Validation of interim Breeding Values as predictors of National Estimated Breeding Values for beef cattle in South Africa

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Abstract

The computation costs required to solve the equations for an individual animal mixed model can be considerable. More frequent evaluations would benefit producers, allowing them to make breeding and management decisions earlier. A procedure was evaluated to obtain approximate estimates of bull breeding values as soon as new information becomes available. Rank correlations obtained between Interim Breeding Values (IBV) and Estimated Breeding Values rank from 0.85 to 0.98 for ADG and 0.92 to 0.99, 0.57 to 0.98, 0.87 to 0.94 and 0.81 to 0.87 for SCR, SHD, KLB and FCR, respectively. These rank correlations indicate that the Interim Breeding Values are good predictors of the corresponding Estimated Breeding Values estimated in the national BLUP evaluation. Application of this procedure for bull evaluation may help the beef producer to make timely accurate decisions about bull selection on grounds of there breeding values predictions, as records become available between two consecutive evaluations. It, therefore, justifies the implementation of IBVs for the beef industry of South Africa on the grounds that it is cost effective (using less computing resources), timely, accurate and easy to relate to existing evaluations.

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Introduction

The animal model has become the method of choice for the genetic evaluation of livestock for economically important traits (Wiggans *et al.,* 1988). Although the animal model has many desirable properties (Kennedy *et al*., 1988), the computational costs and time required for routine genetic evaluations might be considerable (Weller *et al.,* 1994). More frequent evaluations would benefit producers, allowing them to make breeding and management decisions in real time.

This is also relevant in South Africa. Under the auspices of the National Beef Cattle Improvement Scheme (NBCIS) numerous growth, reproduction, feed efficiency and body measurement traits are recorded. A national genetic evaluation for beef breeds participating in the NBCIS is done annually. Estimated Breeding Values (EBVs) for data from growth test that end after the national analysis are, therefore, only available the following year. Thus, many animals, especially breeding bulls, are selected before their EBVs are available. A continuous evaluation scheme, in which solutions are updated as new records become available, would address this problem and would increase genetic progress of beef cattle by decreasing the generation interval (Misztal *et al.,* 1991). Various methods have been suggested for addition of new information without iteration on the complete data file (Weller *et al*., 1994).

Sallas & Harville (1981) suggested a recursive prediction methodology for mixed models, and Martinez & Rothschild (1983) applied it to sire evaluation, including relationships amongst sires across periods. With recursive estimation, information from the current period is combined with information from previous periods. This method is not practical for large data files because it requires inversions of the coefficient matrix of the mixed model equations (Martinez & Rothschild, 1983). Jamrozik & Schaffer (1991) compared three different methods to update animal genetic evaluations, but none was satisfactory.

Wilson & Willham (1988) used a procedure where the contemporary group fixed effects of measured young animals are estimated by adjusting these records for the predicted breeding values of parents obtained from the last national cattle evaluation, if available, and then by obtaining a weighted average of adjusted records. The difference between the performance record of an animal and the contemporary group estimate was used to obtain a prediction of effect due to the Mendelian sampling for that animal. Interim expected progeny differences were computed as half the sum of the expected progeny differences of sire and dam for each trait of interest plus half the effect due to the Mendelian sampling of the animal. This method is base on the same principles as the method discussed in the Beef Improvement Federation Guidelines for Uniform Beef Improvement Programs (1996).

The aim of this study was to evaluate an updating procedure that allows immediate estimation of calf interim breeding values (IBV) as new information becomes available in the period between analyses of the population.

Materials and Methods

Data from the Afrikaner, Bonsmara, Brangus, Drakensberger, Hereford, S.A. Angus, Santa Gertrudis and Sussex beef breeds, participating in an on-farm or in a central growth test of the NBCIS between 1990 and 2000 were used in this study to evaluate a method to calculate IBVs for average daily gain (ADG), scrotum circumference (SCR), shoulder height (SHD), Kleiber ratio (KLB) and feed conversion ratio (FCR).

After weaning selected bull calves participate in either an on-farm (Phase D) growth test or in a centralized (Phase C) growth test. Traits measured in both Phases are ADG, SCR and SHD while FCR are measured in Phase C and KLB in Phase D test.

