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## Dairy farm profit according to the herd size, milk yield, and number of cows per worker

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**Abstract:** The study evaluates the associations of the farm herd size (HERD), the milk yield (MY, kg/cow per year), and cows per worker (CW) with the production, reproduction, and economic traits in 60 commercial dairy herds (34 633 cows) in the Czech Republic. Each parameter was split into 3 groups. The largest herds ( $\geq 750$  cows) had the highest profitability of costs without subsidies ( $-3.8 \pm 4.3\%$ ), the lowest cost for roughages (1.2 CZK/L milk), and the lowest cost for breeding operations (0.17 CZK/L milk), but the highest costs for the cereal grains and concentrates (2.4 CZK/L milk). Herds with the lowest MY ( $\leq 7 499$ ) had the lowest profitability of costs without subsidies ( $-15.8 \pm 3.93\%$ ), the highest total costs (9.27 CZK/L milk), the highest labour costs (1.6 CZK/L milk), and the highest cow depreciation costs (0.97 CZK/L milk). Herds with the lowest CW ( $\leq 39$ ) had the highest mean labour costs (1.51 CZK/L milk) and the highest costs for breeding operations (0.22 CZK/L milk). Herds with the highest CW ( $\geq 60$ ) and the lowest CW ( $\leq 39$ ) also differed in the total feed costs (4.1 vs. 3.73 CZK/L milk) and the costs of cereals and concentrates (2.34 vs. 1.96 CZK/L milk). The increasing herd size tended to be accompanied by higher milk yields and the overall efficiency.

**Keywords:** cows, profit, production, reproduction

One of the dairy industry most prominent trends of the past decade has been its increasing globalization. The significantly increased demand for dairy products in the large emerging economies, many of which cannot be supplied domestically, has increased the magnitude of the global dairy trade (von Keyserlingk et al. 2013). The current economic situation is complicated; the consequences of the economic crisis are still visible and the companies are searching for ways to achieve the growth (Hýblová 2014). At the same time, advances in the genetics, nutrition, and herd management have resulted in the increased milk yields and an associated reduction in the numbers of farms and cows in many countries (von Keyserlingk et al. 2013). The improvement of agricultural productivity is a consequence of a more efficient use of the production factors (Špička and Machek 2015). Many dairy farmers have adopted new technologies to boost the dairy farm profitability

and have changed the overall management of their dairy herds (Stelwagen et al. 2013). Given the policy changes within the European Union, the dairy herd size is expected also to increase in many European countries. Managing more cows may have implications for the herd performance in the post-quota era (Jago and Berry 2011). In the Czech Republic, the overall process of the agriculture transformation has been most markedly reflected in the areas of the farm animal husbandry and production. The main reasons lie in the full liberalization of prices and the discontinuance of the relatively massive subsidies on the production or consumption prices since the 1990s. This has been reflected in a sharp decline in the number of farms with greatly increased herd sizes (MACR 2010).

As explained by Bailey et al. (1997), the economies of scale on modern dairy farms: (1) reduce the investment per cow, (2) lower the variable costs of production per

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unit, and (3) increase the labour and management efficiency. According to Olegginy et al. (2001), the increased herd size and specialization within the farm operation can bring efficiency improvements, which are in fact now becoming vital for the survival. Bailey et al. (1997) concluded that only dairy herd sizes in the range of 500 to 1 000 cows would be economically viable for the start-up operations. Von Keyserlingk et al. (2013) added that large herds tended to increase the production and to reduce the unit cost of milk, mainly as a result of spreading fixed costs across more production. In most countries with milk processing industries operating on a high level, farm income from milk sales is determined by the milk yield, the milk components (fat, protein, and lactose), and the milk quality (e.g., somatic cell counts) (Wolfova et al. 2007). It has also been shown that different milk pricing systems strongly influence the profitability of the milk production (Heikkilla et al. 2008). Cow fertility, too, plays an important role in the milk production and profitability of dairy herds (Giordano et al. 2012). Fertility has decreased in accordance with the rising milk production and such management changes as the growing numbers of cows per 1 worker and the time spent within the confinement housing (Grimard et al. 2006). Finally, the successful return on investment improves when the herd management is based on the quality heifer rearing, although it is often overlooked (Krpálková et al. 2014a).

Within this context, the objective of this study was to evaluate the association of the farm herd size (**HERD**, number of cows), the milk yield (**MY**, kg/cow per yr), and cows per 1 worker (**CW**, cows/worker) with the production, reproduction, and economic traits.

## MATERIALS AND METHODS

Data from 60 Czech commercial dairy operations comprising 34 633 dairy cows were collected during 2012 (1 year) using a questionnaire. The collected data included the production and reproduction parameters, rearing costs, economic parameters, and other dependent variables (Tables 1 and 2). The independent variables were the herd size (HERD, number of cows), the milk yield (MY, kg/cow per year), and the number of cows/worker (CW). All parameters were measured as part of a standard milk recording system (ICAR 2013).

