Effects of rearing, sire and calving season on growth and milk efficiency in dairy cows

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ABSTRACT: 32 primiparous cows were used. We tested the hypotheses that live weight and milk efficiency were influenced by the system of rearing from the second week of life to weaning, by the sire, and by the season of calving. Three groups were created according to a rearing system (A – pens with automatic drinking cups, H – individual huts and N – pens with nursing cows). Primiparous cows originated from four sires and were divided according to the season of calving (spring, summer, autumn and winter). Group N had the highest LW (540.5 kg) and group A the lowest (504.8 kg) in the 1st month of the first lactation. In the 10th month of lactation, the weights were 554.5 kg (A), 566.9 kg (H), and 575.1 kg (N). ADG from the 2nd to 10th month of lactation were statistically different between the groups. Other significances were found by the comparison of animals according to sires ($P < 0.05$). Group N had the highest milk efficiency almost in all months of lactation. The lowest production was recorded in group A. Daughters of the sire F_3 reached the highest milk production except the seventh and eighth months. Significant differences were calculated in the 5th and in the 6th month between daughters of sires F_3 and F_1. Dairy cows calving in summer showed the lowest milk yield in the 3rd, 4th, 7th and 9th month. The most productive were cows calving in WIN and in SP. Group N achieved the highest production of milk for 305-day lactation (N 6 894.1 ± 879.8 kg) and animals fed from automatic drinking cups the lowest (A 5 757.5 ± 865.5 kg). A similar trend was recorded also in FCM milk. The content of fat was highest in group A (4.1%) and the lowest in group H (3.57%). Animals of group N produced highly significantly more proteins than group A (215.3 kg versus 180.9 kg, $P < 0.01$). Group A produced the significantly lowest amount of lactose and nonfat solids over 305 days of lactation. The content of total solids was the highest in group A. Production of total solids was the highest in group N and the lowest in group A (846.5 kg versus 749.8 kg; $P < 0.05$). The effect of the sire lineage was significantly expressed in milk production and in the content of fat, proteins, lactose, nonfat solids and total solids. The production of milk, proteins, lactose, nonfat solids and content of fat and lactose for 305-day lactation statistically differed according to the season of calving. Dairy cows calving in WIN yielded the highest amount of milk and proteins, cows calving in SP produced the highest amount of lactose and nonfat solids. Dairy cows calving in SU produced the lowest amount of milk, protein, lactose and nonfat solids.

Keywords: dairy cows; rearing; sire; season of calving; growth; milk production; milk composition

Abbreviations: LW = live weight; ADG = average daily gain; SP = spring; SU = summer; AU = autumn; WIN = winter

In the present agriculture, farm animals should be kept in harmony with their physiological and safety needs and should manifest natural behaviour. Modern methods of animal husbandry should be based on these principles. We can suggest five critical spheres: relation between mother and calf, life in the group of animals of the same age, possibility of exercise, manner of milk drinking, friendly environment, etc.

Dairy cows are the only mammalian domestic animals that are routinely separated from their offspring immediately after giving birth. The mutual relation between mother and descendant is violently interrupted if it were ever formed (Krohn, 2001). Apart from immediate welfare problems, the early separation of mother and calf is likely to have negative implications for the health, e.g. poor udder health, endemic calf diseases (diarrhoea and respiratory diseases), high susceptibility to stress and disease, and instability of social structures in the herd (Albright and Arave, 1997).

Calf housing can be a major source of weakness in animal welfare. Animals can be housed in groups or in individual pens, under conditions ranging from complete environmental control to minimal shelter, and provided with a wide range of space per animal. A good calf and heifer housing facility can help provide well-grown replacement animals ready to enter the milking herd at 24 months of age (Heinrichs *et al.*, 1994).

Raising calves for replacements is an expensive item on dairy farms. Healthy, productive herd replacements are the result of good management from birth until the cow enters the milking herd. The variety of housing systems used for heifer-calf rearing has been outlined. According to Wells *et al.* (1996) in the USA 42.3% of calves are kept in calf huts, 21.1% in individual pens in calf barns and 10.5% in cow barns, 8.4% tied in cow barns and 4.7% tied in calf barns, 13% are reared in group pens (6.4% in calf barns and 6.6% in cow barns).

Heifers reared during the milk-feeding period in isolation produced significantly more milk than heifers from group housing (Arave *et al.*, 1985). In a similar experiment using monozygous twins Arave *et al.* (1992) found that pre-weaning isolation affected growth but it did not affect the first lactation milk yield. Except the system of rearing genetic factors can also influence milk production, especially sire lineage (Šoch *et al*., 1998; Gavalier *et al*., 2000; Bouška *et al*., 2003), environment or season of the year (Žižlavský and Mikšík, 1986; Suchánek, 1987; Kadlečík *et al*., 1992; Brouček *et al*., 1995).

