INCLUSION OF TIME-REGION-AGE-PARITY EFFECT IN THE CANADIAN GENETIC EVALUATION FOR PRODUCTION TRAITS

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INTRODUCTION

Several estimates of genetic trends have been published in the dairy species over the last few years (Bonaiti and Boichard, 1990; Canon and Munoz, 1991; Wiggans and VanRaden, 1991; Banos et al., 1992; Barillet et al., 1992; Bonaiti et al., 1993). Those estimates are assumed to be unbiased because they have been computed using mixed model methodology (Sorenson and Kennedy, 1984; Kennedy et al. 1988). However, Bonaiti et al. (1993) have shown that pre-adjustments for age or parity effect may affect the estimation of genetic trend. Discrepancies between estimates of genetic trend have been recently reported (Banos et al., 1992, 1993).

While a bias in genetic trends has little influence on within-country selection, it may have some effect on across-country evaluations. Countries that wish to participate in the biyearly routine evaluation run by INTERBULL, are responsible for validating their own genetic trends before submitting the national proofs to INTERBULL.

Bonaiti et al. (1994) proposed three methods to validate the estimation of genetic trends in dairy populations. In the first one, proofs derived from a multiple lactation animal model are compared to proofs derived from first lactation only. Estimated genetic trends with both models are expected to yield similar results. In the second method, the within-sire daughter yield deviations are analyzed by daughter birth year and are expected to remain stable. The third method analyses variations of official proofs over time by regression.

The first objective of this research was to validate the genetic trends for production traits in the Canadian Holstein population using the first method, i.e. a comparison of trends based on first lactation evaluation and based on a all lactations evaluation. The second objective was to investigate the effect of inclusion of a time-region-age-parity effect in the current genetic evaluation model. Finally, results from the July run using the new model were compared to the July official run for all breeds, Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey.

MATERIALS AND METHODS

Data from the January '95 run for milk, fat and protein yields were used to validate the genetic trend for the Holstein breed. The current model, that produces the official proofs, includes a herd-year-season-parity fixed effect and the animal and permanent environment random effects. Parity has two levels: first and later lactations. The current model was run on first lactation only. The same data (all lactations and first lactations) were analysed using a new model that included the interaction term time-region-age-parity (**TRAP**):

- Time: 6 levels for milk and fat yield (<1971; 71-75; 76-80; 81-85; 86-90; >1990) and 3 levels for protein yield (<1985; 86-90; >1990).
- Region: 5 levels (Atlantic Canada, Quebec, Ontario, Prairies, British Columbia).
- Age classes within Parity (32 levels) (Table 1).

Table 1. Parities and age classes.

Parity	Class	Age (mo)	Parity	Class	Age (mo)	Parity	Class	Age (mo)
1	1	18-23		12	41-43		23	69-71
	2	24		13	44-49		24	72-77
	3	25	3	14	40-49	5	25	64-77
	4	26		15	50-51		26	78-81
	5	27-28		16	52-53		27	82-85
	6	29-31		17	54-55		28	86-91
	7	32-35		18	56-59	6	29	76-96
2	8	28-36		19	60-63		30	97-110
	9	37	4	20	52-63		31	111-129
	10	38		21	64-65		32	≥ 130
	11	39-40		22	66-68			

Thus, four sets of proofs were computed: all lactations without the TRAP effect (official proofs, ALL WITHOUT); all lactations with the TRAP effect (ALL WITH); first lactations without the TRAP effect (FIRST WITHOUT); first lactations with the TRAP effect (FIRST WITH).

Average of proofs by year of birth were computed for all four data sets. The genetic trends were estimated using PROC GLM with the following models:

$$\mathbf{y_{first} = a_{first} + b_{first}X}$$

$$\mathbf{y_{all} = a_{all} + b_{all}X}$$

where y is the average bull proof by year of birth, weighted by the number of bulls per year, and X is the year of birth of the bull. The differences between the two slopes (b_{all}-b_{first}) is the bias that must be greater than .01*genetic standard deviation to be considered significant (based on INTERBULL guidelines). Three different set of analyses were carried out to estimate the genetic trend, depending on the selection of data: AI proven bulls born after 1980, AI proven bulls born after 1970, and all AI proven bulls. Averages of TRAP solutions were computed for all traits for the Holstein breed.

