Genetic Correlations Amongst Body Weight, Fat Yield, Protein Yield And Body Condition Score In Ayrshire Cows

R. I. Cue

Introduction

The relationships amongst cow body weight, lactation fat and protein yield and body condition score are important determinants of cow profitability. Larger cows have a greater voluntary feed intake and produce more milk, but will have higher feed maintenance requirements. In Quebec (Valacta, 2008) the phenotypic trend for heifer weight and calving and mature cow calving weight has been positive; over the past 20 years Ayrshire mature cow calving weight has increased from 498 kg to 552 kg, a phenotypic trend of approximately +3 kg per annum . Some of this may be the result of selection for larger cows, some of this may be improved management and feeding, and some may be a correlated response for selection for increased production. It is therefore of interest to examine the genetic and environmental correlations between body weight and milk production. Body weight and body condition score are interrelated, several studies have indicated that it is important to consider both traits. Quebec milk recording routinely records body weight and body condition score after calving; thereby providing the opportunity to study these traits and their correlations with production over multiple lactations. The objective of this study was therefore to examine the heritabilities and correlations amongst body weight and body condition score at calving, and lactation fat and protein yield in Ayrshire cows in Quebec over their first 3 lactations.

Material and methods

Data source and editing. Data were extracted from the Quebec milk recording program (Valacta) for cows calving from January 2000 to May 2007. This study was limited to the Ayrshire breed, which is the second most popular breed in Quebec; ~ 9% of cows are Ayrshire. Only completed lactations were kept, and cows were required to have a first lactation fat yield. The data were restricted to the first three lactations only, there were not enough records in subsequent lactations to warrant their inclusion. Table 1 shows the numbers of records for each trait and parity. Edits typically used for analyzing such data were applied; lactation length had to be between 75 and 500 days, body weight at calving, on a parity specific basis had to be at least 400 kg and less than 1100 kg. Body condition scores (recorded on a 1 to 5 scale) were checked to ensure that individual scores were used and not group averages, using the approach of Bastin (2010) whereby the standard deviation within any herd-recording date had to be at least 0.25. Body weight was the first recorded value after calving, and similarly for body condition score. Most cows have body weight recorded, if recorded, at the first test-day after calving, and few cows have multiple recording within a lactation; hence only the first record after calving was retained. Likewise for body condition score, only the first recorded value was retained. It was required that body weight and body condition score be recorded within the first 65 days after calving. There were not enough animals with multiple observations within each parity to consider a multiple regression model for these two traits. As can be seen in Table 1, there were many fewer body weight and body condition records in all parities; this is a limitation of these analyses. Canada uses 2 seasons of calving (October to March, and April to September); herd-year-season-parity classes were required to have at least 5 records (cows) to be included in the analyses. Age at calving classes were formed by month of age within each parity. All animals in the data were required to have an identified sire. Then the Ayrshire Canada pedigree file (supplied by the Canadian Dairy Network) was searched to add all relationships back from the cow for 4 generations. Any animal without data records, with only 1 offspring and with unknown parents was removed, in an iterative process, since such animals are considered to be uninformative. A total of 46949 identities were finally obtained. Table 2 presents the raw means and averages; for the statistical analyses body weight, fat yield and protein yield were scaled to have means of the same order of magnitude as body condition score, to aid the numerical stability of the multi-trait analyses.

Table 1: Data summary, numbers of records for each trait

Trait Parity	Body weight	Fat Yield	Protein Yield	BCS
1	8921	23234	23234	1991
2	4659	15766	15766	1095
3	2444	9337	9337	582

Table 2: Means and standard deviations

Trait number	Trait	Mean	S.D.
1	Calving weight (kg), parity 1	531.3	46.3
2	Fat kg, parity 1	267.9	85.0
3	Protein kg, parity 1	221.9	70.3
4	BCS, parity 1	2.93	0.43
5	Calving weight (kg), parity 2	545.9	50.0
6	Fat kg, parity 2	279.8	70.4
7	Protein kg, parity 2	236.0	74.4
8	BCS, parity 2	2.86	0.49
9	Calving weight (kg), parity 3	569.5	53.9
10	Fat kg, parity 3	284.5	96.9
11	Protein kg, parity 3	238.5	79.0
12	BCS, parity 3	2.91	0.55

