# Tail posture and motion as a possible indicator of emotional state in pigs

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## Summary

In the current study, the aim was to investigate whether tail posture and motion can be an indicator of the emotional state of pigs and if the tail posture of the pig is affected by social breeding value (SBV), coping style and/or housing. Emotional state can be defined in two dimensions: valence and arousal. Two batches of 96 finishing pigs were studied in a one generation selection experiment with a 2x2 set up and were housed in a barren or straw bedded pen. In each pen, 6 pigs (3 male, 3 female) were housed. A back-test was done to determine the coping style of the pigs with two categories; high resister and low resister pigs. When possible, each pen held 3 high resisters and 3 low resisters pigs. Furthermore, half of the pens contained pigs with low SBV and the other half contained high SBV pigs. Tail condition scores were determined weekly. A novel environment test (150 sec) with a small arena was performed at 3.5 weeks of age to test the fearfulness of the pigs. Behaviours and vocalisations were recorded together with the tail posture and motion. Four different tail posture and motion categories were recorded; curled tail, hanging tail, tail between legs and tail wagging. Furthermore, home pen observations were performed to link behaviours to a tail posture or motion.

The most performed tail posture in the novel environment test and the home pen observations was a hanging tail posture (60%), while curled tail was performed 30% of the time and tail between the legs and tail wagging occurred both 5% of the time. A curled tail was linked with active behaviour (high arousal), whilst a hanging tail was linked with inactive behaviour (low arousal). No effect of SBV or coping style was found in the novel environment test on the tail postures and motion. In the home pen observations, low SBV pigs showed more tail between the legs than high SBV pigs ($P<0.05$). High resisters kept their tail curled more often than low resisters ($P<0.01$). Also, high resister pigs with a low SBV showed a curled tail more often than the other treatment groups ($P<0.05$). Tail between the legs occurred more often in barren housed pigs than in enriched housed pigs ($P<0.05$), which could link this tail posture to a negative emotional state. Housing had an effect on the tail condition score; barren housed pigs without straw had more tail damage than enriched pigs ($P<0.0001$). Positive correlations were found between eating/drinking and a curled tail, social behaviour and tail between legs, and negative social behaviour and manipulation with a wagging tail ($P<0.0001$).

To conclude, a curled tail could be linked to a positive emotional state, with high arousal. A hanging tail may be linked to a neutral state, neither positive nor negative. Pigs with their tail between the legs may be associated with a negative emotional state and low to medium arousal. Tail wagging can be associated with a negative emotional state, with high arousal. However, conclusions should be made carefully, because still little is known about the link between emotional states and behaviour. Positive tests could be done to make the link between a positive emotional state and a certain tail posture more clear. Also, tests that elicit a more fearful response than the novel arena test could confirm results from the current study.

## Sammanfattning

Syftet med denna studie var att undersöka om svansens hållning och rörelse kan utgöra en indikator på känslotillståndet hos grisar och om grisens svanshållning påverkas av socialt avelsvärde (SBV), stresshanteringsstil och/eller inhysning. Emotionellt tillstånd kan definieras i två dimensioner: valens och uppmärksamhet. Två omgångar med 96 slaktsvin studerades i ett selektionsexperiment på en generation med utformningen 2x2 och hölls i en box som var tom eller försedd med ströbädd. I varje box hölls 6 grisar (3 hanar, 3 honor). Ett ryggtest utfördes för att bedöma stresshanteringsstilen hos grisarna enligt två kategorier; högt motstånd och lågt motstånd. Om möjligt innehöll varje box 3 grisar med högt motstånd och 3 grisar med lågt motstånd. Dessutom innehöll hälften av boxarna grisar med lågt SBV och den andra hälften av boxarna innehöll grisar med högt SBV. Svanshållningens gradering bedömdes varje vecka. Ett test i okänd miljö (150 s.) i en liten arena utfördes vid 3,5 veckors ålder för att testa hur rädda grisarna var. Beteende och vokalisering registrerades tillsammans med svansens hållning och rörelse. Fyra olika svanshållningar och rörelsekategorier registrerades; ihopringlad svans, hängande svans, svans mellan benen och svans viftande. Utöver detta gjordes observationer i hemboxen för att koppla beteenden till svansens hållning och rörelse.

Den vanligast utförda svanshållningen i testet i okänd miljö och i observationerna i hemboxen var en hängande svanshållning (60%), medan ihopringlad svans utfördes 30% av tiden och svans mellan benen och viftande svans båda förekom 5% av tiden. En ihopringlad svans kopplades till aktivt beteende (hög uppmärksamhet), medan en hängande svans kopplades till inaktivt beteende (låg uppmärksamhet). Ingen effekt av SBV eller stresshanteringsstil erhölls i testet i okänd miljö på svansens hållning och rörelse. I observationerna i hemboxen hade grisar med låg SBV svansen mellan benen mer än grisar med hög SBV ($P<0.05$). Grisar med högt motstånd i ryggtestet hade sin svans ihopringlad mer än de med lågt motstånd ($P<0.01$). Dessutom visade grisar som hade högt motstånd och lågt SBV en ihopringlad svans oftare än de andra behandlingsgrupperna ($P<0.05$). Svans mellan benen förekom oftare hos grisar som hölls i en box utan halm än hos grisar som hölls i en box med halm ($P<0.05$), vilket kan koppla denna svanshållning till ett negativt känslotillstånd. Inhysning hade en effekt på bedömningen av svansskador; grisar utan halm hade mer svansskador än grisar med halm ($P<0.0001$). Positiva korrelationer erhölls mellan äta/dricka och ihopringlad svans, socialt beteende och svans mellan benen, och negativt socialt beteende och manipulering med en viftande svans ($P<0.0001$).

Sammanfattningsvis, en ihopringlad svans kunde kopplas till ett positivt känslotillstånd, med hög uppmärksamhet. En hängande svans kan kopplas till ett neutralt tillstånd, varken positivt eller negativt. Grisar med svansen mellan benen kan kopplas till ett negativt emotionellt tillstånd, och låg till mellan uppmärksamhet. Svansviftande kan kopplas till ett negativt emotionellt tillstånd, med hög uppmärksamhet. Dock ska slutsatser dras försiktigt, eftersom man fortfarande bara vet litet om kopplingen mellan känslotillstånd och beteende. Positiva test skulle kunna göras för att få kopplingen mellan ett positivt emotionellt tillstånd och en särskild svanshållning tydligare. Även test som utlöser en högre rädslereaktion än testet i den okända miljön kan bekräfta resultaten från denna studie.

# 1. Introduction

### 1.1 Current issues in pig husbandry systems

The barren, stimulus-poor environment can cause welfare problems in finishing pigs (Wemelsfelder *et al.*, 2000). Scientific literature shows that a large welfare problem for barren housed pigs is the oral behaviour directed to pen fittings or pen mates (Ruiterkamp, 1987; McKinnon *et al.*, 1989). This is probably because pigs are highly motivated to explore and forage, even when enough food is available (Wood-Gush and Vestergaard, 1991). If pigs are provided with straw this strongly influences behavioural activities of the pigs (Beattie *et al.*, 1995; Bolhuis *et al.*, 2005). The reason for this is that straw provides a motivation and outlet for exploratory and manipulative behaviour involving the snout and the mouth (Arey, 1993; Lyons *et al.*, 1995; Morgan *et al.*, 1998; Guy *et al.*, 2002). The supply of straw is generally considered to improve the comfort and welfare of pigs (Arey, 1993), but also peat, mushroom compost and sawdust can be used as substrate, and would increase their welfare (Beattie *et al.*, 1998).

Tail biting is an example of oral manipulations that often occur in barren pens, and it can result in wounds and haemorrhages (Fraser & Broom, 1997) and even in crippling and death (van Putten,1961 Fritschen and Hogg, 1983). The open wound can also spread infections through the pigs in the pen (Schroder-Petersen and Simonsen, 2001). That provision of substrate can prevent undesirable behaviour such as excessive tail biting, ear biting and stereotypy has been confirmed by many studies (Fraser, 1975; Burbidge *et al.*, 1994; Spoolder *et al.*, 1995).

### 1.2 Emotional states in sentient beings

Animal welfare concerns are generally based on the assumption that animals can experience pain or pleasure (Dawkins, 1990; Mendl and Paul, 2004; Boissy *et al.*, 2007). The European legislation on animal welfare is based on these concerns, and the aim of this legislation is ‘to ensure improved protection and respect for the welfare of animals as sentient beings’ (European Union, 1997).

One factor relating to an animal’s welfare is its emotional state (WelfareQuality®, 2009). However, it is difficult to determine the emotional state of the animal. Defining emotional state is difficult as well. Multiple definitions have been given throughout the years. Cabanac (2002) concluded in his review about emotion that the best definition is from Panksepp (1986), namely; “*any mental experience with high intensity and high hedonic content* (pleasure/displeasure)”. Mendl *et al.* (2010) suggested that emotions can be defined in two fundamental underlying dimensions: valence and arousal, see figure 1. Valence can be explained as a pleasure to displeasure that is felt by a sentient being. Arousal is the degree of excitement (from sleep to fanatic excitement; Spinka *et al.*, 2001). Emotional states can be experienced positive or negative, like a reward or a punishment, pleasant or unpleasant (Mendl *et al.*, 2010). A neutral state is not seen as an emotional state (Mendl *et al.*, 2010).