The method used to calculate IBVs in this study, was based on the procedure that is used by the Beef Improvement Federation and has been discussed in the Beef Improvement Federation Guidelines for Uniform Beef Improvement Programs (1996).

The procedure to calculate IBVs is as follows:

The first step is to adjust each record for all covariates included in the national evaluation model for a specific breed as well as correcting the measurement for the influence of both parents' EBVs. The same model that has been used in the national evaluation must be used in the calculation of IBVs for trait and breed. The age of the animal at the end of the test and the age of the dam were included as linear and quadratic covariates in the national analyses for the Afrikaner, Hereford, Sussex and S.A. Angus breeds. For the Drakensberger and Bonsmara breeds only the animal's age at the end of the test was included as a linear covariate. Table 1 is a summary of the models used in the national analysis for each breed and trait.

Because of the little influence that the dam has on ADG, SCR, SHD, KLB and FCR at the end of the growth test, the maternal effect on these traits was ignored.

Therefore, for the Afrikaner, Hereford, SA Angus and Sussex breeds, the adjustments were:

$$y^* = \text{measurement} - ((b_1 * age)+(b_2 * age^2)+(b_3 * damage)+(b_4 * damage^2)) - (½\, EBV_{sire} + ½\, EBV_{dam})$$

where y^* = Adjusted measurement
b_1, b_2, b_3 and b_4 are the regression factor of each covariate on trait y, unique for each trait and breed,
age = age of the animal at the end of the test
damage = age of the dam of the animal
EBV_{sire} = Best Linear Unbiased Prediction of the breeding value of the sire and
EBV_{dam} = Best Linear Unbiased Prediction of the breeding value of the dam.

The second step was to compute the contemporary fixed effect (|):

$$| = \frac{\sum_i((1/r_i)(y^*_i))}{\sum_i (1/r_i)}$$

where: $r_i = \sigma^2_e$ when both parents are known
$r_i = ¼\, \sigma^2_a + \sigma^2_e$ when one parent is known
$r_i = ½\, \sigma^2_a + \sigma^2_e$ when both parents are unknown

and:

σ^2_a = additive genetic variance obtained from the last national genetic evaluation of $breed_i$
σ^2_e = residual variance obtained from the last national genetic evaluation of $breed_i$

The value of | will be unique for each contemporary group.

Table 1 Models used in the national analysis

Breed	Trait	Age	Age^2	Dam Age	Dam Age^2	Initial Weight	Test End Weight	Contemporary Group
Afrikaner	ADG	X	X	X	X			X
	SCR	X	X	X	X			X
	SHD	X	X	X	X			X
	KLB	X	X	X	X			X
	FCR	X	X	X	X			X
SA Angus	ADG	X	X	X	X			X
	SCR	X	X	X	X			X
	SHD	X	X	X	X			X
	KLB	X	X	X	X			X
	FCR	X	X	X	X			X
Bonsmara	ADG	X						X
	SCR	X						X
	SHD	X						X
	KLB	X						X
	FCR	X						X
Brangus	ADG	X		X				X
	SCR						X	X
	KLB	X		X		X		X
Drakensberger	ADG	X						X
	SCR	X						X
	SHD	X						X
	KLB	X						X
	FCR	X						X
Hereford	ADG	X	X	X	X			X
	SCR	X	X	X	X			X
	SHD	X	X	X	X			X
	KLB	X	X	X	X			X
Santa	ADG	X						X
	SCR	X					X	X
	SHD						X	X
	KLB	X		X				X
Sussex	ADG	X	X	X	X			X
	SCR	X	X	X	X			X
	SHD	X	X	X	X			X
	KLB	X	X	X	X			X

The third step was to compute the Mendelian Sampling Effect for each animal:

$$\phi_i = \frac{\sigma^2_a}{\sigma^2_a + 2r_i} \times (y^*_i - |)$$

The fourth and last step was to compute the IBV for each trait and animal as follows:

$$IBV_i = ½EBV_{sire} + ½EBV_{dam} + \phi_i$$

IF parent(s)' EBV(s) are unknown, the parent(s)' EBV(s) were replaced by the average EBV of the parent(s)' birth year group.
IF parent(s) are unknown, the EBV(s)' of parent(s) were replaced by the average of the base population.

