Productive and reproductive performance of Uruguayan Holstein and Uruguayan Holstein x New Zealand Holstein Friesian cows in a predominantly pasture-based system

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ABSTRACT

The performance of Uruguayan Holstein (UH) and UH x New Zealand Holstein Friesian first cross (UH-NZHF) cows was investigated over 1 year using 62 cows offered predominantly native pasture. Accumulated 305 day yields of milk, fat, protein and milksolids (fat+protein) were not affected by the strain. The UH cows produced 0.5 L/d more milk than UH-NZHF cows at Day 240 of lactation (P <0.05). Fat and lactose percentages were greater in UH-NZHF cows (3.72 vs 3.44% and 5.02 vs 4.94%, respectively, P <0.0001). Protein percentages tended to be greater in UH-NZHF cows (3.31 vs 3.27%, P = 0.08). The UH cows were 49 kg heavier (569 vs 520 kg, P <0.001) and required a greater energy requirement for maintenance. The UH-NZHF cows produced more milksolids per kg of $BW^{0.75}$, (P <0.01). Pregnancy rates tended to be greater in UH-NZHF cows (87 % vs 71%, P = 0.08) and were greater when the first 40 days of service were considered (61 vs 35%, P = 0.04), which may be related to a differential energy partitioning according to strains.

Keywords: production; reproduction; Holstein strains.

INTRODUCTION

Uruguayan dairy production systems are characterised by grazing herds, with 70% of the diet being grazed pasture, hay and silage and the remainder grain-based concentrates (Chilibroste, 2002). Milk payment is based on milksolids production, with a deduction for milk volume. The genetic origin of Uruguayan dairy herds is mostly from the confined production systems of North America and Canada where total mixed rations are fed. In contrast, the Uruguayan system is based on grazed pasture, similar to that of New Zealand. On the other hand, most Uruguayan soils have a poorer fertility with a lower phosphorus content than New Zealand soils. Consequently the lifespan of improved pastures is shorter and thus, dry matter utilization is lower. Genetic emphasis in North America and Canada has been on volume of milk production and type characters (Shook, 2006). Simultaneously with this increase in milk production per cow, fertility has declined in the last decades (Lucy, 2001).

Several comparative studies have shown differences in performances between the North American Holstein and New Zealand Holstein Friesian (NZHF) cows. North American cows are heavier, produce more milk volume, have lower protein, fat and lactose percentages, lower fat yields and lower fertility than NZHF cows (Laborde *et al*., 1998; Mwansa & Peterson, 1998; Harris & Kolver, 2001). Although the NZHF strain has been introduced in Uruguay, there has been no comparison of the productive and reproductive performance of both Holstein strains in South America, specially taken into account the different environment.

Thus, the experiment reported here, compared the productive and reproductive performance of two strains of Holstein: Uruguay Holstein (UH) vs crossbred UH-NZHF in a typical commercial productive system in Uruguay.

MATERIALS AND METHODS

Experimental design

Uruguayan Holstein (n = 31, 569 kg live weight) and UH-NZHF first cross (n = 31, 520 kg live weight) cows were selected 60 days before calving and paired according to lactation number, economic merit for farm profit of previous lactation, expected calving date and body condition score (3.32 ± 0.06). There were 18 and 13 UH cows experiencing their second or third lactations respectively and, 18 and 13 UH-NZHF cows experiencing their second or third lactations respectively. The UH-NZHF cows were progeny of NZHF sires and randomly assigned UH dams from the same herd. The economic merit index of each cow selected was estimated from production data of their previous lactation and calculated as the sum of breeding values for live weight and lactation yields of milk, fat and protein weighted by their corresponding economic values derived from the milk payment and farm costs.

TABLE 1: Description of feeds offered.