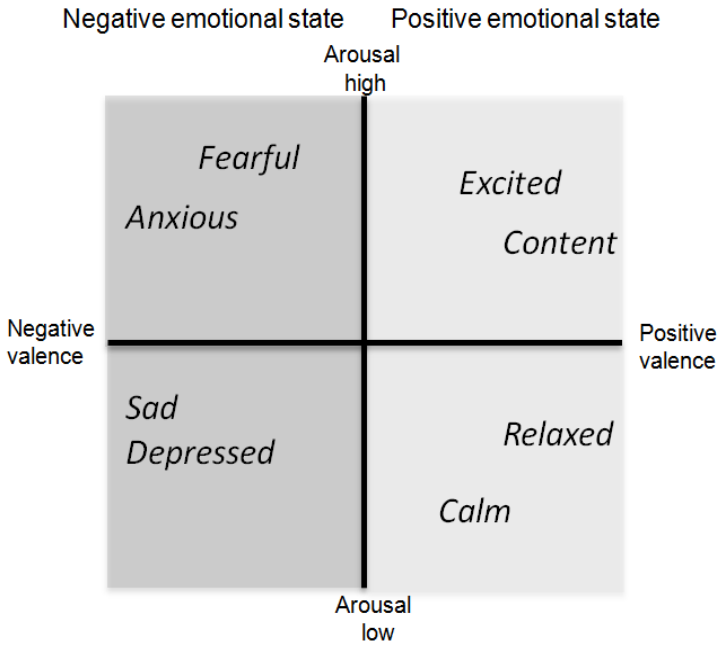


**Figure 1. Two dimensional approach of emotional states. The left side of the figure represents a negative emotional state and the right side a positive emotional state. Words in italics indicate possible locations of specific affective states. Adapted from Russell and Barrett (1999) and Mendl *et al.* (2010)**

Constructing a tool to measure pig welfare can be difficult and complex due to the many factors influencing welfare (Courboulay *et al.*, 2009). LeDoux (1996) suggests that the best objective and exact way to measure emotional state of an animal, is to look directly at the processes within the brain, for example hormone transport or neurotransmitter release. Another more practical way to measure the emotional state is to observe behaviour. However, with some behavioural measures it is hard to say whether the emotional state is positive or negative (Watson *et al.*, 1988; Russell, 2003). For example, nosing wall is seen often as exploration and a positive behaviour, but during a fear test, nosing wall can be seen as searching for an escape route and this is seen as negative behaviour.

### 1.3 Expressing emotions by using the tail

In primitive vertebrates and fish the function of the tail was mostly for locomotion, with the development of legs this function is less clear, but still important (Young, 1961). In many species, the tail is still used for activities that are related to locomotion, but the tail can also be used for protection, anti-predator behaviour (Kiley-Worthington, 1975; Hickman, 1979) and (intraspecific) communication (Caro *et al.*, 2004).

In ungulates an erected tail is associated with alarm and flight behaviour (e.g., Alados, 1986), or to display their rump patches during social interactions (Guthrie, 1971). Stankowich (2008) suggested that tail erection on his own occurs as a result of motor reflexes during arousal. While tail wagging, side-to-side tail movements, is used for intraspecific communication in deer (Caro *et al.*, 2004) and dogs (Tembrock, 1968; Fox, 1971; Orotolani, 1999). Stuart and Stuart (1997) suggested that tail wagging in ungulates is simply indicating arousal and does not have other functions. Tail wagging has been described as a sign of ‘restlessness’ in cattle (Sylvester *et al.*, 2004) and ‘frustration’ in antelope

(Kiley-Worthington, 1978), but excitement, comfort and relaxation in dogs (Fox, 1969; Kleiman, 1972; Prince, 1975). A hanging tail is seen in ungulates (Guthrie, 1971) as in dogs (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998) as a neutral or 'switched off' tail. While keeping the tail between the legs reflect fear and/or submission in dogs (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998). Furthermore, in dogs the tail posture and tail motion are found to be related to the emotional state that the animal is experiencing (Fatjo *et al.*, 2007).

Wild boars have a straight tail, whilst pigs can have their tail in a curl. This is probably due to domestication. Not much is known of the function of the pig's tail. The tail posture could be linked to behavioural activity levels. Active pigs have their tail usually in an upwards curl (Kleinbeck and McGlone 1993), while resting pigs usually keep their tail relaxed or 'switched off'. Pigs have their tail in a curled posture approximately 75% of the time and in a hanging posture 25% of the time (Zonderland *et al.*, 2009). Furthermore, Kiley-Worthington (1976) showed that tail wagging significantly increased in food frustrated situations and others found that it increased shortly after surgical procedures (Noonan, 1994; Hay *et al.*, 2003). However, just after tail docking, pigs often clamp their tail stump between the hind legs without showing any signs of tail motion (Noonan, 1994). It is suggested by Noonan (1994) that this tail posture indicates stress or pain. A wound and/or pain could also be the result of tail biting. A similar pattern is seen in groups of pigs where tail biting occurs (Zonderland *et al.*, 2009). Zonderland *et al.*, (2009) showed that tail damage from tail biting can be predicted by observing the tail posture of the pigs. Also McGlone *et al*. (1990) and Statham *et al.* (2008), showed that during a tail biting outbreak, pigs tended to keep their tails between the legs, while curled pig tails were observed more in pens without a tail biting outbreak (McGlone *et al.*, 1990). Active pigs with their tail in an upward curl usually lack any tail damage (Zonderland *et al.* 2009). Furthermore, when pigs have a damaged tail, they often show more tail wagging (Zonderland *et al.*, 2009), this is probably due to skin irritation (Kiley-Worthington, 1976). Tail postures of pigs may give more insight into the emotional state of a pig at a specific moment in time.

**1.4 Emotions in behavioural tests**

Fear and anxiety are two emotional states induced by the perception of a danger or a potential danger that threatens the integrity of the animal (Boissy, 1995). Fear and anxiety can be evaluated through the exposure to a novel object in a novel object test (Forkman, 2007). Another example of a test that is frequently used is the Human Approach test, which is specifically developed for farm animals, where the animal is either approached by a human or is free to approach a human (Forkman, 2007). Another test that is applied to a wide range of farm animals, such as ruminants, pigs, horses and poultry, is the Novel Environment test. This test is in literature commonly called 'Novel Arena test' or 'Open-field test' (Forkman, 2007).

In the novel environment test, a pig is placed in a novel arena, varying mostly from 5 $m^2$ up to 10 $m^2$ (up to 8 weeks of age; Forkman, 2007), and the behavioural response to the new situation is noted (Von Borell, 1992; Beattie, 1995; Forkman, 2007;). Behaviours that are commonly recorded are: locomotion, activity (e.g. lying, standing, standing immobile and exploration), eliminative behaviour

(defecation, urinating) and vocalisations (e.g. squeals, grunts; Forkman 2007). Types of behaviour such as standing immobile and escape behaviour, like jumping, could be appropriate parameters to measure fear in this fear test (Dalmau *et al.*, 2009). These behaviours are seen as indicators of a negative emotional state (Ruis *et al.*, 2000; Moe *et al.*, 2006), but also defecating and urinating are linked to a negative emotional state in fear tests (Lang *et al.*, 2000).

Vocalisations can show the emotional state of the pig (Mendl *et al.*, 1997). Vocalisations can indicate specific emotional states occurring spontaneously or induced by external events and contexts (Weary & Fraser 1995; Schrader & Todt 1998). It is known that pigs release a large variety of vocalisations like squeals, grunts, and screams, depending on the valence of the context (Manteuffel *et al.*, 2004) and on the intensity of emotion (Marx, *et al.*, 2003). Screaming is usually linked to pain and a high level of stress (Marx *et al.*, 2003). While squealing can express excitement and activity during isolation (Marchant *et al.*, 2001) and indicate fearfulness (Fraser, 1974; Marchant *et al.*, 2001; Bolhuis *et al.*, 2004; Kouwenberg *et al.*, 2009). Grunts show a more positive emotional state and can be linked to positive behaviours like exploration (Spinka *et al.*, 2001) and maintaining social contact with group mates (Fraser, 1974; Schrader and Todt, 1998). According to Schon *et al.* (2004) grunts are linked to a low stress level.

**1.5 Coping style**

Pigs can show a wide variation in responses when exposed to the same stressful situation (Schouten & Wiepkema, 1991; Lawrence *et al.*, 1993) for example in fear tests. The individual reaction pattern in pigs is often called; 'coping styles' or 'coping strategies'. Coping styles could help to gain insight in the personality of pigs. A coping style is a behavioural and physiological reactivity to challenges (e.g. Benus *et al.* 1991; De Boer *et al.* 2003). Coping styles are usually described as two extremes such as shy or bold, active or passive, proactive or reactive and hawk or dove (Koolhaas *et al.*, 2010).

To determine coping styles in pigs a so called back-test is used (e.g. Hessing *et al.*, 1994; Ruis *et al.* 2000; Van Erp-Van der Kooij *et al.*, 2000; Bolhuis *et al.* 2004). During the back test, the animals are individually placed on their back and manually restrained for 60 seconds. During this restraint, the behavioural reaction is assessed (see Hessing *et al.*, 1993 for a detailed description of the test). In general, the animals are categorised in two groups, for example high resistant when the animal struggle at least twice (Hessing *et al.*, 1993) and show more than 25 vocalisations, versus low resistant when they struggle less than twice (Hessing *et al.*, 1993) and show less than 25 vocalisations. Animals with different coping styles react in different ways; in mice and rats for instance aggressive individuals are more likely to be high resisters, whereas non-aggressive individuals appear to be low resisters (reviewed by Benus *et al.* 1991; Koolhaas *et al.* 1999, 2001). Jensen *et al.* (1995) criticised the two-classification approach of the back-test, because it is the selection of extremes. Regardless of this criticism, many other studies have used the back-test with positive outcomes (e.g. Hessing *et al.*, 1994; Ruis *et al.*, 2000; Ellenbroek *et al.*, 2002). It seems to be that the back-test is a proper way to show the individual differences in pigs.

