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GENETIC PARAMETERS FOR GROWTH IN CHAROLAIS CALVES

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ABSTRACT

Genetic parameters for birth weight (BW), weight at the beginning (WB), in the middle (WM), and at the end of grazing season (WE), as well as weight at the age of one year (WY) were estimated. Data were collected on 319 Charolais calves. The total number of records, including pedigree data (parents and grandparents) was 377 animals. Variance and covariance components were estimated by REML method using the VCE-5 package. The effects of sex, parity and year of birth were included in the models for all traits. Age of calves at the beginning of grazing season was included as linear regression in models for all traits except for birth weight. The age of calves in the middle, at the end of grazing season, and age at approximately one year were included as linear regression in the models for corresponding weights. Direct additive genetic effect was included in models for all traits as random effect. Estimated heritabilities for BW, WB, WM, WE and WY were 0.62 ± 0.06, 0.23 ± 0.09, 0.35 ± 0.08, 0.29 ± 0.07 and 0.23 ± 0.07, respectively.

Key words: cattle / calves / breeds / Charolais / genetic parameters / body weight / variance / heritability / genetic correlation

GENETSKI PARAMETRI ZA RAST PRI TELETIH ŠAROLE PASME

IZVLEČEK

Ocenjeni so bili genetski parametri za rojstno maso (BW), telesno maso na začetku (WB), sredini (WM) in na koncu pašne sezone (WE) ter ob starosti enega leta (WY). Podatki so bili zbrani na 319 teletih šarole pasme. Skupno število zapisov vključno s podatki o poreklu (starši in stari starši) je bilo 377 živali. Komponente varianc in kovarianc so bile ocenjene z metodo REML in uporabo VCE-5 paketa. Vplivi spola, zaporedne telitve in leta rojstva so bili vključeni v modele za vse proučevane lastnosti. Starost telet na začetku paše je bila kot linearna regresija vključena v modele za vse lastnosti razen v model za rojstno maso. Starost telet na sredini in na koncu paše ter starost ob približno enem letu pa je bila kot linearna regresija vključena v modele za pripadajoče telesne mase. Direktni aditivni genetski vpliv je bil vključen v modele za vse lastnosti kot naključni vpliv. Ocenjene heritabilitete za BW, WB, WM, WE in WY so bile 0,62 ± 0,06; 0,23 ± 0,09; 0,35 ± 0,08; 0,29 ± 0,07 in 0,23 ± 0,07.

Ključne besede: govedo / teleta / pasme / šarole / genetski parametri / telesna masa / varianca / heritabiliteta / genetska korelacija

INTRODUCTION

Ratio between dairy and suckler cows has been changed since the introduction of milk quotas in EU and consequently in Slovenia, too. In Slovenia, suckler cows represent about 40% of the total cow population and the percentage is still increasing. The most widespread breed in suckler herds is locally adapted Simmental cattle. Slovenian Brown cattle are used as suckler cows in a few herds only. Recently, an increased number of purebred beef cattle, like Charolais and Limousine, are reared in cow-calf system on pastures. The first purebred Charolais animals were imported to Slovenia from France in 1965. Lately, small groups of Charolais cattle and semen of sires were imported, too. In the last five years beef recording and selection of purebred beef breeds is getting more intensive. The semen of the best sires is still imported from France to prevent inbreeding, and to achieve faster genetic progress in purebred Charolais herds.

A number of studies have been done in different parts of the world on larger populations of Charolais cattle included. Heritabilities for weaning weight were reported to range between 0.13 and 0.33 (Phocas and Laloë, 2004; Donoghue and Bertrand, 2004; Crews *et al*., 2004; Bennett and Gregory, 1996; Duangjinda *et al*., 2001) while heritability for weight at one year was 0.34 (Bennett and Gregory, 1996). On the other hand in Slovenia, only one study has reported genetic parameters for Charolais and Limousine calves has been performed so far (Simčič *et al*., 2006). According to the well known fact that genetic evaluation is useful if genetic and non-genetic parameters for each population are estimated, we have decided to estimate genetic parameters for Charolais calves in one of Slovene herds for the start.

The aim of this study was to estimate the genetic parameters for weaning weight (weight at the end of grazing season) and weight at one year of age in Charolais calves. Birth weight, weight at the beginning and weight in the middle of grazing season were also analysed.

