Performance and longevity of dairy heifers born during winter 1 (W1) and reared according to three growth profiles during winter 2 (W2) in a strategy based on first calving at 36 months of age

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Abstract: Two experiments were performed simultaneously to test the hypothesis that restricted growth patterns during winter two (W2) affect further performance of dairy heifers born during winter one (W1) first calving at 36 mo of age. A total of 158 dairy heifers born during three successive winters (1994 to 1997) were considered at two experimental herds (INRA, Le Pin au Haras and Mirecourt) located in two different parts of France. Breeds of animals were Holstein (Ho) and Normande (No) at le Pin, and Holstein (Ho) and Montbeliarde (Mo) at Mirecourt. At the beginning of W2 (348-365 d of age on average), animals were housed and subject to a restricted feeding strategy to show an average daily gain (ADG) of 600, 400 or 200 g/d at Le Pin au Haras, and 500, 200 and -200 g/d at Mirecourt, respectively, during W2. During pasture seasons, management and feeding were similar for all animals. As expected, body weight differed between treatments at the end of W2 ($P < 0.05$), but it was similar when first calving at 36 mo of age. Overall fertility in heifers and cows was not affected by feeding treatments. In both herds, performance during the first lactation was generally not affected by feeding treatments, with the exception of the 600 g/d group of heifers at Le Pin showing lower milk performance calculated on a 4% basis and a deteriorated milk composition ($P < 0.05$) when all lactations were considered. However, when calculated on a productive life day basis, they had the best milk production on a 305 basis ($P < 0.05$). Of the 158 animals that started the experiment, 41% were culled because of reproductive disorders (troubles of reproduction, n = 22 or empty, n = 45), probably because of the seasonal calving system. Other differences noted between herds were mainly due to breeds involved, with Mo cows having lower milk performance on average (- 800 kg per lactation, $P < 0.001$) but a better longevity (4.5 vs. 2.4 lactations at culling, respectively) when compared with Ho animals. No cows exhibited also lower milk performance in comparison with Ho animals on a 305 d length basis ($P < 0.001$), but this was not counterbalanced by any improved longevity (3.0 and 2.5 lactations at culling, respectively). These results indicate that, in a 36 mo of age at first calving strategy, it is possible to voluntary reduce ADG during a short growth period without any major effects on performance at short and long terms.

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Performance and longevity of dairy heifers born during winter 1 (W1) and reared according to three growth profiles during winter two (W2), in a 36 mo of age at first calving strategy

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Abstract

Two experiments were performed simultaneously to test the hypothesis that restricted growth patterns during winter two (W2) affect further performance of dairy heifers born during winter one (W1) first calving at 36 mo of age. A total of 158 dairy heifers born during three successive winters (1994 to 1997) were considered at two experimental herds (INRA, Le Pin au Haras and Mirecourt) located in two different parts of France. Breeds of animals were Holstein (Ho) and Normande (No) at le Pin, and Holstein (Ho) and Montbeliarde (Mo) at Mirecourt. At the beginning of W2 (348-365 d of age on average), animals were housed and subject to a restricted feeding strategy to show an average daily gain (ADG) of 600, 400 or 200 g/d at Le Pin au Haras, and 500, 200 and -200 g/d at Mirecourt, respectively, during W2. During pasture seasons, management and feeding were similar for all animals. As expected, body weight differed between treatments at the end of W2 ($P < 0.05$), but it was similar when first calving at 36 mo of age. Overall fertility in heifers and cows was not affected by feeding treatments. In both herds, performance during the first lactation

was generally not affected by feeding treatments, with the exception of the 600 g/d group of heifers at Le Pin showing lower milk performance calculated on a 4% basis and a deteriorated milk composition ($P < 0.05$) when all lactations were considered. However, when calculated on a productive life day basis, they had the best milk production on a 305 basis ($P < 0.05$). Of the 158 animals that started the experiment, 41% were culled because of reproductive disorders (troubles of reproduction, n = 22 or empty, n = 45), probably because of the seasonal calving system. Other differences noted between herds were mainly due to breeds involved, with Mo cows having lower milk performance on average (- 800 kg per lactation, $P < 0.001$) but a better longevity (4.5 vs. 2.4 lactations at culling, respectively) when compared with Ho animals. No cows exhibited also lower milk performance in comparison with Ho animals on a 305 d length basis ($P < 0.001$), but this was not counterbalanced by any improved longevity (3.0 and 2.5 lactations at culling, respectively). These results indicate that, in a 36 mo of age at first calving strategy, it is possible to voluntary reduce ADG during a short growth period without any major effects on performance at short and long terms.

Key words: feed restriction; winter; rearing; heifers; breed; longevity

1. Introduction

Seasonal calving systems are generally based on grazing optimisation, and as a result, feeding strategy is closely connected to the seasons. In such systems, breeding is also generally seasonal, and first calving usually occurs at 24 or 36 mo of age. First calving at 36 mo of age strategy is not rare in European dairy systems based on seasonal feeding strategy and using either late- (e.g., Normande) or early-maturing (e.g., Holstein) breeds. This strategy is aimed at reducing labour and feeding costs (Hoch et al., 2003). Indeed, as daily gain from birth to farrowing is lower in a 36 mo of age at 1st calving strategy than in a 24 mo of age at 1st calving strategy, diets with less concentrate and more roughage can be used in the former system. However, these arguments could also be tackled by additional extra costs (12 months of supplementary maintenance more, delayed return to investment…).

In case of unfavourable summer for hay and/or silage production, fodder availability during following winter could be however limited, thus leading to feed deficits for the entire herd. To preserve milk production of adults, heifers may be faced to a severe feed restriction, and consequently, may have very low or even negative growth performance during this period. However, these animals generally exhibit catch-up growth performance while grazing in comparison with normal fed heifers during the same period (Le Cozler et al., 2010). Moreover, such alternated low to high feeding allowance could be of interest (Park et al., 1989; Ford and Park, 2001) to elicit compensatory development and increase lactation potential. In general, the less average daily gain (ADG) during winter is, the highest the compensatory increase observed thereafter will be. In a 36 mo of age at 1st calving system, another strategy in unfavourable conditions could be to preserve all dairy cows and some of the growing heifers (i.e., generally those close to be inseminated), but assert a severe feed restriction for the younger reared animals (i.e., those around 12 mo of age). To our knowledge, the impacts of such a severe feeding and rearing strategy on latter performance are not known. The present experiment aimed at studying the effect of different patterns of growth restriction during winter 2 (W2) of rearing on performance and longevity of different breeds of heifers born during winter 1 (W1), and first calving at 36 mo of age.

