Tail biting behaviour in pigs

ODD[1] model description

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1. Purpose

The purpose of the model is to gain more insight in the causation of tail biting behaviour of growing pigs in conventional housing. The model simulates the patterns of tail biting behaviour. Tail biting has two roles: biter, and victim. As a result of potentially biting and potentially being bitten, pigs end up into four tail biting categories. Tail biting behaviour could emerge when the internal motivation of pigs to explore could not be fulfilled. The effect of a redirected exploratory motivation, behavioural change in victims and preference to bite a lying pig on tail biting patterns was tested in our model.

2. Entities, state variables, and scales

Table 1. Entities included in the model with their state variables and units of measurement

Entity	Variable	Description	Unit
Pig	Exploration drive	Internal state affecting exploration behaviour	Unitless (0-1)
	Feeding drive	Internal state affecting feeding behaviour	Unitless (0-1)
	Sleeping drive	Internal state affecting sleeping behaviour	Unitless (0-1)
	Biting drive	Internal state affecting tail biting behaviour	Unitless (0-1)
	Biting threshold	Threshold level for performing tail biting behaviour	Unitless (0-1)
	Movements	Sum of performed moving behaviours per pig	Number
	Feedings	Sum of performed feeding behaviours per pig	Number
	Explorations	Sum of performed exploration behaviours per pig	Number
	Restings	Sum of performed resting behaviours per pig	Number
	Sleepings	Sum of performed sleeping behaviours per pig	Number
	Bites	Sum of performed biting behaviours per pig	Number
	Bitten	Sum of performed received tail bites per pig	Number
Environment	Pigs	Number of pigs in the pen	Number

Temporal and spatial resolution: One time step represents one minute and simulations were run for 720 minutes (diurnal day time of 12 hours). The model world represents a barren pen of 10 square meter with a concrete floor and ad libitum access to feed. The pen is not wrapped (pigs cannot move outside the ‘walls’ of the pen).

3. Process overview and scheduling

Each time step, pigs (in a random order) update their internal states. These internal states are exploration drive, feeding drive, sleeping drive and biting drive. When an internal state is above a threshold, pigs become motivated to perform the behaviour relat-

[1] The model description follows the ODD (Overview, Design concepts, Details) protocol for describing individual- and agent-based models (Grimm et al. 2006, 2010).

ed to the internal state. When all drives are lower than the thresholds, a pig is not motivated to perform a behaviour and it randomly moves or rests. Internal states in the model change after a pig performs a behaviour (for a flowchart of these processes, see Figure 2 in Boumans et al. (2016)).

4. Design concepts

Basic principles.
Many studies support the hypothesis that tail biting is a redirected behaviour that occurs when the environment lacks appropriate stimuli. In our model we test three factors (combined and separately) as explanatory factors for emergence of non-damaging tail biting behaviour in pigs: motivation to bite tails (as redirected behaviour), behavioural change in a victim and preference for biting the tail of a lying pig.

We use the concept of motivation for behavioural decision-making: motivation for a behaviour is the balance between an energy drive and threshold level, and feedback mechanisms can affect the motivation (Hogan, 1997). Furthermore, behavior is the result of several motivational systems, in which behavior is result of the highest motivation (which is described as the state-space approach by (McFarland and Sibly, 1975).

Emergence.
The model has two main emergent results:
- The incidence of tail biting behaviour in pigs
- The distribution of pigs into four tail biting pig categories (biter, victim, biter and victim, neutral).

Furthermore, the model also produces patterns in other pig behaviours, such as feeding, exploring, and resting. These results, however, are only slightly affected by the emergence of tail biting behaviour and therefore mainly calibrated to represent the time budget of pigs observed in intensive housing systems (Bolhuis et al., 2005).

Adaptation, objective.
Pigs adapt their behaviour based on their highest motivation to fulfil their internal needs.

Learning, prediction.
Pigs do not learn, nor predict future conditions.

Sensing.
In order to bite a pen mate, pigs have to sense where the other pigs are. Biters select a victim that is closest (if switch "victim-lying?" is off) or a nearby pig with the highest sleeping drive (if switch "Victim-lying?" is on).

Interaction.
Pigs interact when a pig performs tail biting behaviour.

Stochasticity.
Stochasticity is used for randomizing initial states during setup of the model. Start values of internal states are assigned randomly. Furthermore, the threshold level for stress is varied randomly to represent individual variation. When pigs are not motivated, they randomly move or rest based on a probability.

Collectives.
No collectives are included.

Observation.
Observations include data showing neutral pigs changing into biters and / or victims and the development in tail biting behaviour in time. Furthermore, the behavioural time budget of pigs is monitored.

5. Initialization

The initial state of the model is assigned randomly at setup, determined by a specified seed for a pseudo-random number generator.

In the initial state of the model, values for internal states are set to a random value based on a normal distribution with a mean of 0 (for sleeping-drive and exploration-drive), or -0.4 (feeding-drive) and a standard-deviation of 0.25. These values were chosen after several simulation runs to correspond to the average levels of the internal states during the simulation. Biting-drive is set to zero in the initial state, assuming that pigs had no motivation to bite tails in the morning after a night of mainly sleeping.

6. Input data

The model does not use any external input.

