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Effect of Raising Dairy Heifers on Their Performance and Reproduction after 12 Months

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Abstract: The objective of this study was to test the hypotheses that a heifer's growth, health, and reproduction after 12 months are impacted by rearing (feeding/housing) before weaning, their season of birth, and the father's lineage. Fifty-one Holstein heifers, born during January–March (SB1), April–June (SB2), July–September (SB3), and October–December (SB4) and originating from four fathers, were assigned to one of the three rearing treatments: restricted suckling (RS), calf in a pen with the mother until the 21st day, sucking three times daily, then group pen (6 kg milk) to weaning; unrestricted suckling (US), calf in a pen with foster cows (6 kg milk) to weaning; and conventional rearing (CR), calf in a hutch until the 56th day, then group pen to weaning (milk replacer 6 kg). After weaning on the 84th day, heifers were kept in groups with the same ration. The growth of the live body weight (LBW), health, and reproduction were recorded. The LBW had a tendency to increase from the 360th to the 570th days in the US, and the reduced growth of the LBW was shown in the CR. Heifers of SB2 had the highest LBW at 570 days of age. The ages of the first insemination service and the conception varied significantly among the rearing groups. The results indicate that a heifer rearing method may have a significant impact on their later growth and fertility.

Keywords: livestock farming; dairy cattle welfare; raising; environment; production; fertility

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1. Introduction

A variety of methods and facilities can be used to raise a replacement dairy animal. In husbandry, the method of separating a cow and their calf shortly after birth has been used for many years, but early weaning from the mother has been shown to affect normal behavioural development with later challenges of environment conditions [1,2]. It is expected that the delayed separation of the calf from its mother may improve the welfare and growth of dairy calves [3–6]. However, reducing the age at which calves are weaned is more cost effective when saving milk and milk replacer (MR) than delayed weaning.

A number of studies have explored keeping cows and calves together and examined the benefits of this natural rearing system [4,7,8]. The suckling systems can be divided into more categories depending on the farming purpose and duration of the suckling period on restricted (also referred to as a single suckling system) and the foster cow system (also referred to as multiple or cow-calf contact system) [1,6,9,10]. Restricted suckling means that the calf is allowed to suckle its own dam during short periods daily [11–14]. In the foster cow system, the calves are kept together and suckle one cow [1,7,8].

However, we must distinguish between milk feeding or milk replacer (MR). Milk is more important in terms of nutrition, normal behaviour [9,10,15–17], and later performance of heifers [18,19]. The prolonged period of fostering and the social facilitation and social learning may result in increased concentrate and hay intake, and higher average daily gains (ADG) after weaning compared with individually kept calves [20–23]. These benefits from suckling period persisted for up to 16 months after separation [2,6,24].

The authors of [25–28] showed that environmental factors affect both prenatal and postnatal life. The season of the year and status of reproductive cycles could have a big impact on when animals become sensitive to increasing heat loads [29]. Exposure to prenatal maternal stressors (hyperthermia) during foetal development can alter postnatal phenotypes and the expression of the genetic potential of the offspring [30–37]. The utero heat stress leads to lower birth weight and LBW at one year of age as well [38–41].

The aim of the present study was to objectively quantify the effects of rearing, the season of birth and the father's lineage on the growth rate, health condition, number of services to conception, and the percentage of conception after the first insemination of dairy heifers.

2. Materials and Methods

The study was performed in Nitra, Slovakia. It was the continuation of a long-term experiment, the first part of which was published last year [42], and evaluated the growth and health condition of calves under the age of 360 days. The present study examines the growth and reproduction of heifers from 361 to 570 days of age.

2.1. Animals and Treatments

The treatment of the animals was approved by the Ministry of Agriculture and Rural Development of the Slovak Republic, no. 115/1995 Z.z. and 377/2012 Z.z. The experiments were carried out in accordance with the Code of Ethics of the EU Directive 2010/63/EU for animal experiments.

