

Environmental factors and progeny affecting milk yield and composition during the first lactation

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Abstract

The purpose of this study was to determine whether the milk yield (MY) of primiparous cows is affected by their housing to weaning, the method of providing liquid feed, sire (S) line, and season of birth and calving. Thirty-two heifer-calves were used in the experiment; 19 heifers were kept in individual housing (IH) and 13 in loose housing (LH) from the second day of life. On the seventh day the IH heifers were divided according to feeding milk replacer (MR) or milk: 10 were relocated from IH to a pen with a computer-controlled feeder (CCF) providing automatic feeding of MR (AF), 9 heifers stayed in IH with bucket drinking (BF). The LH heifers were moved to a nursing cows pen (UF). Heifers were kept in free-stall housing after the first calving. The cows were also divided according to the sire, season of birth and calving. LH primiparous cows produced more milk throughout the first eight months of lactation, more MY, FCM and protein for 305 d lactation ($P < 0.05$). UF cows had the highest MY throughout the first lactation and reached the significantly highest milk yield and FCM (6894.1; 6541.9 kg), whereas AF cows, the lowest (5757.5; 5820.9 kg; $P < 0.01$) for 305 days of lactation. The contents of fat and total solids (TS) were the highest in group AF. Sire lineages differed in the contents of fat, protein, lactose, non-fat solids (NSF), TS, and MY, lactose and NSF. Cows born and calved in the summer showed lower MY and FCM yields. The most productive cows were born and calved in the winter and spring.

KEY WORDS: heifers, rearing, housing, sire, calving season, cow performance

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INTRODUCTION

Calves are usually separated from their mother during the first week of life and fed by milk replacer (MR). In Denmark, 86% of the calves are removed from their mother immediately after calving, 83% of the calves are placed in individual housing (IH) and 97% are fed milk from a bucket (Vaarst et al., 2001). Only about 10% of calves, particularly from small herds, are fed with native milk until weaning (Krohn et al., 1999). According to recent results from Swedish farms, 68% used IH during the milk-feeding period, 15% had calves in loose housing (LH) with bucket feeding and 13% housed the calves in LH with computer controlled feeder (CCF) (Svensson et al., 2000). Lack of movement in hutches (IH) can be adverse for calves. However, heifers reared in isolation until weaning gave significantly more milk than heifers from loose housing (Arave et al., 1985). According to Kaczor (2000), the housing system had no significant effect on the DWG of calves. Arave et al. (1992) found that pre-weaning isolation affected growth, but did not affect first lactation milk yield.

The early separation of the calf from the cow is of course important for maximum production, but this system can be disadvantageous for the calves. On the other hand, uncontrolled access to the mother by the calf can reduce the milk yield (MY) of the mother, but daily weight gains (DWG) of nursed calves are higher than of separated calves (Metz-Stefanowska, 1987; Khalili et al., 1992). Strzetelski et al. (2001) and Niwińska and Strzetelski (2004) reported better performance of calves fed by milk replacer more frequently. Bar-Peled et al. (1997) found that heifer calves reared by their own mother had better growth, earlier age at calving, and a tendency towards higher MY than calves fed MR.

Rearing of heifers is important for next performance, but other factors also influence milk yield after calving (Krzyżewski et al., 2004). DWG and milk yield are affected by several factors, including season (Tancin, 1991; Kaczor, 2000; Maltz et al., 2000) and ambient temperature in particular (Shearer and Beede, 1990; Knizkova et al., 2003).

These previous studies can provide some insight into the effects of housing, milk-feeding, sire lineage, season of birth and calving. However, they are inadequate as a basis for recommending environmental factors, as none of those studies examined how rearing of animals to weaning from milk or milk replacer can influence later adult production. Little research has been conducted to directly compare indicators of milk efficiency in dairy heifers reared in different individual housing and feeding designs.

This information is needed for educational programs and decision making by the industry and by dairy producers. Better knowledge of the effects of environmental conditions on milk yield are needed to better predict the effects of seasonal heat stress.

The purpose of this study was to test the hypotheses that milk efficiency is impacted by the housing of heifers from the second to seventh day of life, the method of feeding milk from the second week of life to weaning, the sire lineage, and season of birth and calving.

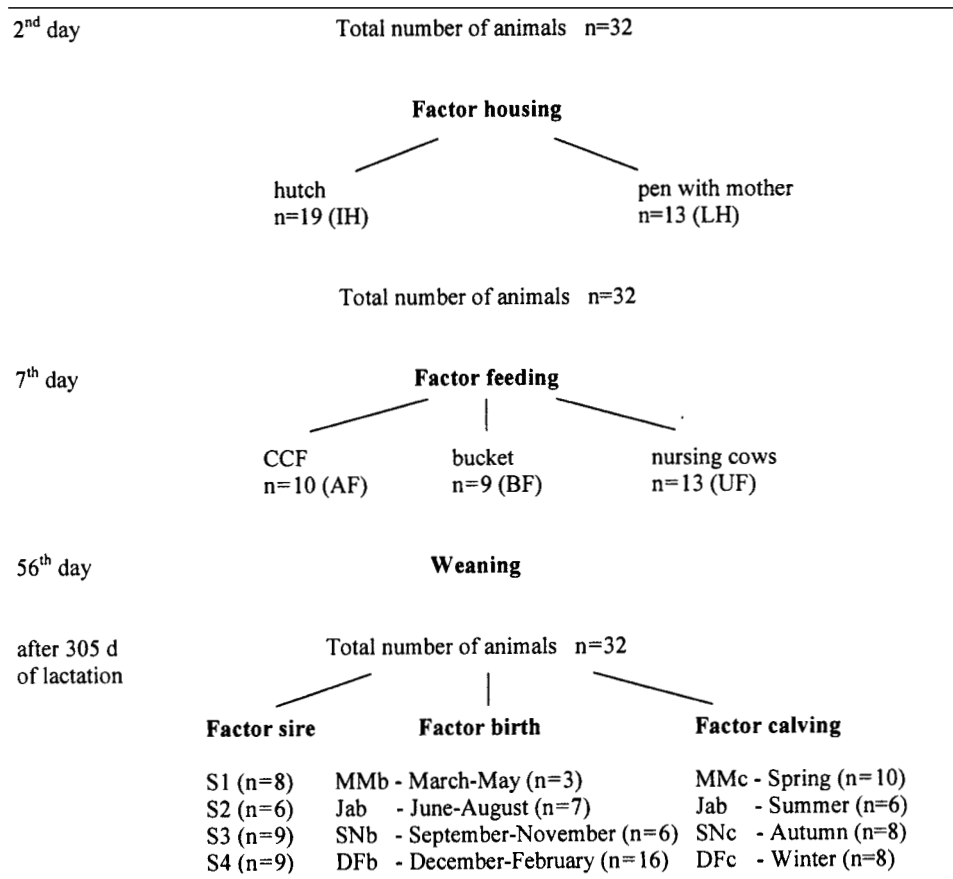
MATERIAL AND METHODS

Experimental design

Thirty-two Holstein heifer-calves were randomly divided in two housings on the second day of life (Table 1).

