Arch. Tierz., Dummerstorf **51** (2008) 5, 415-425

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The effect of inbreeding on milk traits in Holstein cattle in the Czech Republic

Abstract

The objective of this study was to explore the effect of the level of inbreeding on the milk production (MP) and the breeding values (BV) of milk production. Data included cows calved in years 1990-2005 at farms in the Czech Republic. Inbred cows were grouped according to F_x coefficient (F_x=1.25%, F_x=2.0-3.125%, F_x=4.0-12.5% and F_x=total). MP and BV of inbred cows were compared with their outbred equals – half-sisters, sharing the same sire (n=2,063), dam reached the same breeding value (±5%) and their first calving happened in the same farm and at the same time (±2 months). The PROC GLM of SAS® with fixed effects (age at first calving, year of calving, number of lactations, first calving interval and relative breeding value of the sire and dam) was applied to all data.

In the examined groups of F_x coefficient milk production of inbred cows at the first lactation decreased of −103.02, −236.8, −472.24 and −247.65 kg of milk. Also an insignificant increase of percentage of fat was found in most of the inbred groups: −0.0025, +0.1204, −0.0064 and +0.0708, as well as percentage of protein: −0.0063, +0.0365, −0.0346 and +0.0157.

A similar tendency was also found when the milk production was represented by breeding values. Breeding value for milk in kg showed a decrease of −36.57, −43.55, −92.23 and −50.81 kg milk. Breeding value for fat percentage showed in inbred animals an increase of +0.0068, +0.0394, +0.0152 and +0.0251%. A similar increase was also found in breeding value for protein percentage: +0.0015, +0.0216, −0.0035 and +0.0134%.

The F_x coefficient increasing by 1% decreases milk production (regression coefficient) by 59.75 kg milk and increases fat and protein by +0.0112% and +0.0030%.

Keywords: inbreeding, inbreeding depression, milk production, breeding value, Holstein cattle

Zusammenfassung:

Titel der Arbeit: **Einfluss der Inzucht auf Milchleistungsmerkmale bei Holstein Kühen in der Tschechischen Republik**

Es wurde der Einfluss der Inzucht auf Milchleistungsmerkmale und Zuchtwerte bei Holsteinkühen untersucht. Erfasst wurden Kühe, welche zwischen 1990 und 2005 in der Tschechischen Republik geboren wurden. Nach der Höhe des Inzuchtkoeffizienten (F_x) der Tiere wurden vier Gruppen (F_x=1,25%; F_x=2,0-3,125%; F_x=4,0-12,5% und F_x= gesamt) gebildet. Die Milchleistungen und Zuchtwerte dieser Tiere konnte mit denen ihrer Zeit- und Stallgefährten Nichtinzucht-Halbschwestern (n=2.063) verglichen werden.

Die Auswertung erfolgte mit dem Programm PROC GLM von SAS®. Als fixe Effekte wurden Alter bei der ersten Kalbung, Jahr der ersten Kalbung, Zahl der Laktationen, Zwischenkalbezeit sowie der Zuchtwert von Vater und Mutter berücksichtigt. Die Leistungen der Inzuchtkühe erreichten bei den Erstlaktationen geringere Werte als die Nichtinzuchttiere und betrugen in den vier Gruppen −103,02, −236,80, −472,24 bzw. −247,65 kg. Beim prozentualen Fett- und Eiweißgehalt lagen diese nicht immer signifikanten Werte bei −0,0025, +0,1204, −0,0064 und +0,0708 % sowie −0,0063, +0,0365, −0,0365 bzw. +0,0157 %. Die gleiche Tendenz, nämlich Senkung der Milchleistung (in kg) der Inzuchtkühe und Erhöhung der Milchkomponenten, konnte auch bei den Zuchtwerten festgestellt werden. Bei den Zuchtwerten für die Milchleistung lag die Inzuchtdepression bei −36,57, −43,55, −92,23 bzw. −50,81 kg. Bei den Zuchtwerten für den prozentualen Fett- und Eiweißgehalt ergaben sich überwiegend höhere Werte. Sie betrugen für Fettprozent +0,0068, +0,0394, +0,0125 bzw. +0,0251% und für Eiweißprozent +0,0015, +0,0216, −0,0035 bzw. +0,0134%. Eine Erhöhung des Inzuchtkoeffizienten um 1% war mit einer Senkung der Milchleistung von 59,75 kg Milch und Steigerung der Fett- bzw. Eiweißprozente von +0,0112% bzw. +0,0030% verbunden.

