Individual charactaristics of adaptive capacity in pigs: welfare, health and production - III: Prenatal stress: consequences for individual pre- en postnatal behavioural and stress physiological characteristics

Projectleader	*Dr. Hans Hopster*
	Institute for Animal Science and Health (ID-Lelystad)
	Division Animal Sciences, Researchgroup Animal Welfare
PhD-student	*Drs. Godelieve Kranendonk*
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Summary

In intensive husbandry systems, the adaptive capacity of pigs is frequently challenged; high stocking densities, mixing, transport, etc. force the fig to draw on this adaptive capacity. There is abundant literature substantiating that there are different adaptive strategies ('coping strategies') in many species, including pigs. In several species it has been shown that prenatal stress of the mother affects the behavioural and physiological adaptive responses of the offspring. As these responses are of overriding importance for the welfare of pigs, it is necessary to gain insight in the effects of prenatal stress on the sow and her piglets, in order to account for these effects when new, welfare-friendly housing systems for pregnant sows are proposed.

The present project therefore addresses the following hypotheses: 1) prenatal stress, as applied by exposing pregnant sows to confinement stress, affects behavioural and physiological variables (incl. Their 'coping strategy') of the piglets during the postnatal period; 2) these effects depend on the gestation period in which the pregnant sow is exposed to the stress; 3) the coping strategy of the pregnant sow has an influence on the fetus and therefore on these effects postnatal; 4) these effects also exist in systems that are supposed to be a good and practical alternative for confinement of pregnant sows, namely large dynamic groups.

With this project, an important contribution will be given towards the development of new housing systems for pregnant sows that take both the pregnant sow and her offspring into account, optimises their adaptive strategies and, as a consequence, increases their welfare.

Results

Ample time has been spent on literature research and on training skills that are relevant in the project, like the non-invasive measurement of heart rate in piglets, the performance of the back test, the collection and processing of saliva and urine samples as well as behavioral observation and analysis. In addition, two experiments have been carried out. In the first experiment, a novel object test has been pharmacologically validated for quantifying fear-responses in four-week old piglets. This novel object test will be used in subsequent experiments to measure differences in fear responses in piglets born from sows that experienced different levels of prenatal stress. Briefly, thirty-six piglets were taken from nine litters and divided into three groups. At testing, the piglets were four weeks old. Thirty minutes prior to testing, the piglets were weighed and injected i.m. with either physiological saline (the control group), 0.4 mg diazepam / kg, or 0.8 mg diazepam / kg. Two minutes before the test, the piglet was taken from its home pen and was equipped with a heart rate monitor (Polar Vantage), to continuously measure heart rate during the test. Subsequently, the piglet was carried to and placed into a familiar testing arena. After five minutes, a blue bucket (the novel object) was lowered from the ceiling. The piglet was left with the bucket for another five minutes, after which the piglet was caught, heart rate equipment was removed and the piglet was returned to its home pen. The test was recorded on video for further analysis.

Preliminary results indicate that mean heart rate is increased in both diazepam-groups, probably caused by a diazepam-induced decrease of parasympathetic nervous system activity. Heart rate effects resulting from the sudden appearance of the bucket did not differ between experimental groups. Latency-time to touch the bucket was not influenced by treatment, nor was the frequency of touching the bucket or the mean distance to the bucket. However, diazepam-treated animals approached the bucket within 50 centimetres more often than saline-treated piglets did (5 versus 2.2 visits). We speculate that the frequency of approaching the novel object within 50 centimetres may be a valid measure of anxiety in piglets.

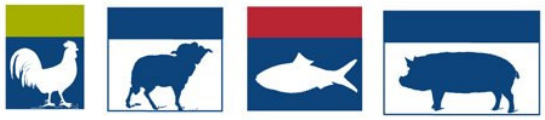
Regarding possible mechanisms underlying the effects of prenatal stress on fetal development, literature research revealed that in rats elevated maternal peripheral corticosteroid levels are a major cause of disturbed brain development. In pigs, only two studies are published in this field of research and both suggested at the most that similar phenomena may play a role in fetal brain development. Moreover, for the initial idea of inducing long lasting elevated corticosteroid levels in sows by exposing them to experimental stressors, no support has been found in the literature.

Because the development of an experimental model for inducing long lasting adrenocortical activation in pigs is extremely time consuming and therefore not achievable within the scope of the current project, we decided to radically adjust the initial experimental approach. Oral administration of cortisol twice daily should guarantee a controlled increase in peripheral corticosteroid levels in sows and should enable us to determine cortisol-induced differences in piglet behaviour or physiology if present. Our new approach first required a dose/response experiment to establish a suitable cortisol dose for use in second parity pregnant sows. Our second question in this experiment concerned the relation between cortisol concentrations in plasma, saliva and urine after an artificial increase of cortisol, to enable avoiding blood sampling in future experiments.

Based on rat literature, our educated guess was that a two- or threefold increase compared to baseline was likely to be high enough to bring about measurable effects on piglet behaviour and physiology. In addition, practical stressors like isolation, applying a nose-sling and transport are known to induce comparable cortisol levels in sows. A dose/response experiment has been carried out with four groups of six second-parity sows. Sows were surgically fitted with a cannula in the internal jugular vein and housed in farrowing crates. Sows in different groups received 0 (placebo), 0.1, 0.3 and 0.9 mg/kg cortisol in a capsule hidden in a candy twice daily at 0830 a.m. and 0830 p.m. At three and 25 days following the start of the cortisol treatment, plasma, saliva and urine (through a catheter) samples were collected each hour from all sows during 24 hr. Sows were sampled twice weekly in between these 24-hour sampling days.
Preliminary results indicated that cortisol concentrations in plasma followed a regular pattern with two peaks at about half an hour after cortisol-administration and a gradual decrease to baseline after approximately 8 hours. Attained cortisol concentrations were dose dependent. The 0.3 dose appeared to meet the criterion of a two- to threefold cortisol-increase. Surprisingly the cortisol concentration in saliva did not seem to keep pace with plasma cortisol concentrations during the whole 24 hour. During daytime saliva cortisol concentrations were significantly lower than during the night, despite comparable cortisol concentrations in plasma. Analysis of cortisol binding globulin concentrations and further study of differences in saliva production and diffusion of cortisol from blood to saliva should elucidate this intriguing phenomenon.

In total 5 sows had to be excluded from the experiment because of various health problems. From the 19 sows that farrowed, three female piglets from each sow were euthanized and adrenals, thymus and spleen were weighed. Furthermore, their brains were collected and stored for future analysis of glucocorticoid receptor density in the central amygdala (mRNA-analysis).

In 2002/2003 a follow-up experiment has started in second-parity sows to determine the sensitive period during gestation with regard to cortisol induced effects on piglet behaviour and physiology. The experiment will be carried out in four rounds with 36 sows that orally receive the 0.3 mg/kg cortisol



dose during either weeks 3-7, 7-11 or 11-15. A fourth treatment group of 12 sows receives a placebo during the whole gestation period. The focus in this experiment will be on neonatal vitality of the piglets, on piglet behaviour in the farrowing environment and after weaning and on their responses during social mixing, after exposure to a novel object and after administration of ACTH. In collaboration with the research group of Dr. Donald Lay (Purdue, USA) additional measurements in mutual experiments will be considered.