Abstract: Effect of the age of the first calving on milk performance and inter-calving period of Polish Holstein-Friesian cows. The aim of the work was to determine the effect of the age of the first calving on milk performance in the 1st, 2nd and 3rd lactation, the sum of yield of milk, fat and protein for three complete lactations and the amount of the mentioned components as calculated per one day of life. The age of the first calving had a significant influence on milk yield only in the first lactation. The percentage fat content did not differ significantly between the groups of the age of calving whereas the studied factor affected significantly the protein content in milk of the cows after the second and third calving. The obtained results indicate that the most favorable economically mating of heifers takes place until the 27th month of life as such animals give the greatest quantities of milk, fat and protein, as calculated per one day of life.

Key words: age of the first calving, milk performance, milk, fat and protein amount as calculated per one day of life.

INTRODUCTION
The period of heifer rearing has a great effect on the later productivity of dairy cows, and the abbreviation of the mentioned period causes the improvement of production profitability. Most of the studies suggest abbreviation of the rearing period; the other ones indicate the higher productivity of animals, being calved at the later age. According to Wilson (2006) and Plate-Church (2006), a heifer which does not become pregnant until the 15th month of life, brings losses in the quantity of ca. 100 USD per month. In the opinion of Heinrich (1993), the rearing of the heifers constitutes 15–20% of all costs in cattle breeding. Many researchers (Mourits et al., 1997; Gardner et al., 1988; Lin et al., 1988; Meyer et al., 2005 and Harel et al., 2006) stated that it was justifiable to lower the age of calving even to 22 months. It does not cause big losses in productivity and, simultaneously, lowers the costs of nutrition. The authors suggest, however, that such early commencement of performance is possible only with the correctly conducted rearing so as the heifers reach the appropriate body weight and height in sacrum at such a young age. Powell (1985), Nilforooshan and Edriss (2004) and Harel et al. (2006) express the opinion that about half of the heifers in the USA are calved at the age of 23–27 months. In the countries where cattle breeding and milk production is found on a high level, we may observe lowering of the age of the first parturition. Also, in Poland there is a small decline of the age of the first...
calving of heifers. In 2010, the mean for the discussed parameter in the herds covered with milk recording was equal to ca. 27 months (Polish Federation of Cattle Breeders and Milk Producers, 2011).

MATERIAL AND METHODS

The studies were conducted with 319 high-yielding cows of Polish Holstein-Friesian breed in Central Poland. The analysis included the cows which had three full lactations completed. The data for analysis derived from breeding documentation (card of cow-heifer). The animals were kept in loose housing barns and fed TMR system.

The aim of the experiment was to determine the effect of the age of the first calving on milk performance in the 1st, 2nd and 3rd (305-day) lactation, sum of the yield of milk, fat and protein for three full lactations and the quantity of milk, fat and protein as calculated per one day of life.

The cows were classified into four groups in respect of the age of the first calving:
1. Below 24 months,
2. 24–27 months,
3. 27–30 months,
4. Above 30 months.

The groups consisted of 27, 179, 64 and 49 individuals, respectively. The average age of the first parturition in the examined population was 26.6 months and it was comparable with the mean in the herds covered with milk recording in Poland, which was equal to ca. 27 months (Polish Federation of Cattle Breeders and Milk Producers, 2011).

The obtained data were statistically developed, using single-factor variance analysis. The program SPSS Statistics 17.0 was employed.

RESULTS AND DISCUSSION

The mean milk yields during 3 first lactations in relation to age of calving are given in Table 1.

Milk yield in the first lactation increased together with the age of calving, excluding the group of heifers which were calved at the age of 27–30 months. The cows which were calved at the latest time, i.e. above the 30th month of life, produced the highest quantities of milk (7649.6 kg).