At birth, 51 Holstein heifers were consecutively assigned to the three rearing treatments groups, balancing for birth weight. Calves in all groups were kept in an individual pen with the mother and received colostrum for the first 24 hours by suckling ad libitum. If some calves did not want to suckle, they were fed with a teat-bottle (two hours after the birth). A total of 11 calves received milk from the bottle (RS = 4, US = 3, and CR = 4). From the 2nd day until weaning, the calves were offered a starter mixture (SM) and alfalfa hay as a free choice. Three rearing treatments groups were observed (restricted suckling, unrestricted suckling, and conventional rearing). The calves in the group of a restricted suckling of dam (RS, n = 18) were kept separately in an individual pen (4.5 × 4.5 m) with the mother (milked from the 2nd day at 05:00 and 16:00) until the 21st day, suckling a mother's udder 10 min 3 times per day (8:00, 13:00, and 18:00). Each calf had its own mother, not a random cow. The cow and the calf were loose. A small part of the pen was separated to be used by the calf (1.2 × 4.5) (Figure 1). The separated part of the pen opened and the calf was released to its mother. From the 22nd day, the heifers were kept in a loose housing pen (6 kg any cow milk per day, 2× daily 3 kg, bucket with nipple). The suckling time of a mother's udder (3 × 10 min) was determined during preparation for the experiment according to Passillé de and Rushen [43]. In the current phase of the experiment, these RS heifer calves were weighed before and after each suckling.

The calves in the group of unrestricted suckling of the foster cow (US, n = 16) were kept for 3 days with their own mother in an individual pen and then a pen with non-milked foster cows from the 4th day to weaning. A foster cow is also referred to as a nursing cow (a cow that nurses alien calves). The heifer calves could suckle at any time, usually 3–5 times per day. A total of 8 cows were used, of which 3 were for the 2nd parity, 4 were for the 3rd parity, and 1 was for the 4th parity. Five cows were in the mid-lactation stage, and three were in the late lactation stage. Foster cows were selected (not randomly) from milking cows of the herd, with the main criteria being milk yield and the ability to accept an alien calf and to be nursed. The distribution of fostered calves by all eight cows was as follows: 1 = 2, 2 = 1, 3 = 4, 4 = 2, 5 = 1, 6 = 1, 7 = 2, and 8 = 3. Heifer calves of the US group suckled colostrum and the mother's milk ad libitum three times a day (3 × 10 min/day) from the second to the third days. They suckled milk of foster cows from the 4th day (suckle at any time) to weaning. The number of US calves per foster cow was determined according to milk yield of the selected cows, ensuring that 6 kg of milk per calf and day is available. Milk yield controls were performed on the last day before moving to the experiment and then weekly thereafter. The US group was housed in a pen of 9 × 4.5 m

(3 nursing cows and 10–12 heifer calves). Calves were not housed individually with a foster cow. Cows were tied in a pen, and calves were kept loose.

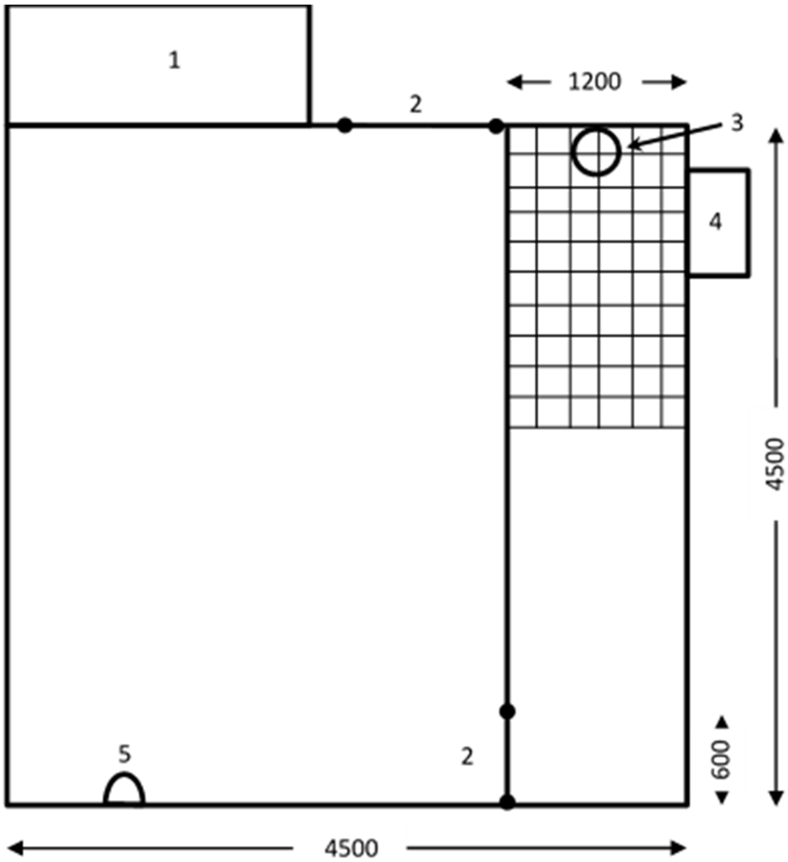

Figure 1. Individual pen for the calf and the mother of the RS group. **1**—Concrete feed trough for cow; **2**—gate; **3**—starter mixture feeder; **4**—hanging hay feeder; **5**—cow drinker.