TABLE 1

Design of the experiment



Calves of the AF treatment received 6 kg of MR per day divided into 4 portions in 6 h intervals (after the first three days, when they were made to drink MR). The amount of MR was increased from the 28th day on to 8 kg per day. Calves of the BF treatment received the same amounts of MR divided into 2 portions in 12 h intervals. The source of protein in MR was powdered whey (Table 2).

TABLE 2

Composition of heifer diets as fed basis, g/1 kg

	DM ¹	CP ²	NEL ³	PDI ⁴	Fat	Fibre	Ca	P
Native milk	0.14	29.6	1.89	9.6	44.8	0	1.25	0.96
Milk replacer	0.94	206	12.1	82.7	166	6	9	7
Starter mixture	0.88	185	7.2	81.3	29	43	10	6
Concentrate	0.86	201	7.1	122	25.6	36	4.9	8.2
TMR	0.43	54.7	2.7	35.2	23.1	94.6	3.4	1.8

¹dry matter; ²crude protein; ³netto energy for lactation, MJ; ⁴protein digestible in small intestine

The number of calves of group UF per nursing cow was determined according to the cow's milk yield (6 kg milk per calf). A maximum of 3 cows were housed in one pen sized 8 × 4.5 m. Calves were allowed to suck *ad libitum* and they also had free access to the feeds of cows.

From the second day until weaning the calves could eat starter mixture and lucerne hay in free choice. The starter composition was, %: extruded soyabean 21.48, oats 16, maize 41, wheat 8.17, wheat bran 3.44, dried lucerne meal 3.65, dried molasses 2.58, protein-vitamin premix (Kalvicin, 2000) 2.81, mineral premix 0.87.

All animals were weaned at the age of 8 weeks. Heifers of all groups were kept in common group pens in loose housing with bedding in age-balanced groups after weaning. They received 1.5 kg of concentrate mixture per day and lucerne hay in free choice from weaning to six months of age. From the age of 90 days they also received maize silage. From day 181, all heifers were fed according to Slovakian recommendations to attain 0.75 kg daily gain (Petrikovic and Sommer, 2002). The TMR composition (DM %) represents: lucerne hay 17, lucerne haylage 32.1, maize silage 40.0, concentrate mixture 9, and mineral/vitamin supplements 1.

Heifers received a supplement of 1.5 kg of concentrate mixture per day until breeding, then 1 kg from the 5th month of gestation, and this amount was gradually increased to 3 kg per day until calving. The concentrate mixture composition (DM %) was: extruded soyabean meal 19.4, extruded rapeseed meal 11.0, wheat 29.5, wheat bran 4.9, maize 31.5 and mineral/vitamin premix 3.7. Equal conditions of nutrition were ensured in all groups.

Heifers were moved to the maternity barn three weeks before the expected date of calving. Primiparous dairy cows were kept in pens with free-stall housing with

access to yards with concrete and fed by TMR twice a day according to the stages of lactation. TMR was balanced according to Slovakian nutrient requirements of dairy cattle (Petrikovic and Sommer, 2002) (Table 3).

TABLE 3

Composition of TTM diets for cows used in the experiment, kg

Indices	1-4 month	5-7 month	From 8. month
Lucerne hay	2	2.5	2
Lucerne haylage	8	7	8
Concentrate mixture	7.8	6.2	4.4
Maize silage	21	17	20
Sugar-beet pulp	-	10	-
Wet brewer's grain	6	5	3
Dry matter	19.8	18.29	16.7
MJ NE _L	130	120.1	104.5
PDI	1.84	1.65	1.44
Crude protein	2.86	2.67	2.31
Calculated milk efficiency	32	27	20

Experimental techniques

Milking was performed twice daily with a milking interval of 12 h in a 2×5 stall herringbone parlour, and individual MY was recorded once weekly (Tuesday evening, Wednesday morning) by Tru-tests. Proportional milk samples were collected every 2 weeks at the morning and afternoon milking and analysed by an infrared analyser. Milk was assayed for fat, protein, lactose, non-fat solids and total solids using infrared analysis (Milkoscan 133, Foss Electric, Hillerød, Denmark).

Heifers were first mated when they were at least 16 months old and when they reached about 360 kg. Body condition score (1-5 points) (Jones, 1994) was used to evaluate the adequacy of the breeding-feeding program at the age of 15 months and 30th day of lactation.

Reproduction and health were observed. BW on the 30th day of lactation was 524.13±44.37 kg. Breeding of cows during the first lactation began at 9 wk post-partum.

Statistical analyses

The data were analysed with a statistical package STATISTIX, Version 2.0 (Anonymous, 1996). The normal distribution of data was evaluated by the Wilk-Shapiro/Rankin Plot procedure. We found a non-normal distribution only in

the somatic cell count. Therefore inter-group comparisons were tested by the Kruskal-Wallis ANOVA (factors: feeding, sire, season of birth and calving) and by the Mann-Whitney U test (factor: housing) in this parameter.

Data for milk yield and milk composition conformed to a normal distribution. Inter-group comparisons in each factor were analysed using a general linear model ANOVA (General AOV/AOCV). The dependent variables were milk production (including components), body weight, and daily gains and the independent variables were housing, feeding, sire, birth and calving season (treatment). The homogeneity of variance of the observed variables in groups, whose average values were being compared, was calculated by preliminary variance tests that determined whether the variabilities were equal. Bartlett's test for equality of variance tests was applied when sample sizes were not equal. The ratio of the largest intra-group variance over the smallest was also tested (Pearson and Hartley test). Significant differences among means were tested by Bonferroni's test. We chose Bonferroni's method from Multiple Comparison Procedures since the number of heifers in groups was unequal (Snedecor and Cochran, 1989). This test is generally more conservative than the others in the statistics packet.

