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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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Corresponding Author: Dr Yannick Le Cozler, PhD

Corresponding Author's Institution: AGROCAMPUS OUEST, UMR1080 Dairy Production

First Author: Yannick Le Cozler, PhD

Order of Authors: Yannick Le Cozler, PhD; Yves Gallard; Frédéric Dessauge, PhD; Jean-Rémy Peccatte; Jean-Marie Trommenschlager; Luc Delaby

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 voluntarily reduce ADG during a short growth period without any major effects on performance at short and long terms.

Suggested Reviewers: Kristen Sejrsen PhD

Senior Scientist, Department of Animal Health and Bioscience, Faculty of Agricultural Sciences, Aarhus
Kr.Sejrsen@agrsci.dk

Major international scientist in heifers management

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A.J. Heinrichs PhD

Senior Scientist, Department of Dairy and Animal Science, Pennsylvania State University

ajh@psu.edu

One of the world leaders specialist in dairy heifers

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

4 **Y. Le Cozler^{a,b,*}, Y., Gallard^c, F. Dessauge^{a,b}, J.R. Peccatte^c, J.M.**

5 **Trommenschlager^d and L. Delaby^{a,b}**

6 ^a *INRA, UMR1080, Dairy Production, F-35590 St-Gilles, France*

7 ^b *AGROCAMPUS OUEST, UMR1080, Dairy Production, F-35000 Rennes, France*

8 ^c *INRA, UE326, Le Pin au Haras Borculo, F- 61310 Exmes, France*

9 ^d *INRA, UR0055, Agro-Systèmes Territoires Ressources Mirecourt, F-88500 Mirecourt,*
10 *France*

11 * Corresponding author. *Tel.: +33 (0)2 23 48 59 18; Fax: + 33 (0)2 23 48 59 00*

12 E-mail address: yannick.lecozler@agrocampus-ouest.fr

13 **Abstract**

14 Two experiments were performed simultaneously to test the hypothesis that
15 restricted growth patterns during winter two (W2) affect further performance of dairy
16 heifers born during winter one (W1) first calving at 36 mo of age. A total of 158 dairy
17 heifers born during three successive winters (1994 to 1997) were considered at two
18 experimental herds (INRA, Le Pin au Haras and Mirecourt) located in two different
19 parts of France. Breeds of animals were Holstein (Ho) and Normande (No) at le Pin,
20 and Holstein (Ho) and Montbeliarde (Mo) at Mirecourt. At the beginning of W2 (348-
21 365 d of age on average), animals were housed and subject to a restricted feeding
22 strategy to show an average daily gain (ADG) of 600, 400 or 200 g/d at Le Pin au
23 Haras, and 500, 200 and -200 g/d at Mirecourt, respectively, during W2. During
24 pasture seasons, management and feeding were similar for all animals. As expected,
25 body weight differed between treatments at the end of W2 ($P < 0.05$), but it was
26 similar when first calving at 36 mo of age. Overall fertility in heifers and cows was not
27 affected by feeding treatments. In both herds, performance during the first lactation

28 was generally not affected by feeding treatments, with the exception of the 600 g/d
29 group of heifers at Le Pin showing lower milk performance calculated on a 4% basis
30 and a deteriorated milk composition ($P < 0.05$) when all lactations were considered.
31 However, when calculated on a productive life day basis, they had the best milk
32 production on a 305 basis ($P < 0.05$). Of the 158 animals that started the experiment,
33 41% were culled because of reproductive disorders (troubles of reproduction, $n = 22$
34 or empty, $n = 45$), probably because of the seasonal calving system. Other
35 differences noted between herds were mainly due to breeds involved, with Mo cows
36 having lower milk performance on average (- 800 kg per lactation, $P < 0.001$) but a
37 better longevity (4.5 vs. 2.4 lactations at culling, respectively) when compared with
38 Ho animals. No cows exhibited also lower milk performance in comparison with Ho
39 animals on a 305 d length basis ($P < 0.001$), but this was not counterbalanced by any
40 improved longevity (3.0 and 2.5 lactations at culling, respectively). These results
41 indicate that, in a 36 mo of age at first calving strategy, it is possible to voluntary
42 reduce ADG during a short growth period without any major effects on performance
43 at short and long terms.

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

45 1. Introduction

46 Seasonal calving systems are generally based on grazing optimisation, and as a
47 result, feeding strategy is closely connected to the seasons. In such systems,
48 breeding is also generally seasonal, and first calving usually occurs at 24 or 36 mo of
49 age. First calving at 36 mo of age strategy is not rare in European dairy systems
50 based on seasonal feeding strategy and using either late- (e.g., Normande) or early-
51 maturing (e.g., Holstein) breeds. This strategy is aimed at reducing labour and
52 feeding costs (Hoch et al., 2003). Indeed, as daily gain from birth to farrowing is
53 lower in a 36 mo of age at 1st calving strategy than in a 24 mo of age at 1st calving
54 strategy, diets with less concentrate and more roughage can be used in the former

55 system. However, these arguments could also be tackled by additional extra costs
56 (12 months of supplementary maintenance more, delayed return to investment...).

