

Studies on some factors influencing the shape of the lactation curve in Romanian Black and White cows

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Abstract

The aim of this paper was to study the effects of farm and parity on the shape of the lactation curve for milk yield, milk fat percentage, milk protein percentage and milk lactose percentage. Researches were carried out on 421 lactations obtained from a population of 260 Romanian Black and White cows reared in the South-eastern Romania. Test day data was modelled using the incomplete gamma function, and then the lactation curves were drawn taking into consideration the effect of farm (farm 1 and farm 2) and parity (lactation 1, 2 and 3+). Both factors had a significant effect ($p < 0.05$) on the shape of the lactation curve, affecting the initial production (parameter a), the rate of increase/decrease to the peak/nadir (parameter b), as well as the rate of decrease/increase of production until the end of lactation (parameter c).

Keywords: cow, farm management, lactation curve, parity, Romanian Black and White.

1. Introduction

Milk production evolution during lactation could be presented graphically as the lactation curve. This curve has three phases: ascendant, plateau and descendant [1,2].

The shape of the lactation curve is a breed characteristic, though it is hard to establish the lactation curve characteristic with high precision for each cattle breed because the milk yield and composition are influenced by a large number of genetic (breed, individual etc.), physiological (parity, age at first calving etc.) and management factors, of which a great influence has the feeding [3].

The range that chemical components of milk vary during lactation is different from one breed to another. In most breeds the fat percentage range from 3 to 5%, protein percentage from 2.5 to 4%, lactose percentage from 4.5 to 5% and the minerals percentage from 0.65 to 0.8%. Generally, the variation of chemical components of the milk

during lactation is lower than the variation of milk yield [1]. From the chemical components of milk, fat percentage has the highest variation during the lactation, followed by protein, while lactose and minerals ha the lowest variation.

The shape of the lactation curve was studied on Red Holstein x Romanian Spotted crossbred cows on 212 lactations [4]. It was concluded that up to 25% Red Holstein genes in cows' genotype did not affected significantly the shape of the lactation curve, but the daily milk production was 15% higher. The shape of the lactation curve depends on the milk secretion rate during lactation, which is dependent of the body condition of animals at calving, feeding level and available feedstuff, as well as of the environmental conditions during lactation [5]

If the genetic aspects that had an influence on the shape of the lactation curve could be precisely determined, then a mathematic model could be elaborated in order to assist in cows selection, improving thus the economic efficiency in cow milk production [6].

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Many scientists that studied the shape of the lactation curve had come to the same conclusion that this was flatter in the first lactation than in later lactations (5,7-9,10-12). This means that lactation persistency, milk increase and decrease rates before and after reaching the peak production were higher and milk production at peak was lower in primiparous cows compared to multiparous cows. Also, cows in first lactation had longer ascendant phase compared to multiparous cows. All these aspects demonstrate that the secretory tissue of the mammary gland in primiparous cows need a longer time to reach the maximum activity compared to multiparous cows. A strong interaction between parity and the average milk production of the farm was observed on the shape of the lactation curve (13,14). The aim of this paper was to study the effect of farm management and parity on the shape of the lactation curve for milk yield and chemical composition in Romanian Black and White cows.

2. Materials and methods

Researches were carried out on 260 Romanian Black and White cows of Holstein-Friesian type reared in two dairy farms from Brăila County, South-eastern Romania. Cows calved from January 2009 until December 2010. Thus, a number of 421 lactations were obtained from the 260 cows. Only those lactations were considered that ended until December 31, 2010 and had at least 11 controls.

Periodical controls were carried out using the official technique [15] with the period of 28 days and the control day in the middle of the period. Milk yield was measured in kilograms by using ICAR approved milkmeters and a total of 9262 milk samples were analysed for fat, protein, and lactose percentage using the in-line devices built in the milking equipment. Data was collected using special designed software built in the milking equipment.

The resulting database was used to calculate the averages for each studied effect: farm with two levels farm 1 (F1, n=128) and farm 2 (F2, n=293), and parity with three levels first lactation (n=87), second lactation (n=84) and third and over third lactation (n=250).

These averages were used to calculate the parameters of the lactation curves by using the gamma incomplete function [16].

$$y_n = an^b e^{-cn}$$

where: e is the base of the natural logarithm; y_n is the milk yield or fat, protein and lactose percentage at the n days from calving; a is the initial level of production; b is the increasing/decreasing rate of production until de peak/nadir; c is the decreasing/increasing rate of production after the peak/nadir.