MATERIAL AND METHODS

Material

Data was collected on 319 Charolais calves (171 males and 148 females) reared at the Educational and Research Animal Husbandry Centre Logatec (Slovenia). Calves were born in years 1995 to 2005 in late winter or spring calving season from January to June. During grazing season, cows and calves had no additional concentrate on pasture, except mineral-vitamin mixture fed *ad libitum*. The average grazing season lasted from the beginning of May to the end of October. The herd was on all-day grazing at 470 m above the sea level on a karst plateau, with short vegetation period. Moreover the plateau is located on the passage of mild Mediterranean and cold Alpine climate. The amount of rainfall differs among years. The end of grazing season coincided with the weaning period/time. Weaned bulls were housed in performance test unit until the age of one year. Weaned heifers were housed during winter period and next spring, at the average age of one year, they were put on pasture.

Besides animal measurements, pedigree file included sires, dams and grandparents, altogether 377 animals. In the analysed period, 24 sires had progeny in the herd. Sires in natural mating had more progeny than AI sires.

In the study, birth weight (BW), body weight at the beginning of grazing season (WB), body weight in the middle of grazing season (WM), body weight at the end of grazing season (WE), as well as body weight at the average age of one year (WY) were analysed. On average calves were weighed five times: at birth, three times during grazing season (beginning, middle, the end) and at the approximate age of one year (Table 1).

Table 1. Descriptive statistics for birth weight (kg) and body weights (kg) up to one year
Preglednica 1. Opisna statistika za rojstno maso (kg) in telesne mase (kg) do enega leta starosti

	Sex / Spol	Male / Biki	Female / Telice
Birth Rojstvo	n BW ± SD, kg	171 47.7 ± 6.6	148 46.0 ± 6.1
Beginning of grazing season Začetek paše	n WB ± SD, kg Age / Starost ± SD, days / dni	146 95.9 ± 25.4 59.5 ± 24.0	123 91.7 ± 26.3 57.5 ± 24.37
Middle of grazing season Sredina paše	n WM ± SD, kg Age / Starost ± SD, days / dni	135 201.7 ± 48.6 144.4 ± 30.4	110 194.6 ± 47.5 147.8 ± 31.8
End of grazing season Konec paše	n WE ± SD, kg Age / Starost ± SD, days / dni	144 270.6 ± 51.9 204.5 ± 30.9	124 251.4 ± 52.7 202.1 ± 34.8
Average age of one year Povprečna starost eno leto	n WY ± SD, kg Age / Starost ± SD, days / dni	114 453.3 ± 54.9 358.33 ± 10.6	88 371.0 ± 52.2 403.7 ± 52.0

BW – birth weight / rojstna masa; WB – body weight at the beginning of grazing season / telesna masa ob začetku paše; WM – body weight in the middle of grazing season / telesna masa na sredini paše; WE – body weight at the end of grazing season / telesna masa na koncu paše; WY – body weight at the age of one year / telesna masa ob starosti enega leta; n – number of calves / število telet; SD – standard deviation / standardni odklon

Methods

Variance and covariance components were estimated by REML procedures using the VCE-5 package (Kovač *et al.*, 2002). The fixed effects in the model [1] differed among traits. The effects of sex, parity, and year of birth were included in models for all traits. Age of calves at the beginning of grazing season was included as linear regression in models for all traits except for the birth weight. Age of calves in the middle, at the end of grazing season, and age at one year were included as linear regression in the models for corresponding weights. Direct additive genetic effect was treated as random effect in the models for all traits.

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{Zu} + \mathbf{e} \quad [1]$$
$$E(\mathbf{y}) = \mathbf{X\beta} \quad [2]$$
$$var(\mathbf{y}) = \mathbf{V} = \mathbf{ZGZ'} + \mathbf{R} \quad [3]$$
$$var(\mathbf{u}) = \mathbf{G} = \mathbf{A} \otimes \mathbf{G}_0 \quad [4]$$
$$var(\mathbf{e}) = \mathbf{R} = \sum^{\otimes} \mathbf{R}_{0i} \quad [5]$$

Where:

$\mathbf{y}$ = vector of observations
$\mathbf{X}$ = incidence matrix for fixed effects
$\boldsymbol{\beta}$ = vector of parameters for fixed effects
$\mathbf{Z}$ = incidence matrix for random effects
$\mathbf{u}$ = vector of random direct additive genetic effects
$\mathbf{e}$ = residual vector
$\mathbf{V}$ = phenotypic matrix of variances and covariances
$\mathbf{G}$ = matrix for variances and covariances of additive genetic effect
$\mathbf{G_0}$ = matrix for variances and covariances of genetic effect among five traits
$\mathbf{A}$ = relationship matrix
$\mathbf{R}$ = matrix for residual variances and covariances
$\mathbf{R_0}$ = matrix for residual variances and covariances among traits

Expected value for observations [2] was equal to the fixed part of the model. Phenotypic matrix of variances and covariances had two components [3] – additive genetic and residual variance. Matrix with genetic variances and covariances [4] was a Kronecker product between the relationship matrix and matrix of genetic effect among five traits. Covariance matrix of residuals [5] was block-diagonal matrix, where matrices R_{0i} were different due to missing measurements for same weights. We assumed the residuals to be identical, independent and normally distributed. Covariances between genetic and environmental effects were assumed to be zero and no variances due to dominance or epistatic effect were assumed to exist.

RESULTS AND DISCUSSION

For the first time genetic variances, covariances and heritabilities were estimated for Charolais population in Slovenia. Although the herd was small in comparison with literature data, genetic parameters belonged to the animals in Slovenian environmental conditions. Genetic variances of BW, WB, WM, WE and WY were 21.78 kg^2, 56.42 kg^2, 303.23 kg^2, 365.47 kg^2 and 457.13 kg^2, respectively (Table 2). Bennett and Gregory (1996) found lower genetic variance for BW (13.12 kg^2) and for weight on 200 days (106.86 kg^2) on Charolais calves. Covariance between BW and weight on 200 days was also estimated by Bennett and Gregory (1996) and was lower (14.42 kg^2) compared to covariance between BW and WE (57.68 kg^2) in our study. Crews *et al.* (2004) also found lower genetic variance of BW and at 205 days weight for Canadian Charolais cattle, which was 11.02 kg^2 and 188.80 kg^2, respectively. Genetic and phenotypic standard deviations (SD) of our research were computed for easier interpretation and comparison with literature. Genetic standard deviations were 4.67 kg, 7.51 kg, 17.41 kg, 19.12 kg and 21.38 kg for BW, WB, WM, WE and WY, respectively. Lower genetic standard deviation for BW (2.45 kg) had Charolais calves reared in Czech Republic (Jakubec *et al.*, 2003), who also had lower genetic SD (16.53 kg) for weight at 210 days, compared to SD for WE. Říha *et al.* (2001) reported of lower SD (16.00 kg) for weight at 120 days in comparison with SD for WM.

Table 2. Genetic variances, phenotypic variances, genetic covariances (above diagonal) and phenotypic covariances (below diagonal) among BW, WB, WM, WE and WY

Preglednica 2. Genetske variance, fenotipske variance, genetske kovariance (nad diagonalo) in fenotipske kovariance (pod diagonalo) med BW, WB, WM, WE in WY

	σ^2_g, kg^2	σ^2_{ph}, kg^2	Covariance / Kovariance, kg^2				
			BW	WB	WM	WE	WY
BW	21.78	35.29		14.98	35.21	57.68	63.47
WB	56.42	240.41	37.26		83.94	94.68	55.70
WM	303.23	866.34	52.44	295.19		322.13	331.40
WE	365.47	1280.21	66.37	328.04	880.60		381.38
WY	457.13	1952.64	78.02	332.00	828.17	1131.08	

σ^2_g – genetic variance / genetska varianca, σ^2_{ph} – phenotypic variance / fenotipska varianca, BW – birth weight / rojstna masa; WB – body weight at the beginning of grazing season / telesna masa ob začetku paše; WM – body weight in the middle of grazing season / telesna masa na sredini paše; WE – body weight at the end of grazing season / telesna masa na koncu paše; WY – body weight at the age of one year / telesna masa ob starosti enega leta

