The International Journal of Multi-Disciplinary Research
ISSN: 3471-7102

Co-variance Components and Genetic Parameters of Growth Traits of Mashona Cattle.

(Conference ID: CFP/276/2017)

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ABSTRACT

Data for weaning weight, yearling weight and 18-month weight from a stud herd of Mashona cattle were analysed for variance components and genetic parameter estimates using the animal model in ASREML. Univariate analyses estimated variance components, heritability and predicted breeding values of animals for growth traits whilst genetic and phenotypic correlations were estimated with multivariate analyses. The least squares mean for direct heritability estimates for weaning weight, yearling weight and 18-month weight ranged from 0.17 ± 0.03, 0.11 ± 0.02 and 0.19 ± 0.03, respectively. The maternal heritability for weaning weight, yearling weight and 18-month weight were 0.08 ± 0.02, 0.04 ± 0.02 and 0.01± 0.02, respectively. The respective maternal permanent environment ratio estimates were 0.14 ± 0.02, 0.10 ± 0.02 and 0.07 ± 0.02 for weaning, yearling and 18-month weight. The genetic correlation estimates between weaning weight and yearling weight, weaning weight and 18-month weight and yearling weight and 18-month weight were 0.18 ± 0.06; 0.48 ± 0.05 and 0.26 ± 0.06, respectively. The corresponding phenotypic correlation estimates were 0.012 ± 0.01, 0.47 ± 0.01and 0.05 ± 0.01. The heritability estimates of Mashona cattle were similar to those reported in the literature. It is concluded that there is adequate additive genetic variance for an effective selection program for growth traits of this stud herd of Mashona.

Key words: *Mashona cattle, weaning weight, yearling weight, variance components, heritability, correlation*

Introduction

Genetic characterization of indigenous breeds is of paramount importance, not only for conservation purposes but also for the definition of breeding objectives and the development of breeding programmes. The indigenous Mashona breed found in Zimbabwe has characteristics that are well recognised and these include low maintenance input, adaptability to harsh conditions, disease tolerance and high fertility. However, unlike in other beef cattle breeds for which variance components and genetic parameters have been adequately reported (Pico et al., 2004; Bwire, 2006; Raphaka, 2008; Praharani, 2009; Dorantes, 2013; Mota et al., 2013 and Assan, 2014), there is insufficient information on the estimates of variance components and genetic parameters for Mashona cattle breed. This poses limitations regarding genetic improvement of the breed, since knowledge of variance estimates and genetic parameters is crucial for accurate estimation of breeding values, optimum combination of traits in selection programmes, optimization of breeding schemes and enhanced prediction of response to selection (Mota et al., 2013).

The aim of the study was to estimate variance components and genetic parameters for weaning, yearling and 18-month weight of Mashona cattle population obtained from fitting animal models, attempting to separate direct genetic, maternal genetic and maternal permanent environmental effects which will be used in the national genetic evaluation of the breed. Genetic estimates are required to design breeding programmes and genetic evaluation systems for Mashona cattle.

Materials and Methods

Data Edits

Edits were carried out using the Statistical Analysis System of version 9.3 (SAS, 2011). Edits removed all animals without weaning weight, yearling weight, date of birth and date of weaning. Duplicate records and outliers were deleted. Outliers were detected by using either formal tests (tests of discordance) or informal tests methods (outlier labelling methods). To increase precision and ensure connectedness in the data, records of sires with less than four progeny were deleted from analysis. Only dams which were three years and older were retained. Calf age was classified into eight classes because some of the classes had fewer observations. Records of progeny of dams with greater than ten progeny were also deleted using statistical analysis system (SAS, 2011). This was done to ensure connectedness and relatedness in the data. After editing the data, 7227 records were left for analysis.

ISSN: 3471-7102

Statistical Analysis

The General Linear Model procedures of SAS (2011) were used to determine whether any of the effects have an influence on the traits ($P < 0.05$). Those having an effect were fitted in the subsequent models to estimate the variance components and genetic parameters. Fixed effects fitted were sex, year-season, calf age and age of dam. Data for these analyses consisted of records of animals born from 1975 to 2011. Consistency checks were performed on identification of animals and their pedigrees. Univariate and multivariate analyses were conducted using animal models in the ASREML program developed by Gilmour et al.(2009) for three growth traits. Three different animal models were fitted. By using estimated (co)variance components from univariate analysis, direct heritabilities (h^2_a), maternal heritabilities (h^2_m) and maternal permanent environmental variances (c^2), were obtained.