Month	Pasture (kg DM/cow/d)	Sorghum silage (kg DM/cow/d)	Grain (kg DM/cow/d)
June	50	1.5	5.5
July	14	3.5	12.0
August	25	3.5	9.0
September	50	0.0	3.7
October	60	0.0	3.7
November	35	0.0	4.3
December	30	0.0	6.3
January	30	1.5	6.3
February	35	1.5	3.5

Only animals that calved with no dystocia or related pathologies between June and August 2007, were maintained in the experiment. During the last month before calving, cows were managed on native pasture as one herd, receiving 11 kg dry matter (DM)/hd/d of a diet composed of 7 kg DM of sorghum silage, 3 kg DM of sorghum grain, 1 kg DM of sunflower meal (36% crude protein), 100 g of urea and a commercial prepartum mineral supplement. After calving, the cows were managed as one herd under a rotational grazing system with supplementary feed added to maintain a pasture cover of 1,200 kg of pasture DM and estimating to provide an intake of 18 kg total DM/cow/d. Table 1 describes diets offered to the cows on the same day as the monthly herd test.

Cows were milked twice-a-day. Milk yield and composition were determined from morning and afternoon herd-test samples at 15-day intervals during the first two months of lactation so as to relate to the endocrine and metabolite determination (Pereira *et al.,* 2010). Subsequently the sampling interval was monthly, until approximately Day 260 of lactation. Cows were dried off when production fell below 5 L/d of milk at the herd test or 60 days before calving. Body condition score was evaluated every two weeks from two months before calving up to 6 months after calving by two independent observers using a scale of 1 = emaciated to 5 = fat (Edmonson *et al*., 1989).

A concentrated calving period was achieved by imposing a breeding period of three months from September to November. During the first two months artificial insemination was used with natural mating used during the last month. The anovulatory postpartum period was determined by progesterone milk concentrations twice weekly, oestrus was detected twice a day. Animals were inseminated 12 hours after heat detection. Pregnancy diagnosis was performed by rectal palpation 60 days after the mating period had finished.

Progesterone determination was determined at the Nuclear Techniques Laboratory, Faculty of Veterinary Medicine, Uruguay. Milk was skimmed at 3000 rpm at 4°C for 15 minutes. Progesterone determination in skim milk was made by a solid radioimmunoassay using a commercial kit (Coat-a-count, DPC, Los Angeles, California, USA). The intra and inter-assay coefficient of variation were 1.5 % and 3.2% for low (0.5 nmol/L) and medium (2 nmol/L) controls respectively. The sensitivity was 0.3 nmol/L. The recommencement of ovarian cycling was defined as the day in which a luteal progesterone concentration in milk was observed (>1 nmol/L), and when this sample was followed by other samples also containing progesterone.

Calculations and statistical analyses

Metabolic energy (ME) requirements were estimated as the sum of the metabolic energy of lactation contained in milk and the metabolic energy required for maintenance. Metabolic energy input was estimated by subtracting or adding the energy from body reserves mobilization or accumulation (National Research Council, 2001) from the energy requirements. Energy efficiency was estimated as ME of milk/ME input.
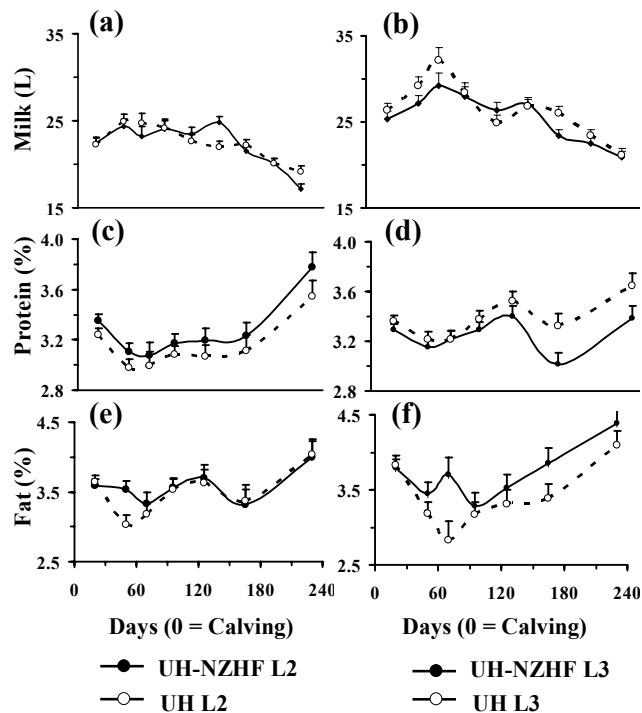
Milk production and composition, body condition score, and energy parameters were analysed using the MIXED procedure for repeated measure analysis (SAS 2000, SAS Institute Inc., Cary, North Carolina, USA.). The statistical model included the effects of strain (UH and UH-NZHF), lactation number (second and third), stage of lactation (30-day intervals), and interactions as fixed effects, and pair and cow within strain and lactation number as random effects. Residual errors were assumed to follow a covariance structure of type autoregressive order 1. Body condition score 60 days before calving and duration of the previous dry period were used as covariates. The Kenward-Rogers procedure was used to adjust the denominator degree of freedom to test significance level of fixed effects. Reproductive variables were evaluated with a generalized lineal model using the GENMOD procedure with a model that included the fixed effect of strain and lactation number and their interaction. Anovulatory interval was analysed with a Poisson distribution and a $\log_{10}$ link. Pregnancy rate was analysed with a binomial distribution and a logit link. Transformed estimates were back transformed for presentation. Significance was considered when $P < 0.05$.

