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# Socialising Piglets in Lactation Positively Affects their Post-Weaning Behaviour

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KEYWORDS

behavioural expression, cross-suckling, free choice profiling, piglet, Qualitative behavioural assessment, weaning, pre-weaning socialization

ABSTRACT

*Although commercial farrowing sheds keep individual litters separated, previous studies have suggested that housing systems that allow socialisation of piglets pre-weaning can reduce aggression after weaning. This study tested whether pigs socialised with non-littermates pre-weaning would show less aggression during mixing at weaning (when piglets are taken from their sows and mixed in group housing), and whether socialisation influenced the time budgets or behavioural expression of piglets at weaning. In total, 353 piglets were followed from birth through to one week after weaning. Piglets from 24 sows were allowed to socialise in groups of four litters ('socialised' treatment group) from 10 d of age; litters from nine sows were followed as controls. Socialised piglets were monitored to determine the prevalence of cross-suckling. Body weight was recorded at birth, prior to weaning and one week after weaning. Continuous video footage was collected for 1.5 days after weaning for behavioural analyses. There was no difference in the body weight of socialised pigs compared to control pigs at weaning or one week after weaning. Quantitative scoring of behaviour revealed no significant difference in aggression displayed between treatment groups or between the sexes; however, compared with overall averages, a greater proportion of socialised males spent time lying (57% of time compared with an average of 43% for the other sex-treatment groups, $P < 0.001$; but less eating/drinking 4% cf. average 8%, $P < 0.001$), and a greater proportion of socialised females were investigating (17% cf. average 12%, $P < 0.001$ with less lying 40% cf. 48%, $P < 0.001$). Qualitative behavioural assessment (QBA) was used to assess the body language of pigs during an active period (the middle of the day after weaning). Observers reached consensus in regard to their assessments of pig behavioural expression ($P < 0.001$). Two main dimensions of behavioural expression were identified, which accounted for 41% and 19% of the correlation between pigs. There were significant socialisation treatment effect ($P = 0.002$ and $P = 0.007$) on both dimensions, with socialised pigs more likely to be described as 'sleepy'/'tired' or 'content'/'relaxed' than control pigs (described as more 'active'/'curious' or 'aggressive'/'dominant'). Because socialising piglets had no effect on body weight pre-weaning, and there was a low occurrence of cross-suckling (2.9 ± 6.5% of piglets recorded suckling), socialisation was not disadvantageous. On the contrary, the behavioural difference at weaning suggests socialising piglets may be beneficial from a welfare perspective.*

## 1. Introduction

Under commercial conditions, young pigs removed from their dams at weaning are generally sorted by weight and sex and then placed into pens in dedicated nursery facilities. Unfortunately, the mixing of non-littermates at weaning causes aggression that is of welfare concern (Parratt et al., 2006). Increased fighting due to mixing (Ewbank and Bryant, 1972) may lead to wounds, infection and abscesses (Teague and Grifo, 1961), and coupled with the challenges of dietary change at weaning, there is generally decreased disease resistance, growth performance as well as increased mortality recorded at weaning (Gross, 1972; Gross and Colmano, 1969). Increased fighting also contributes to reduced post-weaning feed intake through reduced time spent eating (Friend et al., 1983; but see Sherritt et al., 1974).

A number of methods have been tested to reduce aggression when mixing unfamiliar pigs. For example, Pluske and Williams (1996) showed that the psychotropic drug amperozide reduced the incidence of aggressive behaviours following mixing of newly-weaned pigs, while lithium added to the diet reduced aggressive behaviours (but also caused vomiting and reduced feed intake, McGlone et al., 1980). A review of the use of pheromones, masking odours and tranquilisers found no notable success of any of these methods (Petherick and Blackshaw, 1987). Increasing dietary tryptophan levels to modulate brain serotonin levels, and hence behaviour, did not reduce stress responses in pigs (Li et al., 2006), and decreased shed illumination (which reduced cannibalism in broiler chickens, Christison et al., 1995), failed to reduce aggression in pigs (Dechamps and Nicks, 1989).

An alternative approach to reduce fighting at weaning is to familiarise piglets with non-litter mates pre-weaning ('socialising'). Socialising piglets has been reported to reduce agonistic behaviour at weaning under intensive pork production conditions (Pluske and Williams, 1996; Weary et al., 2002). Piglets may be more predisposed to accept non-familiar piglets at a younger age (Pitts et al.,2000), since it is during this period of socialisation after leaving the nest that piglets learn to form social relationships through non-aggressive and playful interactions (Petersen et al., 1989). Pre-weaning is clearly an important time for piglets to develop behavioural flexibility and therefore the capacity to adapt to new challenges (Cox and Cooper, 2001), and hence is a time when piglets establish behavioural responses which they later rely on in life (Fagan, 1981). Additionally, although piglets still fight when socialised pre-weaning, fighting is of shorter duration (Pitts et al., 2000) and injuries are less severe because the piglets are smaller (Jensen et al., 1994). Pre-weaning socialisation therefore allows piglets to develop important social skills (Chaloupková et al., 2007) that can not only improve the young pigs' abilities to adapt to the post-weaning environment (Cox and Cooper, 2001), but also benefit them during the grower/finisher period (D'Eath,2005; Hillmann et al., 2003; Kutzer et al., 2009).

Socialising can also increase feed consumption by piglets, both before and after weaning (Weary et al.,2002), which may lead to increased weight gain pre- and post-weaning (but see Rantzer et al., 1995; Weary et al.,2002). Pre-weaning socialisation therefore potentially has production benefits in addition to reducing the chance of injury at weaning (Pitts et al., 2000). Nevertheless, one of the concerns regarding allowing mixing of suckling piglets is the incidence of cross-suckling and competitive exclusion of subordinate piglets. Although it can be considered a natural phenomenon (Maletinska and Spinka,2001), cross-suckling is generally avoided under industry conditions due to fears of suckling disruption (preventing some piglets from suckling) and potential injury to both the sow and the piglets. Reduced milk intake and weight gain in the presence of cross-suckling has been reported in some studies (Algers et al., 1990; Pedersen et al., 1998), while cross-suckling may also lead to increased fighting for udder position which can lead to teat and udder damage (Brown et al., 2005; Olsen et al., 1998). Mixing and cross-suckling can also agitate the sow (Pedersen et al., 1998). It is understood that sows can distinguish between their own and alien piglets by odour (Horrell and Hodgson, 1992);in a multi-suckling system a sow has limited possibilities of allowing only her own piglets to suckle and not alien piglets, and as a result she may terminate suckling bouts(e.g. by standing) where alien piglets are present (Pedersenet al., 1998). Depending on the housing system, anecdotal reports suggest that some sows can become aggressive and attack the alien piglets, or withhold and/or terminate suck-ling bouts for anything up to a day or more, unless sedated (Blackshaw, 1986; Harper, 2001; White, 2013). However, published studies suggest that any disturbances to lactation only last for a few hours (Jensen, 1986) or days (Weary et al., 2002) and have no follow-on effects on growth rates (Maletinska and Spinka, 2001; Wattanakul et al., 1997). It should also be noted that not all studies on multi-suckling systems observed cross-suckling (Kutzer et al., 2009), and giving the piglets sufficient time to bond to their own sow (including recognising her lactation call) and establish a teat order may reduce the incidence of cross-suckling (D'Eath, 2005; Newberry and Wood-Gush, 1985).

