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Postpartum anoestrous intervals and reproductive performance of three genotypes of Holstein-Friesian dairy cattle managed in a seasonal pasture-based dairy system.

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ABSTRACT

An extended postpartum anovulatory interval (PPAI) is the major form of infertility in New Zealand (NZ) dairy cattle. Recently, Holstein cows, originating from North American genetic strains (Overseas; OS), have been widely used in NZ. Worldwide, there is concern over an apparent decline in the fertility of Holstein-Friesian dairy cattle. This study determined whether differences existed in PPAI, BCS and parameters of reproductive performance between NZ and OS Holstein-Friesians. One hundred and forty-six records from 88 NZ animals of high genetic merit for milk production (NZH), 81 records from 48 NZ animals of low genetic merit (NZL), and 137 records from 88 OS high genetic merit animals that calved in Years 1 (all two-year-olds) and 2 (two- and three-year-olds) were included. Over both years PPAI in two-year-olds were significantly shorter in OS (20 days shorter) and NZL (12 days shorter) than in NZH animals ($P<0.05$). Body condition score at calving, and BCS loss from calving to four weeks postpartum were not different between strains. In Year 1 of the study significantly more NZH than NZL or OS 2-year-olds were treated for anoestrus prior to the start of mating ($P=0.001$). Other measures of reproductive performance did not differ significantly between strains. The differences in PPAI require further investigation.

Keywords: Holstein-Friesian; calving; conception rate; postpartum anovulatory interval.

INTRODUCTION

In seasonal pasture-based dairying systems it is important to maintain a 365-day calving interval. This necessitates the rapid resumption of ovulatory activity in the postpartum period and high conception rates so that the calving period is compact. The major form of infertility in New Zealand (NZ) dairy cows is an extended postpartum anovulatory interval (PPAI; (Macmillan, 2002), a problem that can be exacerbated by low body condition score (BCS) at calving (McGowan, 1981; McDougall *et al.*, 1995). Untreated extended PPAI can affect the intervals from the planned start of mating (PSM) to first insemination and to conception, indicators of the compactness of the following calving period. Holstein cows, originating from North American genetic strains (Overseas; OS), have been widely used in NZ in recent years (Harris & Kolver, 2001). A study of Holstein Friesian cows in NZ sire-proving herds found that cows with a high proportion of OS ancestry had longer intervals from calving to first service and were less likely to conceive to artificial insemination than cows with a high proportion of NZ ancestry, suggesting a possible delay in the initiation of postpartum cyclicity (Harris & Winkelman, 2000; Harris & Kolver, 2001).

The Dexcel Holstein-Friesian Strain Trial was established at Hamilton, New Zealand, to examine the physical and financial performance of three strains of dairy cattle under pasture-based systems, with a range of feed allowances. The purpose of the work reported here was to examine and compare reproductive performance, and in particular length of PPAI in Strain Trial animals.

MATERIALS AND METHODS

One hundred and forty six records from 88 animals of high genetic merit (breeding worth October 2002 = $130 and an average of 24.5% OS genetics, NZH), 81 records from 48 animals of low genetic merit (breeding worth = $-20 and an average of 6.9% OS genetics, NZL) and 137 records from 88 animals of high genetic merit (breeding worth = $102 and an average of 90.5% OS genetics, OS) that calved in Year 1 (all two-year-olds) and 2 (two- and three-year-olds) from the Dexcel Strain Trial were included in the study. For analysis of PPAI and BCS only animals that calved within the first 6 weeks of the calving period were included. For further details on the design and feed allowances of the Dexcel Strain Trial refer to Harris *et al.*, (2003).

A management decision was made to bring the planned start of calving forward by one week between Years 1 and 2. In both years treatment for prolong PPAI was proactive, from one week before the planned start of mating animals were treated for anoestrus if they had been calved for at least 28 days at that time and milk progesterone concentrations remained below 2ng/ml. Oestrus was induced by the insertion of a CIDR device (Pharmacia) for 6-days, followed by 1mg of oestradiol benzoate (Cidirol, Bomac Laboratories Ltd) 24-hours after CIDR removal. The breeding period was six weeks of artificial insemination and six weeks of bull mating. Transrectal ultrasonographic scanning was used to detect pregnancies at approximately 60 days after the planned start of mating and again 30-40 days after the bulls were removed. Pregnancies were aged at scanning to confirm dates of conception, relative to known insemination and service dates, and this information was used in the calculation of reproductive data, including percentage pregnant at 42 days after the PSM (P42), the interval from PSM to conception and first service conception rates. A final pregnancy test was carried out in late lactation, but for Year 2 only data from the first 2 tests was available.

