Genetic Evaluation of Semen and Growth Traits of Young Simmental Bulls in Performance Test

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SUMMARY

The objective of this study was to estimate genetic and environmental variances and heritabilities for body measurements, daily gain, semen volume and semen concentration of young Simmental bulls. In addition, genetic trends for those traits were analyzed. Data utilized in this study consisted of records of 955 young Simmetal bulls born from 1974 to 1995 and were provided by the Performance Test Station - Varazdin. The test for growth traits started at the age of 120-d, and finished at 365-d. Generally, body measurements were taken every month, but there were animals with lost records. In order to smooth data and predict values at ages of 205- and 365-d, the spline analysis was applied. The following growth traits were derived: weights, heights at withers, hearth girth, and chest depth, predicted at 205- and 365-d of age, respectively. Further, average daily gain from 205- do 365-d was calculated. The semen collection started at approximately 11 months of age. The records included semen volume and concentration. Variance and covariance components and associated heritabilities were estimated by REML from a set of single-trait animal models. Fixed effects were defined as birth year and season, and animal effect was defined as random effect. The heritability estimates for growth traits ranged from .14 to .38. Heritability estimate for semen concentration was moderate (.26). Thus, the improvement of concentration, or at least not negative genetic trend, can be expected even if only phenotypic selection is practiced. This cannot be said for semen volume, as heritability estimate in the present study was low (.04). In this study no clear genetic trend for semen nor growth traits were detected.

KEY WORDS

Cattle, Semen, Growth, Heritability, Genetic trend

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Genetski parametri za svojstva sperme i rasta mladih simentalskih bikova iz performance testa

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SAŽETAK

Cilj rada bio je procjena genetskih i okolišnih varijanci i heritabiliteta za tjelesne mjere, dnevni prirast, volumen i koncentracije sperme mladih simentalskih bikova. Osim toga procijenjeni su genetski trendovi za navedena svojstva. U radu su analizirani podaci iz performance testne stanice od 955 mladih bikova rođenih između 1974 i 1995 godine. Test za svojstva rasta započeo je u dobi od 120 dana, a završio s dobi od 365 dana. U pravilu bikovi su u testu mjereni svakih mjesec dana. Spline analizom procijenjene su tjelesne mjere u dobi od 205 i 365 dana, pri čemu su izvedeni slijedeći pokazatelji rasta: težina, visina grebena, opseg prsa i dubina prsa. Osim toga procijenjen je prosječni dnevni prirast od 205 do 365 dana. Polučivanje sjemena počelo je u dobi bikova od 11 mjeseci. Za svaki ejakulat izmjereni su volumen i koncentracija sjemena. Komponente varijance i kovarijance procijenjene su REML metodom koristeći animal model. Godina i sezona definirani su kao fiksni utjecaji, a utjecaj same životinje kao slučajan. Procijenjeni heritabiliteti za svojstva rasta kretali su se od .14 do .38. Za koncentraciju sjemena procjena je bila 0.26. Povećanje koncentracije ili u najmanju ruku ne negativni genetski trend može se očekivati čak i samom fenotipskom selekcijom. Međutim, zbog niskog heritabiliteta (.04) to isto se ne može očekivati za volumen sjemena. Ni za jedno od promatranih svojstva nije utvrđen jasan genetski trend.

KLJUČNE RIJEČI

govedo, sperma, rast, heritabiltet, genetski trend

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INTRODUCTION

Selection scheme for the improvement of Simmental cattle in Croatia includes a performance test of young bulls on growth and type traits. At the end of performance test bulls are selected by use of a selection index which contain milk, beef and type traits. On the other hand, for semen quality the young bulls are phenotypically preselected by independent culling. A bull not having semen volume at least 2 ml and semen concentration at least 500 x 10^9 /ml is culled out. This culling is done prior to final selection in performance test. So far objective selection for semen quality has not been possible because environmental (Schwab et al., 1987; Mathevon et al., 1998), and management (Almquist, 1973; Mathevon et al., 1998) factors affections semen production have not been taken into account.

