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Embryo survival, progesterone profiles and metabolic responses to an increased feeding level during second gestation in sows

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Abstract

This study describes reproductive and metabolic responses in sows fed at two different feeding levels from day 3–35 of second gestation. After insemination, 37 sows were assigned to one of two treatments: 1) Control: 2.5 kg/day of a gestation diet; 2) Plus Feed 3.25 kg/day of a gestation diet (+30%). Sow weight, back fat and loin muscle depth were measured at farrowing, weaning, start of treatment, day 14 after start treatment and end of treatment. Frequent blood samples were taken for progesterone, luteinizing hormone (LH), glucose and insulin, insulin-like-growth-factor-1 (IGF-1), non-esterified-fatty-acids (NEFA) and urea analysis. At day 35 after insemination sows were euthanized and their reproductive tract collected to assess ovarian, embryonic and placental characteristics. Plus Feed sows gained 5.4 kg more weight and 0.9 mm more back fat and tended to be heavier at slaughter compared to Control sows (193 vs. 182 kg, $P = 0.06$). No difference in loin muscle gain was found. Treatment also did not affect vital embryonic survival, which was 72.1 ± 3.9% for Control and 73.4 ± 3.2% for Plus Feed sows, resulting in, respectively, 15.9 ± 0.9 and 15.7 ± 0.7 vital embryos. No effect of treatment on any of the ovarian, embryonic or placental characteristics was found. Progesterone profiles during the first month of gestation, and LH characteristics at day 14 of gestation were not different between treatments. Progesterone concentration was lower ($P < 0.05$) 3 h after feeding compared with the prefeeding level on days 7–11 after first progesterone rise for Plus Feed and on days 8–10 after first progesterone rise for Control sows. At day 15, preprandial glucose and insulin concentrations were not different between treatments, insulin peaked later (48 vs. 24 min) and at a higher concentration in Plus Feed than in Control sows. Furthermore, glucose area under the curve (AUC) tended to be lower (−171.7 ± 448.8 vs. 1257.1 ± 578.9 mg/6.2 h, $P = 0.06$, respectively) for Plus Feed vs. Control sows. IGF-1 concentration was not different between treatments, but NEFA concentrations were lower for Plus Feed vs. Control sows (149.5 ± 9.2 vs. 182.4 ± 11.9 μm/L, respectively, $P = 0.04$) and urea concentration tended to be higher in Plus Feed than in Control sows (4.3 ± 0.1 vs. 3.9 ± 0.1, respectively, $P = 0.13$). None of the metabolic parameteres were related to reproductive measures. In conclusion, feeding 30% more feed from day 3 till d 35 of second gestation increased weight gain and resulted in lower NEFA concentrations, but did not affect progesterone, LH or IGF-1 and embryonic and placental characteristics.

Keywords: Sow; Reproduction; Feeding level; Metabolism; Progesterone

1. Introduction

Lactation weight losses in sows can be substantial, especially in primiparous sows in which weight losses can reach up to 20 to 30 kg [1–4]. These losses have

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been related with reduced subsequent reproductive performance [1,5]. An increased feed intake during the early stages of the subsequent pregnancy may help to quickly recover from these lactation losses and thereby overcome the negative effects on farrowing rate and litter size in subsequent parity. In gilts, however, several studies have found a negative effect of an increased feed intake during early pregnancy on embryonic survival [6–8], although a recent study did not substantiate this [9]. In multiparous sows, embryonic survival does not seem negatively affected by feeding level in early pregnancy [10–13]. In contrast, Sørensen and Thorup [14] reported significant positive effects on litter size, +0.3 piglet, when sows were fed 49.9 vs. 31.2 MJ ME day^{-1} in the first 28 days after insemination. Also a recent study by Hoving et al. [15] found positive effects of an increased feed intake in the first month of pregnancy of first and second parity sows (39.0 vs. 30.0 MJ ME day^{-1}) on subsequent litter size (+ 2 piglets). Thus, whereas most gilt studies find that a high feeding level in early pregnancy lowers embryo survival, older parity sows may have equal or higher embryo survival at a high feeding level.

Lower embryonic survival in gilts on a high feeding level has been related to decreased systemic progesterone concentrations [6,7], caused by an increased clearance in the liver related with an increased metabolic rate [16]. Injections of exogenous progesterone in gilts on a high feeding level, to restore progesterone concentrations in high fed gilts, have shown to alleviate the negative effects of feeding level on embryonic survival [17,18]. Besides the negative effects of metabolic clearance on progesterone concentrations, a higher feed intake may also have a positive effect on progesterone concentrations. Insulin like growth factor-1 (IGF-1) and insulin are both positively influenced by feeding level [8] and Langendijk et al. [19] reported a positive correlation ($r = 0.7$) between IGF-1 concentration on day 1 after ovulation and early progesterone rise (12–36 h after ovulation). Furthermore, Yuan et al. [20] reported an increase of *in vitro* progesterone production in large luteal cells when these cells were incubated with 100 ng/mL IGF-1. Besides this direct effect, insulin or IGF-1 may also have an indirect effect on progesterone production via stimulation of luteinizing hormone (LH) secretion by the pituitary [21]. Furthermore, endometrial IGF-1, its receptors and binding proteins play an important direct role in early embryonic development and placentation (reviewed by Geisert and Yelich [22]), and might be influenced by systemic IGF-1 concentrations [23].

Between day 12 and day 29 of gestation, progesterone production is largely dependent on LH stimulation [24–26]. Higher feeding levels have been found to increase LH secretion [27], which might subsequently increase progesterone production after day 12 of pregnancy.

So, feeding level can affect embryonic development and survival by different pathways, several of them involving progesterone dynamics. In second parity sows, i.e., sows weaned from their first litter, progesterone concentrations and relationships with embryo survival, related to feeding level, may be markedly different from gilts, since these sows have suffered substantial weight losses and need to restore their body reserves. Metabolic indicators for fat and nitrogen metabolism (respectively, non-esterified-fatty-acids (NEFA) and urea) are therefore also measured in this study. Hoving, et al. [15] showed that feeding sows 30% more feed during early second or third gestation, improved sow body development as well as reproductive performance. This study aims to find physiological explanations for these effects of feeding level on litter size, by describing reproductive and metabolic responses in sows fed different feeding levels during the day 3–35 of second gestation.

2. Materials and methods

All experimental procedures were approved by the Institutional Animal Use and Care Committee of Wageningen University (Wageningen, the Netherlands).

2.1. Animals, housing and feeding

In total, 37 crossbred (Yorkshire x Dutch Landrace) first parity sows were used. Between October and December 2010, the animals arrived in three batches (n = 10, n = 14 and n = 13, respectively) at day 80 ± 4 of first pregnancy at the experimental farm 'de Haar' of Wageningen University in Wageningen, the Netherlands.

On day 103 ± 0.5 of first gestation, sows were fitted with an indwelling jugular vein catheter as described by Soede et al. [28], to allow frequent blood sampling. After surgery, sows were housed in individual farrowing crates. From day 2 after surgery, gestation feed was gradually, in a 7-day period, replaced with the commercial lactation diet (13.1 MJ ME/kg, 15.5% Crude protein and 0.8% lysine) which was fed throughout lactation. Within 3 days after farrowing, litters were standardized to 11 to 13 piglets. Feed allowance gradually increased in the first 14 days of lactation to a