Schlüsselwörter: Inzucht, Inzuchtdepression, Milchleistung, Zuchtwert, Holsteinkühe

Introduction

Observing of the inbreeding depression of quantitative traits is very important for animal breeding. Inbreeding has been studied as a specific question in small populations (KALLWEIT and BAULAIN, 2001; WOKAC, 2003; KHAN et al., 2007) and a general problem of breeding work (FREYER et al., 2005; PIRCHNER, 2004). In cattle breeding a depressive influence of inbreeding was examined e.g. in reproduction (BEZDÍČEK et al., 2007; CASSELL et al., 2003; CASSELL et al., 1998), exterior (BEZDÍČEK et al., 2005; SUTHERLAND and LUSH, 1962) and other quantitative traits. THOMPSON et al. (2000a, 2000b) evaluated the impact of inbreeding in Holstein and Jersey breed. Inbred cows with F_x>10% showed increasing in the age at first calving of 25 days in Jerseys and 26 days in Holsteins. Inbreeding is considered one of the most important factors affecting the genetic structure and performance of breeding population (BIEDERMANN et al., 2003; 2004). The inbreeding depression is hence closely related to health and economics of cattle breeding. Selection of specimens for further breeding cannot be based on phenotype manifestation of the traits, which is identified by a milk yield control. The selection is made according to a hereditary disposition, which is defined by a breeding value. In this study we focused on observing of inbreeding depression of milk yield of cows and it means both the absolute reached milk yield during the 1^{st} lactation (kg of milk, % of fat and % of protein) and estimated breeding values of these traits.

Several authors have already examined the inbreeding depression in milk yield of cows or the content of milk components. ALLAIRE and HENDERSON (1965) found a milk yield depression of −12.6 kg for each per cent of inbreeding coefficient. This research was carried on in Holstein cattle in the USA. Also GAALAAS et al. (1962) examined an influence of inbreeding on milk production at the first to the fourth lactation. They found the following regression for lactations I-IV: −47.8 kg, −19.0 kg, −8.2 kg and −11.9 kg of milk. An average inbreeding depression was −21.8 kg. Also THOMSON and FREEMAN (1967) examined an inbreeding effect on milk production. They evaluated all animals born between the years 1930 and 1964 in Iowa State University herd in the USA. The regression was −23.0±11 kg of milk. Nowadays, MIGLIOR (1992; 1995a; 1995b) intensively studies the influence of inbreeding on production traits of cattle. In a group of 150,000 Jersey cows the author calculated a regression coefficient for milk production on the level of −9.84 kg of milk (MIGLIOR, 1992). When the F_x coefficient raised over 12.5% the inbreeding depression was even more noticeable. In the same year MIGLIOR (1995b) evaluated the level of inbreeding in Holstein cattle. The author based his calculations on kinship and milk yield of cows in the 1^{st} lactation in the Canadian population involving more than 92,000 Holstein cows. The calculated depression was −25 kg of milk for each 1% rise of the inbreeding coefficient. The author also founds a positive correlation of increasing inbreeding and the content of fat and protein. For F_x=5.0% he states an increase of fat percentage of 0.025% and for F_x=12.5% the fat percentage increased of 0.0625%. HERMAS et al. (1987) observed an inbreeding depression in two herds in the USA and calculated an increase of fat percentage of +0.002% when the F_x coefficient raised by 1%. The effect of inbreeding on milk production in Irish Holstein-Friesian dairy cows study PARLAND et al. (2007). 12.5% inbred cows had milk production reduced by 61.8 kg. The 12.5% inbred animal was also expected to have a 2% greater incidence of dystocia and a 1% greater incidence of stillbirth.

