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Comparison of selected reproductive characteristics in Overseas and New Zealand Holstein-Friesian cows grazing pasture or fed a total mixed ration

G.A. VERKERK, S. MORGAN AND E.S. KOLVER

Dairying Research Corporation, Private Bag 3123, Hamilton, New Zealand.

ABSTRACT

Lactating overseas and NZ-derived Holstein-Friesian cows were fed either pasture or total mixed ration (NZGrass, n=14; NZ TMR, n=14; OSGrass, n=12; OS TMR, n=13). For cows ovulating before breeding began, mean postpartum anoestrous intervals (PPAI) were 39±6, 29±4, 27±6 and 23±2 d, respectively. Of 13 cows with PPAI <21d, seven were OS TMR and one was NZGrass (P<0.02). Of seven with PPAI >43d, four were NZGrass (P<0.05). Growth of the first dominant follicle and corpus luteum through time, and day of emergence of the second follicle wave, measured by transrectal ultrasonography, did not differ between treatment groups. Feeding system affected mean plasma progesterone concentration at emergence of the second follicle wave and number of subordinate follicles recorded during the first follicle wave (4.5 ± 0.4 and 6.1 ± 0.5 ng/ml, P<0.02; 6.2 ± 0.6 and 4.1 ± 0.7 follicles/d, P<0.05; for grass and TMR, respectively). In summary, both genotype and feed system affected length of PPAI, while feed system influenced aspects of peripheral hormone profiles.

Keywords: dairy cow; postpartum anoestrus; ovarian follicle; progesterone

INTRODUCTION

In recent years, New Zealand's dairy industry breeding objectives to increase milksolids production have resulted in an increased proportion of imported Holstein-Friesian genetics in the national dairy herd. Most of the imported genetics reaching commercial dairy herds have been effectively filtered through industry sire-proving schemes, but there is still concern about whether they are appropriate for the New Zealand industry since selection processes overseas have been based on performance in year-round calving, concentrate-based feeding systems. There is evidence that genotype x environment interactions can occur. In Ireland, milk production responses due to increased genetic merit were lower in grass-based, low-input systems than in high-input systems, suggesting that the high-merit cows were unable to consume enough additional feed to enable them to express their potential increased production (Ferris *et al.*, 1998). Similar genotype x environment interactions were observed in an Australian farmlet study in which the difference in milk production between high and medium genetic merit cows increased with increasing levels of concentrate feeding (Fulkerson *et al.*, 1997). It is relevant, therefore, to compare the performance of both overseas and New Zealand-derived dairy cows under differing management conditions.

While studies show clear genetic advantages for yields of milksolids in northern hemisphere-derived cows, there is evidence that these cows experience significant reproductive difficulties that may limit their survival. In a grass-based systems study in Ireland in which the breeding period was restricted to 13 weeks, high-genetic-index cows of largely United States Holstein-Friesian origin had a 25% non-pregnancy rate compared to 6% for medium-genetic-merit "local" cows (Dillon and Buckley, 1998). There is also evidence that the reproductive performance of the New Zealand dairy herd is changing, and reproductive failure now accounts for 43% of all cows culled. A study of data from the national database from 1973 to 1998 showed that submission rates in the first 21 days of mating fell by 11.4% in Holstein-Friesian cows, but by only 5% for Jersey cows, although there was no evidence of changing conception rates (Burton *et al.*, 1999). This could be a consequence of changes in farm management systems, genotypic changes, or both. A study at Massey University to compare two lines of Friesian cows bred for the same breeding worth, but with either heavy or light body weights, reported differences in conception rates to first service (54% and 65% for heavy and light lines, respectively; Holmes *et al.*, 1999). It is of note that the heavy strain was 28% North American genotype but only 8% of the light strain.

Seasonal dairy production systems require efficient reproductive processes. This study was initiated, as part of a study of the production performance of a group of Overseas and New Zealand-derived Holstein-Friesian cows being managed grazing pasture or being fed a total mixed ration (TMR), to measure the postpartum anoestrous interval, and to examine ovarian structures and determine plasma progesterone concentrations during the first follicle wave of a single cycle.

