Effects of Some Management Factors on Milk Production in First-calf Heifers

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ABSTRACT : The objective of this study was to investigate whether milk performance is impacted by the housing of heifers from the second to the seventh day of life, the method of feeding milk from the second week of life to weaning, the sire lineage and by the season of birth and season of calving. From 32 Holstein heifer-calves, which spent their first day of life in a loose housing maternity pen with their mother, 19 heifers were randomly placed in hutches (IH), and 13 stayed in a loose housing maternity pen (MP). At the seventh day IH heifers were assigned to one of two treatments, 10 heifers were randomly taken from IH and relocated to a loose housing pen with an automatic feeding station (AD), 9 calves stayed in hutches with bucket drinking (BD). MP heifers were moved to a group pen with nursing cows (UD). All animals were weaned at the age of 8 weeks (56 days) and kept in group pens. After calving, they were in free-stall housing. Trial cows were divided according to the sire, season of birth and calving. The five-factorial ANOVA revealed that among all the factors taken into account in this study, only sire lineage and season of birth had significant effects. The production of milk, FCM and protein were higher in the MP group than in the IH group. The UD group tended to have the highest production of milk, FCM, protein, lactose, SNF and total solids (TS) and the AD group the lowest. The content of fat and TS were highest in the AD group. Effects of the sire were significant for average daily gains (ADG) from birth to weaning (0.55±0.03 kg, $p<0.05$), contents of fat (3.81±0.08%, $p<0.05$), protein (3.13±0.02%, $p<0.05$), and TS (12.67±0.12%, $p<0.05$). In the season of birth evaluation, statistical difference was found only in the content of protein (3.13±0.13%, $p<0.05$). Cows born in March-May had the highest % protein and cows born in June-August the lowest (3.21±0.04 vs. 3.06±0.05%). Dairy cows born and subsequently calving in December-February had the highest production of milk, protein and TS, and dairy cows born in June-August the lowest. FCM and fat yields were highest in the group born in September-November and lowest in the group born in June-August. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 5 : 672-678)***

Key Words : Dairy Cow, Milk Performance, Rearing, Housing, Sire Lineage, Season of Birth and Calving

INTRODUCTION

Pre-weaning environment of calves may have an important impact on adult performance. It is probable that very early weaning reduces adaptive abilities of calves and decreases their resistance to stress during some management procedures, particularly during group mixing and transport. In many herds, calves are removed from their mother immediately after birth and fed with milk replacer from the fourth day of life. Only about 10% of calves, particularly from small herds, are fed with whole milk until weaning (Krohn et al., 1999).

Appropriate housing facilities can help to insure that well-grown replacement heifers are ready to enter the milking herd at 24 months of age. The early separation of the calf from the cow is popular in the dairy industry, and is deemed by some to be essential to maximize production. Other advantages of weaning calves as early as possible are the reduction in the risk of diseases associated with milk feeding and the savings in food and labor costs. Others consider this practice to be against nature. Uncontrolled access to the cow by the calf can reduce milk yield, but growth rate of nursed calves is faster than the separated calves (Broucek et al., 1995; Paputungan and Makarechian, 2000).

Spatial restriction in individual housing can have a stressful effect. However, 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 did not affect first lactation milk yield. The milk production is seasonally affected by several factors including the animal’s endocrine and metabolic state (Cho et al., 2004; Lee and Han, 2004).

The objective of this study was to determine whether the milk production of heifers are affected by their housing at the first week of life, the feeding of milk or milk replacer, the sire line and the season of birth and calving. We tested hypotheses (H_0) that growth of BW during milk-feeding period and after the first calving, milk and composition of milk are not impacted by the housing of heifers from the second to seventh day of life (factor H), the sire lineage (factor S), the season of calving (factor C), the method of feeding milk from the second week of life to weaning (factor F), and by the season of birth (factor B).

MATERIALS AND METHODS

Management of the experiment

Effect of sire lineage (Factor sire lineage S) : Trial

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Received July 5, 2005; Accepted December 30, 2005

heifers were originated from four sires: group S_1 (n = 8), group S_2 (n = 6), group S_3 (n = 9) and group S_4 (n = 9).