<table>
<thead>
<tr>
<th>Age of calving (months)</th>
<th>Number of animals</th>
<th>LSM SE</th>
<th>Lactation 1</th>
<th>Lactation 2</th>
<th>Lactation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 24</td>
<td>27</td>
<td>LSM 6339.70</td>
<td>8149.30</td>
<td>8530.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 70.68</td>
<td>90.85</td>
<td>95.10</td>
<td></td>
</tr>
<tr>
<td>24–27</td>
<td>179</td>
<td>LSM 7362.90 A</td>
<td>8199.80</td>
<td>8581.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 7.45</td>
<td>8.29</td>
<td>8.68</td>
<td></td>
</tr>
<tr>
<td>27–30</td>
<td>64</td>
<td>LSM 7203.60 a</td>
<td>8037.90</td>
<td>8270.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 28.25</td>
<td>31.52</td>
<td>32.44</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>49</td>
<td>LSM 7649.60 b</td>
<td>8281.40</td>
<td>8347.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 43.87</td>
<td>47.49</td>
<td>47.87</td>
<td></td>
</tr>
</tbody>
</table>

Values of figures in the same columns, marked with the same letters, differ significantly; big letters AA – P ≤ 0.01; small letters aa – P ≤ 0.05.
The lowest one was produced by the primiparous cows whose age of calving was found below 24 months (6339.7 kg). The differences between the groups were statistically confirmed (P ≤ 0.01; P ≤ 0.05).

The increase of yield was also indicated by Lee (1976), Brzozowski et al. (1985), Hibner et al. (1993), Pirlo et al. (2000) and Nilforooshan and Edriss (2004) and Sawa (1998).

The considerably lower productivity of primiparas, calved below 2 years of life, was indicated by Litwińczuk and Borkowska (1987), Gnyp and Litwińczuk (1997) and Czerniawska-Piątkowska et al. (2005). The results, as being presented in Table 2, differ from the results of the studies of Dobkowski (1965) and Wójcik (2001) who stated that after calving at the age of 33–34 months, the lowering of yield had place. The studies of Guliński et al. (2003) showed that calving after 26th month of life caused decline of production. In the opinion of Fisher et al. (1983) the age of calving did not affect significantly the level of production of primiparous cows.

In the second lactation, the differences in yield were already not as high as during the first one and they were statistically insignificant (Tab. 1). The earlier calved cows compensate the losses caused by earlier parturition and the yield becomes equalized.

A small differentiation in respect of the yield in the second lactation was also indicated by Swanson (1961), Brzuski et al. (1988) and Sawa (1998) who indicates, however, that the higher production level was obtained by the cows which were calved between 25 and 27 month of life. The results of own studies are different than those ones obtained by Litwińczuk and Borkowska (1987), Gnyp and Litwińczuk (1997) and also, Piech and Tarkowski (2003) who stated that the heifers calved between the 27th and 30th month of life obtained the highest performance. The examined population includes high-yielding dairy cows and it may be a reason for different results. The experiment conducted by Wójcik (2001) indicates a constant increase of yield together with the age.

The analysis of milk yield in the third lactation (Tab. 1) revealed that the greatest quantities of milk were produced by the cows from 2 first categories of the calving age. The differences between the groups were not statistically confirmed.

The obtained results were similar to those ones obtained by Swanson (1961) and Sawa (1998) who stated that the cows in the third lactation, as being calved earlier for the first time, reached the higher yield. Wójcik (2001) as well as Piech and Tarkowski (2003) do not report on the meaningful effect of the age of calving on the yield after the third parturition. In the studies of the recent authors, however, the cows calved above the 30th month of life had a significantly lower yield as compared to the remaining ones. Different tendencies were obtained by Czerniawska-Piątkowska et al. (2005). Their experiment showed that the highest yield was found in the animals calved at the latest time.

The data concerning the fat and protein content in the milk of the examined cows are given in Table 2.

Fat content in the milk of cows in the first lactation was decreased together with the increase of the age of the first calving but differences between the groups were insignificant.
Similar results were obtained by Piech and Tarkowski (2003) and Petraškiene et al. (2007). The analysis of the results, as being presented by the authors, indicates the decline of fat content together with the prolongation of the non-productive period. Completely different results were obtained by Swanson (1961), Gnyp and Litwińczuk (1997), Pirlo et al. (2000), Wójcik (2001) and Nilforooshan and Edriss (2004). In the opinion of the mentioned researchers, fat content in primiparas was increasing together with the age of the first delivery.