Cows on the participating farms were housed in the free-stall barns and milked in the parlour systems.

All calves were housed in the individual hutches equipped with buckets for water and fed a starter mixture. The diet of the heifers and cows consisted of the TMR (a mixture of forage and grain). The composition of the diets differed depending on the region, breed, management, and the use of the feeding company services.

Costs and net profit per L of milk produced were calculated according to a certified methodology used in the Czech Republic (Poláčková et al. 2010). The total feed costs included those for cereal grains, concentrates, and roughages. The total costs included the total feed costs, labour costs, the costs of fuel and energy, the 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 (i.e., direct payments to support dairy farmers) (CZK) was calculated as follows:

$$NP = TSM - TCc2 \quad (1)$$

$$TCc2 = TCc1 - SC \quad (2)$$

where TSM = total sales of milk, TCc2 = total accumulated costs for all cows less secondary revenues, TCc1 = total accumulated costs for all cows, SC = secondary products (i.e., rearing of calves, manure).

TCc1 includes the costs of 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 the business success (Poláčková et al. 2010). The purpose in using this parameter was the possibility of using it for making a yearly comparison among farms regardless of the herd size.

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

## Statistical analyses

The data were analysed using a PROC MIXED model in the SAS 9.2 (SAS Institute 2008) on the independent variables HERD, MY, and CW. The data were grouped according to the number of herds

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and the specific variables' boundaries that showed more statistical differences. Tukey's test was used to determined significant differences among the means (Verbeke and Molenberghs 2000) and significance was declared when  $P < 0.05$ . The general statistical model was:

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

where  $y_{ijkl}$  = value of the dependent variable (Tables 1 and 2);  $\mu$  = overall mean;  $B_i$  =  $i^{\text{th}}$  breed effect ( $i$  = 32 Holstein breed: 18 646 cows, 18 Czech Fleckvieh breed: 7559 cows, 10 both breeds: 8428 cows);  $R_j$  = effect of  $j^{\text{th}}$  region of farm ( $j$  = frequency of the studied farms [from 60 farms in total] in each of the 12 studied Czech 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);  $D_k$  = effect of  $k^{\text{th}}$  HERD, MY, or CW (Tables 1 and 2); and  $e_{ijkl}$  = random error. Breed ( $B_i$ ) was considered as a fixed effect and the region of farm ( $R_j$ ) as a random effect. The independent variables HERD, MY, and CW were categorized in 3 groups (high, medium, and low) to help in interpreting the results of the analyses.

## RESULTS AND DISCUSSION

### Associations between herd size and profit

Jago and Berry (2011) had found no associations between the herd size and the milk production, except that the protein and fat amount increased with the herd size. In our study, the highest producing herds (MY  $\geq 9000$  kg) were those with the largest number of cows in the herd ( $809.07 \pm 100.11$  cows). The difference in the mean MY between the largest and smallest herds was 442 kg. Percentage components (protein and fat) in milk did not differ significantly by the herd size, although the highest mean levels of the milk components were found in the largest herd group (not significant). It has previously been reported that large herds had a superior reproductive performance relative to the non-expanding and small herds (Faust et al. 2001). Animals in the expanding herds calved for the first time at a younger age, had a shorter calving interval, and were inseminated artificially at a higher rate (Jago and Berry 2011). Although the differences were not statistically significant, visible tendencies in our study correspond with these earlier findings.

Culling rates also tend to increase with the herd size and milk yield. This probably relates to the CW and the amount of time available. Faust et al. (2001) found that culling increased when there were more than 50 cows per full-time employee. Nevertheless, we found no significant differences in culling rates according to HERD or CW, except that the highest mean incidence of culling due to the movement disorders, at  $19.94 \pm 2.31\%$ , occurred with the lowest CW  $\leq 39$  and the highest mean at  $21.17 \pm 2.50\%$  occurred when HERD  $< 750$ . Culling rates often increase when a herd expands as a result of buying cows from various sources (Alvasen et al. 2012; Derks et al. 2014). Also, generally the average parity number in cows reportedly decreases as the rate of expansion accelerates and as herd size increases (Olegginy et al. 2001; Alvasen et al. 2012). However, our results did not confirm these findings. The analysis of the survivability of calves in the evaluated HERD and CW groups showed the best results in the groups HERD  $\geq 750$  cows and CW  $\geq 60$  cows. Those differences (of between 2 and 3 percentage points) between the highest and lowest CW groups were found to be statistically significant, however, only for the death rate and the total loss of calves (Table 1).

