Comparison Between Genetic Parameters For Birth Weight Of Egyptian Buffaloes Estimated By Random Regression And Multi-Trait Models

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Introduction

Calf birth weight information is used as an indicator trait for calving ease in animal selection to minimize the risk of dystocia. Although genetic evaluation of this trait has been extensively studied among various cattle breeds, little is known about its genetic aspects in water buffalo (Barbosa, et al. 2006). Calf birth weight can be considered as a longitudinal trait of the dam. The conventional approach for the genetic evaluation of this trait has been to use multi-trait models (MTM) that treat birth weights recorded at different ages of the cow as different traits. However, it is a trait that lends itself to analysis using a random regression model (RRM), due to its longitudinal nature. Therefore, the objectives of this study were to estimate heritability and permanent environmental portion of birth weight, as a trait of the dam, in a herd of Egyptian buffalo, using RRM and MTM and to compare the results obtained.

Materials and methods

Data: Calf birth weight records representing the first ten lactations of 2139 Egyptian buffaloes were collected during the period from 1973 to 2002 from a herd belonging to the Animal Production Research Institute (APRI), the Ministry of Agriculture, Egypt. After edits, 7875 records on 2139 cows, offspring of 728 sires and 1370 dams were used for the analysis. Data were classified according to cow, sire, dam, year-season of calving (contemporary group, CG), sex of calf and parity. Year was divided into 4 seasons, *viz.* Winter, Spring, Summer and Autumn. Records were distributed over 10 parities and 120 CG.

Statistical analysis: A multiple trait model (MTM), considering calf birth weights in each parity as separate traits, was carried out. The model included dam's direct and permanent environmental effects. Fixed effects for multiple trait analysis were as for RR analysis. Covariance functions (CF) have been proposed as an alternative to deal with trajectory or longitudinal data (Meyer & Hill 1997). The RRM for records over time was:

$$y_{ij} = F + \sum_{m=0}^{n-1} b_m \emptyset_m(p_{ij}) + \sum_{m=0}^{n-1} \alpha_{im} \emptyset_m(p_{ij}) + \sum_{m=0}^{n-1} \gamma_{im} \emptyset_m(p_{ij}) + \varepsilon_{ij}$$

Where y_{ij} is the jth birth weight record of the ith cow, F is the fixed effects of CG and sex of calf, $\emptyset_m(p_{ij})$ are the covariates as a function of parity with p_{ij}, the jth parity of cow i standardized to the range of -1 to +1, and with $\emptyset_m$ the mth orthogonal Legendre polynomial for the nth order of fit, b_m is the mth fixed regression coefficients, α_{im} and γ_{im} are the mth additive and permanent environmental random regression coefficients for cow i, n is the order of fit (n=3) and ε_{ij} is the measurement error

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that was assumed to be independently distributed with heterogeneous variance for each parity. The matrices K_G and K_P, corresponding to the additive genetic and permanent environmental covariance functions (G and P) were estimated for the corresponding random regression coefficients. MTM and RRM Analyses were carried out using WOMBAT package (Meyer, 2006).

Results and discussion

Number of records, means and their standard deviations are presented in Table 1. Calf birth weight increased from the first parity (27.68) up to the sixth (36.03), and decreased slightly thereafter. The highest mean observed in parity six coincided with the lowest standard deviation, while the highest standard deviation was observed in parity 10.

Table 1: Number of cows, means and standard deviations (SD) per parity

Parity	Number of records	Mean±SD
1	1875	27.68±6.42
2	1496	31.49±6.53
3	1159	33.88±6.33
4	914	35.53±6.45
5	738	36.03±6.20
6	586	36.53±5.69
7	457	36.13±6.54
8	315	36.24±6.15
9	200	36.12±6.90
10	135	36.34±7.17