2. Material and methods

Two experiments were performed simultaneously at two different experimental herds, located either in the western (Experiment 1) or in the eastern (Experiment 2) parts of France. Herds used different feeding strategies and management, as well as different breeds. Common rearing strategy is summarized on Figure1. All animals included ion these experiments were born during three successive winters (1994 to 1997).

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Experiment 1: Holstein and Normande heifers

Experiment 1 was performed at the INRA experimental farm of Le Pin au Haras (48°44'N; 0°08'W; 140-248 m above sea level, Normandy, France). It included a total of 78 heifers born during three successive calving winter seasons (W1, December to February) of either Normande (No; n = 34) or Holstein (Ho; n = 44) breeds (Table 1). Animals were reared according to procedures detailed by Le Cozler et al. (2010). Briefly, all heifers were reared similarly from birth until the end of the first grazing period (S1). Thereafter (winter 2, W2), they were housed and fed indoors with a restricted feed allowance to achieve ADG of either 600 (n = 26, H), 400 (n = 25, M) or 200 (n = 27, L) g/d during this period. The 600 g/d growth group was considered to be close to the standard condition used in dairy herds when first calving occurred at 36 mo of age. Diets were mainly composed of corn silage, straw, rapeseed meal, urea and minerals (Table 2). At the end of W2, all heifers followed similar rearing until calving. Pregnant heifers joined the cow herd three weeks approximately before the expected date of calving, to facilitate their adaptation to new housing (e.g., stable, automatic doors) and feeding conditions.

After calving and during winter (November to the end of March), all cows were continuously housed indoors, with deep straw bedding and a grooved concrete-floor alley along the feeding table. They were offered free access to corn silage, and a complement (cereals, sugar pulp beat, and soybean meal) was added according to individual milk yield. The lactation ration was formulated to meet requirements based on individual production levels (INRA, 1988). During grazing seasons (April to November), all cows grazed pasture on a rotational management system (Hoden et al., 1991). When necessary, they received corn or grass silage with a complement to maintain a normal milk production.

Calving usually occurred in special individual boxes. Calving period started at the beginning of December and ended in March. Because of the seasonal calving strategy, the reproductive period started in March and ended in mid-June for both heifers and cows.

Experiment 2: Holstein and Montbeliarde heifers

The 2nd experiment was performed at the INRA experimental farm of Mirecourt (48°18'N; 06°08'W; 261-378 above sea level, Eastern part of France). It included a total of 80 heifers born during three successive calving winter season (October to February, W1). Both Holstein (Ho; n = 42) and Montbeliarde (Mo; n = 38) animals were used (Table 1). Animals were reared similarly to those in experiment 1, except some of the rearing procedures that were adapted due to feedstuff availability. Animals were housed and fed indoors at the end of the first grazing season (S1). Three feeding levels were used to achieve ADG of either 500 (n = 27, H), 200 (n = 27, M) or -200 (n = 26, L) g/d during winter 2 (W2). Several sources of roughage and concentrates were available and used (Table 2), to achieve experimental daily gain goals. Similarly to the 600 g/d ADG during W2 group of animals in experiment 1, the 500 g/d group was considered to be close to standard feeding used in dairy herds where first calving occurred at 36 mo of age in this experiment (Troccon et al., 1994). Experimental diets were mainly composed of soybean, cereals (wheat or barley), urea and roughage, primarily straw, grass and alfalfa hay and /or grass silage. Minerals were also added (Table 2). At the end of W2, all heifers followed similar treatments until calving: they were grazing during summer seasons and fed mainly with roughage (straw, grass silage, hay) and wheat or barley during winter 3 (W3). During grazing seasons (S1, S2 and S3; April to the end of November), they rotationally grazed a perennial ryegrass sward. As for experiment 1, roughage were offered during summer when necessary.

Pregnant heifers joined the cow herd two weeks on average before the expected date of calving. Contrary to Experiment 1, no special facilities were used for calving. After calving and during winter (November to the end of March), all cows were continuously housed indoors, with deep straw bedding and a grooved concrete-floor alley along the feeding table. As for growing heifers, ingredients could vary according to feedstuff available, providing that milking production was preserved. Cows were generally offered diets based on corn and/or grass silage, hay and/or straw, and a complement (cereals, sugar pulp beat, and/or soybean meal), together with minerals, was added. The ration was adapted according to individual milk yield, as the lactation ration was formulated to meet requirements based on individual production levels (INRA, 1988). During grazing season (April to November), all cows grazed pasture on a rotational management system. When necessary, they received hay, corn or grass silage with a complement to maintain a normal milk production.

Calving started at the beginning of October and ended in February, but around 90 % cows calved before the end of December. Reproductive period started in December and ended in mid-June for both heifers and cows.

Procedures for oestrus synchronisation in the 2 experiments

In both experiments, all heifers were inseminated after oestrus synchronisation during winter 3 (W3) of rearing, so that calving should occur at around three years of age. Cows were not served during the first 63 d (experiment 1) or 45 d (experiment 2) following calving. For heifers and cows, oestrus was synchronised using a progestin ear implant (norgestomet) in conjunction with an intramuscular estrogen injection (Crestar®, Intervet, Angers, France), without any consideration of ovarian activity. A second synchronisation was eventually performed on similar cows three weeks later. When delay from calving was shorter than 63 days at the second synchronisation (experiment 1), no treatment was applied to cows and these animals were served when detected in heat (20 to 25 % of all calving cows each year). After nine days of treatment, the ear implant was removed. Heifers and cows generally exhibited signs of oestrus within 24-96 h and then were inseminated. A test of the plasma progesterone level was performed 21 d after insemination to check for the onset of gestation. For animals that did not show any oestrus according to this test, an echographic inspection was performed to confirm pregnancy at 42 d after insemination on average, only in experiment 1. Cows and heifers coming back into heat were inseminated until the end of the reproductive season (June).

