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Analysis of milk production, age at first calving, calving interval and economic parameters in dairy cattle management

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Lenka Krpálková[1], Jan Syrůček[1], Jindřich Kvapilík[1], Jiři Burdych[1,2]*

[1]Department of Cattle Breeding, Institute of Animal Science, Přátelství 815, 10400 Prague 10 - Uhříněves, Czech Republic
[2]VVS Verměřovice s.r.o, Verměřovice 159, 561 52 Verměřovice, Czech Republic

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Abstract

The objective of this study was to evaluate main indicators of milk production on total 60 commercial dairy herds from the Czech Republic during a 9-yr period (2006-2014). Breakeven points and sensitivity analysis were used and associations of age at first calving (AFC), milk yield (MY) and calving interval (CI) were analyzed. Lowest AFC≤749 d showed the highest fertility, the lowest death rate of calves and lowest profitability without subsidies -2.49 %. Highest MY≥9,000 kg showed the highest fertility, lowest AFC, lowest feed costs and total costs 8.58 CZK (0.32 EUR) per L of milk and subsequent highest profitability 2.37 %. The analysis of fertility showed that herds with the lowest CI (≤389 d) achieved lowest cow depreciation costs 0.71 CZK (0.03 EUR) per L of milk, highest total costs 9.72 CZK (0.36 EUR) per L of milk and highest profitability 1.29 %. Breakeven points for the price of milk ranged between 7.81 and 8.75 CZK (0.29 and 0.32 EUR) per L in yr 2007 and 2014. Increase in input prices should adversely affect the increase the price of milk. The increase of price of milk by 1 % in 2014 will cause an increase in profit of CZK 745 (27.6 EUR) per cow per year.

Key words: dairy cows, rearing period, reproduction costs, sensitivity analysis, breakeven points, profitability

Introduction

Dairy farmers face a complex dilemma of wishing to minimize costs associated with maximizing economic productivity (Mourits et al., 1999). Commercial dairies are in the business of producing the rawinputs for use in the production of dairy products. As in any business, dairies desire to see a return on investments and thus have adopted new management strategies aimed to improve economic well-being. The adoption of these strategies has improved the quality and production efficiency of dairies and has provided the consumer with a relatively cheap supply of dairy products (Arbel et al., 2001). Production per cow has increased and herds have increased in size to capture economies of scale benefits (Honarvar et al., 2010).

A basic approach to reducing inputs may be at the beginning to shorten the nonproductive period of dairy heifers, which can be accomplished by breeding heifers earlier to reduce the age of first parturition (Abeni et al., 2000). Krpálková et al. (2014a) found that although it is often pursued as a management target, low AFC does not always lead to the most profitable outcome in dairy herd management. Local conditions on each farm remain important. The production costs for feeds and depreciation of costs vary widely from farm to farm. Market prices also vary, because they follow changes occurring in agricultural product markets. In most cases, however, an increase or decrease of input and output prices by as much as 20 w% did not alter the optimal decisions (Heikkilä et al., 2008). Lee

*Corresponding author/Dopisni autor: Phone/Tel.: + 420 267 009 529; E-mail: lenka.krpalkova@centrum.cz

and Kim (2007) concluded that even when cows have high levels of production they may not provide expected economic benefits due to their overall decline in other traits. All these facts should be taken into consideration when planning the overall management of dairy cattle. Krpálková et al. (2014a) concluded that farm profitability is greatly influenced by the changing prices of inputs and outputs on agricultural markets.

The objective of this study was to evaluate main indicators of milk production using breakeven points and sensitivity analysis and associations of age at first calving (AFC), milk yield (MY) and calving interval (CI) with herds' production traits and economic performance.

Materials and methods

Data from year 2006-2014 were collected by means of a questionnaire from in total 60 Czech commercial dairy herds (Holstein and Czech Fleckvieh breed). Data collected included production and reproduction parameters, rearing costs, economic parameters, and other dependent variables (Tables 1, 2, 3 and 4). The farms were located in 12 regions within the Czech Republic. The independent variables, in percentages (%), were AFC, MY and CI. Farms' records with respect to reproduction and production traits were measured within the Czech Republic milk recording system (ICAR, 2013). Other data were obtained using the questionnaire.

Table 1. Development of basic production and economic indicators in milk production

Year / Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014
n	19	39	48	49	55	49	62	72	80
Arability, %	85.63	80.56	77.69	79.55	76.19	78.23	78.38	78.31	77.61
No. of dairy cows per farms (size of herd)	688	679	611	615	623	646	571	580	582
No. of dairy cows per 100 ha of agricultural land	25.11	26.24	24.79	24.64	25.13	24.47	25.09	25.16	26.39
No. of dairy cows per cowman	40	45	49	47	48	49	47	48	52
Milk yield per cow and year, L	7146	7247	7662	7558	7666	7823	7976	7896	8113
Marketability, %	95.07	96.00	93.96	95.89	95.82	95.65	95.77	96.13	96.52
Market milk production per cow and year, L	6596	6877	7167	7105	7284	7423	7595	7598	7836
Market milk production per ha of agricultural land, L	1662	1833	1901	1871	1940	1978	2005	1999	2140
Market milk production per cowman, L	256682	307758	366062	333414	350273	364703	357378	365228	406640
Protein, %	3.37	3.38	3.37	3.38	3.41	3.41	3.41	3.42	3.43
Fat, %	3.89	3.83	3.83	3.90	3.93	3.88	3.90	3.90	3.90
Milk price, CZK/L	7.86	8.44	8.50	6.25	7.54	8.37	7.76	8.63	9.51
Conception rate after 1st insemination (heifers), %	-	58.87	56.19	58.91	60.77	61.84	58.02	59.21	58.63
Conception rate after all inseminations (heifers), %	-	59.69	53.04	57.29	61.02	60.82	56.48	58.77	58.07

