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GENETIC VARIABILITY OF GROWTH TRAITS IN PERFORMANCE TESTING OF BULLS

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ABSTRACT: Performance test of young bulls represents the first step in the process of genetic improvement of cattle. This procedure is important especially for beef and dual-purpose breeds and for those traits that are measurable in the live animals. In the most case those traits are suitable for direct selection and also they have influence on the level of production later in the life of animals. One of the most important groups of traits in performance testing of bulls is growth traits. In order to estimate heritability and genetic variability of growth traits, data on 371 Simmental performance tested bulls was used. Analysed traits were birth weight, body weight at different ages, average and relative daily gains. Since the structure of data disables implementation of Animal Model procedure, additive genetic variances and heritability of traits were obtained using restricted maximum likelihood (REML) methodology applied to sire model. Heritability estimates for birth weight, test-on (120 days of age) and test-off (365 days of ages) body weight were 0.23, 0.25 and 0.30, respectively. For pre-test average daily gain, average daily gain in test and lifetime average daily gain heritability were 0.27, 0.39 and 0.29, respectively, while heritability for pre-test relative daily gain, relative daily gain in test and lifetime relative daily gain were 0.29, 0.22, and 0.26, respectively.

Introduction

The aim of performance testing is to provide means to compare bulls from different herds under standard environmental conditions in test station to identify genetically superior bulls for breeding. Selection of bulls based on performance testing results is especially important for those traits that are measurable early in the life and characterised with medium or higher value of heritability (i.e. growth traits such as average daily gain, body weight etc.). Growth traits are the most important group of traits that are measured and controlled in performance testing of bulls. Since that all environmental factors (such as nutrition, care of animals etc.) are under control, it is assumed that all variation in growth and body development of young bulls during the test is under genetic control.

The aims of this study were to analyse genetic variability and heritability of growth traits in performance testing of Simmental bulls.

Material and Methods

Animals and Traits. For this study, data on 371 performance tested Simmental bulls was used. All bulls were born between 1983 and 1996 and tested between 1983 and 1997. The following growth traits were studied: **(I)** body weight at birth *(BrW)*, initial weight at the start of test in the age of 120 days *(BW1)*, monthly measured body weights in test *(BW2-BW8)*, and final weight at the end of test in the age of 365 days *(BW9)*; **(II)** average daily gain (ADG: pre-test, in-test, life-time gain, and periodically measured on monthly bases during the test period); and **(III)** relative growth rate (RGR: pre-test, in-test, life-time gain, and periodically measured on monthly bases during the test period).

Statistical Analyses. Due to the incomplete pedigree file, components of variance were obtained using restricted maximum likelihood (REML) methodology applied to sire model. The fixed effects were year, season or month of birth, herd of origin and group in test while sire component was treated as random effect. Obtained negative values for some components of variances were set to zero.

Results and Discussion

Birth weight of tested Simmental bulls in average was about 45 kg (SD ± 6 kg), test-on weight in the age of 120 days was about 195 kg (SD ± 25 kg), while test-off weight in the age of 365 days was about 516 kg (SD ± 37 kg) (table 1).

Table 1. Mean, standard deviation and heritabilities for body weights.

Trait	Mean (kg)	SD (kg)	h^2	σ^2_A	σ^2_P	σ^2_E
BrW	45.11	6.11	0.23	6.696	29.725	26.796
BW1	194.78	24.71	0.25	116.212	465.600	414.757
BW2	231.53	25.09	0.25	125.424	499.664	444.791
BW3	271.63	28.27	0.36	232.252	641.207	539.597
BW4	313.18	30.47	0.65	479.032	738.553	528.977
BW5	354.52	32.19	0.39	278.988	723.710	601.653
BW6	396.07	33.48	0.40	302.104	759.707	627.537
BW7	436.08	34.53	0.26	205.884	803.478	713.404
BW8	474.99	35.64	0.24	207.104	872.951	782.343
BW9	515.86	37.17	0.30	295.280	980.233	851.048

Heritability of 0.23 for birth weight of tested Simmental bulls was in range of values previously published by *Mohiuddin **(1993)***. On the other hand, *Koots et al. **(1994)*** obtained slightly higher value of heritability for these traits. An estimate of heritability for test-on weight (0.25) also was in range for values obtained by sire model reported by *Mohiuddin **(1993)*** and very similar to results of *de Matos et al. **(2000)***, *Bennett and Gregory **(1996)**, Gregory et al. **(1995)*** and *Koots et al. **(1994)***. Heritability of 0.30 for test-off weight was identical to results found by *Mohiuddin **(1993)*** and *Kemp et al. **(1984)***.

Changes in variances of body weights during the test shows very similar patterns. Increasing values of the phenotypic and residual variances during the test are very similar to changes in body weights in the same age. On the other hand, the results demonstrated that there was an association between additive variance and phenotypic and residual variances only during the first half of test. Later during the test additive variance has slightly different patterns than phenotypic or residual variances. This is probably due to effect of compensatory growth that influences variation in growth variances during the test *(Bogdanovic, **1997**; Bogdanovic et al., **1998**)*.