Effect of season of birth (Factor season of birth B) : Trial animals were born throughout the year, therefore, they were divided according to the date of birth in individual seasons of the year into four groups: group B_1 (March-May; average temperature (AT) 9.1°C; n = 3), group B_2 (June-August; AT 20.8°C; n = 7), group B_3 (September-November; AT 8.6°C; n = 6), group B_4 (December-February; AT-2.5°C; n = 16).

Effect of housing from the second to seventh day of life (Factor housing H) : Thirty-two (32) Holstein heifer-calves were randomly divided into two groups (19 and 13 heifers) on the second day of life, after having nursed their mothers for the first day. Heifers from the first group were moved from individual maternity pens into individual housing (IH) in hutches (n =19), heifers from the second group stayed in maternity pens (MP) with their mother (n = 13).

Effect of feeding milk from the second week of life to weaning (Factor feeding F) : Ten heifers were randomly taken from individual hutches on the seventh day and relocated to a loose housing pen with the automatic feeding station (AFS). The remaining nine heifers stayed in individual hutches. Heifers, which were with the mother until the seventh day (n = 13), were moved to a group pen with nursing cows.

If we consider the milk feeding methods, it is obvious that three groups of calf-heifers were created. Heifers kept in the group pen with the AFS received milk replacer through an artificial nipple (automated drinking, group AD; n = 10), heifers kept in individual hutches received milk replacer from an artificial nipple of the bucket (bucket drinking, group BD; n = 9), and the third group were on nurse cows (udder drinking, group UD; n = 13). All animals were weaned at the age of 8 weeks (56 days).

Effect of season of calving (Factor season of calving C) : Trial heifers were calved throughout the year, therefore, they were divided into four groups: group C_1 (March-May; AT 8.8°C; n = 10), group C_2 (June-August; AT 22.1°C; n = 6), group C_3 (September-November; AT 9.3°C; n = 8), group C_4 (December-February; AT -3.1°C; n = 8) - factor C.

All heifers were kept (56 days) in common loose housing bedded pens (in the same barn) according to age and size. After weaning 10 heifers were kept in a pen 4.5×4.5 m (2 m^2 per animal), from the seventh month another 10 heifers were in a pen 4.5×6 m (2.7 m^2 per animal). Heifers were housed in pens regardless the distribution of factors H and F in age-balanced groups.

Heifers were moved to group pens (9×4.5 m) in the maternity barn three weeks before the expected date of calving. Three days before the expected date of calving or after the appearance of calving symptoms they were moved to an individual 4.5×4.5 m maternity pen. First-calf dairy cows were kept in pens with free-stall housing with access to paved lots and fed according to stage of lactation.

Feeding from the birth to 180 days

All calves sucked colostrum free choice from their mother during the first 24 h. Calves from groups AD and BD received colostrum and mothers milk free choice three times a day from a nipple bucket from the second to seventh day. Calves of the group UD were allowed to suck their dams *ad libitum*, but their mother was milked from the second day after calving.

AD calves were drank from the eighth day by an AFS. After the first three days, when they were made to drink milk replacer, they were given 6 kg milk replacer per day divided into 4 portions at 6 h intervals. The amount of milk replacer was increased to 8 kg per day from the 28^{th} day. The AFS was computer-programmable and software was available to register time points continuously and the amount of food ingested per visit.

Calves of the treatment BD after the first three days received 6 kg of milk replacer per day from a nipple bucket. The replacer was divided into 2 portions at 12 h intervals and from the 28^{th} day 8 kg per day in two portions. Milk replacer contained of 30% dried whole whey, 20% dried butter milk, 15% soybean flour, 15% wheat gluten feed, 19% coconut and palm oil, and 1% vitamins-minerals premix.

Animals from the treatment UD were moved to a nursing cow pen on the eighth day. The number of calves per one nursing cow was determined according to their milk yield (6 kg milk per each calf). A maximum of 3 cows were housed in one 8×4.5 m pen. Calves were allowed to suck *ad libitum* and they also had free access to straw, hay and silage.

From the second day until weaning the calves could eat starter mixtures and alfalfa hay free choice. They received 1.5 kg of concentrate mixture per day and alfalfa hay free choice from weaning to six months of age. From the age of 90 days they also got corn silage.

Feeding from the 180th day to calving

The heifers were fed according to the current standard specifications from the age of 180 days to calving. Corn silage and alfalfa hay formed the basis of feed rations the year round. From the 181st d, all heifers were fed the same diet according to Slovakian recommendations for intake of dry matter to attain 0.75 kg ADG. The TMR contained alfalfa hay, alfalfa haylage, corn silage, concentrate mixture and mineral/vitamins supplements.