Conception rate after 1st insemination (cows), %	-	38.14	38.23	40.30	38.83	39.24	38.05	38.78	39.70
Conception rate after all inseminations (cows), %	-	43.73	39.78	41.77	41.48	41.38	39.81	41.81	43.05
Culling cows, %	35.25	30.00	28.54	30.54	33.77	33.23	34.11	34.06	31.68
Insemination index	-	-	2.24	2.19	2.21	2.17	2.25	2.23	2.25
Calving interval, d	403	396	409	411	401	399	406	407	403
Open days, d	127	123	127	126	122	120	121	121	119
Age at first calving, d	-	818	805	789	794	769	790	793	786
Number of calves from 100 cows	88.65	92.31	92.39	92.46	93.18	96.96	95.59	96.20	98.08
Deaths of calves, %	-	3.85	7.94	4.84	7.15	5.58	6.17	6.05	4.53
Total losses of calves, %	-	7.15	13.01	11.06	13.54	11.94	12.54	13.07	10.30
Labor costs, CZK/L	1.32	1.22	1.36	1.25	1.20	1.25	1.33	1.29	1.24
Feed costs, CZK/L	3.92	3.58	3.78	3.50	3.68	3.83	3.78	3.97	4.00
IOFC, CZK/l	3.94	4.86	4.72	2.75	3.86	4.54	3.99	4.66	5.51
Veterinary and breeding operations, CZK/L	0.49	0.62	0.60	0.57	0.55	0.54	0.54	0.55	0.54
Depreciation of cows, CZK/L	0.89	0.87	0.85	0.79	0.86	0.85	0.85	0.83	0.82
Depreciation of assets, CZK/L	0.45	0.42	0.48	0.53	0.47	0.51	0.43	0.45	0.42
Insurance of property and cows, CZK/L	0.06	0.08	0.07	0.06	0.04	0.06	0.07	0.06	0.06
Repair and maintenance, CZK/L	0.20	0.19	0.20	0.16	0.21	0.27	0.27	0.28	0.24
Energy, CZK/L	0.27	0.24	0.27	0.29	0.30	0.27	0.30	0.28	0.23
Overheads, CZK/L	0.78	0.76	0.72	0.81	0.79	0.75	0.99	1.00	1.09
Other costs, CZK/L	1.00	0.52	0.56	0.57	0.59	0.60	0.59	0.51	0.60
Total costs with indirect costs, CZK/L	9.38	8.51	8.90	8.54	8.68	8.95	9.14	9.22	9.23
Total costs with indirect costs, CZK/cow	61852	58497	63789	60687	63225	66419	69421	70077	72309
Total costs, CZK/L	8.63	7.81	8.49	8.12	8.26	8.52	8.73	8.74	8.75
Net profit without subsidies, CZK/L	-0.77	0.63	0.01	-1.86	-0.73	-0.15	-0.97	-0.10	0.76
Net profit without subsidies, CZK/cow	-5067	4334	77	-13 221	-5313	-1 140	-7334	-785	5 936
Profitability of costs without subsidies, %	-8.90	8.07	0.13	-22.93	-8.83	-1.80	-11.06	-1.18	8.66

CZK = Czech crowns (1 EUR = 27 CZK)

Table 2. Association of age at first calving (AFC, d), milk yield (MD, kg) and calving interval (CI, d) on life production an economic parameters.