The aims of the present study were to investigate the effects of pre-weaning socialisation on behaviour pre-weaning (cross-suckling and body weight gain), as well as post-weaning observations (time budgets for 1.5 days after weaning, and assessment of behavioural expression of pigs through qualitative behavioural assessment; QBA).

## 2. Methods

### *2.1. Animals and experimental design*

This study was carried out at a large commercial piggery in Western Australia under approval of the Animal Ethics Committee at Murdoch University (permit number R2412/11) and the farm owners/managers (who wish to remain anonymous). We examined the effects of pre-weaning socialisation on behaviour during mixing at weaning, which was achieved without interfering with the general piglet or sow management practices under the current farrowing system used at the piggery. At the conclusion of the study, the pigs continued on within the farm's grower/finisher facility.

A total of 353 piglets from 33 sows were marked individually, allowing them to be followed through to post-weaning. Piglets from 24 sows were socialised pre-weaning ($n$ = 256 piglets); for comparison, litters from another nine sows were monitored as control animals ($n$ = 97 piglets). Sows used in the study were Large White × Landrace, mated to Large White × Landrace boars. The average parity of the sows was 3.11 ± 0.37 (range 1–7) with an average gestation length of 114 ± 0.1 days. Litter sizes at birth aver-aged 11.6 ± 0.57 (range 5–16). All piglets included in this study were born over a period of three days. Cross-fostering took place in the first 48 h after farrowing, as per normal practice (redistributing some piglets from large litters to sows with fewer piglets). Piglets were weighed (digital scales) within 24 h of birth, at the same time as tagging, ear notching and iron injection. Creep feed (Kettridges, Pic-ton, Western Australia; 21% crude protein, 1.35% available lysine, 15.4 MJ DE/kg) was provided ad libitum from 8 dafter farrowing.

Facilitation of socialisation of piglets was carried out from around 10 days of age (Fig. 1) by removing sections of the farrowing crate walls, thereby allowing four litters access to a common walkway and all four crates (Fig. 2). For the six socialised groups (i.e., six groups of four sows, to make 24 sows and litters in total), each litter was marked with stock marker paint (a different colour for each litter) to allow for behavioural monitoring. For the nine control litters, each litter was allowed access to the walkway, providing the animals with additional space during pre-weaning. It should be noted that because socialisation involves allowing piglets to roam into other pens or a communal space, this means inevitably increasing the space each piglet has access to and also increases the spatial complexity of their environment; it is therefore impossible to completely separate the social and purely physical enrichment factors.

### 2.2. Pre-weaning observations

#### 2.2.1. Cross-suckling

The 24 socialised litters were observed from the day of mixing through to weaning. For every sow, $n$ = 15 lactation events were recorded (total 360 lactation events). There are two types of cross-suckling piglets: some piglets will only occasionally cross-suckle (less than five times overall lactation events recorded for each sow), but habitual cross-sucklers will cross-suckle more than they suckle from their own mothers and, once established in the teat order, habitual cross-sucklers will usually be faithful to the sow that was not their mother (Olsen et al., 1998). Although we attempted to follow individual piglets through all suckling bouts, we have greater confidence in our estimations of which sows allowed cross-suckling (sows that had one or more alien piglets suckling over at least three consecutive lactation events). The percentage of cross-suckling piglets was therefore calculated including and excluding these sows. We tested the influence of time (days post mixing) on the proportion of cross-suckling by mixed-model ANOVA, with mixed-group ID and sow ID included as random factors. The percentage of cross-suckling piglets showed a Poisson distribution.

#### 2.2.2. Body weight gain

Piglets were weighed within 24 h of birth, the day before weaning, and 7 days after weaning. Body weight data were analysed by mixed-model ANOVA including treatment as a fixed effect, sow ID and sex as random factors, and pigletage and prior body weight readings of each piglet as covariates. Body weight was normally distributed for each age group (Kolmogorov–Smirnov test).

### 2.3. Post-weaning behavior

Piglets were weaned each Thursday at this farm, and therefore piglets ranged in age from 21 to 24 days at weaning. All piglets were weighed the day before weaning. On the day of weaning, sows were removed and taken to dry-sow housing. Piglets from each treatment group were then grouped in a single pen sorted by sex and loaded onto a truck for transport to the grower facility (5 km away). Once at the grower facility, groups of 40 pigs were held in climate-controlled sheds (each pen: 6.5 × 2.2 m, stocking rate: 0.36 $m^2$/head). The animals for this experiment were retained in six pens (two adjacent pens of socialized females, two adjacent pens of socialised males, one pen of control females and one pen of control males). Each pen had two feeders with the same feed as used in the farrowing facility, and two drinking facilities: one nipple drinker and one bowl. Farm staff then went through the groups of pigs, sorting them further by size and removing lame or injured animals to a sick-pen for treatment. The total time from removal of the sows took ∼6 h.

To avoid interfering with normal farm procedure, post-weaning video footage collection (under natural lighting conditions) commenced when farm staff had stopped moving through the pens, for 4 h (14:00 h until dusk at 18:00 h) and from dawn to dusk the following day (06:00 h to19:00 h ∼36 h since weaning). Two types of video footage were collected:

1. Continuous footage was collected for quantitative scoring of time budgets for four of the pens (one per sex/treatment combination). Four digital cam-eras (15 fps; Panasonic SDR-H250 camcorders, Belrose, NSW, Australia) were placed on tripods in the laneway between the pens, covering an estimated 90% of the pen area (there was a blind-spot immediately in front of the camera). This footage was used to compare behavior between treatment groups and determine the most appropriate time point to conduct the QBA scoring.
2. Throughout the 1.5 days after weaning, a series of video clips (each 1-min in length) were collected for QBA using a hand-held camera (the same Pana-sonic SDR-H250 camcorder

models), focussing on a randomly-selected individual in each pen and following this animal as it moved through the pen. The cameraman rotated past each of the six pens of pigs filming the animal closest to one of two grid-point locations in the pen (visualised as the centre of each half of the pen; these grid points were not marked in anyway). A total of 110, 1-min clips were collected over the 1.5 days post-weaning. Analysis of time budgets (see results) indicated that the pigs were most active 21–24 h after mixing for weaning; the 1-min clips collected during this 3-h time window were used for QBA (all the clips within this 3-h period were used, meaning that there was no further selection process required).