Similar conclusions were studied also by CASANOVA et al. (1992), who studied an influence of inbreeding in Braunvieh breed in Switzerland. The authors found an increase of milk protein percentage of 0.001%/1% F_x. KROGMEIER et al. (1997) calculated a depression of milk yield for 1% increase of F_x at the 1st, 2nd and 3rd lactations between −10.14 and −11.01 kg of milk. Also SMITH et al. (1998) carried on a vast research in the field of inbreeding. An average inbreeding depression for 1% rise of the value of inbreeding coefficient was −26.65 kg of milk in the 1st lactation. The lifelong production showed depression of −177.17 kg of milk. Impact of no additive genetic effects in the estimation of breeding values for fertility and correlated traits studied WALL et al. (2005). Inbreeding had a significant and unfavourable effect on all traits. The difference between a no inbred animal and an animal with an inbreeding coefficient of 10% was a 2.8-d increase in calving interval, a 1.7-d increase in days to first insemination, a 1% increased probability to return to estrus at first service, 0.03 more inseminations, a 0.27-unit decrease in body condition, and a 0.54-kg decrease in milk on test nearest d 110.

Materials and methods

The inbreeding depression of milk yield of Holstein cows was determined by evaluating of the 1st standardized lactation in the following traits: kg of milk, % of fat and % of protein. The inbreeding depression of milk yield was also observed from the point of view of the breeding values of the following traits: relative breeding value for protein in kg (RBV), breeding value for milk in kg (BVMkg), breeding value for fat percentage and breeding value for protein percentage. The breeding values were evaluated for all the finished lactations.

For the proper comparison each inbred cow (the range of F_x coefficient 1.125-12.5%) was assigned to at least one outbred equal (2,063 equals in sum). Inbred cows with their outbred equals were matched on characteristics such as (1) identical sire, (2) first calving interval occurs in the same farm, (3) first calving happened in the same year and period (±2 months) and (4) dam reached the same breeding value (±5%). Inbred cows and their matched outbred equals were subsequently divided according to the inbreeding coefficient of inbred cows into three groups (F_x=1.25%, F_x=2.0-3.125%, F_x=4.0-12.5%). The level of inbreeding – inbreeding coefficient F_x, was calculated as follows (WRIGHT, 1922):

$$F_x = \sum 0.5^{n+n'+1}(1+F_a)$$

where: Σ=sum over all path through to common ancestor, n=the number of generations from the sire to the common ancestor, n'=the number of generations from the dam to the common ancestor, F_a=the inbreeding coefficient of the common ancestor

Data were analysed using PROC GLM of SAS®. The effects of inbreeding and other factors were estimated from the model as follows:

$$Y_{ijklmno} = \mu + F_i + AC_j + YC_k + CL_l + CI_m + BVS_n + BVM_o + e_{ijklmno}$$

where: $Y_{ijklmno}$=corrected value, μ=mean value, F_i=F_x coefficient level/in%/(F_x=1.25, F_x=2.0-3.125, F_x=4.0-12.5), AC_j = age at first calving/in months/ (≤25.0; 25.1-28.0; 28.1≥), YC_k= year of first calving (≤1995; 1996-1998; 1999-2000; 2001≥), CL_l = number

of lactations (≤1.5; 1.6-2.5; 2.6-3.5; 3.6≥), CI_m = first calving interval/ days/ (≤400; 401≥; only 1st lactation), BVS_n = relative breeding value of the sire for milk production in kg (≤94; 95-108; 109≥), BVM_o = relative breeding value of the dam for milk production in kg (≤94; 95-108; 109≥), $e_{ijklmno}$ = residual error.
Calculations were processed for inbred cows and outbred equals separately. A following comparison of average values between outbred and inbred groups of the same F_x level has been made.
In this work, data included cows calved in years 1990-2005 at farms in the Czech Republic. Processing of breeding values data and monitoring of milk traits was finished toward January 2008. Calculations were performed on 253,286 Holstein cows.

