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Evaluation of Hereford and first-cross cows on three pasture systems. III. Milk yield and its influence on calf performance

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SUMMARY

Milk yield was determined by the weigh-suckle-weigh method over 2 years (1983 and 1984 calvings), for a total of 305 purebred Hereford (H × H) and first-cross Brahman × Hereford (B × H), Simmental × Hereford (S × H) and Friesian × Hereford (F × H) cows grazing three pasture systems at Grafton, New South Wales, Australia. The age of the cows ranged from 6 to 11 years. The data were used to evaluate different estimates of milk yield and to examine the effects of milk yield on growth of calves up to weaning.

Of all the cow traits studied, average lactation milk yield (average of early, mid and late-lactation milk yields) had the highest correlation coefficient with calf 210-day weight ($r = 0{\cdot}73$) and pre-weaning average daily gain (ADGtotal, $r = 0{\cdot}73$), and explained $> 50\,\%$ of the variation in the calf traits. However, milk yield was also moderately correlated with other cow traits (liveweight and body condition score). Thus, to predict calf performance, milk yield data may not be required if detailed data on other cow traits are available. This is supported by the finding that differences in the coefficients of determination (R^2) between models for calf 210-day weight and ADGtotal which included average lactation milk yield and other cow traits (highest $R^2 = 69\,\%$) and models which included other cow traits but no milk yield estimate (highest $R^2 = 57\,\%$) were $< 13\,\%$.

Cow breed rankings for average lactation milk yield were similar to those for calf 210-day weight and ADGtotal. On high quality pasture, S × H and F × H cows produced the most milk (S × H, 7·5 kg/day; F × H, 8·3 kg/day; B × H, 5·7 kg/day; H × H, 5·5 kg/day) and weaned the heaviest calves (S × H, 255 kg; F × H, 252 kg; B × H, 215 kg; H × H, 217 kg), while on low quality pasture, B × H and F × H cows produced the most milk (B × H, 4·2 kg/day; F × H, 3·7 kg/day; S × H, 2·9 kg/day; H × H, 2·7 kg/day) but B × H cows weaned the heaviest calves (B × H, 180 kg; F × H, 168 kg; S × H, 159 kg; H × H, 124 kg).

INTRODUCTION

Improvement in cow productivity through crossbreeding has been demonstrated in many studies as reviewed by Long (1980), Kempster & Southgate (1984) and Davis & Arthur (1994). This improvement is effected by using breeds with characteristics which complement each other (breed complementarity) and through hybrid vigour. Over 50 % of the variation in calf pre-weaning growth has been attributed to its dam's milk yield (Totusek *et al.* 1973; Butson *et al.* 1980). Dairy breeds are often used in crossbreeding for beef production, with the expectation that the resultant dairy–beef crossbred cow will produce more milk, and hence wean heavier calves, compared to traditional beef cows.

In a series of studies reported earlier (Barlow *et al.* 1994; Hearnshaw *et al.* 1994*a*), the productivity of first-cross cows was higher than that of purebred Hereford cows under high, medium and low quality pastures in a subtropical environment. Among the first-cross cows, breed rankings for calf performance changed across pasture systems. The first-cross cows were Brahman × Hereford, Simmental × Hereford and Friesian × Hereford. Thus it was expected that there will be marked differences in milk production among the cow breeds. Hence this data set provides an

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opportunity to examine the milk yield/calf performance association over a range of breeds and pasture systems.

Repeated measurements of milk yield during a lactation is expensive to obtain in beef cattle. Therefore it would be useful to establish an optimal stage during lactation at which milk yield should be measured, to obtain an estimate representative of total lactation milk yield. The objective of this study was to evaluate different estimates of milk yield of Hereford and first-cross cows grazing three pasture systems, and to examine the effects of milk yield on growth of their calves up to weaning.