2.4. Registration and measurements

Individual BW was measured at birth and, on average, every three weeks thereafter. Since the duration of winter differed between years of birth and between calendar years (from 126 to 168 d, Table 3), BW was corrected (by extrapolation) according to age, and daily or monthly weight gains were then calculated. During winter seasons (W2 and W3), daily feed allowances and refusals were recorded on a per-pen basis. Informations regarding heifers and cows at calving were scored according to their degree of difficulty (1= no difficulty; 2= minor difficulty; 3= major difficulty or caesarean section). Newborn calves were identified and weighed within 24 h after birth. Reasons for culling heifers and cows were classified as (1) reproduction (failure to conceive or not pregnant), (2) calving difficulties, (3) disease, (4) accident, (5) mastitis, (6) inadequate performance (less than 20 kg milk/d during the first four weeks of lactation), (7) replacement and age, and (8) miscellaneous.

2.5. Calculations and statistical analysis

Analyses were performed on a herd basis. For cows that were culled within 100 d after calving, lactation number at culling was then (*n*+1), but their lactating performances were included in the data only until the end of parity *n*. This means that days in milk (DIM) > 100 counted for the current and previous lactations and DIM < 100 counted only toward all previous lactations. Milking production and performances were calculated on a 305-d basis for all animals as: 305 Milk (kg) = total milk produced (kg) x (385 / (lactation length (d) + 80)). This method is used in the French evaluation system as a reference and had been discussed by Barbat et al. (1995). An identical procedure was used for calculating fat and protein yield. Milk yield also was calculated on a 4% fat content basis, using the following formula: 4% Milk (kg) = total milk produced (kg) x (0.4 + 0.015 x fat concentration (g/kg)). Growth performance data were analysed on a per-animal basis, using statistical models that included the effect of treatment during winter 2 (H, M, and L), year of birth (1994/95, 1995/96 and 1996/97), breed (No, Mo and Ho) and their possible interactions were kept when significant.

Values of least squares means (breed or feeding treatment) were compared using p-diff tests in GLM options of SAS® statistics software (version 8.0; SAS Institute, Inc., Cary, NC). Other co-variables were tested and kept in the model when necessary. Analysis performed on milk and longevity data included year of lactation. For data concerning reproduction, health and culling, the CHISQ option of the FREQ procedure and the LOGISTIC procedure were used (SAS software). Survival analysis based on the number of cows was studied with the LIFEREG procedure. For all tests, level of significance was 0.05. P. Values less than 0.10 are discussed as trends.

3. Results

Age at 1st artificial insemination (AI) was around 800 d, so that experimental animals first calved at the average age of 1081 d. Small differences were noted between the two herds. Experimental treatments started at 348 and ended at 461 d of age at Le Pin, and 365 and 510 d of age at Mirecourt, respectively. Winter housing during year three started at 700 and 730 d of age at Le Pin and Mirecourt locations, respectively, and ended at 840 and 870 d, respectively. The duration of experimental treatment was then slightly lower at Le Pin (114 to 131 d, 124 d on average) than at Mirecourt (151 to 167 d, 160 d on average, Table 3).

3.1. Body growth and development

Observed ADG did not exactly match those expected (Table 3). The highest differences were noted for heifers born during winter 1995/1996 for treatment H (+29% on average in the two herds) and treatment M (especially at Mirecourt where

ADG was 98% greater than that expected). Moreover, heifers born during winter 1996/97 had generally a lower ADG than expected for treatment L and M treatments at Mirecourt. In all cases, observed ADG was highly variable among animals (i.e., coefficient of variation (CV) ranged from 77 to 176 g/d, Table 3).

As expected, animal growth was altered during W2 in both herds, with L heifers showing a stronger depression in their growth profile (Figure 1). At the end of the experimental period (480 d on average), the L, M and H heifers weighed 323, 339 and 369 kg, respectively, at Le Pin ($P < 0.05$) and 297, 346 and 369 kg at Mirecourt, respectively ($P < 0.05$). An increase in growth performance was observed when animals turned to pasture at the end of W2. The most severely restricted animals during W2 had the highest BW gains during this period ($P < 0.01$). However, BW at 600 d of age still ranged from L < M < H groups (i.e., 420, 437 and 448 kg at Le Pin, and 387, 424 and 436 kg at Mirecourt for L, M and H heifers, respectively; $P < 0.05$). On the opposite, BW at calving was not different between treatments or breeds at Le Pin, whereas H heifers were heavier than L heifers at Mirecourt ($P < 0.05$). In this latter herd, BW of M animals were intermediary to those observed in L or H heifers. At this stage, no difference in BW was noted between breeds, whatever the herd considered.

3.2. Animal survival, health and culling

Thirty-one heifers were culled during rearing, mainly because they did not become pregnant before the end of the reproductive period. The percentage of culled animals before first calving was not affected by treatment during W2, and did not differ between breeds. Main reason for culling was reproductive disorders but no significant difference was noted between breeds or treatments.

Figure 2 considers only animals with a productive life, i.e., calving at least once. Only around 35 % (Le Pin) to 45% (Mirecourt) of these animals were however still present 1100 d after their first calving. Parity at culling did not differ between treatment at

Mirecourt (4.0, 3.2 and 3.2 for L, M and H cows, respectively) or at Le Pin (2.8, 3.0 and 2.4, respectively). Whereas age at culling was lower for H cows than M cows at Le Pin (1675 and 2034 d, respectively, $P < 0.05$), there was no difference in the same trait at Mirecourt. However, in this latter herd, Mo cows had a higher parity (4.5 vs. 2.4) and were older (2363 vs. 1749 d) at culling than Ho cows ($P < 0.01$), whereas there were no breed-associated differences in the same traits at Le Pin.

3.3. Reproductive and productive performances

Overall fertility in heifers was not affected by any of the treatments. Similarly, fertility rates at 1st AI did not differ (averaging 48% at Le Pin, and 50% at Mirecourt, data not shown). There were no breed-associated differences in the percentage of successful gestations after one AI and of calving difficulties.

The duration of lactation did not differ between treatments or breeds at Mirecourt (Table 4). However, it was significantly reduced for H heifers at Le Pin when considering overall lactations. During lactation one, feeding treatment did not affect productive performances, with the exception of fat production that was the lowest ($P < 0.05$) in H cows at le Pin only (-18 kg and -36 kg, when compared to L and M treatment, respectively). Most performances were also affected by breeds, with Ho cows having better results than other breeds in the two experimental herds. Especially, Ho primiparous cows produced 1160 kg more milk on a 305 days basis than primiparous No cows at Le Pin ($P < 0.01$), and the difference was + 462 kg in favour of the formers compared to Mo cows at Mirecourt ($P < 0.05$). The same conclusions can be drawn for milk yield calculated on a 4 % basis at Le Pin ($P < 0.05$), but breed-associated difference on this trait was greater than the previous one (milk production on a 305 d basis) at Mirecourt (+ 914 kg in favour of Ho cows).