In a subsequent analysis data from the all lactations July '95 run were used for the Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey breeds. The same two models, as described above, were applied to all lactations data, with few exceptions: the region effect was excluded for the coloured breeds, and time effect had only three levels for the Brown Swiss (<1985; 1986-90; >1990).

RESULTS

Results from the new model were compared to the results from the current model in terms of genetic trends, correlations, and ranking of bulls and cows.

VALIDATION OF GENETIC TREND

Figure 1 shows the genetic trend for the Holstein bulls for milk yield, when the current model was applied to first and all lactations data. Estimates for all traits of the genetic trend, computed by the regression analysis are shown in Table 2 (current model). Figure 2 shows the genetic trend for the Holstein bulls for milk yield, when the new model, including TRAP, was applied to first and all lactations data. Estimates for all traits of the genetic trend, computed by the regression analysis, and relative biases are shown in Table 3 (new model).

Figure 1. Genetic trend for AI Holstein bulls - Milk yield
Current model (January '95)

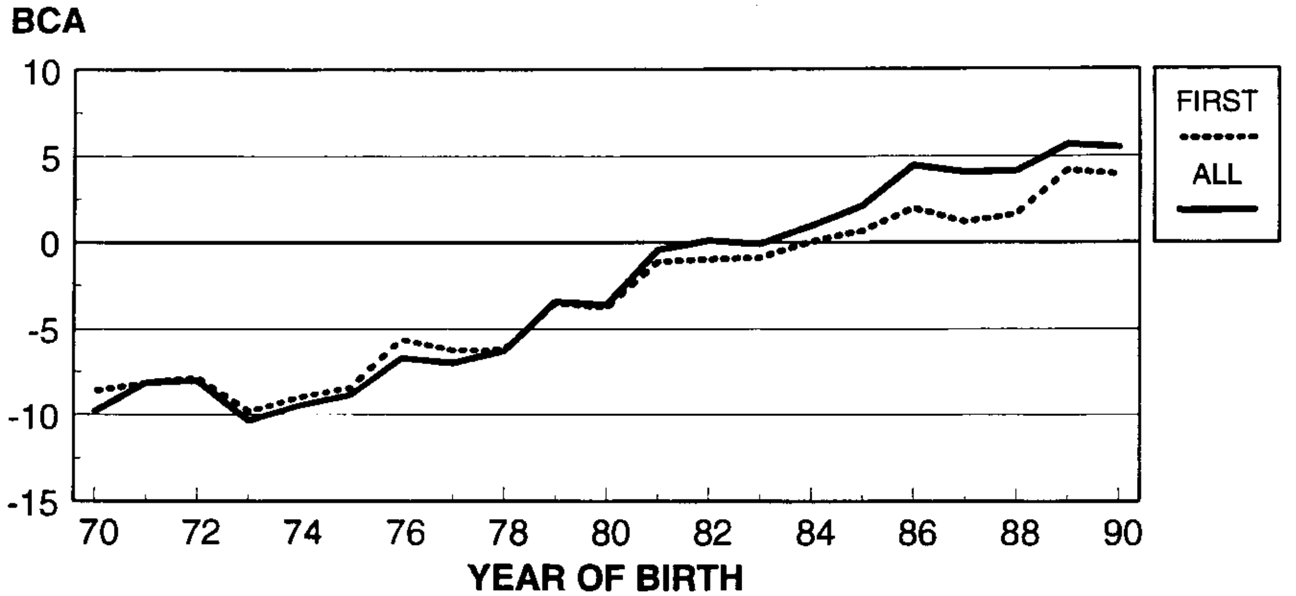


Table 2. **Estimates of genetic trends and biases for milk, fat and protein yield[¥], using first lactation and multiple lactations data sets (current model) - Holstein January 95 proofs.**