The aim of this experiment was to study the influence of the rearing system of dairy heifers on their live weight and milk production in the first lactation.

MATERIAL AND METHODS

We tested the hypotheses that live weight and milk efficiency were influenced by the system of rearing from the second week of life to weaning (factor SR), by the sire lineage (factor F) and by the season of calving (factor C).

Tested factors

We used 32 Holstein heifers for this purpose. On the second day, they were randomly divided into two groups after having nursed their mothers for the first day. Heifers from the first group were moved from individual maternity pens to individual huts (19 heifers), heifers from the second group remained in maternity pens with mothers (13 heifers). Ten heifers were randomly taken from individual huts on the seventh day and relocated to loose housing pens with automatic drinking cups for milk (group A). The remaining nine heifers remained in individual huts (group H).

Heifers that were with mothers until the seventh day ($n = 13$) were moved to a group pen with nursing cows (group N). Thus, three groups of animals were created according to the system of rearing during the milk-feeding period (A, H and N, factor SR).

Experimental heifers originated from four sires: F_1 (BS-19, $n = 8$), F_2 (BS-22, $n = 6$), F_3 (DIX-1, $n = 9$) and F_4 (KLK-2, $n = 9$) – factor F.

Experimental heifers calved throughout the year, therefore they were divided into four groups: C_1 (March–May, $n = 10$), C_2 (June–August, $n = 6$), C_3 (September–November, $n = 8$), C_4 (December to February, $n = 8$) – factor C.

All animals were weaned at the age of 8 weeks. The animals of all groups were kept in common group pens in loose housing with bedding in age-balanced groups after weaning. Heifers were moved to group pens of the maternity barn three weeks before the expected date of calving, and three days before the expected date of calving or after the appearance of calving symptoms they were moved to individual maternity pens 4.5 m × 4.5 m in size where they calved. They were kept in the same housing conditions during the first lactation.

Feeding

All calves sucked colostrum from mothers *ad libitum* during the first 24 hours. Calves from groups A and H received colostrum and mother's milk *ad libitum* three times a day from a bucket with nipple from the second to the seventh day. From the second to the seventh day calves of group N sucked mother's udders three times per day. Mothers were milked from the second day after calving.

Calves of treatment A drank from automatic drinking cups since the morning of the eighth day. After the first three days, when milk replacer started to be administered, they received 6 kg of milk replacer per day divided into 4 portions in 6-hour intervals. The amount of milk replacer was increased to 8 kg per day since the 28th day. After the first three days, when milk replacer started to be administered, calves of treatment H received 6 kg of milk replacer per day from a bucket with nipple divided into 2 portions in 12 h intervals, and 8 kg per day in two portions since the 28th day. Milk replacer contained minimally 20% of proteins and minimally 20% of fat. Animals from treatment N were moved to a nursing cow pen on the eighth day in the morning. The number of calves per one nursing cow was determined according to their milk yield (6 kg milk per each calf). Maximally 3 cows were housed in one pen 8 m × 4.5 m in size.

From the second day to weaning the calves received starter mixtures and lucerne hay *ad libitum*. They received 1.5 kg of concentrate mixture per day and lucerne hay *ad libitum* from weaning to six months of age. From the age of 90 days they were also fed maize silage. The heifers were fed according to the current standard specifications from the age of 180 days to calving. Maize silage and lucerne hay formed the basis of feed rations all the year round.

From the 181st day, all heifers were fed the same diet according to Slovakian recommendations for intake of dry matter to attain 0.75 kg average daily gains. They received 1.5 kg of concentrate mixture per day until breeding, then 1 kg until the 5th month of gestation, and this amount was gradually increased to 3 kg per day until calving. Equal conditions of nutrition were ensured in all groups.

After calving, during the first lactation, the heifers were fed a mixed diet consisting of maize silage, lucerne haylage, lucerne hay, barley straw, brewer's grains, sugar-beet pulp, and concentrate mixture for high-yielding cows.

The total mixed ration was supplied to troughs by a feeding wagon once a day during milking. Feeding was allowed throughout the 24-hour period, except during milking. The total mixed ration was balanced according to Slovakian nutrient requirements of dairy cattle. The feed ration included the factors and equations adopted for maintenance, growth, reproduction and lactation. First-calvers were kept in pens with free-stall housing and fed according to the stages of lactation.