Genetic variances can differ among cattle population for several reasons. Estimates depend on a sample or poor data structure (Bennet and Gregory, 1996). Experimental or field data are subjects to loss of data due to selection or death of animals. This can be also said for animals in progeny test, where animals are progenies of selected sires that represent the best animals in the population. Further, the problem in finding objective estimates can be due to small amount of data available, because the number of sires needed for a breeding program is relatively small. This is especially true for traits that can be measured only on male animals such as semen traits. Techniques are now available to account for selection. Utilization of pedigree information in an animal model (or similar models) can partly account for selection (Sorensen and Kennedy, 1983).

Correct estimates of genetic and environmental variances are essential in any breeding program. Diverse estimates of heritability have been reported for semen traits in the literature. Moderate to high heritabilities were found for semen production traits in different cattle populations (Ducrocq and Humboldt, 1995). Makulska et al. (1993) and Schlote and Munks (1980) reported relatively low estimates. If estimates of heritabilities are moderate to high, the improvement of semen traits can be expected even if only phenotypic selection is practiced. Therefore, for evaluation of young bulls in performance test, the estimates of heritabilities for growth and semen traits are necessary. The objective of this paper was to estimate genetic and environmental variances and to evaluate genetic trends for some body measurements in different ages, daily gain, and semen volume and concentration of young Simmental bulls from the performance test station in Croatia.

MATERIALS AND METHODS

Data utilized for this study were provided by the Performance Test Station-Varaždin and consisted of body measurements and semen volume and concentration of 955 young Simmetal bulls born from 1974 to 1995. These bulls were offsprings of sires and dams according to National breeding program for Simental cattle. Animals entered Station at the age of 60 days with average weight of 130 kg (Mikulić and Nazansky, 1995). Actual test began at 120 d of age. Bulls were fed a diet of hay and concentrate. During the whole period bulls were offered hay ad libitum. Concentrate was given twice a day as follows. When animals had entered Station small amount of concentrate P.II was given. Concentrate was gradually increased so bulls received 4 kg daily at 120 d of age and 6 kg at the age of 300 d. At cca. 300 d of age concentrate P.II. was replaced with concentrate P.III. This concentrate was gradually increased up to maximum 8 kg daily. During the whole test period bulls were fed individually. The concentrate P.II. consisted of 30% corn, 30% oats, 15% wheat bran, 22% soybean meal, 1% hostafos, 1% bone meal and 1% vitamin-mineral supplement, with 16.1% digestible protein and 1.07 oats units. The concentrate P.III. consisted of 35% corn, 40% oats, 7% wheat bran, 15% soybean meal, 1% hostafos, 1% bone meal and 1% vitamin-mineral supplement, with 13.4% digestible protein and 1.13 oats units.

The test for growth traits started at the age of 120-d, and finished at 365-d. However, the measurements of most animals were taken up to 450-d. Generally, body measurements were taken every month, but there were animals with lost records. Only animals with at least six weight records were used in the analysis. In order to smooth data and predict values at ages of 205- and 365-d, the spline analysis using Transreg procedure (SAS, 1989) was applied, i.e. growth was explained by two simple regression lines with the knot at 285th day of age. From those regression lines the following growth traits were derived: weights, heights at withers, hearth girth, and chest depth, predicted at 205- and 365-d of age, respectively. Further, relative growth traits were also derived, defined as ratio of growth values predicted at 205-d and 365- d, and also average daily gain from 205- to 365-d.

The semen collection started at approximately 11 months of age. Records included semen volume and concentration. Number of semen collections per bull varied. The maximum number of collected ejaculates were up to 15. Only those ejaculates were used whose time between collection were at least seven days. There was a lot of variation in volume and concentration among ejaculates within bulls which could not be explained. Thus, the means of ejaculates collected per bull were calculated and used in the further analyses.