3.

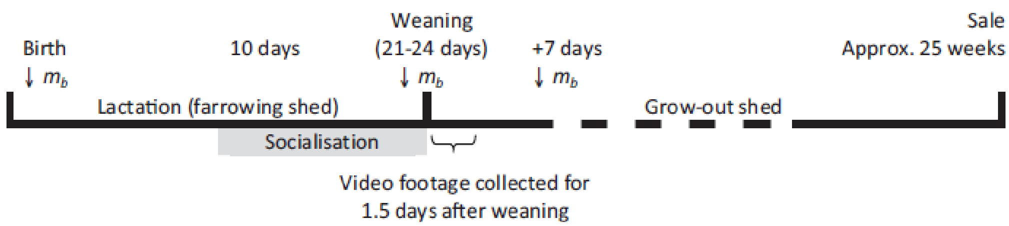



**Fig. 1. Timeline of this study. Socialisation of litters took place between 10 days of age and weaning (at 21–24 days). Body weight (mass mb) was recorded <24 h after birth, 1 day before weaning, and 7 days after weaning.**

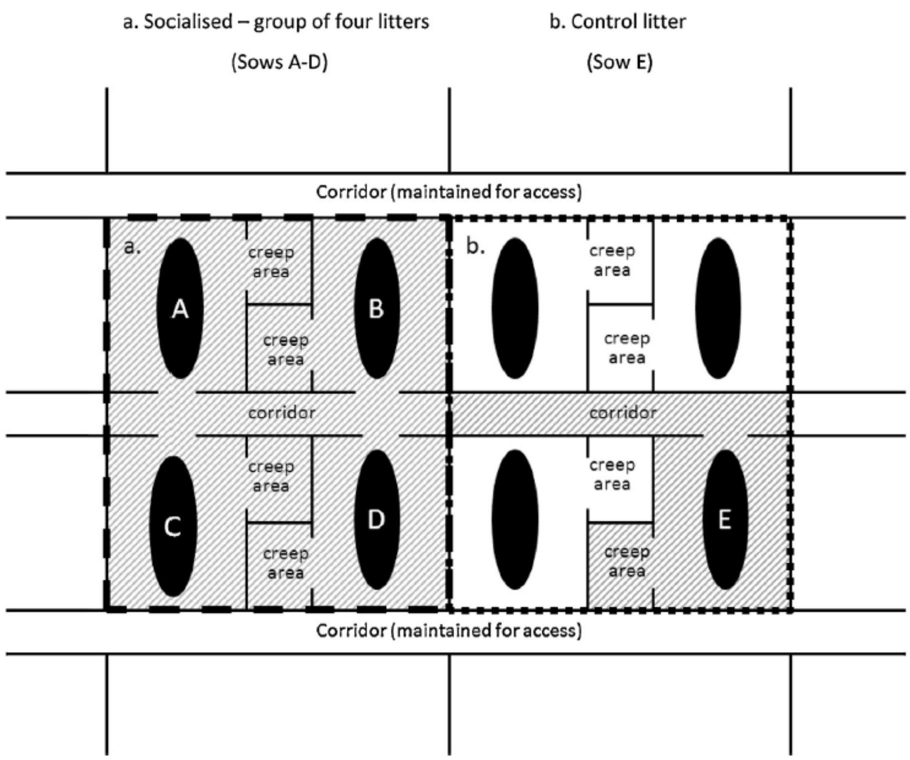



**Fig. 2. Diagrammatic representation of the layout of the pens. Piglets of 4 adjacent sows ((A)–(D)) were 'socialised' by allowing them access to the common corridor from ~10 days of age (left hand side shaded area). Control litters of other sows (E) were given access to the corridor but not allowed to mix with other litters (right hand panel shaded area). The farrowing crates measured 2 × 2.2 m with a sow confinement area 1.4 m wide, the corridors were 0.6 m wide. The crates had a feeder for the sow and two nipple drinkers, one at sow height and one at piglet height.**

*2.3.1. Time budgets*

Pig behaviour was scored using instantaneous scan sampling of the footage for 5-min intervals (similar to published studies of pig behaviour; e.g. Nakamura et al., 2011). Every 5 min, the footage was stopped and the behaviour of every individual (i.e. max. n = 40) within the field of view was scored by one observer into one of seven behaviour categories (aggression, investigating, eating/drinking, walking, standing, sitting, and lying; see Table 1 for full description). Pearson's $\chi^2$ analyses were per-formed with expected values calculated from the overall averages for each behaviour (averaged across treatments, sexes and all time points). We used these quantitative analyses to identify a 3-h window of peak activity (21–24 h after weaning) to carry out the QBA analyses (since the greatest proportion of animals were active at this time, we maximised our chances of determining treatment differences).

**Table 1. Terms used to score behaviour in time budgets.**

| Category | Definition |
|---|---|
| Aggression | Pigs engaged in actions (e.g. fighting, biting, shoulder to shoulder aggressive stance, mounting, belly-nosing) which caused the recipient to react negatively. Where the recipient moved away, the event was scored as one pig behaving aggressively, where the recipient subsequently retaliated, it was scored as two aggressive pigs. If the recipient did not react negatively, the instigator was described as investigating |
| Investigating | Instances of chewing, nosing and exploring the pen or penmates |
| Eating/drinking | Pigs were deemed as eating/drinking if they were interacting with feed or water. Behaviour was described as investigating if the behaviour was not the food or water itself (e.g. a pig nosing the underside of the water bowl, trying to lift it) |
| Walking | Ambulation, movement without touching anything with nose or mouth |
| Standing | All four legs supporting body with no ambulation or touching anything with their nose or mouth |
| Sitting | Hind quarters on the floor, front legs supporting body |
| Lying | Whole length of body on the floor or on other pigs, i.e. not supported by their legs |

*2.3.2. Behavioural expression (qualitative behavioural assessment)*

Qualitative behavioural assessment is a method of quantifying the behavioural expression of animals. QBA has been used to study the behaviour of a number of species, including adult pigs (Rutherford et al., 2012; Temple et al., 2011b; Wemelsfelder et al., 2000, 2001, 2009, 2012).