All models included the same fixed effects which were mentioned above except for calf age which was different per each trait studied. Multivariate analysis using animal model and ASREML program were used for predicting the genetic and phenotypic correlations among growth traits. The following linear statistical model was used:

$$Y_{ijklmn} = \mu + s_i + tc_j + d_k + c_l + f_m + g_n + h_n + e_{ijklmn}$$

Where: Y_{ijklmn} = observed measurements of weaning, yearling and 18- month weight, μ = overall constant level of the weighed trait (weaning, yearling and 18- month weight), s_i = fixed effect of i^{th} sex of calf (i = male, female), tc_j = fixed effect of j^{th} year and season of birth (j= 1975… n), d_k = linear effect of k^{th} dam age (k= 3......13), c_l = fixed linear effect of l^{th} calf age (l = age wean, age yearling & age long yearling), f_m = the random effect of animal m, g_n = random effect of dam n, h_n = random maternal permanent environmental effect of dam n, e_{ijklmn} = random error.

Results and Discussion

The number of observations means and standard deviations of the weights after editing are presented in Table 1. Weaning weight ranged from 120 kg to 250 kg while yearling weight ranged from 150 kg to 315 kg. The coefficients of variation (CV) for growth traits were within the range of 9 to 15%; presumably reflecting the differences between environments, in particular differences in ages.

Table 1: Number of observations, means, standard deviations (SD) and coefficients of variation (CV) for Mashona calf growth

Trait	N	Mean (kg)	SD (kg)	CV	Minimum (kg)	Maximum (kg)
Weaning weight	7227	176.7	25.91	15	120	250
Yearling weight	7227	195.8	25.28	13	150	315
18-month weight	7227	284.6	25.80	9	193	380

The overall means for weaning weight and yearling weight were 176.7kg and 195.8kg which were lower than the averages of 256kg and 262kg reported for this breed by Tawonezvi et al. (1989). Also, the overall mean for 18-month weight was higher (284.8kg) than 267kg reported for this breed by Tawonezvi et al. (1989). Variance components estimates for all growth traits studied are shown in Table 2. Additive genetic variance for all traits studied was consistently higher than maternal variance in Mashona cattle. The phenotypic and residual variance of Mashona cattle increased from weaning weight to 18-month weight. The highest residual variance and phenotypic variance was observed in yearling weight and the lowest in weaning weight. The variances for maternal permanent environmental effects were decreasing from weaning weight (49.73 kg) to 18-month weight (25.95kg).

Table 2: Estimates of (co)variance components for weaning weight, yearling weight and 18-month weight of Mashona cattle

Trait	σ^2_a	σ^2_m	σ^2_c	σ^2_e	σ^2_p
Weaning weight	57.55 ±10.09	25.89 ± 8.00	49.73 ± 7.23	204.65 ± 6.78	337.82 ± 7.08
Yearling weight	45.14 ± 9.81	14.19 ± 6.90	38.90 ± 7.07	306.91 ± 8.08	405.14 ± 7.55
18-month weight	70.74 ± 11.60	3.20 ± 5.47	25.95 ± 5.82	278.91 ± 8.30	378.80 ± 7.29

σ^2_a = direct genetic variance; σ^2_m = maternal genetic variance; ^2_c = maternal permanent environmental variance; σ^2_e = residual variance and σ^2_p = phenotypic variance

Variance components estimates for all growth traits studied were in particular ranges as those reported by other researchers. Maternal variance for all growth traits studied was consistently lower than additive genetic variance in Mashona cattle. Similar results have been reported in the study of Aziz et al. (2005) in Japanese black cattle. However Elzo et al. (1998), found that in Zebu cattle additive genetic variance for weaning weight and yearling weight was lower than maternal genetic variance. Phenotypic variance of Mashona cattle increased from weaning to 18-month weight and this was in agreement with results by other researchers such as Bwire (2006); Raphaka (2008); Mashiloane et al. (2009); Praharani (2009); Cucco et al. (2010); Asan (2011); Ebangi et al. (2012); Neser et al. (2012); Mota et al. (2013) and Asan (2014). The residual variance also increased from weaning weight to 18 month. Lee et al.(2000) reported that error variance for estimated genetic values increases as the differences between true and variance component estimates decreases.

Estimates of direct heritability for weaning weight obtained in this study were within the range reported by other workers which varied from 0.07 (Demeke et al., 2003) to 0.4 (Praharani, 2009). The direct heritability estimates for yearling weight ranged from 0.13 (Pico et al., 2004) to 0.5 (Praharani, 2009). The estimates for 18 month weight ranged from 0.11(Lee et al., 1991) to 0.36 (Assan, 2013).