MATERIALS AND METHODS

Animals

Holstein-Friesian dairy cows of either overseas (OS) or New Zealand (NZ) origin were managed under systems of either all-pasture diet (Grass) or a total mixed ration (TMR: maize silage, grass silage, and concentrate with no pasture) in a 2x2 factorial design. Details of the management of these animals in the first year of the trial have been described elsewhere in this proceedings (Kolver *et al.*, 2000). Overall management was similar in year 2, and this paper reports a study of selected reproductive characteristics during spring 1999 at which time the treatment groups were comprised of NZGrass (n=14), OSGrass (n=12), NZ TMR (n=14) and OS TMR (n=13). Cows were either two or three years old, but due to the total number of cows in the trial being small, no distinction for age was made in the analyses.

Post-partum anovulatory intervals

The length of the postpartum anovulatory interval (PPAI) for each cow was determined from milk progesterone profiles. Milk samples were collected twice weekly, from calving to the start of mating, by hand-stripping from the udder after the afternoon milking. At each sampling 30ml of milk was collected, mixed with 33 mg potassium dichromate (Merck, Germany) as a preservative, and stored at 4˚C for no more than 7 days before analysis. Milk progesterone concentrations greater than 1.5 ng/ml were considered to indicate luteal activity. Day of first postpartum ovulation was defined as four days before the day on which milk progesterone concentrations first exceeded 1.5 ng/ml.

Ovarian structures

Regular examination of the ovaries by transrectal ultrasonography began on day 2 or 3 following an oestrous event (day 0 = day of oestrus). This was either the second or third postpartum oestrous event for those cows examined. A total of 24 cows were submitted for ultrasonography, being 4 for OS TMR, 8 for OSGrass (one of which had a hormonally induced first oestrus), 6 for NZ TMR and 6 for NZGrass. This group of cows was restricted due to a limited window in which the examinations could be carried out within the framework of the overall trial. Ovarian structures were recorded diagrammatically and their size estimated from the ultrasound image. Ultrasound examination continued until the second follicle wave was clearly established, i.e., the diameter of the second dominant follicle (DF2) exceeded that of the first (DF1). Blood samples were taken daily from each cow by coccygeal venipuncture into heparinised vacutainers on each day that they were examined. Tubes were immediately placed into iced water, centrifuged (1200g) within one hour of collection, and an aliquot of plasma stored at -20˚C until assayed.

Progesterone assays

Concentrations of progesterone in milk and plasma were determined using a commercial RIA kit (Coat-A-Count‘, DPC, CA, USA). Inter-assay CV’s were 6.5%, 9.3%, and 3.7% while the intra-assay CV’s were 9.8%, 7.8% and 18.8% for standard concentrations of 4.5, 3.0 and 0.4 ng/ml, respectively.

Statistical analyses

Results are reported as mean ± sem. Length of PPAI was compared by general linear model (GLM) ANOVA for main effects of genotype and feed system, and for their interaction. Proportional variables were compared by c-square analysis. Ovarian structure variables included daily diameter of DF1 and the corpus luteum, days to maximum diameter of DF1, days to emergence of DF2, and the number of subordinate follicles recorded/day during the period of dominance of DF1 (i.e., the period before DF2 emerged). Ultrasound and progesterone data were examined by GLM-ANOVA for main effects of genotype and feed system, and for their interaction.

RESULTS

Postpartum anovulatory intervals

Of the 53 cows from which milk samples were taken to determine the PPAI, 34 had ovulated before breeding started (8/14 NZGrass, 8/14 NZ TMR, 7/12 OSGrass and 11/13 OS TMR). Mean PPAI for cows in each treatment were 39±6, 29±4, 27±6 and 23±2 days for NZGrass, NZ TMR, OSGrass and OS TMR, respectively. Effect of genotype on PPAI approached significance (adjusted means: 24.6±3.2 and 33.6±3.4 days for OS and NZ strains, respectively; $P<0.07$) but not there was no significant effect of feeding system, and no significant interaction.

Cows were classified according to whether they were <21, 22-42, or >43 days postpartum at their first ovulation. Of the 13 cows that were <21 days, proportionately more were OS TMR and fewer were NZGrass (n=7 and 1, respectively with 3 each for OSGrass and NZ TMR; $P<0.02$). Of seven cows with PPAI >43 days, proportionately more were NZGrass (n=4 and 1 each for the other three treatments; $P<0.05$).

TABLE 1: Mean (± sem) maximum diameter of the first dominant follicle (DF1; mm), day of maximum diameter of DF1, day of emergence of the second dominant follicle (DF2) and the mean number of subordinate follicles recorded/day during the period of dominance of DF1 for Lactating overseas and NZ-derived Holstein-Friesian cows were fed either pasture or total mixed ration (NZGrass, NZ TMR, OSGrass, OS TMR).