### 1.6 Genetics

Vitality of an animal can depend on characteristics of the group (Griffing 1967, 1976; Moore *et al* 1997; Bijma & Wade 2008). Pigs on commercial farms are kept in large groups, therefore positive and negative social interactions have great impact (Rodenburg *et al.*, 2010). Bergsma *et al.* (2008) indicate that part of the effects an animal has on pen mates has a genetic background. Commercially kept pigs are selected on individual production traits, and not by including their effects on group members (Muir, 2005). A side-effect of the current genetic selection method might be an increase in negative social behaviours (Rodenburg *et al*., 2010). Including social genetic traits in the breeding goal when selecting finishing pigs, may solve these behavioural problems (Ellen *et al.*, 2007).

Including social genetic traits of pigs, which are the heritable effects of pigs on their group members, in the selection process may be a method to indirectly select for behaviour. This could be done for production traits like growth. The heritable effects a pig can have on its pen mate can be expressed in Social Breeding Value (SBV). Bergsma *et al*. (2008) showed that pigs can have significant effects on growth rate and feed intake of pen mates. The mechanism behind these social genetic effects is still unknown.

High SBV pigs are expected to have a positive effect on average daily gain (ADG) of their group mates. Rodenburg *et al.*, (2010) found that pigs with high SBV were less aggressive under stable conditions than low SBV pigs. The increase of ADG could be due to the decrease in aggression (under stable conditions) as negative social encounters could result in lesions. The healing of lesions is energy costly, leaving less energy for growth. Also, lesions could cause infection, leading to illness and reduced feed intake (Regula *et al.*, 2000). Besides lesions, stress caused by negative social encounters could result in a reduced immune response and a decrease in ADG.

However, research showed that high SBV pigs were more aggressive just after mixing (de Vries, unpublished results; Canario *et al* 2010). Results from de Vries (unpublished results) and Canario *et al.* (2010) showed that pigs with a high SBV for growth had more lesions to the front of the body just after mixing than pigs with a low SBV.

Of the three hypotheses that exist on the mechanism behind SBV for growth one could explain this mechanism: Pigs with high SBV show:

- More positive social behaviour, such as nose contact or nosing a pen mate's body
- Less negative behaviour, such as fighting and biting
- Less overall activity than low SBV pigs.

The current study might give insight in the changes that may occur in social behaviour of SBV selected pigs.

SBV of pigs for growth can be calculated with the help of a statistical formula (Muir, 2005; Bijma *et al.* 2007; Bergsma *et al*, 2008). The formula shows that the phenotype of individual i is influenced by its genetics (A) and the environment (E), but also by the genes of its pen mates (n-1) and their environment.

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$$P_i = A_{D,i} + E_{D,i} + \sum_{i \neq j}^{n-1} (A_{S,j} + E_{S,j})$$ (Griffing, 1967)

**1.7 Study aim and research questions**

The aim of this study is to investigate whether tail posture and motion in pigs indicates their emotional state and if SBV, housing and/or the coping strategy affect the tail posture during a novel environment test and in the home pen.

The following research questions will be investigated;

*Can tail posture (and tail motion) be used as an indicator of the emotional state of pigs?*

I. Is there a relationship between tail posture and behaviour in the home pen?
II. Is there a relationship between tail posture and behavioural responses to a novel environment test?
III. Can vocalisations during a novel environment test be associated with tail posture?

*Is behaviour, tail posture and tail motion affected by housing conditions, coping style and/or SBV (or their interaction)?*

## 2. Materials and methods

### 2.1 Experimental design

In this experiment, 32 Landrace sows with either a high SBV (+2.72 g average daily gain (ADG), n=16) or a low SBV (-1.50 g ADG, n=16) were used to produce offspring with either a high SBV or a low SBV. The sows were inseminated with boars (synthetic line of Large White) with either a high or low SBV. Per batch approximately 200 piglets were born at an experimental farm of the Institute for Pig Genetics in Beilen, The Netherlands.

At approximately four weeks of age, piglets were weaned and 96 of the 200 piglets per batch were transported to the experimental facility 'The Haar' of Wageningen University, the Netherlands. For this study two successive batches were studied, leading to a total of 192 crossbred finishing pigs. The pigs were slaughtered at 23 weeks of age.

### 2.2 Animals & Housing

*Before weaning*

Piglets were housed with their sow in a barren conventional housing system with farrowing crates until they reached the age of four weeks. The pens were 2.25m x 3.25m, with 53% slatted floor and 47% concrete floor. The lights were on from 7 o'clock in the morning until 4 o'clock in the afternoon. Litters were set at a maximum of 14 piglets with cross fostering after one week of age. Male piglets were castrated at day 3. The pigs were not tail docked, nor teeth clipped.

*After weaning*

At the research facilities in Wageningen the pigs were housed in a 2x2 experimental arrangement, with SBV (high or low) and housing conditions (barren or enriched) as fixed factors. The two batches of pigs were housed in two different stables located near each other. There were 16 pens per batch, that each contained six pigs. Per treatment four pens were available. The pigs remained in their group of six until slaughter. The groups per pen contained three barrows and three gilts and three high resisters and three low resisters whenever possible. The piglets were subjected to a back-test at approximately 3 weeks of age. Based on the results the pigs were categorised into either high resisters or low resisters. The pens in batch 1 were 2.25m x 3.25m, with 40%slatted floor and 60% concrete floor, the pens in batch 2 were 1.90m x 320m with 53% slatted floor and 47% concrete floor. The pens contained one dry pellet feeder with conventional feed and one water nipple. Eight pens were barren; a ball and chain were present from day one, a jute bag from week 8. The barren-housed pigs were provided with a hand full of sawdust daily from week 6 to prevent escalation of tail biting outbreaks. The other eight pens were enriched deep litter pens with straw bedding, and in these pens, the floor was completely solid with straw and sawdust bedding there was also a ball, chain and a jute bag present. The soiled straw was cleaned daily by the animal caretakers, and new straw added in the enriched pens on a daily basis. In the stable a light regime of 12:12 was used. At weaning the animals had an ear label and received back numbers with blue marking spray for identification purposes, the numbers were sprayed on a weekly base. Temperature in the stable was kept between 25°C-27°C in the first week after weaning, and gradually lowered to 20°C until slaughter.

**2.3 Observations**

*Novel environment test*

At 3.5 weeks of age 174 piglets were taken to a small novel environment test. The experimental novel environment was a wooden (concrete plex) box of 125 cm (width) x 125 cm (length) x 62.5 cm (height). The novel environment was located in the passageway in front of the farrowing pens, out of sight of and out of direct auditory contact with sows and piglets. The piglet was placed on the concrete flooring of the corridor, within the box, which was open at the top. A heating lamp above the box kept the temperature in the box at for batch one between 17.6 °C-19.3°C and for batch 2 at 13°C at pig height, to prevent cold stress. The novel environment test was videotaped with a Panasonic HDC-DX1 Camcorder. The test was started when the piglet was placed and released in the middle of the box and last for 150 seconds per piglet.

Behaviours and vocalisations were scored live with a continuous behaviour sampling by two observers (one scored the behaviour, one the vocalisations). Behaviours were based on literature linked to either a positive or negative emotional state (see Table 1, for behavioural description see appendix I). When behaviours were not clearly positive or negative, a neutral state was ascribed. The links of behaviours and emotional states were based on literature when possible.

Tail posture/motion were recorded on video and scored with a continuous behaviour sampling method using the novel environment ethogram. Three different tail postures were recorded; curled tail, hanging tail or tail between legs (see appendix I). One tail motion was recorded; tail wagging. In this study tail wagging was recorded as side to side movement of the erected tail (not curled) and not as Kiley-Worthington (1976) indicates that tail wagging is a simple motor reflex to shift behaviours when calm.

The piglets were subjected to the test in random order (corrected for SBV, sex). All piglets were tested once. Between each tested piglet, faeces and urine was removed with water and the floor was dried with towels afterwards.

**Table 1. Behaviours of piglets linked with either an emotional state or a neutral state during the novel environment test. References are stated in the last column when found.**

| Behaviours | Emotional state | Reference |
|---|---|---|
| Nosing floor | Positive | Spinka *et al.*, 2001 |
| Nosing wall | Positive | Spinka *et al.*, 2001 |
| Standing alert | Negative | Von Borell and Ladewig, 1992; Beattie *et al*., 1995; Forkman *et al*., 2007 |
| Standing | Neutral | |
| Walking | Negative | Von Borell and Ladewig, 1992; Beattie *et al*., 1995; Forkman *et al*., 2007 |
| Defecate/urinate | Negative | Antoniadis and McDonald, 2000 |
| **Vocalisations** | | |
| Short grunt | Positive | Schon *et al*., 2004; Spinka *et al*., 2010 |
| Long grunt | Positive | Schon *et al*., 2004; Spinka *et al*., 2010 |
| Squeal | Negative | Fraser, 1974; Marchant *et al.*, 2001; Bolhuis *et al.*, 2004; Kouwenberg *et al.*, 2009 |

*Home pen behavioural observations*

Live behavioural observations were done using an instantaneous scan sampling with a four-minute interval, where both behaviour, tail posture and tail motion were recorded. Again, behavioural categories were linked to an emotional state based on literature when possible, see Table 2 (for behaviour descriptions see appendix II). The same tail posture categories were used as in the novel environment test. Before observation started, pigs received a spray-painted number on their back for identification. The observer ensured that the pigs were active before observations. All pigs of each batch were observed once a week during 16 minutes. Observations for batch 1 were done from life week 18 until life week 22. Observations for batch 2 were done from life week 15 until life week 20. All observations were done by the same observer.

**Table 2. Behaviours of piglets linked with either an emotional state or a neutral state during in the home pen observations. References are stated in the last column when found.**

| Behaviours | Emotional state | References |
|---|---|---|
| Eating/drinking | Positive | Cabanac 1992; Carver 2001; Custers & Aarts 2005; Rolls 2005; Burgdorf & Panksepp 2006 |
| Exploration | Positive | Boissy *et al*., 2007 |
| Positive social | Positive | Boissy *et al*., 2007 |
| Active | Neutral/positive | Boissy *et al*., 2007 |
| Inactive | Neutral/negative | Boissy *et al*., 2007 |
| Negative social | Negative | Blackshaw *et al*., 1997 |
| Manipulative | Negative | Arey, 1993; Guy *et al.,* 2002 |

Observations were done during the active period of the pigs; from 8.00 until 11.30 h and 14.00 until 17.30 h. Observations were done with PSION handheld computers with Observer 9 software (Noldus Information Tech. B.V., Wageningen, The Netherlands).