According to Jago and Berry (2011), the herd size and milk price have less impact on the dairy farm profitability than might be thought. Our results showed that the largest HERD group achieved the highest profitability of costs ( $-3.77 \pm 4.33\%$ ) and the lowest total costs ( $8.32 \pm 0.38$  CZK) per L of milk (Table 2). Rodriguez et al. (2013) have reported that larger herds can capitalize on the economies of scale and reduce their unit costs of production by milking more cows. They related that Holstein herds larger than 1000 cows had a significantly lower total cost of production and a larger milk net income per unit of the produced milk than did the herds with fewer than 1000 cows. Herds with  $> 1000$  cows had \$1.05 lower total cost/45.4 kg of milk and \$0.74 greater milk net income/45.4 kg milk than did the herds with  $< 1000$  cows. Herds with  $> 2000$  cows did not differ statistically from the herds with 1000–2000 cows in terms of the total cost or income/kg milk, although their total cost of production was numerically smaller. Faust et al. (2001) pointed out that every dairy cow has very high fixed costs associated with buildings, land, and labour. The more milk the cow produces and the greater is the feed efficiency, therefore, the more profitable it is. In our study, those herds having the greatest number of cows per worker (CW  $\geq 60$  cows)

Table 1. Effect (mean ± SD) of milk yield (MY, kg/cow per yr), herd size (HERD, number of cows), and number of cows per worker (CW) on lifetime production, reproduction, and health parameters

Item	MY (≥ 9000)	MY (8999–7500)	MY (≤ 7499)	HERD (≥ 750)	HERD (749–400)	HERD (≤ 399)	CW (≥ 60)	CW (59–40)	CW (≤ 39)	Mean	SD
n (farms/cows)	14/10 626	25/14 627	21/9 379	14/14 770	31/16 280	15/3 583	12/7 913	30/18 443	18/8 276	60/34 63260/34 632	
MY	–	–	–	<b>8255 ± 248<sup>a</sup></b>	<b>7623 ± 174<sup>b</sup></b>	<b>7813 ± 236<sup>b</sup></b>	7802 ± 265	7992 ± 182	7616 ± 215	7986	1178
Protein, %	<b>3.38 ± 0.03<sup>b</sup></b>	<b>3.44 ± 0.02<sup>a</sup></b>	<b>3.46 ± 0.03<sup>a</sup></b>	3.46 ± 0.03	3.43 ± 0.02	3.41 ± 0.03	3.45 ± 0.03	3.42 ± 0.02	3.42 ± 0.02	3.41	0.12
Fat, %	<b>3.84 ± 0.05<sup>b</sup></b>	<b>3.96 ± 0.03<sup>a</sup></b>	<b>3.95 ± 0.04<sup>a</sup></b>	3.96 ± 0.05	3.91 ± 0.03	3.95 ± 0.04	3.93 ± 0.05	3.93 ± 0.03	3.93 ± 0.04	3.90	0.19
SCC (x1000 cell/ml)	254.48 ± 21.27	233.47 ± 15.01	262.54 ± 18.92	233.61 ± 9.84	245.58 ± 3.78	265.69 ± 8.50	261.25 ± 3.21	242.17 ± 3.80	251.14 ± 7.06	249.88	64.76
Conception rate at 1st service (heifers, %)	59.43 ± 2.00	58.55 ± 1.72	55.54 ± 2.47	60.27 ± 2.23	57.52 ± 1.58	57.89 ± 2.12	59.86 ± 2.34	58.39 ± 1.62	57.24 ± 1.90	57.80	7.85
Overall conception rate (heifers, %)	56.27 ± 2.13	58.40 ± 1.84	56.86 ± 2.63	59.25 ± 2.36	57.01 ± 1.67	55.92 ± 2.24	58.77 ± 2.47	56.16 ± 1.71	57.95 ± 2.00	56.32	8.43
Conception rate at 1st service (cows, %)	40.23 ± 1.96	40.72 ± 1.69	37.60 ± 2.42	<b>43.07 ± 2.04<sup>a</sup></b>	<b>38.74 ± 1.51<sup>b</sup></b>	<b>38.94 ± 2.15<sup>b</sup></b>	39.24 ± 2.30	40.80 ± 1.59	39.05 ± 1.87	38.04	9.47
Overall conception rate (cows, %)	<b>42.72 ± 1.89<sup>a</sup></b>	<b>43.45 ± 1.63<sup>a</sup></b>	<b>39.30 ± 2.33<sup>b</sup></b>	42.60 ± 2.14	42.43 ± 1.68	40.39 ± 2.40	43.67 ± 1.81	41.92 ± 1.54	41.25 ± 2.23	39.76	9.83
HERD	<b>809.07 ± 100.11<sup>a</sup></b>	<b>608.31 ± 69.37<sup>b</sup></b>	<b>535.22 ± 81.40<sup>b</sup></b>	–	–	–	671.75 ± 101.51	639.93 ± 62.98	545.47 ± 98.32	577.20	350.00
CW	46.91 ± 5.49	46.92 ± 3.80	44.65 ± 4.46	<b>56.85 ± 4.68<sup>a</sup></b>	<b>42.17 ± 3.27<sup>b</sup></b>	<b>43.17 ± 4.44<sup>b</sup></b>	–	–	–	46.81	17.12
Culling of cows, %	34.53 ± 2.28	33.95 ± 1.60	33.14 ± 1.85	32.69 ± 2.03	35.25 ± 1.41	31.75 ± 1.97	32.95 ± 2.16	33.88 ± 1.49	34.08 ± 1.80	34.14	7.53
Movement disorders, %	16.67 ± 2.85	18.51 ± 1.99	15.18 ± 2.48	<b>21.17 ± 2.50<sup>a</sup></b>	<b>14.49 ± 1.80<sup>b</sup></b>	<b>17.41 ± 2.44<sup>b</sup></b>	<b>16.14 ± 2.66<sup>b</sup></b>	<b>15.46 ± 1.84<sup>b</sup></b>	<b>19.94 ± 2.31<sup>a</sup></b>	17.19	8.88
Mammary gland diseases, %	14.58 ± 3.64	13.80 ± 2.54	14.89 ± 3.16	15.29 ± 3.24	15.89 ± 2.33	10.30 ± 3.16	16.22 ± 3.42	14.89 ± 2.36	12.16 ± 2.96	10.89	7.01

