Advanced statistical analysis of tail bite scores at weaning

A short term scientific mission at GenPhySE INRA, France
Lisette van der Zande

Abstract

Most studies that focus on tail biting behavior are with pigs that are at least 4 weeks old. In a pilot study of Topigs Norsvin, tail damage was observed before weaning. Therefore, the focus of this study is on tail damage at weaning in order to learn about the development of tail biting behavior during lactation. Together with Laurianne Canario from GenPhySE INRA in France the data is analyzed. Data of 12,372 piglets born between January 2016 and February 2017 is used. Piglets were tail docked and 24% of the piglets were cross fostered. Two models were analyzed, first an indirect animal model with heterogeneous residuals for group size. The second model was the same as the first, but a permanent environment effect for the biological dam was added. Cross fostered piglets have less tail damage. In addition, the permanent environment of the biological dam explain 5% of the phenotypic variance. Due to the cross fostering, gestation might have an influence on the development of tail damage during weaning. Tail damage is found to be moderately heritable (0.14 – 0.20), which implies one can select against tail damage and thus less damaging behavior.

Introduction

According to PubMed, 63 scientific articles were published on tail biting in pigs in the last 10 years. Approximately half was focused on the later phase of a pigs life, either grower-finishing phase or at the abattoir (Schrøder-Petersen et al., 2001; Kritas et al., 2004). Some studies follow pigs throughout their lives, starting after weaning (Zonderland et al., 2008). The few studies who focus on piglets before weaning are oriented to the effects of tail docking. In a pilot study of Topigs Norsvin, tail biting behavior and damage was already observed in one week old piglets (unpublished). Therefore, the focus of this study is on tail damage at weaning in order to learn more about the development during lactation of tail biting behavior.

A piglet already needs to engage in social behavior already minutes after it is born. This young age is an important period in learning and understanding social behavior. During lactation, multiple litters can be housed together with sows housed in crates or loose. Van Nieuwamerongen et al. (2015) shows that group housed litters with loose housed sows had a lower frequency of manipulative behavior before and after weaning. Group lactation where sows remained confined in crates showed the same effect (Hessel et al., 2006). By socializing piglets pre weaning, piglets show post weaning less aggression and agonistic behavior, and display more play behavior (Hessel et al., 2006; Chaloupková et al., 2007; Van Nieuwamerongen et al., 2015).

It is challenging to estimate genetic parameters of behavioral traits because extensive phenotypes are necessary which is labor intensive. Nevertheless, often genetic variance is found in behaviors studied. For example, aggression has an estimated heritability ranging between 0.17 and 0.46 (Løvendahl et al., 2005; Turner et al., 2008). When the heritability is low, indirect genetics effects can help to pick up additional genetic variance that otherwise would be missed with a classic animal model. Social behavior has a performer and receiver, both might have a genetic contribution. With the classic animal model, you can estimate the performer or the receiver but not both simultaneously. With indirect genetic effects, one can include both effects in one model, and therefore pick up extra genetic variation that was missed in the classis model. In addition, indirect genetic effects is a way to analyze traits that are difficult to measure. Tail damage is easy to measure, identifying the biter is more challenging. When tail damage is analyzed, the direct effect is for the likelihood to get tail damage, the indirect effect will be the effect of the pen mate, who will cause the damage, and thus a biter effect.

The purpose of this short term scientific mission (STSM), with the COST Action CA15134 Synergy for preventing damaging behavior in group housed pigs and laying hens (GroupHouseNet), is to test advanced statistical analysis of tail bite scores at weaning in collaboration with Laurianne Canario at INRA Toulouse. Canario has experience with the analysis of early life effects, therefore we will also look into the contribution of the dam in the development of tail biting behavior (Canario et al., 2017). In the present study, we will analyze tail damage at weaning including indirect genetic effects. From these models, genetic parameters will be shown. Furthermore, we present the contribution of the dam in the development of tail biting behavior.

Material & Methods

Data

Records of 12,372 piglets of Topigs Norsvin pure bred Z-line (Large White) born between January 2016 and February 2017 at a nucleus farm in Canada were analyzed. Piglets were born from 1208 litters. The sows were housed in crates during gestation, farrowing, and lactation. The tails of the piglets were docked. The piglets were individually weighted at birth. In total, 24% of the piglets were cross fostered (CF) to form 1025 groups. We selected groups on size from 8 to 15 piglets, since the smaller and larger group sizes did not have enough records. At approximately three weeks of age, the piglets were weaned. The group was weighted at weaning. This value was divided by the number of piglets alive during weaning to calculate average piglet weaning weight. During weaning, the tails were scored on tail damage (0/1). In order to be involved in the tail damage at weaning, we assumed the piglet should be alive at least 7 days before weaning. Piglets who died within the period of 7 days before weaning had no tail damage observation. The full pedigree of 5 generations was available.