*Tail condition score*

A tail condition score was done on a weekly basis during the observation weeks. The tail condition was scored per individual pig on a scale from 1 to 4 (see table 3), based on the protocol from Zonderland *et al.* (2008, 2010).

**Table 3. Tail condition score for piglets with description**

| Class | Damage | Definition |
|---|---|---|
| 1 | No | No tail damage visible |
| 2 | Hair removed | The tail lacks its hair partially or completely |
| 3 | Bite marks | Small damages/bite marks are visible. These individual bite marks have the size of a pinhead |
| 4 | Wound | Clearly visible wound |

**2.4 Statistical analysis**

Results were analysed with SAS 9.2 (SAS Inst. Inc., Cary, NC, USA). Residuals were checked for normal distribution. Variables with skewed distributions were transformed with either square root (frequencies) or with log (durations) before analysis.

The data of the novel environment test (N=174) was analysed with a mixed model with the fixed effects: batch, pen, coping style, SBV, unit, sex, date. Pen (nested in SBV) and batch were added as random effects for the novel environment data. Behaviours recorded in the home pen (N=192) and tail condition scores (N=192) were also analysed with a mixed model, but with housing as an extra fixed effect. Random effects were pen (nested in SBV, housing and batch) and batch. Main effects and interactions between factors were tested. For the home pen data and tail condition scores, the interactions SBV*coping style, SBV*housing and coping style*housing were tested.

For the tail condition data, mean scores per pig for all observations were used for analysis. When transformation did not result in a normal distribution of residuals (Shapiro-Wilk W>0.8), effects were analysed with a generalised linear mixed model (glimmix) with a normal distribution. The fixed and random effects that were used in the glimmix were the same as the mixed model. Behaviours observed were categorised based on the study by Temple *et al.* 2011 (see appendix 1). Moreover, behaviours were categorised in active and inactive behaviours. The inactive behaviours were lying, lying with eyes closed (Bolhuis *et al.* 2005) and sitting. The rest of the behaviours were categorised under active behaviour.

Pearson correlation was done on the normally distributed data of the novel environment data, with the variables nosing floor, nosing wall, standing alert, standing and walking and with the four different tail posture and motion categories; curled, hanging, between legs and wagging. Skewed data was analysed with Spearman rank correlation test. These variables were defecating/urinating, short grunt, long grunt and squeal with the tail postures. Very little jumping occurred, hence jumping was omitted from the data analysis. The behavioural category ‘other’ was not analysed either, since this was a category that contained various unrelated behaviours. Tail wagging was the only tail motion in the novel environment test that was scored as an event (frequency), no correlations could be done with the tail wagging data.

Chi square test was done to determine whether a relationship between tail posture and motion with different behaviours was present. All four different tail posture and motion categories were tested per behavioural category.

When durations were used for analysis, mean percentage of behaviours/tail postures was obtained by adding all durations of the behaviour in seconds and dividing this by the total time of observation. This was multiplied by 100 to get the mean percentage. When frequencies were used for analysis, means percentages were determined. Frequency in percentages was obtained by adding the frequency of certain behaviour and dividing it by the total of that certain behaviour and then multiplying it by 100.

## 3. Results

### 3.1 Novel environment test

No effect was found of either SBV or coping style on tail postures of pigs in the novel environment test, see Figure 2. A hanging tail was the most commonly performed tail posture in the novel environment test, after that a curled tail.

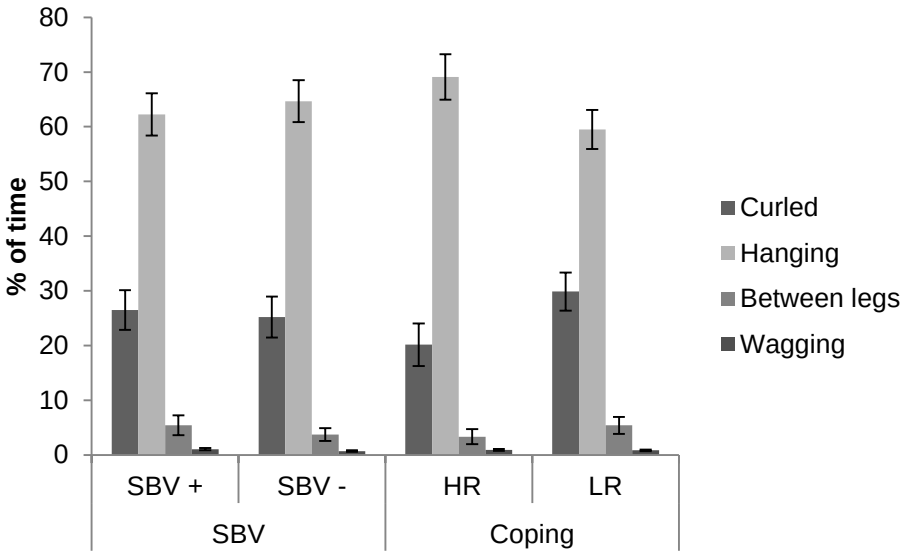


**Figure 2. The mean percentage of recordings (± SEM) of tail postures of high and low SBV and high or low resisters during the novel environment test**

A relationship was found between a curled tail and the behaviour "nosing wall" (P< 0.001). No effect of coping style and SBV on the behaviours or vocalisations with different tail postures was found.

**Table 4. Mean percentage of recordings (± SEM) of the behaviours (duration) and vocalisation (frequency) with tail posture or motion in the 150-sec novel environment test**

| | Curled | Hanging | Between legs | Wagging |
|---|---|---|---|---|
| *Behaviour* | | | | |
| Nosing floor | 27.3±1.57 | 66.37±1.66 | 5.05±0.68 | 1.26 |
| Nosing wall | 32.31±0.15**** | 64.35±0.18** | 2.51±0.04 | 0.84 |
| Standing alert | 25.02±0.95 | 68.96±1.20 | 5.17±0.35 | 0.85 |
| Standing | 27.24±1.34 | 66.75±1.41 | 5.03±0.55 | 0.98 |
| Walking | 30.01±0.73 | 64.91±0.83 | 3.79±0.30 | 1.29† |
| Tail wagging | 92.13±0.11 | 5.62±0.02 | 2.25±0.01 | - |
| Defecating/urinating | 67.61±0.06 | 28.17±0.04 | 4.23±0.02 | - |
| *Vocalisation* | | | | |
| Short Grunt | 26.32±1.22 | 69.63±2.17 | 4.06±0.533 | - |
| Long Grunt | 34.60±0.86 | 62.11±1.01 | 3.30±0.12 | - |
| Squeal | 43.28±0.16 | 55.22±0.20 | 1.50±0.01 | - |

† P < 0.01
* P < 0.05
** P < 0.01
*** P < 0.001
**** P < 0.0001

A small negative correlation was found between short grunts and a curled tail (P<0.01), whereas a small positive correlation was found between short grunts and tail between the legs (P<0.001, Table 5). The time spent on nosing wall was positively correlated with the curled tail posture; however this was a small correlation (Table 5).

**Table 5. Correlation coefficients for behavioural activities/ vocalisation of pigs with different tail postures during a novel environment test**

| | Curled | Hanging | Between legs |
|---|---|---|---|
| ***Behaviour*** | | | |
| Nosing floor | 0.08 | -0.10 | 0.06 |
| Nosing wall | 0.17* | -0.12 | -0.07 |
| Standing alert | -0.03 | 0.09 | -0.04 |
| Standing | 0.04 | -0.07 | 0.08 |
| Walking | 0.12 | -0.06 | -0.05 |
| Defecating/urinating | 0.05 | -0.01 | -0.03 |
| ***Vocalisations*** | | | |
| Short Grunt | -0.24** | -0.07 | 0.27*** |
| Long Grunt | -0.09 | 0.05 | 0.11 |
| Squeal | 0.08 | -0.01 | -0.05 |

* P < 0.05
** P < 0.01
*** P < 0.001

### 3.2 Home pen observations

No difference was found for hanging and wagging tails. Tail between the legs occurred less often with high SBV than with low SBV (P<0.05). Coping style had an effect on the frequency of curled tails (P<0.01, see table 6). Curled tails occurred more with high resister pigs with a low SBV (P<0.05) than with low resister pigs with a low SBV or high/low resisters with high SBV. The interaction SBV*coping had an effect on the frequency of curled tails (P<0.05). No other interactions were found between the factors.

**Table 6. Mean percentage of recordings (± SEM) of tail posture shown during home pen observation, with the effect of SBV (S), coping (C) and the interaction between SBV and coping (SC)**

| | High SBV | | Low SBV | | Effects | | |
|---|---|---|---|---|---|---|---|
| Tail posture | HR | LR | HR | LR | S | C | SC |
| Curled | 31.98±0.07$^{a}$ | 31.37±0.06$^{a}$ | 37.99±0.09$^{ab}$ | 25.64±0.06$^{ac}$ | ns | ** | * |
| Hanging | 59.88±0.09 | 59.45±0.08 | 51.97±0.09 | 59.28±0.07 | ns | ns | ns |
| Between legs | 2.91±0.03$^{a}$ | 3.06±0.03$^{a}$ | 4.80±0.04$^{a}$ | 9.03±0.05$^{b}$ | * | † | † |
| Wagging | 5.23±0.03 | 6.12±0.03 | 5.24±0.04 | 6.05±0.03 | ns | ns | ns |

ns = non-significant
† P< 0.1
* P < 0.05
** P < 0.01

Pigs in barren housing had their tail more often between their legs than in enriched housing (P<0.05, Figure 3). The tail posture hanging was the most performed tail posture in barren as well as in enriched pens.