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Continued Table 1

Item	MY (≥ 9000)	MY (8999–7500)	MY (≤ 7499)	HERD (≥ 750)	HERD (749–400)	HERD (≤ 399)	CW (≥ 60)	CW (59–40)	CW (≤ 39)	Mean	SD
Postpartum complications, %	<b>12.44 ± 2.15<sup>a</sup></b>	<b>9.15 ± 1.50<sup>b</sup></b>	<b>12.75 ± 1.87<sup>a</sup></b>	10.64 ± 1.98	10.28 ± 1.43	13.09 ± 1.94	13.61 ± 2.00	10.11 ± 1.42	10.83 ± 1.78	21.06	10.07
Low fertility, %	22.32 ± 3.13	18.21 ± 2.18	23.07 ± 2.72	21.47 ± 2.91	20.74 ± 2.09	19.99 ± 2.84	21.26 ± 3.01	19.59 ± 2.08	22.21 ± 2.61	14.16	11.63
Services per conception	2.21 ± 0.12	2.12 ± 0.07	2.23 ± 0.13	<b>2.23 ± 0.11<sup>a</sup></b>	<b>2.23 ± 0.07<sup>a</sup></b>	<b>1.98 ± 0.10<sup>b</sup></b>	2.14 ± 0.12	2.18 ± 0.07	2.17 ± 0.09	2.25	0.42
Calving interval, d	<b>398.15 ± 6.42<sup>b</sup></b>	<b>401.47 ± 4.05<sup>b</sup></b>	<b>411.30 ± 5.22<sup>a</sup></b>	398.89 ± 5.89	406.93 ± 4.11	405.40 ± 5.59	400.20 ± 6.17	404.59 ± 4.24	407.12 ± 5.01	406.41	22.11
Days open, d	<b>114.39 ± 4.98<sup>b</sup></b>	<b>110.63 ± 3.45<sup>b</sup></b>	<b>127.29 ± 4.05<sup>a</sup></b>	111.33 ± 4.75	121.20 ± 3.32	116.75 ± 4.51	114.22 ± 5.01	115.93 ± 3.43	122.05 ± 4.06	120.69	19.24
Age at first calving, d	<b>770.74 ± 14.02<sup>b</sup></b>	<b>791.98 ± 9.69<sup>b</sup></b>	<b>820.18 ± 12.18<sup>a</sup></b>	784.79 ± 13.24	799.24 ± 9.59	807.40 ± 12.63	781.01 ± 13.78	804.69 ± 9.48	797.93 ± 11.61	789.12	68.88
Number of lactations	2.42 ± 0.18	2.52 ± 0.12	2.64 ± 0.16	2.43 ± 0.17	2.53 ± 0.12	2.66 ± 0.15	<b>2.68 ± 0.17<sup>a</sup></b>	<b>2.57 ± 0.11<sup>ab</sup></b>	<b>2.39 ± 0.14<sup>b</sup></b>	2.49	0.58
Death rate of calves, %	<b>5.42 ± 1.28<sup>b</sup></b>	<b>5.53 ± 0.89<sup>b</sup></b>	<b>8.18 ± 1.04<sup>a</sup></b>	6.05 ± 1.20	6.42 ± 0.84	7.11 ± 1.14	<b>5.56 ± 1.22<sup>b</sup></b>	<b>5.97 ± 0.84<sup>b</sup></b>	<b>7.81 ± 0.99<sup>a</sup></b>	6.11	4.58
Total loss of calves, %	<b>11.11 ± 1.48<sup>b</sup></b>	<b>11.45 ± 1.02<sup>b</sup></b>	<b>14.78 ± 1.20<sup>a</sup></b>	11.68 ± 1.39	13.07 ± 0.97	12.75 ± 1.32	<b>11.19 ± 1.43<sup>b</sup></b>	<b>12.41 ± 0.97<sup>ab</sup></b>	<b>13.85 ± 1.16<sup>a</sup></b>	12.39	5.01
Total weaned calves per 100 cows	<b>97.45 ± 2.74<sup>a</sup></b>	<b>99.99 ± 1.90<sup>a</sup></b>	<b>91.56 ± 2.23<sup>b</sup></b>	97.57 ± 2.65	96.34 ± 1.85	95.09 ± 2.51	98.75 ± 2.75	95.78 ± 1.87	95.62 ± 2.23	95.91	9.06