They received 1 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. Equal conditions of nutrition were ensured in all groups.

Table 1. Daily rations for cows

Feed/composition	Rations (kg)		
	E	M	L
Corn silage	21	17	20
Alfalfa haylage	8	7	8
Alfalfa hay	2	2.5	2
Wet brewer's grain	6	5	3
Sugar-beet pulp	-	10	-
Concentrate mixture	7.8	6.2	4.4
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

PDI = protein digestible in small intestine; E = early lactation.
M = mid lactation; L = late lactation.

Feeding during the lactation

The feed was a total mixed ration (TMR) consisting of corn silage, alfalfa haylage, alfalfa hay, barley straw, brewer's grain, sugar-beet pulp and concentrate mixture for high-yielding cows. The TMR was supplied to the troughs by a feeding wagon twice a day during milking. Feeding was allowed throughout the 24-h period, except during milking. TMR 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, and consisted of the following stages: early lactation (first four months), mid lactation (5^{th} to 7th month), and late lactation (Table 1).

Observations

Milking occurred twice daily with a milking interval of 12 h in a 2×5 stall herringbone parlor, and individual milk yields were recorded once weekly (each Tuesday PM, Wednesday AM) by Tru-tests. Proportional milk samples were collected fortnightly at the morning and afternoon milking and analyzed for milk fat, protein, and lactose content by infrared analysis in the Milk laboratory (RIAP, Nitra).

Heifers were first bred when they were at least 16 months old or when they reached about 360 kg. Reproduction and health were observed. Cows were weighed monthly. Age at calving (AD = 822 d, BD = 814 d, UD = 828 d) was not different. Breeding of cows during the first lactation began at 9 week post-partum.

Statistical evaluations

The Descriptive Statistics procedure of statistical package STATISTIX (Anonymous, 1996) was used for computing of mean, standard deviation, standard error of the mean, minimum and maximum. Values are expressed as means±SEM., because the sample sizes are not the same for all groups.

The normality of data was evaluated by Wilk-Shapiro/Rankin Plot procedure. This method examines whether a variable conforms to a normal distribution. A rankit plot of each variable was produced, and an approximate Wilk-Shapiro normality statistic was calculated. The tested variables that showed values of $W>0.80$ were considered normal and therefore were then submitted to an ANOVA. We found that all variables conformed to a normal distribution.

The homogenity of variance of the observed variables in groups, whose average values are being compared, was calculated by preliminary variance tests which determined whether the variabilities are equal. Bartlett's test for equality of variance tests was applied with an unequal size

Table 2. Mean squares of five-factorial analysis of variance

Index	Housing Df = 1	Sire Df = 3	Calving Df = 3	Feeding Df = 1	Birth Df = 3	Wit+Res Df = 20
BW wean	31.51	170.10	61.04	0.03	138.91	67.77
ADG to wean	0.00	0.05*	0.01	0.01	0.06	0.01
BW 30 d	4.30	638.11	1,766.47	570.55	8,044.04	1,245.43
Milk kg	30,839.29	1,551,946.3	666,455.04	56,280.32	389,092.10	641,379.13
FCM kg	97,563.68	542,246.39	97,260.76	19,960.87	581,954.78	423,000.93
Fat %	0.08	0.57*	0.19	0.01	0.16	0.12
Fat kg	260.52	1746.81	111.46	9.56	1510.40	681.68
Protein %	0.00	0.05*	0.02	0.00	0.04*	0.01
Protein kg	56.26	691.57	824.06	125.56	616.67	536.55
Lactose %	0.00	0.01	0.00	0.00	0.01	0.01
Lactose kg	30.39	4,103.88	1,686.82	214.16	930.58	1,715.26
SNF %	0.04	0.11	0.06	0.10	0.08	0.05
SNF kg	804.57	8,140.38	4,297.08	1,678.21	3,670.58	5,049.23
TS %	0.22	1.09*	0.61	0.31	0.28	0.31
TS kg	933.14	8,136.14	3,197.27	1,792.28	8482.74	8,255.31

Df = degrees of freedom; Wit+Res = within+residual; * $p<0.05$.
BW wean = body weight at the weaning.
ADG to wean = average daily gain from birth to weaning.
BW 30 d = body weight at the 30 day of lactation.