MATERIALS AND METHODS

Background and management

Purebred Hereford (H × H) and first-cross Brahman × Hereford (B × H), Simmental × Hereford (S × H) and Friesian × Hereford (F × H) cows born from 1973 to 1977 at the Agricultural Research and Advisory Station at Grafton, New South Wales, were used in this study. The cows had been allocated to pastures of high, medium or low nutritive value (pasture system) immediately after they had been weaned at 7–8 months of age, and stayed on those pastures all their lives. The high quality pastures were on alluvial soils where the forage species were kikuyu (*Pennisetum clandestinum*), paspalum (*Paspalum dilatatum*), Rhodes grass (*Chloris gayana*) and white clover (*Trifolium repens*). The stocking rate on these pastures over summer was 1·4 cows/ha. When summer-growing pastures were dormant or frosted (April–October), ryegrass (*Lolium multiflorum*) was established each year with irrigation and 34 kg N/ha fertilization, to produce forage for grazing at a stocking rate of 4 cows/ha. Medium quality pastures were on red earth soils which supported the same species as above, in addition to carpet grass (*Axonopus affinis*), but there was no ryegrass establishment. Stocking rate was 1·5 cows/ha. Available phosphorus in soils of high and medium quality pastures was > 40 mg/kg (bicarbonate extraction) from previous fertilizer application. Low quality pastures were on unfertilized sandstone soils (available phosphorus < 10 mg/kg) with grass species being predominantly carpet grass, blady grass (*Imperata cylindrica*), blue couch (*Digitaria didactyla*) and native grasses. Details of the pasture systems have been presented by Barlow *et al.* (1988, 1994).

Table 1. *Number of cow and calf pairs used, presented within year of birth of calf, cow breed and pasture system (high, medium and low nutritive value) subclass*

Year of birth of calf	Cow breed*	Pasture system			
		High	Medium	Low	Total
1983	H × H	10	15	15	40
	B × H	15	13	18	46
	S × H	16	14	11	41
	F × H	16	15	15	46
1984	H × H	10	13	4	27
	B × H	11	14	11	36
	S × H	13	17	6	36
	F × H	16	13	4	33
Total		107	114	84	305

* H × H, B × H, S × H and F × H correspond to purebred Hereford, first-cross Brahman × Hereford, Simmental × Hereford and Friesian × Hereford, respectively.

This study was commenced in 1983 using a total of 305 cow and calf pairs out of a total of 434 pairs available after the 1983 and 1984 calvings. The pairs not included in the study calved either too early or too late in the calving season. The numbers of cow and calf pairs used are presented in Table 1, within year of birth of calf, cow breed and pasture system subclasses. The age of the cows ranged from 6 to 11 years. Details of the mating and calving management have been provided by Hearnshaw *et al* (1994*a*). Calves were nursed by their dams until weaning. The calves were *c.* 7·5–9 months of age at weaning. Male calves were castrated at *c.* 3–4 months of age.

Measurements and traits

Measurements taken on all cows and calves have been described by Barlow *et al.* (1994) and Hearnshaw *et al.* (1994*a*). For this study, calf traits used included age and weight taken at birth, at mid-lactation and at weaning. Average daily gain (ADG) was calculated for the early (birth to mid-lactation, ADGearly), late (mid-lactation to weaning, ADGlate) and the entire (birth to weaning, ADGtotal) pre-weaning period. Weaning weight adjusted to 210-days of age (210-day weight) was also calculated for each calf. Cow traits used included weight and body condition taken just prior to the start of the mating season (pre-mating) and at weaning. Body condition was scored on a scale of 1–9, with 9 representing an obese cow. Change in weight (weight change) and in body condition (condition score change) of cows from pre-mating to weaning of calves were calculated. Milk yield was

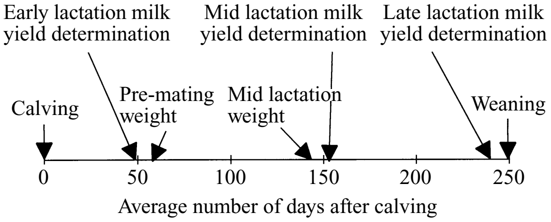

Fig. 1. Time scale of the various phases of the study.

determined for each cow at early, mid and late-lactation. A time schedule for the various phases of the study is presented in Fig. 1.