RESULTS

Milk production

Milk yield at Day 260 of lactation was affected by the strain. UH cows produced more milk than UH-NZHF cows (Figure 1). This was due to the greater peak milk production of third lactation UH cows which was consistent with the reduced fat

FIGURE 1: Milk production (a) and (b), percentage of protein (c) and (d), and percentage of fat (e) and (f) in the milk of Uruguayan Holstein x New Zealand Holstein Friesian (UH-NZHF) and Uruguayan Holstein cows in the second (L2) and third (L3) lactation groups.
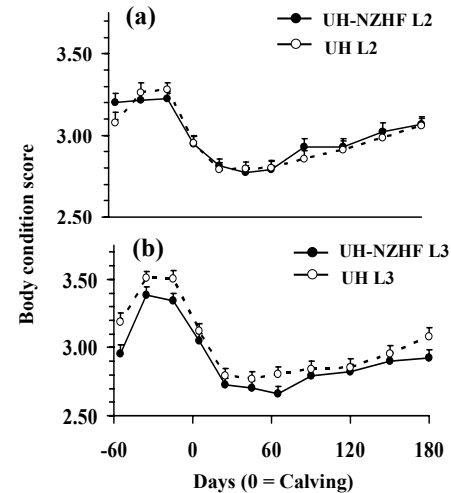

FIGURE 2: Body condition score in Uruguayan Holstein x New Zealand Holstein Friesian (UH-NZHF) and Uruguayan Holstein cows in (a) the second (L2) and (b) third (L3) lactation groups.

percentage observed and with losses in body condition score (Figure 2). Fat and lactose percentages were greater in UH-NZHF than in UH cows (3.72 ± 0.05 vs $3.44 \pm 0.05\%$ and 5.02 ± 0.02 vs $4.94 \pm 0.02\%$, P <0.0001) and protein percentage tended also to be greater in UH-NZHF cows (3.31 ± 0.02 vs. $3.27 \pm 0.02\%$, P = 0.08). Fat and protein percentages were similar (P = 0.15 and P = 0.66 respectively) between second and third lactation UH-NZHF cows, whereas in UH cows the protein percentage was greater in second lactation cows than in third lactation cows (P = 0.0005). Across strains, protein percentage was greater in second lactation cows than third lactation cows (P <0.03). Lactose percentage was greater in UH-NZHF than UH cows during their third lactation (Table 2 and Figure 1).

Accumulated production over milk, fat, protein and milksolids (fat + protein) over the 305 days of lactation were not affected by the strain (Table 2), but were affected by parity. Third lactation cows produced more milk and more fat than second lactation cows. Although yields of protein and milksolids were greater in third lactation UH-NZHF cows than in second lactation UH-NZHF cows, there were no differences related to parity in UH cows.