Results and discussion

Differences in milk production according to used effects at group of inbreed and outbreed cows is mentioned in Table 1 and 2. Table 1 shows milk production traits in the form of breeding values (RBV, BVMkg, BV for fat percentage, BV for protein percentage), Table 2 shows the reached absolute values at the 1st lactation (kg of milk, % of fat, % of protein).
The milk production traits of inbred animals (breeding value for milk in kg and kg of milk in the 1st lactation) show an apparent decrease in the observed values. They are the lower the higher the F_x coefficient is. This decrease is statistically significant mainly in the absolute production in kg of milk at the 1st lactation (Table 2 – 6389.43, 6295.91 and 6064.61 kg) and also when the milk production traits are represented by breeding values (Table 1 – BVMkg +123.03, +89.21 and +81.23 kg). On the other hand equals of these cows showed very stable values of milk production both at the 1st lactation (Table 2 – 6409.15, 6461.79 and 6442.40 kg) and the breeding values for milk in kg (Table 1 – +185.21, +166.49 and +198.70 kg). The observed effects showed highly significant ($p \leq 0.01$) differences mainly in RBV of a sire and RBV of a dam. Table 1 and 2 clearly show that raising the level of parents (their RBV) caused a raising production both in inbred and outbred cows. E.g. when the RBV values of the sire were the lowest, the inbred cows reached an average production at the 1st lactation 5878.79 kg of milk., −118.55 BV of milk and 95.42 RBV for protein in kg. On the other hand also daughters of the sires with the highest breeding value reached evidentially higher yields: 6567.09 kg of milk; +314.39 BV kg of milk and 110.72 RBV for protein in kg (Table 1 and 2). We can see the same tendency in the breeding values of a dam. Also the year of calving of the cows was an effect with a highly significant difference ($p \leq 0.01$). Table 1 and 2 clearly show the raise of milk production in particular years both in inbred and non-inbred cows.
Differences in milk production of inbred and outbred cows are mentioned in Table 3 and 4. Table 4 shows the reached absolute values of milk yield at the 1st standardized lactation (kg of milk, % of fat, % of protein) and their comparison within the groups of inbred and outbred cows. Table 3 follows these traits in the form of breeding values (RBV for protein in kg, BVMkg, BV for fat percentage and BV for protein percentage).

Table 1
Variability of breeding values in inbred and outbred cows – for each model effect separately (Die Variabilität der Zuchtwerte von Inzucht- und Nicht-Inzuchtkühen, gegliedert nach Inzuchtgrad und Untersuchungsmodellen)

	RBV		BVMkg		BV for fat percentage		BV for protein percentage	
	Inbred cows	Outbred equals	Inbred cows	Outbred equals	Inbred cows	Outbred equals	Inbred cows	Outbred equals
	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM
n	722	2,063	722	2,063	722	2,063	722	2,063
F_x								
1	104.16	106.08	123.03	185.21	−0.019	−0.04	0.02	−0.01
2	102.84	105.59	89.21	166.49	0.01	−0.05	0.04	−0.01
3	103.25	106.95	81.23	198.70	0.002	−0.01	0.02	0.01
p	n.s.	n.s.	n.s.	n.s.	n.s.	2-3*	1-2*	n.s.
Age at first calving								
1	103.84	106.47	124.85	193.94	−0.02	−0.04	0.02	0.00
2	102.38	104.78	68.02	161.18	0.02	−0.01	0.03	0.01
3	104.03	107.36	100.59	195.27	−0.01	−0.05	0.03	−0.02
p	n.s.	2-3**	n.s.	n.s.	1-2*	1-2* 2-3*	n.s.	2-3**
Year of calving								
1	109.19	110.75	209.79	262.85	−0.02	−0.05	0.01	−0.02
2	104.34	106.79	109.68	149.97	−0.01	−0.02	0.04	0.02
3	100.85	104.27	33.27	150.57	0.01	−0.02	0.02	0.00
4	99.28	103.01	38.54	170.47	0.02	−0.04	0.04	0.00
p	1-2** 1-3** 1-4** 2-3** 2-4**	1-2** 1-3** 1-4** 2-4** 2-3*	1-2** 1-3** 1-4**	1-2** 1-3** 1-4**	n.s.	n.s.	n.s.	1-2*
Number of lactations								
1	105.02	106.88	142.83	182.18	−0.01	0.00	0.01	0.02
2	100.81	106.73	22.53	191.09	0.01	−0.05	0.10	−0.01
3	105.58	105.40	145.38	154.07	0.01	−0.03	0.03	−0.01
4	102.74	105.80	76.60	206.53	−0.02	−0.05	0.01	−0.02
p	3-4*	n.s.	n.s.	n.s.	n.s.	1-2*	3-5*	1-2* 1-3*
Calving interval								
1	103.59	105.33	81.97	143.11	0.01	−0.02	0.04	0.01
2	103.17	106.39	103.06	192.90	−0.01	−0.01	0.01	−0.01
3	103.51	106.90	108.43	214.39	0.01	−0.07	0.03	−0.01
p	n.s.	n.s.	n.s.	1-2* 1-3*	n.s.	1-3* 2-3*	1-2*	n.s.
BVS								
1	95.42	98.18	−118.55	−14.78	0.06	0.04	0.05	0.02
2	104.12	106.72	97.62	181.59	0.01	−0.03	0.03	−0.01
3	110.72	113.72	314.39	383.59	−0.07	−0.11	0.01	−0.02
p	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	1-2* 1-3** 2-3**	1-2** 1-3** 2-3**	1-2* 1-3**	1-2* 1-3** 2-3*
BVM								
1	99.32	101.95	−32.28	51.27	0.02	−0.01	0.04	0.01
2	103.94	105.60	105.24	165.68	−0.01	−0.02	0.02	0.01
3	106.99	111.06	220.50	333.45	−0.02	−0.07	0.02	−0.02
p	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	1-2** 1-3** 2-3**	n.s.	1-3** 2-3**	n.s.	1-3* 2-3*