	ONLY FIRST LACTATIONS WITHOUT EFFECT	ALL LACTATIONS WITHOUT EFFECT	BIAS ALL–FIRST	GENETIC SD (1%)
MILK				.150
Bulls ≥ 1980	0.667	0.886	.219	
Bulls ≥ 1970	0.739	0.933	.194	
All Bulls	0.548	0.700	.152	
FAT				.154
Bulls ≥ 1980	0.849	1.040	.191	
Bulls ≥ 1970	0.831	0.999	.168	
All Bulls	0.602	0.724	.122	
PROTEIN				.138
Bulls ≥ 1980	0.869	1.068	.199	
Bulls ≥ 1970	0.829	0.965	.136	
All Bulls	0.675	0.771	.096	

[¥] All values expressed in ETA BCA per year

Figure 2. Genetic trend for AI Holstein bulls - Milk yield Model with TRAP (January '95)

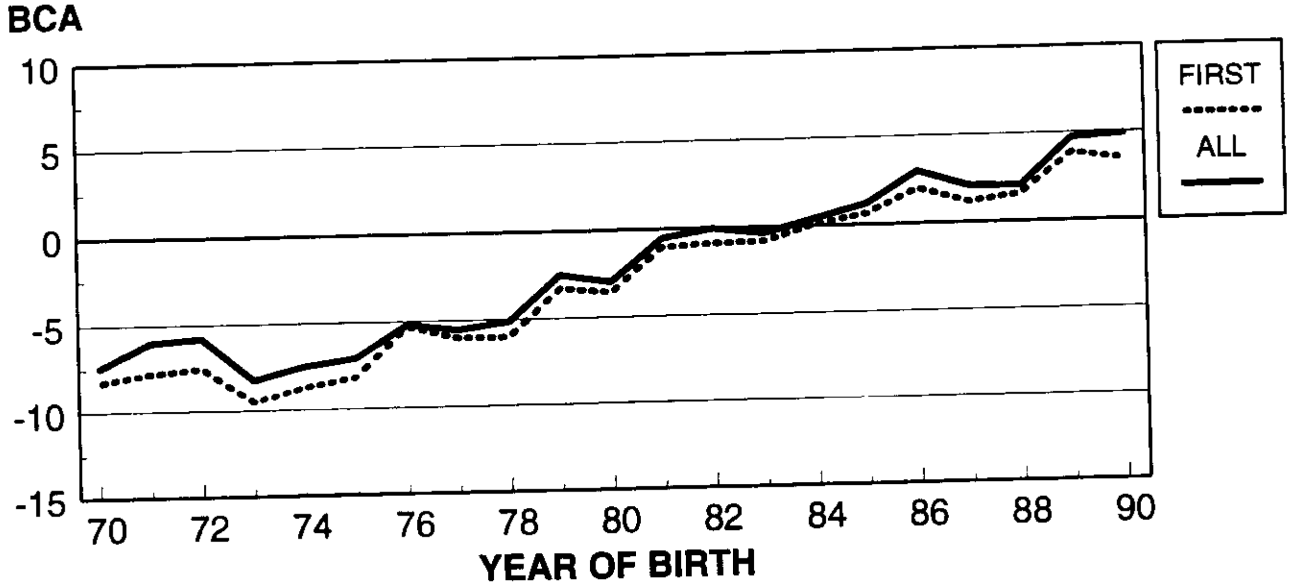


Table 3. **Estimates of genetic trends and biases for milk, fat and protein yield[¥], using first lactation and multiple lactations data sets (new model with TRAP) - Holstein January 95 proofs.**

	ONLY FIRST LACTATIONS WITH EFFECT	ALL LACTATIONS WITH EFFECT	BIAS ALL–FIRST	GENETIC SD (1%)
MILK				.150
Bulls ≥ 1980	0.619	0.651	.032	
Bulls ≥ 1970	0.705	0.684	-.021	
All Bulls	0.301	0.282	-.019	
FAT				.154
Bulls ≥ 1980	0.822	0.835	.013	
Bulls ≥ 1970	0.811	0.768	-.043	
All Bulls	0.328	0.298	-.030	
PROTEIN				.138
Bulls ≥ 1980	0.820	0.804	-.016	
Bulls ≥ 1970	0.793	0.734	-.059	
All Bulls	0.327	0.297	-.030	