Early lactation (first four months): feed ration contained 19.8 kg dry matter, 130 MJ NEL, 1.84 kg PDI, 2.86 kg crude protein and 3.43 kg crude fibre. Calculated milk efficiency of this total mixed ration was 32 kg milk.

Mid-lactation (5th to 7th month): Feed ration contained 18.29 kg dry matter, 120.1 MJ NEL, 1.65 kg PDI, 2.67 kg crude protein and 3.42 kg crude fibre. Calculated milk efficiency of this total mixed ration was 27 kg milk.

Late lactation: Feed ration contained 16.7 kg dry matter, 104.5 MJ NEL, 1.44 kg PDI, 2.31 kg crude protein. Calculated milk efficiency of this total mixed ration was 20 kg milk.

Observations

Cows were milked twice daily in a 2 × 5 stall herringbone parlour. Milk yield was measured once weekly (each Tuesday PM, Wednesday AM) by Tru-tests and samples were taken twice monthly to determine milk composition in composite AM-PM samples. Fat, protein, lactose, nonfat solids, total solids and somatic cell counts were determined by the Milk Laboratory (RIAP, Nitra, Slovak Republic) using an infrared analyser.

The weight of each cow was measured monthly. Heifers were bred for the first time when they were at least 16 months old or when they reached about 360 kg. Reproduction and health were observed. The ages at calving (A = 822 d, H = 814 d, N = 828 d) were not significant.

Table 1. Effect of sire line on average daily gains (kg)

Sire	*n*	Mean	S.D.	Min	Max	Significance
Month 2–10						
F_1	8	0.53	0.29	0.14	0.93	9.67
F_2	6	0.11	0.21	–0.03	0.53	0.0216*
F_3	9	0.14	0.40	–0.60	0.87	$F_1 : F_2$*
F_4	9	0.25	0.16	0.07	0.63	

*$P < 0.05$; S.D. = standard deviation of the mean; F = sire

Statistical evaluation

The data were analysed with a statistical package Statistix (Analytical Software, Tallahassee, FL, USA). The normal distribution of data was evaluated by Wilk-Shapiro/Ranking Plot procedure. We found that in the case of the assessment of ADG and somatic cell counts, one or few points departed from the linear trend of the plot indicating non-normality. Approximate Wilk-Shapiro normality statistics were also lower. For this reason, the Kruskal-Wallis ANOVA procedure was more suitable for the comparison of groups. Significant differences between groups were tested by Comparisons of Mean Ranks.

Between-group comparisons of body weights, milk production and milk composition were analysed using a general linear model ANOVA (General AOV/AOCV). Significant differences between means were tested by Bonferroni's test.

RESULTS AND DISCUSSION

Growth

Cows in group N had the highest LW (540.5 ± 52.6 kg) and cows from group A the lowest LW (504.8 ± 36.5 kg) in the first month of lactation. The differences were not significant. In the last, tenth month of lactation, the average weight was 554.5 ± 42.3 kg (A), 566.9 ± 45.3 kg (H), and 575.1 ± 58.3 kg (N). Differences in the comparison of the sire lineage and the season of calving were not significant.

ADG for the period from the second to the tenth month of lactation was statistically different between the groups during the milk-feeding period. The highest gain was recorded in animals of group A (0.41 ± 0.30 kg) and the lowest gain in cows from group N (0.09 ± 0.23 kg).

Other significances were found by the comparison of animals according to the sires ($P < 0.05$). Dairy cows after sire F_1 had a daily gain 0.53 ± 0.29 kg and daughters after sire F_2 only 0.11 ± 0.21 kg per day (Table 1).

Dairy cows of group N had an advantage of higher LW after calving. The difference of about 35.7 kg and 18.6 kg in comparison with group A and H could be obviously very important. That was caused by better growth in the rearing period. A number of studies showed that the feeding of increased quantities of milk or milk replacer improved the rate of calf weight gains (Appleby *et al*., 2001; Jasper *et al*., 2002). Our last results of the experiment using the same heifers before calving (Brouček *et al*., 2001) showed that the rearing conditions had a long-term effect on the growth variables. The calves fed by nursing cows grew faster than the conventionally fed calves before weaning, probably as a result of the higher intake of milk. And that even when we limited the amount of milk by the number of calves per one cow.

An increased growth in live weight in group N continued until the age of 630 days. The order of groups according to the average live weight at 21 months was: N (491 kg), H (486.5 kg), A (477 kg). However, the growth of first-calvers of group N did not continue like we had expected during the first lactation. Although these feed rations were calculated according to nutrient requirements, they were not sufficient for these dairy cows with regard to their high milk yield.

