Estimation of genetic parameters for body weight in Charolais calves in Slovenia

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ABSTRACT

The aim of the present study was to estimate genetic parameters for growth traits of Charolais calves in Slovenia. Analysed traits included birth weight (BW), weight at the beginning (WB) and at the end of grazing season (WE), as well as yearling weight (WY). Data were collected on 340 Charolais calves. The total number of records, including pedigree data (parents and grandparents) was 401 animals. (Co)variance components were estimated by REML method for the animal model that included fixed effects of sex, parity and year of birth 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 at the end of grazing season, and age at approximately one year were included as linear regression in the models for corresponding weights. Random effects included direct and maternal additive genetic effects. Direct heritabilities ($h^2_a$) were decreased from 0.74 at birth to 0.19 at yearling weight. Inversely, maternal heritabilities ($h^2_m$) were increased from 0.04 at birth to 0.12 at all other included weights. Direct-maternal genetic correlation ($r_{am}$) was negative for all weights except for yearling weight (0.10).

Key words: Body weight, Charolais calves, (Co)variance components, Heritability.

RIASSUNTO

STIMA DEI PARAMETRI GENETICI RELATIVI AL PESO CORPOREO SU VITELLI CHAROLAIS ALLEVATI IN SLOVENIA

Il fine di questo studio è stato quello di stimare i parametri genetici relativi ai caratteri di accrescimento di vitelli Charolais in Slovenia. I caratteri analizzati comprendevano il peso alla nascita (BW), il peso all’inizio (WB) e alla fine (WE) della stagione di pascoloamento, il peso ad un anno di età (WY). Sono stati raccolti i dati da 340 vitelli Charolais, ma il numero totale di rilievi, inclusi i dati di pedigree (parents e grandparents) era riferito a 401 soggetti. Le componenti della (co)varianza sono state stimate attraverso il metodo REML per un animal model che includeva gli effetti fissi del sesso, del numero di parti e dell’anno di nascita nei modelli relativi a tutti i caratteri esaminati. L’età dei vitelli all’inizio della stagione del pascolo è stata inclusa come regressione lineare nei modelli relativi a tutti i caratteri eccetto il peso alla nascita.
Čepon et al.

Introduction

Regarding the natural resources in Slovenia, the most acceptable rearing technology for suckler cows is based on forage. In the last few years the number of cows in suckler herds has been increasing and the number of small farms with market milk production has been decreasing. The most important breeds for beef production in Slovenia are breeds with high consumption ability and with excellent feed conversion. One of such breeds is the Charolais which is widespread on permanent grassland with lower quality forage.

A number of studies have been carried out in different parts of the world on larger populations of Charolais and some other beef cattle breeds. A very useful review of published genetic parameter estimates for beef production traits were given by Koots et al. (1994a) and Koots et al. (1994b). Direct heritabilities for weaning weight of different beef breeds were reported to range between 0.13 and 0.33 (Bennett and Gregory, 1996; Duangjinda et al., 2001; Crews et al., 2004; Donoghue and Bertrand, 2004; Phocas and Laloe, 2004) while direct heritability for yearling weight was 0.34 (Bennett and Gregory, 1996). On the other hand in Slovenia, there is only one study that has reported genetic parameters for Charolais and Limousine calves to date (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, the genetic parameters were preliminarily estimated for Charolais calves in one of the Slovenian herds. A large number of suckler herds will be included in the estimation of genetic parameters in the future and the results will be used in the Slovenian selection schemes.

The aim of this study was to estimate the genetic parameters for weight at the end of grazing season and yearling weight in Charolais calves. Birth weight and weight at the beginning of grazing season were also analysed.

Material and methods

Data

Body weight of 340 Charolais calves (183 males and 157 females) was recorded. Calves were born in years 1995 to 2007 in late winter or spring calving season from January to June. They were reared at the Educational and Research Animal Husbandry Centre Logatec (Slovenia). The most calves (60-96%) were born in February and March, while 3-36% in January and in April 3-19% of calves were born in all the studied years. Individual births (1-2) were also recorded in May and June. Those few calves were put on pasture after the beginning of grazing season on average three weeks after calving. 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
Genetic parameters for body weight

The analysed traits included birth weight (BW), body weight at the beginning of grazing season (WB), body weight at the end of grazing season/weaning weight (WE), as well as yearling weight (WY). On average, calves were weighed four times: at birth, twice during grazing season (beginning and end) and at the approximate age of one year. The number of weight records was the highest at birth (340), while at the beginning of grazing the number of animals was lower (291) because of mortality after birth due to pneumonia and diarrhoea. During grazing only two animals were lost due to injuries. A lot of animals were sold after weaning; therefore, the number at one year is lower (224) (Table 1).

