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SHORT COMMUNICATION

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Genetic parameters for post-weaning visual scores and reproductive traits in Suffolk sheep

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Abstract

The aim of this study was to estimate the coefficients of heritability and genetic correlations among visual scores (conformation, C_{PW}; precocity, P_{PW}; musculature, M_{PW}) and reproductive traits: age at first lambing (AFL) and scrotal circumference (SC) evaluated at 180 days of age in Suffolk lambs. In the statistical model only the additive genetic effect was considered as random effect. The heritability estimates by univariate analyses for C_{PW}, P_{PW}, M_{PW}, AFL and SC were 0.08, 0.12, 0.09, 0.20 and 0.22, respectively. The genetic correlations among AFL and C_{PW}, P_{PW}, M_{PW} were -0.26, 0.19, and 0.08, respectively. The genetic correlation among SC and C_{PW}, P_{PW}, M_{PW} were, respectively, 0.54, 0.88 and 0.86, and between AFL and SC was 0.26. The direct selection for conformation, precocity and musculature at 180 days of age and age at first lambing will provide slow genetic progress due to low heritability estimates. It is possible to obtain genetic gain in sexual precocity through selection on scrotal circumference in Suffolk rams. The favorable genetic correlation among visual scores and SC and between C_{PW} and AFL, indicated the possibility to gain in genetic progress for reproductive traits through indirect selection of the visual scores in Suffolk sheep.

Additional keywords: conformation; genetic correlation; heritability; musculature; sexual precocity.

Abbreviations used: ADAM (dam age); AFC (age at first calving); AFL (age at first lambing); C_{PW} (conformation); M_{PW} (musculature); P_{PW} (precocity); SC (scrotal circumference).

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Introduction

Visually assessed traits, such as conformation (C_{PW}), precocity (P_{PW}) and musculature (M_{PW}), have been included in beef cattle breeding programs in order to select the animals with higher meat yield, since selection based only on body weight would not be enough (Faria *et al.*, 2009). Furthermore, it is expected an improvement on the selection efficiency by avoiding long-legged individuals and animals with inadequacy in their muscular development (Kippert *et al.*, 2006). In addition, reproductive efficiency of the ewes, which is associated to the number of weaned lambs per dam and to the overall herd profitability, is considered one of the most important factors in lamb production systems (Kern *et al.*, 2010). The age at first lambing (AFL) is a common and easy-to-measure selection criterion which is related to the age at puberty (Montoya, 2010). It is worth to mention that the younger the ewe at first lambing, the longer is its reproductive life, resulting in more offspring produced and faster return on investment (Short *et al.*, 1994). Other traits such as lambing intervals, litter size and litter weight could also be included as selection criteria (Mokhtari *et al.*, 2010; Vanimisetti & Notter, 2012; Zishiri *et al.*, 2013). However, due to lack of data in Brazilian sheep production, it is necessary the use of correlated traits to obtain better results in reproduction.

Male reproductive traits have also been widely used as selection criteria, mainly because they have larger progenies, and therefore, the prediction of their genetic values is more accurate. It is well known that scrotal circumference (SC) is often favorably correlated to both weigh performance and AFL (Toe *et al.*, 2000). Thus, in order to achieve better results in a breeding program, coefficients of genetic correlation between growth and reproductive traits and the prediction of correlated responses to selection should drive the inclusion of growth and reproductive traits on selection indexes (Boligon *et al.*, 2008).

The aim of this study was to estimate the genetic parameters for conformation, precocity, musculature, age at first lambing, and scrotal circumference in Suffolk lambs at 180 days of age.