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

76 **2. Material and methods**

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

82 **Experiment 1: Holstein and Normande heifers**

83 Experiment 1 was performed at the INRA experimental farm of Le Pin au Haras
84 (48°44'N; 0°08'W; 140-248 m above sea level, Normandy, France). It included a total
85 of 78 heifers born during three successive calving winter seasons (W1, December to
86 February) of either Normande (No; n = 34) or Holstein (Ho; n = 44) breeds (Table 1).
87 Animals were reared according to procedures detailed by Le Cozler et al. (2010).
88 Briefly, all heifers were reared similarly from birth until the end of the first grazing
89 period (S1). Thereafter (winter 2, W2), they were housed and fed indoors with a
90 restricted feed allowance to achieve ADG of either 600 (n = 26, H), 400 (n = 25, M) or
91 200 (n = 27, L) g/d during this period. The 600 g/d growth group was considered to
92 be close to the standard condition used in dairy herds when first calving occurred at
93 36 mo of age. Diets were mainly composed of corn silage, straw, rapeseed meal,
94 urea and minerals (Table 2). At the end of W2, all heifers followed similar rearing until
95 calving. Pregnant heifers joined the cow herd three weeks approximately before the
96 expected date of calving, to facilitate their adaptation to new housing (e.g., stable,
97 automatic doors) and feeding conditions.

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

107 Calving usually occurred in special individual boxes. Calving period started at the
108 beginning of December and ended in March. Because of the seasonal calving

109 strategy, the reproductive period started in March and ended in mid-June for both
110 heifers and cows.

111 **Experiment 2: Holstein and Montbeliarde heifers**

112 The 2nd experiment was performed at the INRA experimental farm of Mirecourt
113 (48°18'N; 06°08'W; 261-378 above sea level, Eastern part of France). It included a
114 total of 80 heifers born during three successive calving winter season (October to
115 February, W1). Both Holstein (Ho; n = 42) and Montbeliarde (Mo; n = 38) animals
116 were used (Table 1). Animals were reared similarly to those in experiment 1, except
117 some of the rearing procedures that were adapted due to feedstuff availability.
118 Animals were housed and fed indoors at the end of the first grazing season (S1).
119 Three feeding levels were used to achieve ADG of either 500 (n = 27, H), 200 (n =
120 27, M) or -200 (n = 26, L) g/d during winter 2 (W2). Several sources of roughage and
121 concentrates were available and used (Table 2), to achieve experimental daily gain
122 goals. Similarly to the 600 g/d ADG during W2 group of animals in experiment 1, the
123 500 g/d group was considered to be close to standard feeding used in dairy herds
124 where first calving occurred at 36 mo of age in this experiment (Troccon et al., 1994).
125 Experimental diets were mainly composed of soybean, cereals (wheat or barley),
126 urea and roughage, primarily straw, grass and alfalfa hay and /or grass silage.
127 Minerals were also added (Table 2). At the end of W2, all heifers followed similar
128 treatments until calving: they were grazing during summer seasons and fed mainly
129 with roughage (straw, grass silage, hay) and wheat or barley during winter 3 (W3).
130 During grazing seasons (S1, S2 and S3; April to the end of November), they
131 rotationally grazed a perennial ryegrass sward. As for experiment 1, roughage were
132 offered during summer when necessary.

133 Pregnant heifers joined the cow herd two weeks on average before the expected
134 date of calving. Contrary to Experiment 1, no special facilities were used for calving.
135 After calving and during winter (November to the end of March), all cows were

136 continuously housed indoors, with deep straw bedding and a grooved concrete-floor
137 alley along the feeding table. As for growing heifers, ingredients could vary according
138 to feedstuff available, providing that milking production was preserved. Cows were
139 generally offered diets based on corn and/or grass silage, hay and/or straw, and a
140 complement (cereals, sugar pulp beat, and/or soybean meal), together with minerals,
141 was added. The ration was adapted according to individual milk yield, as the lactation
142 ration was formulated to meet requirements based on individual production levels
143 (INRA, 1988). During grazing season (April to November), all cows grazed pasture
144 on a rotational management system. When necessary, they received hay, corn or
145 grass silage with a complement to maintain a normal milk production.

