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Does litter size affect emotionality, spatial learning and memory in piglets?

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ABSTRACT

Average litter size has steadily increased over the past decades in the pig farming industry. Large litters are associated with an increase of piglets born with a lower birth weight and reduced overall piglet viability. The aim of our study was to investigate whether litter size affects emotionality, learning and memory in pigs. Ten piglets from large litters (≥18 piglets) were compared with ten piglets from small litters (≤13 piglets). Piglets from two different suppliers, using different breeds, (hereafter called: Source) were tested. Effects were determined of Litter size and Source on birth weights and growth rates, on emotionality of the piglets measured in an open field test (OFT) at 5 weeks of age, and on effects of OFT-induced stress as indicated by salivary cortisol. The effects of Litter size and Source on spatial learning and memory in a holeboard task were assessed between 9 and 14 weeks of age. Small litter piglets from Source 1 grew faster than large litter piglets from the same source. This effect of Litter size was not found in piglets from Source 2. In the OFT, no effects of Litter size on behaviours were found. However, piglets from Source 1 had lower baseline cortisol levels, made more escape attempts and showed higher locomotor activity during the OFT than piglets from Source 2. During the acquisition phase of the holeboard task, piglets from Source 2 learned the reference memory component faster and reached a higher overall working memory level in the reversal phase than piglets from Source 1. Our results show that Source (i.e. supplier and/or breed) influenced performance in behavioural tasks, and that the occurrence of litter size effects was supplier or breed dependent.

1. Introduction

Over the last few decades, high production levels of domesticated pigs with regard to growth and reproduction have been established through genetic selection, the control of reproductive cycles and improvements in husbandry management (Prunier et al., 2010). This has caused a considerable increase in the average litter size of pigs, especially in countries with a large pig industry such as The Netherlands, Denmark, France and Germany (Rutherford et al., 2011). Large litter sizes may affect the welfare of both the sow and her piglets (Rutherford et al., 2013). For example, large litters are associated with increased discomfort for the sow during farrowing and an increase in sow teat damage (Norring et al., 2006; Mainau et al., 2010). Sows have a limited uterine capacity, therefore large litters cause intra-uterine crowding (IUC). The uterine circulation increases with a larger number of foetuses, but not proportionally. The limited extent to which the blood flow of the uterus can be increased, results in a decrease of blood flow, oxygen and nutrient availability per foetus (Père and Etienne, 2000). IUC causes competition for resources between foetuses and has detrimental effects on placental development, resulting in increased pre- and neonatal mortality and reduced overall piglet viability (Wahner and Fisher, 2005).

Litter size correlates negatively with size and weight at birth, and birth weight variability within large litters is greater compared to that in small litters (Quiniou et al., 2002; Beaulieu et al., 2010). Litter size also shows a negative correlation with pre-weaning weight gain (de Passillé and Rushen, 1989). Moreover, the risk of

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crushing by the sow is higher in piglets from large litters, as they are generally weaker at birth. Due to their smaller average size, they also have poorer thermoregulatory abilities, and possibly a reduced colostrum intake. Thus, large litter piglets have decreased vitality and therefore an increased risk to die before weaning (Herpin et al., 2002; Rutherford et al., 2013).

Human babies that are born at term but small for gestational age (SGA) or have experienced foetal growth restriction, show poorer neurodevelopmental outcomes than babies that are appropriate for gestational age (Arcangeli et al., 2012). A follow-up study of SGA children showed that they had poorer school performance at adolescence than controls (Larroque et al., 2001). The authors argue that "foetal adaptation to conditions that retard growth during gestation may not be successful in maintaining brain development". Similarly, SGA and foetal growth retardation in rats have negative effects on postnatal growth, metabolism, neurological development and learning ability (Ogata et al., 1985; Saito et al., 2009).

Studies on pigs that are born with a low birth weight (LBW) have been inconclusive. Gieling et al. (2012) found that LBW piglets had higher working memory scores than NBW piglets at the start of the reversal phase of a holeboard task. In a follow-up study, LBW piglets selected with stricter criteria showed improved reference memory performance in both the acquisition and the reversal phase of the same holeboard task (Antonides et al., 2015), warranting further studies. It is conceivable that all piglets from large litters suffer from IUC, as they deal with greater competition over oxygen, space and nutrients than piglets from small litters. Therefore, normal birth weight (NBW) piglets from large litters may have undergone more limitations during foetal (cognitive) development than NBW piglets from small litters.