The interactions between observed factors (housing, feeding, sire, birth and calving) were also computed using two-way ANOVA with the interactions model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{ij} + \varepsilon_{ijk}$$

where Y_{ijk} is a dependent variable, μ is the overall mean, α_i is the effect of factor A on the level i , β_j is the effect of factor B on the level j , γ_{ij} is the interaction between factor A on the level i and factor B on the level j , and ε_{ijk} is the residual error.

The results given in the text are expressed as means \pm SD.

RESULTS

Housing

The heifers of group LH had a higher BW at weaning at 56 days than heifers from group IH (80.28 ± 8.99 vs 67.89 ± 12.01 kg; $P < 0.01$) and higher DWG from birth to weaning (0.68 ± 0.16 vs 0.47 ± 0.19 kg; $P < 0.01$). Age at calving was not significantly different between groups.

LH cows had a higher MY throughout the first eight months of lactation (Figure 1). The greatest and highly significant difference was in the fifth month of lactation (780.5 ± 132.2 kg vs 636.9 ± 128.4 kg; $P < 0.01$). As we can see in Figure

2, except in the ninth month, LH cows always produced more FCM in comparison with the IH cows. However, a significant effect of this factor was obvious only in the fifth month (710.1 ± 102.3 kg vs 588.6 ± 96.8 kg; $P < 0.05$).

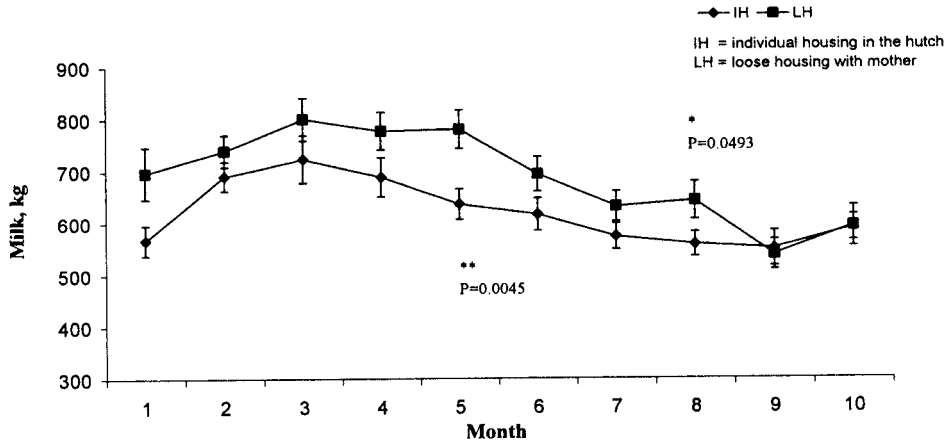


Figure 1. Milk yield according to the housing of calves from 2nd to 7th day of life (means \pm SE)

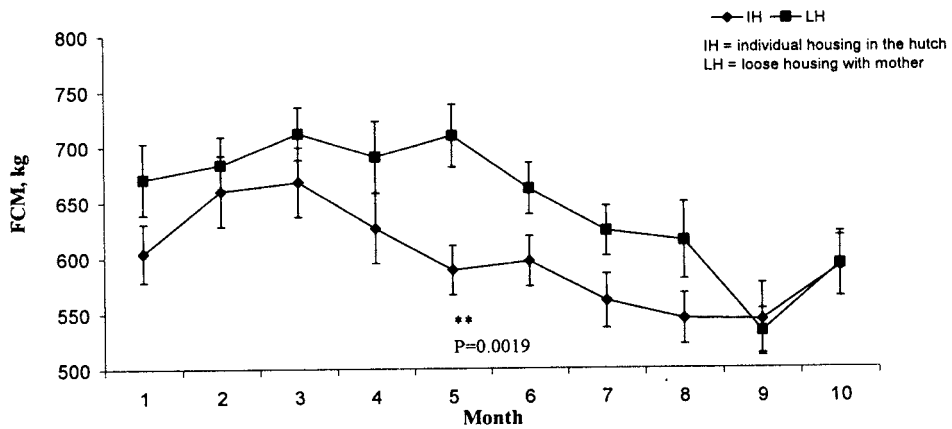


Figure 2. FCM according to the housing of calves from 2nd to 7th day of life (means \pm SE)

The MY in the 305 days of lactation (Table 4) was also higher in LH cows than in the IH group ($P < 0.05$). Significant differences were also found in the productions of FCM ($P < 0.05$) and protein ($P < 0.05$).

The average score at 15 months of age was 3.12 ± 0.42 and 2.6 ± 0.48 on the 30th day of lactation.

TABLE 4
Effect of of housing from the second to seventh day of life on growth and 305 days milk production

Indices	Group	n	Mean	SD ¹	SE ²	F/P ³
BW at the 56 d, kg	IH	19	67.89	12.01	2.75	9.94
	LH	13	80.28	8.99	2.49	0.0037**
DWG from birth to 56 d, kg	IH	19	0.47	0.19	0.04	9.70
	LH	13	0.68	0.16	0.05	0.0040**
Milk, kg	IH	19	6202.10	923.99	211.98	4.50
	LH	13	6894.10	879.78	244.01	0.0423*
FCM, kg	IH	19	5986.4	669.20	153.53	5.45
	LH	13	6541.9	649.16	180.04	0.0265*
Protein, kg	IH	19	193.22	27.35	6.27	5.56
	LH	13	215.32	23.91	6.63	0.0250*

¹ standard deviation of the mean; ² standard error of the mean; ³ F-value/P-value

* P<0.05; **P<0.01

Feeding of milk

BW at weaning was the highest in UF heifers and the lowest in AF heifers (P<0.001). Similarly, DWG during the milk-feeding period was also the highest in UF heifers (P<0.001) (Table 5).