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

149 ***Procedures for oestrus synchronisation in the 2 experiments***

150 In both experiments, all heifers were inseminated after oestrus synchronisation
151 during winter 3 (W3) of rearing, so that calving should occur at around three years of
152 age. Cows were not served during the first 63 d (experiment 1) or 45 d (experiment
153 2) following calving. For heifers and cows, oestrus was synchronised using a
154 progestin ear implant (norgestomet) in conjunction with an intramuscular estrogen
155 injection (Crestar®, Intervet, Angers, France), without any consideration of ovarian
156 activity. A second synchronisation was eventually performed on similar cows three
157 weeks later. When delay from calving was shorter than 63 days at the second
158 synchronisation (experiment 1), no treatment was applied to cows and these animals
159 were served when detected in heat (20 to 25 % of all calving cows each year). After
160 nine days of treatment, the ear implant was removed. Heifers and cows generally
161 exhibited signs of oestrus within 24-96 h and then were inseminated. A test of the
162 plasma progesterone level was performed 21 d after insemination to check for the

163 onset of gestation. For animals that did not show any oestrus according to this test,
164 an echographic inspection was performed to confirm pregnancy at 42 d after
165 insemination on average, only in experiment 1. Cows and heifers coming back into
166 heat were inseminated until the end of the reproductive season (June).

167 **2.4. Registration and measurements**

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

180 **2.5. Calculations and statistical analysis**

181 Analyses were performed on a herd basis. For cows that were culled within 100 d
182 after calving, lactation number at culling was then ($n+1$), but their lactating
183 performances were included in the data only until the end of parity n . This means that
184 days in milk (DIM) > 100 counted for the current and previous lactations and DIM $<$
185 100 counted only toward all previous lactations. Milking production and performances
186 were calculated on a 305-d basis for all animals as: 305 Milk (kg) = total milk
187 produced (kg) \times (385 / (lactation length (d) + 80)). This method is used in the French
188 evaluation system as a reference and had been discussed by Barbat et al. (1995). An
189 identical procedure was used for calculating fat and protein yield. Milk yield also was

190 calculated on a 4% fat content basis, using the following formula: 4% Milk (kg) = total
191 milk produced (kg) x (0.4 + 0.015 x fat concentration (g/kg)). Growth performance
192 data were analysed on a per-animal basis, using statistical models that included the
193 effect of treatment during winter 2 (H, M, and L), year of birth (1994/95, 1995/96 and
194 1996/97), breed (No, Mo and Ho) and their possible interactions were kept when
195 significant.

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

204 **3. Results**

205 Age at 1st artificial insemination (AI) was around 800 d, so that experimental animals
206 first calved at the average age of 1081 d. Small differences were noted between the
207 two herds. Experimental treatments started at 348 and ended at 461 d of age at Le
208 Pin, and 365 and 510 d of age at Mirecourt, respectively. Winter housing during year
209 three started at 700 and 730 d of age at Le Pin and Mirecourt locations, respectively,
210 and ended at 840 and 870 d, respectively. The duration of experimental treatment
211 was then slightly lower at Le Pin (114 to 131 d, 124 d on average) than at Mirecourt
212 (151 to 167 d, 160 d on average, Table 3).

213 **3.1. Body growth and development**

214 Observed ADG did not exactly match those expected (Table 3). The highest
215 differences were noted for heifers born during winter 1995/1996 for treatment H
216 (+29% on average in the two herds) and treatment M (especially at Mirecourt where

217 ADG was 98% greater than that expected). Moreover, heifers born during winter
218 1996/97 had generally a lower ADG than expected for treatment L and M treatments
219 at Mirecourt. In all cases, observed ADG was highly variable among animals (i.e.,
220 coefficient of variation (CV) ranged from 77 to 176 g/d, Table 3).

221 As expected, animal growth was altered during W2 in both herds, with L heifers
222 showing a stronger depression in their growth profile (Figure 1). At the end of the
223 experimental period (480 d on average), the L, M and H heifers weighed 323, 339
224 and 369 kg, respectively, at Le Pin ($P < 0.05$) and 297, 346 and 369 kg at Mirecourt,
225 respectively ($P < 0.05$). An increase in growth performance was observed when
226 animals turned to pasture at the end of W2. The most severely restricted animals
227 during W2 had the highest BW gains during this period ($P < 0.01$). However, BW at
228 600 d of age still ranged from $L < M < H$ groups (i.e., 420, 437 and 448 kg at Le Pin,
229 and 387, 424 and 436 kg at Mirecourt for L, M and H heifers, respectively; $P < 0.05$).
230 On the opposite, BW at calving was not different between treatments or breeds at Le
231 Pin, whereas H heifers were heavier than L heifers at Mirecourt ($P < 0.05$). In this
232 latter herd, BW of M animals were intermediary to those observed in L or H heifers.
233 At this stage, no difference in BW was noted between breeds, whatever the herd
234 considered.

