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Modelling the lactation curve of rabbit does: Towards a model including fit suitability and biological interpretation

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Abstract

This work proposes an adequate empirical model for the 28-day lactation curve of rabbit does, including fit suitability and biological interpretation. A total of 15,400 test-day milk records were used, corresponding to 550 lactations collected from 134 hybrid New Zealand × Californian rabbit does during five consecutive lactations. To develop this model, five different functions were compared (quadratic, potential, beta-modified, gamma and Gauss models), evaluating their fitting ability to mean and individual lactation curves, and the suitability of their parameters to gather the sources of variation (genetic selection level, type of diet, parity order and gestation overlapping degree) on lactation curve shape. The possible relationship between model parameters and main performance traits was also evaluated. From the results of the present work, it may be concluded that beta-modified equation [Milk yield (g/day)$=k\times(\text{day}/30)^{a}\times(1-(\text{day}/30))^{b}$] could be proposed as an alternative to quadratic models for daily milk yield prediction of reproductive rabbit does. When compared to quadratic models, beta-modified model give a slightly better fit to average ($R^2=0.986$ vs. 0.985; RMSE = 5.648 vs. 5.813) and individual (Residuals = 21.31 vs. 21.37 g; Mean square prediction error = 883.0 vs. 897.2 g^2) lactation curves, especially of those curves showing a lower lactation peak height and a greater persistence of milk yield. However, the most important advantage of the beta-modified model was the greater biological interpretation of its parameters (k regulates the curve height, while a and b regulate the milk yield of ascending and descending period, respectively) and the ability to gather curve changes. This latter aspect is revealed by the relationship of the parameters with main performance traits of lactating does (energy intake, live weight and body reserves mobilisation). Although further research on developing an optimal model is needed, the use of this type of models could provide additional information for a better understanding of the curve shape effect on the performance, body condition and health of reproductive rabbit does.

Keywords: Lactation curve; Model fitting; Performance traits; Body condition; Reproductive rabbit does

1. Introduction

In dairy species, the study of lactation curve prediction models is most frequent, because these models

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have a wide variety of applications, such as extension of incomplete records for use in genetic evaluations, formulation of rations, economic evaluation of different management schemes, etc. (Groenewald et al., 1995). The most well-known and commonly used model to describe lactation curves, especially applied to cattle, is the incomplete gamma function or Wood's model (Wood, 1967), which is defined by three parameters related to the shape of the lactation curve. However, many alternative lactation curve models have been suggested, including more or less parameters in the function than Wood's model (Morant and Gnanasakthy, 1989; Grossman and Koops, 1988). In the Grossman model, the parameters may be given a biological interpretation (Gipson and Grossman, 1989), while Neal and Thornley (1983) proposed a mechanistic model based on the biology of lactation.

As rabbit is not a dairy species, the study of models to predict their lactation curves is less important. However, milk yield and lactation curve shape of rabbit does can affect important production parameters, such as litter performance, measured as the litter growth or the survival index during lactation, mobilisation of body fat tissue of the doe, time to next effective mating, etc., as different authors have reported (McNitt and Lukefahr, 1990; Mohamed and Szendrö, 1992; Xiccato et al., 1995; Fernández-Carmona et al., 2001).

Many works on nutrition of rabbit does report milk production data, but not about the shape of the lactation curve. In fact, few works have studied the lactation curve from a modelling point of view: Lebas (1968), McNitt and Lukefahr (1990) and Sabater et al. (1993). Most of these works attempted to fit the mean lactation curve of rabbit does to a quadratic regression (Milk (g/day)$=a+b\times\text{day}+c\times\text{day}^2$) for different commercial breeds (McNitt and Lukefahr, 1990) or for different diets and litter size (Sabater et al., 1993), showing good fitting results.

However, although the quadratic equation seems to be an easy model to describe the whole process in large lactations (35 days or more), important changes have been produced in lactation curve shape in recent years, as a consequence of earlier weaning of pups (from 42 to 25–28 days) and greater litter size, which could argue the suitability of this model. On the other hand, the quadratic model shows a difficult biological interpretation of its parameters compared with other non-linear models never tested in rabbits. The development of models able to take in the possible environmental and individual differences as changes in parameters with a higher biological interpretation may improve the knowledge about their effect on reproductive rabbit doe performance. Therefore, the aim of this study was to propose an adequate empirical model for the lactation curve of rabbit does, including fit suitability and biological interpretation. To develop this model, five different functions were compared, evaluating their fitting ability to mean and individual lactation curves, and the suitability of their parameters to gather the sources of variation (genetic selection level, type of diet, parity order and gestation overlapping degree) on lactation curve shape. Finally, the possible relationship between model parameters and main performance traits was also evaluated.

2. Materials and methods

2.1. Animals

A total of 15,400 test-day milk records were analysed, corresponding to 550 lactations collected from 134 hybrid New Zealand × Californian rabbit does during five consecutive lactations (first to fifth reproductive cycle). The cross-bred females came from mating does of line V to bucks of the A line, both selected within line for litter size at weaning (from the Animal Breeding Unit of the Universidad Politécnica de Valencia, Spain). In order to evaluate the possible curve shape variations caused by genetic level, two types of cross-bred animals, hereafter called H1 and H2, were compared. The H1 ($n=67$) and H2 ($n=67$) does came from the cross of females of generations 15 and 26 of line V with bucks of generations 16 and 29 of line A, respectively. Generations 29 of line A and 26 of line V were the current generations, whereas the 16th generation of line A and the 15th of line V were old generations, stored as frozen embryos and thawed and transferred to obtain live adults contemporary to the current generations.

2.2. Diets

One of the main factors affecting milk yield and composition is feed composition and especially the