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Review of PhD thesis of Sunil Khatiwada
titled “Exploring social complexity and the benefits of social relationships
in domestic pigs”

performed under the supervision of Dr hab. Irene Camerlink from the Institute of Genetics
and Animal Biotechnology of the Polish Academy of Sciences,
and Professor Dr Simon P. Turner from Scotland’s Rural College (SRUC)

PhD candidate

Sunil Khatiwada submitted a PhD thesis, which is a compilation of four published manuscripts under a properly selected title that jointly represent performed studies. Publications’ total Impact Factor is 9.8, and 470 points based on the list of the Ministry of Science and Higher Education. Combined, it presents more than sufficient basis to fulfil the requirements for a Doctoral title in Poland.

Scientific and substantive value of the thesis

The thesis demonstrates high originality in its experimental setup, in its thorough evaluation of different behaviours and their impact on other aspects of pig husbandry. Moreover, throughout the course of the project, a substantial number of detailed observations of animal behaviour were recorded, and appropriate statistical analyses were selected. The **introduction** chapter provides a solid overview of existing knowledge and leads the reader to the thesis’s scientific hypotheses and objectives. The literature is properly selected. **Hypothesis and aim** are clearly defined and linked with separate publications. The chapter on **materials and methods** precisely

presents the different experimental setups in each paper that is part of the thesis. All information provided here is in line with the four published manuscripts. Below are presented the highlights of each chapter.

Paper 1 presents a clear distinction between snout proximity and snout contact, which is a more complex approach than describing them jointly as “nosing”. This work clearly distinguishes those two behaviours and links them with different types of pigs’ “personalities”. Importantly, the behavioural observations made on pigs are linked to average daily gain, a highly relevant trait for farmers, indicating that certain types of pigs will be affected more than others. Moreover, the results of this work are placed within a broader perspective that accounts for risk-taking, social recognition, and affiliative behaviour, which is highly beneficial for the field.

Papier 2 describes the snout contacts as a key affiliative behaviour during re-grouping with potential welfare implications. Using social network analysis is a major strength of this work, especially given its application at both the group and individual levels. This analysis captures the dynamic rather than static social structures, which aligns with modern behavioural ecology. The main findings are that snout contact is frequent and predominantly affiliative, and as groups stabilise, the pigs interact with fewer partners but more frequently. This provides a new perspective. Moreover, heterophily was observed, with pigs preferring non-littermates and individuals with different early experiences; and sex differences with males initiating more contact, whereas females being more central. These findings enrich our understanding of pig sociality beyond dominance and aggression.

Paper 3 is unique in its use of a large-scale, multi-group design. It is rather rare in pig leadership studies, which often rely on small sample sizes or single groups. It presents a clear operational definition of leadership, i.e. the first pig to touch the human during the human approach test. Moreover, this study addresses the integration of personality (coping style), filling a gap in the literature linking leadership to coping strategies. Finally, a clear distinction is made between the sexes – females are much more likely to be the leaders than males, which enriches our understanding of pig social systems and supports observations of wild boar.

Paper 4 presents a social buffering theory in pigs, which is moving beyond simple “familiar vs unfamiliar” to graded relationship strength. The experimental setup required observing sibling relationships to identify those with strong and weak ties, rather than making artificial pairings.

Various measurements of behaviour, vocalisations, and cortisol levels provide a rich picture of stress level/coping and social support. The results indicate the need to change/monitor management practices, as familiar pigs should be kept together during stressful procedures like regrouping and transport.

Editorial correctness of the thesis

Correction needed - There was a change in the name of the Ministry overseeing science in Poland. Currently, it is the Ministry of Science and Higher Education, not the Ministry of Education and Science.

Otherwise, excellent editorial work on the thesis: chapter order, Figure and Table editing etc. The final version requires removing line numbers.