7. Submodels

Update internal states and check motivations (motivated?)
Motivations are calculated as the difference between the internal state (drives) and the threshold level. Threshold levels for exploration drive, feeding drive and sleeping drive are zero. To represent individual variation among pigs, the threshold for biting-drive randomly varies per pig, based on a normal distribution with a mean of 0.5 and standard-deviation of 0.05. When pigs are not motivated, they randomly move or rest based on a probability. This probability (respectively 0.14 and 0.86) was calibrated to correspond to empirically observed behavioural time budgets of pigs (e.g. Bolhuis et al., 2005). Internal states in the model change after a pig performs a behaviour (Figure 1).

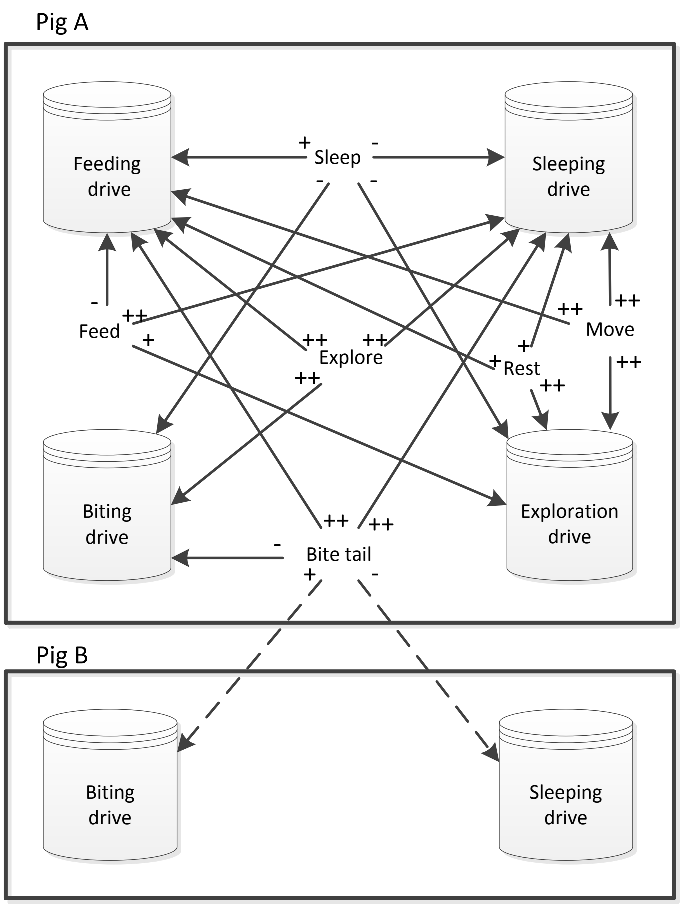

Figure 1. Feedback mechanisms of performed behaviours on internal states of pigs in the model. Arrows indicate the effect of behaviours on internal states (in cylinders), where minuses or pluses indicate the strength of the effect (see Table 2 for values). Solid arrows represent feedback mechanisms within an agent. Dashed arrows represent the effect of tail biting behaviour of a biter (Pig A) on a victim (Pig B) when behavioural change in a victim as a factor is included in the model.

Table 2. Feedback values of performed behaviours on internal states of pigs in the model per time step.

Internal states	**Change per time step**		
	+	**++**	**-**
Exploration drive	0.05	0.17	-0.10
Feeding drive	0.09	0.18	-1.11
Sleeping drive	0.17	0.21	-0.20
Biting drive	0.05	0.276	-0.09

Behaviours

Pig behaviours in the model are sleeping, resting, feeding, exploring, moving and tail biting. These behaviours represent the most common behaviours of pigs. Behaviour of pigs kept in barren intensive housing systems, in their active period during daytime, consists of about 70-80% lying behaviour and 20-30% active behaviours, such as feeding, exploring and moving (e.g. Bolhuis et al., 2005).

Move
A pig:
- moves random to a location in the pen. It faces to the nearest pig and moves backward half a step.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of movements with 1

Feed
A pig:
- Faces and moves to one of the feeding troughs.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of feedings with 1

Try to explore
A pig:
- Turns by a random number of degrees. If it can move it moves forward two steps. It faces to the nearest pig and moves backward half a step.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of explorations with 1

Bite tail
A pig:
- If PREF is included: Moves to a nearby inactive pig (a pig with resting of sleeping performed as last behaviour) in sight of two steps and a viewing angle of 180 degrees and select it as victim. After biting it moves random to a location in the pen.
- If PREF is not included: Moves to the closest pig and selects it as victim. After biting it moves random to a location in the pen.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of tail bites with 1

The victim:
- If IMP is included: Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of being bitten with 1

Rest
A pig:

- Moves to the closest pig, moves backward half a step.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of restings with 1

Sleep
A pig:

- Moves to the pig with the highest sleeping drive and moves backward half a step.
- Adjusts its internal states (see Figure 1 and Table 2)
- Increases its number of sleepings with 1

8. Simulation experiments

The effect of factors combinations in four scenarios was tested:

1. Reference setting (motivation for biting as sole factor)
2. Motivation + preference for biting a lying pig.
3. Motivation + behavioural changes in a victim.
4. Motivation + preference for biting a lying pig + behavioural changes in victims.

Furthermore, the sensitivity of model results to parameter values was tested (changing one parameter per simulation with an alteration of 50%). As well as the sensitivity of the model to individual variation in pigs (initial internal states and threshold for biting drive).

Model results can be found in Boumans et al. (2016).

References

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