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**Assessment of individual- and group-level behavioral variation in dairy cattle –
from personality to social networks**

zur Erlangung des akademischen Grades
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Objectives of research

In modern dairy husbandry systems social groups are created and regularly changed according to the milk production and nutritional needs of cows. It is now recognized that there are consistent differences between cows within a group and that both individuals and groups may significantly differ regarding their welfare states. Nonetheless, currently little consideration is given to individuality and social behavior when managing groups of dairy cows. The personalities of individual cows and the group-level patterns of affiliative and agonistic interactions are potentially interconnected and may also influence welfare. However, little knowledge exists about the personality traits dairy cows express within the social environment, and it is unclear if these traits show temporal stability. Moreover, complex social interactions in groups of cattle beyond dyadic encounters are understudied, partly due to the time consuming nature of data collection. In contrast to agonistic relationships, knowledge about the role of affiliative bonds is limited, and no measure exists to integrate positive and negative interactions into one complete descriptor of sociality. Besides the understanding of behavioral processes in dairy cow groups, standardized and practical methods are needed to enable the application of this knowledge. With the increasing availability of advanced technical solutions in livestock farming, automatic data collection can facilitate management practices that better fit the needs of cows.

Therefore, in this thesis a common framework for individual- and group-level analysis of social behavior was used to better understand how the behavioral characteristics of individual cows and the behavior in the social group may influence welfare. In addition, the thesis focused on developing novel methods, facilitating the practical assessment of personality and social behavior in dairy cattle. Accordingly, three main objectives were assessed:

- 1) Investigating personality in adult lactating cows. Specifically, assessing if (a) personality traits, revealed by a number of classical individual tests, express stability over a longer period of time, and (b) personality shows consistency between individual and group contexts, measured by a developed practicable group test in the home pen.
- 2) The comprehensive analysis of the social environment in a free-stall barn. This included (a) determining a suitable time scale for the analysis of affiliative and agonistic interactions, (b) investigating the relationship between the structure of these two behaviors and also combine them into one measure, and (c) assessing the long-term temporal stability of individual social behavioral characteristics.
- 3) Facilitating the automated assessment of agonistic behavior on the group-level by validating an electronic-feeder-based algorithm for detecting the dominance hierarchy in lactating dairy cow groups in different facilities.

Main findings

Regarding the temporal and contextual stability of personality the following main findings were published in PLoS ONE 2018; 13(10):e0204619.

- Behavior of cows in a novel arena, novel object, and novel human test showed between-individual variability and within-individual consistency over 6 months.
- Two personality traits (Activity/Exploration, and Boldness) were identified based on parameters measured in the individual tests, confirming the multidimensional nature of personality in cattle.
- A practical novel object test performed within the social group of the cows showed a positive association with object contact and movement in the individual tests.
- This group test did not show temporal consistency and the repeated test indicated the impact of changing group composition on individual behavior.
- The group test could be an addition to other behavioral measures to characterize the expression of personality in the every-day social environment of cows.

The analysis of the social environment in dairy cow groups resulted in the following main findings, which were published in Applied Animal Behaviour Science 2019; 210:60-67.

- Continuous video observation of social interactions over 2-3 days provided a reliable snapshot about the affiliative and agonistic behavior in free-stall housed small dairy cow groups.
- Most agonistic interactions occurred at the feeder, highlighting the relevance of this area for automatic social interaction detection.
- Social network analysis revealed between-group and between-individual differences in affiliative as well as agonistic behavior that were stable over 6 months. This provides evidence for social complexity beyond dyadic interactions and indicates distinct personality traits related to social behavior.
- Affiliative and agonistic networks did not show any association, and on the dyadic level many symmetric displacement and asymmetric grooming relationships were observed.
- Network measures were used in a newly developed balance index to combine affiliative and agonistic interactions into one measure of social experience.

Finally, the following key findings are included in the third study, which was submitted to Journal of Dairy Science (under review):

- An algorithm using data from electronic feed and water bins was validated in multiple facilities for recording agonistic interactions on the individual-level and detecting the dominance hierarchy on the group-level.
- A 20 to 30 s time interval between the occupancy of two cows at one bin can be used to reliably estimate the number of competitive replacements and the dominance structure of groups.
- This algorithm is a practical tool to be used in further studies to investigate the relationship between aggressiveness, dominance, and welfare of dairy cows.

Conclusions

This thesis demonstrates that dairy cows consistently differ in their behavioral reactions in various ways, corresponding to individual personality and the emergence of a complex social environment in the barn. The findings suggest that the level of individuals and the level of social groups should also be taken into account when assessing dairy cattle welfare, in contrast to focusing solely on farm-level evaluation. The automatic detection of agonistic behavior and dominance is one important step in the direction of practically recording individual and group-level variation in social behavior. The knowledge and new methods presented in this thesis will help to improve the welfare of dairy cattle by minimizing the costs and maximizing the benefits of living in a group.