Item	AFC (≥800)	AFC (799 -750)	AFC (≤749)	MY (≥9,000)	MY (8,999–7,500)	MY (≤7,499)	CI (≥410)	CI (409–390)	CI (≤389)	Mean	SD
n	94	123	70	60	118	123	122	117	56	-	-
Milk yield, kg	7,678±95	7,805±72	8,855±94	-	-	-	7,621±72	7,668±67	7,747±115	7,833	1,356
Protein, %	3.42±0.02	3.39±0.01	3.41±0.02	**3.35±0.02** ^{b}	**3.39±0.01** ^{ab}	**3.42±0.02** ^{a}	3.39±0.01	3.40±0.01	3.39±0.02	3.39	0.12
Fat, %	**3.84±0.02** ^{b}	**3.90±0.02** ^{a}	**3.92±0.02** ^{a}	3.88±0.03	3.86±0.02	3.91±0.02	3.91±0.02	3.87±0.02	3.90±0.03	3.89	0.20
Conception rate after 1st insemination (heifers)	49.49±3.78	55.30±2.86	51.90±3.73	**60.13±5.04** ^{a}	**53.69±3.16** ^{ab}	**49.50±3.59** ^{b}	**50.84±3.06** ^{b}	**53.14±2.87** ^{ab}	**60.98±5.07** ^{a}	58.15	10.35
Conception rate after all inseminations (heifers)	48.12±3.71	52.20±2.86	48.49±3.70	**55.77±4.91** ^{a}	**53.57±3.08** ^{a}	**44.29±3.70** ^{b}	**49.01±3.12** ^{b}	**49.84±2.82** ^{b}	**58.76±4.96** ^{a}	57.52	12.25
Conception rate after 1st insemination (cows)	**32.22±2.22** ^{b}	**35.13±1.67** ^{ab}	**37.98±2.20** ^{a}	37.52±2.97	35.41±1.86	33.58±2.12	33.94±1.76	33.95±1.67	36.65±2.95	37.25	9.09
Conception rate after all inseminations (cows)	36.52±2.82 ^{ab}	34.91±2.17 ^{b}	**40.17±2.84** ^{a}	37.30±3.77	36.49±2.36	36.49±2.86	35.91±2.36	36.11±2.15	42.22±3.78	39.48	12.38
Size of herd (number of cows)	**627.55±5.79** ^{b}	**638.11±4.36** ^{ab}	**647.58±5.71** ^{a}	655.57±8.41	648.86±5.15	637.24±5.90	646.02±5.08	646.34±4.76	648.71±8.16	644.20	361.49
Culling of cows, %	**31.26±2.05** ^{a}	**29.35±1.45** ^{ab}	**26.92±2.02** ^{b}	26.03±2.73	29.29±1.68	30.53±1.95	29.48±1.64	28.20±1.55	28.92±2.75	32.21	8.72
Services per conception	2.27±0.05	2.30±0.04	2.35±0.05	2.23±0.06	2.28±0.04	2.34±0.04	**2.36±0.04** ^{a}	**2.26±0.04** ^{b}	**2.23±0.06** ^{b}	2.27	0.38
CI, d	**419.96±6.99** ^{a}	**407.21±5.15** ^{ab}	**402.94±6.66** ^{b}	**397.70±9.03** ^{b}	**405.12±5.56** ^{ab}	**413.79±6.20** ^{a}	-	-	-	405.29	37.84
Days open, d	131.28±1.87 ^{a}	125.56±1.40 ^{b}	**127.58±1.83** ^{b}	**122.98±2.49** ^{b}	**125.72±1.52** ^{ab}	**129.77±1.74** ^{a}	**128.27±1.51** ^{a}	**126.20±1.41** ^{b}	**123.23±2.50** ^{c}	125.60	18.77
Age at first calving, d	-	-	-	**743.94±18.90** ^{b}	**786.95±11.83** ^{b}	**790.92±13.52** ^{a}	786.66±11.63	776.59±11.10	771.19±19.50	782.03	83.80
Number of lactation	2.38±0.08	2.49±0.06	2.45±0.08	2.41±0.11	2.43±0.07	2.57±0.08	2.46±0.06	2.55±0.05	2.47±0.10	2.46	0.51
Death rate of calves, %	**6.13±0.67** ^{a}	**4.92±0.47** ^{ab}	**4.63±0.62** ^{b}	4.16±0.85	5.04±0.54	5.61±0.60	5.18±0.51	5.27±0.49	4.84±0.86	5.66	4.46
Total loss of calves, %	**11.05±1.02** ^{a}	**8.89±0.74** ^{b}	**10.09±0.97** ^{ab}	9.23±1.35	9.73±0.85	10.02±0.94	**8.58±0.78** ^{b}	**11.06±0.74** ^{a}	**9.15±1.31** ^{ab}	11.65	4.87
Total weaned calves per 100 cows	89.96±1.39 ^{b}	94.14±1.01 ^{a}	**94.32±1.32** ^{a}	**96.30±1.84** ^{a}	**94.79±1.14** ^{a}	**89.95±1.26** ^{b}	93.03±1.10	92.77±1.03	92.84±1.76	93.31	10.07
Total feed costs, CZK/L	3.66±0.08	3.71±0.06	3.78±0.08	**3.52±0.11** ^{b}	**3.72±0.07** ^{a}	**3.85±0.08** ^{a}	3.69±0.07	3.80±0.06	3.72±0.11	3.80	0.64
Labor costs, CZK/L	1.31±0.06	1.35±0.05	1.27±0.06	**1.32±0.09**	**1.30±0.05**	**1.38±0.06**	1.30±0.10	1.33±0.08	1.43±0.14	1.32	0.49
Costs for veterinary services, CZK/L	0.28±0.02 ^{b}	0.28±0.01 ^{b}	0.31±0.02 ^{a}	0.24±0.02 ^{b}	0.28±0.02 ^{b}	0.30±0.02 ^{a}	0.28±0.01	0.30±0.01	0.29±0.02	0.30	0.13
Costs for breeding operations, CZK/L	0.19±0.01	0.20±0.01	0.20±0.01	**0.18±0.01** ^{b}	**0.19±0.01** ^{ab}	**0.21±0.01** ^{a}	0.21±0.01	0.19±0.01	0.20±0.01	0.19	0.07
Cow depreciation costs, CZK/L	0.78±0.04 ^{b}	0.84±0.03 ^{ab}	**0.90±0.04** ^{a}	0.85±0.05	0.84±0.03	0.81±0.04	**0.85±0.03** ^{a}	**0.84±0.03** ^{a}	**0.71±0.05** ^{b}	0.85	0.31
Total costs, CZK/L	8.74±0.16	8.87±0.12	9.08±0.16	**8.58±0.23** ^{b}	**8.74±0.14** ^{b}	**9.33±0.16** ^{a}	**9.02±0.13** ^{b}	**9.13±0.12** ^{b}	**9.72±0.20** ^{a}	8.99	1.36
NP, CZK/L	-0.20±0.15	-0.23±0.12	-0.40±0.15	**-0.05±0.22** ^{a}	**-0.20±0.13** ^{a}	**-0.61±0.15** ^{b}	**-0.37±0.12** ^{b}	**-0.53±0.11** ^{b}	**-0.08±0.20** ^{a}	-0.40	1.51
PROF, %	**0.29±1.83** ^{a}	**-0.39±1.39** ^{ab}	**-2.49±1.81** ^{b}	**2.37±2.52** ^{a}	**0.08±1.55** ^{a}	**-5.26±1.77** ^{b}	**-2.01±1.42** ^{b}	**-4.10±1.33** ^{b}	**1.29±2.28** ^{a}	-2.73	17.08