[¥] All values expressed in ETA BCA per year

TIME-REGION-AGE-PARITY SOLUTIONS

The new effect (TRAP) had a total of 960 subclasses for milk and fat (6 time periods, 5 regions, 32 age-parity classes), and 480 levels for protein (3 time periods, 5 regions, 32 age-parity classes). Descriptive statistics for the solutions of the TRAP effect are shown in Table 4.

Table 4. Descriptive statistics for the TRAP effect solutions.

Trait	N	Mean	SD	Minimum	Maximum
Milk	960	-.308	1.370	-6.349	4.068
Fat	960	-.344	1.407	-5.186	3.658
Protein	480	-.306	1.583	-6.236	5.070

Figures 4 to 9 show the solutions for TRAP for the Ontario region for milk yield, for the Holstein breed.

Figure 4. TIME-REGION-AGE-PARITY SOLUTIONS < 1971 - ONTARIO - MILK YIELD - HOLSTEIN

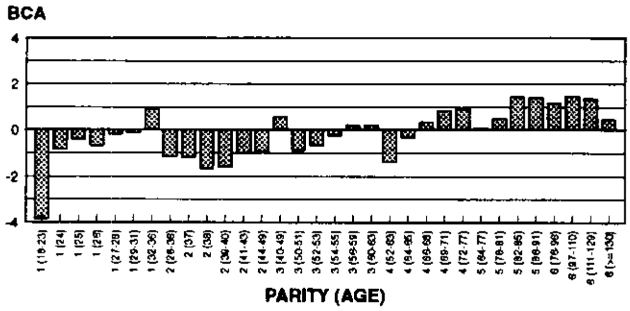


Figure 5. TIME-REGION-AGE-PARITY SOLUTIONS 1971-75 - ONTARIO - MILK YIELD - HOLSTEIN

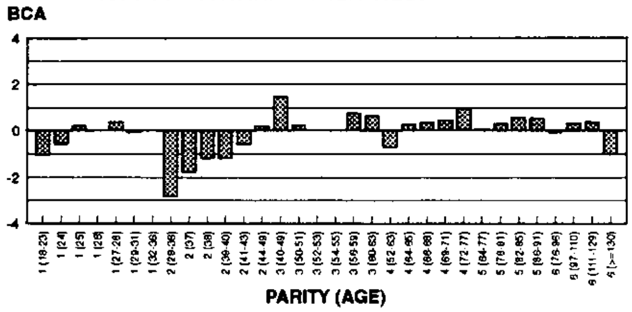


Figure 6. TIME-REGION-AGE-PARITY SOLUTIONS 1976-80 - ONTARIO - MILK YIELD - HOLSTEIN

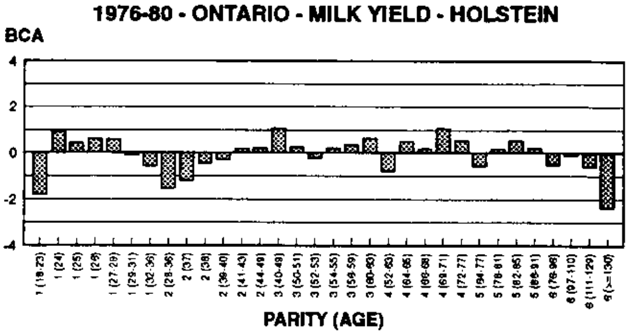


Figure 7. TIME-REGION-AGE-PARITY SOLUTIONS 1981-85 - ONTARIO - MILK YIELD - HOLSTEIN

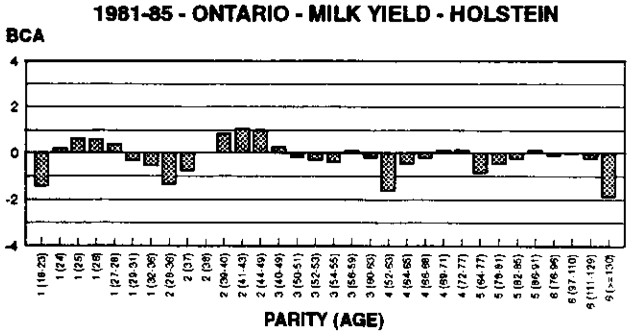


Figure 8. TIME-REGION-AGE-PARITY SOLUTIONS 1986-90 - ONTARIO - MILK YIELD - HOLSTEIN

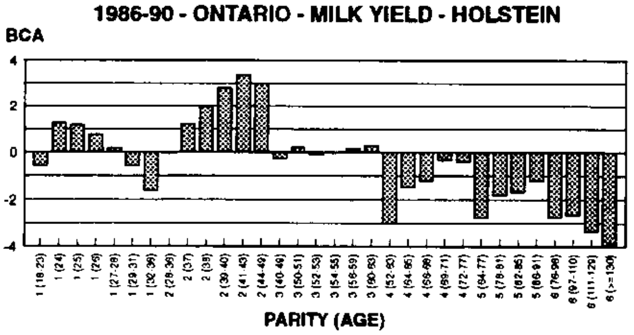
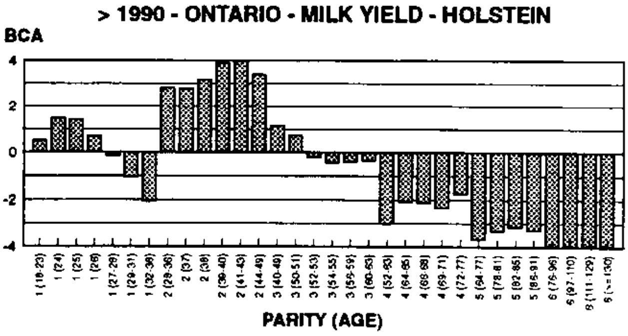


Figure 9. TIME-REGION-AGE-PARITY SOLUTIONS > 1990 - ONTARIO - MILK YIELD - HOLSTEIN



PROOFS (JULY 95 PROOFS)