Table 3. Effect of sire lineage

Index	Group	n	Mean	SEM
ADG to weaning (kg)	S_1	8	0.54	0.07
	S_2	6	0.37	0.04
	S_3	9	0.65	0.05
	S_4	9	0.59	0.08
Fat (%)	S_1	8	3.97	0.15
	S_2	6	4.11	0.11
	S_3	9	3.33	0.13
	S_4	9	3.96	0.11
Protein (%)	S_1	8	3.13	0.05
	S_2	6	3.06	0.05
	S_3	9	3.08	0.03
	S_4	9	3.24	0.04
TS (%)	S_1	8	13.11	0.28
	S_2	6	12.61	0.26
	S_3	9	12.07	0.14
	S_4	9	12.94	0.14

S_1-S_4 (used sires).

of samples. The ratio of the largest within-group variance over the smallest was also tested (Pearson and Hartley test).

The effects of housing H_i, sire S_j, season of calving C_k, type of feeding F_l and season of birth B_m traits of analyzed dairy cows were evaluated by five-factorial analysis of variance with the all effects considered as fixed effects and with error term as random effect distributed as $N\sim(0, \sigma^2)$ by model equation

$$y_{ijklmn} = \mu + H_i + S_j + C_k + F_l + B_m + e_{ijkjlmn}.$$

We remark, that sire effect in our experiment is considered as fixed effect, besides the daughters of the sires are studied in the all other fixed effects and their sires are not random sample as by experiments with breeding value estimation.

The five-factorial analysis of variance were performed by statistical package of SPSS for Windows, Release 8.0 (Norusis, 1998).

RESULTS

On the basis of five-factorial ANOVA we could confirm of assigned hypotheses only in factors Sire and Season of birth (Table 2). Effects of housing, season of calving and feeding milk had not statistically significant F tests. It is for this reason that we can consider the results of these effects only tendencies or influences.

Effect of housing from the second to seventh day of life

Body weight (BW) at the weaning and ADG from the birth to weaning were higher in MP cows (80.28±2.49 vs. 67.89±2.75 kg and 0.68±0.05 vs. 0.47±0.04 kg). Similarly, milk production, FCM and protein were higher in first-calf heifers kept in loose housing (MP) than those kept in individual housing (6,894.1±244.01 kg vs. 6,202.1±211.98 kg; 6,541.9±180.04 kg vs. 5,986.4±153.53 kg; 215.3±6.63 kg vs. 193.2±6.27 kg).

Effect of sire lineage

Effects of the sire were significant for ADG from birth to weaning (0.55±0.03 kg, $p<0.05$), contents of fat (3.81±0.08%, $p<0.05$), protein (3.13±0.02%, $p<0.05$), and total solids (TS) (12.67±0.12%, $p<0.05$) (Table 3).

Effects of season of the calving

Cows calved in the winter were the heaviest at the weaning (81.17±3.61 kg) and they had the highest ADG to weaning (0.67±0.07 kg). Dairy cows calved in the winter and in the spring had a tendency yielded the most (6,942.5±187.61 kg and 6,924.9±312.31 kg, respectively), while dairy cows calved in the summer yielded the least (5,764.4±387.20 kg).

Cows calving in the winter produced the most protein (218.9±4.63 kg) and cows calving in the summer the least (178.7±13.29 kg). The content of lactose was the highest in the group of cows calving in the spring and lowest in the group calving in the fall (5.07±0.03% vs. 4.93±0.03%).

Cows calving in the spring producing of solid non fat (SNF) the most and those calving in the summer the least (620.5±28.11 kg, 522.6±33.42 kg).

Effect of feeding milk from the second week of life to weaning

BW at the weaning and ADG from the birth to weaning were the highest in UD cows and the lowest in AD cows (80.28±2.49 vs. 61.96±2.95 kg and 0.68±0.05 vs. 0.36±0.03 kg). Cows of group UD had the highest BW and cows from group AD the lowest (540.5±14.58 vs. 504.8±11.54 kg) in the first month of lactation.