IBVs were estimated for ADG, SCR, SHD, KLB and FCR and were compared to their corresponding EBVs obtained from the national BLUP analysis. Genetic components as well as the b-values used to estimate the IBVs were the same as the values used in the compared national BLUP analysis. Spearman rank correlations were obtained for each breed and trait, using the SAS package (1996).

Results and Discussion

Table 2 presents the general statistics of EBVs and IBVs for each breed and trait. Comparisons between breeds cannot be made due to differences in models, base years and (co) variance structures used in the analyses.

In general, the EBVs and IBVs were similar. The greatest difference between the maximum EBV and the maximum IBV (144.68 kg) was for ADG of the SA Angus breed (phase D). The minimum IBV and EBV for ADG only differed with 40,582 g, while the mean differed with 1.159 g and the standard deviation differed with 8.481 g. Therefore, because of the similarity of the means and the difference in the standard deviations between the EBVs and IBVs for this trait, the differences in the minimum and maximum values are marginal. The differences between the IBVs and EBVs for the ratio traits are greater than for the other traits probably due to two traits a being involved in a ratio trait with different variances contributing to its expression. For example, the maximum IBV (1.282) for the Santa Gertrudis KLB ratio was almost half of that of the corresponding EBV (2.043). Once again it can be explained by the mean EBV and IBV being basically the same (-0.023 *vs*. –0.024), but the standard deviation of 288.050 for the IBVs being much less than the standard deviation of the corresponding EBVs of 370.467.

Table 3 presents the Spearman Correlations (rank correlation) between the EBVs and IBVs for the different traits and breeds. Table 3 shows that although the EBVs and IBVs may differ in values, the ranking of the animals in their contemporary groups will remain basically the same.

The lowest rank correlation for ADG was 85% for the Sussex breed. Correlations for the other breeds were 90% and higher. The highest rank correlation for ADG was 98% for the Santa Gertrudis breed.

The average rank correlations between the EBVs and IBVs or SCR were the highest of all traits, ranking from 92% for SA Angus (Phase C) to 99% for the Afrikaner and Bonsmara (Phase D) breeds (Table 3). The rank correlations between the IBVs and EBVs for SHD were 85% for the SA Angus (Phase C), 92-95% for the Santa Gertrudis (Phase D), Afrikaner (Phase C) and Drakensberger (Phase C) and 96-98% for the Afrikaner (Phase D), Bonsmara (Phase D), Drakensberger (Phase D), Hereford (Phase D) and SA Angus (Phase D) breeds. The rank correlation between the EBVs and IBVs for SHD for the Sussex (57%) breed was unexplainably low and requires further investigation.

The rank correlations for KLB and FCR were generally lower than those for the other traits. This can be explained by these traits being ratios, involving two traits that have to be measured accurately with different variances involved. The lowest correlation of 87% for KLB was for the Hereford (Phase D) breed followed by the Sussex (Phase D) and Brangus (Phase D) breeds while the lowest correlation of 81% for FCR was for the Drakensberger (Phase C) breed. The highest correlations for KLB and FCR were those of the SA Angus Phase D (94%) and Afrikaner Phase C (87%) breeds, respectively.

Except for the correlations between the EBVs and IBVs for SHD of the Sussex breed, IBVs predict EBVs accurately and should therefore be a good indication of the EBVs in the following national evaluation.

Rank correlations obtained in this study between EBVs and IBVs were in agreement to Wilson & Willham's (1988) study where they reported rank correlations between interim expected progeny differences (IEPD) and expected progeny differences (EPD) of 0.93, 0.93 and 0.96 for birth weight, weaning weight and yearling weight, respectively, where the sire's and dam's EPDs from the previous national analysis were known. Wilson & Willham (1988) finds a decrease in the rank correlation when the EPDs of the dam or sires or both were unknown. In attempting to minimize this problem in this study, a mean EBV was given to a dam or sire if their EBVs were unknown but the dam or sire was known. This mean EBV was the mean EBV of all the animals born in the same year as the dam or sire. When the dam or sire was totally unknown, the mean EBV of the base animals for that trait was just as the dam or sire's EBV. Although different traits were under investigation the methods of calculating IBVs and IEPDs was based on the same principles. Wilson & Willham (1988) have also reported and increase in the rank correlation with an increase in contemporary group size up to 20.