	NZGrass	NZ TMR	OSGrass	OS TMR
Number of cows	6	6	8	4
Maximum diameter of DF1	16.3 (1.3)	14.3 (2.3)	15.8 (0.5)	14.3 (1.2)
Day to maximum DF1	9.7 (0.8)	10.3 (1.1)	9.5 (0.8)	10.5 (1.3)
Day of emergence of DF2	10.5 (0.7)	10.5 (0.9)	10.4 (0.5)	10.8 (0.6)
Number of subordinate follicles during DF1/day	6.1 (0.4) [a]	4.9 (0.7) [b]	6.5 (0.5) [a]	3.9 (0.7) [b]

[a, b] differences associated with feed system ($P<0.05$)

Ovarian structures

The mean diameters of DF1 and the corpus luteum on each day are presented in Figure 1, and calculated variables are given in Table 1. One animal in each of the NZGrass and NZ TMR groups had two corpora lutea during the examination period. The distribution of cycle number (2nd or 3rd cycle) at the time of examination was similar for each treatment group. Mean diameters of the DF1 and corpus luteum on any day, the day of maximum diameter of the DF1 and the day of emergence of the second follicle wave were not affected by either genotype or feeding system, nor were there any significant interactions. There was a significant effect of feed system, but not of genotype, on the number of subordinate follicles recorded/day during the first follicle wave (adjusted means: 6.2±0.6 and 4.1±0.7 follicles recorded/day for grass and TMR, respectively; $P<0.05$).

Plasma progesterone levels

Mean daily plasma progesterone profiles for each

FIGURE 1: Mean daily diameters of the first dominant follicle and the corpus luteum as measured by transrectal ultrasonography during days 2 to 14 of one cycle for each treatment group (NZ: □, OS: O; Grass: open; TMR: closed; DF1: complete line; corpus luteum: broken line).

