

Modeling Feeding Behavior and Associated Welfare and Productivity of Pigs: an Agent-based Approach

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Introduction

For animals living in groups such as commercially kept growing pigs, social factors can play an important role in feed intake. Social conflicts around the feeder can change feed intake related behavior of pigs, such as the number of feeder visits, duration of the visits and feeding rate [1]. Conflict situations can increase aggressive behaviors, increase stress, and reduce feed intake. Reduced feed intake in itself can affect growth and health of pigs, increase stress and may result in abnormal behaviors, such as tail biting or oral stereotypies [2]. Altogether, conflict situations and reduced feed intake may impair pig welfare and productivity. The aim of this study was to identify key factors controlling feeding behavior of growing pigs and to examine the effect of social factors on feeding behavior and associated welfare and productivity. Results of this study provide a theoretical framework for a computer simulation (agent-based model), that allows to explore effects of social factors in various situations on feeding behavior of pigs and associated welfare and productivity indicators.

Theoretical framework

A theoretical framework was constructed, based on empirical data and theories in literature, to identify the essential elements affecting feeding behavior of pigs. Behavioral patterns around feeding result from a complex interaction between various mechanisms. To understand how these mechanisms interact, the framework integrates knowledge of ethology, physiology, psychology, and nutrition at animal level and knowledge on the effect of group dynamics and housing conditions on feeding behavior. Many empirical studies show the effect of pig characteristics, physiological factors, nutritional factors, physical factors, and social factors on feeding behavior of pigs [e.g. 1, 3, 4]. Various ethological and psychological theories that explain behavior include psychological factors, such as goals, motivations, emotions and expectations [e.g. 5, 6]. Unfortunately, empirical data on the effect of psychological factors on feeding behavior is limited. To include psychological factors in the theoretical framework, and to explain and understand how internal and external factors affect feeding behavior, theories of motivation are applied in the framework. These theories state that internal factors can affect the response of animals to external factors, and explain that both internal and external factors can motivate an animal to perform a certain behavior.

Agent-based model

Based on the theoretical framework, pig feeding behavior is modeled in an agent-based model. Agent-based modeling (ABM) is a computational modeling method based on heterogeneous agents. Agents are individuals or entities in the simulation with programmed characteristics that can act autonomously and can interact with other agents and the environment. Each agent can adapt and change its behavior during the simulation, allowing for unpredicted and complex behavioral patterns to emerge at a higher level. ABM is a suitable approach for addressing complex and multilevel systems and gaining insight in the interaction of the individual components and the effect on system behavior [7].

In this study, a two dimensional and spatially explicit agent-based model was constructed and implemented in Netlogo 5.0.3 [8]. The environment in the model represents a conventional barren housing pen for group housed pigs with one feeder and ad libitum access to feed. The agents represent growing pigs from the age of 10 till 25 weeks. Variation in pig characteristics can be modeled, for example, by assigning pigs different growth capacities (associated with genotypes) or different coping styles (associated with active or passive stress responses). Dynamics of feeding behavior are modeled by combining a nutritional and physiological growth model [9, 10] with a mechanistic control of feed intake and physiological feedback mechanisms. The control of feed intake is affected by five factors: pig characteristics, feed characteristics, physiological factors, psychological factors, and social factors (Figure 1). The theoretical framework is implemented in the model as two processes within each agent. The first process concerns the formation of feeding motivation and other motivational states in the pigs, the second process is directed at decision-making, i.e. how pigs act behaviorally on the feeding motivation. The processes in the simulation are updated every time step (representing one minute).