By including relationships among animals, a total of 2717 animals were included in the variances estimation. Descriptive statistics were calculated using the Univariate procedure (SAS, 1990). Variance and covariance components were estimated by REML from animal models of the general form:

$$\mathbf{y} = \mathbf{X}\beta + \mathbf{Z}_a\mathbf{a} + \mathbf{e}$$

where **y** is a vector of observed traits, b is a vector of fixed effects, **a** is a random vector of additive genetic effects, **X**, and $\mathbf{Z_a}$ are incidence matrices relating **β, a** to **y,** and **e** is a random vector of error effects.

The model has the following distributional assumptions:

$$E[\mathbf{y}] = \mathbf{X}\beta$$

and

$$\mathrm{var}\begin{bmatrix}\mathbf{a}\\ \mathbf{e}\end{bmatrix} = \begin{bmatrix}\mathbf{A}\sigma_a^2 & 0\\ 0 & \mathbf{I}\sigma_\mathbf{e}^2\end{bmatrix}$$

where σ^2_a is the additive genetic variance, and σ^2_e is the error (environmental) variance. Vectors **e** and **a** were assumed to be uncorrelated. Also, **A** is the additive genetic relationship matrix and **I** is the identity matrix.

A set of single-trait animal models were used to estimate genetic and environmental variances and heritabilities for growth and semen traits. Fixed effects were defined as birth year and season (Winter = December, January and February, Spring = March, April and May, Summer = Jun, July and August, and Fall = September, October and November). Animal effect was defined as random effect.

Calculations were carried out using the Multiple Trait Derivative Free Restricted Maximum Likelihood program (MTDFREML, Boldman et al., 1993), a set of programs employing the simplex procedure to locate the maximum of the log likelihood (*logL*). Convergence was considered to have been reached when the variance of function values (*-2 logL*) in the simplex was less than 10^{-9}. To insure convergence of *logL* to a global maximum the single trait models were run several times restarting the program with initial values from the previous run. When the *-2 logL* and estimates were similar in successive analyses it was concluded that convergence reached the global maximum. To present genetic trends mean breeding values were plotted against years when animals were born. Breeding values of animals were calculated as Best Linear Unbiased Predictors (BLUP) from the animal model defined before.

RESULTS AND DISCUSSION

Descriptive statistics of the traits are presented Table 1. Weight at 205 and 365 days of age and daily gain were considerably higher than in performance test of young Simmental bulls in other countries (Averdunk et al. 1988; Schleppi et al. 1994). Also, the young bulls analyzed in this paper produced more semen than reported by Ducrocq and Humbolt (1995) and Mathevon et al., (1998) for young Normande and Montbeliard bulls, respectively, which can be explained with positive relationship between weight and semen volume.

Genetic and environmental variances and heritability estimates are presented in Table 2. Heritability estimate for growth traits ranged from .14 to .38. Heritability estimates for wither height, hearth girth and chest depth agree with values reported by the other authors for animals in similar Testing Stations (Wenzler, 1980; Hanset et al., 1998). Relatively low estimate (.14) was found for average daily gain from 205 to 365 days. Considerably higher heritabilty estimates for daily gain (.35) were reported by Wenzler (1986) and Averdunk (1988) for Simmental bulls in Germany. For weight gain from 210 to 330 d of age, Schleppi et al. (1994) reported heritability of .35 and .28 for young Simmental and Braunvieh bulls, respectively.

