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Genetic relationships between weight gain and feeding behaviour of ad libitum-fed pigs and weight gain of heavy pigs under restricted feeding

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RIASSUNTO – Correlazioni genetiche tra il comportamento alimentare di suini in regime *ad libitum* e l'accrescimento di suini pesanti sottoposti ad alimentazione ristretta. *Obiettivo di questo studio è stata la stima delle correlazioni genetiche intercorrenti tra l'accrescimento (cDG) di suini ibridi pesanti sottoposti a alimentazione ristretta e accrescimento (pDG), consumo (DFI) e comportamento alimentare di suini di linea pura alimentati ad libitum. I caratteri di comportamento alimentare considerati sono stati il tempo giornaliero di alimentazione (TV), il numero di pasti (NM) e la velocità di ingestione (FR). Sono stati analizzati i dati di 1.136 suini ibridi e 2.272 suini di linea pura testati in stazioni di controllo alimentare automatizzate. I suini ibridi e puri erano progenie dei medesimi padri. Tutti i caratteri hanno presentato stime di ereditabilità superiori a 0,3. La correlazione genetica più elevata (0,937) è risultata quella tra i due caratteri di accrescimento. Sono state ottenute stime di correlazione genetica di media entità tra cDG e caratteri di comportamento alimentare, ma caratterizzate da errori standard tendenzialmente elevati.*

KEY WORDS: pigs, feeding behaviour, weight gain, genetic correlations.

INTRODUCTION – Pig breeding in Italy aims to obtain heavy pigs for production of typical cured end products. Detailed guidelines related to animals, weight, age, feeding regime, carcass and fresh ham traits impose constraints on this type of production. The definition of the breeding goal is performed at the level of commercial pigs, which, in many cases, are crossbred animals originated by crossing of 3 or 4 pure lines. Fattening of commercial pigs for dry cured ham production is commonly based on the use of restricted feeding. Evaluation of purebred breeding candidates for live traits relies on performance testing programs where individual recording of voluntary feed intake and feeding behaviour traits is made feasible by the use of automated feeding stations and *ad libitum* feeding. Appropriate use of phenotypic information on live traits of performance tested purebred pigs fed *ad libitum* for improving crossbred performance under restricted feeding requires estimates of genetic correlations for traits of relevance.

The aim of the present study was to estimate genetic parameters and to analyse genetic relationships between weight gain, feed intake and feeding behaviour traits of *ad libitum*-fed purebred pigs and weight gain of crossbred heavy pigs under restricted feeding.

MATERIAL AND METHODS – Individual weight records of 1,136 crossbred pigs (594 castrated males and 542 gilts) were collected over a 270-d test. Crossbred pigs were progeny of 34 C21 Gorzagri boars and 121 Large White-derived crossbred sows. For each animal the first weight was recorded at 60 d of age and then sequentially at 30-d intervals up to slaughtering. The dataset contained from 6 to 8 weight records per pig. The pigs were grouped by sex in 65 different fattening groups. Individual weight gain (cDG) was computed as the slope of the linear regression of individual weights on age (cDG). A second set of data contained records on weight gain (pDG), feed intake (DFI) and feeding behaviour traits of 2,272 Gorzagri C21 purebred pigs which were progeny of the same boars which originated crossbred pigs. These data were collected during a performance testing program using automated feeding stations which ended when pigs were 120-d old (average weight 130 kg). Pigs were fed ad libitum and feeding behaviour traits were: number of meals per day (NM), feeding time per day (TV), and feeding rate (FR) calculated as the ratio of DFI to TV. Crossbred and purebred traits were analysed with different animal models. For cDG the model was:

$$cDG_{ijkl} = \mu + animal_i + FG_j + WEA_k + \varepsilon_{ijkl}$$

where:

cDG_{ijkl} = individual weight gain (kg/d), μ = intercept, $animal_i$ = additive genetic effect of the pig, FG_j = fixed effect of the fattening group (65 groups), WEA_k = fixed effect of age at weaning (5 classes), and ε_{ijkl} = random residual.

For purebred traits the model was:

$$y_{ijkl} = \mu + animal_i + TG_j + CLAGE_k + \varepsilon_{ijkl}$$

where:

y_{ijkl} = an observation on pDG, DFI, TV, NM or FR, μ = intercept, $animal_i$ = additive genetic effect of the pig, TG_j = fixed effect of the group of testing (date of start of test-feeding station, 293 levels); $CLAGE_k$ = fixed effect of class of age at the start of test (7 levels); and ε_{ijkl} = random residual. Pedigrees were traced back for as many generations as possible. Estimation of heritabilities and genetic correlations was based on multiple traits REML procedures. Heritability was also estimated for each trait using univariate procedures. Estimates of variance components were obtained using VCE software (Groeneveld, 1990).