Fifteen volunteer observers (recruited by advertising across the university by word of mouth, including people with a range of backgrounds but not pig experts) were required to attend two sessions on the university campus or by correspondence. Observers were given detailed instructions on completing the sessions but were not told about the experimental treatments. The two sessions are detailed below:

<u>Session 1: Term generation</u>

Free choice profiling (FCP) has been used extensively in the field of food science (Arnold and Williams, 1985). FCP is a powerful technique as it allows observers to generate their own terms that they feel comfortable using. It also prevents observers from projecting suggested criteria onto the animals or from being biased by the terms given to them (Wemelsfelder, 2007; Wemelsfelder and Lawrence, 2001).

Observers were shown 12 video clips of pigs demonstrating a wide range of behaviour (collected by following individuals on an ad hoc basis undertaking divergent behaviour; including both socialised and control piglets) to allow observers to describe as many aspects of the pigs' expressive repertoire as possible. After watching each clip, observers were given 2 min to write down any words that they thought described that animal's behavioural expression. There was no limit imposed to the number of terms an observer could generate, but terms needed to describe not what the animal was doing (i.e. physical descriptions of the animal such as walking, chewing, drinking), but how the animal was doing it. The descriptive terms were then edited to remove those that described actions (e.g. sitting, walking), and terms that were in the negative form were transformed to the positive for ease of scoring (e.g. unhappy became happy). Each word for each observer was listed alphabetically (to effectively randomise the list) and attached to a 100-mm visual analogue scale ranging from minimum to maximum.

Session 2: Quantification

Observers watched the 1-minclips of the experimental pigs (n = 24 clips; six clips for each group). The experimental clips were ordered so that no two clips of the same treatment-sex combination were seen back-to-back. Observers used their own unique list of terms to quantify each term for each experimental pig. Their descriptive terms were sorted alphabetically (to effectively randomise the presentation order of terms), and presented to observers with a 100-mm visual analogue scale adjacent to each term (Microsoft Excel). Observers scored animals by placing a mark on the visual analogue scale reflecting the intensity of the animal's expression on each descriptive term (i.e. somewhere between 0 = minimum and 100 = maximum for that term). Observers were given detailed instructions on completing the sessions but were not told about the experimental design or treatments.

QBA analysis

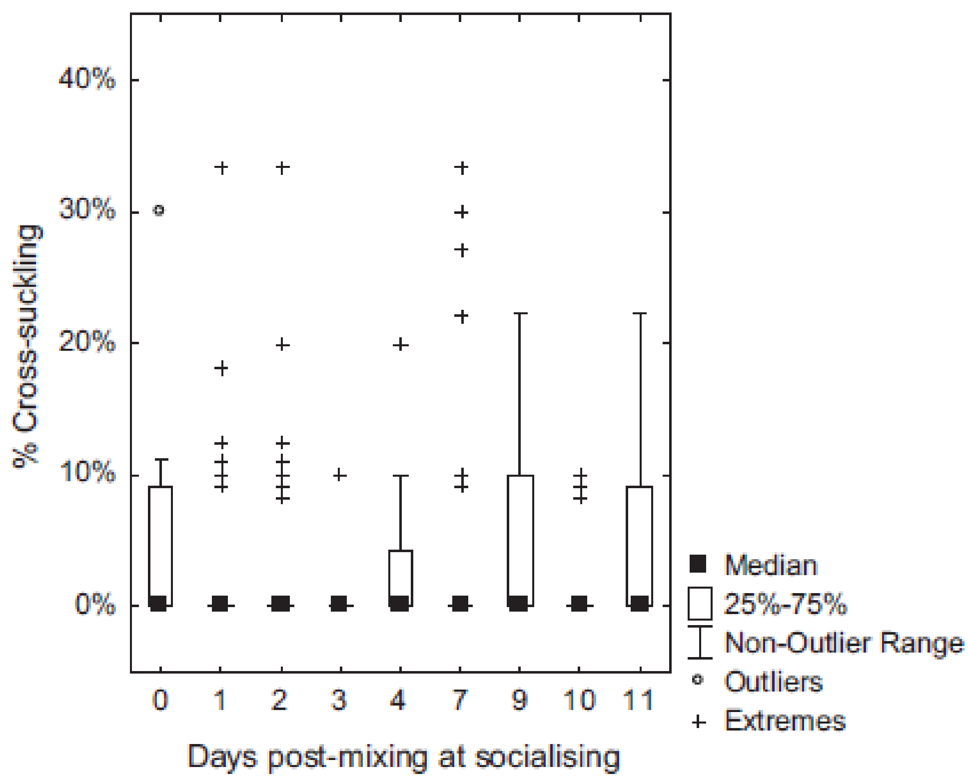
The observer scores generated from the 24 video clips were analysed by Generalised Procrustes Analysis (GPA) using a specialised software edition written for Françoise Wemelsfelder; for a detailed description of its procedures, see Wemelsfelder et al. (2000). Briefly, GPA calculates a consensus or 'best fit' profile between observer assessments through complex pattern matching. This consensus profile has several main dimensions (usually two or three) explaining the variation between animals. Each animal receives a quantitative score on each of these dimensions ('GPA dimension scores'), so that the animal's position in the consensus profile can be graphically represented in two- or three-dimensional plots. Each plot represents each pig in each treatment where the position of the pig indicates its scores on each GPA axis. To compare treatments, the GPA scores for each dimension were analysed using a mixed-model ANOVA with socialization treatment and sex as the fixed variables, observers as the random variables, and BoxCox-transformed GPA dimension scores as dependant variables (Kolmogorov–Smirnovtest for normal distribution).

The GPA dimensions were interpreted by correlating the animals' scores to the observers' individual scoring patterns, producing word charts describing the consensus for individual observers that can be compared for linguistic consistency. From these word charts, a list of terms from all observers describing the consensus dimensions was produced. Those that correlated strongly with each GPA dimension ($r > |0.6|$ on GPA dimension 1, $r > |0.5|$ on GPA dimension 2) were chosen to represent each GPA dimension.

