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Associations of reproduction and health with the performance and profit of dairy cows

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Abstract: The objective of the study was to evaluate the associations of the variable intensity in culling of dairy cows and culling due to the movement disorders, mammary gland diseases, long calving interval, low fertility and postpartum complications with production, reproduction and economic parameters on 60 commercial dairy herds. The data encompassed 34 632 cow records from the Czech Republic 12 regions and were collected during a 1-yr period (2012). The milk yield during the production period was analysed relative to the reproduction and economic parameters. The main reasons for culling cows were fertility problems and movement disorders, followed by the low milk yield, mammary gland diseases, and postpartum complications. The analysis of fertility showed that the herds with the longest calving intervals (≥ 410 d) and the highest culling due to fertility (≥ 25% of the total) achieved the lowest milk yields. The average difference between the highest and lowest calving interval (≤ 389 d) groups was 721 kg/cow per yr. The lowest reported profitability of costs was for the longest calving interval and the highest postpartum complications groups. Although the reproductive performance directly affects the dairy farm profitability, the dairy cows' production potential should be considered when making culling decisions in order to achieve the most profitable management strategy.

Key words: culling rate, fertility, health, profit

A higher milk production may not translate into a higher profitability if the cow fertility, longevity, and health decline (Lee and Kim 2007). The milk yield and the reproductive performance are both considered fundamentally important to achieve a high profitability (Bello et al. 2012). Moreover, the declining reproductive performance has a negative effect on the milk production (Giordano et al. 2013; Galva et al. 2013; Butler et al. 2010). Heikkila et al. (2008) argued that the declining fertility is the most common reason for culling in the high-producing herds. A common interpretation of historical trends is that the increasing milk yield likely leads to a decreasing reproductive performance (Bascom and Young 1998; Royal et al. 2000; Lucy 2001). Bello et al. (2012) describe this problem as sometimes being more complex and antagonistic. Kadokawa and Martin (2006) added that dairy cows have certain biological limits and any disruption leads to difficulties in their performance. The inadequate herd reproductive performance, manifested as prolonged calving intervals, the increased involuntary culling, or both, can result in less milk and fewer calves per cow per year. The consequences of a greater involuntary culling include increased replacement costs and, ultimately, lower net returns (Sewalem et al. 2008). On the other hand, Butler et al. (2010) and Arbel et al. (2001) have expressed a view that extending the calving interval could lead to better results in high-producing cows. Lee and Kim (2007) stated that high-producing cows lose the benefit of their high production levels because of their increased morbidity and a high probability for involuntary culling. The term "cull" here refers to all cows that leave the dairy herd, regardless of where they end up or the conditions under which they leave. Dairy producers often encounter difficult

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decisions on a daily basis. One of the toughest can be deciding whether to maintain and treat or to cull a cow (Cabrera 2012). The optimum annual culling rate in terms of farm profitability has been suggested to be between 25 and 30% (Bascom and Young 1998; Smith et al. 2000). Dairy cows leave the herd for a variety of reasons, and this could be a voluntary decision or an involuntary event. The reasons why cows are culled also can be helpful in identifying the problems in herds. High incidences of culling due to mastitis, feet and leg problems (movement disorders), postpartum diseases, or reproduction can help to identify the weaknesses in the farm management (Smith et al. 2000). The resulting trait that could considerably affect overall profitability is longevity. Sewalem et al. (2008) found that high longevity in the herd increases production for two reasons: First, a greater proportion of the culling decisions is based on production. Second, the proportion of mature cows, which produce more milk than the young cows, is increased.

The objective of this study was to evaluate the associations of culling of cows (**CULL**), and particularly due to the movement disorders (**MD**), the mammary gland diseases (**MGD**), the long calving interval (**CI**), a low fertility (**LF**) and the postpartum complications (**PC**), with the herds' production traits and economic performance.

MATERIALS AND METHODS

The data were collected by the means of a questionnaire from 60 Czech commercial dairy herds comprising 34 632 dairy cows during 2012 (1 yr). The data collected included the production and reproduction parameters, rearing costs, economic parameters, and other dependent variables (Tables 1, 2 and 3). The farms were located in 12 regions within the Czech Republic. The independent variables, in percentages (%), were CULL, MD, MGD, CI, LF and PC. Farms' records with respect to the reproduction and production traits were measured within the Czech Republic milk recording system (ICAR 2013). Other data were obtained using the questionnaire.

Cows on the participating farms were all kept in free-stall barns and milked in free-stall parlour systems. All the calves were housed in individual hutches equipped with buckets for water and a starter mixture. The diet of the heifers and cows consisted of the TMR (a mixture of forage and grain). The composition of diets differed depending on the region, breed, management, and the use of the feeding company services.

Costs and net profit for the dairy herds were calculated per 1 l of milk produced according to a certified methodology used in the Czech Republic (Poláčková et al. 2010). All economic results are presented in CZK (Czech crowns), and 1 US dollar equals approximately 20 CZK. The total feed costs included those for roughages, cereal grains and concentrates. The total costs included the total feed costs, labour costs, fuel and energy costs, costs for veterinary services and breeding operations, depreciation of intangible and tangible fixed assets, cow depreciation costs, overhead costs, and other costs.