Besides animal measurements, pedigree data included sires (28), dams (36) and grandparents (79). In the analysed period, 28 sires had progeny in the herd. Sires in natural mating (8) had more progeny (274)

Table 1. Descriptive statistics for birth weight (kg) and body weights (kg) up to one year.

| Sex       | Male   |   | Female  |   |
|-----------|--------|---|---------|---|
| Birth:    |        |   |         |   |
| Calves    | n      | 183| 157     |   |
| Weight    | kg ± SD| 48.0± 6.6| 46.3± 5.9|
| Beginning of grazing season: |        |   |         |   |
| Calves    | n      | 158| 133     |   |
| Weight    | kg ± SD| 98.9± 27.9| 94.8± 29.4|
| Age       | days ± SD| 59.7± 23.8| 57.7± 24.4|
| End of grazing season: |        |   |         |   |
| Calves    | n      | 156| 133     |   |
| Weight    | kg ± SD| 276.6± 55.4| 258.8± 58.5|
| Age       | days ± SD| 206.9± 31.7| 208.6± 41.8|
| Average age of one year: |        |   |         |   |
| Calves    | n      | 126| 98      |   |
| Weight    | kg ± SD| 458.3± 55.8| 370.3± 52.8|
| Age       | days ± SD| 358.4± 10.4| 421.7± 57.4|

SD: standard deviation.
compared to 20 AI sires with 66 progeny.

**Statistical analysis**

Fixed part of the model was determined by the least square method using the GLM procedure (SAS Institute Inc, 2001). The statistically significantly fixed effects in the model differed among traits. The effects of sex, parity, and year of birth were included in models for all traits ([1], [2], [3], [4]). The age of calves at the beginning of grazing season was included as linear regression in models for WB, WE and WY. The age of calves at the end of grazing season and the age at one year were included as linear regression in models [3] and [4] for WE and WY. Model [1] was used for the estimation of birth weight, model [2] for the estimation of weight at the beginning, model [3] for the weight at the end of grazing season and model [4] for the yearling weight in the analysis.

\[ y_{ijkl} = \mu + S_i + P_j + Y_k + a_{ijkl} + m_{ijkl} + e_{ijkl} \quad [1] \]

\[ y_{ijklm} = \mu + S_i + P_j + Y_k + b_I(x_{ijkl} - \bar{x}) + a_{ijklm} + m_{ijklm} + e_{ijklm} \quad [2] \]

\[ y_{ijklm} = \mu + S_i + P_j + Y_k + b_I(x_{ijkl} - \bar{x}) + b_{II}(w_{ijkl} - \bar{w}) + a_{ijklm} + m_{ijklm} + e_{ijklm} \quad [3] \]

\[ y_{ijklm} = \mu + S_i + P_j + Y_k + b_I(x_{ijkl} - \bar{x}) + b_{II}(z_{ijkl} - \bar{z}) + a_{ijklm} + m_{ijklm} + e_{ijklm} \quad [4] \]

where:

- \( y_{ijkl} \) = birth weight (BW), kg;
- \( y_{ijklm} \) = body weights (WB, WE, WY), kg;
- \( S_i = \) sex; \( i = 1, 2; \)
- \( P_j = \) parity; \( j = 1, 2, 3; \)
- \( Y_k = \) year; \( k = 1, \ldots 13; \)
- \( x_{ijkl} = \) age of calves at the beginning of grazing season, days;
- \( w_{ijkl} = \) age of calves at the end of grazing season, days;
- \( z_{ijkl} = \) age of calves at approximately one year, days;
- \( a_{ijkl}, a_{ijklm} = \) direct additive genetic effect;
- \( m_{ijkl}, m_{ijklm} = \) maternal additive genetic effect;
- \( e_{ijkl}, e_{ijklm} = \) residual.

Random part of the model covered direct and maternal additive genetic effects. Variance and covariance components were estimated by REML method using the VCE-5 package (Kovač et al., 2002).

\[ y = X\beta + Z_\alpha a + Z_m m + e \]

where \( y \) is a vector of records, \( \beta \) is a vector of unknown parameters for fixed effects, \( a \) and \( m \) are vectors of random direct genetic and maternal genetic effects, respectively, and \( e \) is a vector of random residual effects. Incidence matrices relate observations for the fixed (X), direct genetic (\( Z_\alpha \)) and maternal genetic effects (\( Z_m \)). Genetic correlations were assumed between direct and maternal genetic effects.