2.4. General statistical treatments

Statistical analyses were performed using GenStat 10.2(VSN International, Hemel Hempstead, Hertfordshire, UK) and Statistica 8.0 (StatSoft-Inc., Tulsa, OK, USA). Carrying out correlation analyses with quantitative data were limited since we only had four treatment groups (we used different footage for the quantitative and qualitative assessments and therefore were restricted to comparing group means). Data are presented as means ± 1 SD and a statistical level of $\alpha \leq 0.05$ is used throughout to denote statistical significance.

**Fig. 3. Percentage cross-suckling observed in the 24 socialised litters of piglets**




## 3. Results

*3.1. Pre-weaning behavior*

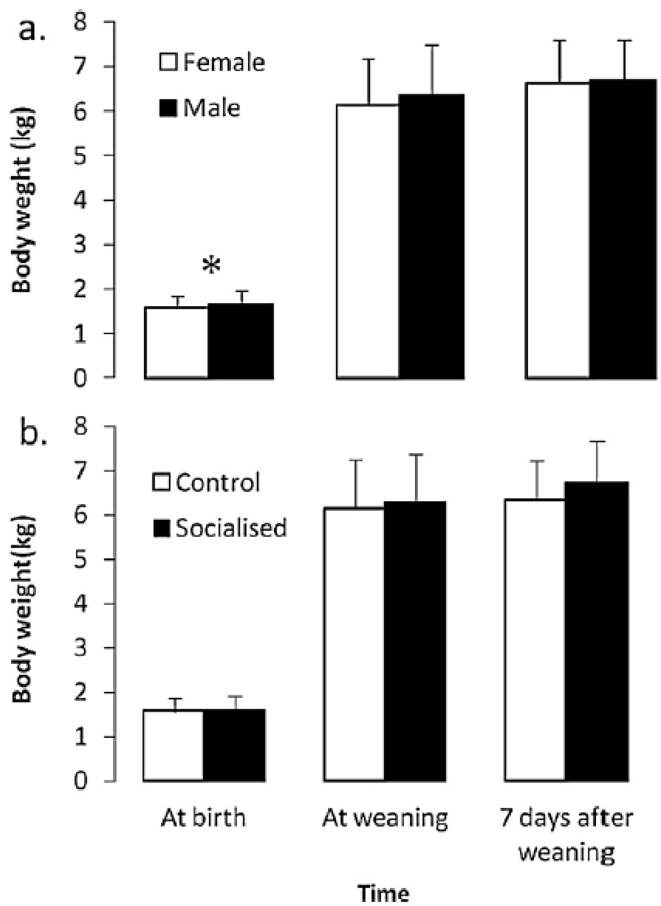
*3.1.1. Cross-suckling*

Alien piglets ('cross-sucklers') (average 2.9 ± 6.5% of piglets suckling, range 0–45% over the 360 lactation events recorded) were present at 22% of all suckling events. Sow ID had a strong effect on the proportion of cross-sucklers (sow: $F_{18,328} = 9.45$, $P < 0.001$), but there was no effect of group (mixed group ID: $F_{5,18} = 0.82$, $P = 0.550$) or time (days post mixing: $F_{8,328} = 1.13$, $P = 0.343$; Fig. 3). We identified two sows that never had alien piglets suckle, but six sows that allowed alien piglets to suckle over at least three consecutive lactation events. Excluding the six sows that habitually allowed cross-sucklers, the percentage of cross-suckling piglets reduced from 2.9% overall, to 1.2%.

*3.1.2. Body weight*

Males (1.65 ± 0.32 kg) were heavier than females (1.56 ± 0.30 kg) 1 day after birth ($F_{1,71} = 5.78$, P = 0.019; Fig. 4a) and there was a strong effect of sow ID ($F_{31,275} = 14.64$, $P < 0.001$) on birth weight, but there was no effect of socialisation treatment at that point ($F_{1,31} = 0.01$, $P = 0.939$; piglets had been allocated to treatment groups but had not been socialised at that stage). The day before weaning (average weight of piglets 6.24 ± 1.09 kg) there was no treatment effect on body weight ($F_{1,29}$ = 0.40, $P$ = 0.534), although there was still a strong effect of sow ID and birth weight (sow: $F_{30,273}$ = 4.37, $P$ < 0.001; sex: $F_{1,272}$ = 0.29, $P$ = 0.591; covariates age: $F_{1,30}$ = 0.04, $P$ = 0.852, weight at birth: $F_{1,38}$ = 48.21, $P$ < 0.001). Similarly, there was no treatment effect ($F_{1,27}$ = 0.14, $P$ = 0.711) on body weight 1 week after weaning (average weight of piglets 6.63 ± 0.96 kg), although there were effects of sow ID and a correlation with previous body weight measures (sow: $F_{30,129}$ = 1.77, $P$ = 0.016; sex: $F_{1,128}$ = 1.89, $P$ = 0.172; covariates age: $F_{1,27}$ = 0.15, $P$ = 0.701, weight at birth: $F_{1,45}$ = 192.95, $P$ < 0.001, weight at weaning: $F_{1,60}$ = 706.47, $P$ < 0.001).

**Fig. 4. Effect of (a) sex and (b) socialisation treatment on piglet bodyweight (mass) at three time points. Values are means ±1SD. *indicates significance (P < 0.05).**




*3.2. Post-weaning behavior*

*3.2.1. Time budgets*

For the ~150 time points that each pen was monitored over the 1.5 days post-weaning, we recorded an average of 33.5 ± 0.6 piglets per scan sample, which averaged 84% of the total number of animals ($n$ =

40) in each pen. Over-all average values for time budgets (averaged across all hours and all treatment groups) were aggression: 2.8%, investigating: 8.3%, eating/drinking: 4.0%, walking: 2.5%, standing: 16.2%, sitting: 0.4%, and lying: 65.8%; these aver-age values were used for comparison with specific time points.

By the middle of the day (~21–24 h after mixing; Fig. 5), pigs were active compared with overall averages across the entire 1.5 day period (only 46% lying), showing more investigating (13%), standing immobile (26%), eating/drinking (6%), and interacting aggressively (4%). This 3-h period (hereafter 'peak activity period') was selected as the time window for QBA due to the amount of activity recorded. During this peak activity period (Table 2, Fig. 6), socialized males displayed more lying ($\chi^2_3$ = 48.82, $P$ < 0.001), less standing ($\chi^2_3$ = 27.19, $P$ < 0.001), and less eating/drinking ($\chi^2_3$ = 18.78, $P$ < 0.001) compared to the averages summed across this 3-h time period for all treatments ($\chi^2$ analysis). Control males displayed more standing ($\chi^2_3$ = 12.14, $P$ = 0.007), eating/drinking ($\chi^2_3$ = 40.95, $P$ < 0.001), and less lying ($\chi^2_3$ = 19.69, $P$ < 0.001). Socialised females showed more investigative behaviour ($\chi^2_3$ = 22.19, $P$ < 0.001) and less lying ($\chi^2_3$ = 23.82, $P$ < 0.001). Control females showed no difference ($P$ > 0.05) from overall averages for any behaviour.