Bold text with different superscripts indicates significance within a row related to the same independent variable (P<0.05). AFC = age at first calving, CI = calving interval, CZK = Czech crowns (1 EUR = 27 CZK), MY = milk yield, NP = net profit without subsidies, PROF = profitability of costs without subsidies

Table 3. Breakeven points for production and economic parameters

Indicators	2006	2007	2008	2009	2010	2011	2012	2013	2014
Milk price, current, CZK/L	7.86	8.44	8.50	6.25	7.54	8.37	7.76	8.63	9.51
Milk price, breakeven point, CZK, L	8.63	7.81	8.49	8.12	8.26	8.52	8.73	8.74	8.75
Milk price, difference, CZK/L	-0.77	0.63	0.01	-1.86	-0.72	-0.15	-0.97	-0.11	0.76
Total cost, current, CZK/cow	61852	58497	63789	60687	63225	66419	69421	70077	72309
Total cost, breakeven point, CZK/cow	56785	62830	63867	47466	57958	65279	62082	69272	78243
Total cost, difference, CZK/cow	5067	-4334	-77	13221	5266	1140	7339	805	-5934
Market milk production, current, L	6596	6877	7167	7105	7284	7423	7595	7598	7836
Market milk production, breakeven point, L	8067	5855	7148	13147	8893	7708	9720	7789	6640
Market milk production, difference, L	-1471	1022	19	-6042	-1610	-285	-2126	-191	1195
Government subsidies, breakeven point, CZK/cow	5067	-4334	-77	13221	5266	1140	7339	805	-5934

CZK = Czech crowns (1 EUR = 27 CZK)

Table 4. Sensitivity analysis of the most important production and economic indicators

Changing parameter		Change in profit in CZK / cow / year							
Year		2007	2008	2009	2010	2011	2012	2013	2014
Market production	+1 %	291	295	155	241	297	262	312	389
	-1 %	-291	-295	-155	-241	-297	-262	-312	-389
Milk price	+1 %	580	609	444	549	621	590	656	745
	-1 %	-580	-609	-444	-549	-621	-590	-656	-745
Feed costs	+1 %	-246	-271	-249	-268	-284	-287	-302	-313
	-1 %	246	271	249	268	284	287	302	313
Veterinary costs	+1 %	-43	-43	-40	-40	-40	-41	-42	-42
	-1 %	43	43	40	40	40	41	42	42
Labour costs	+1 %	-84	-97	-89	-88	-93	-101	-98	-97
	-1 %	84	97	89	88	93	101	98	97
Depreciation cows	+1 %	-60	-61	-56	-62	-63	-64	-63	-64
	-1 %	60	61	56	62	63	64	63	64
Calving interval	+1 %	-25	-23	-23	-23	-24	-23	-23	-24
	-1 %	26	24	24	24	24	24	24	25
Loss of calves	+1 %	-2	-3	-3	-4	-3	-3	-4	-3
	-1 %	2	3	3	4	3	3	4	3
No. of weaned calves	+1 %	26	23	24	24	24	24	23	24
	-1 %	-26	-23	-24	-24	-24	-24	-23	-24

CZK = Czech crowns (1 EUR = 27 CZK)

Cows on participating farms were all kept in free-stall barns and milked in free-stall parlor 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 TMR (a mixture of forage and grain). Composition of diets differed depending on the region, breed, management, and use of feeding company services.

Costs and net profit for the dairy herds were calculated per L of milk produced according to a certified methodology used in the Czech Republic (Poláčková et al., 2010). Economic results are presented in Czech crowns (CZK), and 1 EUR equals approximately 27 CZK. Total feed costs included those for roughages, cereal grains and concentrates. Total costs included total feed costs, labor 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:

$$NP = TSM - TCc2 \quad [1]$$

$$TCc2 = TCc1 - CWIC \quad [2]$$

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 purchased feed and bedding, self-produced feed and bedding, medicines and disinfectants, other direct costs and services, labor 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 yearly comparison among farms regardless of herd size.

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

Statistical analyses

Data were analyzed using a PROC MIXED model in SAS 9.2 (SAS Institute, 2008) on the independent variables AFC, MY and CI (Table 2). In this analysis were used in total 43 farms with at least 5 repeating of calculated variables in evaluated period (yr 2006-2014). 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:

$$y_{ijkl} = \mu + B_i + R_j + Y_k + D_m + e_{ijk} \quad [4]$$

where y_{ijkl} = value of the dependent variable (Tables 2); μ = overall mean; B_i = i^{th} breed effect (i = 26 for Holstein breed, 10 for Czech Fleckvieh breed, 7 for both breeds in the herd); R_j = effect of j^{th} farm; Y_k = effect of k^{th} year; D_m = effect of k^{th} AFC, MY and CI (Tables 2); e_{ijkl} = random error. Breed (B_i), farm (R_j) and year (Y_k) was considered as a fixed effect.