Models

A linear direct-indirect animal model was used in ASReml 4.0 to estimate genetic parameters for tail damage (Model 1).

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z_D a_D} + \mathbf{Z_S a_S} + \mathbf{Wc} + \mathbf{e}, \qquad \textit{(Model 1)}$$

where $\mathbf{b}$ is a vector of fixed effects, with incidence matrix $\mathbf{X}$ linking observations to fixed effects; $\mathbf{a_D}$ is a vector of direct breeding values, with incidence matrix $\mathbf{Z_D}$ linking observations on individuals to their direct breeding value; $\mathbf{a_S}$ is a vector of indirect genetic effects, with incidence matrix $\mathbf{Z_S}$ linking observations to their indirect genetic effect; $\mathbf{c}$ is a vector of group effects, with incidence matrix $\mathbf{W}$ linking observations to the group; and $\mathbf{e}$ is a vector of random residuals. The variance structure of the model terms are: $var\begin{bmatrix}\mathbf{a}_D\\ \mathbf{a}_S\end{bmatrix} = \mathbf{C} \otimes \mathbf{A}$, where $\otimes$ is the Kronecker product of matrices, $\mathbf{A}$ is an matrix of additive genetic relationships between individuals based on a five generation pedigree, and $\mathbf{C} = \begin{bmatrix}\sigma^2_{A_D} & \sigma_{A_{DS}}\\ \sigma_{A_{DS}} & \sigma^2_{A_S}\end{bmatrix}$, where $\sigma^2_{A_D}$ is the direct genetic variance, $\sigma^2_{A_S}$ is the indirect genetic variance, and $\sigma_{A_{DS}}$ is the direct-indirect genetic covariance; $var[\mathrm{c}] = \mathbf{I}\sigma^2_{\boldsymbol{c}}$, where $\mathbf{I}$ is an identity matrix; $var[\mathrm{e}] = \begin{bmatrix}\sigma^2_{e_8} & \cdots & 0\\ \vdots & \ddots & \vdots\\ 0 & \cdots & \sigma^2_{e_{15}}\end{bmatrix}$, where on the diagonal separate residuals are estimated for each group size, the off-diagonal is fixed at zero.

To estimate for permanent environment of the sow, model 1 was extended with a permanent dam effect (Model 2).

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z_D a_D} + \mathbf{Z_S a_S} + \mathbf{Wc} + \mathbf{Vd} + \mathbf{e}, \qquad \textit{(Model 2)}$$

where $\mathbf{d}$ is a vector of permanent dam effect, with incidence matrix $\mathbf{V}$ linking observations to the permanent dam effect. The variance structure of the permanent dam effect is $var[\mathrm{d}] = \mathbf{I}\sigma_d^2$, where σ_d^2 is the permanent dam variance.

The correlation between direct and indirect genetic effect can be calculated as follows:

$$r_{DS} = \frac{\sigma_{A_{DS}}}{\sqrt{\sigma_{A_D}^2 * \sigma_{A_S}^2}}$$

Results

First we tested for fixed effects. In both models, the same fixed effects were defined namely: gender, year*month, group size, litter of origin, CF, birth weight, CF*birth weight, weaning weight*group size. All effects had in both models a p-value smaller than 0.05, expect for the interaction between weaning weight and group size in Model 2, which had a p-value of 0.06.

Figure 1 shows the interaction between CF and birth weight. It shows that victims who are not CF have an higher birth weight, whereas victims who are CF have a lower birth weight. In addition, CF piglets had less tail damage in general (not shown).