235 **3.2. Animal survival, health and culling**

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

241 Figure 2 considers only animals with a productive life, i.e., calving at least once. Only
242 around 35 % (Le Pin) to 45% (Mirecourt) of these animals were however still present
243 1100 d after their first calving. Parity at culling did not differ between treatment at

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

250 **3.3. Reproductive and productive performances**

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

255 The duration of lactation did not differ between treatments or breeds at Mirecourt
256 (Table 4). However, it was significantly reduced for H heifers at Le Pin when
257 considering overall lactations. During lactation one, feeding treatment did not affect
258 productive performances, with the exception of fat production that was the lowest (P
259 < 0.05) in H cows at le Pin only (-18 kg and -36 kg, when compared to L and M
260 treatment, respectively). Most performances were also affected by breeds, with Ho
261 cows having better results than other breeds in the two experimental herds.
262 Especially, Ho primiparous cows produced 1160 kg more milk on a 305 days basis
263 than primiparous No cows at Le Pin ($P < 0.01$), and the difference was + 462 kg in
264 favour of the formers compared to Mo cows at Mirecourt ($P < 0.05$). The same
265 conclusions can be drawn for milk yield calculated on a 4 % basis at Le Pin ($P <$
266 0.05), but breed-associated difference on this trait was greater than the previous one
267 (milk production on a 305 d basis) at Mirecourt (+ 914 kg in favour of Ho cows).

268 Similarly, overall mean milk yield per lactation and per cow was not affected by the
269 feeding treatments (Table 4). However H cows produced less milk 4% than L and M
270 animals (-538 kg on average, $P < 0.05$) at Le Pin only. At Le Pin and Mirecourt,

271 breed-associated differences were observed on all parameters ($P < 0.05$), except
272 lactation length. The differences were in favour to Ho cows, and were generally more
273 marked at Le Pin than at Mirecourt. This resulted especially in a greater milk yield
274 calculated on a 4% or a 305 d basis for Ho animals than for No and Mo ones ($P <$
275 0.01). As far as milk composition is concerned when all lactations were pooled, a
276 significant effect of treatments during W2 was observed at Le Pin only. In this herd, H
277 cows produced less fat and protein than L and M cows that produced milk with a
278 similar biochemical composition. Protein and fat productions were also higher for Ho
279 cows in comparison of No cows (Le Pin, $P < 0.01$) or Mo ones (Mirecourt, $P < 0.01$).
280 In addition, lactation rank had a positive impact on all parameters ($P < 0.05$),
281 whatever the herd considered.

282 When analyses were done on productive day of life basis (Table 5), treatment had a
283 slight effect on milk production calculated on 305 days at Le Pin only, with H cows
284 showing the best results compared to L and M ones (20.2 vs. 17.8 kg on average, P
285 < 0.05). Breed affected all performance calculated per day of productive life, with the
286 exception of milk on a 305 d basis at Mirecourt. Protein and fat in the milk were
287 greater for Ho cows than No and Mo animals ($P < 0.05$). In both herds, lactation rank
288 at culling had a positive effect ($P < 0.05$) on these parameters, and year of birth also
289 affected the results at le Pin mainly (Table 5).

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

294 **4. Discussion**

295 First calving at 36 mo of age allows the use of less concentrate and/or forage, which
296 usually leads to a reduced daily gain during housing winter periods. The
297 compensatory increase in growth obtained during grazing seasons needs therefore

298 to be optimized to compensate for extra-additional costs such as more heifers in the
299 farm, 12 additional months of maintenance, delay in the return-on-investment and a
300 slow genetic progress (Le Cozler et al., 2010). One of the main interests of present
301 study then consists on the comparison of the immediate and long-term responses to
302 strategies to reduce ADG during a short period. Another interest of present
303 investigation was the possibility to perform such trials in two herds geographically
304 localized in two different areas of France, and with differences in both feedstuff and
305 breeds of animals. Climate-related difference in the duration of winter housing
306 between the two herds also resulted in differences on treatment durations that might
307 have affected the final results. As reported in other experiments and previously
308 discussed (Le Cozler et al., 2009; 2010), year of birth also affected overall
309 performance per day of productive life, likely because the chemical composition of
310 diets estimated from the ingredients slightly varied from year to year. This was
311 especially the case when feeding regimes were adapted to the feedstuff availability,
312 as it happened at Mirecourt.

313 **4.1. Elicited growth patterns**

314 At 6 mo of age, mean BW of heifers corresponded to 24 to 29 % of mature BW (i.e.,
315 650 to 750 kg depending of the breeds) and was attained following an ADG of 817,
316 766 and 772 g/d for Ho, Mo and No heifers, respectively. These values were close to
317 those recommended by Troccon et al. (1994). Many studies have investigated
318 possible effects of ADG prior to puberty on subsequent performances (Le Cozler et
319 al., 2008 for a review). They generally recommended a high growth rate during the
320 first 6 mo of age to ensure optimal body development, even when animals first calved
321 at 36 mo of age. Thereafter, a subsequent decrease in growth rate is generally
322 recommended to prevent excessive fatness and bad reproductive and productive
323 performances (Troccon et al., 1994). This was realized in the current study with ADG

324 of 610, 568 and 600 g/d from birth to first insemination for Ho, Mo and No heifers,
325 respectively.