Material and methods

Data edition

Data from 4,315 Suffolk lambs born between 1992 and 2007 in a commercial herd (Sementes e Cabanha Butiá Ltda., in Passo Fundo – Rio Grande do Sul, −28°15′46″, −52°24′24″) in Southern Brazil were analyzed. A single qualified evaluator observed the visual traits as follows: The capacity of meat production through the size (length) of the animal's trunk at the time of evaluation was defined as C_{PW}. The body development, represented by ribs arching and legs structure, was used to assess P_{PW} scores. Lastly, M_{PW} was evaluated as the muscle development on the main cuts, such as leg and shoulder. The scores were assigned from 1 to 5 for C_{PW}, P_{PW} and M_{PW}, according to the medium animal (score 3) within each contemporary group.

Subsets of 1,815 males (offspring of 84 rams and 618 ewes) and 1,041 females (offspring of 78 rams and 494 ewes) were used for SC and AFL evaluation, respectively. Animals weighing less than 20 or more than 70 kg at 180 days of age (W180), younger than 130 days or older than 240 days of age (A180), and those born to ewes older than 10 years old (ADAM) were excluded from the dataset. After edition, records from 1,987 individuals for C_{PW}, P_{PW} and M_{PW}, 827 females for AFL and 1,160 males for SC were used for statistical analyses. The summary of pedigree information for Suffolk sheep is presented in Table 1.

Previously, the means and standard deviations obtained for the traits in Suffolk sheep were calculated and could be observed in Table 2.

Statistical analyses

A linear animal model was used in order to estimate the variance and covariance components for C_{PW}, P_{PW}, M_{PW}, AFB and SC using Wombat software (Meyer, 2007). The model was:

Table 1. Summary of pedigree information for Suffolk sheep

Item	N	%
Individuals in total	2,255	100.0
Individuals in data file	1,987	95.8
Individuals without offspring	1,353	62.6
Individuals with offspring	807	37.4
Individuals with unknown sire	183	8.1
Individuals with unknown dam	258	11.4
Individuals with both parents unknown	3	0.1
Sires	105	4.6
Dams	702	31.1
Sires with progeny in data	105	4.6
Sires with records and progeny in data	47	2.1
Dams with progeny in data	702	31.1
Dams with records and progeny in data	587	26.0
Inbred individuals	1,450	64.3

$$Y = X\beta + Za + \varepsilon$$

where Y is the vector of observed phenotypes, β and *a* are vectors of fixed and additive genetic effects, respectively, X and Z are incidence matrices associated with each corresponding effect, and ε is the vector of random residual effects, assumed to be normally distributed.

The model for C_{PW}, P_{PW}, M_{PW}, included the fixed effects of year and type of lambing (single or multiple) and, as covariates, the linear effect of animal age (AA), and linear and quadratic effects of dam age (ADAM). Regarding to AFL, the model included as fixed the effects of first lambing and type of lambing, and linear and quadratic effects of the dam age at the moment of the ewe's first lambing (ADEFL) as covariates. Type of lambing was considered to be single or multiple due to the high number of twin pregnancies (93%) and low number of triple lambing (7%). The maternal permanent environmental effect was not included in the

Table 2. Means and standard deviations of traits in Suffolk sheep.

Trait	Females	Males
Weight at 180 days of age, kg	45.2 ± 8.8	48.7 ± 9.2
Yearling age, days	187 ± 20	186 ± 19
Average age of dam at lambing, yr	3.7 ± 1.7	-
The dam age at the moment of the ewe's first lambing, yr	5.68 ± 1.7	-
Average age at first lambing, months	23.93 ± 6.9	
Scrotal circumference, cm	-	31.1 ± 4.0

analyses because it was noticed that the majority of the sheep (58%) farrowed only once, so including this effect could erroneously influence the genetic parameters. According to Maniatis & Pollott (2003), the estimation of maternal effects and their correlation with the direct effect depends on the pedigree relationships.

For SC model, the contemporary group (CG, animals born at same year and management group) was considered as fixed, whereas linear effect of animal age (A180) and linear and quadratic effects of weight adjusted for 180 days (W180) were included as covariates.