Peak/nadir production is calculated as $y_{max} = a(b/c)^b e^{-b}$, and the days from calving when this production is reached is calculated as $n = b/c$.

Using these parameters, the lactation curves were drawn and presented in graphs according to the two factors studied.

3. Results and discussion

Figure 1 presents the lactation curve for milk yield in the two studied farms. The level of the milk yield was significantly higher ($p < 0.001$) in F2 than in F1. Thus, the parameter a was higher in F2 than in F1 (17.4 kg vs. 10.4 kg).

The shape of the lactation curve for milk yield was different in F1 compared to F2. Thus, in F1 the daily milk yield increased more rapidly ($b = 0.12672$) up the peak yield of 17.7 kg at 184 days in milk and decreased slower thereafter ($c = 0.00069$) compared to F2 where milk yield increased slower ($b = 0.08988$) and for shorter time (77 days) until the peak of 23.6 kg, then decrease more rapidly ($c = 0.00117$). Thus cows in F2 had sharper lactation curves than cows in F1, being more difficult to manage from the nutrition point of view.

The lactation curves for fat percentage in the two farms are shown in Figure 2. In F1 the initial level of fat percentage (a) was significantly higher than in F2 (4.5% vs. 3.5%, $p < 0.001$). Fat percentage decrease (b) until the nadir was higher in F1 than in F2 (-0.034076 vs. -0.011118), the nadir point was reached later in lactation (140 vs. 36 days), the fat percentage at nadir was higher (3.9% vs. 3.4) and then the increase rate (c) was slower (-0.000244 vs. -0.000308). These characteristics made the shape of the lactation curve to look flatter in F2 than in F1.

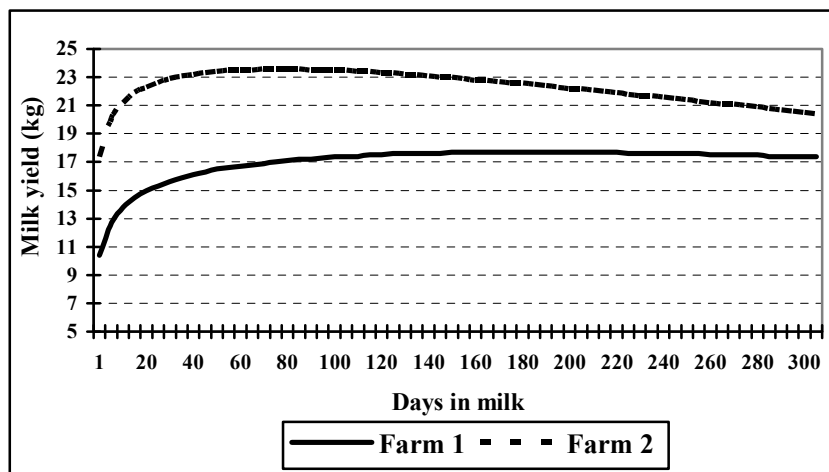


Figure 1. The shape of the lactation curve for milk yield according to the farm management in Romanian Black and White cows

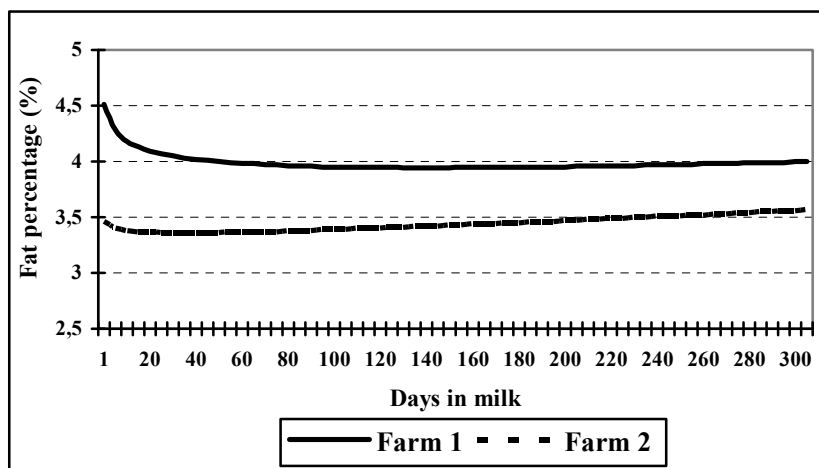


Figure 2. The shape of the lactation curve for fat percentage according to the farm management in Romanian Black and White cows

Figure 3 shows the lactation curve for protein percentage according to the farm. Again, there was a great difference between the two farms regarding the shape of the lactation curve for protein percentage. The initial protein percentage was higher in F2 than in F1 (4.6 vs. 3.78%, $p < 0.001$), but also, the F2 cows had a steeper lactation curve for protein than cows in F1. In F2 the decreasing rate of the protein percentage to nadir, as well as the increasing rate afterwards was higher than in F1 (-0.087727 and -0.000602 vs. -0.012979 and -0.000124, respectively). Even though the initial protein percentage was higher in F2 than in F1, the nadir value was lower, and was reached later in lactation (3.3% and 146 days vs. 3.6% and 104 days, respectively).