Critical remarks

GENERAL

Statistics: Even though the statistical methods and analyses are described in great detail, the lack of a model itself in each manuscript is problematic. Descriptive presentation of statistics sometimes overcomplicates the actual method/model used. This can make it more difficult for the readers to reuse the proposed models. Any statistical program requires actually defining the statistical model; simply copying those lines and properly defining each parameter in the text would be enough. Since the thesis is a compilation of published manuscripts, it would not be possible to edit/change in the Thesis booklet.

General discussion: This section largely repeats the results and parts of the discussion from the four publications. Almost no additional evaluation/interpretation is provided to further advance the conclusions. The reason is that each of the four publications is discussed separately, without linking their results. (With an insufficient exception regarding publications 1 and 2.) For example, it could be discussed in depth “how early-life socialisation (P1, P2) might influence leadership (P3) or social buffering (P4) later in life?” or “should cortisol levels also be linked with behaviours studied in P1-3 and what would be the benefit of that?”. This chapter also does not address the limitations of the studies, which would be helpful to other researchers performing similar experiments and would also clearly show a critical take on PhD candidate’s

own work. This brings the final remark: the general discussion lacks suggestions for further studies based on the findings and/or limitations of the presented work.

SPECIFIC

Paper 1: It is unclear why a correlation of 0.3 between behaviours of interest was assumed to be high enough to make further decisions about data analysis. Were there other reasons for this decision? Regarding differences in housing conditions, although the two types are included as covariates, the behavioural variation associated with them warrants further discussion. Also, the positive correlation between aggression and both snout behaviours complicates the narrative of “risk avoidance.” This deserved a deeper exploration in discussion. The same would be expected for unrelated pigs, which show more snout contact, thereby challenging the affiliative hypothesis, but this is not fully reconciled.

Paper 2: Various statistical analyses are performed in this study; the methods section could benefit from clearer justification for each model. In terms of differences between the sexes, the discussion does not explore hormonal influences, sex-specific social strategies, or implications for welfare or management. How could husbandry practice benefit from those results in the differences between sexes?

Paper 3: Leadership is described as a binary variable. Would it be possible to analyse it as a continuous trait, which could reveal subtler patterns? What would be needed to do that if feasible? Also, the discussion could explore whether leadership in human contact reflects boldness, social motivation, or reduced fear of humans, rather than leadership per se, since the animals will react differently to a human than to a pen mate.

Paper 4: Saliva cortisol concentration is a great non-invasive measure of stress level. However, the current literature indicates that simultaneous measurement of dehydroepiandrosterone (sulphate) and its ratio is more informative for properly defining stress levels and coping with stress. Why was the dehydroepiandrosterone (sulphate) concentration not included in this study? Also, regarding the analyses' statistical power, the sample size is based on previous work, but cortisol is notoriously noisy. The lack of treatment effect may partly reflect limited power to detect subtle hormonal differences, especially when subdividing by housing, sex of “buddy”, and time of day. Was this aspect evaluated?

Final remarks

The submitted thesis presents highly relevant results that are valuable for the field of animal behavior studies and pig management practice. The thesis is prepared in a proper editorial manner that helps the reader follow the research from a gap in knowledge, through a hypothesis, to results and implications. The weakest part of the thesis is the general discussion, which is, in large parts, merely a summary of the results rather than a chapter that discusses the study's limitations, their interrelationships, and possible next steps not covered in this thesis.

I, the undersigned, hereby affirm that the doctoral dissertation submitted by **Sunil Khatiwada** satisfies the requirements set forth in Article 13(1) of the Act of 14 March 2003 on Academic Degrees and the Academic Title, and on Degrees and Title in the Arts (Journal of Laws No. 65, item 595, as amended).

I therefore petition the Scientific Council of the Institute of Genetics and Animal Biotechnology of the Polish Academy of Sciences to admit **Sunil Khatiwada** to proceed to the subsequent stages of the doctoral proceedings.

2/02/2026

data sporządzenia recenzji

Sell-Kubicki

podpis recenzenta