (Gipson and Grossman, 1989, 1990; Montaldo et al., 1997; Macciotta et al., 2007; Menéndez-Buxadera et al., 2010), but it is known that the shape of the lactation curve in this species is greatly affected by environmental conditions, especially in local breeds under extensive or semi-extensive farming systems (Fresno et al., 1992; Rota et al., 1993; Peña et al., 1999). The major factors affecting lactation curve shape include breed, kidding season, age of the doe, litter size, herd and feeding practices (Morand-Fehr and Sauvant, 1980; Gipson and Grossman, 1990; Wahome et al., 1994; Ruvuna et al., 1995; Montaldo et al., 1997; Macciotta et al., 2007). Thus, studies on the lactation curve of a breed, herd or population may express some peculiarities of goat productive behavior in their own context, which must be studied in further detail.

Currently, breeding values for production traits in dairy cattle selection programs are often predicted with random regression models (Jensen, 2001; Schaeffer and Jamrozik, 2008), which take into account the trajectory of milk yield throughout lactation. Nevertheless, the use of such models in selection of dairy goats has been adopted in limited situations, mostly in goats farmed in intensive conditions (Andonov et al., 2007; Zumbach et al., 2008), but it is not clear whether those functions could also be suitable for breeds kept in semi-extensive production systems. Therefore, preliminary work with a large amount of information is needed to assess the usefulness of different lactation curve models in extensively or semi-extensively produced breeds, before a test-day model can be widely adopted in their genetic evaluations.

Murciano-Granadina is the most cosmopolitan Spanish goat breed (Camacho-Vallejo et al., 2010), and it is farmed in several countries in Europe, Africa and South America. The breed is generally kept in semi-extensive systems under different climatic conditions, grazing on natural pastures and shrubs throughout the year, with supplementation in critical periods, based on either by-products or commercial feed supplements. Under these conditions, the average total yield for a standardized lactation length of 210 days is 416.0 ± 197.9 kg for milk, 19.54 ± 7.12 kg for fat, 13.25 ± 5.31 kg for protein and 52.33 ± 17.16 kg for dry matter (unpublished data). Notwithstanding, the productive potential of Murciano-Granadina goats should be much higher, as indicated by record yields above 1500 kg (Delgado et al., 2012). The breed does not show seasonal reproductive behaviour and bucks are often kept in permanence with goats, so milk is produced throughout the whole year, which could explain their short lactation length.

An active national breeding program of the Murciano-Granadina breed aimed at improving milk yield and composition has been in place for some years (Analla et al., 1996), and a large data set has been generated through its milk recording program. This information is useful to gather baseline information which can be used to further develop the genetic improvement program of Murciano-Granadina dairy goats. Furthermore, the vast amount of data currently available in this program can provide information which may serve as a model, extending the conclusions to other goat breeds maintained under different management conditions.

In the present paper, the lactation curve of Murciano-Granadina goats farmed under semi-extensive conditions is modeled with standard mathematical functions to: (1) assess the suitability of the different models to describe the lactation curve in this breed; (2) characterize the evolution of milk yield throughout lactation; (3) investigate how different environmental and biological factors affect the shape of the lactation curve.

Table 1
Number of test-day records by level of the factors considered.

Factor	Number of records
Total	518,557
Region	
Granada	232,679
Almeria	114,336
Cordoba	171,542
Kidding season	
Spring	159,636
Summer	94,529
Autumn	112,732
Winter	151,660
Kidding type	
Single	224,589
Twin	263,384
Triplet or more	30,584
Lactation number	
First	160,044
Second	144,328
Third	91,145
Fourth	55,580
Fifth or upper	67,460

2. Materials and methods

2.1. Data

The historical archives of the official milk recording program carried out by the National Breeders Association of the Murciano-Granadina Goat Breed were used in this research. Milk recording was carried out according to A4 methods of ICAR (1990), and the mean lactation length was 210 days. Data collected between 2004 and 2010 were edited to exclude lactations with less than 6 records, daily yields greater than 10 kg or below 0.2 kg, and yields recorded at 0 days or after 280 days from parturition.

The edited file contained 518,557 test-day records corresponding to 69,330 lactations of 38,039 does in 130 herds located in three dairy recording nuclei (Granada, Almeria and Cordoba). Animals were grouped into five parity classes (1, 2, 3, 4 and $\geq$5), four kidding seasons (Winter, Spring, Summer, Fall) and three classes of kidding type (single, twin, triplet or more). The distribution of records by the different levels of the above mentioned classification factors is reported in Table 1.

Overall, the information used in this study is perhaps one of the more complete data sets available for dairy goats, and could thus provide insight which can be useful for other goat breeds.

2.2. Mathematical functions

Daily milk yield was first averaged by day of lactation for the full data set and for each level of classification factor (region, kidding season and type, lactation number). Then, average curves were fitted with six mathematical functions, to model the lactation curve as a function of days in milk (t). The first four functions were chosen because they have been widely used in dairy cattle and, to a lesser extent, in sheep and goats. These functions were: