Does environmental background (intensive-raised \textit{vs.} outdoor-raised) influence the behaviour of piglets at weaning?

“A thesis submitted in partial fulfilment of the requirements of the degree of Bachelor of Animal Science, Murdoch University, WA.”

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Declaration

“This thesis has been composed by myself and has not been accepted in any previous application for a degree. The work, of which this is a record, has been done by myself and all sources of information have been cited” (Yvonne Lau)
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Chapter 1 General Introduction

Mixing pigs is a common practice in the modern swine industry. Pigs are usually mixed at weaning and at the early growing stage to efficiently utilise housing facilities (Li and Wang 2011). Piglet weaning imposes severe nutritional, psychological and physical stressors on piglets with a period of low food intake and poor growth in the first week after weaning (Pajor 1991). Mixing with unacquainted pigs also induces aggression which results in injuries (O’Connell et al. 2005). Since fights among older pigs are more intense and cause more injuries than fights among younger pigs, exposure to unacquainted pigs at an early age to familiarise each other can be a means to reduce mixing-induced aggression (Pluske and Williams 1996). This socialisation prior to mixing at weaning may also serve to reduce the psychological stress of mixing at this time (Sanders et al. Submitted 4 March 2013).

The development of an objective measurement of animal welfare is important to all animal production industries. Objective measures are needed to provide these industries with the tools needed to improve current farming practices and to provide assurance to consumers of animal welfare integrity of their products. The assessment of affective states in animals is challenging but vital for animal welfare studies. One approach which may be effective in capturing affective states of animals is Qualitative Behavioural Assessment (QBA) (Rutherford et al. 2012). QBA is an integrated measure that characterises behaviour as a dynamic, expressive body language (Sanders 2011). It integrates information from multiple behavioural signals and styles of behavioural expression (body language) directly in terms of an animal’s emotional expression. (Rutherford et al. 2012). Using descriptors such as ‘timid’ or ‘confident’, we can summarise different aspects of an animal’s interaction with the environment (Wemelsfelder et al. 2009). QBA is a relatively quick and non-invasive method that is also versatile enough to be used under a wide range of industry situations; this means QBA may be useful to compare animals under a range of scenarios (Fleming 2011).
Aims of this thesis

This study investigated the behaviour of piglets raised under different housing conditions. Comparing the behaviour of outdoor-raised and farrowing shed-raised piglets at weaning in response to four challenges (isolation, a novel object, food or a non-sibling piglet). My hypotheses are:

Outdoor-raised piglets:
- $H_1$: able to cope with isolation better,
- $H_2$: are more interested in novel objects,
- $H_3$: are more interested in food, and
- $H_4$: are less aggressive towards non-siblings

than farrowing shed-raised piglets. To assess the behaviour of these piglets, I used methods to quantify the duration of behavioural categories, as well as the piglets’ behavioural expressions (QBA).
Chapter 2 Literature review

In this literature review, I discuss weaning and housing issues in regards to pig welfare, the current industry standards regarding housing, and the use of QBA and quantitative measures of animal welfare.

Pig welfare and behaviour

Stress is a routine part of life and occurs in the context of social dynamics (feeding, mating, aggressive interactions) and coping with the environment (heat, cold and novel environmental situations) (Kittawornrat and Zimmerman 2011). Welfare issues arise in pig production when there is a mismatch between a pig’s instincts and its environment (Stolba 1984). This happens when instinctual behaviour is prevented and behavioural impulses are then expressed inappropriately. Feral pigs are normally active during the day and spend most of their active time in foraging-related activities which includes rooting, grazing and exploring with their snouts (Kittawornrat and Zimmerman 2011). In comparison, while supplied with basic necessities (food, water and shelter), domestic pigs in commercial production continue to express exploratory behaviours and preferentially select environments (pens) with novel objects to investigate (Stolba 1984). Where they have little stimulation in their environment, the natural tendency of pigs to chew objects can be misdirected to other pigs; ears and tails are the easiest targets (Kittawornrat and Zimmerman 2011). Tail biting is a behaviour and welfare problem that has been attributed to a complex number of factors that includes crowding, lack of bedding, poor ventilation, and disease (Stolba 1984).

Weaning

Weaning can be a very stressful period for piglets. The weaning transition is a complex period during which piglets have to cope with abrupt separation from their mother, mixing with other litters in a usually new environment, and switch from highly digestible milk to a less digestible more complex solid feed. Weaning is also associated with low and variable feed and water intake, resulting in a transient growth check. Lallès et al. (2007) reported that 50% of weaned piglets consume their first meal within 24 hours post weaning, but 10% would still not have eaten until up to 48 hours later. Thus energy requirements for maintenance for these pigs would only be met by energy reserves for 3 days post-weaning, and take 8-14 days to recover to pre-weaning levels (Lallès et al. 2007).
Following the withdrawal of sow’s milk, weaners are highly susceptible to enteric diseases partly as a result of the altered balance between developing beneficial microbiota and the establishment of intestinal bacterial pathogens (Lallès et al. 2007). Pigs coexist with a diverse and dense commensal microbiota in their gastrointestinal tract; most of these microbes are beneficial, providing necessary nutrients against harmful pathogens for the host (Pajor 1991). The microbial colonisation of the porcine intestine begins at birth and follows a rapid succession during the neonatal and weaning period (Lallès et al. 2007). Pigs weaned in a production environment experience major changes in intestinal microbiota composition that are influenced by diet and environmental factor (Lallès et al. 2007).

Weaning in free-ranging domestic pigs is a gradual process, taking 8-19 weeks to complete (Jensen and Recén 1989). However in a commercial pig production, weaning of piglets takes place early, typically at 3-5 weeks of age. Weaning at such a young age presents a big problem to the weaners from trying solid foods for the first time to interacting with unfamiliar pigs.

One way to avoid stress of mixing at weaning is to allow litters to mix before weaning (Jensen and Recén 1989), where piglets are allowed to come into contact with other sows and non-littermate piglets and engage in playful social interactions. Petersen et al. (1989) suggested that the period from around a week after birth until weaning represented a natural ‘socialisation period’ when piglets form social relationships. De Jonge et al. (1996) demonstrated that piglets that were reared in a group-farrowing system were better adapted to non-social and social challenges, and were less aggressive to unfamiliar piglets at weaning compared to piglets that were reared in individual farrowing pens. The authors also reported that, compared to confinement-farrowed pigs, pigs farrowed in groups in outdoor systems exhibited puberty earlier and had a lower basal cortisol level (a steroid hormone that is released in response to stress), suggesting that exposure to enriched environments in early life increase resistance to stress in adulthood. Olsson et al. (1999) reported that pigs reared under poor conditions (little stimulation, and little space to run and explore) exhibited more aggressive and less threatening behaviours, along with higher cortisol levels when they encountered an opponent; this indicates poor social skills developed in early life. The authors suggested that changes in behavioural patterns in early life would pursue into adulthood, with the consequence that pigs reared in enriched environments were less susceptible to stressors.
while pigs reared under poor environment were more susceptible. Li and Wang (2011) demonstrated that pigs in group farrowing system were less aggressive and more tolerant of unfamiliar opponents compared to pigs from a confinement housing system; the mean duration of fights was less, and unfamiliar pigs started fighting sooner than familiar pigs (see Table 1). This was probably due to their exposure to large social groups early in life. The authors concluded that social interactions with non-litter mates early in their life enhances behavioural development, contributing to better adaptation to social challenges at mixing and later in production life.

Table 1: Fighting among pigs that were born in a group farrowing and a confinement system during the initial 24 h mixing in a grow-out finishing barn (Li and Wang 2011).

<table>
<thead>
<tr>
<th>Item</th>
<th>Group-farrowing</th>
<th>Confinement-farrowing</th>
<th>S.E.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency of fighting, min</td>
<td>12.4</td>
<td>510.1</td>
<td>48.5</td>
<td>340.1</td>
</tr>
<tr>
<td>Transformed data</td>
<td>1.0*</td>
<td>2.0</td>
<td>1.3*</td>
<td>2.0</td>
</tr>
<tr>
<td>Total duration of fights, s/h</td>
<td>116.3</td>
<td>5.1</td>
<td>2.2*</td>
<td>0.12</td>
</tr>
<tr>
<td>Transformed data</td>
<td>1.0*</td>
<td>0.4</td>
<td>0.8*</td>
<td>0.3</td>
</tr>
<tr>
<td>Frequency of fights/h</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Transformed data</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Percentage of total fights, %</td>
<td>93.0*</td>
<td>61.0</td>
<td>96.0*</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Current industry standards regarding housing

The trend towards the production of swine in intensive systems greatly accelerated after 1980, and has resulted in sophisticated, capital-intense facilities designed to reduce manual labour and increase efficiency (Kittawornrat and Zimmerman 2011). For decades, it has been standard practice to keep sows housed individually in crates for the duration of gestation; however the use of indoor systems raises the most serious welfare issues (RSPCA 2011). Welfare issues arise from the fact that pigs are intelligent, social animals with a complex range of behaviours and needs. There has been growing societal pressure, expressed through government legislation as well as retailers and consumers’ purchasing choices, to abolish livestock systems considered detrimental to farm animal welfare (Taylor 2006).

Farrowing crate system

Farrowing crates are designed to physically and behaviourally restrict the sow to prevent her from accidently crushing her piglets. Farrowing crates are aimed at providing a comfortable, hygienic environment for sows and litters whilst making management as easy as possible (Taylor 2006). Crates also protect the stockperson from sow aggression, allowing free access for litter management tasks. Conventional farrowing crate systems provide pig producers
with excellent working conditions and pig mortality is less than 10% (Taylor 2006). However these benefits come at a cost of $1,000 or more per sow place (Taylor 2006). Piglets raised in farrowing crates have no opportunity to engage in normal behaviours (e.g. rooting, wallowing, or exploring their environments) or to interact socially with non-littermates pigs. Thus the sows show high levels of stereotypical behaviours (e.g. biting bars and swaying their heads) as well as unresolved aggression (RSPCA 2011).