**Fig. 5. Time budget of behaviour for all pigs (all treatment groups together). Footage was collected immediately after piglets were introduced to their weaning pens (between 2pm and 6pm on day 1), and the entire following day for comparison. Footage could not be collected overnight (O/N) due to poor lighting conditions.**

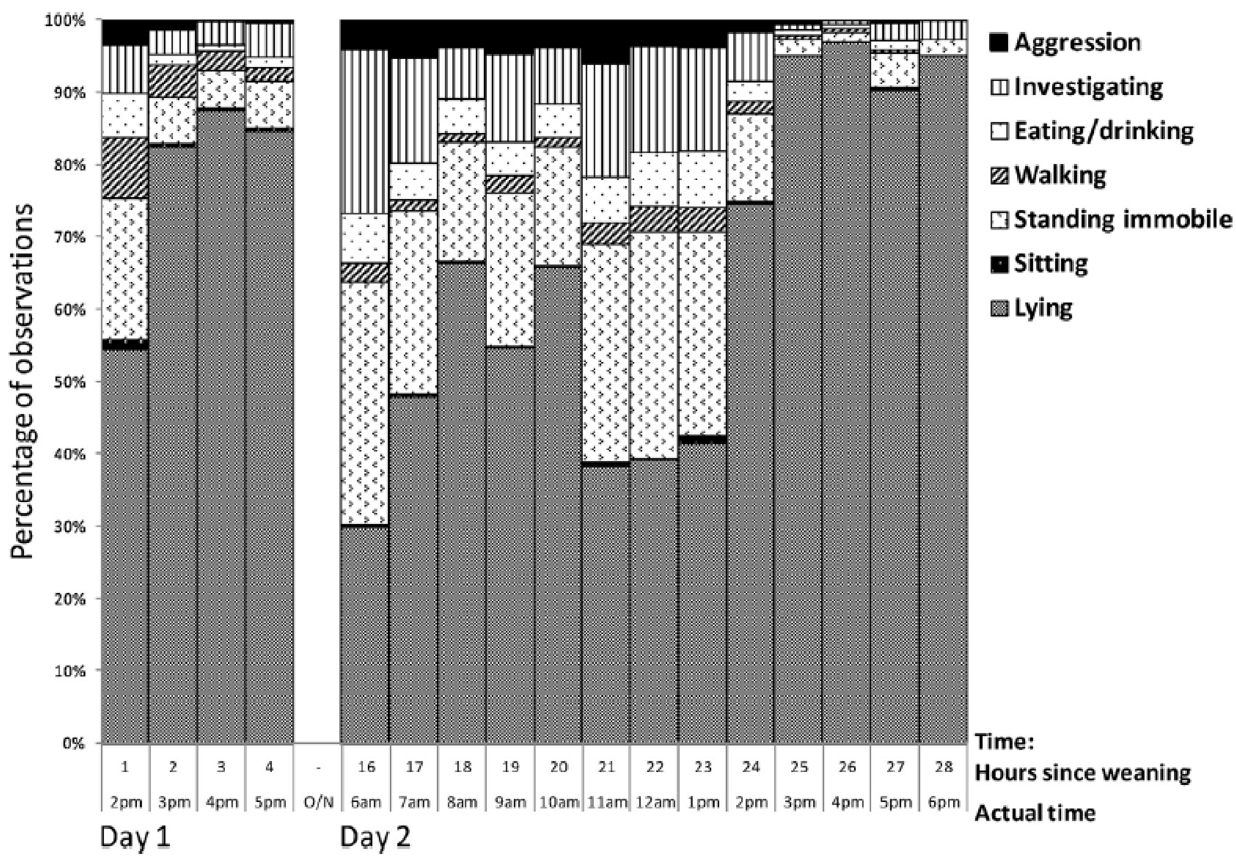
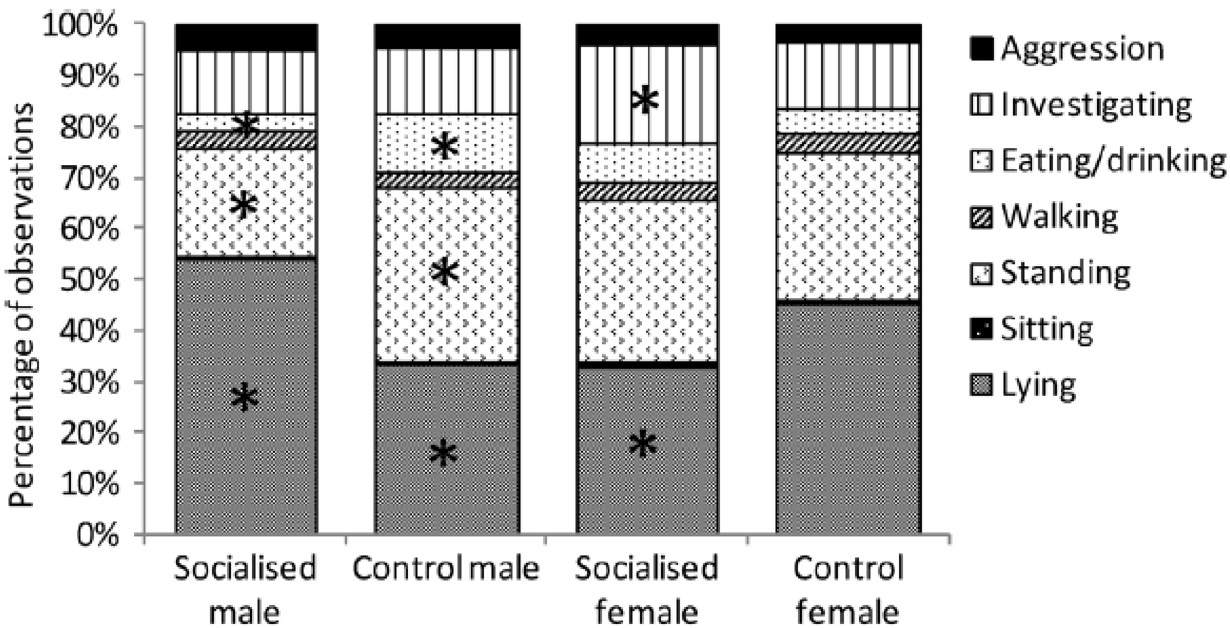