UF cows had the highest MY throughout the first lactation. BF cows yielded more only in the third, ninth and tenth months (Figure 3). The lowest milk efficiency in all months was recorded in group AF. A significant difference was found between groups UF and AF in the sixth month (694.1 ± 120.2 kg vs 560.4 ± 116.4 kg, P<0.05). Highly significant differences were found in the fifth month, when group UF milked 780.5 ± 132.2 kg, group BF 729.9 ± 93.5 kg and group AF only 553.3 ± 93.7 kg (P<0.01).

Except in the second, third, ninth and tenth months of lactation, production of FCM was always the highest in group UF (Figure 4). In contrast, the animals of group AF fed by the CCF had the lowest production. A highly significant difference was found in the fifth (710.1 ± 102.3 kg vs 547.2 ± 94.7 kg; P<0.01) and sixth months (662.2 ± 84.2 kg vs 561.3 ± 95.1 kg; P<0.05).

TABLE 5
Effect of feeding milk from the second week of life to weaning on growth and 305 days milk production

Indices	Group	n	Mean	SD ¹	SE ²	F/P ³
BW at the 56 d, kg	AF	10	61.96	9.34	2.95	9.88
	BF	9	74.49	11.57	3.86	0.0005***
	UF	13	80.28	8.99	2.49	UF:AF***; BF:AF*
DWG from birth to 56 d, kg	AF	10	0.36	0.10	0.03	11.48
	BF	9	0.59	0.21	0.07	0.0002***
	UF	13	0.68	0.16	0.05	UF:AF***; BF:AF**
BW at the 30 d of lactation, kg	AD	10	504.8	36.49	11.54	1.96
	BD	9	521.89	32.85	10.95	0.1586
	UD	13	540.54	52.56	14.58	N.S.
Milk, kg	AF	10	5757.5	865.5	273.70	5.57
	BF	9	6696.1	746.0	248.68	0.0090**
	UF	13	6894.1	879.8	244.01	UF:AF**
	AF	10	5820.9	797.3	252.12	3.42
	BF	9	6170.3	469.3	156.43	0.0463*
	UF	13	6541.9	649.2	180.04	UF:AF*
Fat, %	AF	10	4.10	0.40	0.13	3.61
	BF	9	3.57	0.55	0.18	0.0399*
	UF	13	3.75	0.37	0.10	AF:BF*
Protein, kg	AF	10	180.9	27.5	8.68	5.93
	BF	9	206.9	20.7	6.92	0.0069**
	UF	13	215.3	23.9	6.63	UF:AF**
Lactose, kg	AF	10	285.0	40.6	12.83	5.78
	BF	9	340.0	40.8	13.60	0.0077**
	UF	13	342.9	47.7	13.24	UF,BF:AF*
Non fat solids, kg	AF	10	515.3	67.5	21.35	5.33
	BF	9	599.9	68.7	22.91	0.0107*
	UF	13	608.9	78.4	21.74	UF:AF*
Total solids, %	AF	10	13.14	0.74	0.23	3.96
	BF	9	12.56	0.59	0.19	0.0302*
	UF	13	12.41	0.57	0.16	AF:UF*
Total solids, kg	AF	10	749.8	95.5	30.20	3.74
	BF	9	832.9	74.1	24.71	0.0359*
	UF	13	846.5	90.9	25.23	UF:AF*

¹ standard deviation of the mean; ² standard error of the mean; ³ F-value/P-value
*P<0.05; **P<0.01; ***P<0.001

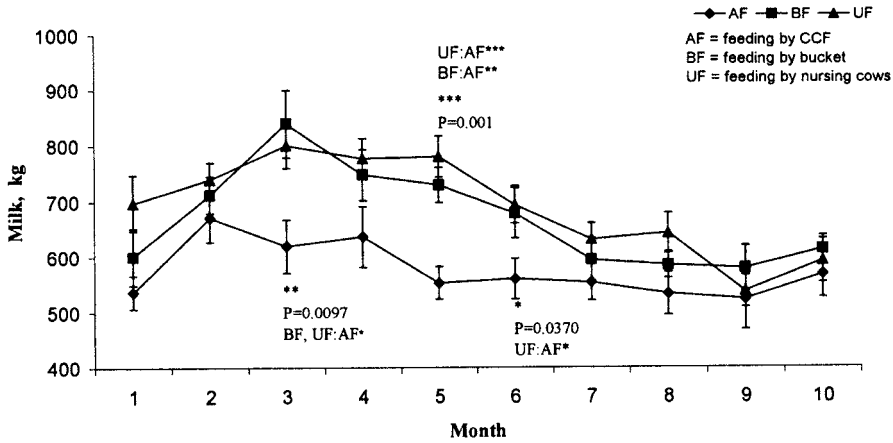


Figure 3. Milk yield according to the method of milk feeding of calves (means \pm SE)

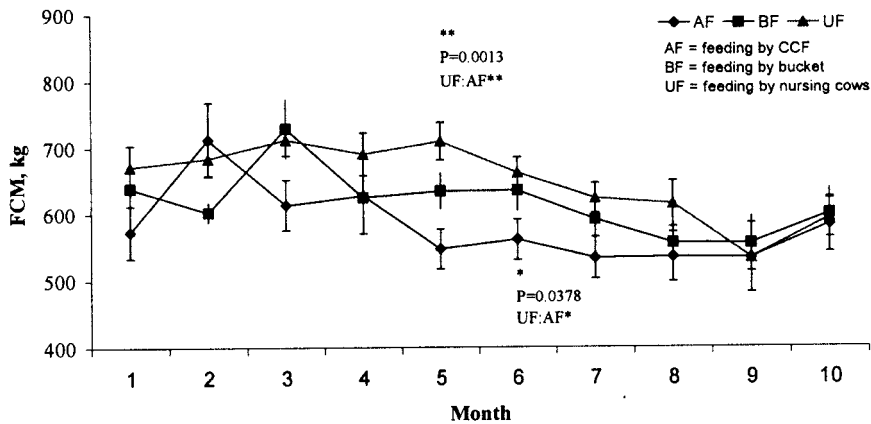


Figure 4. FCM according to the method of milk feeding of calves (means \pm SE)

The UF cows reached the highest MY, and AF cows, the lowest ($P < 0.01$) for 305 days of lactation (Table 5). A similar trend was also recorded in FCM ($P < 0.05$). The contents of fat and TS were the highest in the AF group (4.10 and 13.14%, respectively).