All these characteristics resulted in flatter lactation curve for protein percentage in F1 than in F2.

The two lactation curves for lactose percentage in milk corresponding to the two studied farms are presented in Figure 4. The two lactation curves had a similar shape, but the initial starting level were different, in F1 the initial lactose percentage was 4.6%, while in F2 it was close to 5%. After that the lactose percentage slightly increased reaching a peak percentage of 4.8% at the end of the normal lactation in F1 and 5.2% at 139 days in milk in F2.

Figures 5 to 8 show the lactation curves for milk production and chemical composition according to the parity of cows.

The initial milk yield was similar for cows in first and third and over third lactation (16.8 and 16.6

kg, respectively), but was significantly lower for cows in the second lactation (11.4 kg, Figure 5).

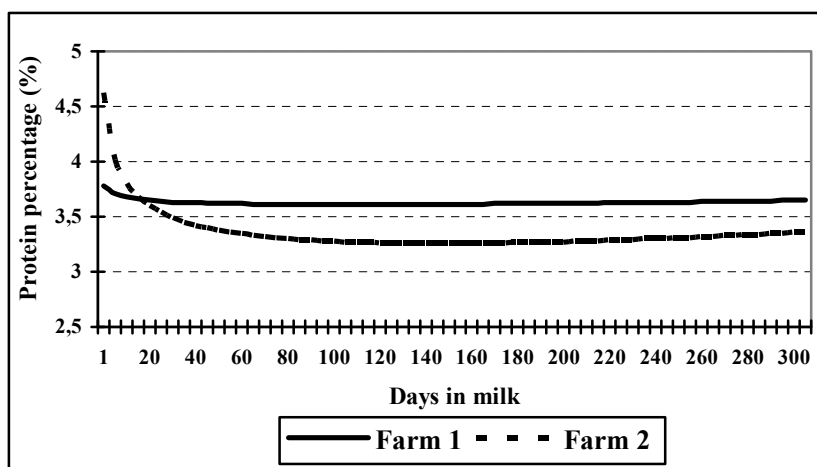


Figure 3. The shape of the lactation curve for protein percentage according to the farm management in Romanian Black and White cows

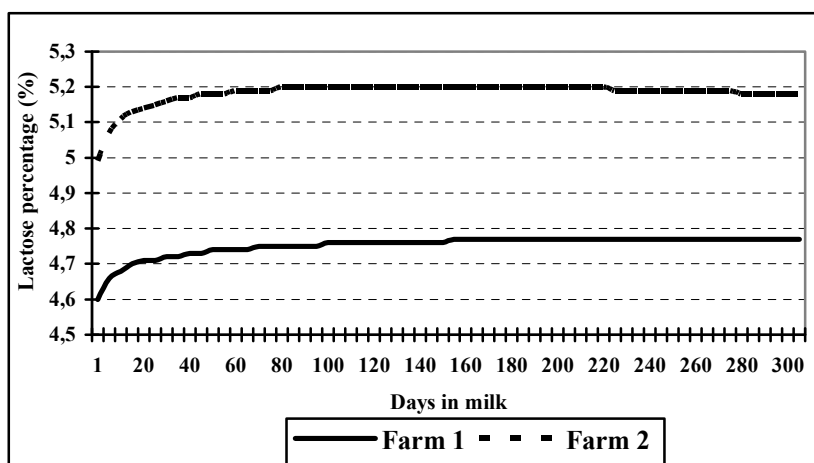


Figure 4. The shape of the lactation curve for lactose percentage according to the farm management in Romanian Black and White cows

The parity significantly affected the lactation curve parameters (*b* and *c*) for milk yield, resulting in different shapes of the curves. Thus, the flattest curve was observed in the first lactation that started at a high level (16.8 kg), has a very slow increase (0.02318) to the peak, which was not very high (18.5 kg) and was reached late in lactation (175 days in milk), then the milk yield decreased very slow (0.00013) until the end of lactation. On the opposite, the second lactation cows showed a very low initial milk yield (11.4 kg), with a very high rate of increase (0.15867) until the peak production, which was almost double than the initial production (20.6 kg) and

was achieved after the first third of lactation (115 days in milk), then the decrease was also abrupt (0.00138). The most typical lactation curve showed the cows in the third or over third lactation. These cows started the lactation a high level (16.6 kg), with a moderate rate of increase (0.09723) up to the peak production that was reached very early (82 days in milk) at a high level (23.1 kg), the followed by a moderate rate of decrease of daily production (0.00118).