Milk yield determination

For each pasture system, a date was chosen during early, mid and late-lactation to determine the milk yield of the cows on that pasture. The dates were chosen such that the average number of days from calving to milk determination day was similar across pasture system. The stages in the study at which milk yield was determined are shown in Fig. 1.

Milk yield was determined by the weigh-suckle-weigh method (Totusek *et al.* 1973). At 15.00 h on the eve of the day of milk yield determination, calves were separated from their dams overnight in holding pens with access to water. At 06.30 h of the day for milk determination, calves were taken to their dams to suckle and each calf was observed to have suckled by 07.30 h. The actual milk yield determination started at 07.30 h by separating cows and calves for 6 h, after which calves were weighed, allowed to suckle their dams, then reweighed. The difference in the weight of the calves represented a 6 h milk yield of their dams. Another 6 h separation of cows and calves was effected, after which calves were weighed, allowed to suckle their dams, then reweighed to determine the second 6 h milk yield. The sum of the two 6 h (morning plus afternoon) milk yields was multiplied by two to obtain an estimate of 24 h milk yield, and is referred to as 'milk yield'. The average of early, mid and late-lactation milk yields is referred to as 'average lactation milk yield'.

Statistical analyses

Data for all traits were analysed by least squares using the GLM procedure of SAS (1990). The model used included the fixed effects of year of birth of calf, pasture system, cow breed, age of cow, sire breed of calf and sex of calf. Age of calf was included as a covariate for the analysis of milk yield data. Preliminary analyses were conducted using all the main effects and all possible interactions up to four-way interactions. Non-significant ($P > 0{\cdot}05$) terms were sequentially eliminated so that the final model for each trait included only the significant ($P < 0{\cdot}05$) terms and the error term. In addition, milk yield was analysed using repeated measures analysis of SAS (1990). The linear and quadratic effects of time (early, mid and late-lactation) and its interactions were included in the model.

Simple and partial correlation analyses were performed for all the traits. In the partial correlation analysis, adjustments were made for the significant ($P < 0{\cdot}05$) fixed effects identified by the GLM least-squares analyses described above. To examine the relative influence of each of the cow traits on calf growth, stepwise multiple regression analysis was performed for 210-day weight and for ADGtotal (using the REG procedure of SAS (1990)) with all the cow traits as explanatory variables. The level of significance for variables to enter or remain in the model was $P < 0{\cdot}05$.

RESULTS AND DISCUSSION

Analyses

Most of the simple correlation coefficients among the different estimates of milk yield, cow traits and calf traits were significantly ($P < 0{\cdot}05$) different from zero. When the data were adjusted for significant fixed effects of pasture system, cow breed and sire breed of calf, a few of the partial correlation coefficients did not differ significantly from zero. All the stepwise regressions were significant ($P < 0{\cdot}05$), with R^2 for the final models being $> 0{\cdot}50$.

Results of the least squares analyses of variance were similar to those reported by Hearnshaw *et al.* (1994*a*) which covered the two birth years of this study and an additional year (1985). The similarity in the results indicates that the sample of 305 cow and calf pairs used in this study is representative of the animals in the original experiment. Results will therefore be presented only for milk yield (not evaluated by Hearnshaw *et al.* (1994*a*)), calf 210-day weight and ADGtotal. The significant ($P < 0{\cdot}05$) sources of variation for these traits were pasture system, cow breed, sire breed of calf, year × pasture system interaction and pasture system × cow breed interaction. For calf 210-day weight and ADGtotal, sex of calf was also significant ($P < 0{\cdot}05$).

In the repeated measures analysis for milk yield, only the linear effect of time (early, mid or late-lactation) was significant ($P < 0{\cdot}05$), with milk yield during early-lactation ($7{\cdot}5 \pm 0{\cdot}1$ kg/day) being higher than that during mid-lactation ($5{\cdot}6 \pm 0{\cdot}1$ kg/day), which in turn was higher than that during late-lactation ($3{\cdot}2 \pm 0{\cdot}1$ kg/day). Time × pasture system interaction was significant ($P < 0{\cdot}05$) for milk yield. Time × pasture system × cow breed interaction was not significant for milk yield, indicating that cow breed rankings for each pasture system were similar for early, mid and late-lactation milk yield. Thus combining early, mid and late-lactation milk yield into average lactation milk yield for the analyses to evaluate the cow breeds is justified. This is in addition to the fact that, of all the different estimates of milk yield, average lactation milk yield had the highest correlation with calf performance.