One of the most important growth traits is average daily gain (table 2). Pre-test average daily gain of 1230 gd^{-1} was higher than gains reported by *de Rose et al. **(1988)*** and *Tong **(1982)***. On the other hand, average daily gain in test (1320 gd^{-1}) was less than gains obtained by *Chewning et al. **(1990)**, Bech Andersen et al. **(1989, 1990)**, de Rose et al. **(1988)**,* and *Tong **(1982)***, and in range of results estimated by *Bittante et al. **(1995)***.

Table 2. Mean, standard deviation and heritabilities for average daily gain.

Trait	Mean (g d^{-1})	SD (g d^{-1})	h^2	σ^2_A	σ^2_P	σ^2_E
ADG 1-2	1210	320	0.17	0.011	0.063	0.058
ADG 2-3	1320	330	0.36	0.030	0.084	0.070
ADG 3-4	1370	330	0.10	0.010	0.103	0.098
ADG 4-5	1360	310	-	0.000	0.071	0.071
ADG 5-6	1370	320	-	0.000	0.083	0.083
ADG 6-7	1320	320	0.59	0.052	0.089	0.066
ADG 7-8	1280	310	0.28	0.024	0.086	0.076
ADG 8-9	1350	380	0.43	0.046	0.108	0.087
ADG pre-test	1230	190	0.27	0.008	0.030	0.026
ADG in-test	1320	130	0.39	0.006	0.016	0.013
ADG lifetime	1290	100	0.29	0.002	0.007	0.006

Results from this study were higher than results reported by *Neumann et al.* ***(1990)***. Estimating variability of pre-test, in-test and lifetime ADG, it could be concluded that variability is much more expressed for periodically measured gains than those measured in longer time frame.

Heritability estimates for periodically measured ADG during the test period varied very widely from 0.10 to 0.59. So wide range of heritability estimates is mostly due to the variation in both additive and residual variances during the test period and it is mainly caused by still remaining pre-test effects.

For accurate evaluation of growth potential of Simmental bulls in test period, it is necessary to estimate heritability for in-test ADG. Heritability of 0.39 for in-test ADG was in range of results for European population of Simmental cattle published by *Bittante et al.* ***(1995)***. Generally speaking, it is expected that in-test ADG has slightly higher value since standard environmental conditions favorably influence expression of additive variances.

Slightly higher value of heritability for life-time ADG than for pre-test ADG (0.29 *vs.* 0.27), suggests that up to age of 365 days one part of variability mainly influenced by maternal effects has been removed. The estimate of heritability for pre-test ADG of 0.27 was on the upper level of results reported by *Koots et al.* ***(1994)*** and slightly higher than those obtained by *Gregory et al.* ***(1995)***. On the other hand, heritability estimate of 0.29 for life-time ADG was on lower level of range found by *Koots et al.* ***(1994)***. It should be pointed out that these results indicate positive selection response if selection on growth up to the age of one year is applied.

From the beginning to the end of test relative daily gains showed almost linear decreasing (table 3). In general, it should be concluded that efficiency of growth decreased with age of bulls. These results are similar to results obtained by *Ahunu and Makarechian* ***(1987)***.

Table 3. Mean, standard deviation and heritabilities for relative daily gain.

Trait	Mean (% d^{-1})	SD (%d^{-1})	h^2	σ^2_A	σ^2_P	σ^2_E
RGR 1-2	0.57	0.169	0.27	0.005	0.019	0.016
RGR 2-3	0.53	0.129	0.20	0.003	0.012	0.011
RGR 3-4	0.47	0.114	0.07	0.001	0.011	0.011
RGR 4-5	0.41	0.093	0.41	0.003	0.007	0.006
RGR 5-6	0.37	0.088	0.14	0.001	0.006	0.005
RGR 6-7	0.32	0.080	0.74	0.004	0.005	0.004
RGR 7-8	0.28	0.069	0.25	0.001	0.004	0.004
RGR 8-9	0.27	0.077	0.53	0.002	0.004	0.003
RGR pre-test	1.20	0.13	0.22	0.003	0.013	0.012
RGR in-test	0.40	0.05	0.32	0.0004	0.001	0.001
RGR lifetime	0.67	0.04	0.26	0.0004	0.002	0.001

The heritability estimate for pre-test RGR was 0.22 and it was lower than h^2 obtained by *Winder et al.* ***(1990)***. Estimates of heritability for realtive daily gain periodically measured during the test displayed wide range of variability. It is much more evidently if comparison between first and second half of test is made. The estimates of h^2 for RGR periodically measured in the first half of test were lower than those obtained in second half of test. These patterns of approving the estimates of h^2 for RGR agree with results obtained by *Kemp* ***(1990)***.

The estimate of heritability for in-test RGR (0.32) was similar to results published by *Kemp* ***(1990)***. These results indicate that in growth efficiency is accumulated not only non-additive component of variation, which is significantly expressed in short time period, but also additive component of variability. It should be pointed out that patterns of change in phenotypic variance of relative growth rate almost-at-all depict biological characteristics of growth efficiency of bulls in performance testing.