Milk production in individual months

As we can see in Table 2, cows from group N, which were nursed by cows during the milk-feeding period, had the highest milk efficiency throughout the first lactation. Animals of group H housed in individual huts yielded more only in the third, ninth and tenth months. The lowest milk efficiency in all months was recorded in first-calvers that drank from automatic drinking cups throughout the milk-feeding period (group A).

A significant difference was found between groups N and A (factor SR) in the sixth month of lactation (694.1 ± 120.2 kg versus 560.4 ± 116.4 kg, $P < 0.05$). A highly significant difference was recorded in the comparison of groups H, N and A (839.6 ± 182.3 kg and 800.4 ± 146.4 kg versus 619.6 ± 151.1 kg, $P < 0.01$) in the third month. Highly significant differences were documented in the fifth month of lactation, when group N milked 780.5 ± 132.2 kg, group H 729.9 ± 93.5 kg and group A only 553.3 ± 93.7 kg (D : A, $P < 0.001$; B : A, $P < 0.01$).

This can be explained by nutrition during the milk-feeding period of these first-calvers. Animals of group N received more valuable liquid nutrition from the udder probably in higher amounts than animals from groups A and H. Bar-Peled *et al.* (1997) used calves that were fed milk replacer in open buckets or were allowed to suckle the dam three times daily. The results indicated that the calves that sucked milk during the first 42 d of age had higher average daily

Table 2. Milk yield during lactation (kg)

Group	*n*	Mean	S.D.	Min	Max	Significance		
						SR	F	C
Month 1								
A	10	536.7	94.9	443.8	767.3	n.s.	n.s.	n.s.
H	9	600.8	152.9	460.6	973.7			
N	13	697.2	180.5	454.6	1 007.7			
Month 2								
A	10	671.5	140.2	494.9	917.7	n.s.	n.s.	n.s.
H	9	712.4	98.9	554.4	866.6			
N	13	739.5	109.7	620.9	991.9			
Month 3								
A	10	619.6	151.2	316.4	895.3	5.47	n.s.	8.55
H	9	839.6	182.3	541.1	1 136.8	0.0097**		0.0003***
N	13	800.4	146.4	618.1	1 020.6	H,N : A*		$C_{4,1}$: C_2**C_4 : C3*
Month 4								
A	10	636.7	173.8	316.4	895.3	n.s.	n.s.	n.s.
H	9	747.9	136.8	522.2	996.8			
N	13	777.2	128.7	581.7	993.3			
Month 5								
A	10	553.3	93.7	425.6	710.5	12.40	4.15	5.23
H	9	729.9	93.5	633.5	931.7	0.0001***	0.0149*	0.0054**
N	13	780.5	132.2	637.0	1 151.5	N : A***	F_3 : F_1*	$C_{4,1}$: C_3*
Month 6								
A	10	560.4	116.4	444.5	816.2	3.70	3.59	5.41
H	9	679.0	135.7	427.0	892.8	0.0370*	0.0260*	0.0046**
N	13	694.1	120.2	462.7	904.4	N : A*	F_3 : F_1*	$C_{4,1}$: C_2*
Month 7								
A	10	554.1	104.3	389.9	710.5	n.s.	n.s.	n.s.
H	9	594.8	118.2	434.0	841.0			
N	13	631.8	105.3	458.5	761.9			
Month 8								
A	10	533.6	123.0	263.9	699.3	n.s.	n.s.	n.s.
H	9	585.5	70.4	495.6	691.6			
N	13	642.8	131.2	471.8	865.2			
Month 9								
A	10	523.2	172.6	282.8	866.6	n.s.	n.s.	n.s.
H	9	579.2	121.6	460.6	816.2			
N	13	537.8	103.3	382.2	693.0			
Month 10								
A	10	568.3	133.1	323.4	770.4	n.s.	n.s.	n.s.
H	9	613.4	74.5	513.2	736.3			
N	13	592.7	142.4	412.5	821.0			

S.D. = standard deviation of the mean
SR = system of rearing; F = sire; C = season of calving
A = pen with automatic drinking cups for milk; H = individual hut; N = pen with nursing cows
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Table 3. Milk yield and milk composition for 305-day of lactation