The low heritabilities obtained for growth traits in this study could be either due to deterioration in management leading to poor nutritional status of the animals, or due to the use of same sire for a number of years, which could decrease additive genetic variation. Generally, results showed a trend of increasing direct but decreasing maternal variance ratios from weaning weight to 18-month weight. The increasing direct heritability of calf weight at weaning is most likely brought on by an increased expression of genes with direct effects on body development (Yazdi et al., 1997). This also confirms the assertion of Robison (1981), Snyman et al. (1995) and Boligon et al. (2011) who concluded that maternal effects in mammals diminish with age. In general, results of the study showed that maternal effects, genetic and environmental effects, are important for growth traits and need to be considered during selection.

However, current maternal heritability estimates were lower than those reported by Abbasi and Ghafouri-Kesbi (2011) who noted that maternal heritabilities for weaning weight tended to be lower than direct heritabilities, showing a greater genetic effect of the calf than its dam for weaning weight. Maternal effects are critical sources of variation for weaning weight and ignoring maternal effects in the model would cause inaccurate genetic evaluation of calves. Smaller estimates of maternal heritability for yearling and 18month weight in the present study agrees with the reports by Robison (1981); Boligon et al.(2011); Assan, (2012) and Everling et al. (2014), that those maternal genetic

ISSN: 3471-7102

effects generally are essential for measurement of weight trait at younger ages and decrease with increasing age. Meyer et al.(1994) suggested that the maternal effects identified in Zebu crosses for post weaning growth traits are a carry-over effect of those affecting weaning weight. Future studies need to investigate the magnitude of the maternal carry-over effects in different breeds under different management systems. In the present study Mashona cattle were kept under the same management and were being influenced by the same environmental effects; however, the differences in magnitude of maternal effects are smaller.

The heritability estimates for the three growth traits are shown in Table 3. Heritability estimates for all growth traits ranged from low to medium. The direct heritability estimates were higher than maternal heritabilities for all growth traits. Maternal heritability estimates decreased as the animal ages for all growth traits. The values for maternal permanent environmental effects in the present study varied from low to medium low and were influenced by the model fitted for all growth traits. The permanent environmental variance accounted for 0.14 ± 0.02, 0.10 ± 0.02 and 0.07 ± 0.02 of the total variance of weaning weight, yearling weight and 18-month weight respectively.

Table 3: Genetic parameters for growth traits of Mashona cattle

Traits	h^2_a	h^2_m	c^2
Weaning weight	0.17 ± 0.03	0.08 ± 0.02	0.14 ± 0.02
Yearling weight	0.11± 0.02	0.04 ± 0.02	0.10 ± 0.02
18- month weight	0.19 ± 0.09	0.01 ± 0.02	0.07 ± 0.02

h^2_a = direct heritability, h^2_m = maternal heritability and c^2 = ratio of maternal permanent environmental effect

The genetic correlations between growth traits were positive and varied from low to medium as shown in Table 4. The genetic correlations estimates obtained for all growth traits were lower than most of the estimates in the literature cited (Beffa, 2005; Raphaka, 2008; Praharani, 2009; Baldi et al., 2010; Gunawani et al., 2012 and Mota et al., 2013). A small direct genetic correlation was estimated between weaning weight and yearling weight; and yearling weight and 18-month weight. Thus, it seems that selecting for heavier weaning weight in this stud herd may possibly not result in substantial increase in yearling weight. Also, it seems that selecting for heavier yearling weight in this stud herd may also possibly not result in substantial increase in 18month weight. The phenotypic correlations estimates obtained for all growth traits were lower than most of the estimates found by Beffa (2005); Raphaka (2008); Praharani (2009); Baldi et al. (2010); Gunawani et al. (2012) and Mota et al. (2013).

Table 4: Genetic correlations (below the diagonal) and phenotypic correlations (above the diagonal) between growth traits of Mashona cattle

Traits	Weaning weight	Yearling weight	18 months weight
Weaning weight	1	0.01 ± 0.01	0.47 ± 0.01
Yearling weight	0.18 ± 0.06	1	0.05 ± 0.01
18- month weight	0.48 ± 0.05	0.26 ± 0.06	1

Conclusion

Heritability estimates for all growth traits ranged from low to moderate. Direct heritability estimates were higher than maternal heritability estimates and maternal heritability decreased as the age increases. Genetic correlations for all growth traits were low to moderate and the corresponding phenotypic correlations were very low between traits. In animal breeding no decision should be taken in isolation. Selection on one trait will thus have consequences on all other traits as well. The estimation of variance components should be seen as the first step in developing a proper breeding objective for Mashona cattle.

Acknowledgements

The Authors would like to explicitly express gratitude towards Dr M. Beffa for recommending improvement and elucidations of the first content. The Stubs family supplied the growth traits records used in the research for which authors are truly thankful. We would also want to acknowledge Ms G. Chipangura for assisting the authors in the process of extracting the Mashona data from Livestock ldentification Trust.

Conflict of interest

There was no conflict of interest cited by any of the authors or supporting parties in the research and writing of this manuscript.

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