Phenotypic variance of BW, WB, WM, WE and WY were 35.29 kg^2, 240.41 kg^2, 866.34 kg^2, 1280.21 kg^2 and 1952.64 kg^2, respectively (Table 2). Phocas and Laloë (2004) estimated lower phenotypic variances for BW (20.0 kg^2) and for weaning weight (1141 kg^2) in Charolais calves reared in France. In a large study, Donoghue and Bertrand (2004) compared phenotypic variance for BW and for weaning weight of Charolais calves reared in four countries. Phenotypic variance for BW and weaning weight were 18.24 kg^2 and 686.58 kg^2 for calves in Australia, 23.08 kg^2 and 838.94 kg^2 for calves in Canada, 18.05 kg^2 and 721.25 kg^2 for calves in the USA, and 25.90 kg^2 and 930.74 kg^2 for calves reared in New Zealand. However, phenotypic variances for BW and weaning weight in herds from different countries shown, that we estimated higher values for phenotypic variances. Phenotypic variance for BW (20.95 kg^2) and weaning weight (837.50 kg^2) in Charolais calves in Canada were also estimated by Crews *et al.* (2004). The only suitable explanation could be environmental conditions.

Phenotypic standard deviations in Charolais calves of our study were computed from phenotypic variance and were 5.94 kg, 15.50 kg, 29.43 kg, 35.78 kg and 44.19 kg for BW, WB, WM, WE, and WY, respectively. Říha *et al.* (2001) reported of lower SD for BW (4.92 kg), but higher SD for weight at 120 days (32.00 kg) and weight at 210 days (43.00 kg) in Charolais calves reared in Czech Republic, compared to SD for WM and WE. On the other hand, Jakubec *et al.* (2003) reported of SD for BW (4.90 kg), weight at 210 days (33.05 kg) and weight at 365 days (52.73 kg) in Charolais calves also reared in Czech Republic.

Heritabilities estimated in this study were between 0.23 and 0.62 (Table 3). The highest heritability was estimated for BW. Phocas and Laloë (2004) estimated lower heritability for BW (0.33) and for weaning weight (0.13) in Charolais calves. Their research included much larger number of calves from 236 herds compared to our 319 calves from one herd. This could be one of the reasons for the difference in estimated heritability. On the other hand, Bennett and Gregory (1996) reported heritability 0.43 for BW, 0.16 for 200-day weight and, 0.34 for 368-day weight in Charolais calves. Only the heritability for weight at 368 days (0.34) was higher than heritability for WY (0.23) in our study. Donoghue and Bertrand (2004) compared heritabilities for BW and weaning weight of Charolais calves reared in four countries. Heritability for BW and weaning weight were 0.34 and 0.22 for calves in Australia, 0.55 and 0.27 for calves in Canada, 0.47 and 0.25 for calves in the USA, and 0.31 and 0.21 for calves reared in New Zealand. Similar to our results, heritability for BW (0.62) and weaning weight (0.29) had calves in Canada (0.55 for BW) and (0.27 for weaning weight). Crews *et al.* (2004) also estimated similar heritability for BW (0.53) and for weaning weight (0.23) for Canadian Charolais calves compared to our estimation.

Table 3. Heritabilities (on the diagonal) for BW, WB, WM, WE, WY, genetic correlations (above diagonal) and phenotypic correlations (below diagonal) among them with standard errors

Preglednica 3. Heritabilitete (na diagonali) za BW, WB, WM, WE in WY in genetske (nad diagonalo) ter fenotipske korelacije (pod diagonalo) med njimi s standardnimi napakami

	BW	WB	WM	WE	WY
BW	0.62 ± 0.06	0.43 ± 0.20	0.43 ± 0.15	0.65 ± 0.14	0.64 ± 0.14
WB	0.40	0.23 ± 0.09	0.64 ± 0.15	0.66 ± 0.15	0.35 ± 0.25
WM	0.30	0.65	0.35 ± 0.08	0.97 ± 0.03	0.89 ± 0.08
WE	0.31	0.59	0.84	0.29 ± 0.07	0.93 ± 0.07
WY	0.30	0.48	0.64	0.72	0.23 ± 0.07

BW – birth weight / rojstna masa; WB – body weight at the beginning of grazing season / telesna masa ob začetku paše; WM – body weight in the middle of grazing season / telesna masa na sredini paše; WE – body weight at the end of grazing season / telesna masa na koncu paše; WY – body weight at the age of one year / telesna masa ob starosti enega leta

However, Duangjinda *et al.* (2001) estimated heritability for weaning weight (0.33) for Charolais calves included in American International Charolais Association. Although different method for heritability estimation was used, the results were very similar to heritability for WE (0.29) estimated in our study.