Net profit (NP) without government subsidies (direct payments to support dairy farmers) (CZK) was calculated as follows:

$$\mathrm{NP} = \mathrm{TSM} - \mathrm{TCc2} \quad (1)$$

$$\mathrm{TCc2} = \mathrm{TCc1} - \mathrm{CWIC} \quad (2)$$

where TSM = total sales of milk, TCc2 = total accumulated costs for all cows less indirect costs, TCc1 = total accumulated costs for all cows, CWIC = indirect costs (i.e., costs of rearing calves, costs of manure disposal).

The TCc1 includes costs of the purchased feed and bedding, self-produced feed and bedding, medicines and disinfectants, other direct costs and services, labour costs, depreciation of intangible and tangible fixed assets, depreciation of adult animals, costs of ancillary activities and overhead (Poláčková et al. 2010).

Profitability of costs (PROF, in %) was calculated according to Equation 3 and was designated as a measurement of business success (Poláčková et al. 2010). The purpose of using this parameter was the possibility it creates for the yearly comparison among farms regardless of the herd size.

$$\mathrm{PROF} = \left(\frac{\mathrm{NP}}{\mathrm{TCc2}}\right) \times 100 \quad (3)$$

Statistical analyses

The data were analysed using a PROC MIXED model in SAS 9.2 (SAS Institute 2008) on the independent variables CULL, MD, MGD, CI, LF and PC. The Tukey's test was used to determine significant differences among means (Verbeke and Molenberghs 2000), and significance was declared when $P < 0.05$. The general statistical model was:

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$$y_{ijkl} = \mu + B_i + R_j + D_k + e_{ijkl} \quad (4)$$

where $\mathbf{y_{ijkl}}$ = value of the dependent variable (Tables 1, 2 and 3); μ = overall mean; $\mathbf{B_i}$ = i^{th} breed effect (i = 32 for the Holstein breed: 18 646 cows, 18 for the Czech Fleckvieh breed: 7559 cows, 10 for both breeds in the herd: 8428 cows); $\mathbf{R_j}$ = effect of j^{th} region of farm (j = frequency of the studied farms [from 60 farms in total] in each of the 12 studied regions: South Bohemia – 7; South Moravia – 5; Hradec Králové – 3; Liberec – 2; Moravia–Silesia – 5; Olomouc – 4; Pardubice – 6; Pilsen – 4; Central Bohemia – 10; Ústí nad Labem – 3; Bohemian–Moravian Highlands –7; Zlín – 4); $\mathbf{D_k}$ = effect of k^{th} CULL, MD, MGD, CI, LF or PC (Tables 1, 2 and 3); $\mathbf{e_{ijkl}}$ = random error. Breed ($\mathbf{B_i}$) was considered as a fixed effect and region of farm ($\mathbf{R_j}$) as a random effect.

RESULTS AND DISCUSSION

Reasons for culling cows

The most common reasons for culling cows were the low fertility followed by the movement disorders, low production, and the mammary gland diseases (Figure 1). It is important to note that the data used in this research included in each instance only one reason for culling. Cows are in fact often culled due to multiple reasons (Derks et al. 2014). Knowing the main reasons for culling cows also can be helpful in identifying the problems within herds (Heikkila et al. 2008). In agreement with our results, Bascom and Young (1998) also found that a higher production led to higher culling rates. Přibyl et al. (2004) had stated that a faster and earlier herd replacement leads to a more rapid increase in the genetic gain and thus in the herd performance and the subsequent economic efficiency of breeding and selection. Conversely, Heikkila et al. (2008) had remarked that a short herd life leads to high replacement costs and limits the breeding selection. Meanwhile, Honarvar et al. (2010) found that extending productive life was associated with the increased farm profitability. On the other hand, extending productive life decreased breeding value for milk yield per year from 101.24 to 87.56 per kg milk (Honarvar et al. 2010). In our study, we observed that the groups of herds with the highest culling (CULL ≥ 40%) and the highest culling due to MD (≥ 25%) achieved the best profitability of costs, at –5.97 ± 4.70% and –4.66 ± 4.72% (P < 0.05), respectively. However, this conclusion needs to be presented with caution, as the estimation of net profit did not include the cost of rearing. Consequently, a high culling rate could result on keeping only “problem-free” cows that would perform nicely, but that are responsible for supporting the rearing cost of all the cows that left the herd (not considered in this study).

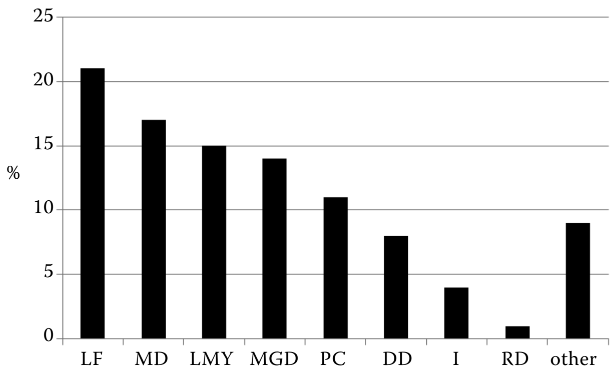

Figure 1. Reasons for culling cows in 60 commercial dairy herds in the Czech Republic (average value)

LF = low fertility, MD = movement disorders, LMY= low milk yield, MGD = mammary gland diseases, PC = postpartum complications, DD = digestive diseases, I = injures, RD = respiratory diseases

The highest culling due to the mammary gland diseases, low fertility and postpartum complications showed the opposite situation. Herds with the higher disease levels tend to have higher culling rates, and the optimal herd replacement varies from farm to farm (Sewalem et al. 2008). Heikkila et al. (2008) had remarked that before culling a cow, it is useful to consider the importance of that animal’s genetic potential and, at least for a cow with a high production capacity, the cost of treatment rather than replacement due to the illness. Cabrera (2012) added that estimating the economic value of a cow’s future performance and replacement as well as the herd replacement decisions and policies in dairy farming are critical because they determine profitability.