Group	*n*	Mean	S.D.	Min	Max	Significance		
						SR	F	C
Milk (kg)								
A	10	5 757.5	865.5	4 350.1	7 121.7	5.57	4.21	4.01
H	9	6 696.1	746.0	5 415.9	8 022.3	0.0090**	0.0141*	0.0171*
N	13	6 894.1	879.8	5 485.6	8 935.6	N : A**	$F_3 : F_{1,4}$*	
Fat corrected milk								
A	10	5 820.9	797.3	4 552.7	6 874.0	3.42	n.s.	n.s.
H	9	6 170.3	469.3	5 628.3	6 840.7	0.0463*		
N	13	6 541.9	649.2	5 479.3	7 645.0	N : A*		
Fat (%)								
A	10	4.10	0.40	3.56	4.65	3.61	7.34	3.44
H	9	3.57	0.55	2.92	4.38	0.0399*	0.0009***	0.030*
N	13	3.75	0.37	2.77	4.12	A : H*	$F_{2,1,4} : F_3$**	
Fat (kg)								
A	10	234.5	33.6	179.0	279.4	n.s.	n.s.	n.s.
H	9	232.8	26.1	202.3	280.5			
N	13	252.3	28.8	205.9	301.6			
Protein (%)								
A	10	3.14	0.16	2.86	3.42	n.s.	3.61	n.s.
H	9	3.11	0.11	2.97	3.33		0.0255*	
N	13	3.15	0.14	2.91	3.42		$F_4 : F_2$*	
Protein (kg)								
A	10	180.9	27.5	138.7	215.4	5.93	2.75	4.69
H	9	206.9	20.7	164.8	233.5	0.0069**	0.0611	0.0090*
N	13	215.3	23.9	181.8	270.8	N : A**		$C_4 : C_2$*
Lactose (%)								
A	10	4.95	0.09	4.76	5.05	n.s.	2.94	3.16
H	9	5.07	0.11	4.89	5.26		0.0499*	0.0403*
N	13	4.99	0.10	4.84	5.14		$F_3 : F_2$*	$C_1 : C_3$*
Lactose (kg)								
A	10	285.0	40.6	217.7	349.3	5.78	4.82	4.35
H	9	340.0	40.8	264.8	409.5	0.0077**	0.0079**	0.0123*
N	13	342.9	47.7	264.5	461.0	N,H : A*	$F_3 : F_{1,4}$*	
Nonfat solids (%)								
A	10	8.93	0.26	8.61	9.39	n.s.	4.28	n.s.
H	9	8.97	0.23	8.61	9.21		0.0131*	
N	13	8.85	0.29	8.39	9.33		$F_{4,1} : F_2$*	
Nonfat solids (kg)								
A	10	515.3	67.5	388.3	615.2	5.33	3.57	4.16
H	9	599.9	68.7	464.6	714.7	0.0107*	0.0264*	0.0148*
N	13	608.9	78.4	497.9	810.9	N : A*	$F_3 : F_4$	

Continuation of Table 3.

Group	n	Mean	S.D.	Min	Max	Significance		
						SR	F	C
Total solids (%)								
A	10	13.14	0.74	12.19	14.54	3.96	5.44	n.s.
H	9	12.56	0.59	11.74	13.40	0.0302*	0.0045**	
N	13	12.41	0.57	11.18	13.42	A : N*	F_1 : F_3**	
Total solids (kg)								
A	10	749.8	95.5	583.7	883.5	3.74	n.s.	n.s.
H	9	832.9	74.1	700.9	954.6	0.0359*		
N	13	846.5	90.9	717.2	1 072.6	N : A*		
Somatic cell counts in thousands per millilitre								
A	10	169.4	225.8	35.4	755.9	n.s.	n.s.	n.s.
H	9	273.4	353.1	20.3	1 082.5			
N	13	257.9	184.9	32.7	555.1			

S.D. = standard deviation of the mean
SR = system of rearing; F = sire; C = season of calving
A = pen with the automatic drinking cups for milk; H = individual hut; N = pen with nursing cows
*P < 0.05;**P < 0.01;***P < 0.001

gains, earlier age at calving, and a tendency of higher milk production than did calves fed milk replacer. Similarly in the experiment of Khalili *et al.* (1992), calves given a high level of milk or milk replacer in early life had a live-weight advantage over similar calves given a lower level of milk. Calves fed more milk remained healthy and gained weight much more rapidly before weaning. This live weight was subsequently maintained. The weight advantage of the *ad libitum*-fed calves persisted for at least several weeks after weaning (Jasper *et al*., 2002).

Another reason why dairy cows fed from automatic drinking cups produced the lowest amount of milk can be their worse health condition at weaning. Calves that receive milk replacer sucking from a common nipple can catch an infection from another ill calf very easily (Doležal *et al*., 2001), and retardation of growth after survived illness is a generally known fact.

Daughters of sire F_3 achieved the highest milk production except in the seventh and eighth months. Significant differences ($P < 0.05$) were calculated in the fifth (799.2 ± 157.9 kg vs. 602.1 ± 113.4 kg) and the sixth months (756.4 ± 118.1 kg vs. 590.8 ± 100.8 kg), always in daughters of sires F_3 and F_1 (Table 2).