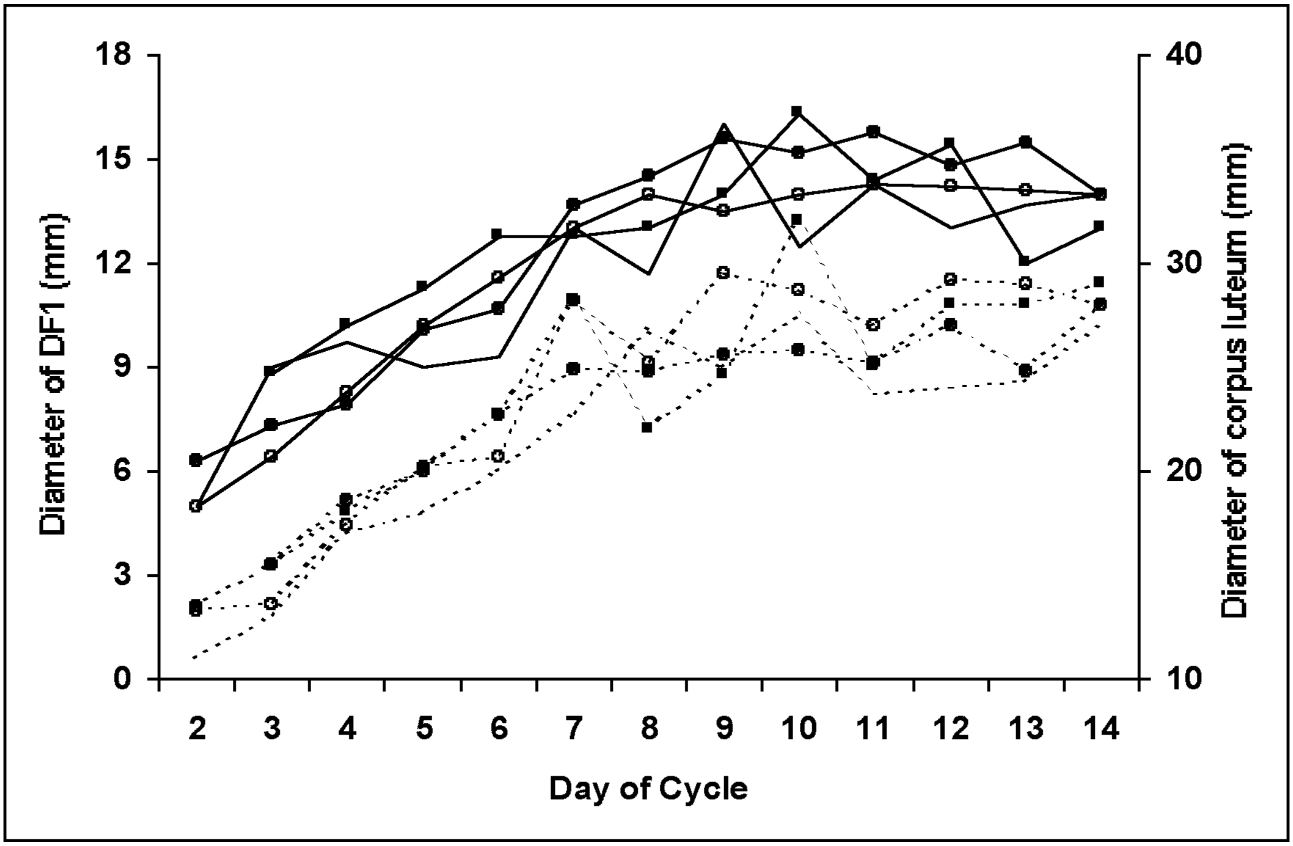
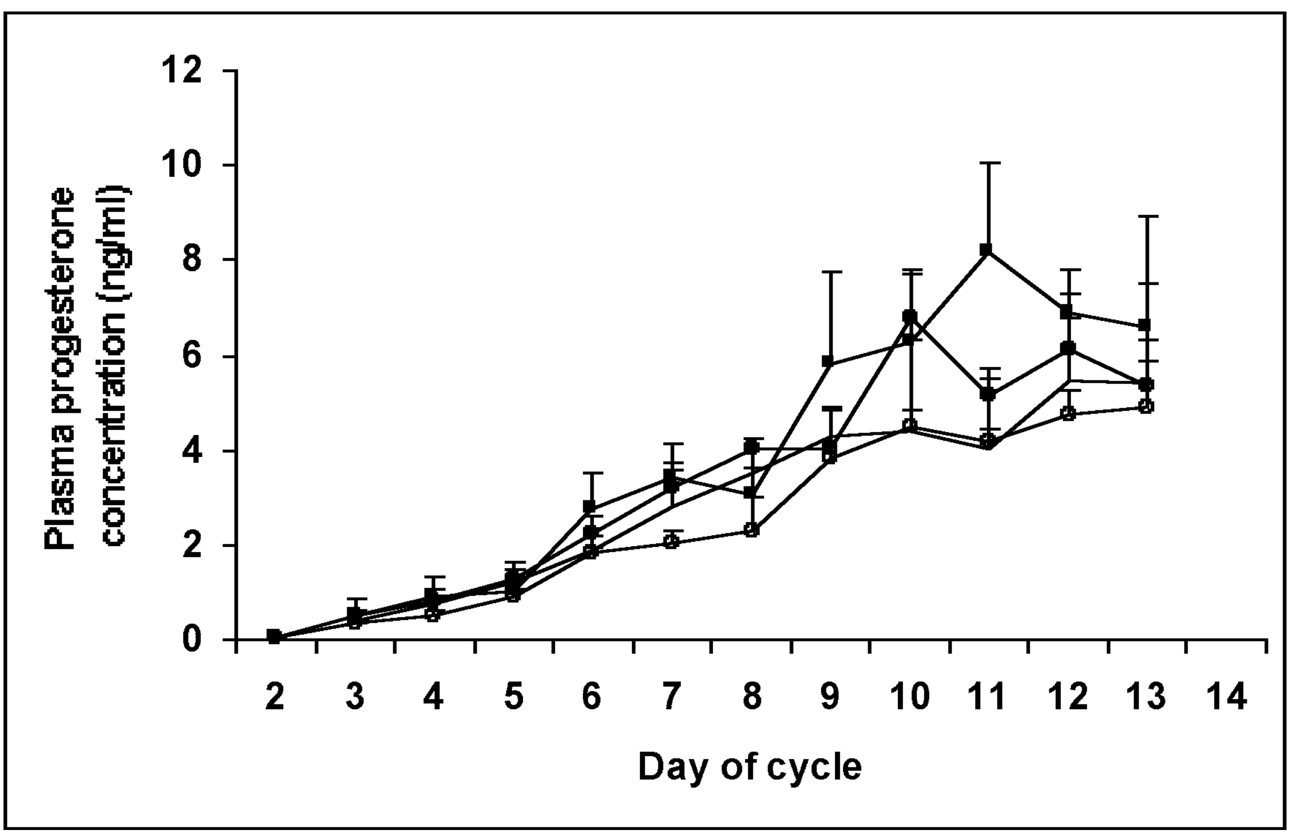


FIGURE 2: Mean daily plasma progesterone concentrations during days 2 to 14 of one cycle for each treatment group (NZ: □, OS: O; Grass: open; TMR: closed). Mean day of emergence of the second follicle wave was between days 10 and 11 for all groups.



treatment group are displayed in Figure 2.