Sire

Heifers after four observed sires differed in BW at birth ($P < 0.05$) (Table 6). The daughters of S_3 reached the highest MY except in the seventh and eighth months

(Figure 5). Significant differences ($P<0.05$) were found in the fifth (799.2 ± 157.9 kg vs 602.1 ± 113.4 kg) and sixth months (756.4 ± 118.1 kg vs 590.8 ± 100.8 kg), always between S_3 and S_1 . For no month of lactation did we find a significant difference among daughters in FCM.

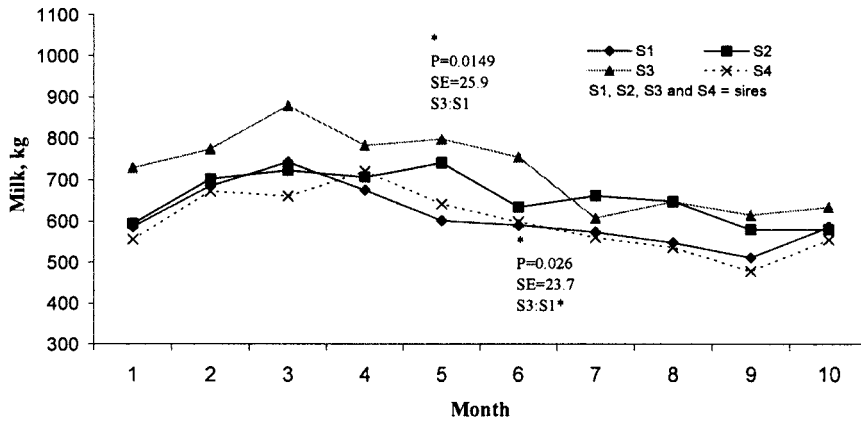


Figure 5. Milk yield according to the sire line

The effects of sire lineage were very significant in fat content ($P<0.001$), production of lactose, and TS content ($P<0.01$) over 305 days of lactation. Statistical significance ($P<0.05$) was shown in MY, protein and lactose contents, as well as in the content and production of NFS (Table 6).

Season of birth

The highest BW at weaning and 180th day of life and the lowest BW were found in DFb and JAb cows (Table 7). JAb cows showed the lowest MY during almost all months of lactation. In contrast, DFb cows had the highest milk production. Highly significant differences ($P<0.01$) among seasons were found in the second (SNb 793.1 ± 127.0 kg and DFb 742.6 ± 96.6 kg vs JAb 586.5 ± 68.0 kg) and fifth (DFb 769.3 ± 127.3 kg vs JAb 542.6 ± 103.6 kg) months of lactation (Figure 6). Significant differences ($P<0.05$) were found in the third (DFb 837.2 ± 160.7 kg vs JAb 619.0 ± 185.8 kg) and fourth months (DFb 774.8 ± 122.1 kg vs JAb 575.6 ± 173.3 kg).

TABLE 6

Effect of the sire on growth and 305 days milk performance

Indices	Group	n	Mean	SD ¹	SE ²	F/P ³
BW at the birth, kg	S ₁	8	39.87	4.73	1.67	3.63
	S ₂	6	44.67	4.84	1.98	0.0248*
	S ₃	9	39.00	1.80	0.60	
	S ₄	9	43.89	4.78	1.59	
Milk, kg	S ₁	8	6098.8	929.80	328.73	4.21
	S ₂	6	6579.3	920.24	375.68	0.0141*
	S ₃	9	7255.8	879.76	293.25	S ₃ :S _{1,4} *
	S ₄	9	5988.3	618.42	206.14	
Fat, %	S ₁	8	3.97	0.42	0.15	7.34
	S ₂	6	4.11	0.29	0.11	0.0009****
	S ₃	9	3.33	0.40	0.13	S _{2,1,4} :S ₃ **
	S ₄	9	3.96	0.33	0.11	
Protein, %	S ₁	8	3.13	0.14	0.05	3.61
	S ₂	6	3.06	0.11	0.05	0.0255*
	S ₃	9	3.08	0.08	0.03	S ₄ :S ₂ *
	S ₄	9	3.24	0.14	0.04	
Lactose, %	S ₁	8	4.99	0.09	0.03	2.94
	S ₂	6	4.91	0.07	0.03	0.0499*
	S ₃	9	5.07	0.05	0.02	S ₃ :S ₂ *
	S ₄	9	5.00	0.14	0.05	
Lactose, kg	S ₁	8	305.10	47.61	16.83	4.82
	S ₂	6	318.32	37.81	15.44	0.0079**
	S ₃	9	368.85	48.55	16.18	S ₃ :S _{1,4} *
	S ₄	9	299.78	34.14	11.38	
Non fat solids, %	S ₁	8	9.01	0.27	0.09	4.28
	S ₂	6	8.62	0.25	0.10	0.0131*
	S ₃	9	8.89	0.19	0.06	S _{4,1} :S ₂ *
	S ₄	9	9.02	0.21	0.07	
Non fat solids, kg	S ₁	8	552.87	76.41	27.01	3.57
	S ₂	6	565.02	72.03	29.41	0.0264*
	S ₃	9	643.74	83.77	27.92	S ₃ :S ₄ *
	S ₄	9	540.25	59.11	19.70	
Total solids, %	S ₁	8	13.11	0.80	0.28	5.44
	S ₂	6	12.61	0.63	0.26	0.0045**
	S ₃	9	12.07	0.43	0.14	S ₁ :S ₃ **
	S ₄	9	12.94	0.42	0.14	S ₄ :S ₃ *

¹ standard deviation of the mean; ² standard error of the mean; ³ F-value/P-value

