EFFECT OF LAMENESS ON MILK PRODUCTION TRAITS IN HOLSTEIN-FRIESIAN DAIRY COWS

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Abstract. The study was conducted to determine the effect of lameness on production traits in dairy cows – milk yield, mil protein and milk fat contents. For this purpose, productivity records of 300 Holstein-Friesian cows (100 from 3 Bulgarian herds) were collected. The results showed that 305-day lactation milk yield of lame cows from the three herds was by 516.8 kg lower compared to that of healthy cows. Milk fat percentage was reduced by 0.16 %, and milk protein – by 0.04 % vs healthy cows. In herd 1, where the average milk yield was the lowest (7074.4 kg), milk yield was by 89.1 kg lower in 38 % of cows affected by lameness. The average milk yield of herd 3 was 7882.3 kg, the milk yield reduction amounted to 565.6 kg in 43 % of lame cows. In herd 2 with the highest milk yield (8660.6 kg), the difference between the lame and healthy cows was 1314.3 kg, and the prevalence of lameness was 61 %. The highest share of lame cows was affected by lameness in the beginning of lactation, 37.3 % - until the 150th day with greatest milk production loss vs healthy cows – 598.3 kg. In the subsequent period of lactation, only 10 % became lame, and milk yield reduction amounted to 211.9 kg.

Keywords: lameness, dairy cows, milk yield

Introduction. Lameness of dairy cows is a clinical sign of claw and hoof diseases, which are multifactorial (Borissov et al., 2010; Penev et al., 2012). In dairy herds, lameness, infertility and mastitis are the health problems with the most serious economic impact (Logue, 1997; Olsen, 1997; O'Callaghan, 2002). The recent intensive development of dairy cattle farming has increased the interest of researchers towards evaluation of the effects of lameness on productivity and milk yield losses. Simbirtsev and Terehov (1982) reported milk yield losses from 5 to 30 % in cows with lameness depending on the clinical signs of pain in extremities. Later, Rousseau (1987) demonstrated that depending on the severity of lameness, cows losses in milk productivity varied between 25 % and 75 %. Some studies reported that milk yields were reduced even before the clinical expression of obvious lameness (Warnick et al., 2001; Green et al., 2002). According to the recommendations of the Ministry of Agriculture and Food of the Republic of Belarus, 2011, a 5 % reduction in milk yield could be observed even in abnormal hoof overgrowth, and losses could attain 14 % in clinically lame cows. Koçak and Ekiz (2006) established decreased average milk yields even before the clinical expression of lameness. They reported a significant influence of lameness on 305-day lactation milk production of 203 kg. Economic analyses, assessing the general effect of lameness on farm budgets, report 4–5 % losses in the income of farmers in the Netherlands (Enting et al. 1997). The losses (both direct and indirect) attributed to lameness were distributed as follows: 34 % from infertility, 25 % from reduced milk yield; 13 % from death or preliminary culling of cows, 13 % from additional labour costs, 8 % from veterinary service costs and 6% from body weight losses of cows (Weaver et al., 2005).

The aim of the present survey was to establish the effects of lameness on milk production of Holstein-Friesian cows in three private dairy farms with different milk yields and free stall production systems.

Material and methods

The animals included in the study were from three private dairy cattle farms reared in different variants of free-stall production systems. On farm 1, cows were reared in a common yard on deep straw litter. On farm 2, the animals were housed in a barn with individual cubicles for rest covered with rubber mats. The individual cubicles of herd 3 were bedded with composted manure and straw. The cows on all farms were fed high concentrate diets and ad libitum total mix rations. All cows were from the Holstein-Friesian breed. The milking on all farms was done in a milking parlour: three times a day until the 150th day of lactation and two times a day after that.

In this survey, 100 cows from each of surveyed farms were selected. Each sample consisted of 10 first-lactation cows, 20 second-lactation cows, 30 third-lactation cows and 40 fourth- and higher lactation animals. The data about milk yields, milk fat and protein percentages were obtained from test-day records of farms and data about lameness from farm management software records. The stage of lameness was evaluated by the five-point scoring system of Sprecher et al. (1997).

A total of 300 lactations were used to evaluate the relationship between lameness and production traits, using data for 305-day (normal) lactation. Cows with lactations <285 days were not included in the survey.