Table 1. Descriptive statistics for growth and semen data of young Simmental bulls

	N	Mean	SD	CV[b]
Growth traits				
205-d Wt[a] (kg)	894	320.1	29.3	9.16
365-d Wt (kg)	894	574.4	39.9	6.95
Dg (g day^{-1})	894	1590.0	194.0	12.22
205-d Ht (cm)	894	112.8	2.8	2.44
365-d Ht (cm)	894	128.7	2.4	1.90
205-d HG (cm)	904	156.6	5.9	3.76
365-d HG (cm)	904	196.3	6.3	3.19
205-d ChD (cm)	894	53.7	1.9	3.57
365-d ChD (cm)	894	65.0	1.9	3.00
Semen traits				
Concentration (10^9/ml)	955	.87	.15	17.43
Volume (ml)	955	3.628	.78	21.53

[a] Wt = weight, Dg = average daily gain from 205 to 365 days, Ht = height at withers, HG = hearth girth, ChD = chest depth, 205-d = trait measured at 205 days of age, 365-d = trait measured at 365 days of age.
[b] CV = coefficient of variation

Table 2. Estimate of genetic (σ^2_a) and error (σ^2_e) variances and heritabilities (h^2) for growth and semen traits of young Simmental bulls

	σ^2_a	σ^2_e	h^2
Growth traits			
205-d Wt[a]	183.57	499.44	.27
365-d Wt	290.17	1127.28	.20
Dg	4380.0	25180.0	.15
205-d Ht	2.35	4.28	.35
365-d Ht	1.85	3.19	.37
205-d HG	6.48	20.50	.24
365-d HG	4.54	28.98	.14
205-d ChD	.58	2.31	.20
365-d ChD	.38	2.70	.12
Semen traits			
Concentration	.00436	.01216	.26
Volume	.0238	.5387	.04

[a] Wt = weight, Dg = average daily gain from 205 to 365 days, Ht = height at withers, HG = hearth girth, and ChD = chest depth.