During the second lactation, the highest fat content was obtained by the cows which were calved at the age of 24–27 months (4.36%). The youngest animals had the lowest quantities of the discussed component in their milk; it was equal to 4.25%. Any significant differences between the means in the particular groups were not found.

When analyzing the percentage fat content in milk in the third lactation, we may state that any significant differences between the particular age groups were not found, similarly as in two first lactations. Except for the third age group of calving (27–30 months) where the lowest fat content was found, the milk of cows from the remaining groups contained practically the same quantities of fat.

The similar results were also reported by other authors. Sawa (1998), Wójcik (2001) and Czerniawska-Piątkowska et al. (2005) did not observe a high differentiation between the means in the age groups.
Protein content in the milk of primiparous cows was inconsiderably decreasing together with the age. The highest content was found in the group of 24–27 months: 3.37%. A similar tendency was observed also by Petraškiene et al. (2007). The mentioned authors stated that the prolongation of the non-productive period caused a decrease of the content of protein in milk. Similar results were obtained by Pirlo et al. (2000). A reverse situation was found in the studies of Piech and Tarkowski (2003) – the primiparas, who commenced milk performance at the earliest time, reached the lowest protein content and those calved at the latest period – reached the highest one.

From the data presented in Table 2, it may be concluded that the age of calving affects significantly protein content in the milk of cows after the second calving. The highest (3.41%) value of the discussed parameter was found in the group of 24–27 months and the lowest one (3.31%) – in the group calved at the age of more than 30 months. The differences between the groups were statistically confirmed ($P \leq 0.05$).

The results obtained in the third lactation are similar as those in the second one ($P \leq 0.05$). The highest protein level was stated in the groups of 24–27 and 27–30 months. They amounted to 3.38% and 3.37%, respectively. The lower yield was found in the oldest and the youngest group (3.31% and 3.3%, respectively). Completely different results were demonstrated by Wójcik (2001) who stated that the age of calving did not affect significantly the protein content in the third lactation.

Table 3 shows the sum of kilograms of milk obtained by cows in three full lactations in the particular age categories of the first calving. The lowest milk yield was observed in the animals which were calved at the earliest time, i.e. before completing the second year of life (25 641 kg). The cows which had their first parturition between the 24th and 27th month of life had the best results in respect of the examined parameter.

Their milk production was equal to 27 277 kg. In the successive age categories, milk yield amounted to 26 207 kg and 27 067 kg, respectively. Any statistically significant differences between the groups were not, however, found.

The similar results were obtained by Sawa (1998). In the opinion of the author, the greatest life performance was recorded for the cows which were calved between the 25th and 27th month of life. The animals, which were calved earlier or later, reached lower milk yield. The results of the experiment of the author (in contrary to the results given in Table 3) indicate that the cows, being calved above the 30th month of life reach the lowest sum of the yield. They produce also significantly lower quantities of milk as compared to the group at the age of 25–27 months. The results, presented by Piech and Tarkowski (2003) differ from the results of own studies. The highest productivity was revealed by the cows which were calved before the 25th month of life and the lowest one – above the 30th month. The lowest yield of the animals calved after completion of the 30th month of life was also indicated by Gnyp and Litwińczuk (1997). The best values for the discussed parameter (similarly as in Table 3) were obtained by the cows, whose parturition occurred between the 24th and 27th month. Somewhat
Different results were presented by Nilforooshan and Edriss (2004) and by Petraškiene et al. (2007). The mentioned researchers report that the prolongation of rearing the heifers leads to lowering of life milk performance.

From the data contained in Table 3, it is followed that the greatest quantities of fat during 3 lactations were produced by the cows which were calved at the age of 24–27 months (1192 kg). The weakest results in this respect were obtained by the cows which were calved at the youngest age – 1098 kg but the differences between the groups were statistically insignificant. On the other hand, the significance of differences between the means in the groups 2 and 3 was revealed \( P \leq 0.05 \). The oldest age category obtained inconsiderably less fat than in case of the cows calved between the 24th and 27th month.

