

MEASURING EFFECTS OF NEW AND FAST INBREEDING ON THE LITTER SIZE OF IBERIAN PIGS

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ABSTRACT

Inbreeding and inbreeding depression are consequences of parental relationship which cannot be easily eluded in small populations of farm animals such as those of local breeds. The distinction between new (F_{new}) and old (F_{old}) inbreeding or between slow and fast rates of inbreeding (ΔF) may improve the understanding of inbreeding depression, particularly in reproductive traits and other related to fitness. The analysis of litter size records of 6,854 litters from 1,988 sows of an Iberian pig line, genetically closed from 1963, showed a remarkable impact of new and fast inbreeding on this trait. A significant negative effect on litter size of a 10% of F_{new} was inferred with a posterior mean (and SD) of -0.205 (0.010) piglets per litter (Posterior $Prob. > 0 = 0.020$), whereas the effect of F_{old} was irrelevant: 0.568 (0.446) piglets ($PP > 0 = 0.900$). A significant effect of -0.030 (0.013) piglets ($PP > 0 = 0.007$) of a rate of new inbreeding of 1% per generation was found. These results may be useful to many practical issues in conservation or selection programs of some breeds or lines of Mediterranean pigs.

Key words: Iberian pig / litter size / new inbreeding / inbreeding depression

1 INTRODUCTION

Inbreeding depression exists in some degree in all the populations and it is often observed in reproductive and fitness traits (Falconer, 1989). An understanding of inbreeding depression is relevant to many practical issues in conservation programs and animal husbandry. In livestock species, evidence for the inbreeding effects comes partially from data recorded in progressively inbred populations (Burrow, 1993). Both simulation and empirical studies show that the level of inbreeding depression may depend upon the rate of inbreeding by generation (ΔF), with the faster rates having more negative impact (Wang *et al.*, 1999; Wang, 2000; Pedersen *et al.*, 2005). Slow inbreeding would lead to a smaller impact for a given inbreeding coefficient (Lacy and Ballou, 1998). Moreover, Wang *et al.* (1999) suggest that the effects of recent inbreeding may represent the impact of new mutations,

whereas the ancient deleterious recessive alleles could have been purged in the population.

The goal of this study was to compare the effects on litter size of metrics of ancient and recent inbreeding and of their respective rates by generation in a closed line of Iberian pigs. To obtain accurate inferences about inbreeding effects, data were analysed using a Bayesian procedure which takes into account all the available information and allows a joint analysis of (co)variance components, systematic effects and breeding values (Rodríguez *et al.*, 1998).

2 MATERIAL AND METHODS

Litter size data (number of piglets born) were collected in an experimental farm (CIA Dehesón del Encinar, Oropesa, Spain) on 6,854 litters born along five decades from 1,988 sows of the Torbiscal composite line

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of the Iberian pig breed, genetically isolated from 1963. The complete genealogy of this strain and their ancestors was available, containing 2,907 triads (individual-sire-dams). The inbreeding coefficient (F) and the number of discrete generation equivalents (EqG_i) were calculated for each individual i respect to a base generation of unknown parents (Wooliams and Mäntysaari, 1995). A partition of these inbreeding coefficients in two components, new ($F_{new,i}$) and old ($F_{old,i}$) inbreeding was performed with respect to an intermediate generation t according to Hinrichs *et al.* (2007). The approximate individual inbreeding rate by generation is calculated according to the expression proposed by Gutiérrez *et al.* (2009): $\Delta F_i = 1 - \sqrt[EqG_i-1]{F_i}$.