*P<0.05; **P<0.01; ***P<0.001

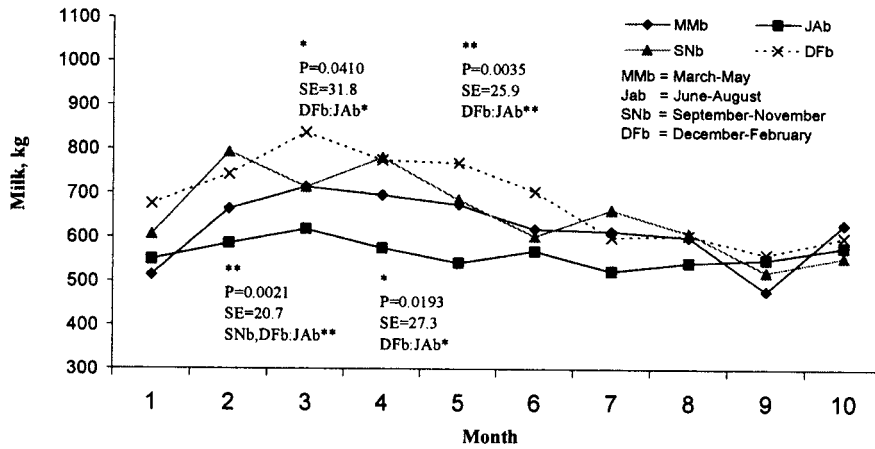


Figure 6. Milk yield according to the season at the birth

TABLE 7

Effect of season of birth on growth and 305 days milk performance

Indices	Group	n	Mean	SD	SE	F/P ³
BW at the 56 d, kg	MM _b	3	76.70	13.87	8.01	8.84
	JA _b	7	59.24	10.41	3.93	0.0003***
	SN _b	6	67.98	6.06	2.47	DF _b :JA _b ***
	DF _b	16	80.05	9.03	2.26	
BW at the 180 d, kg	MM _b	3	184.93	33.48	19.33	7.24
	JA _b	7	152.04	13.08	4.94	0.0010**
	SN _b	6	157.72	15.83	6.46	DF _b :JA _b **
	DF _b	16	186.13	18.89	4.72	DF _b :SN _b *
DWG from birth to 56 d, kg	MM _b	3	0.66	0.26	0.15	15.84
	JA _b	7	0.29	0.09	0.03	0.0000***
	SN _b	6	0.45	0.06	0.03	DF _b :JA _b ***
	DF _b	16	0.69	0.14	0.03	MM _b :JA _b **
DWG from birth to 180 d, kg	MM _b	3	0.81	0.19	0.11	8.85
	JA _b	7	0.60	0.07	0.02	0.0003***
	SN _b	6	0.63	0.09	0.03	DF _b :JA _b ***
	DF _b	16	0.80	0.09	0.02	DF _b :SN _b ** JA _b :MM _b *
BW at the 30 d of lactation, kg	MM _b	3	586.67	56.86	32.83	6.44
	JA _b	7	496.86	30.58	11.56	0.0019**
	SN _b	6	493.17	25.85	10.55	MM _b :JA _b ,SN _b **
	DF _b	16	535.94	37.15	9.29	
Milk, kg	MM _b	3	6211.0	703.51	406.17	3.53
	JA _b	7	5639.7	1047.2	395.79	0.0277*
	SN _b	6	6538.8	746.25	304.65	DF _b :JA _b *
	DF _b	16	6882.5	825.67	206.42	

TABLE 7 continued

Indices	Group	n	Mean	SD	SE	F/P ³
FCM, kg	MM _b	3	6108.1	480.57	277.46	3.82
	JA _b	7	5563.5	843.45	318.80	0.0206*
	SN _b	6	6668.1	623.17	254.41	SN _b :JA _b *
	DF _b	16	6344.2	536.90	134.22	
Fat, %	MM _b	3	3.93	0.55	0.32	3.14
	JA _b	7	3.96	0.37	0.14	0.0407*
	SN _b	6	4.17	0.28	0.11	
	DF _b	16	3.59	0.47	0.12	
Fat, kg	MM _b	3	241.58	23.83	13.76	3.74
	JA _b	7	220.51	30.07	11.37	0.0224*
	SN _b	6	270.17	23.74	9.69	SN _b :JA _b *
	DF _b	16	239.41	26.85	6.71	
Protein, kg	MM _b	3	198.83	23.79	13.73	5.26
	JA _b	7	173.51	32.19	12.17	0.0053**
	SN _b	6	201.56	13.74	5.61	DF _b :JA _b **
	DF _b	16	215.63	21.78	5.44	
Lactose, %	MM _b	3	5.12	0.12	0.07	6.83
	JA _b	7	4.93	0.09	0.03	0.0013**
	SN _b	6	4.91	0.08	0.03	MM _b , DF _b :
	DF _b	16	5.04	0.08	0.02	JA _b , SN _b *
Lactose, kg	MM _b	3	318.65	35.53	20.51	4.29
	JA _b	7	277.91	49.05	18.54	0.0130*
	SN _b	6	316.62	27.21	11.11	DF _b :JA _b *
	DF _b	16	347.96	46.55	11.64	
Non fat solids, kg	MM _b	3	561.48	64.73	37.37	4.56
	JA _b	7	499.93	82.22	31.08	0.0101*
	SN _b	6	568.52	50.09	20.45	DF _b :JA _b *
	DF _b	16	617.12	72.43	18.11	
Total solids, kg	MM _b	3	800.29	67.84	39.17	3.86
	JA _b	7	720.44	108.68	41.08	0.0198*
	SN _b	6	827.25	52.86	21.58	DF _b :JA _b *
	DF _b	16	849.50	84.24	21.06	

¹standard deviation of the mean; ²standard error of the mean; ³F-value/P-value

*P<0.05; **P<0.01; ***P<0.001

Except for the ninth month, the lowest FCM was recorded in JAb cows. The greatest absolute difference at the level of 218.4 kg was in the fourth month of lactation (SNb 767.6±113.7 kg vs JAb 549.2±158.3; P<0.05). There were differences between SNb (790.8±172.4 kg) and JAb (612.6±61.4 kg) in the second month and between DFb (678.3±108.2 kg) and JAb (524.7±87.7 kg) in the fifth month.

In the assessment of 305 days lactation (Table 7), DFb cows showed the highest MY, protein, lactose, NFS and TS and JAb cows the lowest (P<0.05).

Production of FCM and fat was the highest in the SNb group and the lowest again in the JAb group ($P < 0.05$).