Bold text with different superscripts indicates significance within a row related to the same independent variable ( $P < 0.05$ )

Table 2. Effect (mean  $\pm$  SD) of milk yield (MY, kg/cow per YR), size of herd (HERD, number of cows), and cows per worker (CW) on costs and profit

Item	MY ( $\geq 9000$ )	MY (8999–7500)	MY ( $\leq 7499$ )	HERD ( $\geq 750$ )	HERD (749–400)	HERD ( $\leq 399$ )	CW ( $\geq 60$ )	CW (59–40)	CW ( $\leq 39$ )	Mean	SD
n (farms/number of cows)	14/10 626	25/14 627	21/9379	14/14 770	31/16 280	15/3583	12/7913	30/18 443	18/8276	60/34 632	60/34 632
Total feed costs	3.82 $\pm$ 0.18	3.82 $\pm$ 0.13	3.87 $\pm$ 0.15	3.85 $\pm$ 0.17	3.78 $\pm$ 0.12	3.94 $\pm$ 0.16	<b>4.10 <math>\pm</math> 0.17<sup>a</sup></b>	<b>3.80 <math>\pm</math> 0.12<sup>ab</sup></b>	<b>3.73 <math>\pm</math> 0.14<sup>b</sup></b>	3.78	0.58
<i>Cereal grains and concentrates</i>	<b>2.39 <math>\pm</math> 0.19<sup>a</sup></b>	<b>2.12 <math>\pm</math> 0.14<sup>ab</sup></b>	<b>2.00 <math>\pm</math> 0.15<sup>b</sup></b>	<b>2.39 <math>\pm</math> 0.17<sup>a</sup></b>	<b>2.02 <math>\pm</math> 0.12<sup>b</sup></b>	<b>2.04 <math>\pm</math> 0.17<sup>b</sup></b>	<b>2.34 <math>\pm</math> 0.18<sup>a</sup></b>	<b>2.16 <math>\pm</math> 0.13<sup>ab</sup></b>	<b>1.96 <math>\pm</math> 0.15<sup>b</sup></b>	2.05	0.60
<i>Roughages</i>	1.35 $\pm$ 0.19	1.28 $\pm$ 0.14	1.58 $\pm$ 0.16	<b>1.16 <math>\pm</math> 0.17<sup>b</sup></b>	<b>1.50 <math>\pm</math> 0.13<sup>a</sup></b>	<b>1.51 <math>\pm</math> 0.17<sup>a</sup></b>	1.59 $\pm$ 0.18	1.32 $\pm$ 0.13	1.39 $\pm$ 0.15	1.44	0.59
Labor costs	<b>1.11 <math>\pm</math> 0.13<sup>b</sup></b>	<b>1.19 <math>\pm</math> 0.09<sup>b</sup></b>	<b>1.60 <math>\pm</math> 0.11<sup>a</sup></b>	<b>1.11 <math>\pm</math> 0.12<sup>b</sup></b>	<b>1.32 <math>\pm</math> 0.08<sup>ab</sup></b>	<b>1.56 <math>\pm</math> 0.12<sup>a</sup></b>	<b>1.26 <math>\pm</math> 0.13<sup>b</sup></b>	<b>1.23 <math>\pm</math> 0.09<sup>b</sup></b>	<b>1.51 <math>\pm</math> 0.10<sup>a</sup></b>	1.33	0.45