*p≤0.05; **p≤0.01; n.s.=non significant; RBV=relative breeding value for protein in kg; BVMkg=breeding value for milk in kg; BV= breeding value; BVS=relative breeding value of the sire for milk production in kg; BVM=relative breeding value of the dam for milk production in kg; LSM=least square means

Table 2
Variability of milk yield in inbred and outbred cows – for each model effect separately (Die Variabilität der Milchproduktion von Inzucht- und Nicht-Inzuchtkühen, gegliedert nach Inzuchtgrad und Untersuchungsmodellen)

	kg of milk		Percentage of fat		Percentage of protein	
Effects	Inbred cows LSM	Outbred equals LSM	Inbred cows LSM	Outbred equals LSM	Inbred cows LSM	Outbred equals LSM
n	722	2,063	722	2,063	722	2,063
F_x						
1	6389.43	6409.15	4.06	4.04	3.28	3.28
2	6295.91	6461.79	4.11	3.96	3.31	3.26
3	6064.61	6442.40	4.07	4.05	3.29	3.31
p	1-3*	n.s.	n.s.	1-2* 2-3*	n.s.	2-3**
Age at first calving						
1	6408.79	6643.85	3.99	3.92	3.29	3.27
2	6205.91	6425.45	4.09	4.07	3.30	3.30
3	6135.25	6244.04	4.14	4.06	3.30	3.29
p	1-3*	1-3**	1-2* 1-3**	1-2** 1-3**	n.s.	1-2*
Year of calving						
1	4887.69	5077.94	4.05	4.01	3.26	3.25
2	6364.55	6532.71	4.13	4.09	3.29	3.29
3	6733.16	6940.62	4.14	4.07	3.32	3.29
4	7014.52	7199.85	3.98	3.90	3.31	3.30
p	1-2** 1-3** 1-4** 2-4** 2-3*	1-2** 1-3** 1-4** 2-3** 2-4**	2-4** 3-4**	1-4* 2-4** 3-4**	1-3*	1-3* 1-4*
Number of lactations						
1	6231.52	6734.89	4.08	4.11	3.31	3.30
2	5958.32	6482.20	4.11	3.98	3.29	3.29
3	6502.12	6372.28	4.11	4.04	3.31	3.28
4	6407.36	6161.76	4.05	3.94	3.27	3.26
p	3-5*	1-3* 1-4** 2-4*	n.s.	1-2** 1-3** 3-4*	n.s.	n.s.
Calving interval						
1	6099.79	6401.41	4.06	4.06	3.31	3.31
2	6459.28	6732.14	4.06	3.99	3.30	3.29
3	6190.88	6179.79	4.11	3.99	3.28	3.25
p	1-2**	1-2** 2-3**	n.s.	n.s.	n.s.	1-3**
BVS						
1	5878.85	6054.41	4.17	4.08	3.32	3.29
2	6304.01	6607.91	4.09	4.03	3.29	3.29
3	6567.09	6651.02	3.97	3.95	3.28	3.27
p	1-2** 1-3** 2-3*	1-2** 1-3**	1-3** 2-3*	1-3** 1-2*	n.s.	n.s.
BVM						
1	6041.40	6208.63	4.11	4.04	3.31	3.29
2	6128.89	6259.63	4.11	4.07	3.30	3.31
3	6579.66	6845.08	4.01	3.95	3.28	3.27
p	1-3** 2-3**	1-3** 2-3**	1-3* 2-3*	1-3* 2-3**	n.s.	2-3**

