Proc. Assoc. Advmt. Anim. Breed. Genet: 26: 62-65

GENETIC RISK FACTORS FOR TAIL BITING IN AUSTRALIAN PIGS AS DETERMINED BY BINOMIAL REGRESSION MODELS

D. van Winden[1], R.Y. Galea[2], M.N. Aldridge[1], P.M. Gurman[1] and S. Hermesch[1]

[1] Animal Genetics Breeding Unit*, University of New England, Armidale, NSW, 2351 Australia
[2] AWSC, The University of Melbourne, Parkville, Victoria, 3010 Australia

SUMMARY

Tail biting has adverse welfare implications and is a costly challenge in commercial pig farms. Tail biting incidents can be reduced by breeding animals with reduced susceptibility to becoming a victim of tail biting. This paper aims to quantify genetic risk factors for being a victim of tail biting. Data on 55,373 pigs representing 9 genetic lines were collected. Pigs were housed on 8 commercial farms in Australia under a range of housing and climatic conditions. Genetic risk factors were compared between lines, breeds and sire or dam types. Line, breed, and line type were all significant risk factors for tail biting ($P < 0.0001$). Landrace pigs and sire lines were least affected by tail biting. Female pigs were generally bitten more often ($P = 0.005$) than males, and while there were significant sex-line interactions, these were not observed for breed or line type. Pigs were more likely to receive tail biting if they experienced more days outside thermoneutral temperatures, defined as 15 to 30°C. Some lines were more affected by temperature stress than others. The Large White breed and dam lines showed the least tail biting during temperature stress. To minimise tail biting, pig farmers are encouraged to consider estimating tail biting risk per line, identify sex differences, and/or reducing temperature stress.

INTRODUCTION

Tail biting behaviour occurs regularly on commercial pig farms around the world (Henry *et al.* 2021), resulting in welfare implications ranging from mild marks to serious infections. Pigs with tail lesions or wounds grow slower, require more feed, and are often condemned at the abattoir (Van Staaveren *et al.* 2021). Pig tail biting is a multifactorial problem, therefore it is difficult to both analyse and consider solutions for this behaviour. Identified risk factors include limited feeding space and lack of available enrichment (D'Eath *et al.* 2014); however, adjusting these may not always be feasible for farmers. Additionally, while docking the tail of the animals is a common mitigation strategy, this may cause pain and does not eliminate incidents (Li *et al.* 2017). Alternative strategies to reduce tail biting are needed.

The incidence rate may also be reduced by selectively breeding pigs that display less tail biting (Canario *et al.* 2020). For example, different breeds have shown varying levels of aggressive behaviour (Breuer *et al.* 2003; Sinisalo *et al*. 2012). However, research on genetic aspects of tail biting is sparse, and it is unclear how genetic effects translate to commercial populations. We hypothesize that there are significant genetic risk factors in commercial Australian pigs for being a victim of tail biting, which also involve significant genotype-by-sex and genotype-by-temperature interactions.

MATERIALS AND METHODS

Data. For this research, data on 55,373 pigs were recorded on 8 commercial farms located across Australia from January 2022 (first birth) to December 2023 (last test). Pigs were kept under ranging

* A joint venture of NSW Department of Primary Industries and Regional Development and the University of New England

housing and climate conditions. Enrichment was not provided systematically. Animals were considered part of the experiment from birth until date of performance testing or death (whichever occurred first), with an average age of 146 days. Animals that lived for less than 30 days were not used in the analysis. The animals included 9 genetic lines from 3 breeds: Large White, Duroc and Landrace, comprising 5 dam lines and 4 sire lines. To allow the separation of farm and breed effects, each line was either held on multiple farms, or on a farm housing several other lines. Males and females were kept in separate pens, but otherwise handled equally.

Tail biting was defined as a binary trait, using scores of 0 (no lesions) or 1 (moderate to severe lesions). To collect tail lesion data, staff manually went through individual pens and recorded tail lesions per pig weekly from weaning until pigs entered performance testing. Average daily temperature was measured on the exterior of every building using automated weather stations. This was converted into temperature stress for each pig by dividing the number of temperature-stress days by the total number of days with a recorded temperature. Temperature-stress days were defined as days when pigs experienced outside average temperatures outside of the recommended thermoneutral zone of 15 to 30°C (The State of Victoria, 2012).