The first-calf heifers fed by nursing cows displayed the highest production of milk (6,894.1±244.01 kg) and animals fed by AFS the lowest (5,757.5±273.70 kg). A similar trend was recorded also in the case of FCM (6,541.9±180.04 kg vs. 5,820.9±252.12 kg), protein (215.3±6.63 kg vs. 180.9±8.68 kg), lactose (342.9±13.24 kg vs. 285.0±12.83 kg), SNF (608.9±21.74 kg vs. 515.3±21.35 kg) and TS (846.5±25.23 kg vs. 749.8±30.20).

The contents of fat and TS were the highest in the AD group (4.10±0.13% and 13.14±0.23%).

Effects of season of the birth

Statistical difference was found only in the content of protein (3.13±0.13 kg, $p<0.05$) (Table 4). Cows of group B_1 had the highest % of protein and cows from group B_2 the

Table 4. Effect of season of birth

Index	Group	n	Mean	SEM
Protein (%)	B_1	3	3.21	0.04
	B_2	7	3.06	0.05
	B_3	6	3.13	0.06
	B_4	16	3.15	0.03

B_1 (March-May), B_2 (June-August), B_3 (September-November), B_4 (December-February).

lowest (3.21±0.04 vs. 3.06±0.05%).

Dairy cows born in the winter (B_4) showed the highest BW at the weaning, ADG from the birth to weaning and production of milk, and dairy cows born in the summer (B_2) the lowest (80.05±2.26 vs. 59.24±3.93 kg; 0.69±0.03 vs. 0.29±0.03 kg; 6,882.5±206.42 kg vs. 5,639.7±395.79 kg). The highest BW on the 30th day of lactation had cows of B1 group and the lowest cows of B2 and B3 (586.67±32.83, 496.86±11.56 and 493.17±10.55 kg). Production of FCM was the highest in the group born in the fall (B_3) and the lowest again in the group born in the summer (6,668.1±254.41 kg vs. 5,563.5±318.80 kg).

Animals born in the fall (B_3) produced 270.2±9.69 kg fat and animals born in the summer (B_2) only 220.5±11.37 kg. Production of the protein was the highest in the animals born in the winter (B_4), and the lowest production in the cows born in summer (B_2) (215.6±5.44 kg vs. 173.5±12.17 kg). The same trend was found also in the production of lactose, SNF and TS: dairy cows born in the winter produced the most and dairy cows born in the summer the least.

DISCUSSION

ANOVA revealed that among all the factors taken into account in this study, only two (sire lineage and season of the birth) had significant effects.

Effects of the sire were expressed for ADG from birth to weaning, contents of fat, protein, and TS. The genetic and environmental influences of sire on milk production are known and have been well documented (Hayes et al., 2003). The sire lineage influences a large part of the population so its genetic qualities are effective as a stabilization factor.

Dairy cows born in the winter showed the highest growth to weaning and production of milk, protein, lactose, SNF and TS. There is probably a close relationship with growth rate. Calves born in winter tended toward higher ADG than did calves born in other seasons. Place et al. (1998) also found calves born in summer had a tendency for decreased average daily gain. The effect of birth season on production may be attributed to changes in either temperature or photoperiod.

This was important in the distributing animals according to the housing from the second to the seventh day of life in that first-calf heifers kept in loose housing yielded more milk, FCM and protein than those kept in individual housing. Similarly, Babu et al. (2003) found that the effects during postweaning phase showed increased performance in group housed calves compared to individually housed ones with a superior ADG (590 vs. 443 g). However, our results suggest that the increase in milk efficiency in cows from loose housing was caused mainly by milk drinking techniques during the milk-feeding period, as will be detailed further on.

What was the most explicit in factor feeding (F) evaluation? The significantly higher production performance of UD cows can likely be explained by a higher live weight at calving compared to AD and BD groups, which was the result of better growth during rearing. Previous results (Broucek et al., 2001) showed that the BW advantage of the calves on nurse cows persisted for at least several months after weaning. This increased BW was subsequently maintained in the UD group until calving. Good body condition at calving seems essential for high milk yield (Dobos et al., 2001; Khan et al., 2004). The reduced production levels by heifers calving at younger ages may be due to differences in the development of the mammary gland at first calving. However age effects were ruled out in this experiment as age at calving did not differ among groups. In spite of this, it appears incorrect to explain the reduced first lactation production in terms of live body weight gains only. The calves fed by nursing cows grew faster than the conventionally fed calves before weaning, probably as a result of a higher intake of milk even though the amount of milk obtained was limited by the number of calves per cow.