*p≤0.05; **p≤0.01; n.s.=non significant; BVS=relative breeding value of the sire for milk production in kg; BVM=relative breeding value of the dam for milk production in kg; LSM=least square means

Table 3
Comparison of breeding values in inbred and outbred cows
(Der Vergleich der Zuchtwerte der Inzucht- und Nicht-Inzuchtkühe)

	$Y_{ijklmno}$			R^2		s_x	
	Inbred cows	Outbred equals	Difference	Inbred cows	Outbred equals	Inbred cows	Outbred equals
RBV							
1.25	100.91	102.34	$-1.43^{n.s.}$	0.4533	0.5183	9.32	8.74
2.0-3.125	102.74	104.55	-1.81^{*}	0.2639	0.3969	10.31	8.61
4.0-12.5	104.51	108.33	-3.82^{**}	0.4331	0.4108	10.36	10.33
All animals	102.58	104.64	-2.06^{**}	0.2851	0.4012	10.27	9.69
BVMkg							
1.25	29.79	66.36	$-36.57^{n.s.}$	0.4011	0.4978	294.77	260.11
2.0-3.125	88.97	132.52	-43.55^{**}	0.2650	0.3852	319.72	250.79
4.0-12.5	124.01	216.24	-92.23^{**}	0.3281	0.4097	340.93	297.01
All animals	81.87	132.68	-50.81^{**}	0.2667	0.3816	321.88	286.60
BV for fat percentage							
1.25	0.0069	0.0137	$0.0068^{n.s.}$	0.1608	0.3220	0.1998	0.1573
2.0-3.125	0.0150	−0.0244	0.0394^{**}	0.0790	0.1672	0.1831	0.1478
4.0-12.5	0.0028	−0.0124	$0.0152^{n.s.}$	0.2165	0.3470	0.1772	0.1751
All animals	0.0112	−0.0139	0.0251^{**}	0.0727	0.1726	0.1869	0.1604
BV for protein percentage							
1.25	0.0099	0.0084	$0.0015^{n.s.}$	0.3053	0.3369	0.0813	0.0765
2.0-3.125	0.0250	0.0034	0.0216^{**}	0.0728	0.0568	0.0958	0.0820
4.0-12.5	0.0097	0.0132	$-0.0035^{n.s.}$	0.3259	0.4154	0.0978	0.0922
All animals	0.0194	0.0060	0.0134^{**}	0.0775	0.0943	0.0957	0.0863

$^{*}p\leq0.05$, $^{**}p\leq0.01$; n.s. =non significant; RBV=relative breeding value for protein in kg; BVMkg=breeding value for milk in kg; BV= breeding value

The charts show clearly that the outbred cows show a decrease in milk production when compared to the inbred cows and this decrease is both in the absolute yield at the 1st lactation (Table 4) and also when the lactation is represented by breeding values (Table 3). The higher the F_x coefficient the more significant the differences are. The inbred cows hence showed, compared to their outbred equals, decrease in milk yield at the 1st lactation of −103.02 kg (F_x=1.25%); −236.8 kg (F_x=2.0-3.125%); −472.24 kg (F_x=4.0-12.5%) and -247.65 kg (F_x=total).The milk production in form of breeding values (BV for milk in kg, RBV for protein in kg) also showed lower values in inbred cows compared to their outbred equals. These differences were the higher the higher the F_x coefficient was and for BVMkg the differences were −36.57 kg (F_x=1.25%); −43.55 kg (F_x=2.0-3.125%); −92.23 kg (F_x=4.0-12.5%) and −50.81 kg (F_x=total) – Table 3. Similar tendencies occurred also for RBV for protein in kg.