The most prevalent reason for culling was reproduction. Farmers may be unaware of the cost that is associated with reproductive culling although the level of reproductive performance directly affects the economic performance of a dairy herd (Lee and Kim 2007; Giordano et al. 2012). The lowest reported profitability of costs was seen in the groups of the longest CI group (–15.22 ± 4.26%; P < 0.05), the highest LF group (–14.08 ± 4.25%; difference non-significant), and the highest PC group (–16.08 ± 4.33%; P < 0.05). These same groups had the highest total

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Table 1. Association of culling of cows (CULL, %), culling because of the movement disorders (MD, %) and the mammary gland diseases (MGD, %) with the life production parameters

Item	CULL (≥ 40)	CULL (39–30)	CULL (≤ 29)	MD (≥ 25)	MD (24–10)	MD (≤ 9)	MGD (≥ 18)	MGD (17–10)	MGD (≤ 9)	Mean	SD
n (farms/cows)	13/6394	31/20 509	16/7729	13/7246	34/21 289	13/6097	14/8061	27/15 765	19/10 806	60/34 632	60/34 632
Milk yield, kg	**7279 ± 248^{b}**	**8159 ± 159^{a}**	**7604 ± 222^{b}**	8066 ± 271	7722 ± 168	8121 ± 262	7744 ± 280	7970 ± 183	7825 ± 218	7986	1178
Protein, %	3.45 ± 0.03	3.44 ± 0.02	3.42 ± 0.03	3.45 ± 0.03	3.42 ± 0.02	3.43 ± 0.03	3.43 ± 0.03	3.41 ± 0.02	3.45 ± 0.02	3.41	0.12
Fat, %	3.93 ± 0.05	3.92 ± 0.03	3.95 ± 0.04	**4.02 ± 0.05^{a}**	**3.90 ± 0.03^{b}**	**3.88 ± 0.05^{b}**	3.88 ± 0.05	3.90 ± 0.03	3.97 ± 0.04	3.90	0.19
SCC (×1000 cell/mL)	249.65 ± 21.81	245.20 ± 13.83	252.19 ± 18.86	263.10 ± 21.13	232.36 ± 13.57	260.88 ± 19.79	215.23 ± 22.21	254.11 ± 14.27	249.85 ± 16.72	249.88	64.76
Conception rate after 1st insemination (heifers)	**61.74 ± 2.38^{a}**	**57.07 ± 1.50^{b}**	**58.31 ± 2.08^{b}**	**58.97 ± 2.21^{b}**	**56.64 ± 1.38^{b}**	**62.34 ± 2.23^{a}**	55.11 ± 2.30	59.30 ± 1.51	58.79 ± 1.83	57.80	7.85
Conception rate after all inseminations (heifers)	60.20 ± 2.55	56.57 ± 1.60	56.72 ± 2.22	59.87 ± 2.44	56.65 ± 1.52	58.37 ± 2.46	55.92 ± 2.49	58.73 ± 1.63	57.13 ± 1.98	56.32	8.43
Conception rate after 1st insemination (cows)	**44.01 ± 2.32^{a}**	**39.27 ± 1.45^{b}**	**38.36 ± 2.02^{b}**	40.71 ± 2.27	39.53 ± 1.41	41.30 ± 2.29	41.12 ± 2.28	38.81 ± 1.50	41.60 ± 1.81	38.04	9.47
Conception rate after all inseminations (cows)	44.18 ± 2.27	40.75 ± 1.43	44.13 ± 1.98	43.88 ± 2.27	42.50 ± 1.41	42.20 ± 2.29	42.98 ± 2.31	42.66 ± 1.52	42.65 ± 1.84	39.76	9.83
Size of herd (number of cows)	517.26 ± 97.78	681.30 ± 62.81	565.11 ± 87.47	671.75 ± 101.51	639.93 ± 62.98	545.47 ± 98.32	724.60 ± 102.94	610.13 ± 67.42	589.13 ± 80.16	577.20	350.00
MD, %	–	–	–	–	–	–	13.85 ± 2.81	17.37 ± 1.84	18.25 ± 2.19	17.19	8.88
MGD, %	–	–	–	**8.94 ± 3.45^{b}**	**15.63 ± 2.14^{a}**	**15.91 ± 3.34^{a}**	–	–	–	10.89	7.01
PC, %	–	–	–	**11.08 ± 2.05^{b}**	**9.51 ± 1.27^{b}**	**15.18 ± 1.98^{a}**	**9.13 ± 2.16^{b}**	**10.73 ± 1.41^{ab}**	**12.76 ± 1.68^{a}**	21.06	10.07
LF, %	–	–	–	**19.55 ± 3.06^{b}**	**19.73 ± 1.90^{b}**	**24.50 ± 2.97^{a}**	20.71 ± 3.16	21.55 ± 2.07	19.56 ± 2.46	14.16	11.63
Services per conception	2.05 ± 0.11	2.19 ± 0.07	2.20 ± 0.10	**2.22 ± 0.12^{a}**	**2.17 ± 0.07^{ab}**	**2.02 ± 0.11^{b}**	2.20 ± 0.12	2.15 ± 0.08	2.12 ± 0.10	2.25	0.42
CI, d	405.68 ± 6.28	402.66 ± 4.03	407.18 ± 5.62	397.86 ± 6.24	408.02 ± 3.87	398.47 ± 6.05	406.06 ± 6.52	403.06 ± 4.27	403.76 ± 5.08	406.41	22.11
Days open, d	**113.51 ± 4.91^{b}**	**114.21 ± 3.15^{b}**	**126.57 ± 4.39^{a}**	114.00 ± 5.32	117.94 ± 3.30	118.97 ± 5.15	116.39 ± 5.44	117.74 ± 3.56	117.42 ± 4.23	120.69	19.24
Age at first calving, d	801.23 ± 14.88	791.64 ± 9.10	806.43 ± 12.65	**787.33 ± 13.82^{b}**	**794.22 ± 8.57^{ab}**	**812.23 ± 13.39^{a}**	794.60 ± 14.29	799.78 ± 9.36	793.65 ± 11.13	789.12	68.88
Number of lactation	**2.34 ± 0.18^{b}**	**2.48 ± 0.11^{ab}**	**2.76 ± 0.15^{a}**	2.51 ± 0.18	2.59 ± 0.11	2.45 ± 0.17	2.38 ± 0.17	2.65 ± 0.11	2.47 ± 0.14	2.49	0.58
Death rate of calves, %	7.88 ± 1.25	6.31 ± 0.81	5.94 ± 1.12	**6.99 ± 1.22^{b}**	**5.30 ± 0.75^{b}**	**8.19 ± 1.18^{a}**	**4.36 ± 1.25^{b}**	**6.44 ± 0.82^{ab}**	**7.17 ± 0.98^{a}**	6.11	4.58
Total loss of calves, %	14.12 ± 1.46	12.71 ± 0.93	11.53 ± 1.30	**13.10 ± 1.38^{b}**	**11.25 ± 0.85^{b}**	**15.21 ± 1.33^{a}**	**10.52 ± 1.45^{b}**	**12.50 ± 0.95^{ab}**	**13.67 ± 1.12^{a}**	12.39	5.01
Total weaned calves per 100 cows	**99.68 ± 2.70^{a}**	**97.45 ± 1.73^{b}**	**92.04 ± 2.41^{b}**	94.03 ± 2.76	95.99 ± 1.71	95.75 ± 2.67	**100.12 ± 2.69^{a}**	**95.58 ± 1.76^{ab}**	**92.74 ± 2.09^{b}**	95.91	9.06