The nutrient quality of whole nursed milk likely exceeded that of the milk replacer. According to Bar-Peled et al. (1997), nursed heifers had higher ADG and milk production than did calves fed milk replacer. Also, replacement of milk with skim milk at 100% level performed the worst under group housed system of rearing (Babu et al., 2003).

Ad libitum feeding from nurse cows could reduce the incidence of diarrhea. If we reverse the group order and try to find causes of lower milk production of dairy cows fed by the AFS, it could be a result of poorer health due to their rearing environment. A common nipple suckled by calves in a group could be a method of spreading disease among that group (Maatje et al., 1993; Seipelt et al., 2003). The rate of adaptation to the change of feed likewise plays a relevant role (Nettisinghe et al., 2003). Larger calves were found to adapt to dry feeding at an earlier age than smaller calves.

Dairy cows calved in winter and in spring yielded the most milk, protein, lactose and SNF, while dairy cows calved in summer the least. According to Cho et al. (2004), the effect of season on milk yield is manifested in a difference in nutrition and feeding. A feed ration of a higher quality in the summer should result in high production comparable to that of the winter period. However, this should not be necessary provided the mixed feed ration is balanced and stable throughout the year.

Data of Dahl et al. (2000) confirmed that a long photoperiod increases milk yield of lactating cows. This is associated with an elevation of an endocrine mechanism for the galactopoietic effects. We must not forget the effects of the photoperiod or temperature during the third trimesters of pregnancy on hormone prolactin, which positively correlated with both photoperiod and temperature. Therefore the duration of the photoperiod or temperature would most likely affect future milk production.

It is possible that dairy cows calved in the period from December to February would reach a higher average production during lactation, particularly due to an effect of a higher persistency of the lactation curve. The most favorable persistency of the lactation curve is in dairy cows calving in January and February, i.e. during a subsequent prolongation of daylight. The least favorable periods of calving as regards milk production are from June to August. Daily light has also been found to impact dry cows (Dahl et al., 2000). Short-day light hours during the dry period probably make cows more responsive to the positive influence of longer daylight once they calve.

It seems that low winter temperatures enable a cow in the first third of lactation to express her full milk yield potential. High temperatures during summer cause stress in dairy cows with decreasing DMI and milk yield (Lu et al., 2003; West, 2003). High temperatures have not only a direct but also a latent effect during a dry period, especially in the last 60 d of gestation. The reason for this may be decreased immunity and transfer of maternal immunoglobulins to colostrums, vigor and ability of the newborn calf to absorb immunoglobulins during hot weather.

IMPLICATIONS

Rearing of heifers can play an important role in dairy husbandry. Understanding the factors that affect milk efficiency may reduce costs and improve milk performance.

Results of this study indicated that management factors during rearing of heifers would be very important after first calving, especially selection of sires as genetic factor.

The manner of drinking during the milk-feeding period and the season of calving showed only a non-significant influence on observed variables in our experiment, which was caused by a smaller number of animals in groups. However, in the case of a large herd of dairy cows, these effects can have a very strong economical impact. The reader should note that the highest milk yields were recorded in heifers, which were raised by nursing cows until weaning and the lowest in heifers fed by AFS. No doubt, the rearing of newborn heifers by nursing cows may create advantages for later production.

Further, the milk efficiency was the highest in first-calf heifers born and calving in the winter and the lowest in first-calf heifers born and calving in the summer. It may be wise to decrease the number of heifers and cows calving during summer by regulating breeding.

REFERENCES

Arave, C. W., C. H. Mickelsen and J. L. Walters. 1985. Effect of early rearing experience on subsequent behavior and production of Holstein heifers. J. Dairy Sci. 68:923-928.

Arave, C. W., J. L. Albright, D. V. Armstrong, W. W. Foster and L. L. Larson. 1992. Effects of isolation of calves on growth, behavior, and first lactation milk yield of holstein cows. J. Dairy Sci. 75:3408-3415.

Babu, L. K., H. N. Pandey and A. Sahoo. 2003. Effect of individual versus group rearing and feeding of different levels of milk and skim milk on nutrient utilization in crossbred calves. Asian-Aust. J. Anim. Sci. 16:1455-1459.

