SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15134
STSM title: Can social structure help to predict tail biting in pigs?
STSM start and end date: 02/12/2019 to 13/12/2019
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PURPOSE OF THE STSM:

In September 2019, I was recruited as a researcher within the PEGASE research unit of the INRA, France, to investigate social behaviour and welfare in pigs. The prerequisite to achieve my research goal is to master social network analysis, a method to study social structures, and identify individual social positions and roles. The study of social structures and individual social positions may help to determine how the behaviour of an individual can influence behaviours of other animals, and to understand how certain behaviours emerge/spread within the group. Social network analysis can thus represent a great tool to study the impact of social structures on the emergence and spreading of damaging behaviour, such as tail biting, in pigs.

Consequently, the objectives of the STSM were:

1) to gain scientific knowledge on social structure and damaging behaviour in pigs by participating in an on-going PhD project on social structure and tail biting in pigs ;
2) to learn and practice the method of social network analysis and to master the use of associated software (Python NetworkX module) ;
3) to foster collaboration between the INRA and the host group in the field of social and damaging behaviour in pigs.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the STSM, I visited the Institute for Animal Breeding and Husbandry of the University of Christian-Albrechts, Kiel, Germany, and was welcomed by postdoc Kathrin Büttner, who has expertise in social network analysis. During my stay, I discussed social network analysis and pig social behaviour with scientists with expertise in social network analysis and/or damaging behaviour in pig farms, including Kathrin Büttner and Irena Czycholl. I also visited pig facilities and assisted PhD student Veronika Drexl in the scoring of tail lesions of growing pigs, in a project that investigates the impact of environmental factors (*e.g.* humidity, room temperature, tail docking, etc) on tail biting.

To practice social network analysis, I was given access to a dataset from an on-going PhD research project of PhD student Thore Wilder. His research investigates how social position of animals in social networks of tail biting and agonistic behaviour can help to predict tail biting outbreaks in growing pigs. During my stay, Thore Wilder teached me how to use the **Python module NetworkX** to construct social network and calculate social network metrics, and the **yEd Grah Editor application** to generate network diagrams.

Research question

While practicing social network analyses, I aimed to answer the following research question: Could social metrics from networks of aggression at weaning help to predict the risk of tail biting later in life in pigs?

Description of the dataset provided by the PhD student

Behavioural data from 6 pens of 24 animals were used. Starting directly after rehousing and mixing, all-occurrences of reciprocal fights were scored on video for the 2 first days following weaning (~16 hours). For each fight, the initiator and the receiver were identified.

Tail lesions were also scored on all the pigs. The scores were: 0, no lesions; 1, superficial lesions (*i.e.* scratches); 2, 'small' deep lesions; and 3, 'large' deep lesions. Lesion score data were transformed as binary variables for further analyses (0, no or superficial lesions; 1, small or large deep lesions). Three timepoints were chosen: the day of the first 'small' deep lesion outbreak (*i.e.* at least 1 pig/pen with score 2); the day of the first 'large' deep lesion outbreak (*i.e.* at least 1 pig/pen with score 3); and the end of the experiment, at 40 days of age. Note that the deep lesion outbreaks occurred around 2 to 3 weeks of age.

Network construction

I build a social network of fights for each pen using the Python NetworkX module. The edges (*i.e.* links between the animals) were weighted (*i.e.* based on the number of interactions between the two animals) and directed (*i.e*. going from the initator to the receiver of the fight). I calculated several social network metrics, but only two were used for statistical analyses:

- **Network density** (*network-level metric*) measures the amount of potential agonistic interactions between animals that are actually present. This parameter ranges between 0 (no connections are present) and 1 (all possible connections are present). My first hypothesis is that the denser the network of fights after weaning, the greater the sum of tail lesion scores in the pen later in life.
- **Degree centrality** (*pig-level metric*) measures how many direct connections an individual has with others. An animal with high **in-degree centrality** is attacked by many different pen mates. My second hypothesis is that an animal with great in-degree centrality at weaning will be more likely to be victim of tail biting (and thus have deep lesions) later in life.

Statistical analyses

Data were analysed using the R software environment. Note that these analyses were preliminary analyses only; further validation of the models would be needed to draw solid scientific conclusions.

The effect of network density on the summed lesion scores at the pen level was analysed using generalised linear mixed models with Poisson error distribution and a log link function. Network density was included as a fixed effect and pen was included as a random effect.

The effect of individual in-degree centrality on the probability of having a deep lesion was analysed using generalised linear mixed models with binomial error distribution and a logit link function. In-degree centrality was included as a fixed effect, and pen was included as a random effect.