Costs for veterinary services	0.25 $\pm$ 0.04	0.28 $\pm$ 0.03	0.29 $\pm$ 0.03	0.26 $\pm$ 0.03	0.29 $\pm$ 0.02	0.26 $\pm$ 0.03	<b>0.20 <math>\pm</math> 0.03<sup>b</sup></b>	<b>0.29 <math>\pm</math> 0.02<sup>a</sup></b>	<b>0.30 <math>\pm</math> 0.03<sup>a</sup></b>	0.27	0.12
Costs for breeding operations	<b>0.17 <math>\pm</math> 0.02<sup>b</sup></b>	<b>0.21 <math>\pm</math> 0.01<sup>a</sup></b>	<b>0.20 <math>\pm</math> 0.01<sup>a</sup></b>	<b>0.17 <math>\pm</math> 0.02<sup>b</sup></b>	<b>0.20 <math>\pm</math> 0.01<sup>a</sup></b>	<b>0.22 <math>\pm</math> 0.02<sup>a</sup></b>	<b>0.18 <math>\pm</math> 0.02<sup>b</sup></b>	<b>0.19 <math>\pm</math> 0.01<sup>b</sup></b>	<b>0.22 <math>\pm</math> 0.01<sup>a</sup></b>	0.20	0.06
Cow depreciation costs	<b>0.84 <math>\pm</math> 0.08<sup>b</sup></b>	<b>0.75 <math>\pm</math> 0.05<sup>b</sup></b>	<b>0.97 <math>\pm</math> 0.06<sup>a</sup></b>	0.26 $\pm$ 0.03	0.29 $\pm$ 0.02	0.26 $\pm$ 0.03	0.80 $\pm$ 0.07	0.90 $\pm$ 0.05	0.81 $\pm$ 0.06	0.85	0.25
Total costs	<b>8.44 <math>\pm</math> 0.44<sup>b</sup></b>	<b>8.55 <math>\pm</math> 0.30<sup>b</sup></b>	<b>9.27 <math>\pm</math> 0.35<sup>a</sup></b>	<b>8.32 <math>\pm</math> 0.38<sup>b</sup></b>	<b>8.68 <math>\pm</math> 0.27<sup>b</sup></b>	<b>9.53 <math>\pm</math> 0.36<sup>a</sup></b>	8.95 $\pm$ 0.42	8.64 $\pm$ 0.29	8.94 $\pm$ 0.34	8.73	1.40
NP <sup>1</sup>	<b>-0.62 <math>\pm</math> 0.46<sup>a</sup></b>	<b>-0.68 <math>\pm</math> 0.32<sup>a</sup></b>	<b>-1.58 <math>\pm</math> 0.37<sup>b</sup></b>	<b>-0.37 <math>\pm</math> 0.40<sup>a</sup></b>	<b>-0.92 <math>\pm</math> 0.28<sup>a</sup></b>	<b>-1.81 <math>\pm</math> 0.38<sup>b</sup></b>	-1.13 $\pm$ 0.45	-0.83 $\pm$ 0.31	-1.17 $\pm$ 0.36	-0.97	1.48
PROF <sup>2</sup> , %	<b>-4.35 <math>\pm</math> 4.83<sup>a</sup></b>	<b>-5.86 <math>\pm</math> 3.35<sup>a</sup></b>	<b>-15.80 <math>\pm</math> 3.93<sup>b</sup></b>	<b>-3.77 <math>\pm</math> 4.33<sup>a</sup></b>	<b>-8.24 <math>\pm</math> 3.02<sup>b</sup></b>	<b>-16.91 <math>\pm</math> 4.11<sup>b</sup></b>	-9.12 $\pm$ 4.73	-8.67 $\pm$ 3.25	-10.35 $\pm$ 3.84	-8.64	15.72