For better approximation, some of the studied traits

were classified in categories as follows:

Lameness (yes/no): 1 – healthy cows; 2 – cows with lameness during the lactation.

Lactation period with lameness: 1 – healthy cows, 2 – lameness between calving to the 150th lactation day; 3 – lameness between the 151st and 305th lactation days.

Calving year: 1 – in 2010; 2 – in 2011;

Calving season: 1 – winter (from December to February); spring (from March to May); summer (from June to August) and autumn (from September to November);

Lactation number: 1st lactation; 2nd lactation; 3rd lactation; 4th and higher lactation.

The effect of non-genetic factors on lameness was evaluated using the following statistical model:

$$Y_{ijklm} = \mu + F_i + G_j + S_k + PL_l + e_{ijkl}$$

where: Y_{ijklm} – dependent variable (lameness), μ – population mean; F_i - herd; G_j – calving year; S_k – calving season; PL_l – lactation number and e_{ijkl} – effect of random factors.

The effects of lameness-associated traits (presence of lameness and lactation period with lameness) on production traits were assessed with one-way analysis of variance.

The least square means (LSM) for each class of fixed factors were derived by analysis of variance (ANOVA).

The data were analysed using the STATISTICA 6 software and graphs were built in Microsoft EXCEL (MS Office, 2010).

Results. In this study, we established the main production traits of all cows, individually and by herds. The average 305-day lactation milk yield was relatively high at a national scale – 7512.80 kg.

The average milk fat percentage was low – 3.47 %. The cows from herd 2 had the highest milk yields with the highest milk fat (3.56 %) and protein (3.28 %) contents over a normal lactation. A similar trend was detected for milk fat and protein in the three herds. Analysis for the effect of studied factors on the incidence of lameness was performed, and its results are presented in Table 1.

Table 1. **Analysis of variance of studied factors on lameness prevalence**

Sources of variance	Degrees of freedom (n – 1)	Lameness (yes/no)		
		MS	F	P
Farm	2	0.86	4.09	*
Calving year	2	0.86	4.13	**
Calving season	3	0.23	1.11	n.s.
Lactation number	3	3.72	17.82	***
Error	288	0.21		
*Levels of significance: * - P<0.05; ** - P<0.01; *** - P<0.001*				

The influence of lameness on production traits for 305-day lactation are is shown in Table 2. It is evident that lameness had a statistically significant effect on the three traits with most pronounced impact on milk fat content (P<0.001); the level of significance of milk yield and milk protein was P<0.01.

Table 2. **Analysis of effects of lameness** (yes/no) **on 305-day milk production traits**

Sources of variance	Degrees of freedom (n – 1)	MS	F	P
305-day lactation milk yield				
Lameness (yes/no)	1	1.99	7.64	**
Error	298	2.614		
Average 305-day lactation milk fat %				
Lameness (yes/no)	1	1.75	22.71	***
Error	298	0.077		
Average 305-day lactation milk protein %				
Lameness (yes/no)	1	0.088	7.4	**
Error	298	0.012		
*Levels of significance: * - P<0.05; ** - P<0.01; *** - P<0.001*				

Figs 1 and 2 depict the Ls means for the three production traits studied depending on the presence or absence of lameness in cows. Lameness had the most significant influence on milk yield, as cows lame throughout the lactation yielded by 516.8 kg less milk over a normal lactation than healthy cows.

The effect of lameness, although statistically significant, was less strong for both milk composition traits (Fig. 2). For milk fat, the average milk fat percentage over a normal lactation exhibited a reduction by 0.16 % vs healthy cows. For milk protein percentage, this reduction was only 0.04 %.

The prevalence of lameness in the three studied herds was different. The second herd had the highest prevalence

during the survey period (61 %). In the other two herds, lameness incidence was under 50 % –38 % and 43% for herds 1 and 3 respectively (Fig. 3).

The analysis of the average milk yields of lame and healthy cows from the three farms is presented on Fig. 4. The highest milk yield was established in affected and healthy cows from herd 2: 8660.6 kg in healthy and 7346.3 kg in lame cows. It was followed by milk yields of herd 3 and the lowest registered values, both in lame and non-lame animals, was observed in herd 1.

An interesting issue which emerged during the investigation was the distribution of lame cows according to the number of lactations. The results are presented on Fig 5.