The lactation curves for fat percentage in milk according to the parity are presented in Figure 6. Again, the shapes of the first lactation and third and over third lactation were similar, the only

difference being the starting level, 3.5% in first lactation and 3.9% in third lactation. The parameters of the curve were similar, *b* parameter was -0.15181 for lactation 1 and -0.012929 for lactation 3+, and *c* parameter was -0.000425 and -0.000398, respectively. The nadir point was 3.4% for lactation 1 and 3.7% for lactation 3+, which

was reached very early in lactation for both classes (36 and 32 days in milk, respectively). The second lactation cows showed an atypical shape for fat percentage, the initial level being also the highest with a very low inflection of the curve throughout the lactation. This resulted into an almost linear increase of the fat percentage from the beginning to the end of lactation.

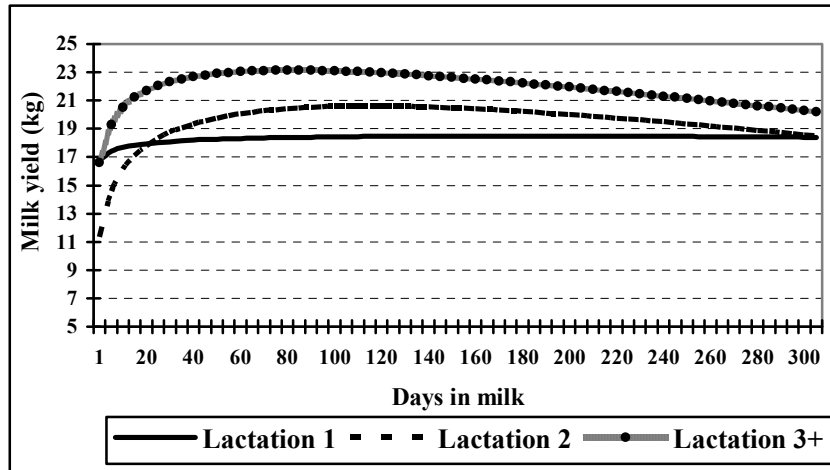


Figure 5. The shape of the lactation curve for milk yield according to the parity in Romanian Black and White cows

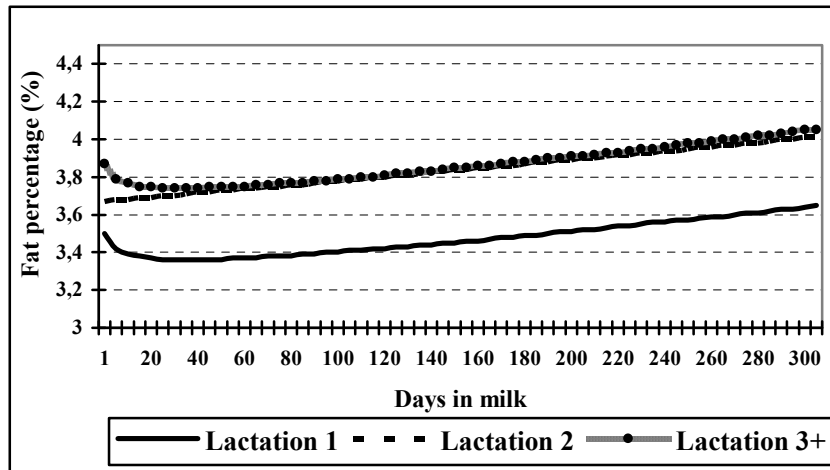


Figure 6. The shape of the lactation curve for fat percentage according to the parity in Romanian Black and White cows

Lactation curves for protein percentage in milk of the cows according to parity are presented in Figure 7. There was observed a similar shape of the lactation curve for protein percentage between lactation 2 and lactation 3+. They both started at the same level, 4.7% in lactation 2 and 4.5% in lactation 3+, they have similar decreasing rate until the nadir percentage (-0.090620 and -0.077678, respectively), and a similar increasing

rate thereafter (-0.000404 and 0.000516, respectively), a very close nadir value (3.2% and 3.3%, respectively), which was reached later by cows in lactation 2 (224 days in milk) than cows in lactation 3+ (150 days in milk).