The covariance function: The estimated CF, the correlation between the coefficients and the corresponding eigenvalues with their contribution to the total variation of additive genetic and permanent environmental effects are listed in Table 2. Constant genetic effect showed moderately positive correlation with the linear regression (0.60), while its correlation with the permanent environmental effect was negative and low (-0.16). The correlations between the constant term and the quadratic term of each of the genetic and permanent environmental effects were positive and low. The correlations between the linear and the quadratic terms of the genetic and the permanent environmental effects were similar in magnitude with opposite sign, being negative in the former. The eignefunctions and eigenvalues contain information about understanding the potential of genetic improvement of calf birth weight. The eigenfunctions of the additive genetic effect are illustrated in Figure 1. The first eigenfunction increased steadily from the first parity up to the end. As the first eigenfunction has the largest eigenvalue attached to it, selection of heifers with heavier calf birth weight may increase birth weight of their calves in later parities. Selection on the second eigenfunction would result in a similar pattern to that of the first, but the magnitude of genetic change would be lower, as the amount of genetic variation associated with it is smaller than the genetic variation associated with the first eigenfunction. The third eigenfunction decreased up to the fifth parity, then leveled off thereafter. Its value was higher than that of the second eigenfunction up to the third parity. The first eigenvalue explained 91.39 and 59.42% of the total genetic and permanent environmental variances, while the second explained 8.61 and 34.6%, respectively (Table 2). The third eigenvalue did not contribute to the total genetic variance, while its contribution to the total permanent environmental variance was 5.95%. These results suggest that third-order polynomial was not needed for the genetic effect, while it was in the case of the permanent environmental effect. Kirkpatrick et al. (1990) stated that the eigenvalue is proportional to the amount of genetic variation in the population corresponding to the attached eigenfunction. They further added that eigenfunction with small eigenvalue represent deformation for which there is little genetic variation. Comparative literature information on RR analysis applied to calf birth weight, as a trait of the dam, was not found.

However, the results of this study suggest that there is scope to alter calf birth weight patterns genetically through dam selection.

Table 2: Estimated coefficient matrices of the covariance function, the corresponding eigenvalues with their contribution (%) to the total variation and the correlation between them (above diagonal) for additive genetic and animal permanent environment effects.

Effect	Coefficient			Eigenvalue	%
	0	1	2		
Additive genetics					
0	12.66	0.60	0.15	13.15	91.39
1	2.39	1.27	-0.70	1.24	8.61
2	0.37	-0.70	0.46	0.00	0.00
Permanent Environmental					
0	3.13	-0.16	0.14	5.58	59.42
1	-0.60	4.13	0.74	3.25	34.63
2	0.37	2.19	2.12	0.56	5.95