The rank correlation between IBVs and EBVs will therefore increase if the EBV of both sire and dam are available from the previous national BLUP analysis, if the animal is reared in 'n bigger contemporary group in which the majority of sires and dams of progeny in the contemporary group have EBVs from the

Table 2 General Statistics: EBV vs. IBV

	Trait	Phase C N	Phase C Mean	Phase C Min.	Phase C Max.	Phase D N	Phase D Mean	Phase D Min.	Phase D Max.
Afrikaner									
EBV	ADG	474	24.926 ± 62.223	-157.931	219.769	4734	24.601 ± 31.606	-108.616	163.184
IBV		474	13.749 ± 53.462	-155.231	199.795	4734	21.896 ± 32.940	-106.649	166.444
EBV	SCR	474	0.240 ± 11.562	-42.115	54.392	4734	4.957 ± 8.434	-28.072	39.855
IBV		474	0.087 ± 11.815	-44.266	54.880	4734	4.619 ± 8.345	-29.262	38.950
EBV	SHD	474	5.145 ± 13.465	-46.339	46.137	4734	8.505 ± 10.762	-27.552	50.378
IBV		474	2.647 ± 13.137	-58.258	43.836	4734	7.495 ± 10.596	-26.787	46.420
EBV	FCR/KLB	474	-0.009 ± 0.270	-0.772	0.968	4734	0.069 ± 0.276	-1.230	1.153
IBV		474	0.006 ± 0.151	-0.507	0.415	4734	0.068 ± 0.285	-1.256	1.197
SA Angus									
EBV	ADG	472	81.412 ± 87.297	-182.367	442.833	2728	27.148 ± 65.273	-181.569	427.231
IBV		472	73.780 ± 90.637	-226.965	331.291	2728	26.009 ± 56.792	-140.987	282.551
EBV	SCR	472	9.157 ± 16.595	-35.708	118.015	2728	7.945 ± 11.896	-48.326	62.510
IBV		472	8.526 ± 17.199	-45.189	115.382	2728	7.607 ± 11.590	-48.443	56.729
EBV	SHD	472	16.253 ± 27.716	-240.999	72.216	2728	12.266 ± 20.167	-58.956	98.842
IBV		472	14.996 ± 25.068	-177.719	73.732	2728	11.468 ± 19.651	-49.811	97.159
EBV	FCR/KLB	472	-0.110 ± 0.209	-1.011	0.688	2728	0.025 ± 0.348	-1.397	1.317
IBV		472	-0.099 ± 0.117	-0.815	0.243	2728	0.027 ± 0.347	-1.097	1.302
Bonsmara									
EBV	ADG	4016	45.034 ± 55.155	-137.640	262.570	41751	33.592 ± 53.105	-161.830	306.970
IBV		4016	40.272 ± 54.530	-151.653	270.998	41751	30.588 ± 53.162	-181.552	330.049
EBV	SCR	4016	3.842 ± 9.622	-31.777	43.828	41747	3.391 ± 10.202	-58.725	46.760
IBV		4016	2.857 ± 9.376	-33.236	43.117	41747	2.703 ± 10.006	-57.805	45.049
EBV	SHD	4015	6.835 ± 13.173	-40.410	67.330	41751	3.359 ± 13.977	-78.440	89.620
IBV		4015	4.829 ± 13.725	-40.820	67.091	41751	2.010 ± 13.569	-72.641	86.262
EBV	FCR/KLB	4016	-0.022 ± 0.173	-0.772	0.808	41751	0.141 ± 0.329	-1.498	2.235
IBV		4016	-0.034 ± 0.108	-0.382	0.553	41751	0.144 ± 0.234	-0.817	1.231
Brangus									
EBV	ADG					673	-4.851 ± 47.680	-200.790	151.530
IBV						673	-4.633 ± 43.864	-168.602	126.742
EBV	SCR					673	1.808 ± 11.993	-49.036	37.034
IBV						673	1.804 ± 12.012	-48.385	36.208
EBV	FCR/KLB					673	-0.046 ± 0.412	-1.782	1.334
IBV						673	-0.044 ± 0.405	-1.415	1.287
Drakensberger									
EBV	ADG	352	7.911 ± 37.159	-94.330	120.770	5794	8.863 ± 34.072	-136.950	151.360
IBV		352	5.798 ± 37.529	-87.194	135.019	5794	8.145 ± 35.186	-143.536	155.317
EBV	SCR	352	3.684 ± 8.419	-20.963	36.333	5794	2.316 ± 9.714	-47.581	43.946
IBV		352	2.547 ± 7.968	-21.157	35.489	5794	1.997 ± 9.699	-49.196	42.829
EBV	SHD	352	5.115 ± 10.031	-27.673	38.391	5794	2.661 ± 11.306	-45.835	45.379
IBV		352	2.997 ± 9.242	-31.161	33.886	5794	2.051 ± 10.973	-41.340	45.882
EBV	FCR/KLB	352	0.050 ± 0.239	-0.901	0.813	5794	0.006 ± 0.239	-1.749	1.007
IBV		352	0.053 ± 0.126	-0.411	0.335	5794	0.013 ± 0.170	-0.656	0.608
Hereford									
EBV	ADG					955	41.661 ± 45.962	-113.024	191.976
IBV						955	39.775 ± 59.927	-207.728	221.269
EBV	SCR					955	6.400 ± 10.734	-37.299	48.035
IBV						955	5.895 ± 10.311	-38.017	43.954
EBV	SHD					955	19.869 ± 19.322	-57.907	158.301
IBV						955	18.784 ± 26.664	-105.489	163.711
EBV	FCR/KLB					955	0.059 ± 0.326	-1.193	1.209
IBV						955	0.062 ± 0.329	-1.156	0.977
Santa Gertrudis									
EBV	ADG					3162	13.616 ± 51.896	-160.892	310.938
IBV						3162	12.141 ± 50.798	-162.088	238.155
EBV	SCR					3162	0.279 ± 11.399	-40.128	38.706
IBV						3162	0.312 ± 11.427	-40.893	39.748
EBV	SHD					3162	3.702 ± 10.017	-42.949	41.645
IBV						3162	3.431 ± 10.294	-36.415	37.876
EBV	FCR/KLB					3162	-0.023 ± 0.370	-1.353	2.043
IBV						3162	-0.024 ± 0.288	-1.043	1.282
Sussex									
EBV	ADG					3968	16.281 ± 60.852	-227.164	286.036
IBV						3968	14.886 ± 48.298	-181.543	241.851
EBV	SCR					3968	0.968 ± 11.399	-57.833	62.583
IBV						3968	0.528 ± 11.352	-60.023	69.769
EBV	SHD					3968	4.909 ± 12.191	-40.676	89.230
IBV						3968	4.265 ± 20.824	-77.490	91.802
EBV	FCR/KLB					3968	0.010 ± 0.321	-1.365	1.360
IBV						3968	0.019 ± 0.223	-0.785	0.918