Outdoor piggeries

The Royal Society for the Prevention of Cruelty to Animals, RSPCA (2011) defines “free range pork comes from pigs that were born and raised with free access to outdoors”. That is, where the sows and growing piglets have access to paddocks, as well as huts or other forms of housing for shelter, and is not confined to sow stalls or farrowing crates. RSPCA approved farming scheme requires that pigs live in a well-managed outdoor system that cater for all their behavioural and physiological needs (referred to as ‘bred free range’), and are transported with care and slaughtered humanely (RSPCA 2011). Free range pork production consists of outdoor paddocks, which includes rooting and foraging areas, wallows and huts for shelter (Australian Pork Limited 2013). Outdoor pigs spend many hours a day exploring environments and foraging, and are able to avoid aggressive behaviours by moving away from other pigs (Hillmann et al. 2003). Outdoor systems are relatively cheap to establish and, if well managed, are considered welfare friendly (Australian Pork Limited 2013). Performance of these systems can be similar to conventional farrowing crates (Taylor 2006). However outdoor systems require specific soil types and climatic areas (Baxter et al. 2012). When compared with indoor systems, a higher labour input using different husbandry skills is needed. In general, free range piglets have a higher mortality compared to intensively-housed pigs (farrowing shed) (Taylor 2006). Many factors can contribute to the death of the piglet including crushing, disease, heat and cold stress and poor nutrition. With good management, free range pigs can have a similar production to indoor pigs. The only con is that growth rate of litters may be affected by seasons (Li and Wang 2011), a study by Baxter et al. (2012) shows piglets grow quicker indoors during winter compared to outdoor system.

In conclusion, a successful housing system should attempt to reconcile the needs between sow, farmer and piglets, and to maximise both productivity and welfare (Baxter et al. 2012). No one system completely satisfies the needs of these three stakeholders and each system has
different merits and drawbacks regarding their performance. It is essential that we continue to assess, scrutinise and strive to improve the welfare of pigs in modern production systems, as the industry continues to evolve.

**Welfare issues associated with pig housing**

Apart from the actual housing environments in which pigs are kept, conditions present in early life may have profound effects on later behaviour and welfare. For example, space allowance during socialisation period can affect the development of social skills needed in later life (Bolhuis et al. 2005). Previous studies have indicated that rearing environment in early life affects behavioural development, which consequently modifies behavioural response of pigs to stressful environments in later stages of the production (Li and Wang 2011).

**Stimulus-poor environments**

In intensive pig husbandry, pigs are generally housed in stimulus-poor environments, and consequently the expression of species-specific behaviours are limited (De Jonge et al. 1996). Barren housing environments may restrict explorative activities like rooting and chewing, which are important elements in the behavioural repertoire of pigs. Piglets in commercial systems generally have limited opportunities to learn how to behave and eat like a normal pig (van de Weerd and Day 2009). This frustration of normal behaviour leads to the development of several maladaptive oral behaviours, such as biting of tails, ears and vacuum chewing that starts early in life (Bolhuis et al. 2005).

**Aggression**

Studies comparing the effects of farrowing system on behaviour of pigs at mixing show that the majority of fighting was observed in open areas and at feeders, with pigs reared in the group-farrowing system fighting was less than pigs reared in confinement systems (Li and Wang 2011). This study suggests that pigs reared in the group-farrowing system maintained the ability to discriminate between pen mates and non-pen mates, and were more tolerant of unfamiliar pigs when mixed in small groups compared to pigs reared in the confinement system. Hillmann et al. (2003) demonstrated that piglets reared in a group-farrowing system
were better adapted to non-social and social challenges, and were less aggressive to unfamiliar piglets at weaning compared to piglets that were reared in individual farrowing pens. Similarly, Olsson et al. (1999) reported that pigs reared under poor conditions (stimulus poor environment) exhibited more aggressive and less threatening behaviour, along with higher cortisol level when encountered an opponent, indicating poor social skills of these pigs.

Species-specific behaviour

Nakamura et al. (2011) noted that piglets reared in indoor systems would find it hard to develop normal behaviour, meaning species-specific behaviour (rooting, exploring), because indoor housing systems consist of small areas and scarce resources. On the other hand, piglets reared in outdoor systems can develop species-specific behaviour freely because outdoor housing systems consist of large areas and abundant resources. Conflict behaviour (tail and ear biting) do not develop in semi-natural conditions but do develop frequently in intensive rearing conditions (Nakamura et al. 2011). Therefore intensive systems causes conflict behaviour resulting in negative effects to physical health and expression of behaviour.

Social behaviour

Housing system can also affect development of social behaviour. For example, fighting has been observed more often post weaning in the indoor system than in the outdoor system (Li and Wang 2011). Playing was observed more often in the outdoor system than indoors (Nakamura et al. 2011). Other behaviours also differ between indoor and outdoor systems, with piglets post weaning in an indoor system spending more time resting, drinking and moving, then those in the outdoor system (Nakamura et al. 2011), this was due to little stimulation of active behaviours. Indoor-raised piglets seek stimulation from the drinker as a plaything and from other individuals. They also showed more conflict behaviours compared to outdoor-raised piglets. On the other hand, outdoor-raised piglets show more exploring and chewing compared to indoor-raised piglets. Piglets prefer soil and plants and those resources stimulate the most investigation and manipulation (van de Weerd and Day 2009). In conclusion, behaviours between the two housing systems were vastly different and also it is important to measure these behaviours quantitatively to assess and improve the welfare of piglets.
How do we assess welfare?

To study and assess animal welfare it is necessary to have an accepted definition of what animal welfare is. However, as yet, no single unified definition of animal welfare has been made despite considerable effort to derive one (Mellor and Stafford 2009, Nakamura et al. 2011). A lot of progress has been made over the last few years in developing new indices of animal welfare. It has been accepted that there is no single measure that can be used by itself (Dawkins 2004, Wickham et al. 2012), integrating a range of behavioural, biochemical and physiological measures to give a picture of an animal’s state of welfare (Dawkins 2004).

Measuring welfare

A relevant welfare assessment system should describe the welfare of the animals and allow the farmer to assess the development over time and to respond appropriately (Main 2001). According to Rousing et al. (2001), a welfare indicator that is relevant for inclusion in an operational welfare assessment system should have the following qualities:

1. A basis in scientific knowledge and ability to express development over time,
2. Be measurable on a commercial farm within a realistic framework, and
3. Be relevant as decision support system for the farmer.

The Freedom Food Scheme is based on five freedoms listed by Farm Animal Welfare Council FAWC (1993) and involves outlining a systematic picture of the standards of resources and records on the farm. RSPCA (2011) believes that “an animal’s welfare should be considered in terms of five freedoms which form a logical and comprehensive framework for analysis of welfare”. The Five Freedoms have largely formed the basis of many welfare assessment measures, assessing animal welfare through housing and environmental ‘inputs’:

1. freedom from hunger and thirst: ready access to fresh water,
2. freedom from discomfort: providing an appropriate environment including shelter and comfortable resting area,
3. freedom from pain, injury and disease: by prevention through rapid diagnosis and treatment,
4. freedom to express normal behaviour: providing sufficient space, proper facilities and company of animal’s own kind, and
5. freedom from fear and distress: be ensuring conditions and treatment which avoid mental suffering. (RSPCA 2011)
However there are no direct animal and stockmanship indicators (‘outputs’) included with the Five Freedoms measures. Mason and Mendl (1993) suggested alternative approaches to measure welfare.

1. Welfare indicators: This takes measurements of basic behavioural, immune, physiological or tissue responses and compares these between groups of animals housed or treated differently.

2. Motivational priorities: This argues that animals are able to perform their own integration of inputs and make sensitive judgements about their own best interests. (Mason and Mendl 1993)

What about introducing Welfare Quality – current integrative assessments that incorporate multiple input and output measures of welfare in pigs.

Fig 1. General concept of animal welfare (Rousing et al. 2001).

In conclusion, animal welfare is seen as integral strategy involving the role of farmers, veterinary surgeons and welfare groups and this coordination is identified as key to delivery of the outputs to ensure a benefit to animals. Ensuring farm animal welfare requires taking
into account all available scientific evidence and these approaches may allow the formulation of various assessment rules.

**Qualitative Behavioural Assessment**

Animal welfare measures require assessments that captures the complexity of animal responses (Rutherford *et al.* 2012). Integration of different processes (behaviour, physiology, health and productivity) is recognised as vital for the development of new animal welfare measures (Fleming 2011). It is important to use approaches that integrate and clearly represent a range of pathways, rather than measuring a single aspect of the animal’s physiology or behaviour.

The assessment of affective states in animals is a critical component to animal welfare research (Wemelsfelder *et al.* 2009). Several approaches have been applied to address affective states, e.g. appraisal theory and cognitive bias (Wemelsfelder *et al.* 2009). Qualitative Behavioural Assessment (QBA), is a whole animal approach where human observers can integrate perceived behavioural signals and details to judge an animal’s behavioural expression (Rutherford *et al.* 2012). Free Choice Profiling allows an observer to choose his/her own terms (e.g. curious/indifferent, calm/nervous) to describe animal behaviour, which can then be used to rate animals using these qualitative descriptors.

Scientific assessment of affective states in animals can be challenging, but is vital for animal welfare studies. Boissy *et al.* (2007) noted that QBA represents one of the most applicable methodologies for assessing emotions in animals. These assessments are sensitive to environmental context, making them informative but also vulnerable to the observers’ biased views of that context (Wemelsfelder *et al.* 2009). Sensitivity to context can also be a potential weakness, it is almost never neutral to observers, and has the potential to bias towards integrating perceived details in certain directions than others. Qualitative methods are frequently criticised for being prejudiced and subjective (Wemelsfelder *et al.* 2009). However if the risks of contextual bias can be understood and reduced, QBA can play an important role in both social and natural sciences. Studies in pigs (Wemelsfelder *et al.* 2009, Rutherford *et al.* 2012) have shown that data generated from these observations are reliable and repeatable. QBA is a valuable methodology for assessing behavioural expression in farm animals under
field conditions, and qualitative rating scales may have useful practical applications to assess animal behaviour (Rutherford et al. 2012).

A validity of a measurement tool is never completely proven; new data can influence the degree of confidence that can be placed on inferences about observers based on their scale scores. To date, QBA has stood up to the process of validation testing from the perspective of its reliability and relationship to quantitative measures of behaviour (Rutherford et al. 2012). An important ongoing question is how QBA outcomes can relate to physiological and neurobiological parameters; this is an issue many scientists consider crucial in demonstrating the biological validity of QBA. Studies to date indicate that QBA scores correlate well to a number of physiological indicators (heart rate and body temperature) in cattle (Stockman et al. 2013) and sheep (Wickham et al. 2012) during transport.

Summary

Animal welfare is a complex issue where problems arise when pig’s instinctual behaviour is prevented and there is a mismatch with its environment. Especially during the early production life of pigs where weaning is a stressful period where depending on the type of housing systems piglets are farrowed in may develop different social skills. For example with exposure to large groups early in life, piglets are less aggressive and more tolerant to unfamiliar pigs. Consequently with good social skills that were developed early in life it leads to decrease mortality due to tolerance of other pigs. A relevant welfare system should allow a farmer to assess and respond appropriately. Qualitative Behavioural Assessment would be an applicable methodology to assess animal welfare helping to improve current farm practices and provide assurance to consumers of animal welfare integrity.

References


Scientific paper - Does environmental background (intensive-raised vs. outdoor-raised) influence the behaviour of piglets at weaning?
Abstract

The rearing environment in early life has been shown to affect behavioural development, which consequently modifies behavioural response of pigs to stressful environments in later stages of production. In the intensive pig husbandry, pigs are often predominately housed in stimulus-poor environments, where opportunities for expression of species-specific behaviour (rooting, exploring or wallowing) are limited. By contrast outdoor pigs are able to explore environments and forage, and are able to avoid aggressive behaviours by moving away from other pigs. Many studies suggested that changes in behavioural patterns in early life would pursue into adulthood, with the consequence that pigs reared in enriched environments were less susceptible to stressors while pigs reared under poor environment were more susceptible. This study uses quantitative measure and qualitative measure (Qualitative Behavioural Analysis (QBA) and Free Choice Profiling (FCP) to compare the behaviour of 30 outdoor-raised and 30 farrowing shed-raised piglets filmed in a Corflute box to various challenges (isolation, a novel object, food or a non-sibling piglet) on the day of weaning. Results show no significance in with piglets coping with isolation and no significance with social interactions between both farrowing shed-raised or outdoor-raised piglets. Farrowing shed-raised piglets were more interested in a novel object (P=0.003) compared with outdoor-raised piglets Outdoor-raised piglets were more interested in eating food (P=0.002) compared with farrowing shed-raised piglets.

Introduction

The intensification of animal production during the last 50 years has led to big changes in the husbandry of pigs. This has resulted in the confinement of animals in environments that may be inadequate to meet their behavioural needs (Fraser et al. 1995). Commercially-viable
alternatives to intensive confinement have to be proposed to answer concerns over the effects of modern husbandry systems on animal welfare. Outdoor systems have been presented as one such alternative. Outdoor housing requires a lower initial capital investment than indoor intensive systems (Hötzel et al. 2004). Importantly, outdoor housing can also offer potential environmental and social benefits which provide better animal welfare outcomes.

Rearing environment in early life has been shown to affect behavioural development, which consequently modifies behavioural response of pigs to stressful environments in later stages of production (De Jonge et al. 1996, Hillmann et al. 2003). In the intensive pig husbandry, pigs are often predominately housed in stimulus-poor environments, where opportunities for expression of species-specific behaviour are limited (De Jonge, Bokkers et al. 1996). This is not ideal from a welfare point of view. For example, de Jong et al. (2000) showed that barren housing conditions hamper the expression of normal behaviour, and piglets perform more manipulative social behaviour like biting and nosing of littermates, developing more abnormal agnostic behaviour than piglets reared in enriched environment. By contrast, piglets reared in a group-farrowing system may be better adapted to non-social and social challenges, and less aggressive to unfamiliar piglets at weaning compared to piglets reared in individual farrowing pens (Hillmann et al. 2003). Group-farrowed piglets spend more time exploring novel environments compared with farrowing shed-raised piglets (Hillmann et al. 2003). Compared to confinement-farrowed pigs, pigs farrowed in outdoor systems exhibit puberty earlier, and have lower basal cortisol levels, suggesting that exposure to enriched environments in early life can increase resistance to stress in adulthood (De Jonge et al. 1996).

To compare the benefits of raising animals under different housing systems, scientists need to objectively and reliably identify how the experience of animals is reflected in their subsequent welfare. Behaviour is a significant component of well-being and should be properly considered in pig welfare assessment, since behaviour reflects their health, welfare, and productivity. Development of harmful behaviours in group-housed animals is also an important welfare measure. In addition to quantifying the evidence of behaviour (i.e. duration, counts), behavioural expression can be used to reveal aspects of an individual’s experience with its environment. Qualitative Behavioural Assessment (QBA) is a ‘whole-animal’ methodology based on the qualitative interpretation of the dynamic style in which animals interact with their environment. It describes not ‘what’ the animals do, but ‘how’
they do what they do (Wemelsfelder et al. 2009). This method relies on the ability of human observers to integrate perceived details of behaviours and their context into judgement of animal ‘body language’ (Napolitano et al. 2012), using descriptors such as ‘calm’, ‘tense’ or ‘content’. Such descriptive terms have an expressive, emotional connotation, and provide information that appears relevant to animal welfare and could be a useful addition to information obtained from quantitative indicators (Wemelsfelder et al. 2009, Rutherford et al. 2012).

This study investigated the behaviour of piglets raised under different housing conditions. I compared the behaviour of 60 outdoor-raised and farrowing shed-raised piglets at weaning in response to four challenges (isolation, a novel object, food or a non-sibling piglet). My hypotheses are:

Outdoor-raised piglets:
- H₁: able to cope with isolation better,
- H₂: are more interested in novel objects,
- H₃: are more interested in food, and
- H₄: are less aggressive towards non-siblings

than farrowing shed-raised piglets. To assess the behaviour of these piglets, I used methods to quantify the duration of behavioural categories, as well as the piglets’ behavioural expressions (QBA).

Materials and Methods


**Animals and housing treatments**

Study animals were piglets with a genetic mix of Landrace, Large White and Duroc. A total of 60 piglets were used (equal numbers of each sex), with 30 piglets from a Craig Mostyn intensive branch in Nambeelup and another 30 piglets from the outdoor-raised farm in Albany. Piglets at both farms are weaned on a Thursday, when the piglets are 21-28 days of age. This study was approved by the Animal Ethics Committee at Murdoch University (Permit number R2574/13).

*Outdoor-raised piggery (Albany):* this is the second largest outdoor piggery in Australia, with 3,500 sows. An average of 1,000 piglets is weaned per week. The farrowing paddocks (each 400 m²) have nine sows and each sow has an average of 8 – 10 piglets. The sows are introduced to the paddock a few days before their farrowing date and each selects one of the nine huts that are available. Fenders are placed at the hut entrances to keep piglets in the hut until 14 days of age, after which the fenders are removed and the piglets are then allowed to interact with other piglets and sows in the paddock. On the day of weaning, all animals are herded together, sows removed and piglets loaded onto a trailer. They are transported ~200m to a sorting shed where they are vaccinated, injected and sorted by sex and size before they were filmed.

*Intensive piggery (Sow Stall Free piggery) (Nambeelup):* Nambeelup piggery has 3,500 sows and weans 1,350 piglets per week. Each sow has an average of 12 piglets each, and piglets are tail docked, teeth ground as per veterinary advice and given an iron injection at day 1 of age. Creep feed is provided from 7 – 10 days of age. Piglets are only allowed to interact with siblings and their mother during lactation; the first time they would interact with non-siblings would be during weaning. During weaning, all piglets were removed from their farrowing crates and herded along corridors to a holding area where they were sorted by size and sex and vaccinated before they are filmed.

**Footage collection and experimental challenges**

Piglets were filmed on the day of weaning (after sorting by sex and size, and vaccination) over two days (23rd and 30th May 2013) for the Nambeelup farm, and one day (20th June 2013) for the Albany farm. Video footage was collected of each focal piglet using three Panasonic HC-V500M digital cameras. The piglets were placed individually within an
experimental arena during filming and the experimental arenas were each made up of four sheets (each 0.9 x 0.9 m) of 5 mm-thick Corflute®, taped together at each side, and a hole cut into a corner of the box for filming. Straw was scattered over the floor. Each Corflute box was identical, and during filming we ensured that only the walls of the Corflute box were visible to the observer to ensure that differences in the surroundings would not bias the observers (Wemelsfelder et al. 2009).

Challenges: Each focal piglet was filmed for 20 min, when it was placed in the box (experimental arena). The animal was left for 5 min to settle in, a ball (novel object) was introduced at 5 min, creep feed at 10 min, and a size- and sex-matched instigator piglet was introduced at 15 min (Table 1).

Quantitative behavioural scores

Time budget analysis was carried out for each individual piglet, categorising the behaviour of the animal (using behavioural categories listed in Table 2 every 15 seconds, making of a total of ~20 observations per individual per challenge. The counts of the incidence of each behavioural category were then transformed into proportions of the total number of observations. These proportions were then arcsine-square root transformed (Microsoft Excel) to be able to analyse the proportion data using parametric statistics.

For each experimental challenge, time budget data were analysed by multivariate analysis of variance (MANOVA) with environment and sex as fixed independent factors and the duration of each of the behavioural categories (lying; standing; sitting; walking; eating; vocalising; jumping; investigating the ball, food bowl, straw or wall; and social interactions – non aggressive and aggressive) as dependent measures. This analysis was followed by Tukey’s Honestly Significant Difference (HSD) post hoc analyses of each of the behavioural categories.

For each behaviour category (eating; lying; sitting; standing; jumping; vocalising; or investigating the ball, food bowl, straw or wall), time budget data were analysed by separate repeated-measures ANOVAs, with environment and sex as fixed factors and the proportions
of time across each treatment as the repeated dependent measures to analyse behaviour across challenges.

**Qualitative Behavioural Analysis (QBA)**

Footage was edited using Corel video studio Pro X4 (Ottawa, Ontario, North America) into 30-second duration clips for each individual for each challenge (isolation, ball, food bowl and instigator); i.e. a total of 240 clips. Ten randomly-selected clips were used for term generation, to show individual and paired piglets exhibiting a range of behaviours (i.e. lying down, through to running and jumping) ensuring that the observers would generate a broad range of descriptive terms. Footage from the isolation challenge was chosen from the middle of the challenge period (3:30-4:00 min from the start of filming), while footage for the other three challenges was chosen when the focal piglets first interacted with the object/instigator. If there was no interaction, footage was also chosen from the middle of the challenge period (7:30-8:00 min for ball, 12:30-13:00 min for food bowl and 17:30-18:00 min for instigator).

Eleven observers were recruited for this study. Prior to commencing the study, they were each asked to complete a survey (Appendix 1) which asked details of their previous contact with farm animals, what kind of food (pork, poultry, lamb, beef etc.) they most often consumed and if they think animal welfare is important.

I used a Free-Choice Profiling (FCP) methodology for QBA, which relies on human observers generating their own descriptor against which to quantify the behavioural expressions of the observed animals (Wemelsfelder et al. 2009). FCP consists of two phases (term generation and quantification), which took place in the observers’ own time.

i) For term generation, observers were shown 10 video clips. At the end of each clip, observers paused the video, allowing them to write down terms they felt described the expressive qualities of the observed animals. When individual observers used both positive and negative antonyms (e.g. ‘happy’ and ‘unhappy’, ‘comfortable’ and ‘uncomfortable’), only the positive term was kept for use in subsequent scoring. These descriptive terms were then sorted alphabetically for each observer (i.e. to effectively randomise the order of presentation of terms), and presented to observers with a 100-mm visual analogue scale adjacent to each term (Microsoft Excel).
ii) In the subsequent four quantification sessions (S1: isolation, S2: ball, S3: food bowl and S4: instigator), observers scored the 60 randomly-arranged video clips for each viewing session on these rating scales, using their own unique list of descriptive terms.

Observers were asked to place 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). These visual analogue scale scores were entered into individual observer Excel files (Microsoft Excel 2003, North Ryde, NSW, Australia).

Observer scoring patterns were analysed using a specialised GenStat software edition (VSN International, Hemel Hempstead, Hertfordshire, UK), using Generalised Procrustes Analysis (GPA). GPA is essentially a process of complex pattern recognition. It is a multivariate statistical technique which does not require fixed variables for its calculation of a consensus amongst the observer’s scores attributed to individual piglets (Napolitano et al. 2012). The observer matrices are represented in virtual space as multi-dimensional configurations, with the number of dimensions for each configuration determined by the number of terms generated by a particular observer. These configurations were calculated through a complex process of rotation and transformation, aimed at finding a ‘best-fit’ consensus profile. GPA provides a statistic (called the Procrustes Statistic) which indicates the level of consensus (i.e. the percentage of variation explained between observers) that has been achieved. By applying GPA to these permutated matrices, a ‘randomised’ profile is calculated against which the consensus profile is tested. A t test statistic (Wemelsfelder et al. 2009) is used to determine statistical significance of the consensus profile from the random profile.

The second step for the analysis involves Principal Component Analysis (PCA), where the number of dimensions of the consensus profile is reduced to a smaller number (usually two or three) of principal dimensions explaining the majority of variation between the observed piglets. Terms of each observer that correlate strongly with the consensus dimensions (Pearsons R> 0.6 to R>0.3, depending on the GPA dimension) were identified and listed to allow interpretation of the GPA axes.

Piglets received a quantitative score on each of the GPA consensus dimensions for each of the four challenges (S1 – S4). These scores were analysed using two-way ANOVA for each of the GPA dimensions, with scores for the GPA dimension as the dependent variable and environment and sex as independent factors.
Comparison between quantitative behavioural scores and QBA scores

A comparison was done with results between quantitative behavioural scores and QBA. Using correlation analysis to find significance with GPA consensus and time budget analysis. Correlation matrices were created for each individual piglet for each of the four challenges (S1 - S4), using the behavioural categories from time budget analysis and GPA consensus from QBA. Pearson’s Correlation Coefficient was then used to calculate the proportion in two tails to find the P value (0.2144; P<0.05, 0.2997; P<0.01 and 0.3301 P<0.001).

Results

Quantitative behavioural scores – comparisons within each challenge

The environment in which piglets were raised significantly influenced their behavioural responses to isolation, a novel object, a food bowl, and the presence of a non-sibling piglet (MANOVA results summarised in Table 4). There was also a significant sex effect for behaviour in the presence of the food bowl. There was no significant effects for the novel
object (ball) challenge, however the trend for an effect of environment on behaviour at this time (P=0.053) warrants discussion of these results.

Tukey’s HSD post hoc analyses were carried out to determine which behavioural categories showed significant differences between the two environmental treatments (data was summarised in Table 4). During the isolation challenge, outdoor piglets spent a longer proportion of time eating food (P=0.032), and jumped more (P=0.020) compared with farrowing shed-raised piglets (Fig 5). When a novel object was added to the boxes, farrowing piglets spent a longer proportion of time interacting with the ball (P=0.003) but less time investigating the walls (P=0.035) than outdoor-raised piglets (Fig 6). When a food bowl with creep feed was placed into the Corflute box, outdoor-raised piglets spent a longer proportion of time eating (P=0.002), lying (P=0.044), and jumping (P=0.048), but less time walking (P<0.001) and interacting with the food bowl (P=0.008) compared with farrowing shed-raised piglets (Fig 8). When a non-littermate was introduced, outdoor-raised piglets spent a longer proportion of time eating food, but less time investigating straw, the ball, walls and food bowl than farrowing shed-raised piglets (Fig 7). When comparing males and females, males were found to be eating more (P=0.020) and walking (P<0.001) more during the food bowl challenge (Fig 4). Interestingly, there were was no significant effect of environment on the social interactions recorded. Similarly, there were no significant environmental effects on the duration of sitting, standing or vocalising.

**Quantitative behavioural scores – comparisons across all challenges**

The results of the repeated-measures ANOVA, comparing piglet behaviour across the challenges, are summarised in Table 7 and 8. In terms of eating, outdoor-raised piglets ate more than farrowing piglets. Farrowing shed-raised piglets played with the ball for a longer proportion of time comparing with outdoor-raised animals (P<0.001; Fig 9); piglets also played with the ball for a longer proportion of time at the start (isolation; 5-10 mins) and spent less time interacting with the ball when a food bowl and instigator is placed in the experimental arena (P<0.001; Fig 10).

Males spent a longer proportion of time eating compared with females. Male piglets spent more time walking in the experimental arena compared with female piglets (P<0.01; Fig 11).
Farrowing shed-raised piglets spent a greater proportion of time interacting with the ball compared with outdoor-raised piglets ($P<0.001$; Fig 9). Farrowing shed-raised piglets also spent a longer proportion of time interacting with the ball during the second challenge (ball; 05-10mins) and spent a lesser proportion of time playing with the ball during the third and fourth challenge (food bowl and instigator; 10-20mins) ($P<0.001$; Fig 10). Similarly piglets spent a longer proportion of time interacting with the food bowl during the third challenge (food bowl; 10-15mins) and a less time when the instigator is placed together in the experimental arena ($P<0.001$; Fig 9). Female farrowing shed-raised piglets spent the greatest proportion of time interacting with the food bowl compared with male farrowing shed-raised piglets and outdoor-raised piglets ($P<0.05$; Fig 12).

Outdoor-raised and farrowing shed-raised piglets interacted with the straw for a longer proportion of time in the first challenge (isolation) and spent a lesser amount of time interacting with the straw with the next three challenges (ball, food bowl and instigator) (Fig 9). In general both farrowing shed-raised and outdoor-raised piglets spent a longer proportion of time interacting with the Corflute wall during the first challenge (isolation). Outdoor-raised piglets spent a greater proportion of time interacting with the Corflute wall as challenges continue compared with farrowing shed-raised piglets, and both outdoor-raised and farrowing piglets stopped interacting with the Corflute wall during the fourth challenge (instigator) (Fig 11). Female farrowing shed-raised piglets spent a longer proportion of time interacting with the Corflute wall compared with outdoor-raised piglets, and with the opposite male outdoor-raised piglets spent a longer proportion of time interacting with the Corflute wall compared with male farrowing shed-raised piglets (Fig 12).

For both outdoor-raised and farrowing shed-raised piglets, a greater proportion of time was spent lying on the ground, sitting, walking, jumping and vocalising during the start of the challenge (isolation) and a lesser proportion of time with the fourth challenge (instigator) (Fig 9).

**Qualitative Behavioural Analysis (QBA)**

Among the 11 observers, ten had some previous experience with farm animals (cattle, sheep, chickens and pigs); six had lived on a rural property before, and all believed strongly that animal welfare is very important and that there was room for improvement of welfare in Australia.
The 11 observers reached a consensus on their assessment of the behavioural expression of piglets and identified any differences between challenges. The t values for the Procrustes Statistics for each of the QBA sessions were all significant (P<0.001; Table 5) indicating a significant difference in the consensus compared with the random profiles generated from the same data sets.

Across the four viewing sessions (each representing one of the four challenges: S1 isolation, S2 ball, S3 food bowl and S4 instigator), there was similarity in the descriptive terms that were highly correlated with each GPA dimension (Table 6). For GPA dimension 1, terms such as ‘calm’, ‘cautious’, ‘content’ and ‘relaxed’ on the low end and, ‘playful’, ‘active’, ‘inquisitive’ and ‘restless’ appear repeatedly at the high ends of each axes. Terms correlated with GPA dimension 2 were also similar, with terms such as ‘anxious’, ‘agitated’, ‘stressed’ and ‘restless’ on the low end and ‘calm’, ‘content’ and ‘relaxed’ at the high end. Terms correlated with GPA dimension 3 were mostly similar, with terms such as ‘tense’, ‘aggressive’ and ‘anxious’ appear in the low end and ‘curious’, ‘alert’ and ‘inquisitive’ at the high end. However with session 4 the term ‘aggressive’ had appeared both low and high end.

There were no significant differences due to environment or sex on any of the three GPA dimensions for the first challenge (S1: isolation).

For the second challenge (S2: ball), there was a significant effect of environment on GPA dimension 1 ($F_{1,56}=4.80$, p=0.032), with outdoor-raised piglets scoring higher on this dimension than farrowing shed-raised piglets (Fig. 2). Outdoor-raised piglets were therefore scored higher for terms such as ‘playful’, ‘active’ and ‘engaged’ than farrowing shed-raised piglets.

For the third challenge (S3: food bowl), there was also a significant effect of environment on GPA dimension1 ($F_{1,56}=7.62$, p=0.007), with farrowing piglets scoring higher on this dimension than outdoor-raised piglets (Fig. 3). Farrowing piglets were scored higher on terms such as ‘curious’, ‘inquisitive’ and ‘active’. There is also a significant effect of environment x sex on GPA dimension 2 ($F_{1,56}=5.50$, p=0.022), with female farrowing piglets scoring higher on this dimension compared male farrowing piglets, while there was a reverse with the outdoor raised piglets where the outdoor-raised males scored higher then female outdoor-
raised piglets. Piglets that scored higher on this dimension showed terms such as ‘calm’ and ‘content’ (Table 5).

**Comparison between quantitative behavioural scores and QBA scores**

The results of correlation analysis to compare which quantitative behavioural scores were correlated with QBA dimensions are summarised in Table 6.

With the first challenge (S1: isolation), standing was significant (P<0.001) correlating with GPA dimensions 1 with descriptive terms such as ‘calm’ and ‘content’. GPA dimension 2 also shows a significance with eating (P<0.001) and investigating straw (P<0.001) scoring high on terms such as ‘calm’ and ‘relaxed’.

For the second challenge (S2: ball), there was a significance with all three dimensions. GPA dimension 1 had a significance with behaviours such as investigating ball, straw and walls (<0.001), scoring high on terms such as ‘playful’ and ‘active’. GPA dimension 2, had a significant effect on standing and investigating wall (P<0.001), with descriptive terms such as ‘bored’ and ‘calm’. GPA dimension 3 had significance with walking and investigating wall (P<0.001), scoring high on terms such as curious and inquisitive.

For the third challenge (S3: food bowl), there was a significance with GPA dimension 1 with behaviours such as jumping and investigating food bowl (P<0.001), with descriptive terms ‘curious’ and ‘inquisitive’. GPA dimension 3 had a significance with walking and investigating wall (P<0.05) scoring high on terms such as ‘curious’ and ‘inquisitive’ as well.

There was no significant difference in correlation between quantitative behavioural scores and QBA dimensions with the fourth challenge (S4: social interaction).
Discussion

This study compared the behaviour of 30 outdoor-raised and 30 farrowing shed-raised piglets in response to various challenges on the day of weaning (isolation, a novel object, food or a non-sibling piglet). Contrary to my first predictions, I found no evidence that outdoor-raised piglets were better able to cope with isolation or were more interested in a novel object than the farrowing shed-raised piglets. I also found no difference in the social interactions between these two groups of piglets. However, I did find that outdoor-raised piglets were more interested in food than the farrowing shed-raised piglets. In this discussion, I will describe the behaviour of these piglets in response to each of the four challenges, and then outline some of the challenges of this study.


**Challenge 1: Isolation**

In terms of quantitative behavioural scores, outdoor piglets spent a greater proportion of their time eating food and jumping (trying to escape from the Corflute box). These differences in behavioural actions were not reflected in their behavioural expressions (recorded using QBA), however, since there were no significant differences on any of the GPA dimensions. Therefore, the hypothesis that outdoor raised piglets are able to adapt to isolation compared to farrowing shed-raised piglets was not supported. Although domestic pigs are socially living animals, basic physiological effects of early isolation from mother and/or siblings are scantily investigated (Kanitz et al. 2004). A study carried out by Herskin and Jensen (2000) showed that isolation increased the occurrence of behavioural indicators of stress such as the frequency of pawing and escape attempts, as well as the decrease in frequency of play. The authors concluded that social isolation is a stressful event compared with group-housed control.

**Challenge 2: Novel object (ball)**

In response to the addition of a novel object (a rubber ball) to the experimental arena, farrowing shed-raised piglets interacted with the ball more than the outdoor-raised piglets. In terms of the QBA data, farrowing shed-raised piglets interacting with the ball were more likely to be scored highly on terms such as ‘playful’ and ‘active’, while outdoor-raised piglets scored more on terms such as ‘calm’ and ‘cautious’, reflecting their reduced time spent interacting with the ball (from the quantitative behaviour scores). Therefore my hypothesis that outdoor-raised piglets are more interested in a novel environment (in this study a ball) compared to farrowing shed-raised piglets was not supported.

Outdoor piglets interact with novel things in their environment on a day-to-day basis, while farrowing shed-raised piglets are deprived of stimuli. This difference could be the reason why farrowing shed-raised piglets in this study displayed more interest in the ball than the outdoor-raised piglets. A finding by de Jong et al. (2000) stating that pigs housed in a barren environment showed an increased amount of exploration of novel objects or environment than enriched-housed pigs. It suggests that pigs housed in a barren environment have a stronger motivation for exploration. Another study by Stolba (1984) found that when supplied with
basic necessities (food, water and shelter), domestic pigs in commercial production continue to express exploratory behaviours and preferentially select environments (pens) with novel objects to investigate. However the study by Hillmann et al. (2003) contradicts this present study, where individual farrowing-raised piglets spent less time exploring objects (P<0.05) compared to group-farrowing-raised piglets.

**Challenge 3: Food bowl**

When a food bowl was introduced to the experimental arena, outdoor-raised piglets spent a longer proportion of time eating creep feed compared with the farrowing shed-raised piglets, which were more interested in playing with the food bowl itself. Therefore my hypothesis that outdoor-raised piglets are more interested in food compared to farrowing-shed raised piglets was supported. There was also a significant effect of environment on the QBA scores applied to these animals. Interestingly female farrowing shed-raised piglets and male outdoor-raised piglets scored higher on descriptive terms such as ‘calm,’ ‘passive’ and ‘relaxed’, while female outdoor-raised and male farrowing-raised piglets scored higher on terms such as ‘anxious’ and ‘frightened’. Male piglets ate more in general compared with female piglets.

A study by Oostindjer et al. (2010) supports the findings of the present study. In their study, Oostindjer et al. (2010) found that enriched-reared (outdoor-raised) piglets were more willing to touch food compared with barren-reared (farrowing shed-raised) piglets. The authors explain their study in terms of social learning, suggesting that food intake may be more efficient when the animals are provided with stimulus- and substrate-rich environments (i.e. outdoor systems), and the mother can show the full range of foraging behaviours. This is very important because after weaning Lallès et al. (2007) reported that only 50% of weaned piglets consume their first meal within 24 hours post-weaning, but 10% would not have eaten until 48 hours later. With the study by (Oostindjer et al. 2010) enriched-reared piglets would have a higher chance of eating sooner post-weaning compared to barren-reared piglets. Environmental enrichment may result in a higher behavioural flexibility and lower reactivity towards unfamiliar stimuli (Leggio et al. 2005). As novel food can be seen as an unfamiliar stimulus, outdoor-raised piglets would be less neophobic towards unfamiliar food then farrowing shed-raised piglets.
Challenge 4: Social interaction

There were no significant differences in social behaviour between outdoor-raised and farrowing shed-raised piglets in terms of the amount of time recorded engaged in aggressive or non-aggressive social interactions. There were also no differences in the behavioural expression scores (QBA scores) of these treatment groups. Therefore, my hypothesis that outdoor-raised piglets would be less aggressive towards non-littermates than farrowing shed-raised piglets was not supported. Hillmann et al. (2003) found that individual farrowing-raised piglets had longer latency until their first contact with an unfamiliar pig compared with group-farrowing-raised piglets (P<0.05), indicating that individual farrowing-raised piglets reacts less strongly toward unfamiliar piglets. Hillmann et al. (2003) study was supported by (Petersen et al. 1989) where the period from around a week after birth until weaning represented a natural ‘socialisation period’ when piglets form social relationships indicating that group-farrowing-raised piglets have the social skills to form a stable hierarchy more rapidly. Unfortunately, this present study did not record the time piglets spent during interaction to make a direct comparison with their data.

A study by D’Eath (2005) to test whether pre-weaning mixing of litters (socialisation) has long term benefits by reducing aggression and improving the social skills of pigs, found that mixing piglets before weaning involved some aggression between piglets. But socialised piglets formed a stable hierarchy more rapidly than piglets that were kept separately. Their study also suggested that socialised piglets (group-housed systems) learnt social skills which benefited them in the longer term, enabling them to more rapidly form stable dominance hierarchies during future aggressive encounters with unfamiliar pigs. This study involves a pair of piglets filmed for a short amount of time (5 min) and a direct comparison cannot be made with a bigger group of piglets to observe for hierarchy.

Comparing across the four challenges

In general both outdoor-raised and farrowing shed-raised piglets spent a greater proportion of time investigating straw, ball and food bowl, vocalising, jumping, sitting and lying during the start of the challenge (isolation) but when an instigator was placed in the experimental arena the piglets decreased the proportion of time displaying those behaviours. This correlates with descriptive terms such as ‘anxious’ and ‘frightened’ (from GPA dimension 2), suggesting that
isolation can be a stressful event which is supported by the study with (Herskin and Jensen 2000).

With walking, both outdoor-raised and farrowing shed-raised piglets also showed a similar decline with the proportion of time spent walking when an instigator was placed in the experimental arena. However farrowing shed-raised piglets spent a longer proportion of time interacting with the food bowl compared with outdoor-raised piglets. This indicates that farrowing shed-piglets were more interested in novel objects. As mentioned before in the study by (de Jong et al. 2000) farrowing shed-raised piglets are raised in stimulus-poor conditions, hence would show a greater motivation for exploration.

Interestingly across the four challenges, males were found to spend a longer proportion of time eating compared with female piglets. A study by Colson et al. (2006) assessing whether it is better to group piglets by sex at weaning or mixing them, found that the presence females in the group it induced competitive behaviour in young males. In the case of this present study, the competitive behaviour in males could suggest why males spent a longer proportion of time eating compared with females.

Comparing quantitative behavioural scores and qualitative behavioural measures

When comparing between quantitative behavioural scores and qualitative behavioural measures. Piglets from session one (isolation) scored high on terms such as ‘calm’, ‘content’ and ‘relaxed’ when standing in the experimental arena and investigating straw. This would indicate that piglets are able to adapt to isolation. However the study as mentioned before by Herskin and Jensen (2000) states that isolation is a stressful event when compared with a group-housed system. A more in-depth study would need to be done to find out the different degrees of isolation that piglets would be able to cope.

With the second challenge (ball), piglets were found to score higher on terms such as ‘playful’, ‘active’, ‘curious’ and ‘inquisitive’ when interacting with the ball, walls and walking. This indicates that piglets are interested in playing with the ball (novel object), this is supported with the study by Hillmann et al. (2003) assessing the reactions of piglets towards a novel environment. The study found that piglets showed less behavioural signs of distress and more explorative behaviour in the novel environment.


**Limitations of this study**

There are a few limitations of the present study which need to be considered in terms of how the data can be interpreted. Longer clips for the QBA sessions, capturing more details of how piglets were interacting with their environment, may have been helpful for observers in forming their scoring. However, longer clips would have required longer viewing sessions. Feedback from several observers indicated that 60 video clips per session (~ 1 hour) was already too long and resulted in observer fatigue. Therefore increasing the length of the clips would have meant showing observers fewer piglets, which would have reduced the power to discern treatment differences.

A wider range observers, recruited from different backgrounds, and including people specifically with experience in management of animals, would also be useful in generating a wider range of descriptive terms. Wemelsfelder et al. (2012) compared the assessments of three observer groups to capture a diverse background of animal experience (pig farmers, animal veterinarians and animal protectionists). The authors reported high inter-observer and intra-observer reliability in their characterisation of pig body language. Therefore, even naive observers are able to reach consensus in their qualitative assessments of the behavioural expression of pigs. Having observers with specific piglet experience may, however increase the variety of terms used. Using terms that other pig-workers can directly relate to is an important aspect of making this method understandable across the industry.

Another possibility would be to increase the number of observers involved for the QBA sessions; however, too many observers may also result in increased noise in the analysis. Several QBA studies (Stockman et al. 2011, Rutherford et al. 2012, Phythian et al. 2013) have used a similar number of observers as used in the present study, indicating that the number of observers use in the present study is comparable with these other studies.

Finally, another way to improve the reliability of these results might be to increase the number of piglets recorded. This study used piglets from two farms owned by the same company; therefore the piglets had similar genetics and many aspects of their management were similar. Comparing piglets from different piggeries with a different management might provide insight into how differences in management systems can alter behaviour of piglets.
Conclusions

In conclusion, this study examined behaviour of piglets from different housing situations on the day of weaning in response to four challenges. Piglets reared in outdoor and farrowing systems differ in their behaviour in response to eating and investigating their environment, but do not differ in terms of their social interactions. Outdoor-raised piglets are more adapted to cope in a novel environment which can indicate a less stressful period during weaning.

In pig production, weaning induces abrupt modifications for young piglets which are not only separated from their mothers but they also have to cope with new solid food, a novel environment and often a new social group. Practical and commercially-viable alternatives to the intense confinement must be offered to answer concerns of the public over the effects of modern husbandry systems on farm animal welfare (Fraser et al. 1995). The breeding of pigs in an outdoor system can be a practicable alternative that provides a physical environment that allows the animals to express a more diverse behavioural repertoire.

Future research

This present study’s results showed that in general males spend a longer proportion of time eating compared with females. More research could be done to find out why males are eating more and should males and females be sorted differently during weaning. Also research could be done to find how much more males are eating compared with females, and using this information, females could be fed a bigger proportion of food each time.

More research could be done on the isolation of piglets from litter-mates and sow, Herskin and Jensen (2000) noted that not many research has delved into the different degrees of social isolation. Since pigs are rarely kept individually, it would be interesting to find out the differences in behaviour or physiology with isolated piglets and group-housed piglets.

This present study’s results showed no significant difference in behaviour between social interactions. However studies by (Hillmann et al. 2003, D’Eath 2005) states that piglets show aggression and fight for hierarchy during weaning. Research involving more piglets recording for a longer period of time in a bigger experimental arena may help me answer the some questions on whether outdoor-raised and farrowing shed-raised piglets show any difference in behaviour when interacting with a non-littermate.
Table 1: Timetable for each piglet during filming, arrows indicates time points where a new challenge is added into the experimental arena (a Corflute box).

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Focal piglet alone in box</th>
<th>Ball added</th>
<th>Creep feed added</th>
<th>Instigator added</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td></td>
<td>5 – 10</td>
<td>10 – 15</td>
<td>15 – 20</td>
</tr>
</tbody>
</table>

Table 2: Description of behavioural terms used in time budget analysis

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying</td>
<td>Whole length of body on the floor, not supported by their legs</td>
</tr>
<tr>
<td>Standing</td>
<td>All four legs supporting body with no ambulation or not touching anything with their nose or mouth</td>
</tr>
<tr>
<td>Sitting</td>
<td>Hind quarters on the floor, front legs supporting body</td>
</tr>
<tr>
<td>Walking</td>
<td>Ambulation: movement without touching anything with nose or mouth</td>
</tr>
</tbody>
</table>
**Eating**
Ingestion of creep feed, with the chewing action of the mouth

**Vocalising**
Act of grunting or screaming

**Jumping**
Any part of the body is not touching the ground

**Investigating ball**
Piglet interacting with ball, e.g. piglet nosing the ball

**Investigating food bowl**
Piglet interacting with food bowl, e.g. piglet nosing the food bowl, trying to lift it (but not ingesting any food)

**Investigating straw**
Piglet interacting with straw, e.g. rooting, nosing straw trying to lift it, digging straw with feet

**Investigating wall**
Piglet interacting with wall, e.g. piglet’s nose or mouth touching Corflute wall

**Social interaction – non aggression**
Any part of focal piglet touching/interacting with instigator and instigator or focal piglet not reacting negatively

**Social interaction – Aggression (Pushing)**
Focal piglet using nose to nudge instigator, causing instigator to react negatively (where instigator moves away from focal piglet)

**Social interaction – Aggression (Biting)**
Focal piglet using mouth to cause injury to instigator, and instigator reacts by moving away from focal piglet

Table: 3: Summary of four separate MANOVA (one for each of the four experimental challenges) with sex and environment as independent variables and behaviours as dependent variables. Values in bold indicate significant values.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Isolation</th>
<th>Ball</th>
<th>Food bowl</th>
<th>Instigator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment</strong></td>
<td><strong>F value</strong></td>
<td><strong>P</strong></td>
<td><strong>F value</strong></td>
<td><strong>P</strong></td>
</tr>
<tr>
<td>Environment</td>
<td>2.27</td>
<td>0.033*</td>
<td>2.01</td>
<td>0.053</td>
</tr>
<tr>
<td>Sex</td>
<td>1.25</td>
<td>0.283</td>
<td>1.08</td>
<td>0.395</td>
</tr>
<tr>
<td>Environment x Sex</td>
<td>1.10</td>
<td>0.378</td>
<td>1.58</td>
<td>0.142</td>
</tr>
</tbody>
</table>

36
Table 4: Summary of Tukey’s HSD tests (following MANOVA for each of the four challenges with sex and environment as independent variables and behavioural categories as the dependent variables) for the effects of environment on each behavioural category in response to four challenges or the effect of sex on the food bowl challenge. Values are p values; those in bold indicate significant values. Orange highlighted cells indicates that outdoor-raised piglets were more likely to perform this behaviour, green colour indicates that farrowing shed-raised piglets were more likely to perform this behaviour and blue highlighted cells indicates that males were more likely to perform this behaviour. Blanks indicate that no action was performed during that time frame (e.g. the piglets could not show social interactions for the first three challenges, when they were in isolation).

<table>
<thead>
<tr>
<th>Behavioural categories</th>
<th>Challenge</th>
<th>Effect:</th>
<th>Environment</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Isolation</td>
<td>Ball</td>
</tr>
<tr>
<td>Eating</td>
<td></td>
<td></td>
<td>0.032</td>
<td>0.135</td>
</tr>
<tr>
<td>Lying</td>
<td></td>
<td></td>
<td>0.069</td>
<td>0.114</td>
</tr>
<tr>
<td>Sitting</td>
<td></td>
<td></td>
<td>0.295</td>
<td>0.890</td>
</tr>
<tr>
<td>Standing</td>
<td></td>
<td></td>
<td>0.575</td>
<td>0.449</td>
</tr>
<tr>
<td>Walking</td>
<td></td>
<td></td>
<td>0.869</td>
<td>0.194</td>
</tr>
<tr>
<td>Jumping</td>
<td></td>
<td>0.020</td>
<td>0.475</td>
<td>0.048</td>
</tr>
<tr>
<td>Vocalising</td>
<td></td>
<td></td>
<td>0.134</td>
<td>0.191</td>
</tr>
<tr>
<td>Investigating</td>
<td>Straw</td>
<td>0.470</td>
<td>0.505</td>
<td>0.521</td>
</tr>
<tr>
<td></td>
<td>Wall</td>
<td>0.808</td>
<td>0.035</td>
<td>0.218</td>
</tr>
<tr>
<td></td>
<td>Ball</td>
<td></td>
<td>0.003</td>
<td>0.158</td>
</tr>
<tr>
<td></td>
<td>Food bowl</td>
<td></td>
<td></td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table 5: Summary of the results for the Generalised Procrustes Analyses for each of the four QBA quantification sessions

<table>
<thead>
<tr>
<th></th>
<th>Challenge</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent variation</td>
<td>Isolation</td>
<td>Ball</td>
<td>Feed bowl</td>
<td>Instigator</td>
</tr>
<tr>
<td>explained by the</td>
<td>41.55%</td>
<td>43.32%</td>
<td>45.08%</td>
<td>41.32%</td>
</tr>
<tr>
<td>consensus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t test results</td>
<td>40.42</td>
<td>49.62</td>
<td>41.51</td>
<td>36.65</td>
</tr>
<tr>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>
Table 6: Terms used by observers to describe behavioural expression of piglets during four challenges (each quantified in a separate viewing session – S1 isolation, S2 ball, S3 food bowl and S4 instigator). The first two terms for each dimension are indicated in bold – these terms have been used to label the axes on graphs etc. Terms shown are those that have the highest correlation with each end of each GPA dimension axis (% of variation in behavioural expression accounted for by each dimension). Terms that correlate strongly with the consensus dimensions (Pearsons r>0.06 to r>0.3) were used and listed to allow interpretation of the GPA axes. TB indicates time budget categories which were significantly correlated with the GPA dimension scores.

<table>
<thead>
<tr>
<th>GPA1</th>
<th>S1 (49%) r&gt; 0.6</th>
<th>Low Values</th>
<th>High values</th>
<th>Treatment effects: 1. environment, 2. sex, 3. interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Playful (3), Restless (3), Active (2), Aggressive (2), Inquisitive (2), Agitated, Brave, Curious, Domineering, Energetic, Excitable, Frustrated, Investigative, Obsessive</td>
<td>Calm (4), Content, Passive</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TB: Standing (p&lt;0.001)</td>
<td>2. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
<td></td>
</tr>
<tr>
<td>GPA2</td>
<td>S2 (50.3%) r&gt; 0.6</td>
<td>Calm (2), Cautious (2), Intimidated, Passive, Relaxed, Tense, Unsure, Wary</td>
<td>Playful (6), Active (2), Engaged (2), Inquisitive (2), Confident, Curious, Energetic, Excitable, Happy, Investigative, Obsessive, Restless, Stimulated</td>
<td>1. $F_{1,56}=4.80$, p=0.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TB: Investigating the ball (p&lt;0.001), straw (p&lt;0.01), walls (p&lt;0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA3</td>
<td>S3 (53.9%) r&gt; 0.6</td>
<td>Calm (3), Passive, Relaxed</td>
<td>Curious (4), Inquisitive (4), Active (3), Playful (3), Domineering, Energetic, Engaged, Excitable, Frustrated, Investigative, Lively, Restless, Stimulated</td>
<td>1. $F_{1,56}=7.62$, p=0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TB: Jumping (p&lt;0.001), Investigating food bowl (p&lt;0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA4</td>
<td>S4 (56%) r&gt; 0.6</td>
<td>Calm (6), Comfortable, Insecure, Laid back, Nonchalant, Passive. Relaxed, Sad</td>
<td>Active (3), Playful (3), Curious (2), Inquisitive (2), Restless (2), Aggressive, Agitated, Confident, Domineering, Engaged, Excitable, Interested, Investigative, Lively, Obsessive</td>
<td>1. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>3. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TB: NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA2</td>
<td>S1 (15.8%) r&gt; 0.4</td>
<td>Low Values</td>
<td>High values</td>
<td>Treatment effects: 1. environment, 2. sex, 3. interaction</td>
</tr>
<tr>
<td>--------</td>
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<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
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<tr>
<td></td>
<td></td>
<td>Scared (3), Frightened (2), Nervous (2), Stressed (2), Tense (2), Unsure (2), Alert, Anxious, Cautious, Intimidated</td>
<td>Calm (3), Relaxed (2), Comfortable, Confident, Content, Engaged, Happy, Inquisitive, Interested, Laid back, Nonchalant</td>
<td>1. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td>Eating (p&lt;0.001), Investigating straw (p&lt;0.001)</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>S2 (19.8%) r&gt; 0.4</td>
<td>Aggressive (4), Frustrated (3), Restless (2), Scared (2), Stressed (2), Tense (2), Agitated, Annoying, Anxious, Bored, Domineering, Frightened, Investigative, Nervous, Obsessive, Passive, Peaceful, Persistent, Protective</td>
<td>Bored, Calm, Content, Happy, Playful, Relaxed, Unmotivated</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td>Standing (p&lt;0.001), investigating the wall (p&lt;0.001)</td>
<td></td>
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</tr>
<tr>
<td>S3 (18.2%) r&gt; 0.5</td>
<td>Anxious (2), Frightened (2), Nervous (2), Restless (2), Scared (2), Unsure (2), Agitated, Frustrated, Protective, Stressed, Tense, Worried</td>
<td>Calm (2), Content, Laid back, Relaxed</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. F₁,₅₆=5.50, p=0.022</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4 (13.5%) r&gt; 0.4</td>
<td>Agitated (2), Frustrated (2), Restless (2), Stressed (2), Aggressive, Anxious, Persistent, Tense</td>
<td>Calm (2), Happy (2), Alert, Content, Curious, Engaged, Inquisitive</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA3</td>
<td>S1 (7.5%) r&gt; 0.3</td>
<td>Agitated (2), Calm (2), Tense (2), Aggressive, Anxious, Content, Frightened, Frustrated, Irritated, Nonchalant, Passive, Persistent, Protective, relaxed, Sad, Stressed, Unmotivated</td>
<td>Alert (2), Curious (2), Happy (2), Inquisitive (2), Unsure (2), Cautious, Confused, Intimidated, Observant</td>
<td>1. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2 (8.7%) r&gt; 0.3</td>
<td>Tense (2), Aggressive, Bored, Frightened, Obsessive, Passive, Peaceful, Persistent, Sad, Scared, Unmotivated</td>
<td>Curious (4), Inquisitive (3), Alert, Calm, Comfortable, Content, Friendly, Relaxed</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td>Walking (p&lt;0.05), investigating wall (p&lt;0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3 (8.8%) r&gt; 0.4</td>
<td>Aggressive, Agitated, Anxious, Frightened, Frustrated, Stressed</td>
<td>Alert, Cautious, Confused, Curious, Inquisitive, Interested, Observant, Playful</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. F₁,₅₆=3.96, p=0.051†</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td>Standing (P&lt;0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4 (7.5%) r&gt; 0.4</td>
<td>Aggressive, Laid back, Stimulated</td>
<td>Aggressive (2), Annoying, Calm, Confident, Nonchalant, Playful, Relaxed, Scared, Stressed, Unmotivated</td>
<td>1. NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. NS</td>
</tr>
<tr>
<td></td>
<td>TB:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Term order is determined firstly by the number of observers to use each term (in brackets if > than 1), and secondly by weighting of each term (i.e. correlation with the GPA dimension). The last column shows a summary of statistical analyses for each dimension. † Borderline statistical significance.
Table 7: Summary of repeated-measures ANOVAs (one for each of seven behavioural categories) showing the effects of environment, experimental treatment, and sex. Values in bold indicate significant factors, with asterisks indicating level of statistical significance: * p<0.05, ** p<0.01, *** p<0.001.

<table>
<thead>
<tr>
<th></th>
<th>Eating</th>
<th>Lying</th>
<th>Sitting</th>
<th>Standing</th>
<th>Walking</th>
<th>Jumping</th>
<th>Vocalising</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>11.93</td>
<td>3.97</td>
<td>0.10</td>
<td>1.33</td>
<td>8.27</td>
<td>6.74</td>
<td>2.37</td>
</tr>
<tr>
<td>Sex</td>
<td>2.30</td>
<td>3.10</td>
<td>1.13</td>
<td>0.52</td>
<td>14.77</td>
<td>0.01</td>
<td>***</td>
</tr>
<tr>
<td>Environment*Sex</td>
<td>2.75</td>
<td>0.06</td>
<td>0.08</td>
<td>3.38</td>
<td>0.45</td>
<td>0.49</td>
<td>0.54</td>
</tr>
<tr>
<td>TREATMENT</td>
<td>1.76</td>
<td>11.6</td>
<td>5.22</td>
<td>2.29</td>
<td>42.96</td>
<td>11.2</td>
<td>31.27</td>
</tr>
<tr>
<td>TREATMENT*Environment</td>
<td>1.93</td>
<td>1.31</td>
<td>0.53</td>
<td>0.10</td>
<td>3.75</td>
<td>*</td>
<td>1.42</td>
</tr>
<tr>
<td>TREATMENT*Sex</td>
<td>2.72</td>
<td>*</td>
<td>0.42</td>
<td>0.60</td>
<td>2.61</td>
<td>1.43</td>
<td>0.36</td>
</tr>
<tr>
<td>TREATMENT<em>Environment</em>Sex</td>
<td>2.71</td>
<td>*</td>
<td>0.43</td>
<td>0.48</td>
<td>1.02</td>
<td>0.29</td>
<td>2.81</td>
</tr>
</tbody>
</table>

Table 8: Summary of repeated-measures ANOVAs (one for each of four interacting behavioural categories) showing the effects of environment, experimental treatment, and sex. Values in bold indicate significant factors, with asterisks indicating level of statistical significance: * p<0.05, ** p<0.01, *** p<0.001.