Similarly, overall mean milk yield per lactation and per cow was not affected by the feeding treatments (Table 4). However H cows produced less milk 4% than L and M animals (-538 kg on average, $P < 0.05$) at Le Pin only. At Le Pin and Mirecourt, breed-associated differences were observed on all parameters ($P < 0.05$), except lactation length. The differences were in favour to Ho cows, and were generally more marked at Le Pin than at Mirecourt. This resulted especially in a greater milk yield calculated on a 4% or a 305 d basis for Ho animals than for No and Mo ones ($P < 0.01$). As far as milk composition is concerned when all lactations were pooled, a significant effect of treatments during W2 was observed at Le Pin only. In this herd, H cows produced less fat and protein than L and M cows that produced milk with a similar biochemical composition. Protein and fat productions were also higher for Ho cows in comparison of No cows (Le Pin, $P < 0.01$) or Mo ones (Mirecourt, $P < 0.01$). In addition, lactation rank had a positive impact on all parameters ($P < 0.05$), whatever the herd considered.

When analyses were done on productive day of life basis (Table 5), treatment had a slight effect on milk production calculated on 305 days at Le Pin only, with H cows showing the best results compared to L and M ones (20.2 vs. 17.8 kg on average, $P < 0.05$). Breed affected all performance calculated per day of productive life, with the exception of milk on a 305 d basis at Mirecourt. Protein and fat in the milk were greater for Ho cows than No and Mo animals ($P < 0.05$). In both herds, lactation rank at culling had a positive effect ($P < 0.05$) on these parameters, and year of birth also affected the results at le Pin mainly (Table 5).

Regardless of feeding treatment during W2, regression analysis however revealed that a 30-days difference in BW at first calving resulted in a 250 kg milk decrease during first lactation ($P < 0.01$; data not shown). No significant relationships were noted between age or BW at calving and milk yield production for higher parities.

4. Discussion

First calving at 36 mo of age allows the use of less concentrate and/or forage, which usually leads to a reduced daily gain during housing winter periods. The compensatory increase in growth obtained during grazing seasons needs therefore to be optimized to compensate for extra-additional costs such as more heifers in the farm, 12 additional months of maintenance, delay in the return-on-investment and a slow genetic progress (Le Cozler et al., 2010). One of the main interests of present study then consists on the comparison of the immediate and long-term responses to strategies to reduce ADG during a short period. Another interest of present investigation was the possibility to perform such trials in two herds geographically localized in two different areas of France, and with differences in both feedstuff and breeds of animals. Climate-related difference in the duration of winter housing between the two herds also resulted in differences on treatment durations that might have affected the final results. As reported in other experiments and previously discussed (Le Cozler et al., 2009; 2010), year of birth also affected overall performance per day of productive life, likely because the chemical composition of diets estimated from the ingredients slightly varied from year to year. This was especially the case when feeding regimes were adapted to the feedstuff availability, as it happened at Mirecourt.

4.1. Elicited growth patterns

At 6 mo of age, mean BW of heifers corresponded to 24 to 29 % of mature BW (i.e., 650 to 750 kg depending of the breeds) and was attained following an ADG of 817, 766 and 772 g/d for Ho, Mo and No heifers, respectively. These values were close to those recommended by Troccon et al. (1994). Many studies have investigated possible effects of ADG prior to puberty on subsequent performances (Le Cozler et al., 2008 for a review). They generally recommended a high growth rate during the first 6 mo of age to ensure optimal body development, even when animals first calved at 36 mo of age. Thereafter, a subsequent decrease in growth rate is generally recommended to prevent excessive fatness and bad reproductive and productive performances (Troccon et al., 1994). This was realized in the current study with ADG of 610, 568 and 600 g/d from birth to first insemination for Ho, Mo and No heifers, respectively.

In the present study, BW at the first successful insemination were higher (503 to 535 kg corresponding to 70 to 82 % of mature BW according to breeds) than commonly observed (450-500 kg at 27 mo of age and 55 to 60 % of mature BW, Troccon et al., 1994). However, it should be reminded that recommendations in a 36 mo of age at first calving strategy are generally higher than those for animals calving at a younger age. In addition, at Mirecourt, information on BW is available during entire lifespan of the herd and it indicates an average mature BW of 707 and 704 kg for Ho and Mo cows older than 1500 d, respectively. Based on these data, BW at 1st calving corresponded to 90 and 91.6 % of mature BW in Mo and Ho cows respectively in the present experiment, which is finally closed to recommendations for animals first calving at 36 mo of age (85 to 90 %; Troccon et al., 1994).

4.2. Effects of feeding treatments on reproduction and production at first lactation

The present results indicate that deleterious ADG (200 g/d or less) around one year of age had no or only limited effects on fertility of heifers first calving at 36 mo of age. In a 24 mo of age at first calving strategy, Troccon and Petit (1989) and Heinrichs (1996) concluded that very low ADG during rearing alters heifer fertility. However, increasing feed allowance during a brief period before ovulation (i.e., a so called "flushing procedure") may restore fertility rates. However, Le Cozler et al. (2010) found only limited effect of previous feed restriction during two successive winters on heifers' fertility. Taken together, it would be concluded that a preserved growth rate during winter should probably be favourable to preserve fertility for heifers first calving at 24 mo of age, but might not be necessary when first calving occurs later.