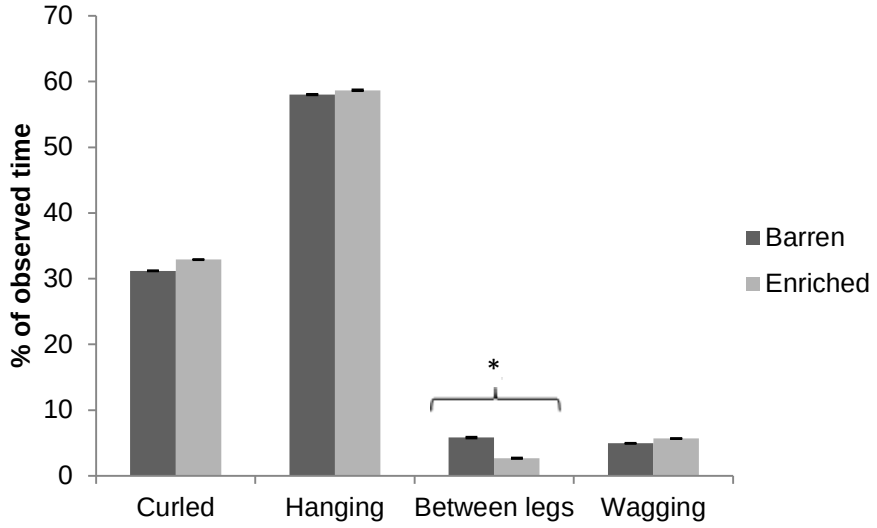


**Figure 3. The percentage observed time (± SEM) of different tail postures in barren and enriched housing (* P < 0.05)**

Inactive pigs showed significantly more hanging tails than active pigs (P<0.0001), while active pigs showed significantly more curled tails (P<0.0001, figure 4). No difference was found for the other tail postures.

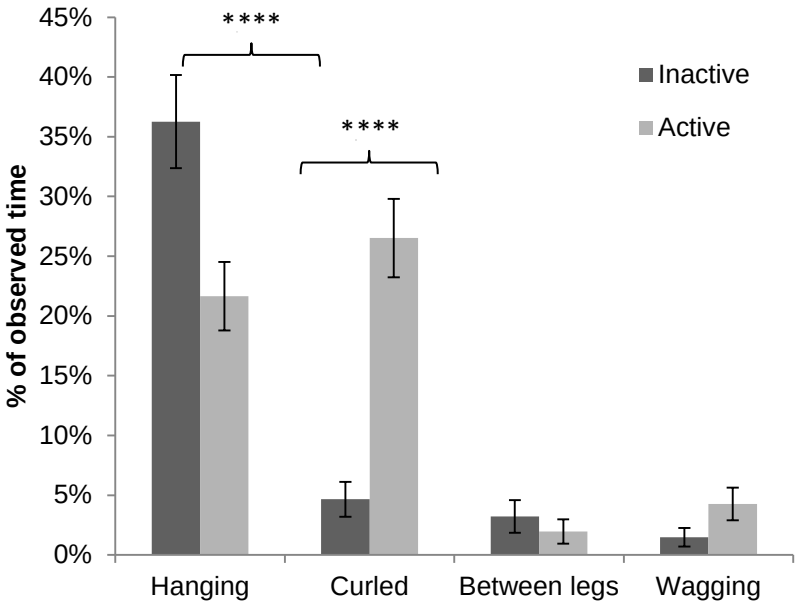


**Figure 4. The percentage observed time (± SEM) of different tail postures of active and inactive pigs (**** P<0.0001)**

Relations were found between the behaviours active (P<0.01), inactive, exploration, eating/drinking (P<0.0001) and manipulative behaviour with a curled tail (P<0.05, Table 7). Exploration, eating/drinking, inactive and active behaviour had a relationship with hanging tail (P<0.0001). While social positive and social negative behaviour had a relation with tail wagging (P<0.0001). The tail between the legs had a relation with inactive behaviour (P<0.01).

**Table 7. Mean percentage observed of time (± SEM) spent on behaviour and tail posture shown during home pen observation and the relation between the behaviour and tail posture**

| | Curled | Hanging | Wagging | Between legs |
|---|---|---|---|---|
| Active | 32.51 ± 0.015** | 56.98 ± 0.020**** | 7.72 ± 0.007† | 2.79 ± 0.005 |
| Inactive | 10.21 ± 0.015**** | 79.52± 0.039**** | 3.22 ± 0.008 | 7.05 ± 0.014** |
| Exploration | 51.30 ± 0.015**** | 37.39 ± 0.014**** | 5.65 ± 0.006 | 5.65 ± 0.005 |
| Eating/drinking | 71.99 ± 0.025**** | 20.04 ± 0.011**** | 5.57 ± 0.006 | 2.41 ± 0.004 |
| Social positive | 35.35 ± 0.006 | 40.40 ± 0.007 | 19.19 ± 0.005**** | 5.05 ± 0.002 |
| Social negative | 38.89 ± 0.005 | 46.30 ± 0.005 | 11.11 ± 0.003 | 3.70 ± 0.001 |
| Manipulative | 33.33 ± 0.004* | 45.83 ± 0.005 | 12.50 ± 0.003**** | 8.33 ± 0.002 |

† P< 0.1
* P < 0.05
** P < 0.01
*** P < 0.001
**** P < 0.0001

Pigs with a low SBV had the tail between their legs while eating/drinking more often than the high SBV pigs (P<0.05, Table 8). Furthermore, pigs with a low SBV had their tail significantly more often between their legs while being inactive than high SBV pigs (P<0.05, Table 8).

Pigs in enriched housing had their tail more often curled while exploring than pigs in barren housing (P<0.05, Table 9). In addition, pigs show significantly more often a hanging tail when active in enriched pens than in barren pens (P<0.05, Table 9). Furthermore, pigs kept their tail between the legs during inactivity more often in barren housing than in enriched housing (P<0.05, Table 9).

Active high resister pigs had their tail curled more often than low resister pigs (P<0.01), as shown in Table 10. Also, low resister pigs showed more wagging tails when performing social positive behaviour than high resisters (P<0.01, Table 10). In addition, high resisters were eating and drinking with a curled tail more often than low resisters (P<0.05, Table 10). High resisters showed more manipulative behaviour while having a hanging tail than low resisters (P<0.01, Table 10). No significant differences between coping styles were found for the tail between legs.

Table 8. Mean % of time spent on behaviour and tail posture shown during home pen observation with SEM, for high and low SBV (*P<0.05)

| | Curled | | Hanging | | Between legs | | Wagging | |
|---|---|---|---|---|---|---|---|---|
| | High | Low | High | Low | High | Low | High | Low |
| Active | 16.82±0.03† | 17.14±0.03† | 17.41±0.05 | 18.37±0.05 | 20.20±0.02 | 8.72±0.01 | 22.60±0.03 | 22.22±0.03 |
| Inactive | 15.89±0.03 | 11.43±0.03 | 64.68±0.2 | 62.24±0.2 | 60.61±0.07* | 56.67±0.07* | 28.25±0.02 | 22.22±0.02 |
| Exploration | 21.50±0.02 | 14.29±0.02 | 8.46±0.04 | 8.16±0.04 | 7.07±0.01 | 17.44±0.01 | 16.95±0.02 | 16.67±0.02 |
| Eating/drinking | 38.32±0.042 | 14.29±0.042 | 5.47±0.02 | 6.12±0.02 | 2.02±0.01* | 10.46±0.01* | 16.95±0.01 | 16.67±0.01 |
| Social positive | 3.74±0.01 | 14.29±0.01 | 1.99±0.01 | 2.04±0.01 | 0.00±0.003 | 4.36±0.004 | 11.30±0.01 | 11.11±0.01 |
| Social negative | 1.87±0.01 | 14.29±0.01 | 1.00±0.01 | 1.53±0.01 | 0.00±0.002 | 1.74±0.002 | 1.69±0.01 | 5.56±0.01 |
| Manipulative | 1.87±0.01 | 14.29±0.01 | 1.00±0.01 | 1.53±0.01 | 10.10±0.004 | 0.61±0.004 | 2.26±0.004 | 5.56±0.004 |

Table 9. Mean % of time spent on behaviour and tail posture shown during home pen observation with SEM, for barren and enriched housing (*P<0.05).

| | Curled | | Hanging | | Between legs | | Wagging | |
|---|---|---|---|---|---|---|---|---|
| | Barren | Enriched | Barren | Enriched | Barren | Enriched | Barren | Enriched |
| Active | 19,81±0.2 | 18,35±0.2 | 15,00±0.05* | 21,21±0.05* | 9,35±0.01† | 9,35±0.01† | 16,67±0.03† | 30,93±0.03a |
| Inactive | 17,93±0.03 | 12,84±0.03 | 67,50±0.2† | 59,59±0.2† | 60,74±0.07* | 56,07±0.07* | 22,22±0.02 | 25,77±0.02 |
| Exploration | 16,03±0.02* | 23,85±0.02* | 7,00±0.04 | 9,59±0.04 | 14,02±0.01 | 18,70±0.01 | 16,67±0.02 | 15,46±0.02 |
| Eating/drinking | 39,62±0.04 | 37,61±0,042 | 5,50±0,02 | 6,06±0,017 | 7,48±0,01 | 9,34±0,01 | 22,22±0,01 | 10,31±0,01 |
| Social positive | 3,77±0,01 | 3,67±0,01 | 2,50±0,01 | 1,52±0,01 | 4,67±0,003 | 3,74±0,003 | 11,11±0,01 | 10,31±0,01 |
| Social negative | 1,89±0,01 | 1,83±0,01 | 1,50±0,01 | 1,01±0,01 | 1,86±0,002 | 0,00±0,002 | 5,56±0,01 | 2,06±0,01 |
| Manipulative | 0,94±0,01 | 1,83±0,01 | 1,00±0,01 | 1,01±0,01 | 1,86±0,004 | 2,80±0,004 | 5,56±0,004 | 5,15±0,004 |