Twice weekly whole milk samples were collected and progesterone concentrations determined using an enzyme-

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linked immunosorbant assay kit (Ridgeway Sciences, Gloucestershire, UK), validated for use in cattle (Sauer *et al.*, 1986). Interassay coefficients of variation for samples with a mean concentration of 2.57 ng/ml and 9.95 ng/ml were 20.45% and 12.5% respectively. Luteal activity was defined as progesterone concentrations of >2ng/ml followed by >3ng/ml in two consecutive samples, with an adjustment for sample timing associated with twice weekly sampling of –1.8 days. Body condition scores were assessed weekly from calving until the planned start of mating by experienced staff on a 10-point scale (1= emaciated, 10 = obese; Macdonald & Macmillan, 1993).

Data was combined according to strains for analysis as feeding level was not found to significantly affect any of the measures studied and to give sufficient numbers for meaningful results. Postpartum anovulatory intervals were analysed using parametric frailty models with normal distribution in which feeding level, age at calving, year where applicable and strain were included as fixed effects and sire as a random effect using the suvReg function in S-Plus (S-Plus 6.1). The censor procedure in GenStat was used to generate estimated PPAI intervals for animals that did not ovulate. Analysis of variance was used to examine the relationship of PPAI and calving BCS (GenStat 6.1). Other continuous data were analysed using the mixed procedure of SAS, with a model that included the fixed effect of strain and year and a random effect of sire, nested within strain. Proportional data were analysed using Chi-squared (SAS, Version 8.1)

RESULTS

Calving dates

Mean calving dates were not different between strains, or between years, despite an earlier planned start of calving in Year 2 (12 July 2002) of the study than in Year 1 (20 July 2001; Table 1). In Year 2 of the study, the mean calving date was significantly earlier in the first lactation heifers than in the 2nd lactation animals (18-Jul ± 3.1 days vs. 10-Aug ± 1.9 days; P<0.0001).

Postpartum anovulatory intervals and body condition scores

Of the 331 cows that calved within six weeks of the PSC in both years, 197 had ovulated by one week before the PSM. Table 1 represents data by strain. Over both years of the study, mean PPAI in two-year-olds was significantly longer in NZH animals than OS and NZL (P<0.05) by 20 and 12 days, respectively. In Year 2 of the study, PPAI were again longer (P<0.01) in NZH than OS and NZL animals by 15 and 14 days, respectively. There was no difference in PPAI between OS and NZL strains. The PPAI was 12 days longer (P<0.0001) in 3-year-olds than 2-year-olds in Year 2. Body condition scores, by strain, are given in Table 2. Calving BCS in 2-year-olds was lower in Year 1 than in Year 2 (4.8 ± 0.04 vs. 5.6 ± 0.05; P<0.0001). In Year 2 BCS at calving was higher in 2-year-olds than 3-year-olds (5.6 ± 0.05 vs. 4.6 ± 0.04; P<0.0001). A significant (P<0.001) negative relationship was found between BCS at calving and PPAI, so that for every unit increase in calving BCS there is a 14.8 day (± 3.2 sem) decrease in PPAI.

Reproductive performance

The remainder of the analysis includes all animals. Indicators of reproductive performance are summarised in Tables 2 and 3. A greater proportion (P<0.001) of NZH and NZL animals were treated for anoestrum in Year 1 of the study than in Year 2. However, in Year 2 the proportion of 2-year-olds treated was significantly lower

TABLE 1: Reproductive outcomes of cows in Years 1 and 2 of the Dexcel Strain Trial, NZH = New Zealand high genetic merit, NZL = New Zealand low genetic merit, OS = overseas high genetic merit. Differing superscripts within a row indicate P<0.05.

	Year	OS	NZH	NZL
Mean Calving date (± sem)	1	3-Aug ± 2.2 d	7-Aug ± 1.8 d	2-Aug ± 2.1 d
	2	4-Aug ± 2.6 d	4-Aug ± 3.0 d	31-Jul ± 3.6 d
Planned start of calving to 50%	1	11 (21)	14 (28)	11 (16)
(and 75%) of animals calved, in days	2	19 (39)	16 (35)	13 (34)
Animals treated for anoestrum (%)	1	34^{a}	75^{b}	53^{c}
	2	28^{ab}	36^{a}	18^{b}
21-day submission rate (%)	1	88	91	92
	2	87	77	87
Interval from PSM to first service	1	10.1 ± 1.29	6.1 ± 1.25	7.6 ± 1.77
(days ± sem)	2	10.4 ± 1.22	11.0 ± 1.25	10.0 ± 1.19

TABLE 2 Ovulations during the postpartum period, and body condition score (BCS) and BCS change, by strain, in cows that calved during the six weeks after the planned start of mating. New Zealand high genetic merit = NZH, New Zealand low genetic merit = NZL, overseas high genetic merit = OS. Differing superscripts within a row indicate P<0.05.