Bold text with different superscripts indicates significance within a row related to the same independent variable ($P < 0.05$). PC = postpartum complications, LF = low fertility, CI = calving interval

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Table 2. Association of calving interval (CI, %), culling due to the low fertility (LF, %) and postpartum complications (PC, %) on the life production parameters

Item	CI (≥ 410)	CI (409–390)	CI (≤ 389)	LF (≥ 25)	LF (24–15)	LF (≤ 14)	PC (≥ 15)	PC (14–7)	PC (≤ 6)	Mean	SD
n (farms/cows)	19/10 534	27/15 405	14/8693	18/9467	24/15 597	18/9 568	15/7772	31/18 845	14/8015	60/34 632	60/34,632
Milk yield, kg	**7369 ± 237^{b}**	**7929 ± 173^{a}**	**8090 ± 247^{a}**	**7530 ± 236^{b}**	**8128 ± 189^{a}**	**7826 ± 218^{ab}**	7872 ± 250	7998 ± 175	7620 ± 262	7986	1,178
Protein, %	3.44 ± 0.03	3.43 ± 0.02	3.44 ± 0.03	3.41 ± 0.03	3.41 ± 0.02	3.46 ± 0.02	3.41 ± 0.03	3.43 ± 0.02	3.42 ± 0.03	3.41	0.12
Fat, %	**4.00 ± 0.04^{a}**	**3.90 ± 0.03^{b}**	**3.92 ± 0.05^{b}**	3.94 ± 0.04	3.93 ± 0.04	3.90 ± 0.04	3.87 ± 0.04	3.95 ± 0.03	3.91 ± 0.05	3.90	0.19
SCC (x1000 cell/mL)	**278.47 ± 17.15^{a}**	**260.04 ± 12.91^{a}**	**199.23 ± 17.37^{b}**	240.51 ± 20.17	238.86 ± 15.36	257.57 ± 17.48	**270.80 ± 19.39^{a}**	**240.85 ± 13.95^{ab}**	**228.55 ± 20.49^{b}**	249.88	64.76
Conception rate after 1st insemination (heifers)	**55.74 ± 2.08^{b}**	**57.59 ± 1.50^{ab}**	**62.62 ± 2.22^{a}**	58.53 ± 2.08	57.29 ± 1.63	59.54 ± 1.89	60.60 ± 2.18	57.87 ± 1.46	57.06 ± 2.21	57.80	7.85
Conception rate after all inseminations (heifers)	**55.12 ± 2.21^{b}**	**56.31 ± 1.60^{b}**	**61.76 ± 2.36^{a}**	56.45 ± 2.22	57.54 ± 1.75	58.80 ± 2.02	58.67 ± 2.34	56.70 ± 1.57	58.86 ± 2.37	56.32	8.43
Conception rate after 1st insemination (cows)	**35.78 ± 2.00^{c}**	**40.06 ± 1.45^{b}**	**43.99 ± 2.14^{a}**	**39.79 ± 1.97^{b}**	**38.07 ± 1.55^{b}**	**43.24 ± 1.79^{a}**	39.09 ± 2.17	40.23 ± 1.46	40.97 ± 2.20	38.04	9.47
Conception rate after all inseminations (cows)	**41.43 ± 2.03^{b}**	**41.38 ± 1.47^{b}**	**45.54 ± 2.17^{a}**	42.78 ± 2.03	41.52 ± 1.60	44.31 ± 1.84	**40.12 ± 2.05^{b}**	**41.98 ± 1.38^{b}**	**46.94 ± 2.08^{a}**	39.76	9.83
Size of herd (number of cows)	553.43 ± 89.60	597.91 ± 65.34	716.65 ± 93.46	627.64 ± 90.61	645.62 ± 72.67	596.54 ± 83.87	585.57 ± 93.36	656.59 ± 65.24	600.36 ± 97.79	577.20	350.00
CULL, %	32.59 ± 1.97	33.24 ± 1.45	36.01 ± 2.04	–	–	–	–	–	–	34.14	7.53
MD, %	16.46 ± 2.65	18.22 ± 1.84	14.93 ± 2.59	16.91 ± 2.49	16.94 ± 2.00	17.07 ± 2.30	**15.15 ± 2.45^{b}**	**15.56 ± 1.71^{b}**	**22.01 ± 2.57^{a}**	17.19	8.88
MGD, %	12.76 ± 3.34	12.93 ± 2.32	17.65 ± 3.27	13.39 ± 3.14	14.25 ± 2.52	15.24 ± 2.91	13.40 ± 3.25	14.25 ± 2.27	15.50 ± 3.40	10.89	7.01
PC, %	11.33 ± 2.05	11.77 ± 1.42	9.47 ± 2.00	10.41 ± 1.91	11.01 ± 1.53	11.71 ± 1.77	–	–	–	21.06	10.07
LF, %	22.29 ± 2.95	21.17 ± 2.05	18.55 ± 2.89	–	–	–	**17.09 ± 2.79^{b}**	**21.15 ± 1.95^{ab}**	**23.60 ± 2.92^{a}**	14.16	11.63
Services per conception	2.26 ± 0.11	2.14 ± 0.07	2.14 ± 0.11	2.17 ± 0.10	2.20 ± 0.08	2.07 ± 0.09	2.10 ± 0.11	2.17 ± 0.07	2.16 ± 0.11	2.25	0.42
CI, d	–	–	–	400.71 ± 5.59	408.27 ± 4.49	400.47 ± 5.18	399.71 ± 5.84	404.49 ± 4.08	406.74 ± 6.12	406.41	22.11
Days open, d	**134.24 ± 3.70^{a}**	**115.52 ± 2.70^{b}**	**104.95 ± 3.86^{c}**	**122.19 ± 4.50^{a}**	**120.29 ± 3.61^{a}**	**109.51 ± 4.17^{b}**	116.38 ± 4.80	115.03 ± 3.36	123.63 ± 5.03	120.69	19.24
Age at first calving, d	794.35 ± 13.69	795.84 ± 9.42	803.96 ± 13.49	**814.18 ± 12.14^{a}**	**789.44 ± 9.73^{b}**	**792.66 ± 11.23^{b}**	776.91 ± 12.48	801.97 ± 8.72	805.72 ± 13.07	789.12	68.88
Number of lactation	2.53 ± 0.18	2.52 ± 0.11	2.59 ± 0.16	2.47 ± 0.16	2.51 ± 0.13	2.64 ± 0.14	2.59 ± 0.17	2.55 ± 0.11	2.46 ± 0.17	2.49	0.58
Death rate of calves, %	**7.08 ± 1.13^{a}**	**6.95 ± 0.83^{ab}**	**5.01 ± 1.18^{b}**	6.07 ± 1.10	5.38 ± 0.88	7.66 ± 1.01	**7.82 ± 1.14^{a}**	**6.01 ± 0.79^{b}**	**5.27 ± 1.19^{b}**	6.11	4.58
Total loss of calves, %	**13.42 ± 1.31^{a}**	**13.13 ± 0.96^{a}**	**10.85 ± 1.37^{b}**	12.94 ± 1.27	11.47 ± 1.16	13.20 ± 1.40	13.14 ± 1.33	12.48 ± 0.93	11.86 ± 1.40	12.39	5.01
Total weaned calves per 100 cows	**89.97 ± 2.33^{b}**	**97.60 ± 1.70^{b}**	**100.22 ± 2.43^{a}**	93.41 ± 2.43	96.30 ± 1.95	96.25 ± 2.25	94.96 ± 2.53	96.20 ± 1.77	94.67 ± 2.65	95.91	9.06

Bold text with different superscripts indicates significance within a row related to the same independent variable ($P < 0.05$). CULL = culling of cows, MD = movement disorders, MGD = mammary gland diseases.

