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Effects of rapid inbreeding on sow fertility traits in a closed herd of Swedish Landrace

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ABSTRACT

In this study we analyzed the effects of rapid inbreeding, calculated from three generations long pedigrees, on fertility traits of sows. The analysis was based on 72 inbred (ranging from inbreeding coefficient 3.12% to 31.25%) and 89 non-inbred sows of Swedish Landrace and all fertility traits were related to the first litter. The analysis was done by regressing fertility traits on inbreeding coefficients (univariate models). The effect of the age of sow at the first successful conception (fixed) was also included into regression models. The available data did not let us to consider the effects of litter inbreeding. When dependent variable was litter size (total number born and number born alive) and number at weaning, the linear regression model was applied. Dependent variables that were distributed according to Poisson distribution, as it was case for the number born dead, mortality during weaning and total number of inseminations, were analyzed by generalized linear regression models assuming Poisson distribution. Significant inbreeding depression was obtained for total number born (b=-0.103, P<0.001), number born alive (b=-0.0910, P<0.01), number at weaning (b=-0.078, P<0.01) as well as the number born dead (P<0.01). On the other hand, significant inbreeding depression was not present for the total number of inseminations (P=0.867) and mortality during weaning (P=0.068). Thus, it was shown that higher inbreeding of sows leads to the reduced fertility.
(Keywords: inbreeding depression, litter size, piglet mortality)

INTRODUCTION

Mating of animals with a common ancestor is defined as inbreeding and is unavoidable in closed populations. The reduction of the population mean for fertility and fitness traits such as are litter size, survival, birth weight, weaning weight is one of the consequences of inbreeding and is empirically observed phenomenon in a large number of livestock populations, see *Fredeen* (1956) for pigs, *Lamberson* and *Thomas* (1984) for sheep, *Burrow* (1993) for beef cattle, and *Miglior* (1994) for dairy cattle. However, the genetic basis of inbreeding depression is still unclear (*Lynch* and *Walsh,* 1997) and a number of topics, from genetic models (*Lynch* and *Walsh,* 1997) to statistical design (*Curik et al.,* 2001, 2002), still remain to be answered. In the large number of studies related to the inbreeding depression in pigs (*Dickerson et al.,* 1954; *Bereskin et al.,* 1968; *Toro et al.,* 1988; *Rodriguez et al.,* 1994; *Culberson et al.,* 1998; *Rodriganez et al.,* 1998; *Belic,* 2001), this topic was mostly studied through statistical analysis of the relationship between dam and/or litter inbreeding coefficient and fertility traits (total number born, total number born alive and total number at weaning) as well as of the relationship between dam and/or litter inbreeding coefficient and fitness traits (weight at birth and weaning weight). In this study, we also included the total number born dead, mortality at weaning and total number of inseminations (all related to the first litter) as traits of interest. Thus, the aim of this research was to estimate the effects of rapid inbreeding in sows on a larger number of traits related to the fertility (total number born, number born alive, number born dead, total number of inseminations, number at weaning and mortality during weaning) using a closed Swedish Landrace herd.

MATERIALS AND METHODS

All animals included into analysis were kept at the Agromeđimurje farm in a closed herd of Swedish Landrace. The analysis was based on 72 inbred (ranging from inbreeding coefficient 3.12% to 31.25%) and 89 non-inbred sows and all studied traits were related to the first litter. Inbreeding coefficients of the sows were calculated following the concept of path coefficients as defined by *Wright* (1922) and were related to the three generations long pedigrees. The effects of inbreeding were analyzed by the linear regression (univariate model) of the dependent variables (total number born, number born alive, number born dead, total number of inseminations, number at weaning and mortality during weaning) on the inbreeding coefficients of the sows. The effect of the age of sow at the first successful conception was divided in three classes (from 178 to 223 days, from 224 to 253 days and older then 253 days) and included into regression models as a fixed effect (except for the model with total number of inseminations). The effects of interaction between fixed variable and inbreeding were also analyzed in all models but as being non-significant they were not further presented. The assumptions of the models were explored through descriptive analysis of the residuals (normality and heterogeneity). For the following traits: number born dead, total number of inseminations and mortality during weaning as dependent variables the assumptions of the models (normality) were not satisfied. For that reason, those three variables were analyzed by Poisson regression (generalized linear models). General linear models (PROC GLM) were used when the analysis was related to the variables that were normally distributed. Otherwise, we used generalized linear models (PROC GENMOD) which assume a Poisson distributed error and with log as a link function. Descriptive statistics of the traits included in the analysis is shown in *Table 1*. All analyses were performed with the SAS statistical package (*SAS Institute,* 1996).