<table>
<thead>
<tr>
<th>Interacting</th>
<th>Ball</th>
<th>Foodbowl</th>
<th>Straw</th>
<th>Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>14.9</td>
<td>**12.84</td>
<td>**</td>
<td>0.95</td>
</tr>
<tr>
<td>Sex</td>
<td>1.95</td>
<td>0.05</td>
<td>0.30</td>
<td>1.37</td>
</tr>
<tr>
<td>Environment*Sex</td>
<td>0.03</td>
<td>**4.35</td>
<td>*</td>
<td>0.57</td>
</tr>
<tr>
<td>TREATMENT</td>
<td>33.81</td>
<td>***23.24</td>
<td>***</td>
<td>13.40</td>
</tr>
<tr>
<td>TREATMENT*Environment</td>
<td>1.54</td>
<td>0.69</td>
<td>1.90</td>
<td>3.76</td>
</tr>
<tr>
<td>TREATMENT*Sex</td>
<td>1.33</td>
<td>*</td>
<td>0.28</td>
<td>0.40</td>
</tr>
<tr>
<td>TREATMENT<em>Environment</em>Sex</td>
<td>0.27</td>
<td>0.24</td>
<td>2.63</td>
<td>*</td>
</tr>
</tbody>
</table>
Fig 1: Terms used by one observer, where the descriptive terms generated under Free Choice Profiling are plotted according to their correlation with GPA consensus dimensions 1 (y-axes) and 2 (x-axes) scores from session 3 (food bowl challenge).
Fig 2: Scatterplot showing the effect of environment on the QBA scores attributed to individual piglets during the novel object (ball) challenge (S2). For this challenge, there was a significant effect of environment on GPA dimension 1 ($F_{1,56}=4.80$, $p=0.032$) but not on the other dimensions.

Fig 3: Summary of boxplot showing the environment of S3 (Food bowl) on GPA dimension 1 comparing farrowing shed-raised piglets and outdoor-raised piglets.
Fig 4: Summary of 2 way ANOVA on environment*sex of S3 (Food bowl) on GPA dimension 2 comparing females and males (sex) and farrowing shed-raised piglets and outdoor-raised piglets.

Fig 5: Summary of MANOVA with environment and sex as fixed independent factors and the duration of each of the behavioural categories (eating and jumping) as dependent measures on isolation.
Fig 6: Summary of MANOVA with environment and sex as fixed independent factors and the duration of each of the behavioural categories (investigating ball and wall) as dependent measures on investigating wall.

Fig 7: Summary of MANOVA with environment and sex as fixed independent factors and the duration of each of the behavioural categories (eating, investigating ball, food bowl and straw) as dependent measures on social interaction.
Fig 8: Summary of MANOVA with environment and sex as fixed independent factors and the duration of each of the behavioural categories (eating, lying, walking, jumping and investigating food bowl) as dependent measures on investigating food bowl.
Fig 9: Summary of repeated measures ANOVA showing challenge effects that influenced the proportion of time that piglets spent investigating straw and ball, wall and straw, vocalising, jumping, sitting and lying.
Fig 10: Summary of repeated measures ANOVA showing environment treatment that influences the proportion of time piglets spent investigating ball, food bowl and jumping.
Fig 11: Summary of repeated measures ANOVA showing the two-way treatment effects that influenced the proportion of time that piglets spent investigating wall, eating and walking.
Fig 12: Summary of repeated measures ANOVA showing sex treatment that influences the proportion of time piglets spent investigating wall, food bowl and walking.
References


Appendices

Appendix 1: Copy of survey given to observers to fill in.

Questionnaire

To keep your identity anonymous please create a unique code from the following

First 2 letters of your mother’s name: [ ] [ ]
First 2 letters of your father’s name: [ ] [ ]
Day of the month you were born: [ ] [ ]

The four letters and 2 numbers together make your unique code (e.g. DEGR08). Your unique code is: __________________________

1. Age: 19 or under ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐
50-59 ☐ 60+ ☐

2. Gender: Male ☐ Female ☐

3. Country of birth: _____________________________

4. Nationality: _____________________________

5. Current position: Undergraduate student ☐
Postgraduate student ☐
University staff ☐
Other: _______________________________________

6. What is your area of study/employment?
____________________________________________

7. Do you currently live on: Urban property ☐
Rural property ☐
8. Have you ever lived on a rural property/environment?  
   Yes ☐  No ☐
   If yes, how long did you live there?
   ☐ Less than one month
   ☐ 1-6 months
   ☐ 6-12 months
   ☐ 1-2 years
   ☐ More than 2 years

9. Have you ever visited a farm that rears animals?
   ☐ Yes  ☐ No
   If yes, what did they farm? (tick all that apply)
   ☐ Pigs
   ☐ Sheep (wool)
   ☐ Sheep (meat)
   ☐ Beef cattle
   ☐ Dairy cattle
   ☐ Chickens (eggs)
   ☐ Chickens (meat)
   Other ____________________________

10. Have you ever visited an abattoir?  ☐ Yes  ☐ No
    If yes what animal was being processed there?
    ☐ Sheep  ☐ Cattle  ☐ Pig  ☐ Chicken
    Other_________________________________

11. Do you have any of the following as pets? (tick all that apply)
    ☐ Dog(s)  ☐ Cat(s)  ☐ Bird(s)  ☐ Fish  ☐ Horse
    ☐ Livestock  ☐ Reptile(s)  ☐ Rodent(s)
    Other_________________________________
12. How often do you eat the following?

<table>
<thead>
<tr>
<th></th>
<th>Pork</th>
<th>Poultry</th>
<th>Lamb</th>
<th>Beef</th>
<th>Fish</th>
<th>Eggs</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Occasionally (less than once a week)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Often (1-4 times a week)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Always (&gt;5 times a week)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

13. What factors do you consider when eating the following:

<table>
<thead>
<tr>
<th></th>
<th>Pork</th>
<th>Poultry</th>
<th>Lamb</th>
<th>Beef</th>
<th>Fish</th>
<th>Eggs</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetarian</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Religion</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Dietary intolerance</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Dislike product</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Animal welfare concerns</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Food safety</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Cost</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other_______________</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
14. Do you believe that purchasing “animal welfare friendly” products can positively influence animal welfare?

☐ Yes  ☐ No  ☐ Don’t know
Comments:__________________________________________________________________
_____________________________________________________________

15. If you consume meat, dairy or eggs, are you personally responsible for purchasing these products?

☐ Yes  ☐ No  ☐ Not Applicable
Comments:__________________________________________________________________
_____________________________________________________________

16. How would you rate your knowledge on animal welfare issues in Australian agriculture?

☐ Strong  ☐ Good  ☐ Average  ☐ None
Comments:__________________________________________________________________
_____________________________________________________________

17. Do you believe animal welfare should be improved in Australia?

☐ Yes  ☐ No  ☐ Don’t know
Comments:__________________________________________________________________
_____________________________________________________________

18. What factors influence your assessment of animal welfare?

☐ Media
☐ Education
☐ Personal experience
☐ Religion
☐ Family/social/peers
☐ Not sure
☐ Other: ____________________
Comments:__________________________________________________________________
_____________________________________________________________
19. As a consumer, would you pay more for products that are produced with higher welfare standards than current industry standards?

☐ Yes  ☐ No

Comments:__________________________________________________________________
_____________________________________________________________

FOR THE FOLLOWING QUESTIONS PUT A DASH ON THE APPROPRIATE PLACE ON THE LINE.

20. How would you rate the animal welfare of livestock in Australia?

Poor  ☐ Excellent

_______________________________________________________________

21. How would you rate your knowledge of welfare issues in the Australian pig industry?

Poor  ☐ Excellent

_______________________________________________________________

22. How would you rate the welfare of livestock housed in intensive farms?

Poor  ☐ Excellent

_______________________________________________________________

23. I can tell how individual pigs are feeling by the way they behave.

Strongly agree  ☐ Strongly disagree

_______________________________________________________________

Comments:__________________________________________________________________

24. I believe animal welfare is important.

Strongly agree  ☐ Strongly disagree

_______________________________________________________________

Comments:__________________________________________________________________
25. My perceptions of animal welfare are influenced by the media.
   Strongly agree  Strongly disagree

   Comments:____________________________________________________

26. It doesn’t matter what the animals background is, they will still be able to tell how an
   animal is feeling.
   Strongly agree  Strongly disagree

   Comments:____________________________________________________

27. People who don’t eat meat are better able to interpret how animals are behaving.
   Strongly agree  Strongly disagree

   Comments:____________________________________________________

28. People who have pets are better able to interpret how livestock are behaving.
   Strongly agree  Strongly disagree

   Comments:____________________________________________________

29. Only people who have experience with livestock are able to interpret how livestock are
   behaving.
   Strongly agree  Strongly disagree

   Comments:____________________________________________________
30. Animal welfare is very important to me and it is my primary concern when purchasing animal products.

   Strongly agree                     Strongly disagree

   Comments:____________________________________________________

31. Price is my primary concern when purchasing animal products.

   Strongly agree                     Strongly disagree

   Comments:____________________________________________________

Thank you for your time!