After having nursed their dams in an individual pen for 24 h, the calves in the conventional rearing group (CR, n = 17) were kept individually in hutches from 2nd to 56th day (bucket with nipple, MR; 2nd day, 3 × 0.5 kg; 3rd day, 3 × 1.0 kg; 4th day, 3 × 1.5 kg; and from 5th day 6 kg/day to 21st day 3 × daily) and then in a loose housing pen from the 57th day (bucket with nipple, MR, 6 kg/day, 2× daily) to weaning. The hutches were made from fibre-glass, used from the second day of life to relocation to group housing at the age of 8 weeks. Each hutch (1.8 × 1.2 m) had an outside fenced yard of 1.8 × 1.2 m, bedded with straw. The hutches were arranged in rows, 0.8 m apart. The heifers could see and touch each other through the openings in the upper part of the pen wall or fenced yard of the hutch.

The calves could eat a starter mixture (SM) and alfalfa hay as a free choice until weaning. The RS and US calves could eat SM and alfalfa hay from a special feeder as a free choice, and the calves had no access to fodder the cows from the trough. Cows could not eat from the calves' feeder (Figure 1). CR group calves received SM from a bucket and alfalfa hay from a crib feeder. All calves were offered the same SM and forage.

The MR with dry matter (DM), 94.7%, was composed of dry whey, dry buttermilk, dry skimmed milk, animal fat, whey dried with vegetable oil, and wheat gluten (crude protein 226 g/kg DM, crude fat 196 g/kg DM, ash 87 g/kg DM, and crude fibre 6.0 g/kg DM). The SM (DM 89.3%) contained barley, wheat, soybean meal, oats, corn, and a mineral mixture (crude protein 214 g/kg DM, crude fat 32 g/kg DM, and ash 81 g/kg DM).

The heifers were also divided (not random) according to the season of the birth (SB1 = January–March, N = 21; SB2 = April–June, N = 14; SB3 = July–September, N = 7;

and SB4 = October–December, N = 9). The division into rearing groups was as follows: RS (SB1 = 9, SB2 = 3, SB3 = 3, and SB4 = 3; 18), US (SB1 = 5, SB2 = 3, SB3 = 4, and SB4 = 4; 16), CR (SB1 = 7, SB2 = 7, SB3 = 1, and SB4 = 2; 17). The seasonal averages of the mean temperature, minimum temperature, and maximum temperature measured on the research farm were as follows: SB1 (1.5 °C, −2.3 °C, and 5.5 °C), SB2 (13.9 °C, 8.1 °C, and 20.0 °C), SB3 (17.7 °C, 12.6 °C, and 24.2 °C), and SB4 (4.6 °C, 1.2 °C, and 8.4 °C).

The experimental heifers originated from four fathers (F1 = 7, F2 = 14, F3 = 21, and F4 = 9). The distribution (not random) was as follows: RS (F1 = 4, F2 = 3, F3 = 6, and F4 = 5; 18), US (F1 = 1, F2 = 7, F3 = 7, and F4 = 1; 16), and CR (F1 = 2, F2 = 4, F3 = 8, and F4 = 3; 17).

All animals were weaned abruptly at the age of 12 weeks and moved to a group housing pen, where equal conditions of nutrition were ensured. Each treatment group had its own pens, and the pens were differentiated by age, so that the age difference in one pen was not higher than 21 days. Approximately 10–15 calves were kept in a pen of 9 × 4.5 m. Each heifer had free access to clean drinking water in a plastic bucket or an automatic drinker throughout the study.

After weaning from milk feeding, all heifers were kept separately in age-balanced groups in loose housing bedded pens with the same ration.

2.2. Diet Management after Weaning

The heifers received 1.5 kg of SM per day and alfalfa hay was offered as a free choice from weaning to 180 days. From the age of 90 days, they were also fed corn silage.

The composition of alfalfa hay (DM 88.8%) was crude protein 212 g/kg DM, total digestible nutrients 595 g/kg DM, acid detergent fibre 294 g/kg DM, neutral detergent fibre 351 g/kg DM, Ca 13.8 g/kg DM, and P 2.6 g/kg DM. Corn silage ingredients (DM 43.21%, pH 4.06) represented 68.6 g/kg DM of crude protein, 406 g/kg DM of starch, 518 g/kg DM of non-fibrous carbohydrates, 12.0 g/kg DM of sugar, 33.4 g/kg DM of crude fat, 232.8 g/kg DM of acid detergent fibre, 345.1 g/kg DM of neutral detergent fibre, 51.8 g/kg DM of ash, 2.2 g/kg DM of Ca, 2.3 g/kg DM of P, 1.5 g/kg DM of Mg, 9.3 g/kg DM of K, and 1.3 g/kg DM of S.