	Year	OS	NZH	NZL
Ovulated by one week before planned start of mating (%)	1 + 2	70^{a}	42^{b}	70^{a}
Ovulated before day 21 postpartum (%)	1 + 2	18^{a}	4^{b}	17^{a}
Ovulated after day 43 postpartum	1 + 2	14^{a}	24^{b}	24^{ab}
Body condition score (BCS)	1	4.8 ± 0.05	4.8 ± 0.06	4.9 ± 0.08
at calving (± sem)	2	5.0 ± 0.09	5.0 ± 0.08	5.1 ± 0.11
BCS change from calving to 4 weeks	1	1.4 ± 0.06	1.2 ± 0.06	1.1 ± 0.07
postpartum (± sem)	2	0.7 ± 0.05	0.7 ± 0.05	0.6 ± 0.06

TABLE 3: Reproductive performance in Years 1 and 2 of the Dexcel Strain Trial, NZH = New Zealand high genetic merit, NZL = New Zealand low genetic merit, OS = Overseas high genetic merit. Final pregnancy rate was after a 12-week mating period. Differing superscripts within a row indicate P<0.05.

	Year	**OS**	**NZH**	**NZL**
First service conception rate (%)	1- CIDR	22%	33%	47%
	1- Cycling	40%	29%	47%
	2- CIDR	37%	33%	50%
	2- Cycling	44%	58%	43%
Interval from PSM to conception	1	37.4 ± 3.83	33.0 ± 3.55	28.4 ± 4.58
(days ± sem)	2	30.4 ± 3.35	26.1 ± 2.53	26.5 ± 3.57
P42 (%)	1	51[a]	68[ab]	75[b]
	2	61	71	64
Final in-calf rate (%)	1	78[a]	91[b]	97[b]
	2	87	88	89

than 3-year-olds (10% vs. 35% respectively; P<0.001). First service conception rates tended to be higher in Year 2 of the study (P=0.068), but were not different between cycling animals and those treated for anoestrus (44 vs. 36%, respectively). When both years' data were combined, P42 rates were higher (P<0.05) in NZH than OS animals. The interval from PSM to first service was shorter in Year 1 than in Year 2 (P<0.05), whilst the interval from PSM to conception was shorter in Year 2 than Year 1.

DISCUSSION

Postpartum anovulatory intervals were longer in NZH than OS animals and NZL, leading to proportionately more NZH being treated for anoestrus. Despite the high level of treatment, NZH animals had similar reproductive performance to OS and NZL strains. Thirty years of selective breeding has not altered the reproductive performance of NZ strains, but appears to have increased the PPAI.

The calving pattern was more spread in Year 2 of the study, but was similar between strains in both years. The change in calving pattern between years can be explained by the change in the age structure of the herds, and the decision to bring the PSM forward between Years 1 and 2. All animals in Year 1 of the study were 2-year-old heifers. Virgin heifers have high first-service conception rates (Lucy, 2001), leading to a compact calving period. Cows calving in Year 1 had just 67 days from the PSC to selection for treatment for anoestrum. As a result, the incidence of anoestrous treatment in Year 1 was high, particularly in the NZH animals. The longer PPAI in NZH relative to the OS strain meant that proportionately more NZH animals were treated for anoestrum. In Year 2 of the study the incidence of anoestrum was lower in the NZ strains than in Year 1.

Age, BCS at calving and BCS loss in early lactation are all factors that affect the length of the PPAI, and, therefore, influence the number of animals requiring treatment for anoestrus within the proactive treatment decision rules used in this study. Older animals tend to have a shorter postpartum anoestrous period than 2-year-olds (McDougall, 1994). However, in Year 2, when the herds consisted of 2- and 3-year-olds the PPAI was longer in 3-year-olds. Cows calving at a BCS of 6 had PPAI 12 days shorter than those calving at a BCS of 4 (McGowan, 1981) and a similar relationship was observed in this study. There was a difference in calving BCS of 1 unit between 2- and 3-year-old animals, leading to a shorter PPAI in 2-year-olds. The difference in PPAI and the 23-day difference in mean calving date explain much of the variation in the incidence of treatment for anoestrus between 2- and 3-year-old animals.