On the other hand the inbred animals show a clear increase in content of milk components that in some cases reaches significant ($p\leq0.05$) or highly significant ($p\leq0.01$) values. The reached differences in inbred and outbred cows for each level of F_x coefficient are as follows: BV% of fat +0.0068 (F_x=1.25%); +0.0394 (F_x=2.0-3.125%); +0.0152 (F_x=4.0-12.5%) and +0.0251 (F_x=total). There was the same tendency for breeding values for protein percentage +0.0015 (F_x=1.25%); +0.0216 (F_x=2.0-3.125%); −0.0035 (F_x=4.0-12.5%) and +0.0134 (F_x=total). The increase of percentage of the milk components content (fat and protein) was also observed in form of absolute values at the 1st lactation (Table 4). Depressive influence of inbreeding on the milk production is clearly visible in the Figure 1, where the decrease of milk yield and breeding values for kg of milk of inbred animals at the 1st lactation is clearly shown. Tables 3 and 4 present a higher variability (s_x value) in inbred animals when compared to their outbred equals. This we can see in all the inbred groups and all the observed traits (Table 3 and 4).

Table 4
Comparison of milk production in inbred and outbred cows in 1st lactation
(Der Vergleich der Milchproduktion von Inzucht- und Nichtinzuchtkühen nach der ersten Kalbung)

	$Y_{ijklmno}$			R^2		s_x	
	Inbred cows	Outbred equals	Difference	Inbred cows	Outbred equals	Inbred cows	Outbred equals
Milk in the 1st lactation (in kg)							
1.25	6380.94	6483.96	−103.02$^{n.s.}$	0.3536	0.5152	1344.38	1112.08
2.0-3.125	6483.01	6719.81	−236.8**	0.3290	0.3398	1364.95	1272.52
4.0-12.5	5858.28	6330.52	−472.24**	0.5592	0.6819	1305.90	1143.90
All animals	6352.37	6600.02	247.65**	0.3741	0.4424	1347.50	1244.73
Fat in the 1st lactation (in %)							
1.25	4.1225	4.1250	−0.0025$^{n.s.}$	0.1681	0.1971	0.5248	0.4480
2.0-3.125	4.1188	3.9984	0.1204**	0.0983	0.1721	0.4652	0.3345
4.0-12.5	4.0380	4.0444	−0.0064$^{n.s.}$	0.1818	0.3184	0.4081	0.3520
All animals	4.1053	4.0345	0.0708**	0.0820	0.1452	0.4738	0.3770
Protein in the 1st lactation (in %)							
1.25	3.3043	3.3106	−0.0063$^{n.s.}$	0.1579	0.2380	0.1954	0.1638
2.0-3.125	3.3238	3.2873	0.0365**	0.0336	0.0425	0.2003	0.1671
4.0-12.5	3.2896	3.3242	−0.0346**	0.0843	0.2375	0.2564	0.1855
All animals	3.3140	3.2983	0.0157*	0.0224	0.0441	0.2098	0.1743