From the 181st to 360th days, all heifers were fed the same total mixed feed ration (TMR). The concentrate mixture (CM) (1.5 kg/day, DM 90.1%) was fed separately; it contained sunflower cake, cotton seed cake, corn, wheat bran, mineral mixture, salt (crude protein 183 g/kg DM, crude fat 35 g/kg DM, and ash 92 g/kg DM). The TMR consisted of corn silage, alfalfa haylage, alfalfa hay, barley straw, sugar-beet pulp, brewer's grain, and mineral/vitamins supplements.

From the 361st to 450th days, the heifers were fed a TMR consisting of corn silage, alfalfa haylage, alfalfa hay, barley straw, brewer's grain, sugarbeet pulp, and CM. The feed ration contained 6.7 kg DM, 64.4 MJ net energy content for lactation (NEL), 0.52 kg protein digestible in the small intestine (PDI), and 1.98 kg of crude protein.

The heifers were fed a TMR consisting of corn silage, alfalfa haylage, alfalfa hay, barley straw, brewer's grain, sugarbeet pulp, and CM from the 451st to 570th days throughout the study. The feed ration contained 8.3 kg DM, 78.3 MJ NEL, 0.57 kg PDI, and 2.62 kg of crude protein [44].

Feeding was allowed throughout the 24 h period. Automatic watering troughs were located next to the feed bunks. The total mixed ration was calculated according to Slovakian nutrient requirements of dairy cattle [44]. Equal conditions of nutrition were ensured in all groups.

2.3. Live Body Weight Growth

Live body weight (LBW) of the heifer calves was recorded each month, from 360 to 570 days. The average daily gain (ADG) was calculated as the average change in live body weight during a specified period. The heifers were weighed on the mobile livestock scale (DVM, Soehnle, Germany), load capacity up to 2000 kg, weighing accuracy ±0.2 kg.

2.4. Health and Reproduction

All animals included in the experiment were appropriately vaccinated and disease tested. Diseases that were managed by law are bovine Tuberculosis and Leptospirosis. The methods of the authors of [45–48] for the daily health evaluation (diarrhoea, respiratory condition, mastitis, clinical laminitis, and injuries) were used. The loss of a foetus was diagnosed when a foetus dies between 43 and 151 days of pregnancy.

The breeding program of heifers began at 13 months of age, limiting live body weight for a breeding age was 360 kg. Heifers were moved into the artificial insemination (AI) breeding pen as they reached the height and weight targets and were ready for breeding. The heifers were bred by AI with frozen-thawed semen. The hormonal breeding programs were not used.

The heat detection was checked twice a day by a combination of visual observation of behavioural signs of oestrus and tail-paint removal. The primary sign of heat was standing to be mounted by a herd mate. The secondary signs include ruffled tail head hair, clear mucus discharge, increased activity, mounting other heifers, and chin resting. The heifers were inseminated 6 to 12 h after observation of behavioural oestrus (performed inseminations twice a day). If a heifer was observed in heat in the morning, we inseminated her in the afternoon. If a heifer was observed in heat in the afternoon, we bred her the next morning. Once-a-day breeding was also used if a heifer was bred in the morning. Re-inseminations at detected oestrus occurred any time after a previous insemination.

Confirmation of pregnancy was performed by transrectal palpation 45 to 60 days after insemination. All inseminations and pregnancy diagnoses were performed by the same operator. For the measure of fertility (reproductive successes) in heifers, we used a number of services per conception (NSC), also referred to as an insemination index. The second parameter was the percentage of conception after the first insemination (PCFI), also referred to as the conception rate to first inseminations.

The NSC represents the mean number of artificial inseminations performed in order to obtain a pregnancy. It was calculated by dividing the total number of breeding for pregnant heifers in the group by the number of pregnant heifers.

The PCFI was calculated as the number of heifers conceiving at the first insemination expressed as a percentage of the total number of heifers or as the proportion of inseminations or services that result in conception [48–50]. The conception rate is then the number of conceptions that resulted in a successful pregnancy expressed as a percentage of the total number of inseminations for those cows [48,50,51].

To determine this values, dates of every insemination were collected and documented. The date of conception for each pregnant heifer was also recorded, based on pregnancy diagnoses.