It is well established that milk production during a lactation is non-linear. Results from studies in beef cattle by Totusek *et al.* (1973) and Jenkins & Ferrell (1984, 1992) indicate that in beef cattle, peak lactation is achieved between 7 and 11 weeks post-partum, after

Table 2. *Means and standard deviations* (S.D.) *for cow and calf traits presented within pasture system subclass*

	High quality		Medium quality		Low quality	
Traits	Mean	S.D.	Mean	S.D.	Mean	S.D.
Cow trait						
Pre-mating weight (kg)	578	62	421	46	344	43
Pre-mating condition score*	6·6	1·0	3·8	0·8	3·0	0·6
Weight at weaning (kg)	557	57	451	44	371	48
Condition score at weaning	6·4	1·2	4·2	0·8	3·6	0·7
Weight change (kg)	−21	22	30	18	27	23
Condition score change	−0·2	0·9	0·4	0·6	0·6	0·7
Calf trait						
Birth weight (kg)	39	6	35	6	35	6
Mid-lactation weight (kg)	187	31	157	31	132	26
Weaning weight (kg)	271	32	240	30	180	35
Age at weaning (days)	246	12	254	13	250	14
ADGearly (g/day)†	1004	132	860	113	641	148
ADGlate (g/day)†	875	136	729	116	479	139
ADGtotal (g/day)†	945	113	806	96	578	132
210-day weight (kg)	237	28	204	23	156	29

* Body condition was scored on a scale of 1–9, with 9 representing an obese cow.

† Early, late and total, represent the periods from birth to mid-lactation, mid-lactation to weaning, and birth to weaning, respectively.

which there is a gradual decline in milk yield. In this study, only the linear effect of time was significant for milk yield. This is probably due to the fact that milk yield was determined only on three occasions during the entire lactation period. The early-lactation milk yield was measured close to peak lactation (50 days post-partum). Since the objective of this study was not to characterize the nature of the lactation curve, milk yield determinations were not done immediately before or after 50 days post-partum.

Effect of milk yield and other cow traits on calf performance

The relationships among calf and cow traits were studied by correlation analyses. Means and standard deviations of the traits are presented in Table 2. Table 3 shows the simple and partial correlation coefficients of the traits. Using the partial correlations, the cow traits were correlated to either calf 210-day weight or ADGtotal in the following order: average lactation milk yield (highest coefficient), mid-lactation milk yield, early-lactation milk yield, late-lactation milk yield, cow body condition and weight at the weaning of their calves, and cow body condition and weight pre-mating. The four estimates of milk yield were all positively correlated with calf 210-day weight and ADGtotal. The magnitude of the correlation coefficients is similar to those reported by Koch (1972), Reynolds *et al.* (1978), Williams *et al.* (1979) and Butson *et al.* (1980). Across the three stages of lactation, mid-lactation milk yield had the highest correlations with average lactation milk yield and calf performance. Thus under situations where milk yield cannot be measured during all three stages of lactation, a measurement taken at mid-lactation appears to be the best indicator of average lactation milk yield. Cow body condition at both pre-mating and weaning was negatively correlated with calf traits. Thus higher calf 210-day weight is associated with lower cow body condition, probably resulting from the fact that cows utilize their body reserves to produce enough milk for their calves.