Genetic correlations among weights were positive and ranged from 0.35 to 0.97 (Table 3). On the other hand, phenotypic correlations ranged between 0.30 and 0.84. The lowest genetic correlation (0.35) was between WB and WY, but the highest one (0.97) was between WM and WE. That genetic correlation showed, that we would quite good estimate WE with WM. BW was more highly correlated with WE and WY (0.65, 0.64) than with WB and WM (0.43 for both). Estimated correlation between BW and WE was 0.65, and was higher compared to the correlation between BW and weaning weight (0.39) estimated by Phocas and Laloë (2004). Crews *et al.* (2004) also found lower genetic correlation (0.33) between BW and weaning weight.

CONCLUSIONS

Genetic parameters for body weights of Charolais calves were estimated for the first time in Slovenia. Data used in our study was collected for a ten year period in a herd reared on the Educational and Research Animal Husbandry Centre Logatec. Genetic and phenotypic variances for body weights estimated in our study were higher compared to literature, because the herd was genetically very heterogeneous and very suitable for intensive selection. The herd was included in a suckler herd recording scheme. With the intention to promote genetic progress, each year, semen of the best sires is imported from France for artificial insemination of best cows in the herd. Higher phenotypic variances could be explained with very changeable environmental conditions in Logatec. It was difficult to successfully adapt the management of the herd to changes in environmental conditions. However, heritabilities for birth weight and for weaning weight were similar or slightly higher to those reported in literature. They might be higher, because of high genetic variances for body weights of genetically very variable calves.

POVZETEK

Krave dojilje predstavljajo v Sloveniji 40 % staleža vseh krav. Najbolj razširjena pasma krav v čredah dojilj je lisasta, v manjši meri pa slovenska rjava. V zadnjem času se povečuje tudi število čistopasemskih čred krav dojilj mesnih pasem šarole in limuzin. Prve živali pasme šarole so bile v Slovenijo uvožene iz Francije v letu 1965. Kontrola in selekcija v čredah pasme šarole postaja vedno bolj intenzivna. Z namenom preprečevanja inbridinga in za doseganje hitrejšega genetskega napredka v čistopasemskih čredah se za osemenjevanje uporablja seme najboljših bikov šarole pasme iz Francije.

V raziskavi smo proučili rast pri teletih šarole pasme. Ocenili smo genetske parametre za rojstno maso, telesno maso na začetku, sredini in koncu paše ter ob starosti enega leta. Podatke smo zbrali od 319 šarole telet (171 ♂, 148 ♀) vzrejenih na Pedagoško – raziskovalnem centru za živinorejo Logatec. Teleta so bila rojena v letih 1995 do 2005 v zimsko-pomladanski telitveni sezoni. Paša je v povprečju trajala od maja do oktobra. Konec paše je sovpadal z odstavitvijo. Zapisi o poreklu so vključevali starše in stare starše telet, skupaj 377 živali.

Komponente varianc in kovarianc so bile ocenjene z REML proceduro s paketom VCE-5. Sistematski vplivi v modelu 1 so se razlikovali glede na lastnost. Vplivi spola, zaporedne telitve in leta rojstva so bili vključeni v model za vse lastnosti. Starost telet na začetku paše je bila vključena kot linearna regresija v modele za vse lastnosti z izjemo modela za rojstno maso. Starost telet na sredini in na koncu paše ter ob enem letu je bila kot linearna regresija vključena v modele za pripadajoče telesne mase. Direktni aditivni genetski vpliv je bil vključen kot naključni vpliv v modele za vse lastnosti.

Variance, kovariance in heritabilitete za telesne mase so bile s to raziskavo prvič ocenjene za teleta šarole pasme v Sloveniji. Genetske in fenotipske variance za telesne mase ocenjene v naši raziskavi (pregl. 2) so bile večje v primerjavi s podatki iz literature. Vzrok je v genetsko zelo raznoliki čredi, ki je zelo primerna za intenzivno selekcijo. Velike fenotipske variance bi lahko razložili z zelo spremenljivimi vplivi okolja v Logatcu. Ocenjene heritabilitete za telesne mase so bile med 0,23 in 0,62 (pregl. 3). Največja je bila za rojstno maso. Tudi heritabilitete so bile večje v primerjavi s podatki iz literature. Eden izmed vzrokov bi lahko bilo večje število čred z večjim številom telet v čredah vključenih v podobne raziskave v literaturi v primerjavi z eno čredo v naši raziskavi. Genetske korelacije med telesnimi masami so bile pozitivne, v rangu od 0,35 do 0,97.

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