Statistical models and analyses. The 12 traits analysed were: body weight, fat yield, protein yield and body condition score, in parities 1, 2 and 3, in that order, as presented in Table 2. Initial analyses were carried out using SAS v9.1.3 to examine fixed effects; all subsequent genetic analyses were done using the Wombat program (Meyer, 2006). Bivariate analyses of all pairs of traits amongst the 12 traits (4 characters*3 parities) were made to obtain initial starting values for the 12-trait animal model, as suggested by Meyer, 2006. For lactation fat and protein yield the statistical model, within each parity, used was: $Y_{ijk} = \mu + hys_i + age_j + a_k + e_{ijk}$. For body weight and body condition score the model included linear and quadratic regressions on the days in milk when the trait was recorded. Thus the model was: $Y_{ijk} = \mu + hys_i + age_j + b_1*dim_{ijk} + b_2*dim^2_{ijk} + a_k + e_{ijk}$. Parameters were estimated using the AI-REML option of Wombat.

Results and discussion

Estimates of heritabilities, genetic and environmental correlations are shown in Table 3. Fat yield and protein yield were highly correlated both genetically and environmentally, but uncorrelated with either body weight or body condition score. Body weight was highly genetically correlated across the 3 lactations (~0.9), whereas the environmental correlations were much lower (~0.3). Interestingly, the heritability of body weight was substantially higher in parities 2 and 3 as compared to parity 1, due to higher genetic variances; the environmental variances for body weight were similar across all 3 parities. Body condition score had genetic correlations of ~0.6 across parities, whilst the environmental correlations were lower. Body weight and body condition score were genetically and environmentally uncorrelated. Regressing the solutions for the random animal effect (effectively the animal EBVs) for calving weight on date of birth gave an annual genetic trend of +0.45 kg while regressing the fixed effects solutions for herd-year-seasons on years gave an environmental trend of ~ +3 kg p.a., consistent with the simply phenotypic averages referred to at the beginning of this paper.

Table 3: Heritabilities (diagonal, bold), genetic correlations (above diagonal), environmental correlations (below diagonal)

trait	1	2	3	4	5	6	7	8	9	10	11	12
1	**.246**	.014	.018	.091	.918	-.083	-.089	-.022	.890	-.198	-.233	.188
2	.051	**.246**	.936	-.217	-.181	.905	.847	-.447	-.105	.889	.810	-.544
3	.055	.982	**.220**	-.207	-.128	.858	.914	-.391	-.110	.864	.897	-.504
4	.114	.051	.068	**.171**	.162	-.178	-.148	.545	.296	-.308	-.263	.658
5	.313	.107	.098	-.012	**.493**	-.246	-.225	.119	.922	-.308	-.303	.273
6	.026	.386	.380	.034	.075	**.233**	.941	-.236	-.284	.955	.889	-.283
7	.029	.390	.393	.032	.077	.979	**.227**	-.183	-.294	.912	.959	-.284
8	.063	.-044	-.059	.176	.182	-.157	-.160	**.196**	.042	-.415	-.304	.634
9	.296	.060	.090	.016	.384	-.017	.006	.219	**.518**	-.367	-.389	.165
10	.036	.291	.280	.050	.063	.488	.489	-.101	.068	**.174**	.939	-.420
11	.048	.298	.294	.055	.077	.496	.508	-.109	.087	.980	**.178**	-.398
12	.021	-.178	-.186	-.008	.088	-.090	-.081	.320	.378	.041	.054	**.494**

The low, non-significant correlations between body weight and production (fat and protein) are in agreement with those reported by Berry (2002).

Conclusion

These results suggest that, in the Canadian Ayrshire breed, production is genetically and phenotypically uncorrelated with either body weight or body condition score. Body weight showed a higher heritability in second and third parities, as compared to first parity. This suggests that mature cow body weight could be relatively easily altered by direct selection, thereby slowing down the trend of increasing body weight.

References

Bastin, C., Loker, S., Gengler, N., Sewalen, A, and Miglior, F. (2010). *J. Dairy Sci*, 17(3):35–67.

Berry, D. P., Buckley, F., Dillon, P., *et al*. (2002). *J. Dairy Sci.*, 85:2030-2039.

Meyer, K. (2006) In *Proc 8th WCGALP communication 27-14*.

Valacta (2008). www.valacta.com