Litter size records were analyzed using a repeatability animal model:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\mathbf{u} - \mathbf{W}\mathbf{p} + \mathbf{e}$$

where \mathbf{y} represents the vector of reproductive data; \mathbf{X} , \mathbf{Z} and \mathbf{W} are known incidence matrices relating systematic ($\boldsymbol{\beta}$) and random (\mathbf{u} and \mathbf{p}) effects to \mathbf{y} ; \mathbf{u} , \mathbf{p} and \mathbf{e} are the vectors of random additive genetic, permanent environmental and residual effects, respectively. The systematic effects in $\boldsymbol{\beta}$ were parity order (six levels: 1st to 5th and ≥ 6 th) and the combinations of fourth seasons by two farrowing buildings (eight levels) and as covariate one of five inbreeding metrics (F , F_{old} , F_{new} , ΔF and ΔF_{new}) in separate analyses. To obtain accurate inferences about inbreeding effects data were analysed by a procedure of Bayesian inference using the Gibbs sampling algorithm implemented in the TM software (Legarra *et al.*, 2008). The usual location and dispersion parameters were cal-

culated from saved samples of marginal posterior distributions of the parameters of interest.

3 RESULTS AND DISCUSSION

The Torbiscal line proceeds from the admixture of four ancient strains of Iberian pigs: the Portuguese Red strains Ervideira and Caldeira and the Black Hairless strains Campanario and Puebla from Extremadura (Spain), with about eight equivalent complete generations registered in the pedigree. Inbreeding coefficients (F) were decomposed in old and new (F_{old} and F_{new}) inbreeding components with respect to this eight generation. The evolution of the inbreeding coefficients and their two components averaged by generation equivalent is described in Fig. 1.

According to the performed mating system avoiding the mating between relatives, during the first three generation equivalents of the Torbiscal line (generations eight to ten), the individual F_{new} values were zero whereas the F and F_{old} inbreeding values were identical. Along the fifth and later generation equivalents, the averaged F and F_{new} inbreeding values increase in a similar way and a small negative trend may be observed for the F_{old} values. The deviation from the linearity of the evolution of F and F_{new} values reflect some changes of the number of reproducers and the moderate selection performed in the initial step of this line.

The mean and standard deviation (SD) of the total number of born piglets in the data base were 8.35 and 2.32 piglets per litter, respectively. Results of the performed analysis of litter size records provide Bayesian in-

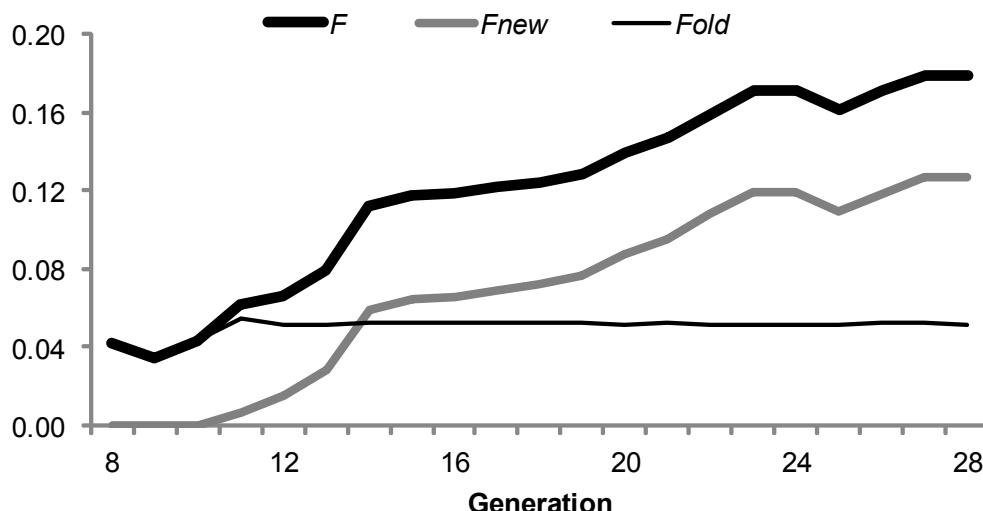


Figure 1: Average inbreeding coefficient (F) and old and new (F_{old} , F_{new}) inbreeding components by successive equivalent discrete generations of Torbiscal Iberian pig line

Table 1: Basic statistics of the regression coefficients (b) on the number of piglets born per litter of different inbreeding metrics