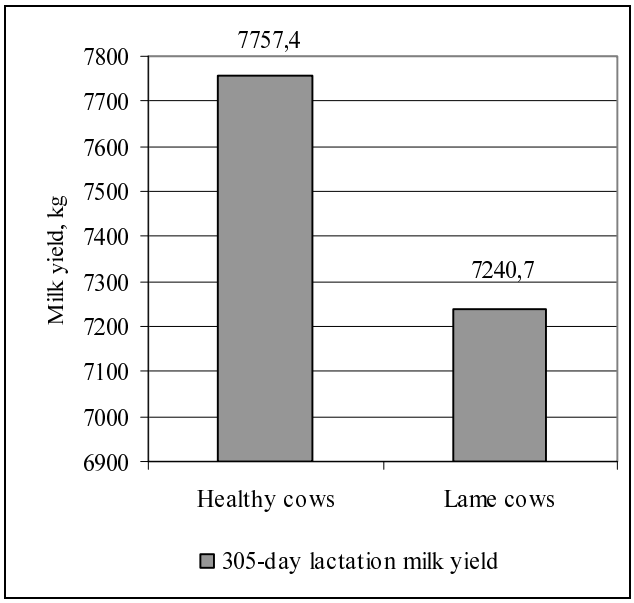

Fig. 1. **LS means for 305-day lactation milk yield in healthy and lame cows**

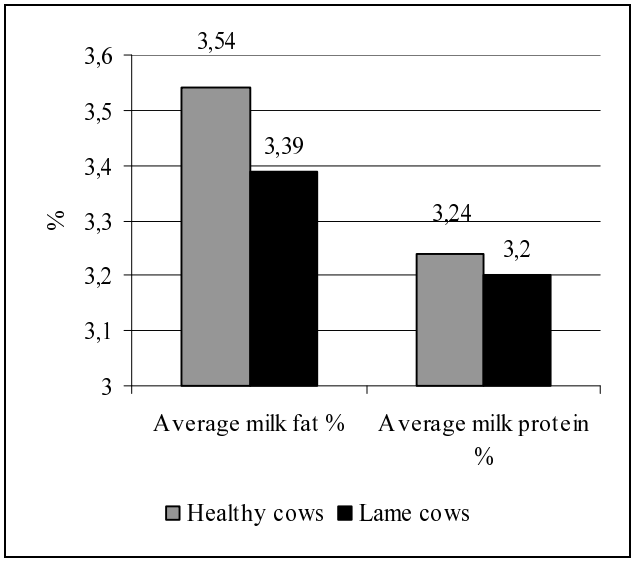

Fig. 2. **LS means for 305-day milk fat and milk protein percentages in healthy and lame cows**