Descriptive statistics for the AI bull proofs with the new model (TRAP) are compared to the bull proofs from the current model (OFF) in Table 5.

Table 5. Descriptive statistics and correlations for the AI bull proofs, all lactations.

Breed	Trait	Correlation	N	Mean	SD	Minimum	Maximum
Ayrshire	Milk (TRAP)		803	-5.60	6.49	-21.70	18.87
	Milk (OFF)	.92	803	-8.88	9.51	-28.13	21.18
	Fat (TRAP)		803	-5.63	6.58	-26.36	15.84
	Fat (OFF)	.93	803	-8.81	9.63	-30.04	17.71
	Prot (TRAP)		460	-2.78	5.88	-22.26	13.76
	Prot (OFF)	.93	460	-3.34	8.56	-25.61	17.55
Brown Swiss	Milk (TRAP)		99	-1.36	6.31	-19.63	12.99
	Milk (OFF)	.99	99	-1.41	6.41	-20.14	13.27
	Fat (TRAP)		99	-1.25	7.20	-19.82	16.67
	Fat (OFF)	.99	99	-1.38	7.14	-20.16	16.57
	Prot (TRAP)		87	-.54	6.03	-15.12	14.55
	Prot (OFF)	.99	87	-.18	6.28	-15.62	14.93
Guernsey	Milk (TRAP)		311	-6.29	6.25	-18.47	13.76
	Milk (OFF)	.92	311	-11.03	8.79	-26.27	18.63
	Fat (TRAP)		311	-5.17	5.66	-16.99	15.01
	Fat (OFF)	.92	311	-9.24	7.69	-23.57	16.89
	Prot (TRAP)		107	-3.05	7.48	-20.28	14.26
	Prot (OFF)	.93	107	-3.89	10.39	-26.37	20.20
Holstein	Milk (TRAP)		4782	-.81	7.80	-31.33	24.81
	Milk (OFF)	.98	4782	-.69	9.07	-34.39	26.53
	Fat (TRAP)		4782	-1.11	7.94	-31.91	24.15
	Fat (OFF)	.98	4782	-.98	9.15	-34.20	26.66
	Prot (TRAP)		4644	-.88	7.22	-26.93	24.39
	Prot (OFF)	.98	4644	-.72	8.60	-29.56	26.81
Jersey	Milk (TRAP)		543	-5.37	9.92	-26.14	39.22
	Milk (OFF)	.94	543	-8.27	12.68	--29.03	41.47
	Fat (TRAP)		543	-4.86	8.06	-19.72	26.69
	Fat (OFF)	.93	543	-7.60	10.75	-27.18	28.94
	Prot (TRAP)		307	-2.19	10.20	-23.11	29.80
	Prot (OFF)	.98	307	-2.43	12.42	-26.15	33.64