Final models obtained from stepwise regressions explained 56–70% of the variation in calf 210-day weight and in ADGtotal (Table 4). Most of this variation was accounted for by milk yield and cow weight at weaning. The other cow traits included accounted for $< 5\%$ additional variation in the two calf traits. Average lactation milk yield accounted for 52·9% of the variation in calf 210-day weight and 52·8% of the variation in ADGtotal, and cow weight at weaning accounted for additional 15·0% (67·9–52·9%) and 15·9% (68·7–52·8%) of the variation, respectively. Cow body condition at weaning accounted for an additional 1·1% or less of the variation in calf 210-day weight and ADGtotal. The contributions of cow weight and body condition at pre-mating, number of days from calving to pre-mating or to weaning, and change in cow weight and body condition were not significant ($P < 0·05$) to enter into the regression model which contained milk

Table 3. *Correlation coefficients* among cow and calf traits*

Trait	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*
Cow weight at pre-mating (*A*)		0·86	0·97	0·81	−0·70	−0·38	0·39	0·46	0·41	0·56	0·68	0·71	0·73	0·72
Cow condition score at pre-mating (*B*)	0·50		0·82	0·89	−0·63	−0·53	0·31	0·35	0·36	0·45	0·58	0·58	0·59	0·59
Cow weight at weaning (*C*)	0·89	0·41		0·80	−0·50	−0·32	0·40	0·45	0·38	0·55	0·69	0·71	0·73	0·72
Cow condition score at weaning (*D*)	0·48	0·69	0·46		−0·53	−0·09†	0·27	0·28	0·24	0·35	0·47	0·49	0·49	0·47
Cow weight change (*E*)	−0·41	−0·28	0·04†	−0·13		0·40	−0·23	−0·31	−0·34	−0·39	−0·39	−0·44	−0·43	−0·44
Cow condition score change (*F*)	−0·04†	−0·41	0·06†	0·38	0·19		−0·18	−0·25	−0·34	−0·33	−0·39	−0·35	−0·38	−0·39
Early-lactation milk yield (*G*)	0·05†	−0·12	0·08†	−0·12	0·05†	0·01†		0·40	0·24	0·75	0·54	0·41	0·52	0·53
Mid-lactation milk yield (*H*)	−0·01†	−0·25	0·01†	−0·27	0·04†	−0·03†	0·23		0·37	0·80	0·61	0·56	0·63	0·62
Late-lactation milk yield (*I*)	0·14	0·06†	0·09†	0·11†	−0·13	−0·20	0·09†	0·20		0·69	0·47	0·47	0·48	0·47
Average lactation milk yield (*J*)	0·10†	−0·16	0·10†	−0·25	−0·02†	−0·11	0·68	0·71	0·62		0·73	0·64	0·73	0·73
Calf ADGearly (*K*)	0·13	−0·14	0·21	−0·25	0·14	−0·14	0·37	0·38	0·29	0·52		0·79	0·96	0·95
Calf ADGlate (*L*)	0·16	−0·16	0·22	−0·20	0·08†	−0·04†	0·16	0·28	0·29	0·36	0·54		0·93	0·92
Calf ADGtotal (*M*)	0·16	−0·19	0·23	−0·26	0·13	−0·08†	0·33	0·40	0·30	0·51	0·91	0·83		0·99
Calf 210-day weight (*N*)	0·19	−0·17	0·25	−0·25	0·08†	−0·10†	0·36	0·39	0·29	0·52	0·89	0·81	0·98	

* Simple correlation coefficients above diagonal and partial correlation coefficients (adjusted for the significant fixed effects of pasture system, cow breed and sire breed of calf) below diagonal.

† Indicates that the correlation coefficient is not significantly ($P > 0·05$) different from zero ($n = 305$).

Table 4. *Stepwise regression of calf 210-day weight* (*kg*) *and average daily gain from birth to weaning* (*ADGtotal*, *g/day*) *on cow traits**

Calf trait	Cow traits which sequentially entered into the regression model	Cumulative percentage of total variation explained ($R^2 \times 100$)		Partial regression coefficient ± S.E.	
		Model with milk yield data	Model without milk yield data	Model with milk yield data	Model without milk yield data
210-day weight	Average lactation milk yield	52·9	—	8·7 ± 0·7	—
	Weight at weaning	67·9	52·2	0·3 ± 0·1	0·2 ± 0·1
	Condition score at weaning	69·0	55·0	−4·8 ± 1·5	−9·2 ± 1·8
	Weight at pre-mating	—	56·8	—	0·2 ± 0·1
ADGtotal	Average lactation milk yield	52·8	—	38·1 ± 3·3	—
	Weight at weaning	68·7	53·4	1·2 ± 0·1	1·7 ± 0·1
	Condition score change	—	55·8	—	−29·5 ± 9·5
	Condition score at weaning	69·3	56·8	−16·1 ± 6·5	−21·5 ± 7·9