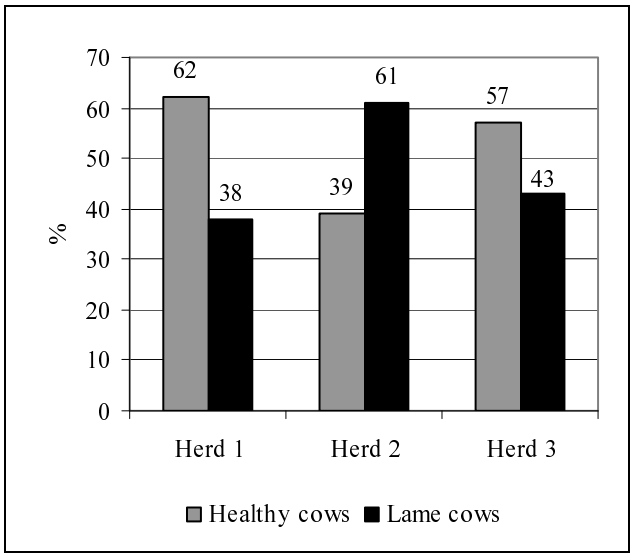

Fig. 3. **Relative proportion of healthy and lame cows by herds**

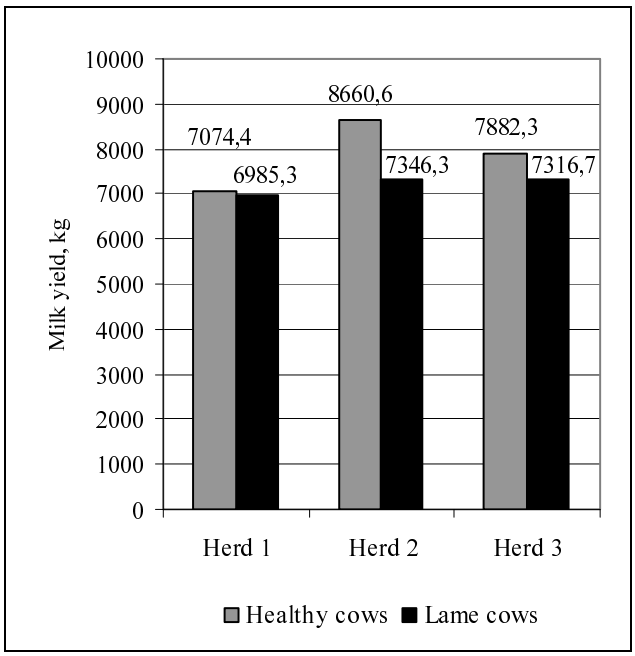

Fig. 4. **LS means for 305-day lactation milk yield of herds depending on the health of cows**

The lowest was the lameness percentage of first-lactation cows – 3.3 %. As age advanced, the incidence became higher to attain 63.3 % or more in cows in their 4th or higher lactation.

The analysis of the effect of lactation number on milk yields of healthy and lame cows is presented on Fig. 6. The lowest milk yield was demonstrated from primiparous cows, either healthy or lame. The milk yield increased parallel to the number of lactation, especially for healthy cows. Lame second-lactation cows yielded 77.4 kg less milk than lame primiparous cows. The productivity of third- and fourth-lactation cows was increased vs that of lame cows with lower lactation number.

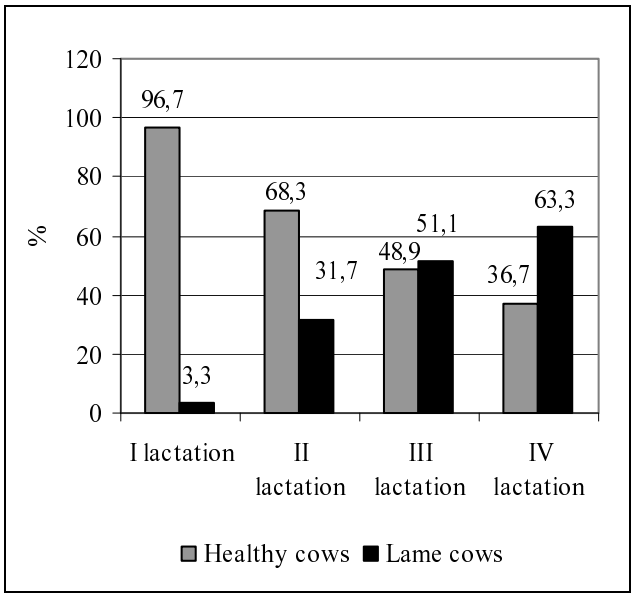

Fig. 5. **Relative proportion of healthy and lame cows according to lactation number**

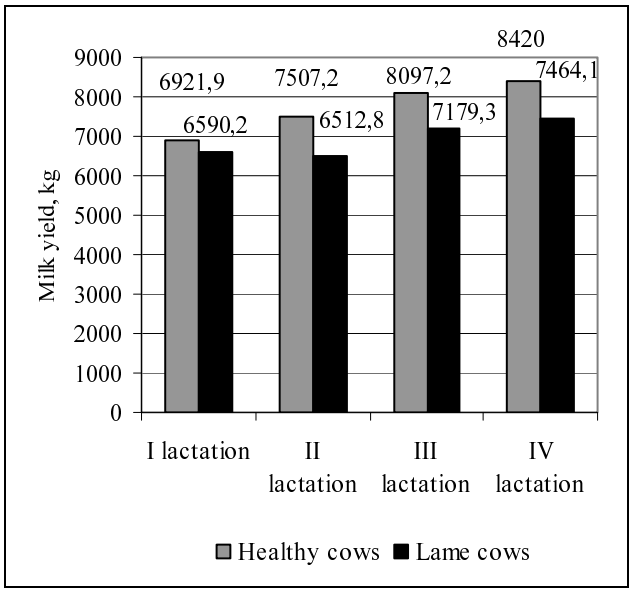

Fig. 6. **LS means for 305-day lactation milk yield depending on the health of cows**