To assess the minimum requirement for profitability of farmers are determined breakeven points (Table 3). The breakeven point is defined as the point in which the company reaches zero profitability of production and the revenues for goods are equal to costs on this production (Strelecek and Kollar, 2002). Breakeven points can be found on the revenue side and on the cost side. Reduction of cost items to the level of total income will be zero profit. Revenues consist of revenues from the sale of milk, which are defined as the volume of milk sold multiplied by the price. Price depends on the market situation (supply and demand) and its change will increase or decrease in revenues irrespective of the level of cost. The breakeven point for the milk price represents a price level at which they are paid out of income all costs. Breakeven points in each year are examined also searched in the case of market milk production, as the second parameter of the yield function. The breakeven point for production the equals the volume of production in the in-kind units for which the volume of revenues equals to the volume of costs (Strelecek and Kollar, 2002). To define breakeven point of production is therefore necessary allocation of costs into variable and fixed. Variable costs are defined as the costs are directly linked to production. Their volume is changes

(increases) with an increase in intensity and volume of production. Conversely, fixed costs characterized by the fact that their amount does not change the volume of production. From this perspective, when a change of production changes only variable costs. The breakeven point of production is determined by the following formula.

$$Q = \frac{FC}{p - vc} \qquad [5]$$

where Q = equilibrium quantity of milk sold; FC = fixed costs; p = price per liter of milk; vc = variable cost per liter of milk.

In the calculations is considered a profit without subsidies, so in analysis of breakeven point is also calculated what should be the level of total government support that has been provided for zero profit.

Sensitivity analysis is performed (Table 4) to evaluate which examined factors has the greatest impact on the level of profitability of the farm. Sensitivity analysis, broadly defined, is the investigation of potential changes and their impacts on conclusions. Furthermore, it is a procedure modeling, where changes are made significant variables (operational and economic indicators) to determine the effects of these changes on the planned result (total income). Increased attention is understandably given to the most important variables. It is possibly the most useful and most widely used technique available to applied economists (including agricultural economists). In the model of determining the profitability of milk production were gradually changed the basic parameters which are differently reflected in the total profit per cow and year. Model dismembering variable costs (feed, veterinary, etc.) and fixed costs (wages, depreciation, energy, etc.). Length of calving interval affect the number of births calves, respectively weaned calves, which is considered in the model as a deduction from the total cost.

Indicator IOFC (Income Over Feed Cost) was calculated which is determined by the difference between market price and feed costs of liter of milk (Ribeiro et al. 2008). Indicator lets you assess what proportion of funds will remain in the business after payment of expenses for feed, and is intended to pay for other expenses (Table 1).

Results and discussion

Development of basic indicators of dairy production

The development of basic indicators of milk production in the Czech Republic (Table 1) in recent years has seen increasing total production of milk per cow and necessary costs of breeding one cow per year. Even if increasing milk yield, costs expressed per liter of milk in the period are raising trend, on the level of CZK 9.23 in 2014. Our found cost for dairy farms are higher than the declared development published by Ministry of Agriculture, in given cost of milk production in Czech Republic for the years 2009 to 2013 were between 8.12 and 8.58 CZK per liter of milk. In a statement on feeding day costs are in our research in 2014 in the amount of 198 CZK, which are comparable to the results of the survey of the Institute of Agricultural Economics and Information, where the cost is based on 195 CZK. In the structure of costs in each year, the largest item is feed cost, which is consistent with research Michalickova et al. (2014), which states that feed constitutes 41 % of the cost of milk production in year 2007 and 2011 in Slovakia. IOFC indicator corresponds to the price of milk in the group and is based on the highest per liter of milk in 2014. Ribeiro et al. (2008) calculated by Holstein cows in Kentucky lifetime income over feed costs on one cow in the amount of $ 3,038. Over the last three years to improve indicators rearing of calves, were reduces deaths and total losses, thus increasing the number of weaned calves. The greatest variability in the examined years is obvious in the price of milk. Development of milk prices in the file of farms corresponds to the development of milk prices in the Czech Republic, which ranged from 2006 to 2015 between 6.14 CZK/L in 2007 and CZK 9.37/L in 2014.

Impact of milk production, rearing intensity and reproduction on economic profit

Ettema and Santos (2004) have reported that only few dairy farms achieved the recommended AFC target. Even when heifers are managed and fed similarly to achieve similar growth rates, variability in AFC is observed. This is dictated by reproduction efficiency at breeding. Poor reproduction increases variability in AFC, even though nutrition and growth rates may be adequate (Ettema and

Santos, 2004). Mourits et al. (1999) had remarked that the optimal AFC is far from uniform and stable. Krpálková et al. (2014b) found that AFC less than 23 months of age proves to be a more suitable option for successful rearing of heifers with optimal subsequent production and reproduction in a herd with suitable management. The average AFC in Holstein cattle has been recommended to be ≤24 months while achieving body size that is adequate to maximize lactation performance, yet control rearing costs (Abeni et al., 2000). In our study the group with lowest AFC (≤749 d ≈ 24.5 months) showed the highest fertility compared to the other evaluated groups ($P<0.05$) (Table 2). Conception rates after first and all inseminations were about 39 % for cows. The shortest periods were also found in this group for days open (128 d) and calving interval (403 d). It turns out that rearing heifers intensively, which leads to lower AFC, can be with evaluating the overall management of a dairy herd in as much as it prevents low fertility a very successful approach. The group of herds with lowest AFC comes from largest herds and the average was 648 cows with lowest culling of cows 27 %.