2.5. Statistical Calculations

The data were analysed by the statistical package STATISTIX, Version 10.0. (Analytical Software, PO Box 12185, Tallahassee, FL, USA). The dependent variables were LBW, ADG, and reproductive and labyrinth parameters. The independent variables were the treatment group (T), season of birth (S), and father's lineage (F). The effects of observed factors (treatment, season of birth, and father's lineage) were evaluated using the General linear model ANOVA (three-factorial with interactions) with all effects considered a fixed effect (treatment) or random effects (season of birth and father's lineage) and with an error term as a random effect distributed by the model equation. We used the classical distribution p values to express the statistical significance: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$. If the p value was in the range of 0.05 to 0.1, we evaluated it as a tendency.

The normality of data distribution was evaluated by the Wilk–Shapiro/Rankin Plot procedure (Analytical Software, PO Box 12185, Tallahassee, FL, USA). All of the parameters were normally distributed, and no relevant outliers appeared. The homogeneity of variance of the observed variables in groups was calculated by preliminary variance tests, which determined whether the variabilities were equal. The Bartlett's test for the equality of variance tests was used for an unequal size of samples. Differences among groups were tested by Comparisons of Mean Ranks. Significant differences among means were tested by Bonferroni's test. All values were reported as means ± standard error of the mean (SE). The interactions between observed factors (treatment, season of birth, and father's lineage) were also computed.

The following model of General AOV/AOCV on observed factors (treatment, season of the birth, and father) was used:

$$Yijk = \mu + Ti + Sj + Fk + \alpha ij + \beta ik + \gamma jk + \varepsilon ijk$$

where $Yijk$ is a dependent variable, μ is the overall mean, Ti is the effect of factor treatment on the level i, Sj is the effect of factor season of birth on the level j, Fk is the effect of factor father's lineage on the level k, αij is the interaction between factor T on the level i and factor S on the level j, βik is the interaction between factor T on the level i and factor F on the level k, γjk is the interaction between factor S on the level j and factor F on the level k, and εijk is the residual error.

3. Results

3.1. Growth

3.1.1. Factor Treatment Rearing (T)

On the 360th day, the LBW was inconclusively the highest in the US group (RS 344.45 ± 9.38 kg, US 355.24 ± 10.83 kg, and CR 332.98 ± 10.11 kg; $p = 0.4021$). The course of more intensive growth of the US group was maintained until the end of monitoring (Figure 2). On the contrary, the lowest growth of the LBW in the period from the 360th to the 570th day was found in the CR group. A statistical difference among groups was found on the 450th day (RS 420.94 ± 8.25 kg, US 439.24 ± 9.53 kg, and CR 406.46 ± 8.89 kg; $p = 0.0333$, US:CR*). At the end of the trial (570 day), no significantly highest LBW was recorded in the US group, with the lowest one found in CR (RS 531.37 ± 9.13 kg, US 542.28 ± 10.55 kg, and CR 519.58 ± 9.84 kg; $p = 0.2420$) (Figure 2). The ADG from the 360th to 570th days were not different (RS 0.89 ± 0.04 kg, US 0.89 ± 0.04 kg, and CR 0.88 ± 0.04 kg; $p = 0.9992$).

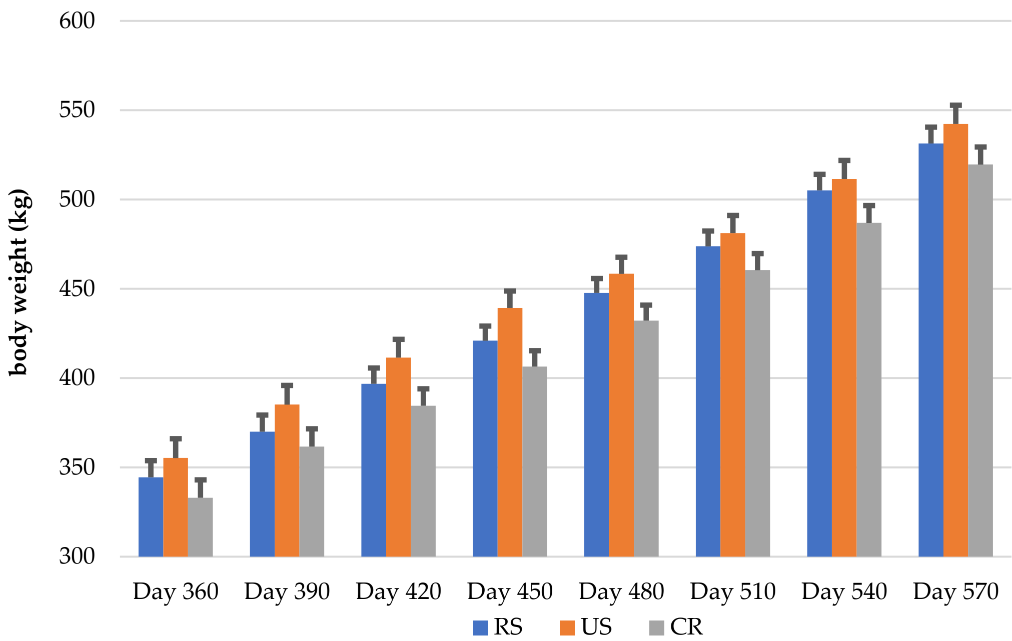

Figure 2. Growth of the live body weight of heifers (kg).