BULL AND COW RANKINGS

Changes in bull and cow rankings between the new model and the current model are shown in Table 6 as percentage of new bulls in the top 100 list, and in Table 7 as percentage of new cows in the top 200 list, for Ayrshire, Brown Swiss, Guernsey and Jersey, and top 400 list for the Holstein breed. Table 8 also shows changes in ranking for the cows when the rank was done according to the current model.

Table 6. Percentage of new bulls in the top 100 list using the new model (top 50 for milk, fat and protein for Brown Swiss and for protein for Guernsey).

	Milk	Fat	Protein
Ayrshire	21%	18%	18%
Brown Swiss	2%	2%	2%
Guernsey	19%	16%	22%
Holstein	14%	11%	11%
Jersey	11%	9%	6%

Table 7. Percentage of new cows in the top 200 list using the new model (top 400 for Holstein).

	Milk	Fat	Protein
Ayrshire	14.5%	16.5%	24.5%
Brown Swiss	1.5%	3%	3.5%
Guernsey	12.5%	14.5%	14%
Holstein	11.75%	13.75%	7.75%
Jersey	7%	11%	7%

Table 8. Top 100 cows after inclusion of TRAP (top 200 for Holstein).

Breed		Milk	Fat	Protein
Ayrshire	Top 100	84	80	80
	Next 100	13	13	12
	Not in top 200	3	7	8
Brown Swiss	Top 100	99	99	94
	Next 100	1	1	6
	Not in top 200	0	0	0
Guernsey	Top 100	85	84	82
	Next 100	14	15	18
	Not in top 200	1	1	0
Holstein	Top 200	179	175	182
	Next 200	19	25	17
	Not in top 400	2	0	1
Jersey	Top 100	93	91	92
	Next 100	7	9	8
	Not in top 200	0	0	0

DISCUSSION

Overestimation of the genetic trend with the current repeatability model was low, when more recent bulls were included in the analysis, and within 1% of the genetic standard deviation when all bulls were considered. The bias observed may result from the fact that BCA factors do not take into account parity and year, and the interaction of these effects with age. One way of addressing this problem is to modify the animal model to include a new effect: parity, age class, time, region and their interactions. Another way would be to change the current BCA factors to account for these new effects. In practice, both approaches can be used simultaneously, with the new factors in the model accounting for any residual effects after standardization of raw records to BCA. In the present study, the inclusion of the time-region-age-parity effect in the model without changing the current BCA factors was successful to account for the small differences in estimated genetic trends between the all lactations and the first lactation run. Furthermore, after the inclusion of TRAP in the model the slope of the estimated genetic trend computed was parallel to the trends computed on first lactation only, thus correcting the slight overestimation for all traits.