The highest costs of veterinary services of 0.31 CZK/L ($P<0.05$), and consequently the highest cow depreciation costs of 0.90 CZK per cow ($P<0.05$), and the lowest level of profitability (-2.49 %) were found for the same lowest group of AFC. Krpálková et al. (2014b) considered that lower AFC had to be evaluated in economic terms for each farm on the grounds that low AFC does not always lead to the most profitable solution. Heikkilä et al. (2008) found that the variability in results from several studies examining optimal AFC depended upon local conditions and the dairy herd management on each farm. Curran et al. (2013) stated that to make a final economic evaluation of shorter rearing period is important to know the biological interrelationships between growth rate and subsequent reproduction and between growth rate and the ability for milk production.

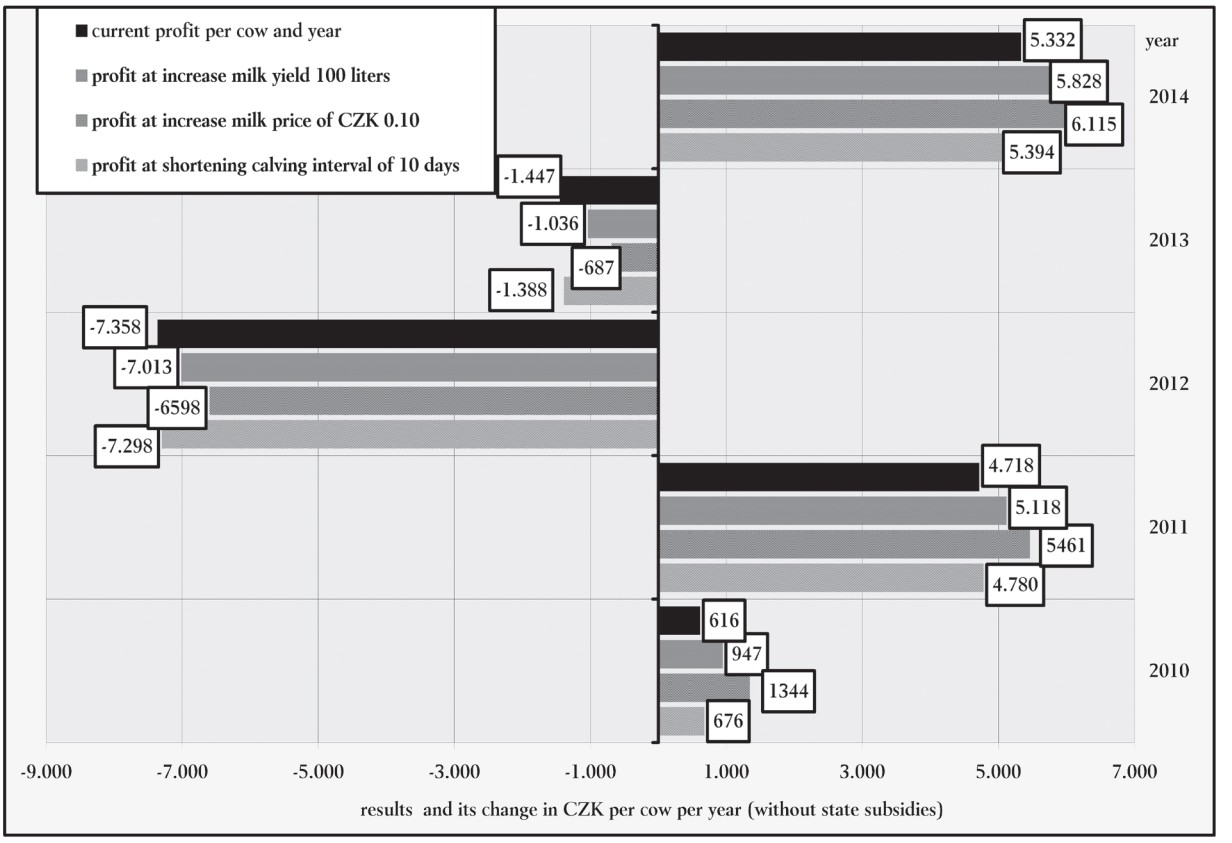
A few years ago, numerous authors confirmed there to be decreasing fertility in high-producing dairy cows (Curran et al., 2013; Lee and Kim, 2007; De Vries and Risco, 2005). However, some studies do not confirm this view and consider that the problem lies in inadequate management and environmental conditions (especially the quality of feedstuffs) in high-producing herds (Kadokawa and Martin, 2006). In this study, the high-producing herds were shown to have the highest conception rates among heifers in average 58 % and cows 37 % (not significant) after first and all inseminations (Table 2). In this group was also observed shortest days open (123 d) and calving interval (398 d). The level of reproductive performance directly affects the economic performance of a dairy herd (Lee and Kim, 2007). Nonetheless, the group of high-producing herds had the lowest content of protein 3.35 %, but was the most profitable in this study - profitability was in average 2.37 %. In our study we found the lowest total costs 8.58 CZK/L in group MY (≥9,000 kg) and also in total feed costs, costs for veterinary services and costs for breeding operations (Table 2). Mourits et al. (1999) had concluded that price movements for milk and production inputs bore large income effects because management practices can only partially adjust to these changes. Kvapilík et al. (2015) reported that even as the average farm milk price in the Czech Republic during 2014 was 9.37 CZK the average of total cost of cows was 9.23 CZK per liter of milk and the average of cost of cows less the costs of the by-products (i.e., costs of rearing calves, costs of manure disposal) was 8.75 CZK per liter of milk. It is evident that dairy farms in the Czech Republic would be operating at a loss without subsidies (Table 2). Heikkilä et al. (2008), too, concluded that price movements for milk and production inputs significantly affect farm profitability. In our study we found that an increase of milk price achieved highest impact on net profit (Table 4). Therefore, an optimal replacement policy does not ensure a dairy herd's good economic performance. Nevertheless, Stevenson et al. (2008) agreed with the statement that the level of rearing heifers is one of the most important factors having a significant effect on subsequent reproduction performance and profitability in dairy herds. In this study, the highest-producing herds achieved the lowest AFC, at 744 d ($P<0.05$). The group of high-producing herds in this study showed the highest total weaned calves per 100 cows. The reason for this probably lies in better nursing care for calves in high-producing herds.