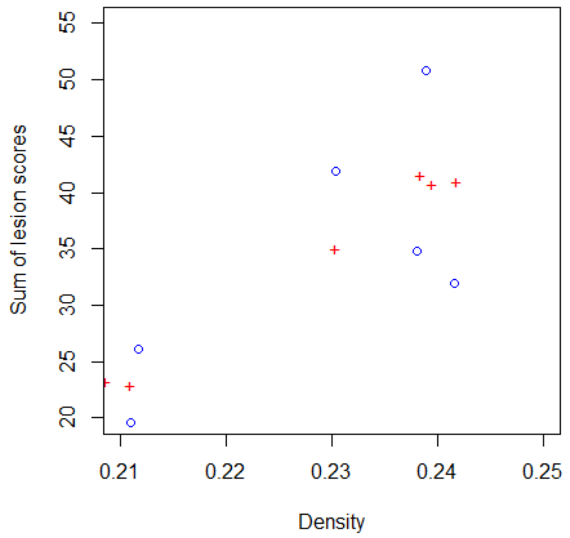
DESCRIPTION OF THE MAIN RESULTS OBTAINED

Network representations

In total, fights from 6 pens of 24 pigs were scored. The median number of edges per pen was 129.5 (min: 114-max: 133). The density of the networks was low, with a median density of 0.23 (0.20-0.24). ***Figure 1*** represents two examples of fight networks from two pens. These networks were generated using the **yEd Grah Editor application**. Note that, in one of the two pens, one pig did not receive or initiate any fights (right top corner of the left network).

Figure 1. *Visualisations of unweighted, directed fight networks from 2 different pens. Each node represents a pig. Each directed edge represents the presence of at least 1 fight from one pig to the other. The size of a node is proportional to the weighted in-degree centrality of the pig.*

Relationship between fight network metrics and tail lesions



The **density of the fight networks** had no impact on the summed tail lesion scores of the pen on the day of the first ‘small’ deep lesion outbreak and on the day of the first ‘large’ deep lesion outbreak ($p > 0.10$ for both). However, the more dense the network of fights at weaning, the greater the sum of lesion scores in the pen at the end of the experiment (day 40 of age; Z = 3.10, $p = 0.002$; ***Figure 2***).

Figure 2. *Sum of lesion scores at the end of the experiment (day 40 of age) in pens with different fight network densities. Blue dots are observed data; Red crosses are predicted values (Correlation coefficient = 0.722).*

The animal **in-degree centrality** did not predict the probability of having deep tail lesions on the day of the first ‘small’ deep lesion outbreak (Z = -0.08, $p = 0.19$), on the day of the first ‘large’ deep lesion outbreak (z = -0.01, $p = 0.70$), or at day 40 of age (Z = 0.05, $p = 0.22$; ***Figure 3***). However, the large 95% confidence intervals of the predicted data indicate that the statistical model may not yield accurate predictions, suggesting that statistical results may not be fully reliable.

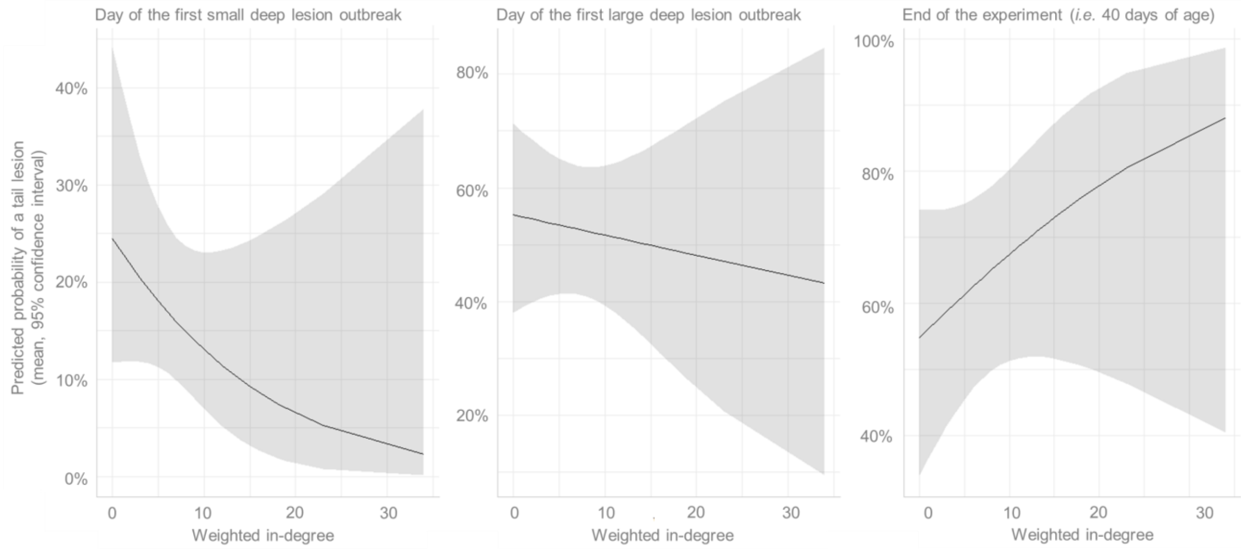


Figure 3. *Predicted probabilities of a deep tail lesion in animals with different weighted in-degree centralities on the day of the first small deep lesion outbreak, on the the day of first large deep tail lesion outbreak and at 40 days of age (end of the trial).*

Conclusions

During the STSM, I gained scientific knowledge on social network analysis and damaging behaviour in pigs *via* discussions with researchers and PhD students working on social networks and tail biting in pigs. I also learned a valid method to analyse social networks using the Python NetworkX module, and to generate networks using the yEd Graph Editor application. Although the statistical models need to be validated, the preliminary statistical analyses on the calculated social network metrics suggest that network-level metrics, such as network density, may help to predict the emergence of tail biting behaviour in growing pigs.