**Results and discussion**

The (co)variance components and heritabilities of direct and maternal effects were estimated for BW, WB, WE and WY for Charolais calves in Slovenian environmental conditions. Direct genetic variances of BW, WB, WE and WY were 24.04 kg², 69.78 kg², 349.25 kg² and 395.71 kg², respectively (Table 2). Bennett and Gregory (1996) found lower direct genetic variances for BW of Charolais (13.12 kg²), Angus (4.66 kg²), Gelbvieh (12.09 kg²), Hereford (10.22 kg²), Limousine (9.93 kg²) and Red Poll cattle (13.92 kg²). They reported direct genetic variances for adjusted 200-day weights which were also lower compared to WE (208 days in average) in this study. Two hundred-day weights \( \sigma_a^2 \) were 106.86 kg² in Charolais, 107.21 kg² in Angus, 210.36 kg² in Gelbvieh, 118.13 kg² in Hereford, 140.10 kg² in Limousine, and 157.33 kg² in Red Poll cattle (Bennett and Gregory, 1996). The similarity in maternal
Genetic variances for BW between these and literature data were found. Maternal genetic variance for BW of Charolais in this study was 1.15 kg², while Bennett and Gregory (1996) found 1.22 kg² in Hereford, 1.40 kg² in Limousine and 1.70 kg² in Charolais breed. However, maternal genetic variances for 200-day weight (Bennett and Gregory, 1996) were lower for Charolais (78.94 kg²), Angus (62.80 kg²), Gelbvieh (67.82 kg²), Hereford (102.94 kg²), Limousine (73.58 kg²) and Red Poll cattle (23.00 kg²) compared to $\sigma^2_m$ for WE in this study (149.61 kg²). Also Crews et al. (2004) found lower maternal genetic variance for the adjusted 205-days weight (83.67 kg²). Covariances between the direct and maternal genetic effects were negative for BW, WB, WE, and positive for WY (Table 2). Negative covariances between the direct and maternal genetic effects were found also by Crews et al. (2004) for BW (-2.95 kg²) and for the adjusted 205-days weight (-47.32 kg²) in Charolais breed.

Genetic and phenotypic standard deviations (SD) were computed for easier interpretation and comparison with the literature. Genetic standard deviations were 4.90 kg, 8.35 kg, 18.69 kg and 19.89 kg for BW, WB, WE and WY, respectively. A smaller genetic standard deviation for BW (2.45 kg) had Charolais calves reared in the Czech Republic (Jakubec et al., 2003), who also had a smaller genetic SD (16.53 kg) for the weight at 210 days, compared to the genetic SD for WE in this study.

Phenotypic variances of BW, WB, WE and WY were 32.35 kg², 209.69 kg², 1205.76 kg² and 2029.92 kg², respectively (Table 2). Phocas and Laloe (2004) estimated smaller phenotypic variances for the BW of Charolais (20.0 kg²), Limousine (7.5 kg²), Blonde d’Aquitaine (22.49 kg²), Maine-Anjou (15.41 kg²) and for the weaning weight of Charolais (1141 kg²), Limousine (662 kg²), Blonde d’Aquitaine (1006 kg²) and Maine-Anjou breed (1118 kg²) compared to the phenotypic variances for BW and WE for Charolais calves reared in Slovenia. In a large study, Donoghue and Bertrand (2004) compared the phenotypic variance for BW and for the weaning weight of Charolais calves reared in four countries. Phenotypic variances for BW and weaning weight were 18.24 kg² and 686.58 kg² for calves in Australia, 23.08 kg² and 838.94 kg² for calves in Canada, 18.05 kg² and 721.25 kg² for calves in the USA, and 25.90 kg² and 930.74 kg² for calves reared in New Zealand. However, phenotypic variances for BW and weaning weight in herds from different countries show that we estimated higher values for phenotypic variances.