Body weight and body condition score

UH-NZHF were lighter than UH cows (520.5 ± 4.6 vs. 569.7 ± 4.7 kg, P <0.005) and third lactation

cows were heavier (P <0.05) than second lactation cows in both strains. Both strains increased body condition score up to 60 days before calving and decreased body condition score after 30 days before calving. This trend was steeper around calving (Figure 2). Third lactation UH cows lost greater body condition score around calving. During the experiment from two months before calving to six months after calving, UH-NZHF cows had a lower body condition score than UH cows (2.96 ± 0.02 vs 3.02 ± 0.02, P = 0.003). Third lactation UH-NZHF cows had the lowest body condition score during the experiment.

Energy efficiency

Both strains had similar ME output in milk (29,550 and 30,155 MJ, UH-NZHF vs UH). Calculated requirements of ME for maintenance in UH was greater than UH-NZHF cows (17,755 and 18,856 MJ, UH-NZHF vs UH, P = 0.01), so total metabolic energy requirements during the lactation were greater in UH cows than in UH-NZHF cows (P <0.0001). Energy from mobilizing body reserves was greater in UH than UH-NZHZ cows (6.27 vs 3.34 MJ/d). Thus, the estimated energy input was similar in both strains (46,287 vs. 47,099 MJ in UH-NZHF and UH cows, respectively). The efficiency of energy utilisation for milk production was higher in UH-NZHF than in UH cows (0.66 ± 0.01 vs. 0.64 ± 0.01, P = 0.02).

Reproduction

No significant differences between strains or lactation number were detected for postpartum anovulatory period which had an average length of 45.2 ± 5d. Days from calving to first oestrus, calving to conception, first service to conception and number of services per conception were similar for both biotypes. Pregnancy rate at six weeks after the start of the mating period was greater in UH-

TABLE 2: Mean ± pooled standard error per cow daily per milk production and milk composition during the first 240 days of lactation and the accumulated production over 305 days of lactation for Uruguayan Holstein x New Zealand Holstein Friesian (UH-NZHF) and Uruguayan Holstein (UH) cows according to the number of lactations they have experienced.

Measurement	Second lactation		Third lactation	
	UH-NZHF	UH	UH-NZHF	UH
Milk composition during the first 240 days of lactation				
Daily milk production (L/cow/d)	22.3 ± 0.6^a	22.4 ± 0.6^a	25.5 ± 0.7^b	26.5 ± 0.7^c
Fat (%)	3.72 ± 0.08^a	3.59 ± 0.08^b	3.89 ± 0.09^a	3.39 ± 0.09^b
Protein (%)	3.32 ± 0.03^{ax}	3.37 ± 0.03^{ay}	3.30 ± 0.04^a	3.18 ± 0.04^b
Lactose (%)	4.92 ± 0.03^{ax}	5.02 ± 0.02^{ay}	5.06 ± 0.03^b	4.85 ± 0.03^c
Accumulated production over 305 days of lactation				
Milk (L/cow)	$6,189 \pm 338^a$	$5,980 \pm 397^a$	$7,627 \pm 602^b$	$7,357 \pm 439^b$
Fat (kg/cow)	217 ± 12^a	219 ± 14^a	293 ± 21^b	243 ± 16^b
Protein (kg/cow)	195 ± 10^a	200 ± 11^a	252 ± 17^b	224 ± 14^{ab}
Milksolids (Fat + Protein) (kg/cow)	413 ± 26^a	417 ± 31^a	547 ± 48^b	468 ± 33^{ab}

[a, b, c] Means within the same row differ significantly (P <0.05).
[x, y] Means within the same row differ significantly (P <0.1).

NZFH than in UH cows (61 vs 35%, P = 0.04). Overall pregnancy rate across both artificial insemination and natural mating, tended to be greater in UH-NZFH cows than in UH cows (87% vs. 71%. P = 0.08).