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Table 3. Association of culling of cows (CULL, %), calving interval (CI, %), culling because of the movement disorders (MD, %), mammary gland diseases (MGD, %), low fertility (LF, %) and postpartum complications (PC, %) with the costs and profitability

Item	CULL (≥ 40)	CULL (39–30)	CULL (≤ 29)	MD (≥ 25)	MD (24–10)	MD (≤ 9)	MGD (≥ 18)	MGD (17–10)	MGD (≤ 9)	Mean	SD
n (farms)	13/6394	31/20 509	16/7729	13/7246	34/21 289	13/6097	14/8061	27/15 765	19/10 806	60/34 632	60/34 632
Total feed costs	**3.63 ± 0.17**^{b}	**3.90 ± 0.11**^{a}	**3.87 ± 0.16**^{a}	3.94 ± 0.17	3.76 ± 0.11	3.86 ± 0.17	3.70 ± 0.18	3.81 ± 0.11	3.92 ± 0.14	3.78	0.58
Cereal grains and concentrates	**1.76 ± 0.17**^{b}	**2.34 ± 0.11**^{a}	**2.01 ± 0.15**^{a}	**2.38 ± 0.18**^{a}	**2.01 ± 0.01**^{ab}	**2.24 ± 0.17**^{b}	2.06 ± 0.19	2.11 ± 0.12	2.25 ± 0.15	2.05	0.60
Roughages	**1.71 ± 0.19**^{a}	**1.26 ± 0.12**^{b}	**1.48 ± 0.16**^{ab}	**1.13 ± 0.18**^{b}	**1.48 ± 0.12**^{a}	**1.46 ± 0.18**^{a}	1.44 ± 0.20	1.39 ± 0.13	1.39 ± 0.16	1.44	0.59
Labour costs	1.32 ± 0.14	1.27 ± 0.09	1.45 ± 0.12	**1.48 ± 0.13**^{a}	**1.22 ± 0.08**^{b}	**1.45 ± 0.12**^{a}	1.47 ± 0.13	1.28 ± 0.09	1.30 ± 0.10	1.33	0.45
Costs for veterinary services	0.29 ± 0.04	0.27 ± 0.02	0.27 ± 0.03	**0.23 ± 0.04**^{b}	**0.31 ± 0.02**^{a}	**0.23 ± 0.03**^{b}	0.26 ± 0.04	0.28 ± 0.03	0.28 ± 0.03	0.27	0.12
Costs for breeding operations	0.19 ± 0.02	0.20 ± 0.01	0.19 ± 0.02	0.20 ± 0.02	0.20 ± 0.01	0.17 ± 0.02	0.18 ± 0.02	0.21 ± 0.01	0.18 ± 0.02	0.20	0.06
Cow depreciation costs	0.85 ± 0.08	0.84 ± 0.05	0.86 ± 0.07	0.80 ± 0.08	0.87 ± 0.0	0.82 ± 0.08	**0.94 ± 0.08**^{a}	**0.76 ± 0.05**^{b}	**0.92 ± 0.06**^{a}	0.85	0.25
Total costs	**8.53 ± 0.42**^{b}	**8.59 ± 0.27**^{b}	**9.37 ± 0.37**^{a}	**8.39 ± 0.42**^{b}	**8.78 ± 0.26**^{ab}	**9.30 ± 0.41**^{a}	8.95 ± 0.44	8.69 ± 0.29	8.93 ± 0.34	8.73	1.40
NP	**–0.82 ± 0.44**^{a}	**–0.75 ± 0.28**^{a}	**–1.58 ± 0.40**^{b}	**–0.48 ± 0.45**^{a}	**–0.99 ± 0.28**^{ab}	**–1.64 ± 0.43**^{b}	–1.23 ± 0.47	–0.90 ± 0.31	–1.09 ± 0.36	–0.97	1.48