RESULTS AND CONCLUSIONS – Descriptive statistics and univariate heritability estimates for each investigated trait are reported in table1.

Table 1. Descriptive statistics and univariate estimates of heritability.

Trait	N	Mean ± S.D.	C.V. (%)	Univariate h^2 ± S.E. (%)
cDG, kg/d	1,136	0.59 ± 0.05	6.51	48.2 ± 5.6
DFI, kg/d	2,272	2.58 ± 0.54	14.86	46.2 ± 5.0
TV, min./d	2,272	51.85 ± 11.16	17.43	56.6 ± 4.9
NM	2,272	14.25 ± 6.13	38.88	37.5 ± 5.1
FR, kg/min.	2,272	0.05 ± 0.01	18.48	44.7 ± 4.9
pDG, kg/d	2,272	0.86 ± 0.13	9.64	31.5 ± 4.6

Average daily weight gain for crossbred pigs under restricted feeding was 0.59 kg/d whereas that of purebred pigs was 0.86 kg/d. These differences are related to the use of different feeding regimes and to different final age of animals at the end of testing. On average purebred pigs had 14 meals per day and spent 51 minutes per day for feeding. Laze visits at the feeding station, i.e. visits with less than 10 grams consumed, were not considered when computing individual NM. Variation of NM was high (C.V. = 39%) and the frequency distribution for this trait was skewed, showing a long right tail. Rate of feed intake was 50 grams per minute.

Univariate estimates of heritability for these traits ranged from 31.5 to 56.6% and standard errors of the parameters were around 5%. These estimates were within the range of values found in literature (Huisman, 2002; Suzuki *et al.*, 2002). The estimated heritability of daily weight gain for crossbred pigs (cDG) was greater than that for purebred pigs (pDG). It should be noted that under unrestricted feeding weight gain is a measure of growth potential, but it is an indirect measure of residual efficiency when a restriction on feeding is practised. Hence, pDG and cDG, albeit computed in the same way, are different traits. Heritability estimates of feeding behaviour traits were high. However, use of these traits in selection programs aiming to improve crossbred performance is strictly related to the existence of a exploitable genetic covariance with crossbred performance.

Heritability and genetic correlations estimates for crossbred and purebred traits obtained in the multivariate analysis are reported in table 2. Estimated heritability for all traits was quite similar to those obtained in the univariate analysis. Estimates of the genetic correlation between cDG and purebred traits showed high standard errors with the exception of the correlation between cDG and pDG. Despite being very high (0.94), this correlation was not 1 and confirmed that cDG and pDG are different traits.

Table 2. Estimates (%) of heritability (diagonal) and genetic correlations (above diagonal) for the investigated traits.

	cDG	pDG	DFI	TV	NM	FR
cDG	48.3 ± 5.8	93.7 ± 10.2	76.0 ± 13.8	10.2 ± 19.0	-64.6 ± 21.4	49.0 ± 16.0
pDG		31.9 ± 3.8	78.0 ± 3.4	26.8 ± 7.5	-44.2 ± 7.9	30.9 ± 7.9
DFI			45.5 ± 4.6	49.0 ± 5.2	-33.6 ± 7.7	29.0 ± 7.1
TV				55.7 ± 4.6	9.9 ± 8.6	-68.5 ± 3.8
NM					35.4 ± 4.5	-44.9 ± 7.9
FR						42.1 ± 4.0

According to the estimated genetic correlations, an increase of DFI and FR and a reduction of NM in the purebred population should lead to an increase of cDG of crossbred heavy pigs under restricted feeding. However, due to large standard errors of estimates, these relationships need to be reconsidered under availability of more phenotypic information. As expected, genetic relationships between traits of purebred animals were estimated more precisely. Under *ad libitum* feeding, genetic relationships between daily weight gain (pDG) and feeding behaviour traits were similar to those obtained for cDG, but the magnitude of the correlation with NM and FR was smaller and that with TV was greater than for cDG.

In conclusion, this study provided estimates of genetic parameters and relationships between weight gain of crossbred heavy pigs under restricted feeding and weight gain and feeding behaviour traits of purebred pigs fed *ad libitum*. Estimated heritability and genetic correlations indicate that feeding behaviour traits and weight gain recorded on purebred animals fed *al libitum* might be used as selection criteria to improve growth performance of crossbred heavy pigs under restricted feeding. However, genetic correlations need to be reconsidered after accumulation of more phenotypic information.

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