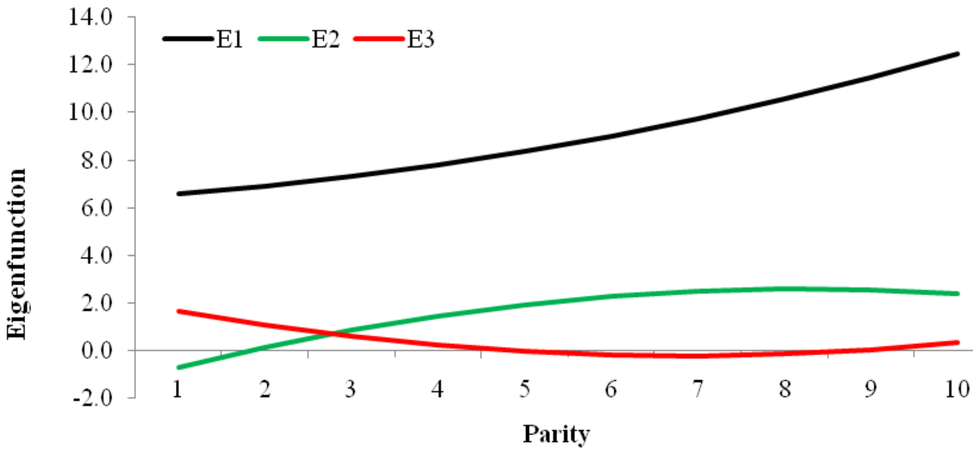

Figure 1: Eigenfunction (E1, E2, E3) for the additive genetic covariance

Heritability (h^2), permanent environmental portion (p^2) and repeatability ($t=h^2+p^2$) estimates of birth weight per parity calculated by RRM and MTM are shown in Table 3. Heritability estimates calculated by RRM were generally low to moderate, ranged between 0.12 and 0.25. The corresponding values estimated by MTM ranged between 0.13 and 0.45. The RRM estimates decreased from the first parity up to the fourth and then started to increase from the fifth parity, while those estimated by MTM had no certain trend. Generally, the MTM estimates were higher than those estimated by RRM, being equal in the eighth parity (0.25). Heritability value of the seventh parity estimated by MTM was markedly higher than the corresponding value estimated by RRM (0.45 versus 0.20). Standard errors of h^2 estimates of the ninth and tenth parities were high, due to the small number of observations in both.

The p^2 estimated by RRM ranged between 0.03 and 0.38. The estimates decreased from the first parity up to the seventh, and then started to increase up to the end. The corresponding values estimated by MTM ranged between 0.05 and 0.18. The estimates decreased from the first parity up to the fourth. Generally, the RRM estimates were slightly higher than those estimated by MTM, except p^2 of parities 6, 7 and 8. The p^2 estimated by RRM for the tenth parity was higher than the corresponding h^2 estimated by the same method.. The estimates of the ninth and tenth parities coincided with high standard errors. Repeatability estimates of the RRM and MTM decreased from the first parity up to the fourth, and then fluctuated thereafter. The highest repeatability estimates calculated by RRM and MTM were observed in the tenth and seventh parities, accounting for 0.60 and 0.54, respectively.

Table 3: Heritability (h^2), permanent environmental portion (p^2) and repeatability estimates of birth weight per parity, calculated by RRM and MTM.

Parity Number	Heritability		Permanent environmental portion		Repeatability	
	Random regression model	Multiple trait model	Random regression model	Multiple trait model	Random regression model	Multiple trait model
1	0.21±0.04	0.15±0.05	0.17±0.05	0.11±0.03	0.38	0.26
2	0.14±0.03	0.22±0.07	0.12±0.03	0.01±0.03	0.26	0.23
3	0.12±0.03	0.13±0.07	0.11±0.03	0.09±0.01	0.23	0.22
4	0.12±0.03	0.16±0.09	0.10±0.03	0.05±0.01	0.22	0.21
5	0.16±0.04	0.25±0.11	0.09±0.03	0.07±0.04	0.25	0.32
6	0.22±0.04	0.17±0.14	0.06±0.04	0.11±0.01	0.28	0.28
7	0.20±0 05	0.45±0.18	0.03±0.04	0.09±0.17	0.23	0.54
8	0.25±0.08	0.25±0.28	0.07±0.07	0.18±0.27	0.32	0.43
9	0.25±0.13	0.19±0.38	0.20±0.13	0.15±0.22	0.45	0.34
10	0.22±0.19	0.30±0.63	0.38±0.19	0.14±0.39	0.60	0.44

No information was found in the literature regarding h^2, p^2 and t of calf birth weight, as a trait of the dam in water buffalo. However, there are some estimates for birth weight in beef cattle. Maternal heritability of birth weight of Austrian beef cattle was 0.10, as reported by Gutierrez et al. (2007). Kriese et al. (1991) obtained higher estimate of maternal heritability in Santagertrudis cattle equal to 0.26. Similarly, Aziz, et al. (2005) reported a value of 0.48 in Japanese Black cattle. The reported values were estimated by multitrait animal models using data of calf birth weight, with fitting maternal genetic effect.

Conclusion

This study is the first attempt for estimation of genetic parameters of birth weight, as a trait of the dam, using RRM. The results indicated that maternal effects are important for the prediction of calf birth weight. The contribution of maternal effects to the phenotypic variance of birth weight may provide producers with information to optimally use the reported estimates when making selection decisions. More work is needed to determine the genetic and permanent environmental correlations between birth weight of calves across the age trajectory of their dams.

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