The maximum fat production by the cows calved at the age of 24–27 months was also indicated by Gnyp and Litwiniczuk (1997). The mentioned authors stated that the worst results in relation to this trait were obtained in case of the cows the parturition of which was delayed above 30th month of life. Dickerson and Chapman represented another opinion (1940); they stated that the sum of fat yield was increasing gradually with the increase of the age of calving. The contrary results were obtained by Petraškiene et al. (2007) who showed that the prolongation of the period from birth to calving caused a decline of life fat production. The similar results are presented in the paper of Meyer et al. (2005).

The results, contained in Table 3, illustrate how the age of calving affected the quantity of the obtained protein. Again, the highest performance was obtained by the cows which were calved the first time at the age of 24–27 months (934 kg) and the lowest amount was found in case of the cows calved at the earliest time (866 kg). The differences were not, however, statistically confirmed.

Milk fat and protein yield, as being calculated per one day of life, is a significant factor from the economical point of view (Tab. 4).

The results presented in Table 3 indicate that the cows calved until 27 months produced the greatest quantities of milk as calculated per one day of life (13.56 and 13.61 kg).

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**TABLE 3. Sum of the milk yield from three full lactations (kg)**

<table>
<thead>
<tr>
<th>Age of calving</th>
<th>Number of animals</th>
<th>LSM</th>
<th>SE</th>
<th>Sum of kg of milk</th>
<th>Sum of kg of fat</th>
<th>Sum of kg of protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>m &lt; 24</td>
<td>27</td>
<td>LSM</td>
<td>SE</td>
<td>25.641</td>
<td>1.098</td>
<td>866</td>
</tr>
<tr>
<td>24–27</td>
<td>179</td>
<td>LSM</td>
<td>SE</td>
<td>27.277 a</td>
<td>1.192 a</td>
<td>934</td>
</tr>
<tr>
<td>27–30</td>
<td>64</td>
<td>LSM</td>
<td>SE</td>
<td>26.207</td>
<td>1.120 a</td>
<td>893</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>49</td>
<td>LSM</td>
<td>SE</td>
<td>27.067</td>
<td>1.165</td>
<td>905</td>
</tr>
</tbody>
</table>

Values of figures in the same columns, marked with the same letters, differ significantly – \( P \leq 0.05 \).
Similar results were also obtained by Gnyp and Litwińczuk (1997). They stated that the cows in the groups below 24 and 24–27 months had identical production and the means for these groups were significantly higher as compared to later-calved cows. Similar results were presented by Gnyp et al. (2006). They indicated that the cows, which were calved before 2 years of life, produced inconsiderably greater quantities of milk. The mentioned authors report also that production of the animals which had their parturition before the 27th month of life was significantly higher as compared to the later-calved ones. Also, Lin et al. (1988) stated that earlier calving caused increase of production as calculated per one day of life.

The results, contained in Table 4 indicate that production of fat as well as of protein was found on the highest level in cows which were calved the first time before the 27th month of life. The differences between the groups were statistically significant ($P \leq 0.01$; $P \leq 0.05$).

In Table 5, the mean inter-calving period for the cows, covered with the studies, is given.

The results, contained in Table 5 indicate that in all groups the inter-calving period was higher than the optimal one.

| TABLE 4. Cow performance as calculated per one day of life (kg/day) |
|-----------------|-----------------|-----------------|-----------------|
| Age of calving | Number of animals | LSM SE | Milk yield | Fat yield | Protein yield |
| < 24 | 27 | LSM | 13.560 a | 0.580 a | 0.460 a |
| | | SE | 0.151 | 0.006 | 0.005 |
| 24–27 | 179 | LSM | 13.610 B,C | 0.590 B,C | 0.470 B,C |
| | | SE | 0.014 | 0.001 | 0.000 |
| 27–30 | 64 | LSM | 12.770 C | 0.550 C | 0.440 C |
| | | SE | 0.050 | 0.002 | 0.002 |
| > 30 | 49 | LSM | 12.480 B,a | 0.540 B,a | 0.420 B,a |
| | | SE | 0.072 | 0.003 | 0.002 |