Phenotypic standard deviations in Charolais calves were 5.69 kg, 14.48 kg, 34.72 kg and 45.05 kg for BW, WB, WE, and WY,

|                | $\sigma^2_a$ (kg²) | $\sigma^2_m$ (kg²) | $\sigma_{a,m}$ (kg²) | $\sigma^2_p$ (kg²) |
|----------------|--------------------|--------------------|----------------------|-------------------|
| BW             | 24.04              | 1.15               | - 1.81               | 32.35             |
| WB             | 69.78              | 25.76              | - 25.73              | 209.69            |
| WE             | 349.25             | 149.61             | - 67.49              | 1205.76           |
| WY             | 395.71             | 244.39             | 30.59                | 2029.92           |

BW: Birth weight; WB: Body weight at the beginning of grazing season; WE: Body weight at the end of grazing season; WY: Yearling weight.
respectively. Říha et al. (2001) reported a smaller phenotypic SD for BW (4.92 kg) and larger phenotypic SD for 210-days weight (43.00 kg) in Charolais calves reared in the Czech Republic, compared to the phenotypic SD for WE in this study. Very similar phenotypic SD were found by Jakubec et al. (2003) for BW (4.90 kg), 210-days weight (33.05 kg) and 365-days weight (52.73 kg) in Charolais from the Czech Republic.

Direct heritabilities \( h_a^2 \) were estimated between 0.74 and 0.19 (Table 3). The highest direct heritability (0.74) was estimated for BW. However, Phocas and Laloe (2004), Bennett and Gregory (1996), Crews et al. (2004) estimated lower heritability for BW 0.33, 0.43, 0.53, respectively. Donoghue and Bertrand (2004) also found lower direct heritabilities for BW of Charolais calves reared in Australia (0.34), Canada (0.55), in New Zealand (0.47) and in USA (0.21) compared to this results. A similarly high direct heritability for BW (0.66) found Bennett and Gregory (1996) in Red Poll cattle, while lower direct heritabilities were found in Limousine 0.38 (Phocas and Laloe, 2004) and 0.47 (Bennett and Gregory, 1996), as well as in Blonde d’Aquitaine 0.37 and Maine-Anjou breed 0.28 (Phocas and Laloe, 2004). Lower \( h_a^2 \) for BW were also found in Angus 0.26 and Gelbvieh 0.38 (Bennett and Gregory, 1996) compared to findings in this study. Additionally, Koch et al. (1994) and Bennett and Gregory (1996) found also lower \( h_a^2 \) for BW (0.46, 0.54) in Hereford breed.

Estimated \( h_a^2 \) for weight at the beginning of grazing and weight at the end of grazing season (WE) were very similar, 0.33 and 0.29, respectively. Estimated \( h_a^2 \) for weight at the end of grazing is similar to \( h_a^2 \) for weaning weight (at 208 days in average) of Charolais cattle reared in Canada (0.27) and in New Zealand (0.25) (Donoghue and Bertrand, 2004). Similar \( h_a^2 \) for weaning weight compared to this study was estimated also by Duangjinda et al. (2001), 0.33 in Charolais and 0.28 in Gelbvieh, but lower (0.24) in Hereford cattle. On the other hand, the lowest \( h_a^2 \) for weaning weight in Hereford (0.16) found Koch et al. (1994) and Phocas and Laloe (2004) in Charolais breed (0.13). The same or quite similar \( h_a^2 \) for a 200-days weight compared to our Charolais cattle had also Limousine (0.29) and Blonde d’Aquitaine (0.32) found by Phocas and Laloe (2004) and Red Poll (0.34), Gelbvieh (0.33), Limousine (0.26), Angus breed (0.25) found by Bennett and Gregory (1996). Nevertheless, quite high \( h_a^2 \) for weaning weight found Lengyel et al. (2004) in Charolais cattle reared in Hungary (0.57), as well as Goyache et al. (2003) in Asturiana de los Valles beef cattle (0.67) in Spain.

Direct heritability for yearling weight (0.19) was the lowest compared to literature data. Bennett and Gregory (1996) found \( h_a^2 \)

| Table 3. | Direct heritability (\( h_a^2 \)), maternal heritability (\( h_m^2 \)), correlation between direct and maternal component (\( r_{am} \)) for BW, WB, WE and WY. |
|---------|------------------|------------------|----------|
|         | \( h_a^2 \)      | \( h_m^2 \)      | \( r_{am} \) |
| BW      | 0.74             | 0.04             | -0.35    |
| WB      | 0.33             | 0.12             | -0.61    |
| WE      | 0.29             | 0.12             | -0.30    |
| WY      | 0.19             | 0.12             | 0.10     |

**BW**: Birth weight; **WB**: Body weight at the beginning of grazing season; **WE**: Body weight at the end of grazing season; **WY**: Yearling weight.
Genetic parameters for body weight

for a 368-day weight in Charolais (0.34), Angus (0.42), Gelbvieh (0.47), Hereford (0.27), Limousine (0.40) and Red Poll cattle (0.54). Also Koch et al. (1994) and Ferreira et al. (1999) found higher $h^2_a$ for WY in Hereford breed, 0.44 and 0.30, respectively.

