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Characterization of a changing relationship between milk production and liveweight for dairy goats undergoing extended lactation

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ABSTRACT

This study aimed to characterize the time-profile of extended lactation (EL) for dairy goats, and the relationships between milk production, liveweight, and intake that are associated with this profile. For this, 20 nonpregnant multiparous dairy goats were monitored daily for about 90 d from the onset of EL [i.e., when an increase in milk yield (MY) was observed]. These 20 individual profiles were pooled to create a group average profile at the onset of EL for the purpose of parameterizing a simple compartmental model. Moreover, 9 of the 20 EL goats were kept to compare their 24-mo profiles of body weight and milk production with those observed during 2 successive normal lactations (NL). Despite being kept in the same environment and on the same feed, a clear change from decreasing to increasing MY was identified (time of change, T_{change}) for all of the 20 EL goats around 330 d in milk. During the whole 24-mo period, EL goats produced as much milk as NL goats but this total milk production was unequally split before (56%) and after (44%) T_{change}. In terms of body weight, the most striking difference between EL and NL goats was the rapid and very high increase (+9.3 kg with an average daily gain of 60.4 g/d) that was observed concurrently with the increase in MY. Model parameterization with the group average profile does not support that the rise in MY drives the increase in resource acquisition as is generally assumed at the onset of an NL. Rather, it demonstrates that the transfer of energy from feed to milk is delayed at the onset of EL. Moreover, assessing the model ability to fit the range of individual profiles showed that the performances over the first 90 d of EL are largely predetermined by the animal state at T_{change}. The analysis of individual variability in EL efficiency showed that it depends both on an increase in resource acquisition and on the potential of goats to partition energy from the diet toward milk production instead of to body tissue gain. Finally, predicting the suitability for EL requires the consideration of more than just milk production for 300 d in milk.

Key words: dairy goat, extended lactation, modeling

INTRODUCTION

Extending the lactation of dairy females beyond 300 d is increasingly considered in the management strategies of cow and goat systems. The practical implications at the herd level have been explored (Rotz et al., 2005; Butler et al., 2010). However, these approaches are often confronted with a multiplicity of factors that potentially affect the efficiency of an extended lactation (**EL**) in a particular situation. This is especially the case for pasture-fed dairy cows where complex effects on production have been put forward as a result of different combinations of season, diet, and breed (Kolver et al., 2007; Grainger et al., 2009; Butler et al., 2010). These findings have stimulated interest in finding generic characteristics of EL that could be used across different nutritional contexts in dairy systems (Dematawewa et al., 2007; Steri et al., 2012). Despite qualitative similarities between the standard 300-d lactation of dairy cows and goats, some evidence exists that goats represent a particular case of EL. In the dairy cow, it is frequently reported that, even under nonlimiting nutritional conditions, milk yield (**MY**) continuously decreases after the normal 300-d period (Grainger et al., 2009). Very few reports exist describing EL in goats but in all of them, it seems that the onset of EL could be defined by an increase in MY (Chastin et al., 2001; Salama et al., 2005). In these 2-yr studies, EL did not lead to significant loss in MY compared with 2 lactations of 300 d with a 12-mo kidding interval. Moreover, it has been observed that well-fed dairy goats can extend their lactation to last from 2 to 4 yr by increasing seasonally their milk secretion although an overarching trend existed for MY to decrease (Linzell, 1973). In this latter study, the seasonal fluctuations in MY throughout the lactation suggested that mammary function is not only affected

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by nutrition but that an underlying, innate, biological mechanism is involved beyond 300 d of lactation. This raises the question, as yet unexplored, of which animal factors influence this onset of EL. Together with the description of Salama et al. (2005), these results indicate the need for better characterization of EL profiles in the dairy goat, not just in terms of MY but also in terms of being able to model the performance parameters linked to nutrient partitioning. Accordingly, the present study aimed to characterize the time profile of EL for dairy goats, and the relationships between milk production, liveweight, and intake that are associated with this profile. Particular focus was given to the period when lactation is normally initiated, which is usually a critical period in dairy goats. A second aim was to model these changes so as to shed light on the animal factors influencing their shape.