Across all strains PPAI were longer in Year 1 than Year 2. The greater loss of body condition from calving to week 4 of lactation, and the lower calving BCS in Year 1 is likely to explain a significant proportion of the variation in PPAI between the two years.

A previous study of Holstein-Friesian cows of varying genotype reported a tendency for shorter PPAI periods in OS compared to NZ animals (Verkerk *et al.*, 2000). This study confirms that, even under pasture-based systems, OS genotype animals have the ability to resume oestrous cycles rapidly after calving. The interval from calving to luteal activity has been investigated and found to have a heritability of 0.16 in UK Holstein-Friesian cattle (Royal *et al.*, 2002). Selective breeding for milk yield over the past 20-30 years appears to have increased the PPAI in NZH compared to NZL strains. The widespread use of treatment for prolonged PPAI in NZ may be contributing to the longer PPAI in NZH animals, by allowing cows with a genetic tendency for a long PPAI to conceive during the artificial breeding period. Although calving BCS was found to affect the PPAI in this study, there was no difference in calving BCS between strains, suggesting genetic differences may account for some of the observed differences in PPAI.

The proportionately higher use of anoestrous treatments in NZH and NZL strain in Year 1 contributed to short intervals from PSM to first service. Despite the interval from PSM to first service being shorter in Year 1 of study, the interval from PSM to conception was shorter in Year 2, due to higher first service conception rates. The use of progesterone treatments, such as CIDRs (Pharmacia) to treat anoestrus has been associated with reduced first-service conception rates, compared to cycling animals (Xu & Burton, 1997). Animal numbers were insufficient to show a significant difference in conception rate between CIDR-treated and cycling cows in this study. However, numerically, the first-service conception rates in CIDR-treated animals were similar to those reported in the literature (Xu & Burton, 1997; Xu & Burton, 2000). This may explain some of the difference in conception rate between the two years.

Overall, the first-service conception rates in this study are low by New Zealand standards, but not in comparison to the 37.1% reported recently in Northern Ireland (Mayne *et al.*, 2002) or first-service calving rates in the UK of 40% (Royal *et al.*, 2000). First-service conception rates of 60-65% in cycling animals have been considered normal in New Zealand (Macmillan & Day, 1982; Burton *et al.*, 1999). Conception rates tended to be somewhat lower in Year 1 of the trial, probably due in part to the lower calving BCS and greater loss of body condition between calving and week 4 of lactation. The InCalf project in Australia has found that cows with a low pre-calving BCS, and cows with greater BCS loss in early lactation had lower first insemination conception rates (Morton, 2000). The narrow genotypes represented in this study and high milk production relative to NZ averages, combined with the small number of animals mean this data set should not be used as an indication of nationwide reproductive performance.

A compact conception and, therefore, calving period is important, if the aim is to maximise days in milk within seasonal systems in which drying off dates are common to all cows in a herd. Final in-calf rates were different between the strains in Year 1 of the study, but not in Year 2, whilst 6-week in calf rates were not different between strains, but were numerically greater in NZH than OS in both years. This is in contrast to previous findings at Dexcel where NZ and OS cows were fed a generous pasture diet and final in-calf rates were higher in each of three seasons in the NZ herd (Kolver, 2001). However, the animals used in that study were imported as embryos, whereas the dams of strain trial animals had to have conceived at least once to be selected for the study, and then conceive to artificial insemination to carry the strain calf. Therefore, there had been some indirect selection for reproductive performance. Of the empty animals in Year 1, seven out of eleven had the same sire, suggesting a genetic effect. Fertility traits have relatively low heritabilities, however, estimates suggest that although the heritabilities are low, the traits are variable enough to allow genetic progress to be made (Pryce & Veerkamp, 1999). The National Animal Evaluation Committee has now incorporated fertility in the Breeding Worth index (Montgomerie, 2002). This may help to eliminate genetic lines with poor fertility from the population.

Data from the first two years of the Dexcel Strain Trial show that OS and NZL animals begin to cycle earlier postpartum than their NZH counterparts and reinforce the importance of BCS and BCS loss on PPAI. Earlier postpartum ovulation did not confer the expected reproductive advantage when anoestrous animals were treated prior to the planned start of mating. In the year when there was lower calving BSC and greater loss of body condition in the first four weeks of lactation there were a greater number of animals treated for anoestrum (particularly in the NZ strains). Further data is required to confirm whether the conception period is more compact in the NZH strain, given the influence of anoestrus treatment on this variable. There does not appear to be a difference in reproductive performance between the three strains. Thirty years of selective breeding may have altered PPAI, but does not seem to have altered the reproductive performance of Holstein-Friesians of NZ ancestry.

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