PROF, %	**–5.97 ± 4.70**^{a}	**–7.45 ± 3.02**^{a}	**–14.96 ± 4.20**^{b}	**–4.66 ± 4.72**^{a}	**–8.83 ± 2.93**^{ab}	**–16.12 ± 4.57**^{b}	–12.77 ± 4.89	–7.07 ± 3.20	–11.49 ± 3.80	–8.64	15.72
Item	CI (≥ 410)	CI (409–390)	CI (≤ 389)	LF (≥ 25)	LF (24–15)	LF (≤ 14)	PC (≥ 15)	PC (14–7)	PC (≤ 6)	Mean	SD
n (farms)	19/10 534	27/15 405	14/8693	18/9467	24/15 597	18/9568	15/7772	31/18 845	14/8015	60/34 632	60/34 632
Total feed costs	**4.11 ± 0.15**^{a}	**3.88 ± 0.11**^{b}	**3.47 ± 0.15**^{b}	**3.71 ± 0.15**^{b}	**3.78 ± 0.12**^{ab}	**3.98 ± 0.14**^{a}	4.03 ± 0.16	3.73 ± 0.11	3.81 ± 0.16	3.78	0.58
Cereal grains and concentrates	2.05 ± 0.17	2.21 ± 0.12	2.04 ± 0.18	2.04 ± 0.17	2.05 ± 0.14	2.32 ± 0.15	2.29 ± 0.18	2.08 ± 0.12	2.14 ± 0.18	2.05	0.60
Roughages	**1.69 ± 0.18**^{a}	**1.33 ± 0.12**^{b}	**1.30 ± 0.18**^{b}	1.36 ± 0.17	1.36 ± 0.14	1.48 ± 0.15	1.50 ± 0.18	1.48 ± 0.12	1.16 ± 0.18	1.44	0.59
Labour costs	1.32 ± 0.12	1.35 ± 0.09	1.31 ± 0.13	**1.55 ± 0.11**^{a}	**1.22 ± 0.09**^{b}	**1.28 ± 0.10**^{b}	1.45 ± 0.12	1.26 ± 0.08	1.33 ± 0.12	1.33	0.45
Costs for veterinary services	**0.33 ± 0.03**^{a}	**0.25 ± 0.02**^{b}	**0.28 ± 0.03**^{ab}	**0.30 ± 0.03**^{a}	**0.30 ± 0.03**^{a}	**0.24 ± 0.03**^{b}	**0.22 ± 0.03**^{b}	**0.31 ± 0.02**^{a}	**0.27 ± 0.03**^{a}	0.27	0.12
Costs for breeding operations	**0.21 ± 0.02**^{a}	**0.21 ± 0.01**^{a}	**0.17 ± 0.02**^{b}	0.18 ± 0.02	0.19 ± 0.01	0.20 ± 0.01	**0.16 ± 0.02**^{b}	**0.21 ± 0.01**^{a}	**0.19 ± 0.02**^{a}	0.20	0.06
Cow depreciation costs	0.93 ± 0.07	0.84 ± 0.05	0.79 ± 0.07	0.88 ± 0.07	0.84 ± 0.06	0.83 ± 0.06	**0.87 ± 0.07**^{a}	**0.89 ± 0.05**^{a}	**0.72 ± 0.07**^{b}	0.85	0.25
Total costs	**9.17 ± 0.38**^{a}	**8.81 ± 0.28**^{ab}	**8.41 ± 0.40**^{b}	9.07 ± 0.38	8.63 ± 0.30	8.87 ± 0.35	**9.29 ± 0.40**^{a}	**8.74 ± 0.27**^{ab}	**8.52 ± 0.41**^{b}	8.73	1.40
NP	**–1.38 ± 0.41**^{b}	**–1.00 ± 0.30**^{ab}	**–0.63 ± 0.42**^{a}	–1.34 ± 0.40	–0.85 ± 0.32	–1.02 ± 0.37	**–1.62 ± 0.41**^{b}	**–0.91 ± 0.29**^{a}	**–0.69 ± 0.43**^{a}	–0.97	1.48
PROF, %	**–15.22 ± 4.26**^{b}	**–7.78 ± 3.11**^{a}	**–6.45 ± 4.44**^{a}	–14.08 ± 4.25	–7.24 ± 3.41	–9.14 ± 3.93	**–16.08 ± 4.33**^{b}	**–8.40 ± 3.02**^{ab}	**–5.59 ± 4.53**^{a}	–8.64	15.72