Results of present study showed that altered growth profiles around puberty had only limited impact on subsequent productive performance. The importance of feed strategy before or after puberty had been already discussed (Le Cozler et al., 2008). Puberty attainment was not directly assessed in the present study, but it can be hypothesised that in early maturing breed such as Holstein, most heifers with an ADG of 740 g/d closed to the recommendation for optimal ADG (Sejrsen et al., 2000; Zanton and Heinrichs, 2005) before 240 d of age showed a first oestrus before the start of the experimental treatments (Le Cozler et al., 2009). This could explain the lack of treatment-associated differences in first lactation milk yield. But all late maturing animals (Montbeliarde and Normande breeds) probably did not have a first oestrus before experimental treatments. Indeed, according to Drogoul et al. (2005), if attainment of puberty is generally around 9 to 10 mo of age in Ho heifers, it is two months later in No heifers and even more for Mo animals. So, whatever the breed and sexual development, animals fed L, M or H levels of feed during winter after the first pasture season had similar lactation performance during first lactation, and no interaction between treatment and breed was noted. These results are in agreement with data from Troccon et al. (1997) and Le Cozler et al. (2010) who show no impact of altered growth performance during two successive winters on first lactation performance. Similarly to what was observed here for animals first calving at 36 months of age, others have also noted no effect of a limited feed intake up to puberty on performance during the first lactation (Hoffman et al., 2007; Zanton and Heinrichs, 2007) on animals first calving at 24 mo of age.

In addition, present results did not show any effects of increased growth during spring on milk performance during first lactation, as already reported (Le Cozler et al., 2010). Ford and Park (2001) observed improved results when growth was altered (using stair-step compensatory nutritional programs). In the previous study, experiment was based on animals first calving at 24 mo of age and differences in age (270 d in the current study vs. 180 d in the latter mentioned experiment) could also explain the discrepancies. This might be due to the degree of catch-up mammary growth which depends on the stage when it occurs (Ford and Park, 2001; Davis-Rincker et al. 2008). Although compensatory growth has been proposed as an interesting tool to manage animals in a 24 mo of age at first calving, the interest of such a practice in a 36 mo of age at first calving strategy remains to be studied and proved.

Finally, a positive relationship between BW at calving and milk production at first lactation was observed in the present study, regardless of experimental treatments. Similar relationships have been already reported by Lin et al (1985) and Waldo et al. (1998). Troccon and colleagues (1994) suggest that these relationships exist whatever the growth profiles are before lactation when first calving occurs at 36 mo of age. This is however opposite to what was stated in a 24 mo of age at first calving strategy (Park et al., 1989; Ford and Park, 2001), in which alternating low and high feeding rates during rearing have a positive impact on subsequent performance.

4.3. Culling, longevity and long-term performance

In the current study, long-term effects of a too slow growth rate during winter two of rearing were observed only in one herd (Le Pin). From a long-term point of vue, levels of production slightly differed between the two herds, with Ho animals from Le Pin usually having higher levels of production than those from Mirecourt. In complement, others studies (Gaynor et al., 1995; Capuco et al., 1998) also indicated possible long-term effects of feed composition during rearing on later adult performance. This suggests that any recommendations for rearing strategies (nutrition, reproduction …) have to be adapted to the levels of animal production in the different herds.

At Le Pin, L and M treatments during W2 had a positive effect on longevity since the number of culling was lower when compared to H treatment. The 42 % of culling observed in this herd is closed to that previously observed, with reproductive disorder being the main reason for culling (Le Cozler et al., 2010). This was probably a possible effect of seasonal calving strategy where reproduction has to be performed in limited times and non-pregnant animals are usually culled.

When all lactations were considered, the L and M winter-feeding level had also positive effects on milk protein and fat contents as well as on 4% milk production per lactation, when compared to H winter feeding level at Le Pin only. However, if the possible effects of regimes during lactation on milk quality are well-known (Hurtaud et al., 2009), such long-term effects of rearing treatments already observed (Le Cozler et al., 2010) are still surprising but need further investigations. However, no more difference was noted between treatments when composition of milk and 4% milk production were calculated per day on productive life. Furthermore, L and M treatments led to a slight detrimental effect on 305 d-milk production per day of productive life. These results clearly show that the possible benefits or detrimental effects of a given rearing strategy during winter two should be different from first lactation and later ones. It points out the necessity of studies following animals during more than one lactation.

Lactation length also differed between treatments at Le Pin but not at Mirecourt. This probably resulted of herd policy, as discussed by Le Cozler et al. (2010). Indeed, herd policy at Le Pin during the 1990s encouraged having high-performance animals (Holstein and Normande animals) and cows with inadequate lactating performances were often culled before 305 d of lactations. In opposition, at Mirecourt, herd policy was different and aimed at keeping Holstein with adequate performances (as for Le Pin), but the level of requested performances for Montbeliarde was in agreement with this breed, i.e., lower than for Holstein heifers.

5. Conclusion

Present results indicated that in a dairy system where first calving occurs at 36 mo of age, it is possible to reduce feed allowance of heifers aged around one year of age, without any major deleterious effects on subsequent performance. In a similar study performed on beef heifers, Dozias et al. (2006) concluded similarly. In case of unfavourable weather conditions leading to limited fodder stock, a feed restriction occurring during a short period of rearing could be encouraged regardless of breed, providing that restriction was not too severe (i.e., during one and not two successive winters). During subsequent lactations, productive performances are lower in case of severe restriction, but because of a positive impact on culling rate, performances calculated on a day of productive life basis do not differ.

The positive effect on longevity questioned on the possible interest of sequential compensatory growth program, not only in an early age at first calving strategy, but also for animals first calving at 36 mo of age. In addition, studies on the impact (or not) of various growth profiles from a dynamic point of view are probably of interest, as suggested by Meyer (2005) and need further development in the future.

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Table 1. Number of heifers per breed by treatment and birth year, according to herd

Table 2. Feed ingredients and correspondent calculated composition

Table 3. Duration of experimental treatment and average daily gain, according to year of birth and herd

Table 4. Overall performances according to treatment and breed

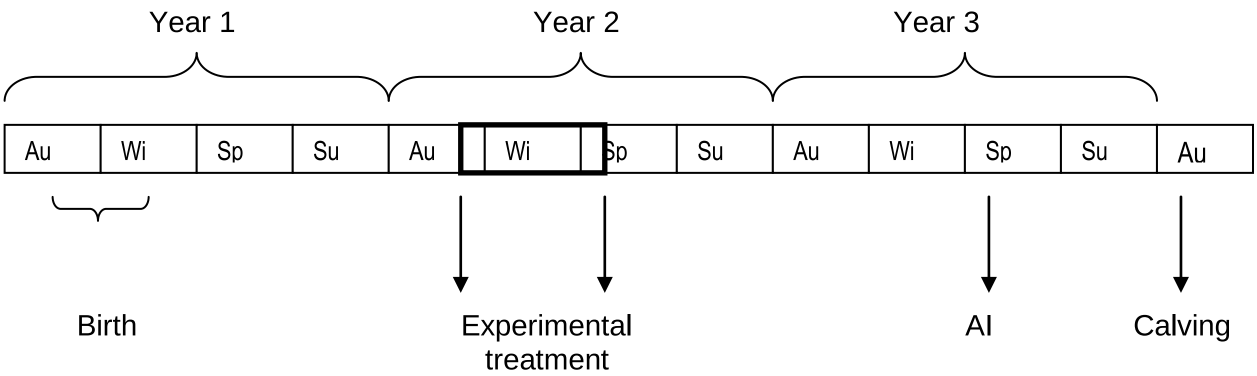
Table 5. Overall performances per day of productive life, age and parity at culling, according to treatment and breed