To evaluate the genetic correlations between productive and reproductive traits were analyzed the combinations: C_{PW} × AFL, P_{PW} × AFL, M_{PW} × AFL, C_{PW} × SC, P_{PW} × SC, M_{PW} × SC and SC × AFL.

Results and discussion

The variance and covariance components for C_{PW}, P_{PW} and M_{PW}, obtained from bivariate analyses including AFL and SC are presented in Table 3. The heritability coefficients obtained by uni and bivariate analyzes were similar for C_{PW}, P_{PW}, M_{PW}, and SC, 0.08 ± 0.03, 0.12 ± 0.03, 0.10 ± 0.03 and 0.22 ± 0.07, respectively. To AFL the estimates of the heritability were moderate (0.20 ± 0.06) with uni and low to high with bivariate analyzes, therefore, the most probably value for the heritability is that closer to the value obtained in the univariate model. It was observed low coefficients of heritability for C_{pw} and M_{pw}, which were combined with high environmental variations. This could indicate a strong influence of non-genetic factors on the visually assessed traits, thus limiting the response to direct selection. For P_{PW}, AFL and SC it was observed moderate coefficients of heritability, indicating that faster genetic progress could be obtained.

The genetic correlation between C_{PW} and AFL was negative, moderate and favorable, indicating that selection for C_{PW} can reduce the average age at first lambing, and therefore, improving the sexual precocity of the flock. Among P_{PW} and AFL, and, M_{PW} and AFL the correlations were of low magnitude, positive and unfavorable, then, higher scores of P_{PW} and M_{PW} will also increase the AFL in the ewes.

The genetic correlation coefficients between SC and the visual traits were high, positive and favorable, suggesting that selection for SC will result in a correlated response for C_{PW}, P_{PW} and M_{PW} through indirect selection, or vice-versa. Furthermore, the correlation between SC and AFL was moderate, positive and unfavorable, showing that selection for SC may have negative correlated response on sexual precocity of females, as observed by Martínez-Velázquez *et al.* (2003) with information of 12 *Bos taurus* breeds at the Meat Animal Research Center (USDA).

It is clear that the late exposure of females to reproduction resulted in higher average AFL, which can be justified by the reproductive management adopted by the Brazilian farming systems. Mating strategies, such as the identification of precocious females (*e.g.* AFL at 1 year old) would decrease the AFL mean (Snowder, 2007). Furthermore, breeding younger ewes would increase their reproductive lifespan (Kern *et al.*, 2010), favoring discard rates and replacement costs (Mekkawy *et al.*, 2009). Although prolificacy in Suffolk sheep is maximal between 4 and 5 years of age (Notter, 2000), it is important to expose the females to reproduction earlier, as this will allow the identification of the early females.

Similar to the variance components results obtained, Qureshi *et al.* (2010) estimated low coefficient of heritability (0.13) for AFL in Kajli sheep, a Pakistanian dual-purpose breed, indicating small genetic gain by

Table 3. Components of (co)variance for conformation (C_{PW}), precocity (P_{PW}), musculature (M_{PW}), age at the first lambing (AFL) and scrotal circumference (SC), obtained by bivariate analyses, for Suffolk sheep.

	C_{PW} × AFL	P_{PW} × AFL	M_{PW} × AFL	C_{PW} × SC	P_{PW} × SC	M_{PW} × SC	SC × AFL
σ^2_{a1}	0.06	0.06	0.08	0.05	0.17	0.08	1.03
σ^2_{a2}	0.04	0.04	0.04	1.30	1.09	1.25	17.81
σ^2_{e1}	0.61	0.71	0.60	0.60	0.64	0.63	4.42
σ^2_{e2}	0.58	0.58	0.58	4.46	4.67	4.47	18.09
h^2_1 ± SE	0.09 ± 0.05	0.08 ± 0.05	0.11 ± 0.06	0.08 ± 0.05	0.21 ± 0.06	0.12 ± 0.05	0.19 ± 0.07
h^2_2 ± SE	0.07 ± 0.05	0.07 ± 0.05	0.07 ± 0.05	0.23 ± 0.07	0.19 ± 0.06	0.22 ± 0.07	0.49 ± 0.11
$\sigma_{a1,2}$	-0.01	0.01	0.00	0.14	0.38	0.28	1.13
$\sigma_{e1,2}$	0.04	0.05	0.01	0.15	0.10	0.00	0.00
$r_{g1,2}$ ± SE	-0.26 ± 0.47	0.19 ± 0.49	0.08 ± 0.44	0.54 ± 0.29	0.88 ± 0.16	0.86 ± 0.20	0.26 ± 0.23