Values in the same columns, marked with the same letters differ significantly – big letters $AA$ $P \leq 0.01$; small letters $aa$ $P \leq 0.05$.

| TABLE 5. The mean inter-calving period (days) |
|-----------------|-----------------|-----------------|
| Age of calving | Number of animals | LSM SE | Inter-calving period |
| < 24 | 27 | LSM | 429 |
| | | SE | 4.738 |
| 24–27 | 179 | LSM | 436 a |
| | | SE | 0.441 |
| 27–30 | 64 | LSM | 418 a |
| | | SE | 1.639 |
| > 30 | 49 | LSM | 422 |
| | | SE | 2.420 |

Values in the same columns, marked with the same letters differ significantly $P \leq 0.05$. 


The best (the shortest) period between the parturition was found for the cows which were the first time calved between the 27th and 30th month of life (418 days). On the other hand, the weakest results were obtained for the cows which were the best in respect of production (24–27 months) – 436 days. The differences between the groups were statistically significant \((P \leq 0.05)\).

In relation to the mentioned parameter, the youngest cows obtained considerably higher value as compared to the oldest animals (429 and 422 days, respectively).

Dickerson and Chapman (1940) stated that the cows being calved before the 25th month of life had the highest value of inter-calving period. The best results in this respect were demonstrated by the cows which were calved between the 26th and 30th month of life. Different results were obtained by Gnyp and Litwińczuk (1997). In the opinion of the mentioned authors, the group calved at the age of 24–27 months was the best one and the group which was calved at the age of 27–30 months was the weakest one. The studies of Szulc and Radzik (1977) showed that the inter-calving period was maintained on the constant level (excluding the cows which were calved before the 29th month of life). A considerable increase of the length of the examined parameter together with the delay of the first parturition was indicated in the studies of Hibner (1982). The mentioned author states that the younger animals have the better fertility. The differences between the results obtained in own studies and those ones, presented by other authors may result from the fact that the examined population consists of high-yielding dairy cows.

CONCLUSIONS

The age of the first calving affected significantly the milk yield only during the first lactation.

The greatest quantities of milk were produced by the cows which were calved at the latest period, i.e. above the 30th month of life. During the successive lactations, any significant differences in productivity of different age groups were not found and the cows calved as younger animals compensated their losses connected with the younger age at parturition and produced a similar and even higher milk quantity.

The highest total milk yield for the first 3 lactations was obtained by the cows, calved for the first time at the age of 24–27 months but except for fat yield; the differences between the mentioned group and the remaining ones were insignificant. This fact indicates the justness of the universally practiced recommendation for the breeders that the optimum age of calving for Polish HF heifers is the age of 24–27 months.

The percentage fat content did not differ significantly between the age groups of calving. On the other hand, the age of calving affected significantly protein content in milk of the cows in the second and third lactation. Significant differences in milk, fat and protein production as calculated per one day of life were found. The best results in this respect were stated for the cows calved until the 27th month of life. Delaying of the first parturition caused the decline of the discussed indicators.
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Streszczenie: Wpływ wieku pierwszego ocielenia na użytkowość mleczną i okres międzyocieleniowy krów rasy polskiej holsztyńsko-fryzyjskiej. Celem pracy było określenie wpływu wieku pierwszego wycielenia na: użytkowość mleczną w 1., 2. i 3. laktacji; sumę wydajności mleka, tłuszczu i białka za trzy pełne laktacje oraz ilość tych składników w przeliczeniu na 1 dzień życia. Wiek pierwszego ocielenia istotnie wpływał na wydajność mleka tylko w pierwszej laktacji. Procentowa zawartość tłuszczu nie różniła się istotnie między grupami wieku wycielenia, natomiast badany czynnik wpływał istotnie na zawartość białka w mleku krów po drugim i trzecim wycieleniu. Otrzymane wyniki wskazują, że najkorzystniejsze, pod względem ekonomicznym, jest takie krycie jałowek, aby ocielenie nastąpiło do 27. miesiąca życia, gdyż od takich zwierząt uzyskuje się największej mleka, tłuszczu i białka w przeliczeniu na jeden dzień życia.

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