326 In the present study, BW at the first successful insemination were higher (503 to 535
327 kg corresponding to 70 to 82 % of mature BW according to breeds) than commonly
328 observed (450-500 kg at 27 mo of age and 55 to 60 % of mature BW, Troccon et al.,
329 1994). However, it should be reminded that recommendations in a 36 mo of age at
330 first calving strategy are generally higher than those for animals calving at a younger
331 age. In addition, at Mirecourt, information on BW is available during entire lifespan of
332 the herd and it indicates an average mature BW of 707 and 704 kg for Ho and Mo
333 cows older than 1500 d, respectively. Based on these data, BW at 1st calving
334 corresponded to 90 and 91.6 % of mature BW in Mo and Ho cows respectively in the
335 present experiment, which is finally closed to recommendations for animals first
336 calving at 36 mo of age (85 to 90 %; Troccon et al., 1994).

337 ***4.2. Effects of feeding treatments on reproduction and production at first*** 338 ***lactation***

339 The present results indicate that deleterious ADG (200 g/d or less) around one year
340 of age had no or only limited effects on fertility of heifers first calving at 36 mo of age.
341 In a 24 mo of age at first calving strategy, Troccon and Petit (1989) and Heinrichs
342 (1996) concluded that very low ADG during rearing alters heifer fertility. However,
343 increasing feed allowance during a brief period before ovulation (i.e., a so called
344 “flushing procedure”) may restore fertility rates. However, Le Cozler et al. (2010)
345 found only limited effect of previous feed restriction during two successive winters on
346 heifers’ fertility. Taken together, it would be concluded that a preserved growth rate
347 during winter should probably be favourable to preserve fertility for heifers first
348 calving at 24 mo of age, but might not be necessary when first calving occurs later.
349 Results of present study showed that altered growth profiles around puberty had only
350 limited impact on subsequent productive performance. The importance of feed

351 strategy before or after puberty had been already discussed (Le Cozler et al., 2008).
352 Puberty attainment was not directly assessed in the present study, but it can be
353 hypothesised that in early maturing breed such as Holstein, most heifers with an
354 ADG of 740 g/d closed to the recommendation for optimal ADG (Sejrsen et al., 2000;
355 Zanton and Heinrichs, 2005) before 240 d of age showed a first oestrus before the
356 start of the experimental treatments (Le Cozler et al., 2009). This could explain the
357 lack of treatment-associated differences in first lactation milk yield. But all late
358 maturing animals (Montbeliarde and Normande breeds) probably did not have a first
359 oestrus before experimental treatments. Indeed, according to Drogoul et al. (2005), if
360 attainment of puberty is generally around 9 to 10 mo of age in Ho heifers, it is two
361 months later in No heifers and even more for Mo animals. So, whatever the breed
362 and sexual development, animals fed L, M or H levels of feed during winter after the
363 first pasture season had similar lactation performance during first lactation, and no
364 interaction between treatment and breed was noted. These results are in agreement
365 with data from Troccon et al. (1997) and Le Cozler et al. (2010) who show no impact
366 of altered growth performance during two successive winters on first lactation
367 performance. Similarly to what was observed here for animals first calving at 36
368 months of age, others have also noted no effect of a limited feed intake up to puberty
369 on performance during the first lactation (Hoffman et al., 2007; Zanton and Heinrichs,
370 2007) on animals first calving at 24 mo of age.

371 In addition, present results did not show any effects of increased growth during
372 spring on milk performance during first lactation, as already reported (Le Cozler et
373 al., 2010). Ford and Park (2001) observed improved results when growth was altered
374 (using stair-step compensatory nutritional programs). In the previous study,
375 experiment was based on animals first calving at 24 mo of age and differences in age
376 (270 d in the current study vs. 180 d in the latter mentioned experiment) could also
377 explain the discrepancies. This might be due to the degree of catch-up mammary

378 growth which depends on the stage when it occurs (Ford and Park, 2001; Davis-
379 Rincker et al. 2008). Although compensatory growth has been proposed as an
380 interesting tool to manage animals in a 24 mo of age at first calving, the interest of
381 such a practice in a 36 mo of age at first calving strategy remains to be studied and
382 proved.

383 Finally, a positive relationship between BW at calving and milk production at first
384 lactation was observed in the present study, regardless of experimental treatments.
385 Similar relationships have been already reported by Lin et al (1985) and Waldo et al.
386 (1998). Troccon and colleagues (1994) suggest that these relationships exist
387 whatever the growth profiles are before lactation when first calving occurs at 36 mo
388 of age. This is however opposite to what was stated in a 24 mo of age at first calving
389 strategy (Park et al., 1989; Ford and Park, 2001), in which alternating low and high
390 feeding rates during rearing have a positive impact on subsequent performance.