Table 1

Descriptive statistics of the traits used in the analysis (n=161)

Variable	Mean	Variance	Minimum	Maximum
Inbreeding coefficient of the sow	4.658	55.681	0	31.250
Total number of inseminations	1.540	0.875	1	5
Age at successful insemination	246.348	1932.840	178	433
Total number born	7.752	7.388	2	16
Number born alive	7.516	7.914	1	16
Number born dead	0.236	0.606	0	6
Number at weaning	7.025	6.124	1	13
Mortality during weaning	0.491	0.514	0	6

RESULTS AND DISCUSSION

The estimated effects of the relationship between sow fertility and inbreeding coefficients of the sow are given in *Table 2* for the total number born, number born alive and number at weaning and in *Table 3* for the number born dead, total number of inseminations and mortality during weaning. All six analyzed effects were negatively related to the increase of inbreeding (mathematically positive relationship between sow inbreeding and total number of inseminations is biologically considered as negative). While significant effects of sow inbreeding were observed for the total number born (P=0.0002), number born alive (P=0.0014), number at weaning (P=0.002) and number born dead (P=0.0069), the effects were not significant for the total number of inseminations (P=0.867) and mortality during weaning (P=0.068).

Table 2

Effects of sow inbreeding on the litter size and number at weaning for the first litter

Variable	Parameter estimate	SE	Lower 95% CL	Upper 95% CL
Total number born	-0.103**	0.027	-0.130	-0.076
Number born alive	-0.091*	0.028	-0.119	-0.063
Number at weaning	-0.078*	0.025	-0.103	-0.053

Parameter estimates are related to linear regression coefficient and 1% change in the inbreeding coefficient of the sow; CL=confidence limit; P values were related to the two sided t-test (P<0.01, ** P<0.001)*

Table 3

Effects of sow inbreeding on the number born dead, total number of inseminations and mortality during weaning for the first litter

Variable	Parameter estimate	Robust SE	Lower 95% CL	Upper 95% CL
Total number of inseminations	0.001	0.008	-0.015	0.018
Number born dead	-0.088*	0.041	-0.168	-0.008
Mortality during weaning	-0.032	0.019	-0.069	0.005

Parameter estimates are obtained by Poisson regression (generalized linear model) and are related to the 1% change in the inbreeding coefficient of the sow; CL=confidence limit; P values were related to the Likelihood ratio statistics for type 3 analysis (P<0.05)*

The biological explanation is that litter size in mammals may be affected by inbreeding of mother, through a decrease in the number of eggs released, mortality caused by lethal genes or through changes in the intrauterine environment. The estimates observed in this study (see *Table 2* and *3*) were around three to fourfold larger then those estimated in other studies (*Dickerson et al.,* 1954; *Bereskin et al.,* 1968; *Toro et al.,* 1988; *Rodriguez et al.,* 1994; *Culberson et al.,* 1998; *Rodriganez et al.,* 1998). There are several speculations why such a strong inbreeding depression has been observed in this study. The simplest explanation is the small sample size. Further, in this study only the effects of inbreeding through three generations were studied and it might happen that the effects of the same level of inbreeding are more detrimental when inbreeding is achieved through close connections (rapid) in comparison to the inbreeding that is achieved through remote connections (slow), as it was hypothesized by *Cothran et al.* (1994) and *Curik et al.* (submitted) and demonstrated by *Wiener et al.* (1992). The fact that the effects of litter inbreeding were not included might also be the potential reason for a higher estimates (more negative). Unfortunately, in this study we were limited by the fact that the whole pedigree and data set was not electronically available and thus we did not consider the effects of litter inbreeding, boar inbreeding as well as the effects of inbreeding coming from the more remote generations (slow inbreeding). How we are currently entering pedigree information and fertility information data into electronic format. Thus, those effects as well as the information from other litters (second and latter litters) will be considered in more details in our future work.

CONCLUSIONS

The obtained results show a consistent negative effect of sow inbreeding on all six analyzed traits. The analyzed effects were significant for total number born, number born alive and number at weaning but were not-significant for total number of inseminations and mortality during weaning. However, the observed indicated trend should be confirmed in a more extensive study taking into account the effects of litter inbreeding as well as the effects of remote versus close inbreeding effects.

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