previous national BLUP analysis and if the next national BLUP evaluation procedures do not change. This was in agreement to Wilson & Willham (1988) study.

Table 3 Spearman Correlations between IBVs and EBVs for different traits and breeds

Breed (Phase)	ADG	SCR	SHD	KLB	FCR
Afrikaner (C)	0.90	0.94	0.93	-	0.87
Afrikaner (D)	0.93	0.99	0.96	0.93	-
Bonsmara (C)	0.97	0.97	0.96	-	0.86
Bonsmara (D)	0.96	0.99	0.98	0.89	-
Brangus (D)	0.94	0.95	-	0.88	-
Drakensberger (C)	0.97	0.95	0.95	-	0.81
Drakensberger (D)	0.94	0.96	0.96	0.90	-
Hereford (D)	0.96	0.97	0.97	0.87	-
SA Angus (C)	0.91	0.92	0.85	-	0.84
SA Angus (D)	0.90	0.97	0.98	0.94	-
Santa Gertrudis (D)	0.98	0.94	0.92	0.91	-
Sussex (D)	0.85	0.98	0.57	0.88	-

Conclusion

In general, IBVs were highly correlated with EBVs, obtained from the complete national genetic analysis for each breed and trait. This procedure is easy to apply and costs involved are low. Application of this procedure for bull evaluation may help the beef producer to make timely accurate decisions about bull selection on grounds of their breeding value predictions, as records become available between two consecutive evaluations. It therefore justifies the implementation of IBVs for the beef industry of South Africa on the grounds that it is cost effective (using less computing resources), timely, accurate and easy to relate to existing evaluations.

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