Statistical analysis. The data were analysed by binomial logistic regression models in R. All models were used to test if recorded tail biting could be predicted by genetic and environmental effects. All models fitted an intercept (i.e. base odds), farm, birth month, and sex as fixed factors, and temperature stress as a covariate. Model 1A additionally fitted genetic line as a fixed factor, and Model 1B fitted both a sex-line interaction, and a temperature-line interaction. Model 2A fitted breed instead of genetic line and 2B the same interactions as for line replaced by breed. Similarly, Model 3A fitted line type instead of genetic line and 3B replaced breed with line type in the interactions.

The robustness of the models was examined using train/test splits. A random test set was generated containing 250 entries with no tail bite and 250 entries with a tail bite. All other entries were used as a training set. This process was repeated 10 times, and the model used an odds-based prediction on each repeat. The model accuracy was defined as the proportion of times where the model correctly predicted the tail biting observation.

RESULTS AND DISCUSSION

Base line effects. Farm and month of birth were significant factors in all models ($P < 0.0001$). Model 1A estimated that different genetic lines had significantly ($P < 0.0001$) different tail biting risks: lines ranged from 0.61 to 3.91 times as likely to be bitten compared to the base animal, which was a female Large White pig in a specific farm born in July 2022. Model 1B (Table 1) included interaction effects. Most sex-line and temperature-line effects were different (both $P < 0.001$) from each other and line estimates were similar to Model 1A.

Breeds and line types. Models 2A and 3A were investigated to estimate differences in tail biting between breeds and line types. Tail biting between breeds and between line types were significantly different ($P < 0.0001$) from each other. Model 2A estimated that compared to Large White pigs, Duroc pigs were 1.25 times as likely to be bitten, and Landrace pigs were 0.83 times as likely to be bitten. This range matches with a previously found 1.38 times difference in tail biting between breeds (Sinisalo *et al*. 2012). According to estimations from Model 3A, dam lines were 1.09 times more likely to be bitten than sire lines.

Model 2B and 3B included interaction effects. There were two discrepancies with previous models: firstly, model 2B (Table 2) found that Duroc pigs were 0.65 times as likely to be bitten than Large White pigs, which was the other way around in model 2A. Secondly, model 3B (Table 3) estimated pigs from dam lines to be 1.569 as likely to be bitten than pigs from sire lines, which was a much larger difference than model 3A.

Table 1. Model 1B: relative odds of being tail bitten on-farm as reported by a binomial regression model (* denotes P < 0.05, ^ denotes base odds)

Factor	Line	As male	Per 1% increased temperature stress
Intercept II: line A, female	1^	0.887	1.002
Line B	0.418*	1.402*	1.005
Line C	0.464	0.387*	1.017
Line D	1.432	0.407*	1.020*
Line E	0.153*	2.832*	1.017*
Line F	3.946*	0.234*	1.010
Line G	0.461*	0.905	1.012*
Line H	0.561	0.911	1.015
Line I	0.893	0.434*	1.014

Table 2. Model 2B: relative odds for pig breeds to be tail bitten on-farm as reported by the binomial regression model (* denotes P < 0.05, ^ denotes base odds)

Factor	Line	As male	Per 1% increased temperature stress
Intercept III: Large White, female	1^	0.945	1.003
Duroc	0.652*	0.776	1.019*
Landrace	0.553*	0.865	1.013*

Table 3. Model 3B: relative odds for pig line types to be tail bitten on-farm as reported by the binomial regression model (* denotes P < 0.05, ^ denotes base odds)

Factor	Line	As male	Per 1% increased temperature stress
Intercept IV: sire line, female	1^	0.868	1.016*
Dam line	1.569*	0.889	1.008*

Sex as a risk factor. According to Model 1A, female pigs were 1.130 times as likely to receive lesions ($P = 0.005$) than males. However, Model 1B found a significant sex-line interaction for 6 out of 9 lines (Table 1). Line C and F had large differences in tail lesion frequency between sexes (males bitten 0.387 and 0.234 times as often as females, respectively). The interaction was reversed in lines B and E (males bitten 1.402 and 2.832 times as often as females, respectively). Line-sex interactions disappeared in Model 2B and 3B. The differences per lines explain other literature finding sex differences to be ambiguous (Zonderland *et al.* 2010).