Negative effects of the summer period were recorded in the evaluation by the season of calving. Dairy cows calving in C_2 (summer) showed the lowest milk yield in the third, fourth, seventh and ninth months of lactation. The most productive were cows calving in C_4 and C_1.

A very highly significant difference ($P < 0.001$) was found in the comparison of all groups of animals in the third month (C_4 874.7 ± 106.6 kg and C_1 845.0 ± 169.8 kg vs. C_2 563.1 ± 133.6 kg, $P < 0.01$; C_4 874.7 ± 106.6 kg vs. C_3 666.4 ± 116.6 kg, $P < 0.05$). Other highly significant differences were recorded in the fifth (C_4 771.0 ± 77.3 kg and C_1 770.3 ± 161.3 kg vs. C_3 581.6 ± 76.9 kg) and the sixth (C_4 715.9 ± 105.5 kg and C_1 713.9 ± 126.9 vs. C_2 517.8 ± 88.7 kg) months (Table 2).

305-day lactation

The first-calvers reared by nursing cows displayed the highest production of milk (N 6 894.1 ± 879.8 kg) and animals fed from automatic drinking cups the lowest (A 5 757.5 ± 865.5 kg) (Table 3). Animals from huts (group H) neared the level of group N (B 6 696.1 ± 746.0 kg). There was a highly significant difference between groups N and A ($P < 0.01$).

A similar trend was also recorded in the case of FCM milk (N 6 541.9 ± 6 549.2 kg versus A 5

820.9 ± 797.3 kg, $P < 0.05$). The content of milk fat was highest in group A (4.10 ± 0.40%) and lowest in group H (3.57 ± 0.55%). The difference was significant ($P < 0.05$). The highest production of milk fat, though not significantly, was recorded in group N (252.3 ± 28.8 kg). In the other groups the differences were negligible (A 234.5 ± 33.6 kg and H 232.8 ± 26.1 kg).

Minimal differences were found between the groups in the content of milk protein (Table 3). A significant differentiation of groups occurred only in the production of milk protein. Animals of group N produced highly significantly more than first-calvers from group A (215.3 ± 23.9 kg versus 180.9 ± 27.5 kg, $P < 0.01$).

Another component of milk, lactose, differed significantly ($P < 0.01$) only in the production over 305 days of lactation. Dairy cows of group A fed from automatic drinking cups during the milk-feeding period produced the least lactose (285.0 ± 40.6 kg), but differences between group N (342.9 ± 47.7 kg) and group H (340.0 ± 40.8 kg) were minimal.

Production of nonfat solids (Table 3) was the lowest in group A (515.3 ± 67.6 kg; H 599.9 ± 68.7 kg and N 608.9 ± 78.4 kg). The difference between groups A and N was significant ($P < 0.05$). The content and production of total solids differed significantly in the comparison of observed groups (Table 3). The content of total solids was the highest in group A, and the difference between A and N was significant (13.14% versus 12.41%). On the contrary, production of total solids was the highest in group N and the lowest in group A (846.5 kg versus 749.8 kg; $P < 0.05$).

No significant difference was found in the counts of somatic cells (Table 3), the value was the highest in group H and the lowest in group A (A 169.400 ± 225.800 per ml, H 273.400 ± 353.100 per ml, N 275.900 ± 184.900 per ml).

Effects of the sire lineage were shown highly significantly in the milk fat content ($P < 0.001$). Daughters of F_3 had the lowest content of milk fat (Table 3), and consequently the differences between their group and the other three groups were significant (F_2 4.11 ± 0.29%, F_1 3.97 ± 0.42%, F_4 3.96 ± 0.33% versus F_3 3.33 ± 0.40%; $P < 0.01$).

The production of lactose and content of milk solids differed highly significantly. Daughters of F_3 produced the highest amount of lactose (368.8 ± 48.5 kg) while daughters of sires F_1 (305.1 ± 47.6 kg) and F_4 (299.8 ± 34.1 kg; $P < 0.05$) the lowest.

The highest content of total solids was found in groups descending from sire F_1 (13.15 ± 0.80%) and F_4 (12.94 ± 0.42%), the lowest content was recorded in daughters after sire F_3 (12.07 ± 0.43%). Differences between groups F_1 and F_3 were statistically highly significant, and between groups F_4 and F_3 (Table 3) significant.

Statistical significances ($P < 0.05$) were shown in indexes of milk production, contents of milk protein and lactose as well as in the content and production of nonfat solids (Table 3).

Daughters of father F_3 produced the highest amount of milk, and the differences were significant in comparison with daughters of fathers F_1 and F_4 (F_3 7 255.8 ± 879.8 kg; F_1 6 098.8 ± 929.8 kg; F_4 5 988.3 ± 618.4 kg).