3.1.2. Season of Birth and Father's Lineage Factors (SB and F)

When evaluating the effect of the season of birth on LBW, significant differences were recorded only at the age of 360 days (SB1 329.19 ± 9.06 kg, SB2 368.11 ± 10.48 kg, SB3 364.49 ± 14.17 kg, and SB4 315.10 ± 12.85 kg; p = 0.0031, SB2: SB1, SB4 *). Throughout the experiment, heifers of SB2 had the highest LBW, heifers of SB4 weighed the least up to 510 days of age, and heifers of SB3 weighed the least up between 540 and 570 days of age (Table 1).

Table 1. Effects of birth season on the heifer's live body growth (kg).

Group	N	Mean	SE	*p* Value/ Significance	Mean	SE	*p* Value/ Significance
		Day 360			Day 390		
SB1	21	329.2	9.1	0.0031 **	366.5	6.9	0.1958
SB2	8	368.1	10.5	SB2: SB1, SB4 *	383.0	20.3	
SB3	5	364.5	14.2		387.4	16.2	
SB4	8	315.1	12.8		355.9	9.2	
		Day 420			Day 450		
SB1	21	394.1	6.4	0.1224	420.9	6.2	0.0772
SB2	8	412.5	20.6		438.7	19.0	
SB3	5	405.6	14.8		424.4	14.7	
SB4	8	383.6	8.6		408.1	8.1	
		Day 480			Day 510		
SB1	21	449.3	6.5	0.1075	474.6	6.6	0.3547
SB2	8	461.0	17.0		482.4	15.9	
SB3	5	446.0	13.1		474.4	12.9	
SB4	8	431.9	7.4		461.7	10.9	
		Day 540			Day 570		
SB1	21	508.6	7.9	0.3982	535.0	7.9	0.6746
SB2	8	507.4	13.8		534.2	12.9	
SB3	5	497.8	14.6		528.8	16.4	
SB4	8	497.7	13.1		533.1	14.2	

* $p < 0.05$; ** $p < 0.01$; SE = standard error of the mean; SB1 = born January–March, SB12 = born April–June, SB3 = born July–September, SB4 = born October–December.

The ADGs were highest in the SB1 group from the 360th day to the 480th day, followed by SB4. The lowest values were mostly observed in the SB3 group. Significant differences were recorded between 390 and420 days (SB1 0.95 ± 0.06 kg, SB2 0.94 ± 0.07 kg, SB3 0.62 ± 0.10 kg, and SB4 0.86 ± 0.09 kg; p = 0.0440, SB1: SB3 *) and between 540 and 570 days (SB1 0.89 ± 0.06 kg, SB2 0.87 ± 0.07 kg, SB3 1.04 ± 0.09 kg, and SB4 1.18 ± 0.09 kg; p = 0.0245, SB2: SB4 *). The ADG for the whole period, from the 360th to the 570th days, differed significantly (SB1 0.98 ± 0.04 kg, SB2 0.81 ± 0.04 kg, SB3 0.73 ± 0.06 kg, and SB4 1.03 ± 0.05 kg; p = 0.0002, SB3: SB1, SB4 **, SB2: SB1, SB4 *) (Table 2). Significant interactions between the rearing group and the season of birth were calculated in the ADG 360 to 390 days (p = 0.0285 *) and in the ADG for the entire experiment (p = 0.0499 *).

No significant differences were found in the father's lineage effect on the growth.

3.2. Health and Reproduction

Two heifers were culled from the RS group, one at 18 months of age due to infections causing a respiratory problem (pneumonia) and the other for an injury (limb fracture) at 19 months of age. One heifer of the CR group had to be culled due to foetal loss (122 days of pregnancy) at the age of 19 months.