Temperature stress as a risk factor. Model 1A estimated pigs that lived more days outside of comfort temperature, experienced 1.009 times more tail biting per percentage of temperature-stress days ($P < 0.0001$). However, Model 1B found a temperature-line interaction effect, with 3 out of 9 lines showing different effects under temperature stress (Table 1). Pigs from lines A and B were resilient to temperature stress, having slightly increased odds of being tail bitten when more often outside of the thermoneutral zone. Comparatively, pigs from line D were the most affected by temperature stress with an estimate of 1.020 times as likely per percentage of temperature-stress days. Model 2B and 3B estimated differences in temperature sensitivity to persist throughout breed (Table 2) and line type (Table 3). Large White pigs were most resilient to temperature stress (1.003 times more tail biting per increase in temperature stress), and Duroc pigs the least (1.019 times more tail biting). Sire lines were less resilient to temperature stress than dam lines: 1.016 and 1.008 times more tail biting, respectively. Practically, this means that from 0% temperature stress to 50% temperature stress, sire and dam lines get bitten 2.21 and 1.49 times more often respectively. These differences explain the change in order of line estimates between breeds and line types when accounting for interaction effects. Most temperature-stress days were below 15°C (51%). This information can be valuable to farmers designing strategies to reduce risk of tail biting caused by temperature stress.

The robustness of the models was tested. Using the random equal train-test split, models reached accuracies of 0.68-0.70. These values are higher than random chance (0.5), indicating that the estimates of the models were relevant, and the models were reasonably robust.

CONCLUSIONS

According to the models presented, genetic line, breed, and line type had significant differences in tail biting incidence rates. Female pigs were more likely to be bitten than male pigs in most lines, but this sex-line interaction disappeared when grouping lines by breed or line type. Exposure to more temperature-stress days increased tail biting, but individual lines had different sensitivities to temperature stress. Large White pigs and dam lines were the most resistant to temperature stress, and Duroc pigs and sire lines had the most increased tail biting when exposed to temperature stress.

ACKNOWLEDGEMENTS

This project was funded in part by the Australian Government (DISR) CRC-P program. The first author received UNE IPRA and APRIL top-up scholarships. The research could not have been completed without the extensive data collection at Rivalea and Sunpork Group, and their invitation for farm visits to gain extensive insight in farm management.

REFERENCES

Breuer K., Sutcliffe M.E.M., Mercer J.T., Rance K.A., Beattie V.E., Sneddon I.A. and Edwards S.A. (2003) *Appl. Anim. Behav.* **84**: 59.

Canario L., Bijma P., David I., Camerlink I., Martin A., Rauw W.M., Flatres-Grall L., van der Zande L., Turner S.P., Larzul C. and Rydhmer L. (2020) *Front. Genet.* **11**: 611073.

D'Eath R.B., Arnott G., Turner S.P., Jensen T., Lahrmann H.P., Busch M.E., Niemi J.K., Lawrence A.B. and Sandøe P. (2014) *Animal* **8**: 1479.

The State of Victoria (2012) 'Victorian Standards and Guidelines for the Welfare of Pigs' Revision 1, Department of Primary Industries Victoria.

Henry M., Jansen H., del Rocio Amezcua M., O'Sullivan T., Niel L., Shoveller A.K. and Friendship R.M. (2021) *Animals* **11**: 2002.

Li Y.Z., Zhang H.F., Johnston L.J., Martin W., Peterson J.D., and Coetzee J.F. (2017) *J. Anim. Sci.* **95**: 4835.

Sinisalo A., Niemi J.K., Heinonen M. and Valros A (2012) *Livest. Sci.* **143**: 220.

Van Staaveren N., Boyle L.A., Manzanilla E.G., O'Driscoll K., Shalloo L. and Díaz J.A.C. (2021) *Vet. Rec.* **188**: e13.

Wallgren P., Johansson M., Wallgren T., Susic Z., Sigfridson K. and Johansson S. (2024) *Acta. Vet. Scand.* **66**: 2.

Zonderland J.J., Schepers F., Bracke M.B.M., den Hartog L.A., Kemp B. and Spoolder H.A.M. (2011) *Animal* **5**: 767.