**Table 2 Percentage of observations (total number of pigs observed within each treatment) for each of seven behavioural categories averaged across a 3-h time window the day after weaning (~21–24 h after weaning). Significant values (bold) indicated as: more (↑) or less (↓) than the overall average values ($P$ < 0.01).**

| Behaviour | Socialised male (%) | Control male (%) | Socialised female (%) | Control female (%) |
|---|---|---|---|---|
| Aggression | 4 | 5 | 4 | 4 |
| Investigating | 12 | 12 | **17** ↑ | 11 |
| Eating/drinking | **4** ↓ | **11** ↑ | 7 | 5 |
| Walking | 3% | 2% | 3 | 4 |
| Standing | **20** ↓ | **32** ↑ | 28 | 26 |
| Sitting | 0 | 0 | 1 | 1 |
| Lying | **57** ↑ | **38** ↓ | **40** ↓ | 50 |

**Fig. 6. Summary of the time budgets for the 3-h time window analysed by qualitative assessment presented by the four treatment groups. ↑ Behaviour more prevalent than the average, ↓ behavior less prevalent than the average.**

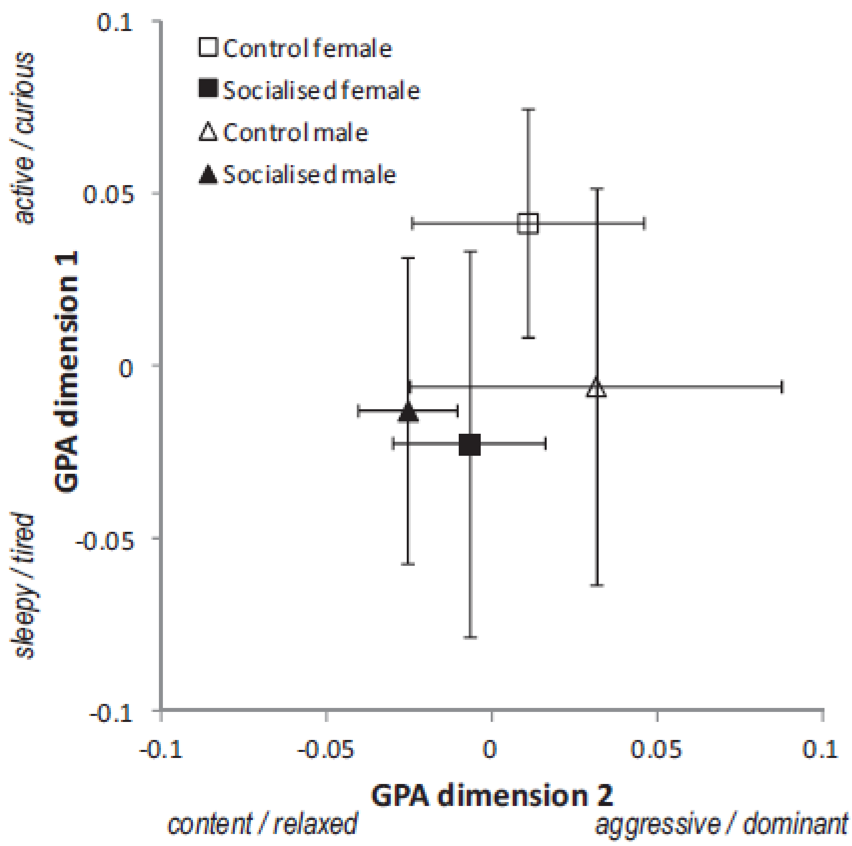



*3.2.2. Behavioural expression*

The 15 observers generated a total of 117 unique terms to describe the pigs in the video clips, with an average of 19.5 (range 13–29) terms per observer. The Procrustes Statistic was 44.96% and this differed from a mean randomised profile ($t_{99}$= 47.2, $P$ < 0.001). Two main GPA dimensions were identified, explaining 40.6% and 19.4% of the variation between animals (GPA dimensions 1 and 2, respectively). Descriptive terms strongly correlated with each GPA dimension are shown in Table 3. Low values for GPA dimension 1 were associated with terms such as 'sleepy'/'tired' and high values with terms such as 'active'/'curious'. Low values for GPA dimension 2were associated with terms such as 'content'/'relaxed', and high values were associated with terms such as 'aggressive'/'dominant'.

Positions of groups of pigs within their treatments on the two GPA dimensions are shown in Fig. 7. There was a treatment effect on GPA dimension 1 (y-axis in Fig. 7) ($F_{1,343}$ = 9.81 $P$ = 0.002), with socialised animals scored as more 'sleepy'/'tired' compared with control animals (more 'active'/'curious'). Neither sex ($F_{1,343}$ = 2.60, $P$ = 0.107) or observer ID ($F_{1,343}$ = 0.23, $P$ = 0.998) had an effect on GPA dimension 1 scores. There was also a treatment effect on GPA dimension 2 ($x$-axis in Fig. 7) ($F_{1,343}$ = 7.46, $P$ = 0.007),with socialised animals scored as more 'content'/'relaxed' compared with control animals (scored as more 'aggressive'/'dominant'). Neither sex ($F_{1,343}$ = 1.78, $P$ = 0.183) or observer ID ($F_{1,343}$ = 0.48, $P$ = 0.943) had an effect on GPA dimension 2 scores.

**Fig. 7. Positions of pigs within their treatments on GPA dimensions 1 and 2. Values are means ± 1 SD for the treatment group.**




## 4. Discussion

The present study showed pre-weaning socialization positively influenced the behaviour of pigs. We recorded minimal cross-suckling (2.9%) and did not find any detrimental effects of socialising on body weight gain during lactation. Although there was no significant difference in the incidence of aggression between treatment groups or between the sexes, compared with overall averages, socialised males spent more time lying (but less eating/drinking), and socialised females were more active (less time lying) investigating. The behavioural expression of piglets suggested that they adapted quicker to the new environment at mixing, with socialised pigs scored higher for descriptive terms that implied they were perceived as more relaxed than control pigs.