* Results from two separate analyses, using milk yield data or no milk yield data. Other cow traits which were included in the full models, but did not meet the criterion ($P < 0·05$) for entry or retention in any of the final models were condition score at pre-mating, age and weight change.

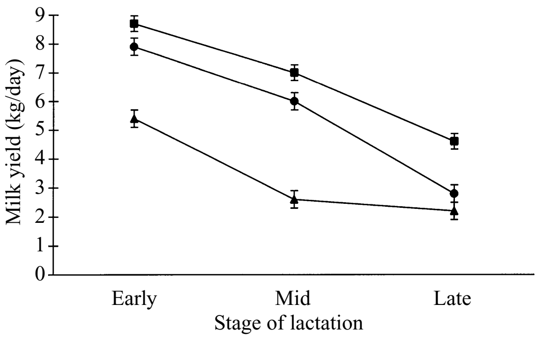

Fig. 2. Effect of pasture system × stage of lactation interaction on milk yield. High (■), medium (●) and low quality (▲) pastures.

yield data. Thus the single most important contributing factor to calf pre-weaning growth is cow milk yield, explaining > 50 % of the variation. This result is similar to that reported by Jeffery & Berg (1971), Rutledge *et al.* (1971), Totusek *et al.* (1973) and Butson *et al.* (1980), which indicated that > 50 % of the variation in calf growth is explained by the dam's milk yield.

There are considerable difficulties and expense in measuring milk yield in beef cattle. The results indicate that milk yield is correlated with the other cow traits (e.g. $r = 0{\cdot}55$ for average lactation milk yield and cow weight at weaning; Table 3). Therefore under situations where milk yield data were not available, will the other cow traits explain a significant proportion of the variation in calf traits? In the analysis without milk yield data (Table 4), the other cow traits accounted for 56·8 % of the variation in calf traits. In contrast, where milk yield data were available, 69·0 and 69·3 % of the variation in calf 210-day weight and ADGtotal, respectively, were accounted for. Therefore, if milk yield data is required only for the purpose of assessing calf performance, then the decision to measure it depends on the degree of accuracy required in the assessment, as only an additional 12–13 % of variation accounted for (69·3–56·8 %) will be realised.

Effect of year and stage of lactation by pasture system interaction

Year effect did not have a significant effect on milk yield but year × pasture system effect was significant. Least squares means for average lactation milk yield for 1983 were 6·4 ± 0·2 kg/day, 5·8 ± 0·2 kg/day and 3·6 ± 0·2 kg/day, and for 1984 were 7·0 ± 0·2 kg/day, 5·3 ± 0·2 kg/day and 3·1 ± 0·3 kg/day, for cows on high, medium and low quality pastures, respectively. The significant interaction was due to the fact that the differences in average lactation milk yield of cows on high quality pasture and those on medium quality pasture were not significant for 1983, but were significant for 1984. Correlation between a cow's 1983 and 1984 average lactation milk yield was used as a measure of the repeatability of a cow's milk production across years. It indicated that the repeatability was medium (r = 0·57 and partial $r = 0{\cdot}45$).