Bold text with different superscripts indicates significance within a row related to the same independent variable ( $P < 0.05$ ). <sup>1</sup>NP = net profit without subsidies; <sup>2</sup>PROF = profitability of costs without subsidies.

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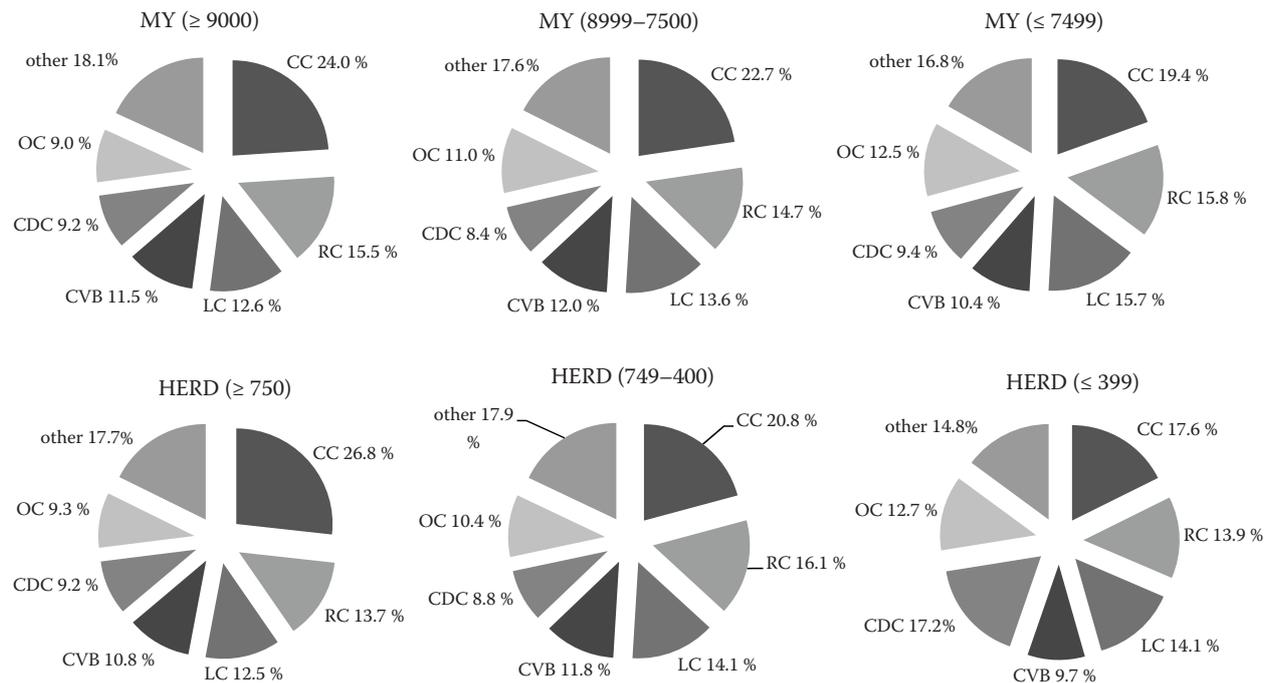


Figure 1. Distribution of total costs on 60 commercial dairy farms in the Czech Republic in 2012

Milk yield (MY, kg/cow per yr) values were grouped as: high ( $\geq 9000$ ,  $n = 14$ ; mean  $\pm$  SD =  $9507 \pm 435$ ), medium (8999–7500,  $n = 25$ ; mean  $\pm$  SD =  $8216 \pm 509$ ), and low ( $\leq 7499$ ,  $n = 21$ ; mean  $\pm$  SD =  $6,698 \pm 484$ ). Herd size was grouped as: high ( $\geq 750$ ,  $n = 14$ ; mean  $\pm$  SD =  $1055 \pm 385$ ), medium (749 to 400,  $n = 31$ ; mean  $\pm$  SD =  $525 \pm 86$ ), and low ( $\leq 399$ ,  $n = 15$ ; mean  $\pm$  SD =  $239 \pm 77$ ). CC = cereal grains and concentrates feed costs, RC = roughages feed costs, LC = labor costs, CDC = cow depreciation costs, CVB = costs for veterinary services and breeding operations, OC = overhead costs, other = costs of fuel and energy, depreciation of intangible and tangible fixed assets, and other.

had the highest feed costs across all subcategories. The total feed costs and the costs of cereal grains and concentrates for that group were  $4.10 \pm 0.17$  CZK and  $2.34 \pm 0.18$  CZK per litre of milk, respectively. The differences between  $CW \geq 60$  cows and  $CW \leq 39$  cows in labour costs, costs for veterinary services, and costs for breeding operations were in favour of a higher CW number (Table 2). The distributions of the total costs according to the HERD groups are shown as percentages in Figure 1. The highest total costs ( $9.53 \pm 0.36$  CZK per L of milk) and the lowest net profit ( $-1.81 \pm 0.38$  per L of milk) occurred for the smallest herds ( $\leq 399$  cows), whereas the highest profitability of cost was achieved for the largest herds ( $-3.77 \pm 4.33$  CZK per L of milk).

### High-producing dairy herd

Researchers and producers commonly believe there is an inherent conflict between the high milk pro-

duction and good fertility, health, and the overall profitability in lactating dairy cows. This possible antagonism is attributed to the competing physiological demands and the divergent genetic selection choices (Leroy and Kruif 2006). Generally, the management and genetic effects are considered separately. However, the selection for an increased production under one management system may lead to greater health risks under other management systems (Windig et al. 2006). Our results diverge from the view that a higher productivity must lead to a lower fertility. The analysis of MY in relation to the reproduction traits showed that the herds with  $MY \geq 7500$  kg/cow per year achieved the overall higher conception rates in cows. Also, those herds with a higher production ( $MY \geq 9000$  kg and MY of 8999–7500 kg/cow per year) had the shortest days open ( $114.39 \pm 4.98$  and  $110.63 \pm 3.45$  d) and calving interval ( $398.15 \pm 6.42$  and  $401.47 \pm 4.05$  d), respectively (Table 1). The reproduction problem lies in the inadequate management and environmental conditions in the high-producing herds (Heikkilä et

al. 2008). These relationships between MY and health vary among herds and between cows within a herd (Kadokawa 2006). We found no significant differences between the MY groups regarding culling due to the movement disorders, mammary gland diseases, and a low fertility.