*4.1. Pre-weaning observations*

The low evidence of cross-suckling found in this study(2.9%, or 1.2% when six sows that habitually allowed alien piglets to cross-suckle were excluded from the estimates) reflects similar findings for previous studies (0%, D'Eath, 2005; <2%, Weary et al., 2002; 0%, Weary et al., 1999). This low occurrence of cross-suckling may be due to nursing synchronisation by the sows in adjacent pens (piglets cannot simultaneously suckle from their own mother and an adjacent sow), or to the time at which socialisation commenced (day 10, by which time teat order is established). In contrast to the view that cross-suckling is strictly a negative behaviour, piglets that may be undernourished (e.g. due to sucking from a low milk-yielding teat) have the opportunity to seek additional nutrients from another sow, which can be regarded as beneficial. In this case, the piglet would likely be better off with additional suckling on a sow that was not their mother than if it had been faithful to its mother.

Literature emphasising negative impacts of pre-weaning socialisation mostly focuses on cross-suckling and disruption to suckling (Pedersen et al., 1998). However, we found no significant difference in body weight between socialised and control piglets at weaning, indicating that socialised piglets were not adversely affected by any increase in competition at the udder. These data support previous studies showing no effect of pre-weaning socialisation on overall piglet growth rate (D'Eath, 2005; Kanaanet al., 2008; Parratt et al., 2006; Pluske and Williams, 1996; Wattanakul et al., 1997; Weary et al., 1999). Another argument against pre-weaning socialisation has been labour or other costs associated with changing housing. However, intensive indoor production systems are highly controlled and intervention with litters (e.g. cross-fostering, keeping below-weight piglets back a week or two on a foster sow) is commonplace. These practices could continue in a multi-suckling system in the presence of litter-mixed housing of piglets.

**Table 3. Terms used by observers to describe behaviour of piglets after weaning which were strongly correlated with the GPA consensus dimensions. The terms shown are those that were correlated with each end of each GPA dimension axis (% of variation in behavioural expression accounted for by each dimension). Term order is determined firstly by the number of observers to use each term (in brackets if greater than 1), and secondly by weighting of each term (i.e. correlation with the GPA consensus dimension). Terms in bold were used to describe the GPA dimensions in the text and graphs. The last column shows a summary of statistical analyses for each dimension.**

| GPA dimension | Low values | High values | socialisation treatment effect |
|---|---|---|---|
| 1 (40.6%) | **Sleepy (13)**, **tired (7)**, relaxed (4), content (3), snuggly (2), dreamy (2), comfortable (2), peaceful, seeking companionship, still, slothish, wanting a cuddle, cuddly, quiet, cold, restful, stable, calm, companionship | **Active (5)**, **curious (5)**, investigative (3), inquisitive (2), restless (2), depressed, frustrated, searching, territorial | $F_{1,343}$ = 9.81, $P$ = 0.002 |
| 2 (19.4%) | **Content (2)**, **relaxed (2)**, comfortable (2), Timid, Investigative, observant, curious, happy, inquisitive, interested | **Aggressive (9)**, **dominant (5)**, playful (5), annoyed (5), excited (4), angry (3), scared (3), energetic (2), irritated (2), active (2), fazed, tetchy, agitated, feisty, dominating, bossy, skittish, bullied, reactive, pushy, confident, assertive naughty, forceful, mischievous, determined, persistent, consistent, frustrated, sexually frustrated, spooked | $F_{1,343}$ = 7.46, $P$ = 0.007 |

*4.2. Behaviour at mixing*

There was no significant difference in aggression between socialised and control pigs over the 1.5 days mixing at weaning or during the 3-h 'active' period identified (21–24 h after mixing). This finding contradicts published results reporting reduced aggression after weaning in piglets that were socialised pre-weaning. Group size may influence the result, as many studies have used small groups (e.g. three to six piglets Weary et al., 1999, 2002), whereas we examined pens of 40 pigs under commercial conditions. The method of assessing aggression may also have an effect. Previous studies have used resident-intruder tests or social encounter tests (examining dominance dynamics in pairs of pigs) or incidence of injuries (Kutzer et al., 2009; Pluske and Williams, 1996; Wattanakul et al., 1997), which inform about hierarchy stabilisation (D'Eath, 2005; de Jonge et al., 1996; Hillmannet al., 2003; Pitts et al., 2000) and also absolute levels of aggression (Erhard et al., 1997). Alternatively, lesion scores (D'Eath, 2005) or fight length (Friend et al., 1983) have been recorded. Play and aggression have been described as a continuum (Silerova et al., 2010), with some authors identifying fighting separate from play when it includes 'serious' biting (Arey and Sancha, 1996; Devillers and Farmer, 2009),head knocks (Chaloupková et al., 2007; Parratt et al., 2006;Yuan et al., 2004) or pushing (Hessel et al., 2006; Masonet al., 2003). By contrast, we relied on the pig's responses rather than a priori definitions, recording aggression as social interaction where one pig moved away from the other and did not find differences in levels of aggression.

By contrast with the wealth of studies that have quantified aggression around weaning (above), there are few data quantifying positive aspects of welfare. QBA has been used as one of 12 welfare assessments incorporated in the European Commission's Welfare Quality® assessments of sows, piglets and fattening pigs, where it is the only measure of positive welfare (Temple et al., 2011a; Wemelsfelder and Lawrence, 2001). In our study, observers reached consensus on their assessment of the behavioural expression of piglets, supporting previous QBA studies in adult pigs (Rutherford et al., 2012; Temple et al., 2011b; Wemelsfelder et al., 2000, 2001, 2009, 2012). We also recorded a significant socialisation treatment effect on both GPA dimension 1 and 2, suggesting that enrichment of the social environment during lactation influenced the behavioural expression of pigs. Socialised pigs scored higher for descriptive terms that implied they were perceived as more relaxed than control pigs—they were scored as more 'sleepy'/'tired' or 'content'/'relaxed' while control animals were more 'active'/'curious' or 'aggressive'/'dominant'. This finding supports the time budget data—socialised animals were also scored as spending more time lying (males), and while females were classified as standing or investigating, observers interpreted their body language as generally relaxed.

In conclusion, we showed positive behavioural responses at weaning for socialised piglets (time budgets and QBA) and support previous studies indicating that a piglet's experience pre-weaning influences their post-weaning behaviour (Cox and Cooper, 2001; Li and Wang, 2011). When piglets are mixed from 10 days of age, there was a low occurrence of cross-suckling and no difference in their weight gain, providing evidence against misgivings about implementing a housing system that incorporates pre-weaning socialisation. Instead, pre-weaning socialisation may be beneficial to piglets from a welfare perspective, including expression of more relaxed behaviour.

**Conflict of interest statement**

We have no conflict of interest to declare.

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