Table 3. **Analysis of the effect of lactation period with lameness on milk traits**

Sources of variance	Degrees of freedom (n – 1)	MS	F	P
305-day lactation milk yield				
Lactation period with lameness	2	1.175	4.499	*
Error	297	2.61		
Average 305-day lactation milk fat %				
Lactation period with lameness	2	0.881	11.43	***
Error	297	0.077		
Average 305-day lactation milk protein %				
Lactation period with lameness	2	0.087	7.5	***
Error	297	0.012		
*Levels of significance: * - P<0.05; ** - P<0.01; *** - P<0.001*				

The presence of lameness and the period of lactation with lameness exerted a statistically significant effect on milk yield and average milk fat and milk protein percentages (Table 3).

The highest share of cows was lame in the beginning of lactation, until the 150th lactation day – 37.3 % of the total number. After that period, only 10 % of lactating cows exhibited lameness – Fig. 7.

The stage of lactation with lameness had also an effect on milk yields. Cows which exhibited lameness until the 150th lactation day had the lowest milk yield – 7159.1 kg, or by 598.3 kg less than healthy cows (Fig. 8). The data showed that lameness after that period had a less significant effect on milk yields, allowing to attain 7545.5 kg 305-day lactation milk yield or by 211.9 kg less than unaffected cows.

There was a tendency towards more pronounced reduction in milk fat content over 305-day lactation (Fig. 9) in cows lame until the 150th lactation day. They demonstrated lower milk fat by 0.16 % as compared to healthy cows. The reduction in cows lame after the 150th lactation day the reduction accounted for 0.13 %.

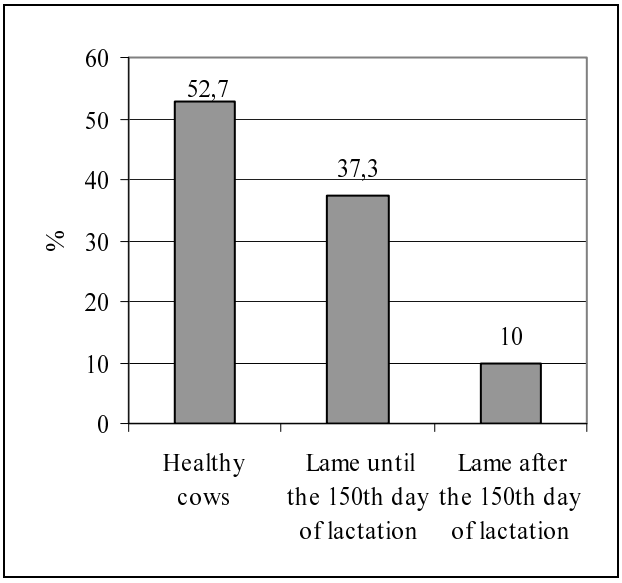

Fig. 7. **Relative proportion of cows with lameness according to lactation period**

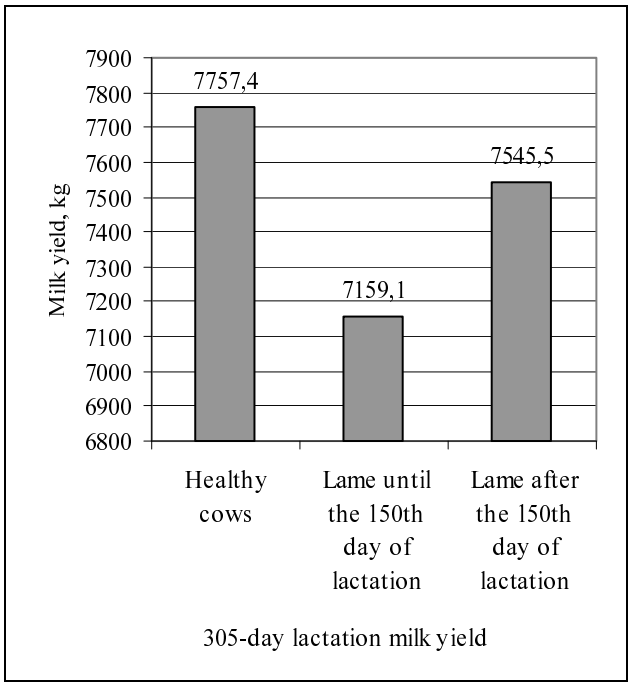

Fig. 8. **LS means for 305-day lactation milk yield depending on the lactation period with lameness**