391 **4.3. Culling, longevity and long-term performance**

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

401 At Le Pin, L and M treatments during W2 had a positive effect on longevity since the
402 number of culling was lower when compared to H treatment. The 42 % of culling
403 observed in this herd is closed to that previously observed, with reproductive disorder
404 being the main reason for culling (Le Cozler et al., 2010). This was probably a

405 possible effect of seasonal calving strategy where reproduction has to be performed
406 in limited times and non-pregnant animals are usually culled.

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

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

428 **5. Conclusion**

429 Present results indicated that in a dairy system where first calving occurs at 36 mo of
430 age, it is possible to reduce feed allowance of heifers aged around one year of age,
431 without any major deleterious effects on subsequent performance. In a similar study

432 performed on beef heifers, Dozias et al. (2006) concluded similarly. In case of
433 unfavourable weather conditions leading to limited fodder stock, a feed restriction
434 occurring during a short period of rearing could be encouraged regardless of breed,
435 providing that restriction was not too severe (i.e., during one and not two successive
436 winters). During subsequent lactations, productive performances are lower in case of
437 severe restriction, but because of a positive impact on culling rate, performances
438 calculated on a day of productive life basis do not differ.

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

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- 528

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

530

531 **Table 2.** Feed ingredients and correspondent calculated composition

532

533 **Table 3.** Duration of experimental treatment and average daily gain, according to

534 year of birth and herd

535

536 **Table 4.** Overall performances according to treatment and breed

537

538 **Table 5.** Overall performances per day of productive life, age and parity at culling,