DISCUSSION

In this experiment, UH-NZHF and UH cows expressed significant differences in milk volume, fat yield and fat percentage at Day 240 of lactation. Several studies in New Zealand comparing North American Holstein (NAH) and NZHF cows (Kolver et al., 2000; Macdonald et al. 2008) have shown that under grazing conditions, both strains produced similar lactation yields of milksolids while the NZHF cows had a lower milk yield and a higher percentage of fat and protein than the NAH cows. The introduction of NAH genes into the New Zealand dairy cow population has resulted in an increase of milk volume with a dilution in the concentration of fat and protein (Laborde *et al.*, 1998; Harris & Winkelman, 2000; Harris & Kolver, 2001). The same trend was observed in this study, fat and lactose percentages were greater and protein percentage tended to be greater in UH-NZHF cows than in UH cows. These results are consistent with the high response to selection for milk production and type traits achieved in the NAH dairy cow population (Shook, 2006) and the high response to selection for yield of milksolids achieved in the New Zealand dairy cow population (Harris & Kolver, 2001).

In this study, no differences for total milksolids yield were observed among strains. This is in agreement with Roche *et al*. (2006) and Kolver *et al*. (2000). However, other studies reported that

NHZF cows presented lower (Harris & Kolver, 2001) or greater (Macdonald *et al.*, 2008) total milksolid yields than NAH cows depending on the feeding system. In the present study, higher milk production was observed in third parity UH cows than third parity UH-NZHF cows, which occurred when cows received more concentrate in the diet (see Table 1 and Figure 1). It is possible that the dry matter intake and hence the milk production potential of UH cows has been limited by total feed offered to them. Indeed, Kolver *et al.* (2000) demonstrated that overseas cows expressed their genetic potential for milk production when a total mixed ration diet was offered. Third lactation UH cows had the lowest concentration of all milksolids in conjunction with the greatest milk volume. This can be interpreted as a dilution effect as has been reported previously (Schroeder & Gagliostro, 2000).

Metabolic energy output in milk was similar in both strains as total milksolid yields were similar between strains. Uruguayan Holstein x New Zealand Holstein Friesian cows weighed 49 kg less than UH cows. As a consequence, calculated requirement of ME for maintenance was lower in the former group resulting in a lower total metabolic energy requirement during the whole lactation. Since the estimated energy from the mobilization of body reserves was greater in UH cows, the total metabolic energy requirements was achieved differentially in the two strains. Recently, Lucy *et al*. (2009) found greater net energy in milk in NAH cows during early lactation than NZHF cows, but not in total lactation. These authors suggested that the diversity of genotypes changes in components of the somatotropic axis during early, but not late lactation

explained the relationship between milk production, body condition score, and feed allowance.

Although UH cows had higher reserves available for mobilisation, the body condition score in UH-NZHF cows was lower during the eight month experimental period. This is in contradiction with most of the scientific literature (Kolver *et al.*, 2000; Macdonald *et al.*, 2008). There is no obvious explanation for this, other than feeding competition could be the cause, since the UH-NZHF cows are almost 10 % lighter than the UH cows.

The greater energy efficiency for milk output found in the UH-NZHF cows is relevant for a system predominantly composed of native pasture where milk payment is based on milksolid yield, with a deduction in the price for milk volume. Small differences in feed efficiency have been reported between NAH and NZHF (Harris & Kolver, 2001).

No difference in postpartum anovulatory period was detected in this study in agreement with Chagas *et al.* (2007, 2009), but in contrast to other studies reporting shorter anovulatory period in the NAH than NZHF cows (Macdonald *et al.*, 2008; Verkerk *et al.*, 2000). Despite the small number of cows in this study, and that only one year's data were considered, pregnancy rates were higher in UH-NZHF than in UH cows. This is in agreement with other studies (Laborde *et al.*, 1998; Macdonald *et al.*, 2008) showing the impact of introducing NAH genes into the New Zealand dairy cow population as high production dairy cows are often associated with a decline in fertility (Lucy, 2001; Butler, 2003).

In conclusion, UH and UH-NZHF cows showed differences in live weight, milksolid concentration and reproductive performance. In spite of having a similar ME output in milk, the higher ME requirement for maintenance and higher energy from body reserves showed by UH cows, suggest better energy use for lactation by the UH-NZHF cows. A new trial designed to control feed intake should be undertaken to confirm this point.

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