MATERIALS AND METHODS

Animals and Housing

Twenty multiparous dairy goats (6 Saanen and 14 Alpine) were selected from the experimental herd of Grignon (France). After kidding in January 2009, these goats were not rebred 7 mo later as would usually be the case for goats with a 12-mo kidding interval in a normal lactation (**NL**). The 2-mo dry period was omitted for the goats in EL, which continued to be milked twice per day. This group was monitored in individual pens from December 21, 2010, to March 7, 2011, to characterize performance at the onset of EL (from about mo 11 to 14 of lactation). Beyond March 2011, 9 of the 20 goats were kept to compare 24-mo EL profiles (the 24-mo kidding interval, including 22 mo of lactation) with NL profiles that were selected a posteriori on the basis of similar BW and MY from 0 to 300 DIM. During their EL, goats were fed the same TMR diet as the other goats from the herd. The TMR consisted of grass hay (250 g/kg of DM), alfalfa (240 g/kg of DM), sugar beet pulp (300 g/kg of DM), brewer's grain (50 g/kg of DM), and concentrate blend (160 g/kg of DM). The concentrate blend consisted of 25% wheat, 25% barley, 30% maize, 15% soybean meal, 3% molasses, and 2% mineral premix composed of 18% P, 14% Ca, and 6% Mg. Energy and protein values of the diet were calculated according to the Institut National de la Recherche Agronomique (**INRA**) tables (Baumont et al., 2007). True protein digested in the small intestine when fermentable N is limiting (PDIN) was 84.4 g/kg of DM and true protein digested in the small intestine when fermentable energy is limiting (PDIE) was 83 g/kg of DM. The net energy content of the diet ($\mathbf{E_{diet}}$) was 6.12 MJ/kg of DM [the INRA system uses a single energy unit for all physiological functions (i.e., the same efficiency is assumed for the conversion of ME to net energy)]. The quantities offered were adjusted weekly to achieve 10% refusals.

Biometric Approach for Characterizing EL with the 24-mo Profiles

Measurements. The profiles of performances of EL and NL were characterized with the data from routine herd monitoring. This was done weekly and included for each goat the average daily MY and a BW measure. Milk composition (fat and protein) and SCC were recorded monthly and are also reported in this study.

Performance-Matching Procedure. To get comparable profiles between EL and NL, the MY and BW curves before the onset of EL (i.e., from conception to wk 30 of lactation) were visually examined. For each EL, the NL candidate whose curves best matched was retained to form a pair. As far as possible, the 9 pairs were formed using NL data from 2010 and 2011. However, due to the requirements for the matching procedure, some NL profiles were chosen among data recorded from previous years.

Time Alignment of EL and the Second Lactation of NL. Visual inspection of the EL curves showed an increase in MY at about 330 DIM that could correspond to a physiological change. To detect more precisely when this change occurred for the different goats, a third-degree polynomial of MY on DIM was fitted for each EL animal in the period 300 to 390 DIM. The time of change ($\mathbf{T_{change}}$) was defined as occurring when the estimated MY was at a minimum in the considered period (i.e., when the first derivative equaled zero).

For comparison with NL, each of the 24-mo EL profiles was split at T_{change}. The second part of EL profiles describing the performances from T_{change} to drying-off was then time aligned and compared with the second lactation of NL.

Statistical Analyses. Data were analyzed with a mixed model that contained the fixed effects of week of lactation (month of lactation for milk composition and SCC), the interaction between week of lactation and the treatment (NL or EL), the random effect of the pair (1 to 9), and the residual error. Analysis was performed with the lmer function from the lme4 package in the R environment (version 2.15.1; R Development Core Team, 2012).

Study of the Onset of EL

Measurements. For the 20 EL goats, MY, BW and DMI were recorded daily for 11 wk, starting from December 21, 2010. During this period, goats were kept in