539 according to treatment and breed

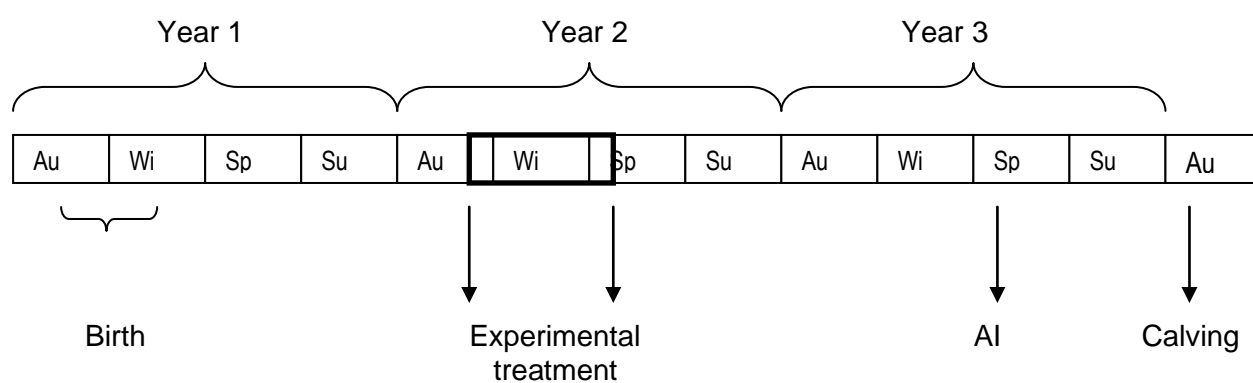
540

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

543

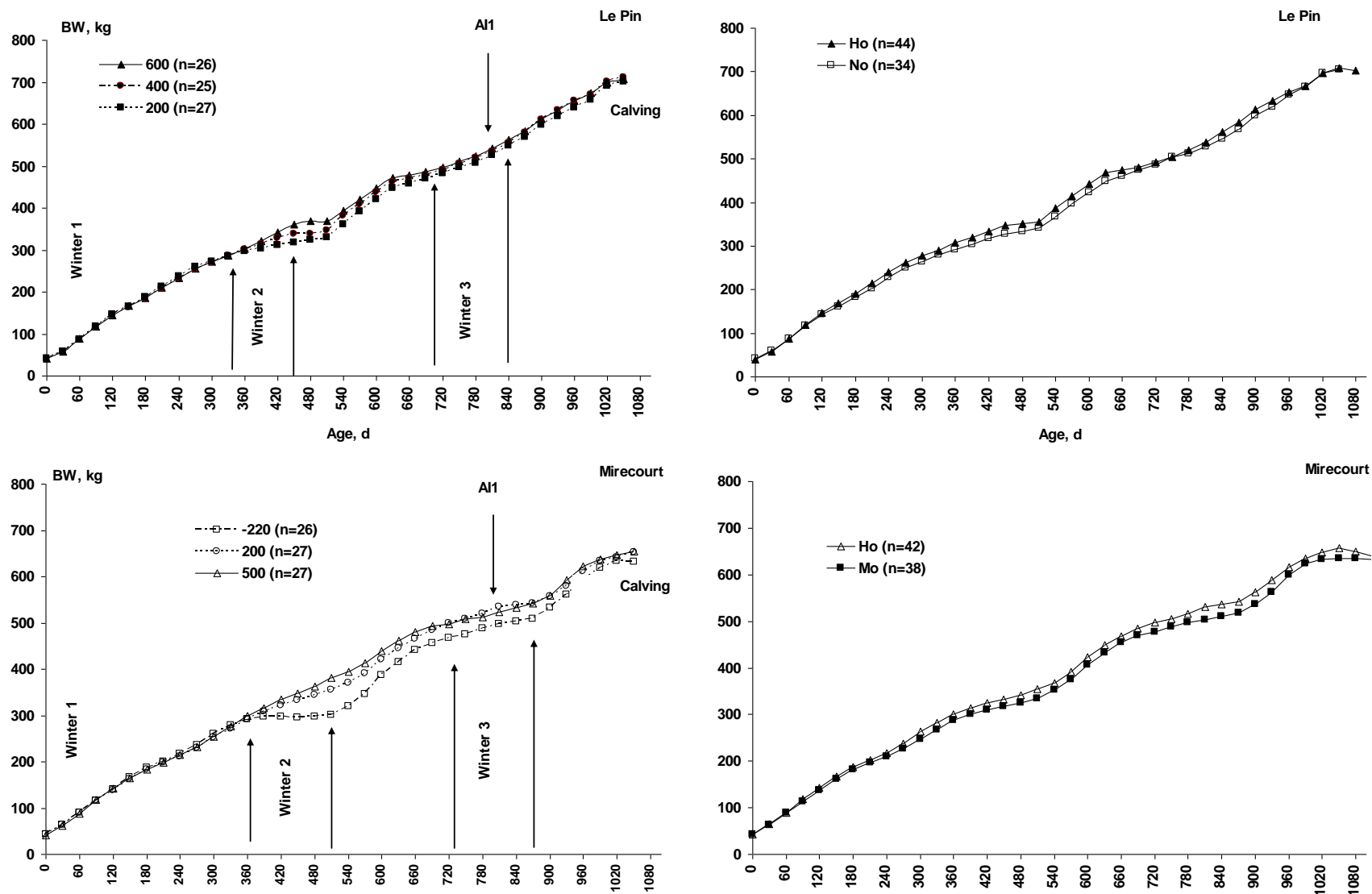
544 **Figure 2.** Percentage of survival dairy heifers from two different herds, according to
545 days in production

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



* Au : autumn ; 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.