Table 10. Mean % of time spent on behaviour and tail posture shown during home pen observation with SEM, for high/low resisters (*P<0.05, **P<0.01)

| | Curled | | Hanging | | Between legs | | Wagging | |
|---|---|---|---|---|---|---|---|---|
| | HR | LR | HR | LR | HR | LR | HR | LR |
| Active | 21.01±0.03** | 17.35±0.03** | 18.75±0.05 | 17.16±0.05 | 8.70±0.01 | 10.31±0.01 | 25.91±0.03 | 21.05±0.03 |
| Inactive | 14.29±0.03 | 16.33±0.03 | 61.98±0.2† | 64.71±0.20 | 69.57±0.07 | 56.70±0.07 | 25.91±0.02 | 21.05±0.02 |
| Exploration | 18.49±0.02 | 21.43±0.02 | 8.33±0.04 | 8.33±0.04 | 8.70±0.01 | 15.46±0.01 | 15.54±0.02 | 15.79±0.02 |
| Eating/ drinking | 39.50±0.04* | 36.73±0.36* | 6.25±0.02 | 5.39±0.02 | 8.70±0.01 | 5.15±0.01 | 20.73±0.01 | 15.79±0.01 |
| Social positive | 4.20±0.01 | 3.06±0.01 | 1.56±0.01 | 2.45±0.01 | 2.61±0.004 | 5.15±0.003 | 5.18±0.01** | 15.79±0.01** |
| Social negative | 0.84±0.01 | 3.06±0.01 | 1.04±0.01 | 1.47±0.01 | 0.00±0.003 | 2.06±0.002 | 1.55±0.01 | 5.26±0.004 |
| Manipulative | 1.68±0.01 | 2.04±0.01 | 2.08±0.01** | 0.49±0.01** | 1.74±0.004 | 5.15±0.004 | 5.18±0.004 | 5.26±0.004 |

A positive correlation was found for eating/drinking with a curled tail (P<0.0001, Table 11). Positive correlations were found for social negative behaviour and the tail postures tail between the legs and wagging (P<0.0001). Furthermore, tail wagging was positively correlated with manipulative behaviour (P<0.0001). While a positive correlation was found between social positive behaviour and the tail between the legs (P<0.0001).

**Table 11. Correlation coefficients for behavioural activities and tail posture of pigs shown during home pen observations**

| Behaviours | Curled | Hanging | Between legs | Wagging |
|---|---|---|---|---|
| Active | 0.07 | 0.06 | 0.08 | 0.25 |
| Inactive | -0.26 | 0.57 | 0.09 | -0.06 |
| Exploration | 0.11 | -0.05 | 0.07 | 0.24 |
| Eating/drinking | 0.42**** | -0.18 | 0.08 | -0.05 |
| Social positive | -0.03 | 0.01 | 0.42**** | 0.15 |
| Social negative | -0.14 | -0.08 | 0.52**** | 0.41**** |
| Manipulative | -0.13 | -0.12 | 0.22 | 0.54**** |

* P < 0.05
** P < 0.01
*** P < 0.001
**** P < 0.0001

### 3.3 Tail condition score

Housing had a highly significant effect on tail condition score (P<0.0001, Figure 5.). Pigs in barren housing had a higher mean tail condition score (2.09 ± 0.06) than pigs in enriched housing (1.46 ± 0.06). There was no effect on tail condition score from coping (HR: 1.77 ± 0.05; LR: 1.78 ± 0.05) or SBV (high: 1.77 ± 0.06; low: 1.78 ± 0.06).There was no interaction between coping, SBV and housing.

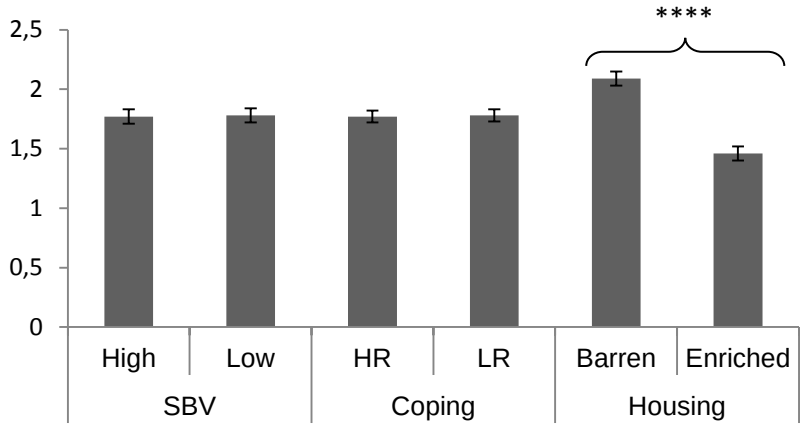


**Figure 5. Mean tail condition score (±SEM) for the different SBV's, coping styles and housing (**** P <0.0001)**

*Tail condition per life week*

The mean number of hanging tails per life week fluctuated (Figure 6A). In week 21, more hanging tails were observed, while the mean tail condition decreased. Figure 6B shows a occurrence of curled tails. An increase of curled tails was observed in week 16 and 17, together with increased tail condition. Figure 6C illustrates that the occurrence of tail between legs increased when the mean tail condition score increased. In life week 21, no tails between their legs was observed and also a drop in tail condition was recorded. In figure 6D, the mean occurrence of tail wagging was high in week 15 and 16 and decreased when tail condition increased. In week 20, the mean occurrence of tail wagging was increased while the mean tail condition decreased.

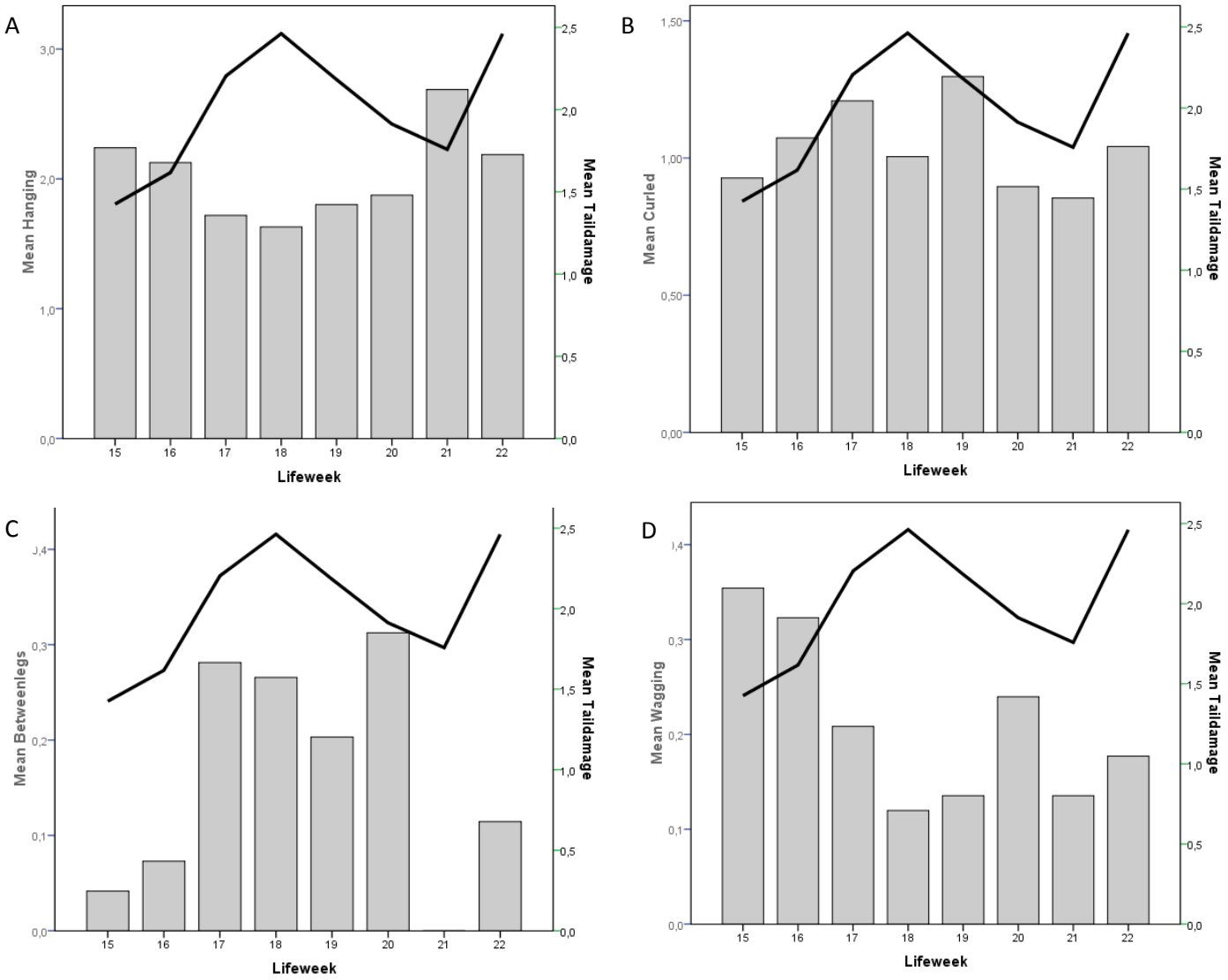


**Figure 6. Mean tail condition shown as a black line for each mean tail posture per life week. A = mean tail condition and tail posture for hanging tail, B= mean tail condition and tail posture for curled tail, C=mean tail condition and tail posture for tail between legs and D= mean tail condition and tail posture for tail wagging. Tail condition scores range from 1 until 4; 1=no damage, 2=hair removed, 3=bite mark and 4=wound**

## 4. Discussion

The aim of this study was to investigate whether tail posture can be used as an indicator of the emotional state in pigs. This was tested with a novel environment test, home pen observations and tail bite scores.