σ^2_a = additive genetic variance; σ^2_e = environmental variance; h² = heritability; SE = standard error; $\sigma_{a1,2}$ = genetic covariance, $\sigma_{e1,2}$ = environmental covariance, and $r_{g1,2}$ = genetic correlation between the first and second traits.

direct selection. The low genetic variances observed for reproductive traits could reflect the high influence of environmental effects (Rosati *et al.*, 2002).

Regarding the visually accessed traits, Janssens & Vandepitte (2004) observed that the Suffolk sheep musculature had moderate heritability (0.29) which could be used as a selection criterion for carcass yield, while heritability for growth traits ranged from 0.34 and 0.57. However, their results differed from the obtained in the present study probably because the authors used a larger scale scores (1 to 9), allowing greater variability among the evaluated animals, which may have resulted in higher variance.

Genetic association between AFL and body development has been reported in beef cattle. For instance, Boligon & Albuquerque (2010) estimated the genetic correlation between age at first calving (AFC) and visually assed traits (conformation, precocity and musculature) at 550 days of age in Nelore. The coefficients (SE) were -0.21 (0.02), -0.26 (0.01) and -0.18 (0.03), for the three cited traits, respectively. The authors concluded that there was an association between body development and reproductive traits, thus selection for visual scores could affect the response to selection for age at first calving. Based on the moderate and favorable genetic correlations between SC and visual traits, the authors concluded that direct selection for SC could be more efficient, although the selection for the visual traits could also influence fertility and sexual precocity. It is worth to mention that visual traits definition varies from study to study.

For SC, the coefficient of heritability estimated in this study (Table 3) was low to moderate and reflects the lack of genetic variability at 180 days of age. Also, the results obtained were lower compared to those estimated from other breeds, such as Rambouillet (0.41) (Matos *et al.*, 1992), Highlander (0.45) (Toe *et al.*, 2000) and Makooei (0.32) (Abbasi & Ghafouri-Kesbi, 2011). Furthermore, Fossceco & Notter (1995) and Al-Shorepy & Notter (1996) showed that coefficients of heritability vary according to the age of the animals, and suggested that measurements at 90 days of age would be the most adequate selection criterion due to the higher genetic variability.

Regarding the genetic correlation between SC and AFL, a moderate, positive and unfavorable estimate was obtained. This result differ from that reported by Toe *et al.* (2000), who obtained high, negative and favorable (-0.57 and -0.78 at 9 and 12 months, respectively) in Highlander sheep and concluded that selection for SC is efficient to obtain genetic gain on sexual precocity of females. These differences could also be by the fact of assuming different parameters in the model.

The main focus of this study was to explore the genetic correlation between visually assessed and reproduction traits in a Brazilian Suffolk sheep herd, since animals have been often selected due to their conformation, precocity and musculatures scores. The direct selection for conformation, precocity e musculature at 180 days of age and age at first lambing will result in a slower genetic progress, probably due to the high influence of environmental effects. For scrotal circumference, it is possible to obtain genetic gain in sexual precocity through direct selection in Suffolk rams while promoting genetic gain for conformation, precocity and musculature. Also, the selection for age at first lambing will provide favorable correlated response to selection on conformation in Suffolk sheep.

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