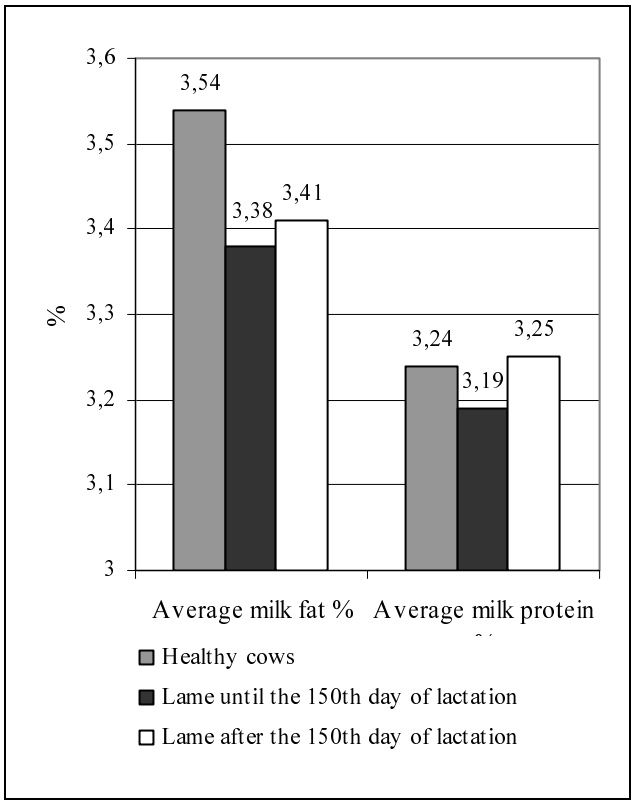

Fig. 9. **LS means for average 305-day milk fat and milk protein percentages depending on the lactation period with lameness**

The average milk protein content decreased only in cows lame until the 150th lactation day (by 0.05 % compared to healthy cows). Cows lame during the second half of lactation showed no difference vs healthy ones, and average milk protein percentage was even slightly higher (by 0.01 %).

Discussion

The data presented in Table 1 show a statistically significant effect of the farm on the prevalence of lameness ($P<0.05$), whereas the calving season was not important. Calving year also influenced significantly the incidence of lameness on farms ($P<0.01$). Poorer traits were exhibited in cows which calved in 2009 and 2010, and the lactation period of those having given birth in 2009 was mainly in 2010. This group consisted mainly from cows from the three herds and their total number was relatively lower than that of cows calved in 2011. The lactation number had also a statistically significant effect on the prevalence of lameness ($P<0.001$).

The effect of lameness on 305-day lactation milk yield, milk fat and milk protein contents was investigated through analysis of variance. Lameness had a statistically significant influence on all three traits (Table 2). The most substantial influence was that on milk fat content ($P<0.001$), whereas the influence on milk yield and milk protein was less pronounced ($P<0.01$). The fact suggested that lameness had a negative effect not only on the quantity, but also on the quality of dairy products and supported the studies of Rukol (2012), as the loss of milk fat and protein in lame cows is essential by reason of the worsened quality of milk and the low yield after processing into dairy products.

Our studies on the effect of lameness on milk yields showed a reduction of 516.8 kg over 305-day lactation (Fig. 1) comparable to the data reported by Amory et al. (2008). Amory et al. (2008) established that in dairy cows, lameness resulted in loss of milk between 370 and 570 kg per lactation. There are studies evidencing that lameness had only a very slight effect on the productivity of affected cows (Boelling and Pollott, 1998a; Gudaj et al., 2012). These results were possibly due to the fact that lameness was more common in highly productive cows (Deluyker et al., 1991), and the higher milk yields partly compensate the reduction after the occurrence of lameness.

According to our studies, lameness had a statistically significant effect on both milk composition traits (Fig. 2). Average milk fat percentage decreased by 0.16% in affected vs healthy cows, whereas milk protein reduction was only by 0.04 %. In agreement with our data, Juarez et al. (2003) also reported lower milk fat and protein contents in lame cows.