When TRAP solutions were plotted, a clear effect of time was detectable: in the first two periods (<1970-1975) younger animal were underestimated and older animal were overestimated, whereas in the last two periods (>1985) younger animal were overestimated and older animal were underestimated, no pattern was present in the other two intermediate periods (1976-1985). Differences among second, third and later lactations were evident over time. In the current model parity effect has only two levels, first and later lactations. Finally differences among age classes within parity were significant. Differences among regions, although not presented in this paper, were detectable. Only results of TRAP solutions for the Holstein study were shown in this investigation. The region effect was excluded when the other breeds were analysed, thus leaving an interaction term of time-age-parity. This effect was negligible for the Brown Swiss, with a larger effect on the Ayrshire, Guernsey and Jersey.

The effect of TRAP reduced the standard deviations of the proofs of AI bulls, in comparison with the standard deviations of the same bulls computed with the current model. The reduction was most evident in the Ayrshire (31-32% reduction), and Guernsey breed (26-29%); smaller in the Jersey (18-25%) and Holstein breed (13-16%); and negligible in the Brown Swiss (1-4%). The same pattern was found for the correlations between the two sets of proofs: very high for the Brown Swiss (.99), moderately high for the Holstein (.98) and Jersey (.94-.98) and relatively lower for the Ayrshire (.92-.93) and Guernsey (.92-.92).

Reranking of bulls and cows varied across breeds, and within breeds among traits. Again the Ayrshire showed the highest degree of reranking, followed by the Guernsey, Holstein and Jersey. Reranking was not observed for the Brown Swiss. Surprisingly Holstein showed more changes in the rankings than the Jersey. Overall the Brown Swiss breed was not affected by the inclusion of the new variable in the model, probably due to a lack of historical data for the breed.

CONCLUSIONS

The genetic trend of Canadian Holstein AI bulls was validated comparing bull proofs derived from a repeatability model to bull proofs derived from first lactation only. Overall, the biases, expressed as differences between the two estimated genetic trends, were low. The subsequent inclusion in the current model of a new effect, time-region-age-parity interaction, accounted for the small biases. Magnitudes of the effect of this new variable varied among breeds, and within breeds among traits.
Plans have been made to include the new effect in the Canadian genetic evaluations for all breeds.

REFERENCES

- Banos, G., G. R. Wiggans, and J. A. B. Robinson. 1992. Comparison of methods to rank bulls across countries. J. Dairy Sci. 75:2560-2568.

- Banos, G., B. Bonaiti, M. Carabano, J. Claus, P. Leroy, P. Rozzi, J. Philipsson, G. Swanson, and J. Wilmink. 1993. Report of a joint research project between INTERBULL and COPA/COGECA on the feasibility of a simultaneous genetic evaluation of Black and White dairy bulls across the European Community countries. Interbull Bull. 9.
- Barillet, F., D. Boichard, A. Barbat, J. M. Astruc, B. Bonaiti. 1992. Use of animal model for genetic evaluation of the Lacaune dairy sheep. Livest. Prod. Sci. 31:287-299.
- Bonaiti, B., and D. Boichard. 1990. Benefits from animal model evaluation of dairy cattle in France. Proc. 4th World Congr. Genet. Appl. Livest. Prod., Edinburgh, Scotland. 13:364-373.
- Bonaiti, B., D. Boichard, A. Barbat, and S. Mattalia. 1993. Problems arising with genetic trend estimation in dairy cattle. Interbull Bull. 9.
- Bonaiti, B., D. Boichard, A. Barbat, and S. Mattalia. 1994. Three methods to validate the estimation of genetic trend in dairy cattle. Interbull Bull. 10.
- Canon, J., and A. Munoz. 1991. Genetic trend for milk production in Spanish Holstein population. J. Anim. Breed. Genet. 108:41-47.
- Kennedy, B. W., L. R. Schaeffer, and D. A. Sorensen. 1988. Genetic properties of animal models. J. Dairy Sci. 71(Suppl. 2):17-26.
- Sorensen, D. A., and B. W. Kennedy. 1984. Estimation of response to selection using least squares and mixed model methodology. J. Anim. Sci. 58:1097-1106.
- Wiggans, G. R., and P. M. VanRaden. 1991. Methods and effect of adjustments for heterogeneous variance. J. Dairy Sci. 74:4350-4357.