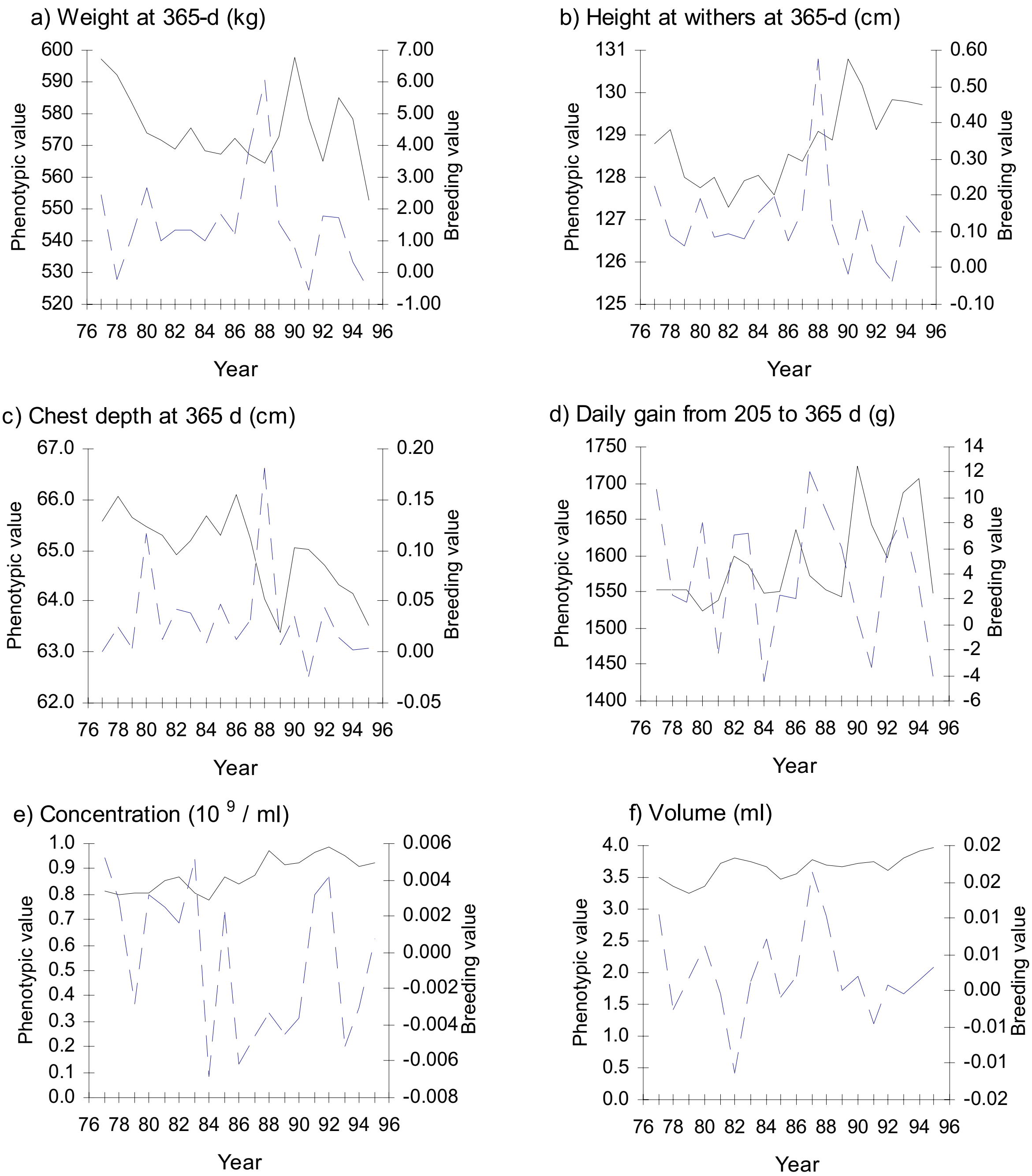

Fig. 1. Average phenotypic (solid line) and breeding value (dashed line) of semen and growth traits per year of birth: a) weight at 365 d, b) height at withers at 365 d, c) chest depth at 365 d, d) average daily gain from 205 to 365 d, e) semen concentration, and f) semen volume.

Estimates of heritability for semen traits reported in the literature are very diverse. Low estimates of heritability have been often reported in the literature for semen volume (Makulska et al., 1993; Stalhammar et al., 1989). Similarly, low estimates were reported by Makulska et al. (1993) and Schlote and Munks (1980) for concentration. On the other hand Ducrocq and Humboldt, (1995) reported moderate to high heritabilities for semen production traits. They argued that if various environmental and management factor, such as frequency of collection, season, duration of sexual preparation, were taken into account, moderate to high heritability estimates could be expected. Unfortunately, in the present study sexual preparation was not recorded. To account for frequency of collection only those ejaculates were used when duration between collections was at least 7 days.

In the present study heritability estimate for semen concentration was moderate (.26).

Thus, the improvement of concentration, or at least not negative genetic trend, can be expected even if only phenotypic selection is practiced. This cannot be said for semen volume, as heritability estimate for semen volume in the present study was low (.04).

Some authors have reported negative genetic correlation between weight of the animal and sperm quality, as well as positive relationship between weight and semen volume (Knights et al., 1984). So the total absence of selection may have negative effect on semen concentration.

Phenotypic and genetic trends for semen concentration and volume, daily gain from 205 to 365 days, and weight and height at 365-d per year of birth are presented in Fig. 1. No clear genetic trend can be detected for any of traits presented. On the contrary, considerable variation can be seen between years. Ducrocq and Humbolt (1995) also observed absence of clear genetic trends for semen concentration and volume in young Normande bulls. The lack of genetic trends for growth traits in the present study could be explained by permanent semen import for AI to produce male calves for performance testing.

CONCLUSION

Moderate heritability estimate was found for semen concentration in young Simmental bulls. Thus, the improvement can be expected even if only phenotypic selection is practiced. On the contrary heritability estimate for semen volume was low. Estimates of heritability for growth traits were moderate to high as could be expected for those traits. Usually, genetic relationships between weights and sperm quality were reported to be negative. If this is true, selection only for growth traits may have negative effect on semen quality traits. In this study no clear genetic trend for semen nor growth traits were detected.

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