Daughters of sire F_4 had the highest content of milk protein in milk (3.24 ± 0.14%) and daughters of F_2 the lowest (3.06 ± 0.11%). The difference was significant ($P < 0.05$).

The highest content of lactose was found out in daughters of sire F_3 and the lowest in daughters of sire F_2 (Table 3). The content of nonfat solids was the highest in groups F_4 (9.02 ± 0.20%) and F_1 (9.01 ± 0.27%) and the lowest in group F_2 (8.62 ± 0.25%). Differences in the levels of F_4 and F_1 were significant in comparison with F_2. Daughters of sire F_3 produced the highest amount of nonfat solids and daughters of sire F_4 the lowest (643.7 ± 83.8 kg versus 540.2 ± 59.1 kg; $P < 0.05$).

The genetic effects on milk production can be clearly manifested by the study of the effect of sires. The sire lineage influences a large part of the population so its genetic qualities are effective as a stabilization factor. The sire is effective during a relatively short period in the herd, so the complex of factors to which its daughters are exposed during rearing should not be of such variability (Frelich and Voříšková, 1997; Košvanec *et al*., 1998; Kúbek *et al*., 2000).

Productions of milk, protein, lactose, and nonfat solids for 305-day lactation statistically differed ($P < 0.05$) according to the season of calving (Table 3). Dairy cows calving in C_4 and in C_1 yielded the most (6 942.5 ± 530.6 kg and 6 924.9 ± 987.6 kg, respectively) while dairy cows calving in C_2 yielded the least (5 764.4 ± 948.4 kg). The cows calving in the C_2 season had the highest content (4.098 ± 0.31%) and cows calving in C_1 the lowest (3.48 ± 0.44%).

Dairy cows calving in C_4 produced the highest amount of milk protein (218.9 ± 13.1 kg) and dairy cows calving in C_2 the lowest (178.7 ± 32.5 kg). The content of lactose was the highest in the group of dairy cows calving in C_1 and the lowest in the group calving in C_3 (5.07 ± 0.11% versus 4.92 ± 0.09%; $P < 0.05$). The production of lactose was also statistically different (C_1 351.9 ± 54.4 kg, C_4 343.7 ± 24.8 kg, C_3 296.1 ± 38.7 kg, C_2 288.5 ± 48.1 kg; $P < 0.05$).

Similar results were obtained in the production of nonfat solids: dairy cows calving in the spring produced the most and dairy cows calving in the summer the least (C_1 620.5 ± 88.9 kg, C_4 611.5 ± 37.3 kg, C_3 529.5 ± 65.5 kg, C_2 522.6 ± 81.9 kg; $P < 0.05$).

The content and production of protein are significantly affected by month of calving. Kadlečík *et al.* (1992) recorded a decrease in production in the period from May to October in Slovak cattle. Holstein dairy cows decreased production from April to September with a minimum in June. According to Žižlavský and Mikšík (1986), pluriparous dairy cows calving in October to December had the highest milk production. Primiparous cows calving in July to September had the lowest production. The highest percentage of fat was observed in dairy cows calving in July to September.

According to earlier sources (Suchánek, 1987), the effect of season on milk yield manifests above all in different nutrition and feeding of dairy cows. A feed ration of higher quality in the summer resulted in higher production in comparison with the winter period. However, this should not be true provided that the total mixed ration is balanced and uniform throughout the year. Apart from nutrition, the length of daylight and different activity of the thyroid gland can also come into play (Tančin, 1991; Dahl *et al.,* 1997).

Dairy cows calving in the period from December to April would reach higher average production during lactation, particularly due to the effect of higher persistency of the lactation curve. According to Suchánek (1987), the least favourable periods of calving as regards milk production are the months of July and August. Dairy cows have low persistency of the lactation curve during the decreasing daylight. The most favourable persistency of the lactation curve is in dairy cows calving in January and February, i.e. during a subsequent prolongation of daylight. The least milk is produced by dairy cows calving in the summer and the highest production is achieved by cows calving in the winter or early spring (Rybanská and Bujko, 2002).

The reason why the summer season displayed more negative effects is obvious. Our findings agree with data of Nový *et al.* (1997), Dolejš *et al.* (1998), Knížková *et al.* (2002). Hot weather causes heat stress in dairy cattle leading to declines in feed intake and production. Thermal stress results in changes in metabolic rate and maintenance requirements, increased evaporative water loss, increased respiration rate, changes in blood hormone concentrations, and redistribution of total blood flow (Brouček *et al.*, 1998; Koubková *et al*., 2002). Decreased milk production is associated with adaptations to heat stress. Higher-yielding cows are generally the most susceptible to heat stress. The failure of homeostasis at high temperatures may lead to reduced productivity or even death.