In this study, pigs had their tail hanging approximately 30% of the time and carried a curled tail 60% of the time. Results of Zonderland *et al*. (2009) showed that pigs had a curled tail approximately 75% of the time and a hanging tail 25% of the time. Zonderland *et al*. (2009) did not take into account the other two tail postures, tail between the legs and tail wagging, so this could cause the slight difference in results. Kleinbeck and McGlone (1993) found that pigs showed a wagging tail for 7% of the time, which is quite similar to the current findings (5% of the time). When looking at activity versus inactivity, active pigs had a curled tail more often than a hanging tail (resp. 50% and 40% of the time). Kleinbeck and McGlone (1993) found that active pigs have their tail in an upwards curl. The difference between Kleinbeck and McGlone's findings and the current findings could be that the pigs scored as active, could be scored passive according to Kleinbeck and McGlone's method. For example, when a pig was lying and chewing straw, this was scored as an active behaviour even though the pig was lying down. Inactive pigs had a hanging tail more often than a curled tail (resp. 80% versus 10% of the time), which is confirmed by Zonderland *et al*. (2009).

### 4.1 Curled tail posture

A small correlation was found between time spent on nosing the wall and a curled tail during the novel environment test. Exploration is associated with a positive emotional state (Boissy *et al.*, 2007). However, no relationship or correlation was found between nosing floor and a curled tail; this could be because nosing floor was performed often while standing still or walking slowly. Nosing wall can be seen as a quite active behaviour. The novel environment test was done to investigate the behavioural response of pigs in a new situation (Von Borell and Ladewig, 1992; Beattie, 1995; Forkman, 2007). No significant effects of coping style or SBV on the tail postures were found. Jumping and screaming has previously been found as proper measurement for stress, fearfulness and a negative emotional state (Lang *et al*., 2000), but very little jumping and screaming occurred. In this study the test area was 1.5$m^2$, Forkman *et al*. (2007) reviewed that a novel area is usually between 5-10 $m^2$. It could be that the size of the test area influenced the outcome in this study. This test is not recommended as a general fear test for pigs by Forkman *et al*. (2007), as the novel environment test might not elicit a strong enough fearful response. A different test could have been more appropriate for this study, like the human approach test or novel object test.

A positive correlation was found for eating/drinking with a curled tail. Eating/drinking is seen as a positive behaviour as it satisfies a need for food/water (Cabanac 1992; Carver 2001; Custers & Aarts 2005; Rolls 2005; Burgdorf & Panksepp, 2006).In the home pen observations; active behaviour, inactive behaviour, exploration, eating/drinking and manipulative behaviour had a relationship with the occurrence of a curled tail. These behaviours, except for manipulation, had all been regarded as indicators of neutral or positive emotional states in previous research (Boissy *et al*., 2007). Manipulative behaviour (tail biting, ear biting and belly nosing) have been regarded as negative and

abnormal behaviour (Arey, 1993; Guy *et al.,* 2002). Pigs show these behaviours often due to a lack of stimuli of their environment (Bolhuis *et al.,* 2005). Performing this behaviour could be rewarding for the pig as it fulfils its motivation to manipulate. These manipulative behaviours are accompanied by a high level of arousal. Tail biting can be negative for the receiver as it could cause injuries (van Putten, 1968). This indicates that a curled tail is probably related to a positive emotional state.

High resister pigs had their tail curled more often than low resister pigs. High resisters are known to react with an active behavioural response while low resisters react with a passive behavioural response (reviewed by Benus *et al*., 1991; Koolhaas *et al*., 1999, 2001). In the current study, active pigs have their tail curled most of the time. Before the behavioural observation, the observer went into the pen to apply a back number on the pigs and then forced them to stand up. High resister pigs could react to this event more actively than low resisters. Low resister where lying down more often than high resisters. This could explain why high resister pigs show more curled tails than low resisters.

Pigs housed in an enriched environment showed more exploration with a curled tail than pigs in barren pens. Barren housing conditions could inflict stress to the pigs (Hessing *et al*.,1992, 1994a; Beattie *et al*., 2000; Oostindjer *et al.*, 2010) and cause a negative emotional state. Pigs in enriched pens have previously showed more exploration than in barren housing (Boissy *et al.*, 2007), which is linked to a positive emotional state (Boissy *et al.*, 2007). To conclude the finding in this study shows that pigs in enriched housing explored more often with a curled tail than pigs in barren housing, this could be because they were more often in a positive emotional state due to the housing conditions.

Kiley-Worthington (1975) concluded that farmers use the curled tail posture of pigs as a health indicator. However, this study is quite dated and conclusions seem to be a bit oversimplified. It is possible that a curled tail is linked to high arousal and partly to a positive emotional state.

**4.2 Hanging tail posture**

No effects of SBV, coping and housing was found on a hanging tail posture. However, an effect was found of housing on active behaviour with a hanging tail in the home pen. Pigs showed more hanging tails while performing active behaviour in enriched housing than in barren pens.

A hanging tail was the most performed tail posture when the pigs where inactive. No studies explain why pigs keep their tail in a hanging position. However, dog tails have been studied many times, including the hanging posture (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998). In dogs and in ungulates, a hanging tail is seen as a neutral signal (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998). In pigs a hanging tail can also be seen as a neutral tail posture. In ungulates, literature mention that the tail is “on” when erected and “off” when the tail is hanging (Guthrie, 1971).

A relationship was found between active, inactive, exploration, eating/drinking and a hanging tail. These behaviours are seen as positive behaviours, but are also neutral behaviours (e.g. walking, sleeping eating/drinking). Hanging tail is mostly seen during neutral behaviours, however sometimes it

is also seen at positive and negative behaviours. A hanging tail cannot be linked to either a positive or a negative valence/emotional state and is seen as a neutral tail posture, or a switched “off” tail.

### 4.3 Tail between legs

No relationship was found between the tail posture tail between legs and behaviours in the novel environment test. However, a small positive correlation was found for short grunts and pigs with their tail between the legs. In addition, a small negative correlation was found for short grunts and pigs with a curled tail. These results show that grunts could possibly be associated with a negative emotional state. Other studies show contradicting results. Previous research have shown that grunts are associated with exploration (Spinka *et al*., 2010), which is linked to a positive emotional state. Also, grunts function as a way to maintain social contact with group mates (Fraser, 1974; Schrader and Todt, 1998), and so can be related to a positive emotional state. It could be that isolated pigs grunt to remain in contact with group mates. However, in this study it was not possible for the pigs to keep in contact with their group mates due to isolation from the group. The pigs did not get in contact with pen mates, which may lead to stress. It has been said that grunts could be linked to a low stress level (Schon *et al*., 2004). Tuyttens (2005) showed that pigs in a novel environment showed many short grunts in the first minute and no squeals, and after the first minute they showed more squeals and less short grunts. Even though studies show that grunts are being associated with positive behaviour, it could be associated with a low stress level, because communication with pen mates fails.

No coping effect was found on the tail posture between legs. There was a SBV effect on this tail posture. Low SBV pigs had their tail between the legs more often than high SBV pigs. One of the hypotheses on SBV is that high SBV pigs show more positive social behaviour than low SBV pigs. In line with this hypothesis, it might be that low SBV pigs showed less social contact and felt fearful towards pen mates. This would explain why these pigs put their tail between the legs more often than high SBV pigs.

While pigs perform active behaviour with a hanging tail, the tail will move from side to side because of the movement of the body. A moving tail is attractive for tail biting pigs (van Putten, 1969). Mean frequency hanging tail decreases when tail condition scores increased, but the frequency of the tail between the legs increased when the tail condition score increases and vice versa. Pigs in barren housing had their tail between their legs more often than pigs in enriched housing. Barren housing conditions offer a stimulus-poor environment that imposes restrictions on the development and expression of species-specific behaviour (Wemelsfelder *et al*., 2000). Barren housing caused a negative emotional state due to stress, (Hessing *et al*.,1994a; Beattie *et al*., 2000; De Jong *et al*., 2000; Oostindjer *et al*., 2010) reflected through pigs with their tail between their legs. Also the tail condition score is higher in barren housing than enriched housing, which also could influence the frequency of the tail between the legs.

Tail biting occurred more often in barren housing, which is confirmed by Bolhuis *et al*. (2005). Tail biting can cause acute pain (Schrøder-Petersen and Simonsen, 2001). Zonderland *et al*. (2008) showed that tail bite outbreaks can be predicted by the number of times that the tail was between the

legs. Current results support this finding. In this study, the number of inactive behaviours had effect on the occurrence of pigs with their tail between the legs. This could be due to tail biting outbreaks. Tail biting occurs mostly when pigs lie down with their tail hanging motionless (Van Putten, 1980; Arey, 1991). Pigs had their tail between the legs during exploration as well, but not as much as when they were inactive.

In this study negative social behaviour and manipulative behaviour is positively correlated with the tail posture tail between legs, these behaviours and tail posture can be linked to a negative emotional state (Arey *et al*., 1993; Noonan 1994; Blackshaw *et al*., 1997; Guy *et al*., 2002). However, a positive correlation also exists for social positive behaviour. This is not expected, because social positive behaviour is linked to a positive emotional state and the tail between the legs can be associated with a negative emotional state. Pigs have a hierarchy, when kept in a group (Ewbank, 1976). For this ranking order, weight is essential; the heaviest animals occupy the top of the hierarchies and the lighter animals occupy the lower positions (reviewed by Ewbank, 1976). It is possible that lighter pigs which are low in rank, are more careful when approaching a high ranked pig as they could be anxious for confrontation, This anxiety could cause lower ranked pigs to put their tail between the legs when performing positive social contact.