Figure 1. Growth of dairy heifers originated from two herds with different breeds and first calving at 36 mo of age

Figure 2. Percentage of survival dairy heifers from two different herds, according to days in production

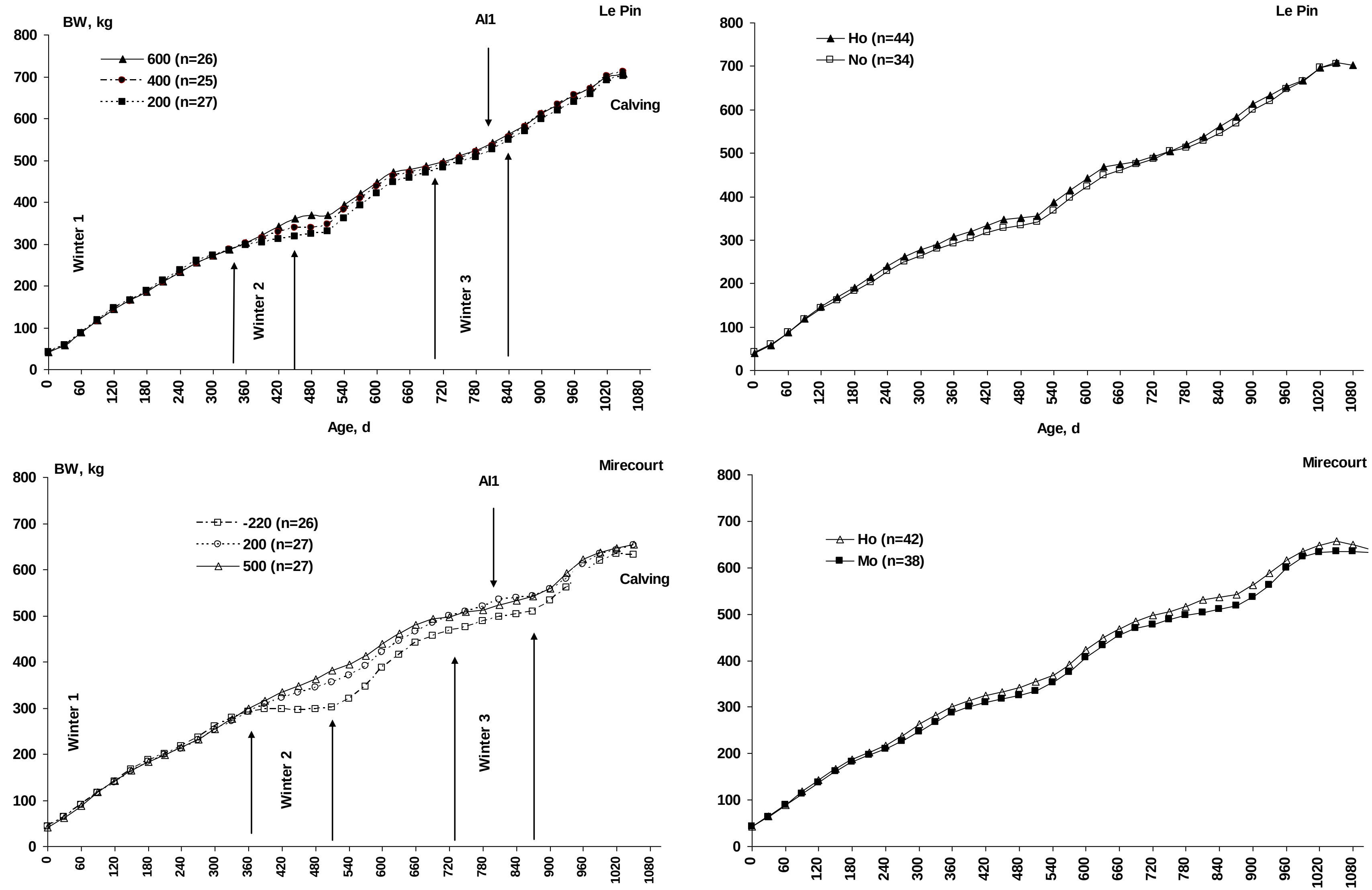
Figure

Figure 1. General design of the experiment used in both herds*



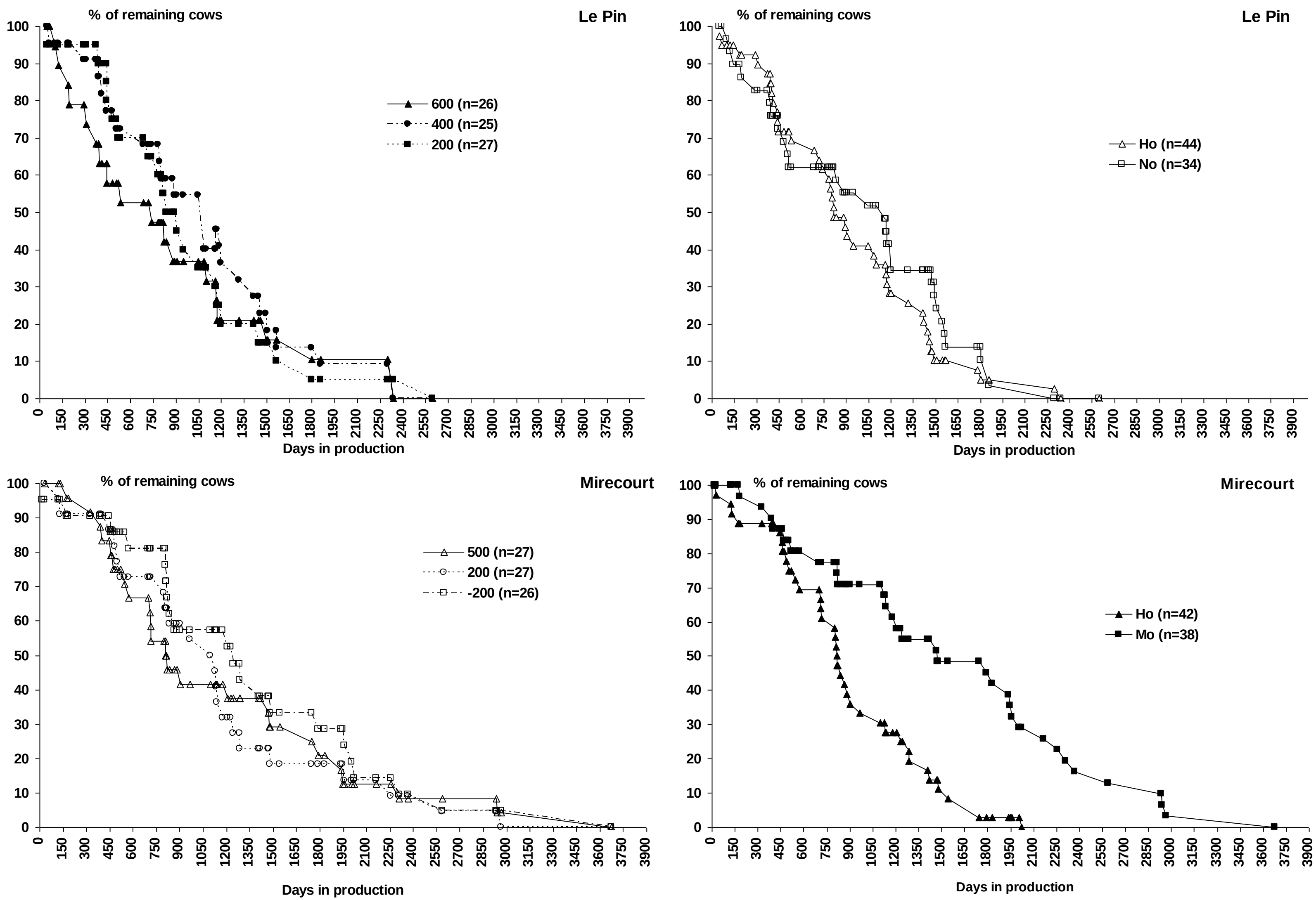
* Au : automn ; Wi : winter, Sp : spring ; Su : summer ; AI : artificial Insemination

Figure 2. Growth of dairy heifers originated from two herds (Le Pin and Mirecourt) with different breeds and first calving at 36 mo of age.



During winter 2, heifers received experimental treatment in order to achieve different daily gains (600, 500, 400, 200 or -200 g/d) during this period. Ho: Holstein; No: Normande; Mo: Montbeliarde. AI1: first artificial insemination

Figure 3. Percentage of survival dairy heifers from two different herds (Le Pin and Mirecourt), according to days in production.



Heifers from different breeds first calved at 36 mo of age and during winter 2, heifers received experimental treatment in order to achieve different daily gains (600, 500, 400, 200 or -200 g/d) during this period. Ho: Holstein; No: Normande; Mo: Montbeliarde.

Table

Table 1. Number of heifers per breed by treatment and birth year, according to herd

Year of birth / treatment	Herd	Treatment (1)															Total
		-200			+200			400			500			600			
		Ho	No	Mo	Ho	No	Mo	Ho	No	Mo	Ho	No	Mo	Ho	No	Mo	
1994/1995	Le Pin	-	-		6	3	-	6	3	-	-	-	-	6	3	-	27
	Mirecourt	5	-	4	5	-	4	-	-	-	5	-	4	-	-	-	27
1995/1996	Le Pin	-	-	-	4	4	-	5	3	-	-	-	-	4	4	-	24
	Mirecourt	3	-	5	4	-	5	-	-	-	5	-	4	-	-	-	26
1996/1997	Le Pin	-	-	-	5	5	-	4	4	-	-	-	-	4	5	-	27
	Mirecourt	5	-	4	5	-	4	-	-	-	5	-	4	-	-	-	27
Total		**13**	**-**	**13**	**29**	**12**	**13**	**15**	**10**	**-**	**15**	**-**	**12**	**14**	**12**	**-**	**158**

Ho: Holstein; Mo: Montbeliarde; No: Normande

