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Embryonic and fetal development in a commercial dam-line genotype

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Abstract

During depopulation of a breeding unit within Swine Graphics Enterprises, extensive data were collected and used to examine relationships among ovulation rate, the pattern of prenatal loss, and placental and fetal development. Groups of Large White × Landrace females ($n = 447$) were slaughtered between day 20–30, 50–55 or 85–90 of gestation, with approximately equal numbers of animals representing gilts and parity 1 (G/P1), parity 2–3 (P2/3), and parity >4 (P4+). Ovulation rate and embryo number were recorded for all animals. With the exception of the G/P1 animals, embryonic and placental weight were recorded for four conceptuses per sow on day 20–30; on day 85–90 two conceptuses per sow were dissected to determine placental and fetal development. Ovulation rate (22.7 ± 0.2 overall) was higher ($P < 0.05$) in P2/3 (23.6 ± 0.4) and P4+ (24.7 ± 0.4) than in G/P1 (20.2 ± 0.5). Embryonic/fetal survival was 61.8 ± 2.1% at day 20–30, 50.2 ± 2.2% at day 50–55 and 48.7 ± 1.9% at day 85–90 and the number of surviving conceptuses was higher ($P < 0.05$) in the P2/3 sows than in other parity groups. There was no relationship between ovulation rate and number of live embryos at day 20–30 or 85–90. At day 20–30 and 85–90, embryo weight was positively correlated with placental weight, but neither placental weight nor embryonic/fetal weight was correlated with number of viable embryos. A parity by gestation day interaction existed; placental weight for P4+ (3.42 ± 0.43 g) was less than for P2/3 (7.55 ± 0.40 g) at day 20–30 ($P < 0.0001$), whereas at day 85–90, placental weight of P2/3 (209.5 ± 8.5 g) was less ($P = 0.05$) than both G/P1 (235.7 ± 7.3 g) and P4+ (235.4 ± 7.1 g). At day 85–90, fetal brain weight, relative to body weight ($R^2 = 0.61$, $P < 0.0001$), and fetal brain:liver weight ratio ($R^2 = 0.35$; $P < 0.0001$) were negatively related to mean fetal weight, and brain:liver weight ratio showed a trend towards a relationship with number of viable fetuses ($P = 0.08$). Parity also affected brain:liver weight ratio ($P = 0.01$). Clearly, high ovulation rates in the higher parity sows have the potential to cause

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excessive in utero crowding of conceptuses in the post-implantation period. Even with moderate crowding, increased brain:liver weight ratios in smaller fetuses in late gestation indicate that uterine capacity impacts fetal development as well as the number of surviving fetuses.

Keywords: Sow; Ovulation rate; Embryos; Placenta; Parity; Embryonic loss; Fetal growth

1. Introduction

The concept of uterine capacity as the ultimate constraint on litter size in swine has been widely studied using different animal models to examine effects of crowding in utero. Techniques including uterine ligation, oviduct resection, unilateral hysterectomy and ovariectomy (UHO; Christenson et al., 1987), superovulation, and embryo transfer have been employed and led to the conclusion that when the number of embryos exceeded 14, intrauterine crowding was a limiting factor for litter size born (Dziuk, 1968). Fenton et al. (1970) determined that uterine capacity only becomes a limiting factor for fetal survival after day 25 of gestation and Knight et al. (1977) further defined day 30–40 of gestation as the critical period when uterine capacity exerts its effects. Subsequent studies in both intact and UHO females support this conclusion (see Vallet, 2000). Wu et al. (1989) restricted the length of uterus available to each fetus and concluded that 36 cm of initial uterine length was required for fetal survival and development. Bennett and Leymaster (1989, 1990a, 1990b) developed a simulation model of litter size and highlighted the importance of interaction among its components, namely ovulation rate, embryonic viability and uterine capacity. The greatest increase in litter size was produced following combined selection for indices of ovulation rate and uterine capacity. Whilst earlier studies addressed uterine capacity in terms of number of embryos, uterine space requirement for embryo survival and time of embryonic loss, less focus has been directed towards associated effects on fetal development in utero. In addition, ovulation rates of animals used in these early studies were relatively low (10–12) compared with ovulation rates >25 reported in contemporary commercial sow populations for which data are available (Orzechowski, 1998; Vonnahme et al., 2002) and the concept of uterine capacity needs to be re-evaluated in such populations.

The extremes of intrauterine growth retardation (IUGR) or “runting” have been described in the pig (Adams, 1971; Widdowson, 1971; Cooper et al., 1978; Hegarty and Allen, 1978; Flecknell et al., 1981), and were identified within a discrete subpopulation of lighter weight fetuses (Royston et al., 1982; Wootton et al., 1983). However, conclusions based only on a consideration of fetal weight may overlook critical effects on fetal development that are established early in gestation. Indeed, Hegarty and Allen (1978) reported that within a litter, runts have a reduced muscle growth potential and, as a consequence, needed 23 days longer to reach a weight of approximately 105 kg (slaughter weight). In addition, data from a study by Aberle (1984) indicated that naturally occurring IUGR may delay myofibre differentiation, preferentially affecting secondary muscle fibre development.

High ovulation rates with only modest increases in litter size born in commercial dam-line sows may result in a dramatic change in the dynamics of prenatal loss (Foxcroft, 1997). This change is associated with crowding of embryos in utero in the immediate post-implantation