Conclusion

Pattern of changes in additive genetic variance indicates that fully expression of genetic potential for growth could be expected in the second half of bull's performance test. It should be noted that changes in phenotypic variances in the first half of the test are much more dependent on variation in residual than on variation in additive variances. Equalizing of additive and phenotypic variances is expected during the second half of the test and removing still remained pre-test effects principally cause it. The estimates of heritability for growth traits show enough genetic variability and therefore it is expecting to gain positive selection response if growth of bulls up to 365 days of age is considered for selection. On the other hand, somewhat lower values of the h^2 estimates for relative growth rate suggest that could be expected weakly selection response if those growth traits are considered for selection. Instead of selection purpose, relative growth rate is much more important for describing general pattern of growth of bulls until one year of age as well as to decide whether or not is necessary to apply certain breeding method in order to improve growth efficiency.

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References

Ahunu, B., Makarechian, M. (1987). Preweaning patterns of growth in three breed groups of range beef cattle. *Can. J. Anim. Sci., 67: 653-661*.

Bennett, G.L., Gregory, K.E. (1996). Genetic (co)variances among birth weight, 200-day weight, and postweaning gain in composites and parental breeds of beef cattle. *J. Anim. Sci., 74: 2598-2611*.

Bech Andersen, B., Madsen, P., Klaustrup, S., Ovesen, E. (1989). Performance testing for beef in 1987/88. *Beretning fra Statens Husdyrbrugsforsog, 653: 77*.

Bech Andersen, B., Madsen, P., Klaustrup, S., Ovesen, E. (1990). Report from the beef bull breeding stations in 1988/89. *Beretning fra Statens Husdyrbrugsforsog, 670: 75*.

Bittante, G., Carnier, P., Gallo, L. (1995). Strategy and methods of selection of dual purpose cattle breeds. *46th Annual Meeting of EAAP, Prague, Czech Republic, 4-7 September*.

Bogdanović, V. (1997). Izvori varijabilnosti za proizvodne osobine bikova tovnih rasa. *Magistarska teza, Poljoprivredni fakultet, Beograd-Zemun*.

Bogdanović, V., Gajić, I., Latinović, D. (1998). Izvori varijabilnosti za osobine porasta bikova tovnih rasa. *XIII Inovacije u stočarstvu, Beograd. Savremena poljoprivreda, 48 (1-2), 69-75*.

Chewning, J.J., Brown, A.H., Johnson, Z.B.Jr., Brown, C.J. (1990). Breed means for average daily gain, feed conversion and intake of beef bulls during postweaning feedlot performance tests. *J. Anim. Sci., 68: 1500-1504*.

de Mattos, D., Misztal, I., Bertrand, J. K. (2000). Variance and covariance components for weaning weight for Herefords in three countries. *J. Anim. Sci., 78: 33-37*.

de Rose, E.P., Wilton, J.W., Schaeffer, L.R. (1988). Estimation of variance components for traits measured on station-tested beef bulls. *J. Anim. Sci., 66: 626-634*.

Gregory, K.E., Cundiff, L.V., Koch, R.M. (1995). Genetic and phenotypic (co)variances for production traits of intact male populations of purebred and composite beef cattle. *J. Anim. Sci., 73: 2227-2234*.

Hanset, R., Michaux, C., Stasse, A. (1987). Phenotypic and genetic parameters of growth traits in successive periods. *In: Korver, S., Averdunk, G., Bech Andersen, B. (Eds.): Performance testing of A.I. bulls for efficiency and beef production in dairy and dual-purpose breeds., 22-27*.

Kemp, R.A., Schaeffer, L.R., Wilton, J.W. (1984). Comparison of beef sire evaluations models for an organized progeny test. *J. Anim. Sci., 58: 1313-1320*.

Kemp, R.A. (1990). Relationships among test length and absolute and relative growth rate in central bull tests. *J. Anim. Sci., 68: 624-629*.

Koots, K.R., Gibson, J.P., Smith, C., Wilton, J.W. (1994). Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. *Animal Breeding Abstracts, 62 (5), 309-338.*

Mohiuddin, G. (1993). Estimates of genetic and phenotypic parameters of some performance traits in beef cattle. *Animal Breeding Abstracts, 61 (8), 495-522*.

Neumann, W., Weiher, O., Nicola, M., Robekamp, W. (1990). The performance test of five breeds of beef cattle, fed high-roughage diets. *Archiv fur Tierzucht, 33: 39-48*.

Schleppi, Y., Hofer, A., Quaas, R.L., Schmitz, F., Kunzi, N. (1994). Relationship between own performance test and progeny test for beef productoin traits in Swiss dual-purpose cattle. *Liv. Prod. Sci., 39: 173-181*.

Tong, A.K.W. (1983). Breed averages and age of dam adjustment factors for birth weight of beef cattle. *Can J. Anim. Sci., 63: 7-15*.

Winder, J.A., Brinks, J.S., Bourdon, R.M., Golden, B.L. (1990). Genetic analysis of absolute growth measurements, relative growth rate and restricted selection indices in Red Angus cattle. *J. Anim. Sci., 68: 330-336.*