(1): treatment: heifers born during winter 1 received feeding levels to reach average daily gain of either -200, +200, +400, +500 or + 600 g/d during winter 2

Table 2. Feed ingredients and correspondent calculated composition

Year of birth	Herd		Treatment*		
			High	Median	Low
1994/1995	Le Pin	Main ingredients	Corn silage, straw, rapeseed meal, urea, minerals		
		Per animal and per day			
		Dry matter, kg	6.21	5.52	4.59
		UFL	5.1	3.67	2.44
		PDIN, g	392	323	259
		PDIE, g	424	343	262
	Mirecourt	Main ingredients	Grass silage, hay, soybean meal	Hay, wheat	Hay or (straw, wheat and urea)
		Per animal and per day			
		Dry matter, kg	7.45	6.48	4.45
		UFL	5.60	4.32	2.37
		PDIN, g	558	258	244
		PDIE, g	512	406	246
1995/1996	Le Pin	Main ingredients	Corn silage, straw, rapeseed meal, urea, minerals		
		Per animal and per day			
		Dry matter, kg	5.99	5.09	4.89
		UFL	4.54	3.06	2.46
		PDIN, g	388	309	277
		PDIE, g	403	306	271
	Mirecourt	Main ingredients	Hay	Straw, wheat, urea	Straw, grass silage, hay
		Per animal and per day			
		Dry matter, kg	8.81	6.29	5.29
		UFL	5.40	4.77	2.62
		PDIN, g	558	483	226
		PDIE, g	418	322	259
1996/1997	Le Pin	Main ingredients	Corn silage, straw, rapeseed meal, urea, minerals		
		Per animal and per day			
		Dry matter, kg	5.91	4.87	3.87
		UFL	4.91	3.70	2.05
		PDIN, g	401	334	242
		PDIE, g	423	336	227
	Mirecourt	Main ingredients	Straw, grass silage, hay	Straw, grass silage, hay	Straw, wheat, barley
		Per animal and per day			
		Dry matter, kg	7.34	6.53	5.12
		UFL	4.99	4.46	2.67
		PDIN, g	325	293	256
		PDIE, g	469	420	256

High, medium and Low corresponded to expected ADG of 200, 400 and 600 g/g at Le Pin, and -200, +200 and +400 g/g at Mirecourt respectively. UFL: Unité Fourragère Lait (1 UFL = 7.115 MJ Net Energy); PDIN: Protein truly Digested in the small Intestine limited by Nitrogen supply; PDIE: Protein truly Digested in the small Intestine limited by Energy supply (Jarrige, 1989).