The ages of the first insemination service (RS 427.3 ± 3.9 days, N = 18; US 412.7 ± 5.3 days, N = 16; CR 448.2 ± 4.7 days, N = 17; p = 0.0386, US:CR *) and the conception (RS 452.1 ± 5.9 days, N = 18; US 441.3 ± 8.8 days, N = 16; CR 472.4 ± 7.3 days; N = 17; p = 0.0420 *, US:CR *) were different. The LBW at the first insemination service and at the conception were as follows: RS 402.4 ± 6.9 kg, N = 18; US 405.3 ± 7.9 kg, N = 16;

CR 405.5 ± 9.2 kg, *N* = 17; *p* = 0.8324; RS 422.7 ± 11.2 kg, *N* = 18; US 433.1 ± 9.2 kg, *N* = 16; CR 426.4 ± 10.7 kg, *N* = 17; *p* = 0.6369.

Table 2. Effects of birth season on the average daily gains in heifers (kg).

Group	N	Mean	SE	*p* Value/ Significance	Mean	SE	*p* Value/ Significance
		From the 360th day to the 390th day			From the 390th day to the 420th day		
SB1	21	1.26	0.22	0.1250	0.95	0.06	0.0440 *
SB2	8	0.30	0.36		0.94	0.07	SB1:SB3 *
SB3	5	0.16	0.34		0.62	0.10	
SB4	8	1.48	0.40		0.86	0.09	
		From the 420th day to the 450th day			From the 450th day to the 480th day		
SB1	21	0.89	0.08	0.3774	0.94	0.06	0.1528
SB2	8	0.87	0.10		0.74	0.11	
SB3	5	0.63	0.05		0.72	0.08	
SB4	8	0.82	0.12		0.79	0.06	
		From the 480th day to the 510th day			From the 510th day to the 540th day		
SB1	21	0.84	0.04	0.1177	1.13	0.13	0.1934
SB2	8	0.71	0.07		0.83	0.09	
SB3	5	0.94	0.08		0.78	0.07	
SB4	8	0.99	0.15		1.20	0.10	
		From the 540th day to the 570th day			From the 360th day to the 570th day		
SB1	21	0.89	0.06	0.0245 *	0.98	0.04	0.0002 ***
SB2	8	0.87	0.07	SB2:SB4 *	0.81	0.04	SB2:SB1,SB4 *
SB3	5	1.04	0.09		0.73	0.06	SB3: SB1,SB4 **
SB4	8	1.18	0.09		1.03	0.05	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; SE = standard error of the mean; SB1 = born January–March, SB12 = born April–June, SB3 = born July–September, SB4 = born October–December.

The percentages of conception after the first insemination were RS 66.66%, *N* = 18; US 56.25%, *N* = 16; CR 58.82%, *N* = 17, and the numbers of services per conception (insemination indexes) (RS 1.39 ± 0.15, *N* = 18; US 1.51 ± 0.17, *N* = 16; CR 1.43 ± 0.16; *N* = 17; *p* = 0.8790) did not differ statistically (Table 3). These reproductive indicators were not statistically different in comparison with the season of birth or father's lineages.

Table 3. Effect of treatment rearing on the reproduction parameters of heifers.

Group	N	Mean	SE	*p* Value/ Significance
		Age of the first insemination (days)		
RS	18	427.3	3.9	0.0386 *
US	16	412.7	5.3	US:CR *
CR	17	448.2	4.7	
		Live body weight at the first insemination (kg)		
RS	18	402.4	6.9	0.8324
US	16	405.3	7.9	
CR	17	405.5	9.2	
		Age of the conception (days)		
RS	18	452.1	5.9	0.0420 *
US	16	441.3	8.8	US:CR *
CR	17	472.4	7.3	
		Live body weight at the conception (kg)		
RS	18	422.7	11.2	0.6369
US	16	433.1	9.2	
CR	17	426.4	10.7	
		Number of services per conception		
RS	18	1.39	0.15	0.8790
US	16	1.51	0.17	
CR	17	1.43	0.16	

* $p < 0.05$; RS = restrictive suckling group; US = multiple suckling group; CR = conventional reared group; SE = standard error of the mean.

4. Discussion

4.1. Growth

4.1.1. Factor Treatment Rearing (T)

In the present study, the LBW differences were mostly not significant. The LBW growth was the highest in the US group, while the lowest growth of the LBW was in the CR group. This was actually a continuation of the previous experiment course [42], when the highest live weight at weaning from milk–liquid nutrition in the US group was recorded. Additionally, the trend of the highest LBW of the US group was shown from the beginning of the present experiment on the 360th day until the 570th day. Please note that these former results support our findings that the increased LBW in US heifers kept with foster cows was a result of greater milk intake to weaning. Additionally, suckling of several calves empties the foster cow udder properly and can increase milk creation. This finding is consistent with previous studies [52–55].