In general, milk yield increases 8–10% on long days, and cows eventually increase intake to support the higher milk yield. The photoperiod does not affect protein or solids content of milk, but it can cause slight decreases in fat content (Dahl *et al*., 1997).

CONCLUSIONS

We studied if the live weight and milk efficiency of dairy cows are impacted by the method of rearing from the second week of life to weaning, their sire, and by the season of calving. Analyses showed clear evidence that these factors influence growth, production and composition of milk.

The highest LW and milk production were recorded in dairy cows that were reared by nursing cows during the milk-feeding period. On the contrary, the lowest LW and milk production were recorded in dairy cows that were fed from automatic drinking cups until weaning. In the comparison of animals according to the sire significant differences in milk performance were found.

Milk efficiency for 305-day lactation was statistically different according to the season of calving. The highest amount of milk and protein was produced by dairy cows calving in the winter, cows calving in the spring yielded the highest content of lactose and nonfat solids. The lowest productions of milk, protein, lactose and nonfat solids were observed in dairy cows calving in the summer.

These results demonstrate that the system of calf rearing is an important determinant of milk production during the first lactation. Dairy cows should not be stressed by elevated temperatures.

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ABSTRAKT

Vlivy odchovu, otce a období otelení na růst a mléčnou užitkovost dojnic

Bylo použito 32 prvotelek. Testovali jsme hypotézy, že živá hmotnost a mléčná užitkovost jsou ovlivňovány metodou odchovu od druhého týdne života do odstavu otcem a obdobím otelení. Vytvořily se tři skupiny podle odchovu (A – kotec s mléčným automatem, H – individuální boudy a N – kotec s kojnými kravami). Prvotelky pocházely od čtyř otců a byly rozděleny podle období otelení (jaro, léto, podzim, zima). Skupina N měla nejvyšší živou hmotnost v prvním měsíci prvé laktace (540,5 kg) a skupina A nejnižší (504,8 kg). V 10. měsíci byly hmotnosti 554,5 kg (A), 566,9 kg (H), a 575,1 kg (N). Průměrný denní přírůstek od 2. do 10. měsíce laktace byl statisticky rozdílný mezi skupinami odchovu. Další průkaznosti v růstu se zjistily v porovnání zvířat podle původu ($P < 0,05$). Skupina N prokázala nejvyšší dojivost téměř ve všech měsících laktace. Nejnižší produkce se zaznamenala ve skupině A. Mimo 7. a 8. měsíce dosáhly nejvyšší produkci mléka vždy dcery otce F_3. Průkazné rozdíly byly vypočítány v 5. a 6. měsíci mezi dcerami býků F_3 a F_1. Dojnice otelené v létě prokázaly nejnižší dojivost ve 3., 4., 7. a 9. měsíci. Nejproduktivnější byly dojnice otelené v zimě a na jaře. Skupina N dosáhla nejvyšší produkci mléka za 305denní laktaci (N 6 894,1 ± 879,8 kg) a zvířata napájená mléčným automatem nejnižší (A 5 757,5 ± 865,5 kg). Podobný trend byl zaznamenán i v případě FCM mléka. Obsah tuku byl nejvyšší u skupiny A (4,1 %) a nejnižší u skupiny H (3,57 %). Zvířata skupiny N produkovala vysoko signifikantně více bílkovin než skupina A (215,3 kg proti 180,9 kg, $P < 0,01$). Skupina A vyprodukovala za 305 dní laktace průkazně nejméně laktózy a beztukové sušiny. Obsah celkové sušiny byl nejvyšší ve skupině A. Produkce celkové sušiny byla nejvyšší u skupiny N a nejnižší u skupiny A (846,5 kg proti 749,8 kg; $P < 0,05$). Vliv původu po otci se průkazně dokázal v produkci mléka, obsahu tuku, bílkovin, laktózy, beztukové a celkové sušiny. Produkce mléka, bílkovin, laktózy, beztukové sušiny a obsahy tuku a laktózy za 305denní laktaci byly průkazně rozdílné podle období otelení. Nejvíce mléka a bílkovin produkovaly dojnice otelené v zimě, dojnice otelené na jaře vyprodukovaly nejvíce laktózy a beztukové sušiny. Nejméně mléka, bílkovin, laktózy a beztukové sušiny nadojily dojnice otelené v létě.

Klíčová slova: dojnice; odchov; otec; období otelení; růst; produkce mléka; složení mléka

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