There was a significant effect of feed system on mean plasma progesterone concentration at the time of emergence of the second follicle wave (adjusted means: 4.5±0.4 and 6.1±0.5 ng/ml for grass and TMR, respectively; P<0.02). There was no significant effect of genotype, and no significant interaction.

DISCUSSION

This study has examined some selected reproductive characteristics of Holstein-Friesian cows of either New Zealand or Overseas strains and fed either pasture or TMR. Although the descriptions are based upon a limited number of cows and differences should not be extrapolated directly to the general population of dairy cows in New Zealand, there were some interesting findings.

The length of the PPAI in cows that ovulated before the start of the breeding period tended to be shorter in the OS than the NZ genotype, and this was also reflected in the significant differences in the proportions of cows in each group that ovulated in either less than 21 days postpartum or more than 43 days postpartum. Data for cows that had not ovulated before the start of the breeding period have not been considered here. This group was largely comprised of later-calving animals, for which there was a management decision to impose a hormonal treatment to initiate oestrus, thus rendering data from them invalid. The finding of a tendency to shorter PPAI intervals in the OS genotype is consistent with previous data. Overseas studies report relatively shorter mean PPAI in Holstein Friesian cows of 30 days (review: Macmillan *et al.*, 1996) compared to New Zealand where the average PPAI is reported to be 45 days (McDougall *et al.*, 1995). The finding that the effect of genotype on PPAI was stronger than the effect of feed system is of particular interest. Limitations to fertility in high-producing Holstein-Friesians in other countries are reported as failure to conceive, rather than failure to cycle before the start of mating or the completion of a voluntary non-breeding period of 60 days (Dillon and Buckley, 1998). Similarly, the study of heavy and light Holstein-Friesian cows at Massey University has identified failure to conceive rather than failure to cycle as limiting reproductive performance (Holmes *et al.*, 1999).

The finding that there were more subordinate follicles present during the period of DF1 in the grass-fed cows with an associated lower plasma progesterone concentrations at the time of emergence of the DF2 is also interesting. This is at variance with a report by Bilby *et al.* (1998), in which lactating cows in New Zealand (pasture-fed) and the United States (TMR-fed) were compared and the United States cows were observed to have more subordinate follicles. The study was carried out across two sites, which could have led to confounding effects of environment. These effects are removed in the present study design in that management approaches for feeding were consistent across genotypes and animals had been allocated randomly within the 2x2 factorial design.

Cows on lower energy diets had fewer follicles that were 9-15 mm diameter, but more that were <9 mm (Lucy *et al.*, 1991). Limitations to total intake which could occur with the grass diet c.f. the TMR diet may have resulted in a less-favourable energy balance for the grass-fed cows and could explain the difference in follicle numbers observed. During much of the observation period, there were no differences in plasma progesterone concentrations between treatments, raising the question as to whether the observed difference at the time of emergence of the second follicle wave was, in fact, real. Diet may influence metabolic clearance of progesterone by altering hepatic blood flow and, hence, alter plasma progesterone concentration, but most observations suggest that increased energy intakes are associated with decreased plasma progesterone (Rabiee *et al.*, 1999b). The results of the current study are at variance with this. While plasma progesterone concentrations are representative only of peripheral hormone status rather than the environment under which ovarian structures develop (Rabiee *et al.*, 1999a), they nevertheless reflect the levels to which central feedback mechanisms and the anterior pituitary are exposed. It could be speculated, therefore, that a lower peripheral progesterone concentration could influence the level of gonadotrophic support to the ovary and consequently the development of subordinate follicles.

In conclusion, this study has indicated that genotype can affect the length of PPAI in lactating Holstein-Friesian cows, while feed system may influence the development of subordinate follicles and hormonal profiles at some stages of the oestrous cycle. Although it is based upon a limited number of cows in an experimental situation, the findings are of sufficient interest to support further investigations in the wider NZ dairy industry, particularly in view of the declining reproductive performance being seen in high-producing cows.

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