The distribution of lame cows in the herds showed considerable differences, with highest prevalence of lameness in herd 2 – 61 %, and the lowest – in herd 1 – 38 % (Fig. 3). It should be noted that in herd 2, the cows had at a time the highest incidence of lameness and highest 305-day lactation milk yield (Fig. 4). The relationship between lameness occurrence and milk yield is also confirmed by the difference in the milk yields of healthy and lame cows (Fig. 4) which was the greatest in this herd – 1314.3 kg. Cows from herd 1, whose average milk yield

was the lowest, and the difference in milk yields of healthy and lame cows was the smallest (89.1 kg), had the lowest prevalence of lameness – 38 %. Herd 3 occupied an intermediate position both with respect to milk yields and lameness incidence. The difference between milk yield of healthy and lame cows was 565.6 kg. The data presented on Fig. 4 showed that as the average milk yield of cows increased the losses of milk because of lameness increased as well.

During the investigation, a statistically significant effect of lactation number on lameness was established. There was a marked trend for increase in lameness prevalence with advancing age in cows, i.e. with increasing lactation number – Fig. 5. A similar trend about increased prevalence of lameness from first to third lactation was reported by Koçak and Ekiz (2006). Together with the increase in lame cows percentage with age the effect of lameness on milk yields becomes more obvious (Fig. 6). In primiparous cows, the difference between 305-day lactation milk yields of healthy and lame cows was 331.7 kg, whereas in fourth-lactation cows – 955.9 kg. The higher is the lactation number the higher is the milk yield mainly of healthy cows. Lame cows of the second lactation exhibited a reduction in milk yield by 77.4 kg vs first-lactation lame cows. This could be due to undetected lameness or non-cured hoof disorder during the previous lactation or the dry period. During the subsequent 3rd and 4th lactations, the milk yields of lame cows increased as compared to those with lower lactation number, which could be attributed to a better development of the udder. Nevertheless, in the third and fourth lactation cows, the differences of milk yields between healthy and lame cows were greater.

The analysis of the relationship between stages of lactation with highest prevalence of lameness showed clearly that it occurred most commonly in the beginning of lactation (the first 150 days) with 37.3 % of all cows being affected (Fig. 7). Apart from the highest incidence of lameness during that period, it was characterised also with most substantial reduction of milk yield (Fig. 8) – by 598.3 kg lower compared to healthy cows. Similar results were also shown by other researchers who reported that the occurrence of lameness during the first 100 days of lactation had an extremely unfavourable effect on lactation milk yields (Warnick et al., 2001; Hernandez et al., 2002). Cows which became lame after the 150th day of lactation exhibited a slight milk yield reduction, by 211.9 kg only. The lameness in the beginning of lactation, when milk yield is the highes,t results in considerable losses of milk, whereas by the end of lactation, losses were smaller proportionally to the smaller milk yields. This is predetermined by the fact that cows with early onset of lameness could not attain their peak yields of milk and this consequently reflected on the 305-day lactation yields, whereas in cows lame during the late lactation (after the 150th lactation day), this negative impact was considerably milder and they could realise at a higher extent their genetic potential. A similar tendency was observed for milk fat content in cows lame until the 150th day of lactation – it was by 0.16 % lower than respective percentage in healthy cows (Fig. 9). Milk protein was almost not influenced by the stage of lactation when lameness has occurred as this trait is mostly dependent on the amount and quality of feed, whereas milk fat was influenced at a greater extent by the genetic potential of cows. In cows with health problems resulting in lameness, the feed intake could be significantly altered and thus, could have a more significant effect on milk fat content.

Conclusion

The average milk yield of lame cows was lower than that of healthy cows. The increased milk yield was related to a higher prevalence of lameness within the herds and to higher losses from milk production. The highest milk yield losses were established in herd 2, where the average milk yield was the greatest. Lameness caused a statistically significant reduction in milk fat percentage and a less pronounced, insignificant decrease in milk protein content. The occurrence of lameness during the first 150 days of the lactation had the strongest influence on the studied production traits of dairy cows. After this period of the lactation, lameness resulted in insignificant milk yield losses and the number of lame cows was 3.7 times lower than those exhibiting clinical lameness until the 150th lactation day.

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