Dono et al. (2013) found that the economic advantage of shortening the mean calving interval by removing cows from the herd that failed to con-

ceive was outweighed by the costs associated with increased herd turnover. They argued that an increase in profitability can occur from having a greater proportion of cows in early lactation, when they are more efficient, and thus to have greater production. In our study, the group of herds with longest CI (≥410 d) had the lowest fertility observed in lower conception of heifers at first 51 % and overall services 49 % ($P<0.05$) and in conception of cows was the same trend (not significant). However the same group achieved the highest number of services per conception 2.36. The longest calving interval was associated with the lowest loss of calves 8.58 % ($P<0.05$). Kvapilík et al. (2015) reported that longer calving intervals (above the optimal of 400 d) decreased average daily milk yield in the herd and smaller numbers of calves and lead to lower calving interval, but without positive economic impacts. In our study we found the same trend. The group of longest CI (≥410 d) achieved the lowest net profit -0.85 CZK per L of milk, highest cow depreciation costs 0.85, and highest total costs 9.02 CZK per L of milk. Similar results found Němečková et al. (2015) that long calving interval (≥440 days) resulted in a loss of 131.77 EUR. However, some studies do not agree with this and consider that the problem lies in inadequate management of high-producing herds, level of lactation persistency, and the genetic potential of animals (Kadokawa and Martin, 2006). Arbel et al. (2001) investigated the effect that extending lactation has on milk production and profitability in the following lactation. Kadokawa and Martin (2006) added that extending CI could help cows with extremely high yields.

Breakeven points of milk production

Breakeven points for the price of milk ranged in set of companies in the Czech Republic between 7.81 CZK per liter in 2007 and 8.75 CZK/liter in 2014 and are dependent on the level of total costs, where annual growth of costs is needed for zero profitability without subsidies to sell milk at a higher price (Table 3). A very big difference between paid



CZK = Czech crowns (1 EUR = 27 CZK)

Figure 1. Amount of profit when changing parameters in the years 2010 to 2014

price for milk and expressed breakeven point in 2009 where it was in the Czech Republic one of the lowest purchase prices of milk. The biggest loss in 2009 for the Czech dairy farmers also mentions Doucha et al. (2012), which evaluated the profitability of dairy cows in 2004 to 2013, and without counting subsidies profitability of the most negative in 2009 (-24.2 %). Limit of profitability for the level of costs says that except to the years 2007, 2008 and 2014 is needed for zero profit without subsidies reduce cost per cow per year (from 2009 to 2013 average of 8.7 %). The results of the exploration Thomsen (2015) conducted in the years 2010 to 2014 in Schleswig-Holstein in Germany shows that the costs in 2014 could be for zero profit still increased by 3.9 % to 47.44 EUR per 100 kg of milk, which talks about the profitability of dairy farming without subsidies in this year. Higher milk production will ensure sufficiently large revenues from the sale of milk, but also according to the model, there is an increase in variable costs (feed cost and veterinary costs). In 2013 the market milk production 7,789 liters generated in the file at an average price of 8.63 CZK per liter sales 67,223 CZK, which would be equivalent to the sum of variable and fixed costs per cow per year. Due to the higher price per liter of milk in 2014 is a breakeven point set at less than the current milk yield and is 6,640 liters. Breakeven points of subsidies given in each year of the requirement to state subsidies to be dairy farming were profitable. In addition to direct payments, Pechrova (2015) confirms the importance of subsidies from the Rural Development Programme of the Czech Republic based on research from 2007 to 2013. In our study negative breakeven point in 2007, 2008 and 2014 demonstrated profitability in dairy production without counting subsidies. Zero profitability is only a minimum requirement for farmers. If aim of farmers should be a profitability of 10 %, assuming the results of 2014, market milk production had to be 8 040 liters, or the price would have to be 9.62 CZK. Credited subsidies would improve the situation and reduce demands. As can be seen from Figure 1, showing a profit in recent years and his change, it is possible to achieve higher profits by improving production parameters, e.g. higher milk yield and shortening calving interval.