Maternal heritability ($h^2_m$) was also estimated (Table 3). Ferreira et al. (1999) indicated that the included maternal genetic effect decreased the estimated direct heritability and best fit the data for the estimation of variances and covariances. In our herd of Charolais calves $h^2_m$ for BW was only 0.04, while for other traits (WB, WW, WY) it was 0.12. Koch et al. (1994) estimated similar $h^2_m$ for BW in Hereford (0.08), as well as Phocas and Lalóë (2004) in Maine-Anjou cattle (0.08), while other authors found higher $h^2_m$ for BW compared to this study. Donoghue and Bertrand (2004) found higher $h^2_m$ for BW of Charolais in Australia (0.13), Canada (0.18), New Zealand (0.13) and USA (0.18). Higher $h^2_m$ for BW were also found for Charolais (0.11), Limousine (0.11), and Blonde d’Aquitaine cattle (0.10) in the study of Phocas and Lalóë (2004).

Maternal heritability for WE (0.12) was comparable to the estimations for weaning weight of Charolais breed in Australia (0.12) and New Zealand (0.14) (Donoghue and Bertrand, 2004), as well as maternal heritability for a 210-days weight in Limousine (0.12) and Blonde d’Aquitaine cattle (0.13) reported by Phocas and Lalóë (2004). Higher $h^2_m$ for BW of Charolais were also found in Hungary (0.32), Goyache et al. (2003) for Asturiana de los Valles (0.32), and Koch et al. (1994) for Hereford breed (0.17).

Lower $h^2_m$ for weaning weight was reported for Gelbvieh 0.08 (Duangjinda et al., 2001) and Maine-Anjou 0.07 (Phocas and Lalóë, 2004). Likewise $h^2_m$ for WY was 0.12 and was higher than $h^2_m$ found in Hereford cattle 0.06 (Koch et al., 1994).

Correlations between direct and maternal genetic components ($r_{am}$) were negative for BW (-0.35), WB (-0.61) and WE (-0.30) (Table 3). The only positive $r_{am}$ was found for WY (0.10). Similar or lower $r_{am}$ for BW and adjusted 205-days weight (WE) were reported by Donoghue and Bertrand (2004) in Charolais from Australia (-0.24, -0.68), Canada (-0.39, -0.33), New Zealand (-0.29, -0.33) and USA (-0.39, -0.58), respectively. Likewise $r_{am}$ for BW in other beef calves were similar or a little lower. Phocas and Lalóë (2004) found $r_{am}$ for BW in Charolais (-0.41), Limousine (-0.59), Blonde d’Aquitaine (-0.49) and Maine-Anjou calves (-0.39). On the other side Koch et al. (1994) found positive $r_{am}$ for BW (0.13) and negative $r_{am}$ for adjusted weaning weight at 200-days (-0.28) in Hereford calves. Quite different $r_{am}$ for the actual weaning weight were reported by Lengyel et al. (2004) in Hungarian Charolais (-0.95), Goyache et al. (2003) for Asturiana de los Valles (-0.76) as well as Phocas and Lalóë (2004) in Maine-Anjou calves for the adjusted 210-days weaning weight (-0.09). Correlation between direct and maternal genetic component for WY was 0.10 and was very similar to $r_{am}$ found by Koch et al. (1994) in Hereford calves.

Conclusions

Genetic parameters for body weights of Charolais calves were estimated for the first time in Slovenia. Data used in this study was collected during 13 years in a herd reared on the Educational and Research Animal Husbandry Centre Logatec. Direct and maternal genetic, as well as phenotypic variances for body weights at different ages estimated in the study were larger compared to the literature. The herd was included in a suckler herd recording scheme. With the intention to promote genetic progress, each year, semen of the genetically superior sires is imported from France for artificial insemination of the best cows in the herd. Larger phenotypic var-
iances could be explained with very changeable environmental conditions in Logatec, which lies on the border of mild Mediterranean and cold Alpine climates. However, direct and maternal heritabilities for birth weight and for weaning weight were similar to or slightly higher than those reported in the literature. Those genetic parameters were preliminarily estimated for Charolais calves in one of the Slovenian herds. In the future, more suckler herds will be included in the estimation of genetic parameters and breeding values will be estimated for sires of the Charolais breed.

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