It should be noted that the behaviours are categorised as positive or negative, could be less positive or less negative than assumed. Not much social positive behaviours were recorded, such as social play. Even though categories were based on literature, little is known about emotional states and the behaviours.

**4.4 Wagging tail**

There was no effect of SBV, coping or housing found on tail wagging in this study. A relationship was found between social positive, manipulative behaviour and tail wagging. Furthermore, positive correlations were found for negative social behaviour and manipulative behaviour with tail wagging. These behaviours all consist of interaction with other pigs. In ungulates, it is discussed that tail wagging plays a role in intraspecific communication and defence against predators (Kiley-Worthington, 1976; Hickman, 1979). It might be that one of the functions of tail wagging is for intraspecific communication, in this case negative social interactions. Social positive behaviour had a small positive correlation with tail wagging. Social positive behaviour could, in many cases, end up in social negative behaviour (personal communication, Bolhuis, 2011). The behaviours can change, for example, from nosing body (social positive) to tail biting (manipulative) or head knocking (social negative). This may explain the positive correlation with social negative and manipulative behaviour with tail wagging. This where small correlations, hence conclusions should be formed carefully.

In dogs, tail wagging is associated with a positive emotional state (Fatjo *et al*., 2007). However, tail wagging (as used in this study) in pigs is often associated with a negative emotional state (Kiley-Worthington, 1975). Kleinbeck and McGlone (1993) found that pig's tail wagged during feeding, this was also the cause in this study, which is regarded as a positive behaviour.

Small positive correlations were found between active behaviour and exploration with tail wagging. These behaviours are done with high arousal. Stuart & Stuart (1997) suggested that in black deer's tail wagging simply indicates arousal and does not have any signalling properties. It might be that in pigs wagging also indicates just arousal.

But in the analyses of batch one, an increase of tail wagging was found after blood sampling. Tail wagging could be seen as an attempt to get some pain relieve from, for example, biting insects (Robertson *et al*., 1994) or after being bitten by pen mates. This confirms the findings of Noonan (1994) that tail wagging increased after surgical procedures which are painful and highly stressful. This could mean that tail wagging can be linked to stressful or painful situations and so, to a negative emotional state.

Furthermore, in one of the observations in this study, a high number of flies in the stable of batch one was observed and an increase of tail wagging was found. Kiley-Worthington (1978) concluded that irritation of flies undoubtedly is responsible for some instances of tail wagging. Nevertheless, the exact number of flies was not recorded, so more research should be done to confirm this finding. Tail wagging has been described as a sign of 'restlessness' in cattle (Sylvester *et al*. 2004) and 'frustration' in antelope (Kiley-Worthington, 1978). Therefore, tail wagging may simply be a component of a posture of agitation, frustration, or restlessness (Kiley-Worthington, 1978; Stankowich, 2008).

**4.5 Tail as communication tool**

Tail postures in pigs could serve as an intraspecific communication method. In canid species, tail posture serves an important role for intraspecific signalling in different environments (Kleiman, 1972). Higher tail positions are associated with confidence and/or aggression, while a lowered tail position may be a neutral signal or reflect fear and/or submission (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998). In ungulates, the tail plays a role in intraspecific communication and defence against predators (Kiley-Worthington, 1976; Hickman, 1979). It is likely that one of the functions of tail posture is for intraspecific communication. Like wild canids and domestic dogs can express emotional state and social status with their tail (Leaver and Reimchen, 2008), and this could also be the case in pigs. If this is the case, tail docking could interfere with the communication between pen mates. Tail docking is a commonly used method for the reduction of tail biting occurrence (Rodenburg *et al*., 2010). In dogs, it was found that a longer tail is more effective at conveying different intraspecific cues, than a short tail (Leaver and Reimchen, 2008). This might be applicable to pigs as well, but further research is needed to confirm this.

## 5. Conclusion

Tail postures and motion may be associated with emotional states in pigs (Figure 7). A curled tail can be linked to a positive emotional state or a positive valence. However, during fearful events, active pigs can also show a curled tail, indicating a link with high arousal. A tail between the legs can be associated with a negative emotional state, or negative valence and low to medium arousal. A wagging tail can be associated with a negative emotional state (negative valence) like frustration or restlessness with high arousal. It can also be suggested that the tail has a function for intraspecific communication, but this is still unclear. A hanging tail can be linked to a more neutral state, neither positive nor negative or seen as a "switched off" tail.

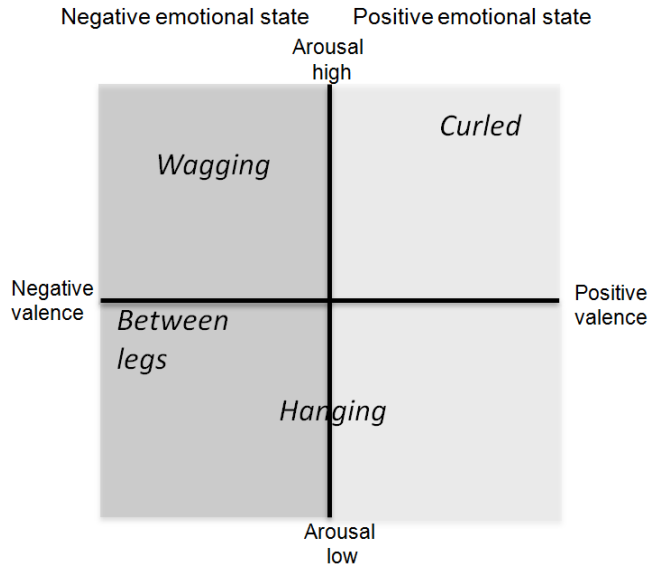


**Figure 7. Two dimensional approach of emotional states. The left side of the figure represents a negative emotional state and the right side a positive emotional state. Words in italics indicate possible locations of tail posture. Adapted from Russell and Barrett (1999) and Mendl *et al.* (2010).**

## 6. Recommendations

Confirmation of the results of the current study could be done with positive tests that elicit more positive emotions, for example placing a group of pigs in a play arena (on different life weeks) or in a positive food test. However, a test eliciting more negative emotions could be done like the human approach test or the novel object test. A larger arena in the novel environment test could also elicit a stronger fear response, which could make it easier to make conclusions about emotional states.

A larger sample size could show more significant effects of SBV. The current study was part of a PhD project, and calculations for significance were done for a sample size of 470 pigs.

Another aspect interesting aspect of tail postures which is worth to look into further, is its function within intra-specific communication.

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## I. Ethogram novel environment test

| Behaviours | Description | Emotional state |
|---|---|---|
| Nosing floor | Exploring the (substrate on the) floor by sniffing, nosing, rubbing, licking or rooting it with the snout. Snout is either in contact or very close to surface. | Positive |
| Nosing wall | Exploring walls of box by sniffing, nosing, rubbing, licking or rooting it with the snout. Snout is either in contact or very close to surface. | Positive |
| Standing alert | Standing motionless with head fixed (up or down) and ears upright, focused on a noise, wall, person, object etc. | Negative |
| Standing | Standing with four claws on the floor without performing any other described behaviour. | Neutral |
| Walking | Walking without performing any other described behaviour. A piglet is walking when all 4 legs are moved. | (When high) Negative |
| Defecate/urinate | Defecating or urinating | Negative |
| **Vocalisations** | **Description** | **Emotional state** |
| Short grunt | A low tone of less than half a second (one note) | Positive |
| Long grunt | A low tone of more than half a second (one note) | Positive |
| Squeal | A high tone (different notes) | Negative |
| **Tail posture/motion** | **Description** | |
| Curled | Curled tail | |
| Hanging motionless | Tail is hanging motionless | |
| Between legs | Tail clamped between the hind legs | |
| Wagging | Tail is wagging from left to right | |

## II. Home pen ethogram

| Category | Behaviours | Description | Emotional state |
|---|---|---|---|
| **Active** | Walking | Walking or running without performing any other described behaviour | Neutral/positive |
| | Standing | Standing without performing any other described behaviour | |
| | Defecate/urinate | Piglets urinates or defecates | |
| | Chewing | Non-feed chewing (e.g. air, dung) or chewing straw | |
| | Comfort behaviour | Rubbing body against objects or pen mate, scratching body with hind leg or stretching (part of) body. | |
| **Inactive** | Lying | Lying without performing any other described behaviour, eyes opened. | Neutral/negative |
| | Sleeping | Lying without performing any other described behaviour, eyes closed. | |
| | Sitting | Sitting or kneeling without performing any other described behaviour | |
| **Eat/drink** | Eating feeder | Chewing at feeder | Positive |
| | Drinking | Having drinking nipple in mouth and swallowing | |
| **Exploration** | Nosing floor | Sniffing, touching or scraping floor | Positive |
| | Nosing object | Nosing above floor level (e.g. walls) | |
| | Rooting | Putting the snout with force in straw or against the pen floor | |
| | Chewing toy | Chewing toy (chain with bal or jute bag) | |
| | Substrate play | Playing (throwing) with substrate like straw | |
| **Positive social** | Nosing contact | Pigs have nose to nose contact | Positive |
| | Nosing body | Touching/sniffing any part of a pen mate except snout | |
| **Negative social** | Fighting | Ramming or pushing a pen mate with or without biting the pen mate. Can be either mutual or individual. | Negative |
| | Head knock | Head knock given at place other than feeder | |
| | Bite | Biting on another pig at other place than feeder | |
| | Fighting at feeder | Push, head knock or bite given at feeder | |
| | Mounting | Standing on hind legs while having front legs on other pig's body | |
| **Manipulative** | Belly nosing | Rubbing belly of a pen mate with up and down snout movements | Negative |
| | Tail biting | Nibbling, sucking or chewing the tail of a pen mate | |
| | Ear biting | Nibbling, sucking or chewing the ear of a pen mate | |

(Behaviour description adapted from Temple *et al.,* 2011)

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