The herds with a higher production (MY  $\geq$  9000 kg and MY of 8999–7500 kg) had lower calf losses. The differences between the highest ( $\geq$  9000 kg) and the lowest ( $\leq$  7499 kg) MY groups for the death rate and the total loss of calves were approximately 3 to 4 percentage points. Similar results were found for the total weaned calves per 100 cows (Table 1). The nursing care for calves in lower MY herds was worst in comparison to that for the higher yielding herds Smith et al. (2000). In our study, a lower death loss was found in the higher MY groups ( $\geq$  7500). Also, the herds with a higher production (MY  $\geq$  9000 kg and MY of 8999–7500 kg/cow per year) had heifers that were younger at the first calving ( $770.74 \pm 14.02$  and  $791.98 \pm 9.69$  d, respectively). The difference in the mean age at the first calving between the highest and lowest MY groups was 50 d (Table 1). Many studies suggest that the earlier the age at the first calving the better (Shamay et al. 2005; Stevenson et al. 2008). Krpálková et al. (2014b) concluded that the lowest average milk yield in the lifetime production was observed in the age at the first calving higher than 24.5 months of age.

The higher MY groups were the most profitable in the present study (Table 2), which also had lower total costs even though they had higher costs for the cereal grains and concentrates. According to Příbyl et al. (2004), the milk production per cow continues to increase by 2% to 3% annually and so the feeding strategies and approaches must correspond to the level of milk yield. Those herds with the best genetics cannot function well without high quality feedstuffs in sufficient amounts. Glanc et al. (2009) have reported that the components in milk (protein and fat) are important for the farm profitability and are positively correlated. Dairy managers must realize, however, that the selection for a higher milk yield can lead to the decline in the milk components on a percentage basis. In our study, the percentage contents of fat and protein in milk were the lowest in the highest MY group (protein  $3.38 \pm 0.03\%$  and fat  $3.84 \pm 0.05\%$ ).

Kvapilík et al. (2013) have reported that the average farm milk price in the Czech Republic during 2012 was 7.67 CZK/L of milk while the average of

the total costs was 9.14 CZK/L of milk. The average costs excluding indirect costs (i.e., the costs of rearing calves, the costs of manure disposal) were 8.73 CZK/L of milk. It is therefore evident that without subsidies, the dairy farms in the Czech Republic would be operating at a loss (Table 2). The lowest net profit per L of milk ( $-1.58 \pm 0.37$  CZK) and the profitability of costs without subsidies ( $-15.80 \pm 3.93\%$ ) occurred in the lowest MY group (Table 2). The distributions of the total costs for all evaluated dairy farms according to MY and HERD level are shown as percentages in Figure 1. The largest single cost item was the total feed costs (i.e., cereal grains and concentrates feed costs, and roughages feed costs), which was the highest in the largest herd size (HERD  $\geq$  750, 40.5%) and the lowest in the smallest herd size (HERD  $\leq$  399 kg, 31.5%). Within the feed costs, significant differences were observed only in the costs of the cereal grains and concentrates (Table 2). Those herds with the highest MY had the highest costs for cereal grains and concentrates per L of milk, at  $2.39 \pm 0.19$  CZK, and the difference between the highest and lowest MY groups per L of milk was 0.39 CZK. The group with the lowest MY had the highest labour costs per L of milk ( $1.60 \pm 0.11$  CZK) and the highest cow depreciation costs per L of milk ( $0.97 \pm 0.06$  CZK). The highest MY group had the lowest costs for the breeding operations ( $0.17 \pm 0.02$  CZK). Increasing milk yields leave the total cost per L and net margin per L relatively unchanged, but the increased milk output substantially boosts the herd's total profit (Buza et al., 2014). Kvapilík et al. (2013) and Heikkilä et al. (2008) found that the price movements for milk, the components in milk, and the production inputs can significantly affect the farm profitability and that the management should therefore adapt to these changes.

## CONCLUSION

This study demonstrates that the herds with higher milk yields are more profitable even though they might have higher cereal grains and concentrates and roughages feed costs. Therefore, the greatest opportunity to increase the likelihood for the dairy farm profitability is to improve the individual animal efficiency through higher milk yields and a higher feed efficiency. A focus on such fundamentals as the cow comfort, the increasing herd size for the sake of efficiency, and taking advantage of the economies of scale and volume improves profitability. In general,

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the highest producing herds were also the largest herds and had the best reproductive performance. Furthermore, a higher number of cows per 1 worker was associated with a higher milk yield, larger herds, and ultimately a higher profitability. It is nevertheless evident that the market milk prices and subsidies have a major impact on the profitability of dairy farms in the Czech Republic.

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