*p≤0.05, **p≤0.01, n.s.=non significant

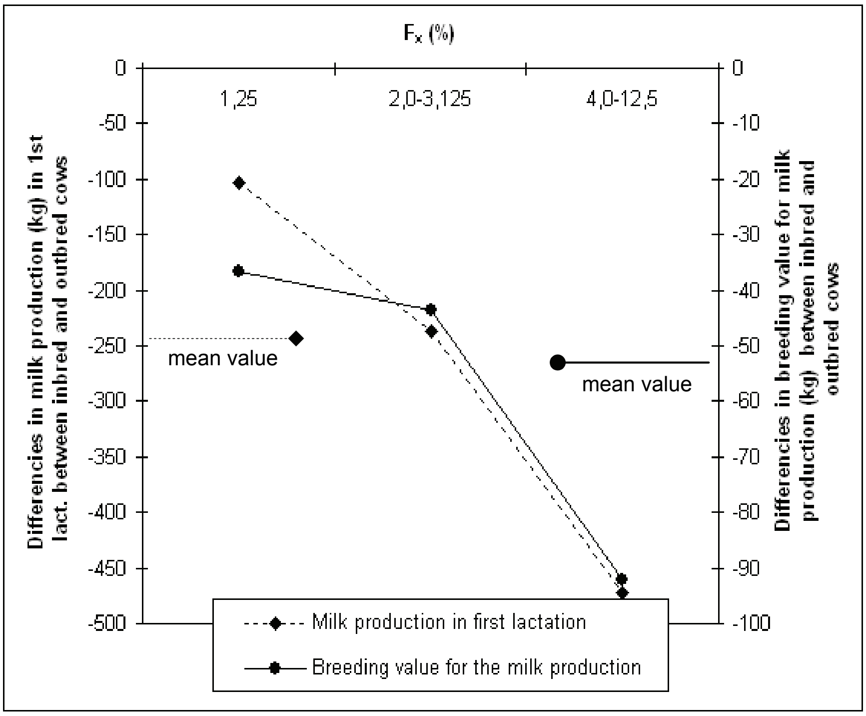

Fig. 1: Differences between inbred and outbred cows in milk production in the 1st lactation (in kg) and in breeding value for milk production in holstein cows (Unterschiede zwischen Inzucht- und Nichtinzucht-Holstein Kühen in der Milchleistung der ersten Laktation und im Zuchtwert für Milchleistung)

The mentioned differences correspond to the subsequently calculated values of correlation and regression coefficients. There was assessed a very low correlations between F_x and differences in milk production (in kg) inbred and outbred cows −0.0866 and also in fat per cent +0.0456 and protein per cent +0.0255. The regression coefficient of milk production was b_{yx}=−59.75 kg (where x=coefficient F_x in%, y = difference in milk production between inbred and outbred cows in kg). In fat and protein per cent were regression coefficients b_{yx}=+0.0112% and +0.0030% (where x=coefficient F_x in%, y=difference in fat or protein content between inbred and outbred cows in%).

Depressive influence of inbreeding on milk yield of cows (in kg) and increase in percentage of fat and protein was proven by other authors in their works, too. Similar – identical level of inbreeding depression of milk yield is found by SMITH et al. (1998). These authors reported an average inbreeding depression for 1% increase of inbreeding coefficient – 26.65 kg of milk. PARLAND et al. (2007) calculated inbreeding depression in cows with F_x=12.5% – 61.8 kg of milk. MIGLIOR (1995a) founds lower average values of inbreeding depression. He calculated a decrease of yield of 26.65 kg/1% F_x. KROGMEIER et al. (1997) calculated a depression of milk yield for 1% increase of F_x at the 1st, 2nd and 3rd lactations between −10.14 and −11.01 kg of milk. GAALAAS et al. (1962) calculated an inbreeding depression of milk yield −21,8 kg/1%F_x. THOMPSON et al. (2000a) found the inbreeding depression for F_x=3.0-5.0% −407 kg of milk and in the group F_x=8.0-12.5% even 572 kg of milk. The results prove the growth of milk yield loss in inbred animals when the F_x coefficient grows.

Most authors indicate increase of milk components (percentage of fat and protein) correlating with increase of F_x coefficient. MIGLIOR (1995b) found an increase of fat content in Holstein cattle for F_x=5% of +0.025% and for F_x=12.5% of up to +0.0625%. CASANOVA et al. (1992) came to similar conclusions. He found an increase of percentage of protein in milk in inbred cows of 0.001%/1% F_x. HERMAS et al. (1987) observed an inbreeding depression in two herds in the USA and calculated an increase of fat percentage of +0.002% when the F_x coefficient raised by 1%.

In conclusion the inbred cows show a statistically significant decrease of milk production in dependence on the value of F_x coefficient when compared to their outbred equals. The depression is visible not only when observing an absolute production at the 1st lactation but also when observing estimated breeding values. The present study also observed a non-evidential increase of fat and protein percentage in milk in inbred animals.

Acknowledgments

This study was supported by the Ministry of Education, Youth and Sports of the Czech Republic (MSM 2678846201).

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Received: 2008-06-04

Accepted: 2008-07-30

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