Bold text with different superscripts indicates significance within a row related to the same independent variable ($P < 0.05$). NP = net profit without subsidies, PROF = profitability of costs without subsidies. Costs and profit are in CZK/L milk. 1 USD = cca 20 CZK.

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costs per 1l of milk (Table 3). Kvapilík et al. (2013) reported that even as the average farm milk price in the Czech Republic during 2012 was 7.67 CZK/l milk, the average of the total cost was 9.14 CZ/KL of milk, and the total costs minus the indirect costs (i.e., the costs of rearing calves, the costs of manure disposal) were 8.73 CZK/L of milk. It is evident that dairy farms in the Czech Republic would be operating at a loss without subsidies (Table 3). The evaluated fertility groups (based on the calving interval and low fertility) demonstrated that a lower fertility was associated with a lower milk yield ($P < 0.05$). Despite the fact that the general historical reproduction trends are unfavourably associated with the milk production (Lucy et al. 2001, De Vries and Risco 2005), however, it is not necessarily true that higher-producing herds have a greater difficulty in getting cows pregnant (Bello et al. 2012). As pointed out by LeBlanc (2010), it is important to separate the biology of the reproductive function from the effects of the economically based management decisions about culling and continued breeding. According to Lee and Kim (2007) and Leroy and Kruif (2006), the improved estrous detection could reduce the number of cows that are removed from the herd for reproductive reasons. A good herd management can achieve lower culling rates for the reasons of fertility. The groups with the highest culling of cows due to fertility (L F ≥ 25%) had the oldest age at the first calving of approximately 26.6 mo (Table 2). Wathes et al. (2008) and Shamay et al. (2005) found that the optimal fertility and maintaining maximum performance were achieved with the age at the first calving in the range of 24 to 25 mo.

The second most prevalent reason for culling (17%, Figure 1) was the foot and legs problems (MD). According to Warnick et al. (2001), the cow lameness results in a poor performance and a substantial economic loss, thus making this a major health concern for many dairy farmers. In our study, the MD ≥ 25% group was the most profitable ($P < 0.05$; Table 1). In the group MD ≥ 25%, there was found the highest concentration of milk components (4.02 ± 0.05% fat; $P < 0.05$). Such milk commands a better price. Not included in calculating profit were, for example, the revenues from selling pregnant heifers. It is worth noting that the age at the first calving in the MD ≥ 25% group was the shortest in average (787.33 ± 13.82 ≈ 25.8 mo) and that indicates a more intensive management in comparison with the other two groups. Krpalkova et al. (2014) added that the intensive farm management can lead to a higher risk in culling in the local undesirable conditions on the farm. Groenendaal et al. (2004) concluded that a dairy operation that increases the milk production due to higher culling rates might very well be more profitable than a dairy with lower cull rates and thus focusing on the cull rate differences between the two dairies might lead to incorrect conclusions. Differences in factors such as milk production, non-feed operating costs, and the pregnancy rate can have as large or even larger impact on profitability than the cull rate. As noted by Main et al. (2012), a cow may have a high production and be profitable, but at the same time the cow must maintain its feet and legs in good conditions. Cows with feet problems commonly may also have – at the same or at a later time – the mastitis, reproduction, or other health problems (Warnick et al. 2001). As seen in Table 1, a high removal rate of cows from the herds due to the MD (≥ 25%) reduces the culling ($P < 0.05$) due to other reasons (MGD, PC, LF). According to Rogers et al. (1988), the optimum average yearly culling rate is about 25%.