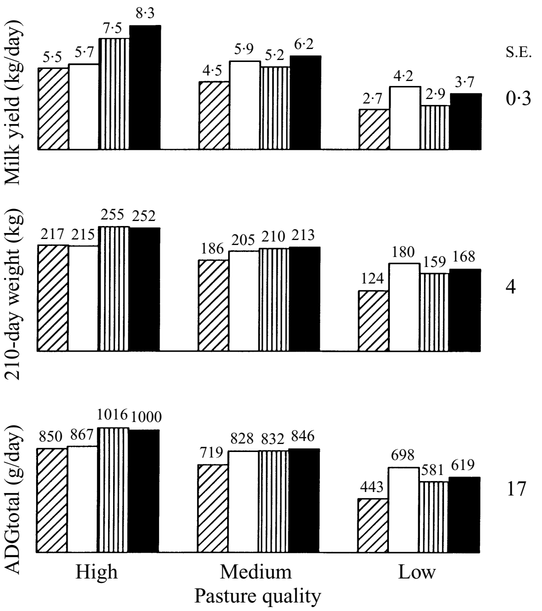

Fig. 3. Effect of pasture system × cow breed interaction on average milk yield of cow, calf 210-day weight and average daily gain from birth to weaning (ADGtotal). Purebred Hereford (▨), Brahman × Hereford (□), Simmental × Hereford (▥), Friesian × Hereford (■).

Milk yield of cows on high quality pasture was higher than that on medium quality pasture, which in turn, was higher than that on low quality pasture, at early and mid-lactation (Fig. 2). By late-lactation the differences in milk yield for cows on medium quality pasture and those on low quality pasture were no longer significant (2·6 ± 0·3 kg/day *v.* 2·2 ± 0·3 kg/day). The rapid drop in milk yield of cows on low quality pasture from early to mid-lactation to a base level which was maintained to late-lactation (Fig. 2), is in agreement with the findings of Jenkins & Ferrell (1984). This result indicates that persistence of lactation is adversely affected by low quality nutrition. Therefore, if better calf performance is required under conditions of low quality nutrition, certain nutritional/management strategies could be adopted. One strategy is to supplementary feed the cows during lactation. This strategy has the potential to improve reproduction during the mating season which starts about mid-lactation. Other strategies include the early weaning of calves at about mid-lactation (5 months of age; Fig. 1), or the creep-feeding of calves from mid-lactation to weaning.

Effect of cow breed on calf performance

The stage of lactation × pasture system interaction was not significant ($P > 0{\cdot}05$) for milk yield, and therefore discussion on cow breed will be based only on average lactation milk yield. Cow breed effect for average lactation milk yield, calf 210-day weight and ADGtotal was significantly ($P < 0{\cdot}05$) influenced by pasture system, and hence cow breed × pasture system interaction effects for these traits are presented in Fig. 3. From one pasture system to the other, means for the two traits of calves with B × H dams did not differ as much as the means for calves with dams of the other three cow breeds. For these traits, cow breed rankings changed from $F \times H = S \times H > H \times H = B \times H$ (high quality pasture) to $B \times H > F \times H = S \times H > H \times H$ (low quality pasture). The ranking of the cow breeds for average lactation milk yield were similar to those for the calf traits but, on low quality pasture, significant ($P < 0{\cdot}05$) differences were obtained only for B × H relative to S × H and H × H.

These results demonstrate the correspondence between calf growth traits and milk yield: with the heaviest calves being weaned by cows of the breed with the highest milk yield. The higher calf weaning weights reported (Barlow *et al.* 1994) for B × H cows on low quality pastures can be explained, in part, by the relatively higher milk yield of the cows on these pastures. It is worth noting that although the dairy cross cow, F × H, and the dual-purpose cross cow, S × H, produced the most milk on high quality pasture, this was not the case on low quality pasture. Thus if dairy cross cows are intended to be used to produce calves with high pre-weaning growth and heavier weights at weaning, then adequate nutrition has to be provided for such cows. These calves would be suitable for slaughter straight off their dams at 9–11 months of age (Australian vealer market). On medium quality pastures, the use of first-cross Brahman cows achieves similar results. If the cattle enterprise is selling weaners to be grown and finished on pasture or feedlot, maximum pre-weaning growth is not necessary as light and medium weight weaners are expected to exhibit compensatory growth during the post-weaning period. It should be noted, however, that if weaning weights are too low, full compensation in liveweight is sometimes not achieved even at older ages (Arthur *et al.* 1994; Hearnshaw *et al.* 1994*b*).

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