Inbreeding effect, b	Posterior Mean	Posterior SD	95% HPD	Posterior Probability ($b > 0$)
Effect of a 10% of inbreeding				
F	-0.166	0.101	-0.358 / 0.029	0.045
F_{old}	0.557	0.449	-0.292 / 1.430	0.900
F_{new}	-0.204	0.099	-0.401 / -0.008	0.021
Effect of a rate of 1% per generation				
ΔF	-0.028	0.013	-0.052 / -0.026	0.014
ΔF_{new}	-0.030	0.013	-0.056 / -0.006	0.007

95% HPD = 95% of highest posterior density interval

ferences about genetic parameters and systematic effects. The posterior means (and PSD) of heritability and coefficient of permanent environmental effects were $h^2 = 0.093$ (0.017) and $p^2 = 0.057$ (0.016).

The posterior means (and PSD) of the different individual inbreeding metrics were 0.120 (0.049), 0.051 (0.009), 0.069 (0.048), 0.007 (0.003) and 0.004 (0.003) for F , F_{old} , F_{new} , ΔF and ΔF_{new} , respectively. The effects on litter size of these five inbreeding metrics measured as their respective regression coefficients on this trait are summarized in Table 1. The comparison among the effects of different F coefficients shows a significant influence on the inbreeding depression both of total and new inbreeding, being insignificant the impact of old inbreeding. The most significant effect corresponds to the new inbreeding, accumulated between the fifth and later equivalent generations. The comparison between the rates by generation shows similar negative significant effects of the new and total inbreeding, indicating a greater impact of fast versus slow inbreeding.

An additional analysis using a model fitting two inbreeding metrics (F_{old} and F_{new}) as covariates was carried out to get a joint inference about the relative effects on litter size of old and new inbreeding. The results confirm the above results showing a significant negative effect of a 10% of F_{new} with a posterior mean (and PSD) of -0.205 (0.010) piglets per litter ($PP > 0 = 0.020$). However, a negligible positive effect of F_{old} was inferred: 0.568 (0.446) piglets ($PP > 0 = 0.900$). This ensemble of results may be relevant to optimize the genetic management of conservation or selection programs of some small breeds or lines of Mediterranean pigs.

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5 REFERENCES

- Burrow H.M. 1993. The effects of inbreeding in beef cattle. Animal Breeding Abstracts, 61: 737–751
- Falconer D.S. 1989. Introduction to quantitative genetics. Essex, Longman: 438 p.
- Gutiérrez J.P., Cervantes I., Goyache F. 2009. Improving the estimation of realized effective population sizes in farm animals. Journal of Animal Breeding and Genetics, 126: 327–332
- Hinrichs D., Meuwissen T.H.E., Ødegård J., Holt M., Vangen O., Wooliams J.A. 2007. Analysis of inbreeding depression in the first litter size of mice in a long-term selection experiment with respect to the age of the inbreeding. Heredity, 99: 81–88
- Lacy R., Ballou J.D. 1998. Effectiveness of selection in reducing the genetic load in populations of *Peromyscus Polionotus* during generations of inbreeding. Evolution, 52: 900–909
- Legarra A., Varona L., López de Maturana E. 2008. TM Threshold model. <http://snp.toulouse.inra.fr/~alegarra/manu-altm.pdf>
- Pedersen K.S., Kristensen P.N., Loeschke V. 2005. Effect of inbreeding and rate of inbreeding in *Drosophila melanogaster*: HSP70 expression and fitness. Journal of Evolutionary Biology, 18: 756–762
- Rodríguez J., Toro M.A., Rodríguez M.C., Silió L. 1998. Effect of founder allele survival and inbreeding depression on litter size in a closed line of Large White pig. Animal Science, 67: 573–582
- Wang J., Hill W.G., Charlesworth D., Charlesworth B. 1999. Dynamic of inbreeding depression due to deleterious mutations in small populations: mutation parameters and inbreeding rate. Genetical Research, 74: 165–178
- Wang J. 2000. Effects of population structures and selection strategies on the purging of inbreeding depression due to deleterious mutations. Genetical Research, 76: 75–86
- Wooliams J.A., Mäntysaari E.A. 1995. Genetic contributions of Finnish Ayrshire bulls over four generations. Animal Science, 61: 177–187