Sensitivity analysis of indicators in dairy production

Sensitivity analysis on nine major economic parameters of dairy cows pointed to the fact that most affects every year resulting economic efficiency of the price of milk (Table 4). Her increase by 1 % in 2014 will cause an increase in profit of CZK 745 per cow per year. The total annual profit per cow would be CZK 12,780, assuming growth of purchase prices of milk by 10 % (Figure 1). Increased sales of milk about same percentage causes a positive profit, which is lower due to effect of growth of variable costs. Increase market milk production by 1 % represents a profit increase of 389 CZK per cow per year in the surveyed period varies depending on the price of milk. Michalickova et al. (2014) presents, that the increase of the milk yield by 1 kg improved the profit by 0.025 EUR per kg of milk. Kvapilik et al. (2015) states that growth in milk production in the Czech Republic up to 1000 kg will be reflected in an increase in profit CZK 0.22 per kg of milk. Wolfova et al. (2007) adds, that in addition to milk yield, somatic cell score was the second most important trait. Krupova et al. (2009) added, that milk components were economically more important for Holstein cattle. Increasing feed costs, e.g. increase of the price of feed components reduces economic profit.

The same effect will increase the price of labor (wages). Michalickova at al. (2014) calculated that the increase of labor costs by 1 EUR reduced the competitiveness of milk production by 0.074 EUR. According to Muminović and Barać (2015) high efficiency and effectiveness of the organisation in terms of its labour cost and use of fixed assets in the generation of value added have direct impact on profitability. Thus, efficient use of existing technology is the key to increase productivity and consequently profitability. In our study reducing the length of calving interval by 1 % in herd represents a larger number of weaned calves, which, according to model, to economy reflects the increased deduction items of calves, and has implications to increase profit by about 24 CZK. Of the examined production parameters, on the other hand, a small impact has into the economy increase or decreases about one percent the losses of calves. In study Krupova at al. (2009)

calf losses at calving and calf losses in the rearing period obtained negative economic weight. The important economic parameter is the depreciation of cows, consisting of revenues from the sale of cows and appreciation to the herd included heifers. By reducing the replacement herd there is fewer numbers of slaughtered cows and declining depreciation of cows, which results in increasing profit per cow per year. Compared to the depreciation of cows are less sensitive to economic efficiency of depreciation of assets, which reflects the investment. At work Kirchweger et al. (2015) have demonstrated that suitable investment can achieve higher production and total income.

Conclusion

Lowest AFC≤749 d achieved lowest profitability without subsidies -2.49 %, highest MY ≥9,000 kg highest profitability 2.37 % and lowest CI (≤389 d) highest profitability 1.29 %. Breakeven points for the price of milk ranged in set of companies in the Czech Republic between 7.81 CZK per L in 2007 and 8.75 CZK per L in 2014. A very big difference between paid price for milk and expressed breakeven point was in 2009 where it was in the Czech Republic one of the lowest purchase prices of milk. Increase of milk price by 1 % in 2014 will cause an increase in profit of CZK 745 per cow per year. Due to inflation, which in years 2006-2014 at an average annual rate of 2.3 %, leads to the annual increase in inputs. The major cost items are feed costs. If there is an increase in input prices and thus also higher costs per liter of milk, it is necessary to also increase the price of milk. Negative breakeven point in 2007, 2008 and 2014 was shown in profitability without counting subsidies. Zero profitability is only a minimum requirement for farmers. If aim of farmers should be a profitability of 10 %, assuming the results of 2014, market milk production had to be 8040 liters, or the price would have to be 9.62 CZK. Otherwise, it is necessary to support farmers using subsidies from the Ministry of Agriculture of the Czech Republic.

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Analiza proizvodnje mlijeka, dobi prvog teljenja, intervala teljenja i ekonomskih parametara u upravljanju mliječnih krava

Sažetak

Cilj ove studije je vrednovanje glavnih pokazatelja proizvodnje mlijeka kod ukupno šezdeset stada komercijalno uzgajanih muznih krava u Republici Češkoj u razdoblju od devet godina (2006.-2014.). Korištene su točke rentabilnosti i analiza osjetljivosti te je analizirana povezanost između starosti prvog teljenja (SPT), prinosa mlijeka (PM) i intervala između teljenja (IT). Kod najnižeg SPT≤749 d utvrđena je povezanost s najvišom plodnošću, najnižom smrtnošću teladi i najnižom rentabilnosti bez subvencija -2,49 %. Kod najvećeg PM≥9000 kg utvrđena je povezanost s najvišom plodnošću, najnižim SPT, najnižim troškovima za stočnu hranu i ukupnim troškovima 8,58 Kč (0,32 EUR) po litri mlijeka i stoga s najvišom rentabilnosti 2,37 %. Analiza plodnosti pokazala je da su stada s najnižim IT (≤389 d) postigla najniži pad vrijednosti krava u iznosu od 0,71 Kč (0,03 EUR) po litri mlijeka, najviše ukupne troškove 9,72 Kč (0,36 EUR) po litri mlijeka i najvišu rentabilnost 1,29 %. Točke rentabilnosti cijene mlijeka kretale su se između 7,81 i 8,75 Kč (0,29 i 0,32 EUR) po litri mlijeka u razdoblju od 2007. do 2014. Povećanje ulaznih cijena trebalo bi imati negativan utjecaj na povećanje cijene mlijeka. Povećanje cijene mlijeka za 1 % u 2014. godini uzrokovat će povećanje dobiti za 745 Kč (27,6 EUR) po kravi godišnje.

Ključne riječi: muzna krava, razdoblje uzgoja, troškovi reprodukcije, analiza osjetljivosti, točke rentabilnosti, rentabilnost

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