The curve for protein percentage in first lactation cows was somehow atypical and very flat, starting at a low initial level (3.5%), with a very low decreasing (-0.006575) and increasing (-0.000093)

rates, to and from a high nadir (3.4%) reached early in lactation (71 days in milk).

Figure 8 show the lactation curves for milk lactose percentage according to the parity of cows. Even though the lactation curve parameters were a little different, cows in lactation 1 and lactation 3+

showed similar shapes of the lactation curves for lactose percentage. The initial starting point was higher in lactation 3+ than in lactation 1 (4.8% vs. 4.6%, respectively), and both groups reached a similar peak lactose percentage (4.9% and 4.8%, respectively).

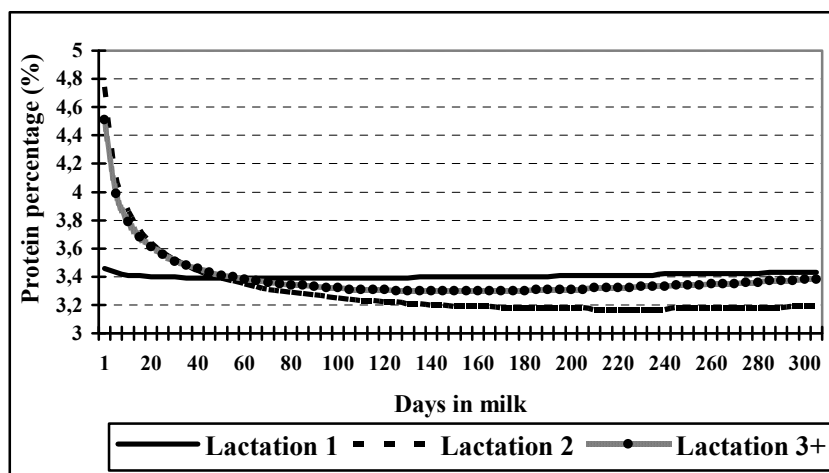


Figure 7. The shape of the lactation curve for protein percentage according to the parity in Romanian Black and White cows

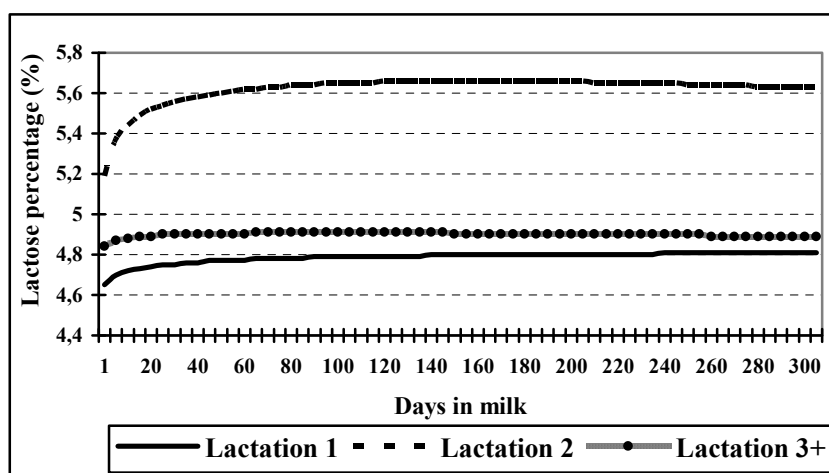


Figure 8. The shape of the lactation curve for lactose percentage according to the parity in Romanian Black and White cows

A different shape and lactation curve parameters were obtained for the second lactation cows. These cows showed a significant higher initial lactose percentage (5.2%), with rapid increasing rate (0.021569) to a very high peak (5.7%), reached at 157 days in milk, and then a rapid decrease (0.000138) until the end of lactation. These patterns make the curve of the second lactation cows to be steeper than those of other cows.

Similar results were obtained in previous works on the shape of the lactation curve carried on Holstein and Romanian Spotted breeds [17-19].

4. Conclusions

Based on our results we can state that the farm management had a significant effect on the shape of the lactation curve for milk yield, as well as for

chemical composition of milk (fat, protein and lactose).

There was a significant influence of the parity of cows on the shape of the lactation curve for milk yield, fat percentage, protein percentage and lactose percentage.

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