In the present study, we assessed emotionality and learning ability in ten NBW piglets from large litters and ten NBW piglets from small litters. Of each litter size category, five piglets originated from one supplier, and five from another supplier. We exposed all piglets to an open field test (OFT), in which behaviours such as activity and vocalizations can be used as measures of emotionality (Donald et al., 2011). We then assessed longer-term effects of litter size on cognitive development using the spatial cognitive holeboard task for pigs (Gieling et al., 2012; Antonides et al., 2015).

We expected that piglets from large litters would display more emotional reactivity during the OFT, as expressed by more locomotion, vocalizations and defecations, more suspicion towards a novel object, and less time spent in the centre of the OFT than piglets from small litters. Additionally, we expected large litter piglets to show a greater surge in cortisol after the OFT than small litter piglets. In the holeboard task, we expected large litter piglets to show lower memory scores and longer trial durations and latencies than piglets from small litters.

2. Material and methods

2.1. Ethical note

This study was reviewed and approved by the animal ethics committee (DEC) of Utrecht University, The Netherlands. The study was conducted in accordance with the recommendations of the EU directive 86/609/EEC. All efforts were made to minimize the number of animals used and to avoid their suffering.

2.2. Animals

Based on the information of litter sizes per supplier over the 6 months prior to selection, we determined the upper and lower 25th percentile of these data, resulting in a selection criterion of 13 or less piglets for small litters, and 18 or more piglets for large litters. Because in only a few litters less than 13 piglets were born, the animals were ordered as two separate batches from a pig breeding farm, hereafter called Source 1. We obtained 10 piglets (T40 × Pietrain), five from each litter size category (small or large). Unfortunately, due to technical problems it was impossible to obtain the second ordered batch from the same source. Instead, a second batch of 10 piglets (Large White × 426 PIC), again five from each litter size category, was supplied by another pig breeding farm, hereafter called Source 2. Source 2 supplied piglets bred and reared under SPF conditions. Note that the effects of supplier are indistinguishable from effects of breed. The experimental design hereby changed from a simple test of the effects of litter size (small vs. large) to a two-factorial design with the factors Litter size and Source.

However, for answering our main question whether litter size affects emotionality, spatial learning and memory in piglets, we still had 10 piglets from small litters and 10 piglets from large litters at our disposal. If effects of Litter size are robust, then Source should not be relevant. At the same time, this design enables us to assess the effects of the additional factor Source and its interaction with Litter size. It adds a second question, namely whether effects of Litter size (if present) is robust, i.e. whether or not it is affected by Source (see also Festing et al., 1998; Shaw et al., 2002).

One piglet per litter from a total of 20 litters was selected within 24 h after birth. All piglets were born to multiparous sows. All piglets of each litter were weighed, including stillborn piglets and piglets that died shortly after birth. The male piglet closest to the average birth weight within its litter was selected and given a different colour ear tag. The male piglet second closest to the average weight of the litter was also marked, in case the selected piglet died before weaning. After the selection process, the piglets remained at the pig breeding farm until weaning.

2.3. Housing

At weaning, when the piglets were approximately four weeks old, they were transported to the research facilities of the commercial pig breeding farm of the Faculty of Veterinary Medicine, Utrecht University, The Netherlands. After arrival at the testing facility, all animals were housed under non-SPF (conventional) conditions. The four groups of five piglets were housed in adjacent pens by litter size category (small or large litter) and supplier (Source 1 or Source 2). The pens (4 m x 5 m) were enriched with straw bedding, rubber balls, a gunnysack and chewing sticks. Ambient temperature in the stable was measured daily and ranged between 4 °C to 27 °C for the piglets from Source 1 (March–May 2014), and between 8 °C and 34 °C for the piglets from Source 2 (April–July 2014). Each pen contained a wooden nest box (3 m x 1.5 m) with plastic flaps along the front. Rubber mats, covered with a thick layer of sawdust and straw were placed on the concrete floor of the nest boxes. A heat lamp warmed the nest box until the piglets were 8 weeks of age. The stable in which the pens were located was naturally lighted and ventilated (unheated). Fluorescent lights in the stable were on from 7:30 h to 16:30 h.

To facilitate individual recognition, the animals were marked with a sprayed letter on their back (Porcimark marking spray, Kruuse, Denmark). Food and water were available ad libitum, except during the 5 weeks of holeboard testing, when the animals were fed a quarter of their daily required amount of food in the morning before testing, half of the amount after testing and the remainder in the late afternoon. This feeding schedule ensured that the piglets would not feel saturated during testing and would be motivated to search for food rewards in the holeboard. Starting in the second week after arrival at the research facility, a radio was playing con-