Bar-Peled, U., B. Robinzon, E. Maltz, H. Tagari, Y. Folman, I. Bruckental, H. Voet, H. Gacitua and A. R. Lehrer. 1997. Increased weight gain and effects on production parameters of Holstein heifer calves that were allowed to suckle from birth to six weeks of age. J. Dairy Sci. 80:2523-2528.

Broucek, J., S. Mihina, M. Uhrincat, V. Tancin, L. Harcek and L. Hetenyi. 1995. Effect of more suckling calves on milk yield and reproduction of dairy cows. Zivocisna Vyroba. 40:59-64.

Broucek, J., C. W. Arave, T. H. Friend, S. Mihina, M. Uhrincat, A. Hanus and P. Kisac. 2001. Effect of rearing methods of dairy-heifers prior to weaning on growth and reproduction. J. Anim. Sci. 79 (Suppl. 1). J. Dairy Sci. 84 (Suppl. 1)/ Poult. Sci. 80 (Suppl. 1)/ 54th Annu. Rec. Meat Conf. II: 270(Abstr.).

Cho, K. H., S. H. Na, J. H. Cho, J. H. Lee and K. J. Lee. 2004. Studies on the development of novel 305 day adjustment factors for production traits in dairy cattle. Asian-Aust. J. Anim. Sci. 17:1689-1694.

Dahl, G. E., B. A. Buchanan and H. A. Tucker. 2000. Photoperiodic effects on dairy cattle: A review. J. Dairy Sci. 83:885-893.

Dobos, R. C., K. S. Nandra, K. Riley, W. J. Fulkerson, L. J. Lean and R. C. Kellaway. 2001. Effects of age and liveweight at first calving on first lactation milk, protein and fat yield of Friesian heifers. Aust. J. Exp. Agric. 41:13-19.

Hayes, B. J., M. Carrick, P. Bowman and M. E. Goddard. 2003. Genotype×environment interaction for milk production of daughters of australian dairy sires from test day records. J. Dairy Sci. 86:3736-3744.

Khan, M. A. A., M. N. Islam, M. A. S. Khan and M. A. Akbar. 2004. Effects of feeding high and low energy levels during late pregnancy on performance of crossbred dairy cows and their calves. Asian-Aust. J. Anim. Sci. 17:947-953.

Krohn, C. C., J. Foldager and L. Mogensen. 1999. Long-term effect of colostrum feeding methods on behaviour in female dairy calves. Acta Agric. Scand., Section A, Anim. Sci. 49:57-64.

Lee, D. H. and K. J. Han. 2004. Genetic relationship between milk production, calving ease and days open at first parity in Holstein cows. Asian-Aust. J. Anim. Sci. 17:153-158.

Lu, C. H., C. J. Chang, P. N. Lee, C. P. Wu, M. T. Chen and X. Zhao. 2003. Functional characterization of mammary gland of Holstein cows under humid tropical summer climates. Asian-Aust. J. Anim. Sci. 16:988-995.

Maatje, I. C., J. Verhoeff, W. D. J. Kremer, A. L. M. Cruljsen and T. S. G. M. van den Ingh. 1993. Automated feeding of milk replacer and health control of group-housed veal calves. Vet. Rec. 133:266-268.

Nettisinghe, A. M. P., H. M. J. Udo and F. A. Steenstra. 2004. Impact of an AI heifer calf rearing scheme on dairy stock development in the western province of Sri Lanka. Asian-Aust. J. Anim. Sci. 17:18-26.

Norusis, M. J. 1998. SPSS 8.0 guide to data analysis. Prentice-Hall, Upper Saddle River, New Jersey, USA.

Paputungan, U. and M. Makarechian. 2000. The influence of dam weight, body condition and udder scores on calf birth weight and preweaning growth rates in beef cattle. Asian-Aust. J. Anim. Sci. 13:435-439.

Place, N. T., A. J. Heinrichs and H. N. Erb. 1998. The effects of disease, management, and nutrition on average daily gain of dairy heifers from birth to four months. J. Dairy Sci. 81:1004-1009.

Seipelt, F., A. Bunger, R. Heeren, D. Kähler, M. Lüllmann and G. Pohl. 2003. Computer controlled calf rearing. In: Proceedings of the Fifth International Dairy Housing Conference, ASAE Publication, No 701P0203, Fort Worth, TX. pp. 356-360.

West, J. W. 2003. Effects of heat-stress on production in dairy cattle. J. Dairy Sci. 86:2131-2144.