Table 3. Duration of experimental treatment and average daily gain, according to year of birth and herd

Year of birth / treatment	Herd	Start	End	Duration of experimental period, d	W2 ADG per treatment*		
					High, H	Median, M	Low, L
1994/1995	Le Pin	01-12-95	05-04-96	126	609 (143)	373 (142)	266 (85)
	Mirecourt	14-11-95	25-04-96	163	436 (127)	151 (96)	-175 (176)
1995/1996	Le Pin	25-11-96	05-04-97	131	748 (124)	496 (170)	207 (128)
	Mirecourt	07-11-96	07-04-97	151	667 (90)	396 (88)	-231 (137)
1996/1997	Le Pin	09-12-97	02-04-98	114	699 (147)	368 (128)	167 (139)
	Mirecourt	13-11-97	29-04-98	167	420 (77)	179 (123)	-84 (92)

* Winter 2 average daily gain: High, H: 600 and 500 g/d for Le Pin and Mirecourt herds, respectively; Median, M: 400 and 200 g/d for Le Pin and Mirecourt herds, respectively; Low, L: 200 and - 200 g/d for Le Pin and Mirecourt herds, respectively

Table 4. Overall performances according to treatment and breed (1)

Le Pin	Feeding treatment			Breed		Root MSE	Statistical significance
	200	400	600	Ho	No		
1st lactation							
n	17	20	20	32	25	-	-
Length, d	303	301	289	301	294	45	
Milk yield, kg	6684	6944	6363	7311	6016	1143	B***
Protein, kg	215	227	204	229	202	36.5	B*
Fat, kg	265[ab]	283[a]	247[b]	288	243	45.3	T*, B**
Milk 4%, kg	6648	7016	6255	7240	6039	1103	B*
Milk 305d, kg	6720	6969	6608	7349	6183	710	B**
all lactations							
n	50	57	42	75	74	-	-
Length, d	301[a]	303[a]	287[b]	302	294	46	T*
Milk yield, kg	7178	7164	6790	7766	6322	1166	B*, L*
Protein, kg	229[a]	231[a]	214[b]	240	210	39.5	T*, B***, L**
Fat, kg	288[a]	290[a]	263[b]	304	257	48.9	T*, B**, L*
Milk 4%, kg	7192[a]	7218[a]	6667[b]	7668	6383	1164	T*, B***, L***
Milk 305d, kg	7241	7192	7062	7822	6506	796	B***, L***

Mirecourt	Feeding treatment			Breed		Root MSE	Statistical significance
	-200	200	500	Ho	Mo		
1st lactation							
n	20	20	23	32	31	-	-
Length, d	308	303	311	319	295	71	
Milk yield, kg	6281	6244	6348	6734	5838	1556	B*
Protein, kg	211	212	215	228	198	51.0	B*
Fat, kg	272	273	270	291	253	67.2	B**
Milk 4%, kg	6595	6602	6589	7052	6138	1608	B*
Milk 305d, kg	6235	6265	6175	6456	5994	808	B*
all lactations							
n	71	61	69	72	129	-	-
Length, d	304	288	297	299	293	66	L*
Milk yield, kg	6980	6668	6787	7155	6468	1518	B**, L***
Protein, kg	230	225	226	237	216	51.4	B**, L***
Fat, kg	300	296	286	312	277	69.2	B***, L***
Milk 4%, kg	7293	7113	7006	7539	6737	1624	B**, L**
Milk 305d, kg	6984	6959	6919	7259	6650	936	B***, L**, (B x L)*

***: P < 0.001; **: P < 0.01; *: P < 0.05; T: feeding treatment; B: breed (No=Normande; Ho=Holstein, Mo= Montbeliarde); L: lactation; Y: year of birth.
Within a row of feeding treatment, mean values with a different letter are significantly different at P < 0.05.
(1) Animals performed at least a 110 d lactation length: 119 out of 127 heifers that calved.

Table 5. Overall performances per day of productive life, age and parity at culling, according to treatment and breed (1)

Le Pin	Feeding treatment			Breed		Root MSE	Statistical significance
	200	400	600	Ho	No		
							-
Protein, kg	0.55	0.57	0.58	0.60	0.54	0.06	B**, Y**, L**
Fat, kg	0.69	0.72	0.71	0.76	0.65	0.08	B*, Y*
Milk 4%, kg	17.3	17.9	18.0	19.2	16.2	1.9	B*, Y**, L*
Milk 305d, kg	17.6[a]	18.0[a]	20.2[b]	19.6	17.6	3.3	T*, B**, Y**
Parity at culling	2.8	3.0	2.4	2.5	3.0	1.46	-
Age, d	1838[ab]	2034[a]	1675[b]	1739	1939	677	T*

Mirecourt	Feeding treatment			Breed		Root MSE	Statistical significance
	-200	200	500	Ho	Mo		
							-
Protein, kg	0.55	0.57	0.55	0.58	0.54	0.07	B*, L*
Fat, kg	0.72	0.74	0.70	0.76	0.69	0.10	B*, L*
Milk 4%, kg	17.4	17.9	17.0	18.3	16.6	2.5	B*, L*
Milk 305d, kg	16.1	17.9	16.4	17.4	16.3	4.2	Y**
Parity at culling	4.0	3.2	3.2	2.4	4.5	1.96	B**
Age, d	2116	1983	2069	1749	2363	850	B**

***: P < 0.001; **: P < 0.01; *: P < 0.05; T: feeding treatment; B: breed (No=Normande; Ho=Holstein, Mo= Montbeliarde); L: lactation; Y: year of birth.
Within a row of feeding treatment, mean values with a different letter are significantly different at P < 0.05.
(1) Animals performed at least a 110 d lactation length