High amounts milk consumption improve the later efficiency of heifers [19,21]. We must also consider the faster adaptation of calves to crude feed and that the loose housing of calves was associated with an increased appetite [56–58]. In our opinion, the higher growth in US heifers was caused by the better liquid nutrition compared with the CR group [2,59,60].

There was a higher LBW in the RS group compared with the CR group. Our results are consistent with other findings [9,14,61] that the growth of suckling calves (RS) are higher than those artificially reared (CR), which probably received less valuable liquid nutrition [5,6,12,62–64].

There was also a lower LBW at 570 d in the CR group compared with groups US and RS (519.6 kg against 542.3 kg and 531.4 kg). The compensatory growth of the CR group was found, but this was not sufficient. It can be seen from almost the same absolute weight gain from the 360th to the 570th days. The CR group had a major initial disadvantage.

4.1.2. Season of Birth and Father's Lineage Factors (SB, F)

We hypothesised that the season of birth may play an important role in growth and behaviour. The highest LBW was observed in SB2 heifers and SB4 heifers, while SB3 heifers weighed the least up to 570 days of age. The ADGs were significantly highest in the SB1 and SB4 groups. The close relationship of LBW growth to seasonal effects is also evidenced by significant interactions between the group and the season.

The significant and persistently greater LBW in the heifers that were not stressed compared with those affected by heat may be explained with the help of additional factors. In farm conditions, they can suffer from stress during several phases of the reproduction, but calves can be significantly affected also by prenatal stress during the mid or late gestation of their mothers [26,27,65]. The effect of prenatal exposure to high temperatures is generally considered the worst. High temperatures at the end of pregnancy generate metabolic changes [41,65–67].

The last trimester of gestation is a critical period for foetal growth and physiological transition into the next period of life. Maternal nutrition during pregnancy on the calf remain of practical significance to livestock producers [32]. Calves born to cows under heat stress during the dry period are lighter at birth and have lower postnatal growth and passive immunity than calves born to cooled cows [28,38,39,41,68–71]. These seasonal differences are likely caused by seasonal metabolic adaptations to enhance survival of the calf in different circumstances [64,66,67,72].

Although heat stress during late gestation is accepted to affect neonate calf foetus [33], this effect is expected to be less significant in the moderate Slovakian climate [69,72]. In the present study, pregnant mothers were intensively managed and a balanced ration was fed. The limited influence of the season on nutritional status was expected. It is possible that seasons combine the effect of the photoperiod, temperature, and nutritional status. Multiple hypotheses have been suggested, but the exact underlying mechanism of these effects remains unclear [28].

In the present study, maternal heat stress during late gestation decreases BW by up to 570 days of age in SB3 group heifers born between July and September. These results corroborated those of other authors [68,69,72–77] and confirm that a calf body weight can be significantly impacted by heat stress during the final weeks of gestation. However, what about the SB4 group? The negative results of heat stress often appear with a delay, and a carry-over effect may be experienced. The summer heat stress may affect the cows until autumn [27,29].

4.2. Health and Reproduction

Although the authors of [33,47–51,78–82] stated that the artificial rearing of calves presents a combination of emotional and nutritional stresses that reduces their immune response and health condition, the incidence of health problems was very low in all treatment groups, and there were no differences in the occurrence of illnesses in the study.

In the present study, differences between groups were calculated only at the first insemination and the beginning of pregnancy. It has always been closely related to LBW, as described by the authors [31,83–85].

The group with the highest LBW (US) was inseminated and fertilised first, and heifers of CR group with the lowest LBW growth were inseminated and fertilised last. There were no significant differences in LBW between the groups during first insemination or fertilisation. Similarly, no significant differences were found in PCFI and NSC. Additionally, no significant differences were calculated in the evaluation of the factors season of birth and father's origin. Studies [26,41] showed that heifers born to heat stressed dry cows have a greater number of services per conception. At the present work, no effect of the exposition of mothers of the SB3 group heifers to heat stress during late gestation was observed on age at AI and on age of first parturition of daughters.

5. Conclusions

This study was conducted to determine whether factors of rearing, season of the birth, and father lineage have an effect on the growth and reproduction of dairy heifers from the 360th to the 570th days.

The live body weight was the highest in the heifers reared in housing with foster cows (US), and the lowest weights were recorded in the heifers reared in hutches (CR). This was also evident at the first insemination service and at the conception, which were the highest in the CR group. The growth was influenced also by the season of birth; the highest growth of live body was found in SB2 heifers.

The results indicate that the method used to rear heifers and the season of birth may have a significant impact on their later growth in puberty and first pregnancy.

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