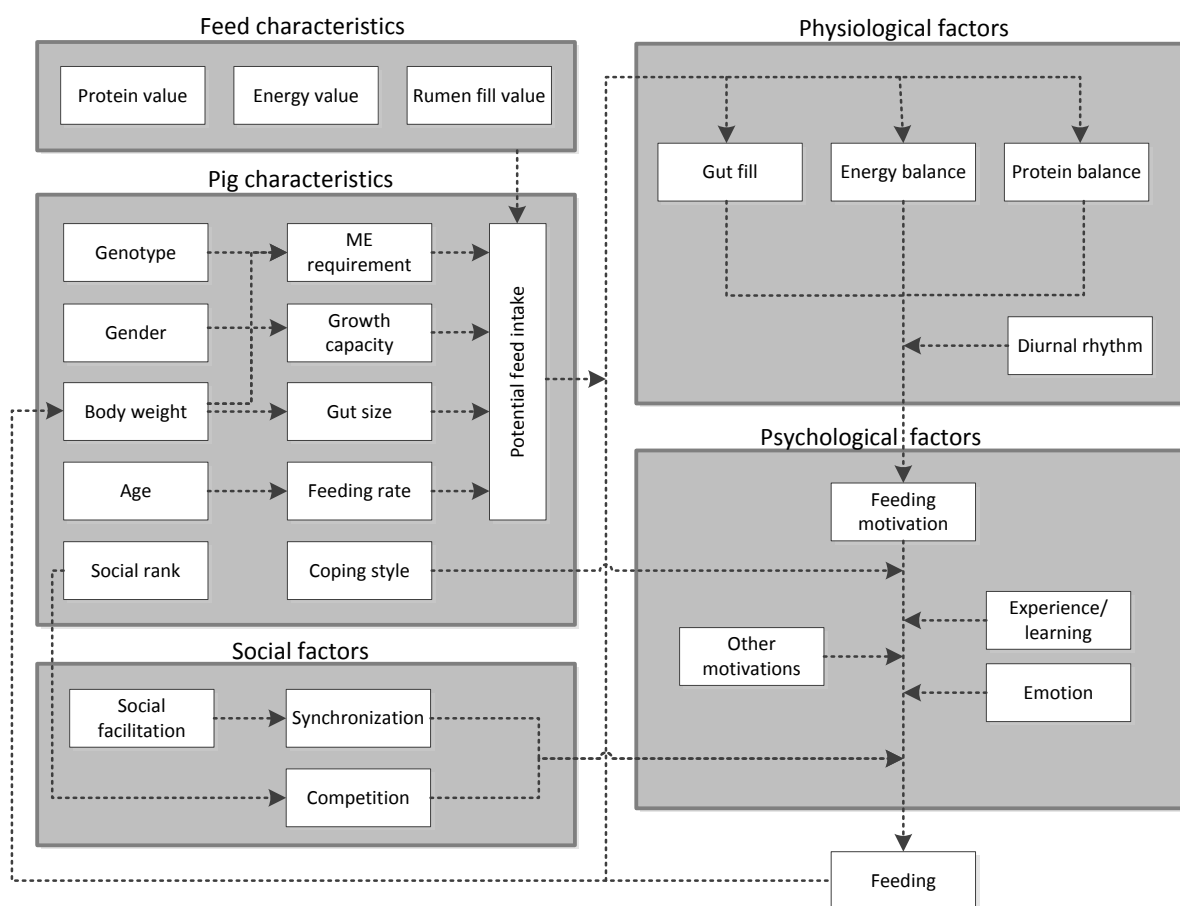


Figure 1. Schematic overview of feeding behavior in the model: the formation of feeding motivation and factors affecting decision-making of pigs to act on feeding motivation.

Model output includes different behavioral components of feeding behavior, such as amount of feed intake, number of visits, meal duration and intervals between meals. Furthermore, output also includes the sequence of behaviors and time budget of pigs (for performing certain behaviors). Behaviors that can precede or follow feeding behavior (e.g. waiting, drinking, or approach) are included in the model to allow pigs to adapt to conflict situations. Adaptation of pigs to conflict situations is affected by coping style, competition (influenced by social

rank), and psychological factors, such as experience or motivations. The model allows to monitor the development of pigs and possible changes in their behavior in time. Furthermore, several welfare and productivity indicators can be assessed, such as number of conflicts, aggressive encounters, stress levels and feed efficiency of pigs (based on feed intake, energy use, and growth).

Conclusion and future work

The interdisciplinary theoretical framework shows how individual variation among pigs and social influences interact multidimensionally and can affect feeding behavior. ABM allows to test theoretical models and to gain insight in causation and consequences of behavior. The agent-based model is developed in two steps to reduce complexity of the model and to understand the effect of internal and external factors separately. The first step is the development of a model that reflects the dynamics of feeding behavior affected by internal factors, such as physiological factors, psychological factors and pig characteristics (by modeling an individual housed pig). The second step concerns the inclusion of social factors and the effect of interaction among pigs (and modeling group housed pigs). Examples of questions that can be studied with this model are: (1) Which internal factors can explain behavioral feeding patterns of a pig?; (2) How can social factors affect feeding behavior and welfare?; (3) How can pig characteristics and group composition affect feeding behavior and welfare? The model in this study is still preliminary and needs to be further refined and evaluated before final conclusions can be drawn. First results show that diurnal behavioral patterns can be modeled in which pigs are more active and perform more feeding behavior during daytime than during the night. In the future, the model will be validated by aligning the model to experimental settings in available experimental data and studies described in the literature, and by comparing results of these studies with the output of the model.

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