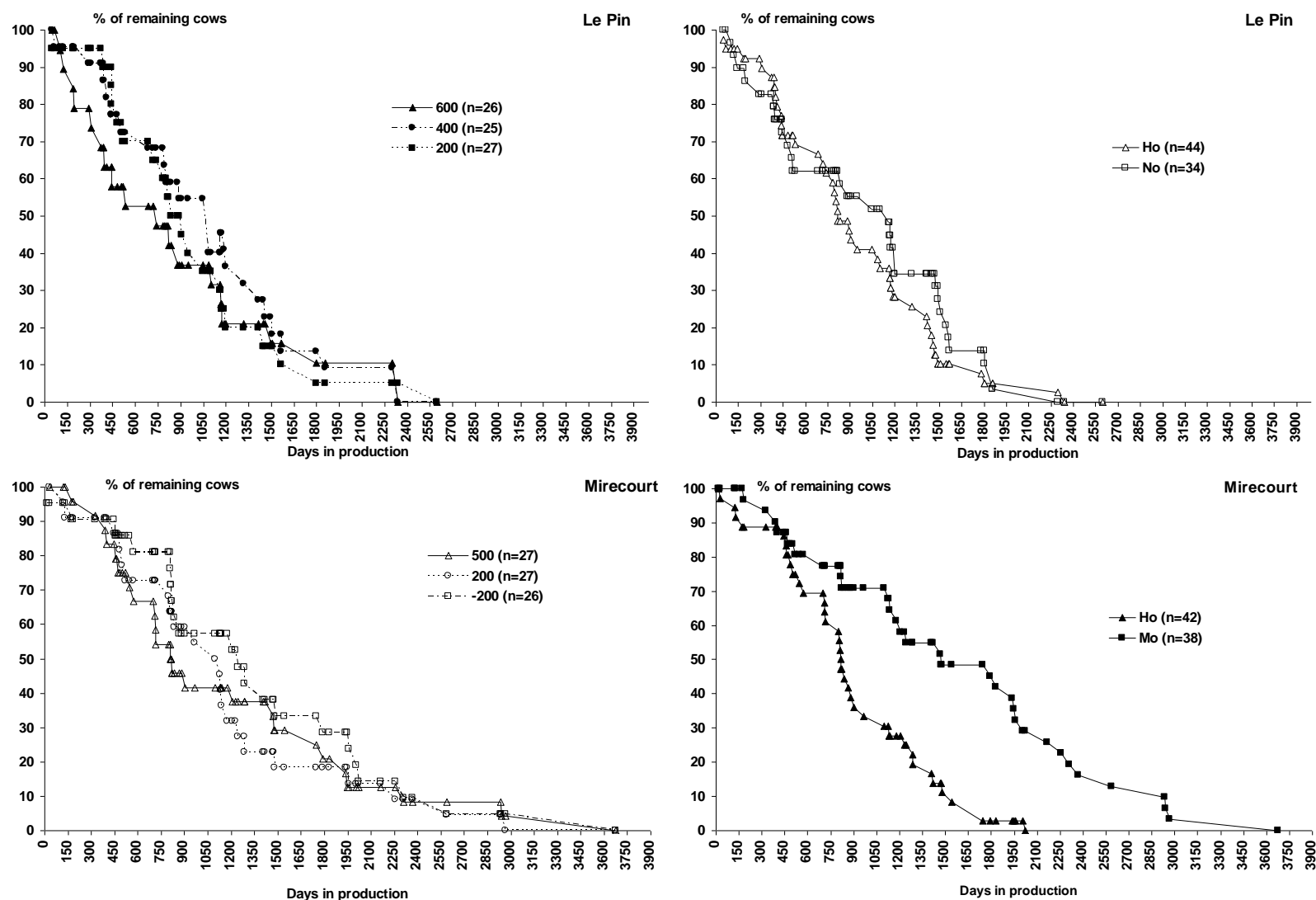


During winter 2, heifers received experimental treatment in order to achieve different daily gains (600, 500, 400, 200 or -200 g/d) during this period. Ho: Holstein; No: Normande; Mo: Montbeliarde. AI1: first artificial insemination

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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.

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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).

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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	Mirecourt	Feeding treatment			Breed		Root MSE	Statistical significance
	200	400	600	Ho	No				-200	200	500	Ho	Mo		
1st lactation								1st lactation							
n	17	20	20	32	25	-	-	n	20	20	23	32	31	-	-
Length, d	303	301	289	301	294	45		Length, d	308	303	311	319	295	71	
Milk yield, kg	6684	6944	6363	7311	6016	1143	B***	Milk yield, kg	6281	6244	6348	6734	5838	1556	B*
Protein, kg	215	227	204	229	202	36.5	B*	Protein, kg	211	212	215	228	198	51.0	B*
Fat, kg	265 ^{ab}	283 ^a	247 ^b	288	243	45.3	T*, B**	Fat, kg	272	273	270	291	253	67.2	B**
Milk 4%, kg	6648	7016	6255	7240	6039	1103	B*	Milk 4%, kg	6595	6602	6589	7052	6138	1608	B*
Milk 305d, kg	6720	6969	6608	7349	6183	710	B**	Milk 305d, kg	6235	6265	6175	6456	5994	808	B*
all lactations								all lactations							
n	50	57	42	75	74	-	-	n	71	61	69	72	129	-	-
Length, d	301 ^a	303 ^a	287 ^b	302	294	46	T*	Length, d	304	288	297	299	293	66	L*
Milk yield, kg	7178	7164	6790	7766	6322	1166	B*, L*	Milk yield, kg	6980	6668	6787	7155	6468	1518	B**, L***
Protein, kg	229 ^a	231 ^a	214 ^b	240	210	39.5	T*, B***, L**	Protein, kg	230	225	226	237	216	51.4	B**, L***
Fat, kg	288 ^a	290 ^a	263 ^b	304	257	48.9	T*, B**, L*	Fat, kg	300	296	286	312	277	69.2	B***, L***
Milk 4%, kg	7192 ^a	7218 ^a	6667 ^b	7668	6383	1164	T*, B***, L***	Milk 4%, kg	7293	7113	7006	7539	6737	1624	B**, L**
Milk 305d, kg	7241	7192	7062	7822	6506	796	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.

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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	Mirecourt	Feeding treatment			Breed		Root MSE	Statistical significance
	200	400	600	Ho	No				-200	200	500	Ho	Mo		
Protein, kg	0.55	0.57	0.58	0.60	0.54	0.06	-	Protein, kg	0.55	0.57	0.55	0.58	0.54	0.07	-
Fat, kg	0.69	0.72	0.71	0.76	0.65	0.08	B**, Y**, L**	Fat, kg	0.72	0.74	0.70	0.76	0.69	0.10	B*, L*
Milk 4%, kg	17.3	17.9	18.0	19.2	16.2	1.9	B*, Y*	Milk 4%, kg	17.4	17.9	17.0	18.3	16.6	2.5	B*, L*
Milk 305d, kg	17.6 ^a	18.0 ^a	20.2 ^b	19.6	17.6	3.3	T*, B**, Y**	Milk 305d, kg	16.1	17.9	16.4	17.4	16.3	4.2	Y**
Parity at culling	2.8	3.0	2.4	2.5	3.0	1.46	-	Parity at culling	4.0	3.2	3.2	2.4	4.5	1.96	B**
Age, d	1838 ^{ab}	2034 ^a	1675 ^b	1739	1939	677	T*	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.

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