Season of calving

Negative effects of the summer period were again found in the evaluation by season of calving. SNc heifers had the lowest BW at the 180th day of life and DWG from birth to 6 months (Table 8). Comparison with MMc heifers gave significant differences ($P < 0.05$). JAc cows showed the lowest MY in the third, fourth, sixth, seventh and ninth months of lactation. The most productive were DFc and MMc cows. A very high difference ($P < 0.001$) was found in the third month (DFc 874.7 ± 106.6 kg and MMc 845.0 ± 169.8 kg vs JAc 563.1 ± 133.6 kg, $P < 0.01$; DFc 874.7 ± 106.6 kg vs SNc 666.4 ± 116.6 kg). Other significant differences were recorded in the fifth (DFc 771.0 ± 77.3 kg and MMc 770.3 ± 161.3 kg vs SNc 581.6 ± 76.9 kg) and the sixth (DFc 715.9 ± 105.5 kg and MMc 713.9 ± 126.9 vs JAc 517.8 ± 88.7 kg) months.

Cows calving in the summer showed lower FCM. The most notable, very highly significant difference was recorded in the sixth month ($P < 0.001$). Animals calving in the winter and spring produced highly significantly more FCM in comparison with animals calving in the summer (DFc 686.4 ± 82.8 kg and MMc 664.3 ± 64.6 kg vs JAc 513.9 ± 78.8 kg; $P < 0.01$). Other significant differences were observed in the third (DFc 768.6 ± 88.4 kg vs JAc 594.4 ± 141.8 kg; $P < 0.05$) and eighth (DFc 663.6 ± 84.5 kg, MMc 568.1 ± 110.4 kg, SNc 528.3 ± 130.1 kg, JAc 520.7 ± 70.7 kg; $P < 0.05$) months of lactation.

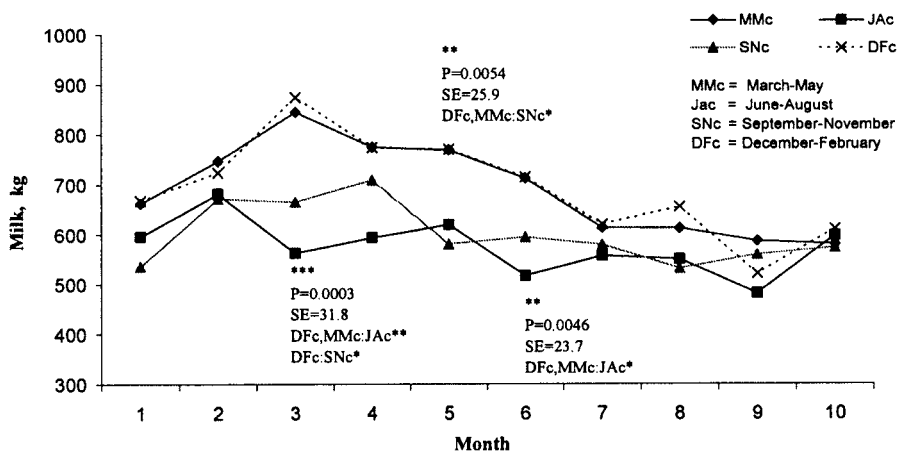


Figure 7. Milk yield according to the season at the calving

TABLE 8

Effect of season of calving on growth and 305 days milk performance

Indices	Group	n	Mean	SD ¹	SE ²	F/P ³
BW at the 180 d, kg	MM _c	10	186.49	16.98	5.37	4.97
	JA _c	6	164.88	14.88	6.07	0.0069**
	SN _c	8	153.31	16.15	5.71	MM _c :DF _c :SN _c *
	DF _c	8	182.85	29.07	10.28	
DWG from birth to 180 d, kg	MM _c	10	0.81	0.09	0.03	4.49
	JA _c	6	0.69	0.09	0.04	0.0108*
	SN _c	8	0.62	0.08	0.03	MM _c :SN _c *
	DF _c	8	0.77	0.16	0.06	
Milk, kg	MM _c	10	6924.9	987.62	312.31	4.01
	JA _c	6	5764.4	948.45	387.20	0.0171*
	SN _c	8	6011.1	809.11	286.06	
	DF _c	8	6942.5	530.64	187.61	
Fat, %	MM _c	10	3.48	0.44	0.14	3.44
	JA _c	6	4.09	0.31	0.13	0.0300*
	SN _c	8	4.01	0.45	0.16	
	DF _c	8	3.81	0.44	0.15	
Protein, kg	MM _c	10	213.16	25.41	8.03	4.69
	JA _c	6	178.67	32.56	13.29	0.0090**
	SN _c	8	189.46	23.07	8.16	DF _c :JA _c *
	DF _c	8	218.90	13.11	4.63	
Lactose, %	MM _c	10	5.07	0.11	0.03	3.16
	JA _c	6	5.00	0.06	0.02	0.0403*
	SN _c	8	4.93	0.09	0.03	MM _c :SN _c *
	DF _c	8	4.98	0.11	0.04	
Lactose, kg	MM _c	10	351.88	54.40	17.20	4.35
	JA _c	6	288.46	48.06	19.62	0.0123*
	SN _c	8	296.11	38.67	13.67	
	DF _c	8	343.73	24.78	8.76	
Non fat solids, kg	MM _c	10	620.52	88.89	28.11	4.16
	JA _c	6	522.58	81.86	33.42	0.0148*
	SN _c	8	529.50	65.49	23.15	
	DF _c	8	611.54	37.27	13.18	

¹standard deviation of the mean; ²standard error of the mean; ³F-value/P-value

*P<0.05; **P<0.01

Production of milk, protein, lactose, NFS and content of fat and lactose for 305 days of lactation statistically differed according to the season of calving (Table 8). DF_c and MM_c cows had the highest MY, while JA_c cows, the lowest. The JA_c cows had the highest fat content and MM_c cows, the lowest. The DF_c cows produced the most protein and JA_c cows the least.

Interactions between factors

We found interactions only between the sire and feeding factors in the BW variable at 8 weeks, ADG from birth to weaning, percentage of protein and lactose in milk ($P < 0.05$).

DISCUSSION

It was found that the production of milk, FCM and protein were significantly higher in the LH group than in the IH group. However, the effect of housing from the second to seventh day of life could be suppressed by the method of feeding milk to weaning. That had a decisive effect on the growth of calves and subsequent milk production. Further investigation of the relationships between feeding and growth during rearing and subsequent milk production, and between housing and growth during rearing would be desirable to analyse whether housing during rearing affects subsequent milk production.