The fourth most prevalent reason for culling (14%, Figure 1) was the mastitis (MGD), despite the fact that culling for a high SCC was minimal (Table 1). Farmers may not realize the impact of the clinical mastitis on the herd turnover. Interestingly, the SCC was seldom stated as a reason for culling. How producers interpret the difference between mastitis and a high SCC is unknown, and culling for the mastitis may include both categories. Rajala-Schultz et al. (1999) found that the daily milk loss during the first 2 wk after the occurrence of the mastitis varied from 1.0 to 2.5 kg; the total loss over the entire lactation varied from 110 to 552 kg and depended on the parity and the time of mastitis occurrence. The MGD ≥ 25% herds had the lowest milk yield and profitability of costs (not significant). High-producing herds may better manage the lower average SCC, although an antagonistic relationship at the cow level might still exist between production level and the risk of the mastitis within herds (Pantoja et al. 2009). Calus et al. (2005) has stated that herds with a higher average protein production had a considerably less mastitis and a lower SCC in milk than the lower-producing herds had. Our study could confirm no associations between culling due to the MGD and the milk yield, the components in milk, or SCC in milk. It was found, though, that the high culling due to the MGD (≥18%) reduced the culling due to the PC (Table 1).

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Optimal calving interval and profit

The optimum calving interval in the economic terms is 12 to 13 mo (Bascom and Young 1998). However, Shoshani et al. (2014) have suggested that, in the herds with less than optimal reproductive performance, farmers must find a balance between income loss caused by the excessive days open and the income loss caused by high culling rates. Several studies have focused on the economics of managing this aspect in relation to the milk production, whereas others have considered the involvement of general farm management in addition to the milk production (Arbel et al. 2001; Butler et al. 2010; Dono et al. 2013). In our study, the group of herds with the longest CI (≥ 410 d) had the lowest mean milk yield (7369 ± 237 kg) and the highest average SCC ($P < 0.05$). The lowest fertility was observed in the lower conception of heifers and cows at first and the overall services ($P < 0.05$). The longest calving interval was associated with the highest loss of calves and the lowest number of the total weaned calves per 100 cows ($P < 0.05$). Kvapilík et al. (2013) reported similar findings that longer calving intervals (above the optimal of 400 d) decreased the average daily milk yield in the herd and smaller numbers of calves. For herds with a poor reproductive performance, Dono et al. (2013) found that the economic advantage of shortening the mean calving interval by removing cows from the herd that failed to conceive was outweighed by the costs associated with the increased herd turnover. They argued that an increase in profitability can occur from having a greater proportion of cows in the early lactation, when they are more efficient, and thus have a greater production. In our study, the highest net profit (–0.63 ± 0.42 CZK per L of milk), the highest profitability of costs (–6.45 ± 4.44%), and lowest total costs (8.41 ± 0.40 CZK per L of milk) occurred in the group of herds with CI ≤ 389 d ($P < 0.05$). However, some studies do not agree with this and consider that the problem lies in the inadequate management of high-producing herds, the level of the lactation persistency, and the genetic potential of animals (Pryce et al. 2001; Kadokawa and Martin 2006). Arbel et al. (2001) investigated the effect that extending the lactation has on the milk production and profitability in the following lactation. The overall benefit for both monitored lactations (that extended and that following) increased by an average $127 per cow. A delay of 60 d with respect to the usual voluntary waiting period in the beginning of inseminations of the high yielding cows has economic advantages. According to Koc (2012), it is possible to achieve a significantly higher milk production from cows with CI of more than 400 d but less than 500 d. Pryce et al. (2001) found the genetic correlation between the milk production and CI to be between r = 0.22 and r = 0.59. Kadokawa and Martin (2006) added that extending CI could help cows with extremely high yields. Therefore, higher milk yields and shorter CI is not always the most profitable combination.

CONCLUSIONS

A low reproductive efficiency was the primary culling reason for 21% of those cows included into this study. Ideally, very few cows should be culled because of the reproductive inefficiency. It is unlikely that all of the cows culled for the reproductive reasons were infertile. The improved estrous detection and the efficient synchronization of reproductive programs may reduce the incidence of culling due to reproduction. The level of reproductive performance directly affects the economic performance of a dairy herd. Those groups with the highest culling due to the fertility problems (low fertility and postpartum complications) achieved the lowest profitability. The lowest profitability and the reproduction problems were found also in the group of herds with the longest calving interval of 410 d or more. Some of these outcomes depend also on the level of a herd's milk productivity. The groups of herds with the highest overall culling and the highest culling due to the feet and legs problems showed the highest profitability. The most productive cows are more likely to be inseminated longer and are less likely to be removed from the herd. The opposite is also true, that the less productive cows are less likely to become pregnant. Culling decisions should also take into account the dairy cows' potential future production.

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