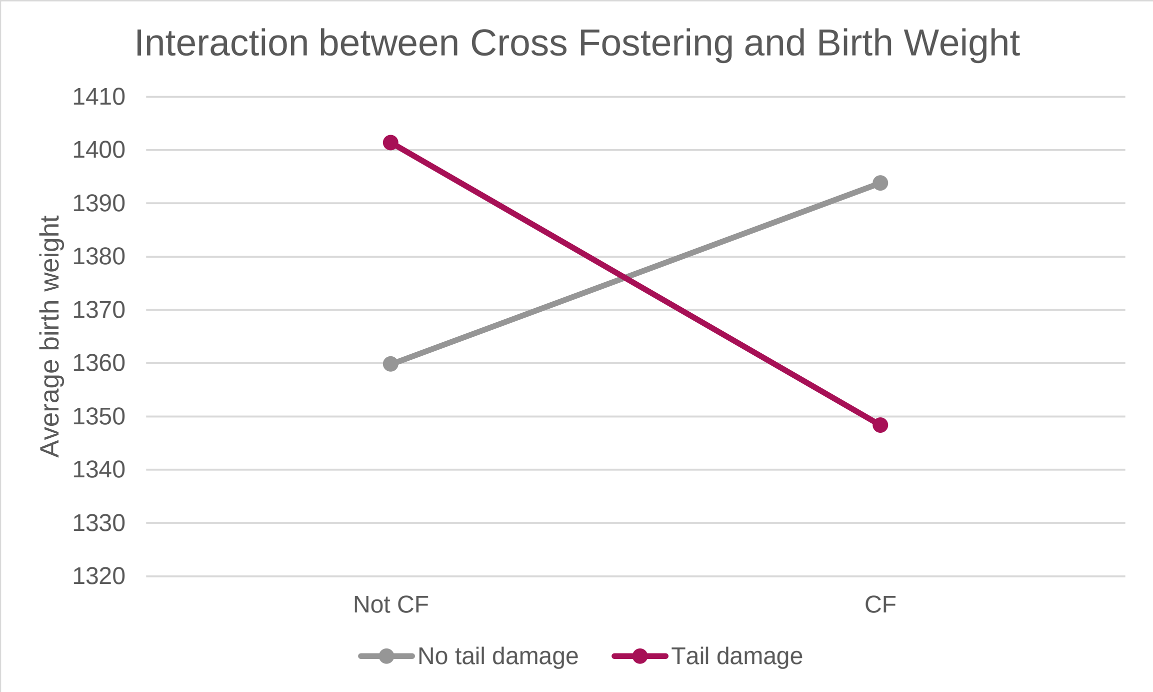

Figure 1 - Interaction of tail damage between cross fostering and birth weight.

Table 1 shows the average ± standard deviation birth weight, weaning weight, group size, and the number of litters needed to make the groups (litters of origin) between the piglets with and without tail damage. Piglets who were heavier at birth and at weaning had on average more often tail damage. Cross fostered piglets had less tail damage. There seems no difference between the group size and litters of origin of tail damaged piglets and no tail damaged piglets, although they were significant as a fixed effect.

Table 1 - Descriptive table of averages ± standard deviations for piglets with and without tail damage. The unit is displayed between brackets.

	No tail damage	Tail damage
Birth Weight (g)	1370 ± 308	1392 ± 317
Weaning Weight (g)	5934 ± 840	6062 ± 796
Group Size (# piglets)	12.3 ± 1.6	12.5 ± 1.5
Litters of Origin (# litters)	1.67 ± 0.7	1.58 ± 0.68

Genetic parameters ± standard deviation are shown in Table 2. The inclusion of the permanent environment of the dam lowers the total genetic variance. The phenotypic variance stays approximately the same. As a result, the heritability is slightly lower in the second model.

Table 2 - Genetic parameters ± standard deviation for both models.

	Model 1	Model 2
Direct genetic variance	0.017 ± 0.004	0.002 ± 0.002
Indirect genetic variance	$2.89 \times 10^{-5} \pm 2.63 \times 10^{-5}$	$4.30 \times 10^{-5} \pm 2.81 \times 10^{-5}$
Covariance direct-indirect	$-8.88 \times 10^{-5} \pm 2.56 \times 10^{-4}$	$2.31 \times 10^{-4} \pm 1.38 \times 10^{-4}$
Group variance	0.021 ± 0.002	0.019 ± 0.002
Permanent dam environment	-	0.004 ± 0.001
Residual	0.057 ± 0.004	0.064 ± 0.004
Total genetic variance	0.019 ± 0.005	0.013 ± 0.005
Heritability	0.20 ± 0.05	0.14 ± 0.05

The contribution of the direct genetic effect dropped significantly when the permanent dam environment was included (Table 3). Furthermore, the indirect genetic effect and the covariance increased significantly. When the permanent dam environment is included (Model 2), the correlation between the direct and indirect genetic variance rises from around zero to 0.76.

Table 3 - Contribution of direct genetic variance, indirect genetic variance, and covariance to the total genetic variation and the correlation between the direct and indirect genetic variance.

	Contribution to total genetic variance			Correlation
	Direct	**Indirect**	**Covariance**	**Direct - indirect**
Model 1	91%	19%	-10%	-0.12 ± 0.34
Model 2	17%	42%	41%	0.76 ± 0.58

Discussion

Piglets who were cross fostered had less tail damage. In addition, when more foreign piglets entered the group, the average of tail damage of the whole group was lower. The effect we observe might have the same background as we see in the group lactation. With group lactation, piglets are forced to interact with unfamiliar pigs earlier than weaning. These piglets show less manipulative behavior.

So when more unfamiliar pigs enter a group, they are all forced to interact with each other before weaning, leading to less tail damage among the group.