The highest production of milk, FCM, protein, lactose, NFS and TS were in the UF group, with the lowest found in group AF. This could be explained by the higher BW at calving. According to the results of Khalili et al. (1992), calves given a high level of milk or MR in early life have a BW advantage over similar calves given a lower level of milk. Differences in BW due to increased DWG in the early life of a calf may be retained subsequently or, in certain situations, the difference in BW may increase later in life. Group UF had just this advantage—these cows had BW's that were higher by 35.7 and 18.6 kg in the 1st month of lactation in comparison with groups AF and BF. This was the result of their better growth in the rearing period. This shows that rearing conditions had a long-term effect on growth until the age of calving.

Before weaning, the suckling calves (UF) grew faster than the conventionally fed calves, probably as a result of a higher milk intake. This was so even when we limited the amount of milk by changing the number of calves per cow. In suckling calves, postnatal growth rates of *ad libitum*-fed calves were greater than in calves fed with a limited intake (Egli and Blum, 1998).

Another reason can be the better quality of nutrition, i.e. native milk versus MR. Animals of group UF obviously received more valuable nutrition from the udder than the animals from groups AF and BF. In the work of Skrzypek et al. (2003), calves fed by whole milk up to weaning showed better growth than calves fed by MR or combination of whole milk and MR. Similarly, in the experiment of Bar-Peled et al. (1997), heifer calves that suckled milk had higher DWG, an earlier age at calving, and a tendency towards greater MY than calves fed MR.

Calves with free access to colostrum and milk were able to digest and metabolize high amounts of feed (Hammon et al., 2002) and higher feed intake was reflected by a higher DWG.

It is probable that very early weaning from the mother (for example, in the case of our AF and BF groups) reduces adaptive abilities of calves and decreases their resistance to stress. Skrzypek et al. (2003) reported that feeding native milk could reduce the incidence of diarrhoea and this could be seen in our case of feeding from buckets or from the CCF, in particular. According to Plath et al. (1998) a higher proportion of calves reared in groups with CCF was affected by diarrhoea and bronchopneumonia and showed lower DWG than calves reared in groups with bucket feeding. The risk of developing respiratory disease was 2.8 times higher in LH with CCF than in calves kept in IH (Svensson et al., 2000).

How can we explain that cows born and calving in the autumn or winter showed the highest production of milk and its components? There is probably an effect of close relationship with BW. Calves born in the winter tended toward higher DWG than did calves born in other seasons. In contrast, calves born in the summer showed a tendency towards decreased DWG (Place et al., 1998). High temperatures during summer can lower immunity and transfer of maternal immunoglobulins to colostrum, the ability of calves to absorb immunoglobulins, and vitality of newborns.

Because the feed ration was the same throughout the year, the negative effects associated with summer are not based on forage quality. However, the effect of season on MY could be related to the changes in either temperature or photoperiod. According to Maltz et al. (2000), the summer-calving cows attained minimal BW sooner than winter-calving cows. They suppose that the negative energy balance during the summer modified the homeorhetic mechanism so that in comparison with winter-calving cows, more nutrients are diverted for repletion of body reserve on the account of their flow to the udder.

It seems that the low temperature in the winter enables a cow in the first third of lactation to express her full MY potential. Heat stress is therefore the main cause of lower MY in cows born and calving in the summer (Knizkova et al., 2000).

CONCLUSIONS

It can be concluded that in primiparous cows, growth during the liquid-feeding period, milk and its composition are affected by the housing of these cows to weaning, feeding milk or milk replacer, the sire line, and the season of birth and calving.

After calving, the animals kept from the second to seventh day of life in loose housing yielded more milk, FCM and protein than those kept in individual

housing. The heifers fed by nursing cows had the highest production of milk, FCM, protein, lactose, NSF and TS after the first calving and the heifers fed by CCF, the lowest.

We therefore recommend devoting more attention in practical conditions to the rearing of heifers descended from high-yielding cows by nursing cows. This method is still considered as extensive, but given the results of elevated milk production in primiparous cows, it would certainly be beneficial.

Effects of the sire were significant for DWG from birth to weaning, contents of fat, protein, lactose, NSF, TS, and yields of milk, lactose and NFS. This notable impact throughout the entire rearing period and lactation must be taken into account in sire selection.

Dairy cows born in the winter showed the highest growth to weaning and production of milk, protein, lactose, SNF and TS. Dairy cows calving in the winter and in the spring yielded the most milk, protein, lactose and SNF, while those calving in the summer, the least.

We presume that reducing the number of first-calf heifers in the summer would facilitate improving the balance of milk production in the course of the year. That means limiting the breeding of heifers in September and October and refraining from synchronizing oestrus during these months.

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STRESZCZENIE

Wpływ czynników środowiskowych i pochodzenia na wydajność i skład mleka krów w pierwszej laktacji

Celem pracy było zbadanie czy na wydajność mleka (MY) pierwiastek wpływa sposób ich utrzymania do odsadzenia, metoda żywienia dietą płynną, linia ojcowska, sezon urodzenia i wycielenia. Spośród 32 jałówek, od 2-go dnia życia 19 utrzymywano indywidualnie (IH), a 13 w pomieszczeniu wolnostanowiskowym (LH). W 7 -ym dniu życia cielęta IH podzielono na 2 grupy: 10 jałówek umieszczono w kojcu z automatycznym podawaniem preparatu mlekozastępczego (AF), 9 - otrzymywało mleko z wiader (BF). Jałówki z grupy LH były odchowywane przez krowy mamki (UF).

Po wycieleniu pierwiastki były utrzymywane w oborze wolnowybiegowej. W ciągu pierwszych 8 miesięcy laktacji krowy-pierwiastki z grupy LH wyprodukowały więcej mleka, a w ciągu 305 dniowej laktacji więcej mleka, FCM i białka ($P < 0,05$). W pierwszej laktacji największą MY i FCM osiągnęły krowy UF (6894,1 i 6541,9 kg), najniższą krowy AF (5757,5 i 5820,9 kg; $P < 0,01$).

Zawartość tłuszczu oraz s.m. (TS) w mleku była największa u krów AF. Wystąpiły różnice w zawartości tłuszczu, białka, laktozy, s.m. beztłuszczowej, TS oraz MY w zależności od pochodzenia krów. MY:FCM były niższe u krów urodzonych i wycielonych latem, najwyższe u krów urodzonych i wycielonych zimą i wiosną.