Relatively, the group variance is around 20% of the total phenotypic variation, which is quite high. The data lacks pen registration, so we were not able to correct the data for pen. Since a group was housed in the same pen, these variances might now be integrated with the group variance. When pen will be added, we expect that the group variance is lower.

In Model 2, we added the permanent environment of the biological dam to the model. We tested the permanent environment of the foster dam, and the genetic component of the biological and foster dam. All of these components had no variance and didn't improve the model. The permanent environment of the biological dam only explains 5% of the phenotypic variation, still it has a large impact on the genetic components in this model (Table 2). This will be discussed later. Even for the cross fostered piglets, the environment of the biological dam had an effect. It might be that for example stress, or hormone changes during gestation have an effect on tail damage at 3 weeks of age. Sorrells et al. (2006) showed that there are behavioral differences of piglets from gilts housed in groups or individually during gestation. So stress during gestation might alter the behavior of the piglets. However, all our sows were housed individually, so this doesn't fully explain this effect.

The genetic variances differ significantly between Model 1 and Model 2 (Table 2 & 3). Both the indirect genetic variance and covariance increase, whereas the direct variance decreases. The total genetic variance is slightly lower, however the heritability stays moderate. The contribution of the genetic components change thoroughly. When the data is analyzed with Model 2, indirect genetic effects are necessary to estimate a moderate heritability. Why the contribution changes so extreme is still unclear to us.

Conclusion

To conclude, socialization shows to have an important role in the early development of behavior. In group lactation we might observe less damaging behavior on a later age compared to traditional lactation housing. In this study, a similar effect was observed with cross fostering. Groups who had more cross fostering events showed as a group less tail damage. Behavior might develop even earlier, due to the permanent environment effect of the biological dam. Since 24% of the piglets was cross fostered, it indicates that something may occur during gestation that alter the development of social behavior. Furthermore we estimated genetic parameters, and tail biting behavior is moderately heritable when indirect genetic effects are included. The contribution of the genetic variances to the total genetic variance fluctuates when the permanent dam effect is added. It is still unclear to us why this happens.

Future collaborations

The collaboration between Topigs Norsvin and GenPhySE INRA will continue to publish the results obtained from the STSM. If Topigs Norsvin generates more data regarding the contribution of the dam in the development of social behavior, Topigs Norsvin and INRA will collaborate again.

References

Canario, L., Lundeheim, N., & Bijma, P. (2017). The early-life environment of a pig shapes the phenotypes of its social partners in adulthood. *Heredity, 118*(6), 534.

Chaloupková, H., Illmann, G., Bartoš, L., & Špinka, M. (2007). The effect of pre-weaning housing on the play and agonistic behaviour of domestic pigs. *Applied Animal Behaviour Science, 103*(1), 25-34.

Hessel, E., Reiners, K., & Van den Weghe, H. A. (2006). Socializing piglets before weaning: effects on behavior of lactating sows, pre-and postweaning behavior, and performance of piglets. *Journal of animal science, 84*(10), 2847-2855.

Kritas, S. K., & Morrison, R. B. (2004). An observational study on tail biting in commercial grower-finisher barns. *Journal of Swine Health and Production, 12*(1), 17-22.

Løvendahl, P., Damgaard, L. H., Nielsen, B. L., Thodberg, K., Su, G., & Rydhmer, L. (2005). Aggressive behaviour of sows at mixing and maternal behaviour are heritable and genetically correlated traits. *Livestock Production Science, 93*(1), 73-85.

Schrøder-Petersen, D. L., & Simonsen, H. (2001). Tail biting in pigs. *The Veterinary Journal, 162*(3), 196-210.

Sorrells, A., Eicher, S., Scott, K., Harris, M., Pajor, E., Lay, D., & Richert, B. (2006). Postnatal behavioral and physiological responses of piglets from gilts housed individually or in groups during gestation. *Journal of animal science, 84*(3), 757-766.

Turner, S., Roehe, R., Mekkawy, W., Farnworth, M., Knap, P., & Lawrence, A. (2008). Bayesian analysis of genetic associations of skin lesions and behavioural traits to identify genetic components of individual aggressiveness in pigs. *Behavior Genetics, 38*(1), 67-75.

Van Nieuwamerongen, S., Soede, N., van der Peet-Schwering, C., Kemp, B., & Bolhuis, J. (2015). Development of piglets raised in a new multi-litter housing system vs. conventional single-litter housing until 9 weeks of age. *Journal of animal science, 93*(11), 5442-5454.

Zonderland, J. J., Wolthuis-Fillerup, M., Van Reenen, C. G., Bracke, M. B., Kemp, B., Den Hartog, L. A., & Spoolder, H. A. (2008). Prevention and treatment of tail biting in weaned piglets. *Applied Animal Behaviour Science, 110*(3), 269-281.