Title: Improved reproductive performance in 14d weaned sows by delaying return to estrus **– NPB #98-190**

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I. Abstract:

Segregated early weaning has been instituted to improve growth, efficiency, and health of weaned pigs. Increased length and variation of wean-to-estrus interval (WEI) and reduced subsequent litter size are common in sows weaned at 14 d or less. This study was designed to determine the effect of a single injection of progesterone (P_4) on WEI, return of pulsatility of luteinizing hormone (LH), and consistency of return to estrus in early-weaned sows. Thirty-eight sows were injected with either 400 mg of P_4 or 8 ml of sesame seed oil at weaning following lactations of 9 to 14 d. Sows were checked twice daily for return to estrus beginning d 3 post-weaning. The WEI ranged from 3 to 14 d with no difference ($P > 0.05$) between treatments. Two sows remained anestrus and were not included in the WEI analysis. The P_4 treated sows had higher ($P < 0.01$) levels of P_4 (4.77 verses 0.40 ng/ml) for approximately 30 h after weaning. The LH data were analyzed for mean LH, number of peaks in a 6 h period, average peak amplitude, and average baseline LH. There were no significant interactions between treatment and time. The single P_4 injection cleared the system too quickly to delay return to estrus. Although P_4 concentrations were elevated in the treated group, no significant change was observed in LH pulsatility or consistency of return to estrus. If this technique is to be effective in delaying return to estrus an alternative delivery system will need to be utilized.

II. Introduction

Segregated early weaning (SEW) procedures have been adopted to improve growth efficiency by enhancing the health status of young pigs. Sow reproductive performance has been shown to significantly decrease, however, with SEW procedures. The reproductive parameters affected most by the adoption of SEW technology are weaning-to-estrus interval (WEI), consistency of return to estrus (Cole et al., 1975; Varley and Cole, 1976; 1978), subsequent litter size and conception rates (Moody et al., 1969; Moody and Speer, 1971).

Sow productivity can be measured as pigs/sow/year (PSY) which is determined by pigs/litter and litters/sow/year. Pigs/litter is an index of ovulation rate, fertilization rate and embryo survival. In previous research, ovulation and fertilization rates were not significantly altered as lactation length was varied over 56 d (Self and Grummer, 1958; Svajgr et al., 1974; Hays et al., 1978). Litters/sow/year is affected by WEI, lactation length, and gestation length. As lactation length decreases, WEI increases (Self and Grummer, 1958; Svajgr et al., 1974; Varley and Cole, 1976; 1978; Hays et al., 1978).

Lactation length is the easiest trait in the litters/sow/year equation to change. The current research, therefore, utilized early weaned sows to allow the high piglet performance of SEW, and concentrated efforts toward improving sow productivity. Progesterone is important in regulating hormones of the estrous cycle. High circulating concentrations of progesterone inhibit estrus and prevent an ovulatory surge of LH. A 400 mg injection of progesterone was sufficient to increase ($P < 0.05$), as well as maintain, circulating concentrations of progesterone above 1 ng/ml for a period of three days in gilts (Liu et al., 1998).

III. Objectives:

Determine whether post-weaning estrus can be effectively delayed by progesterone administration resulting in a more consistent return to estrus in early weaned sows. Determine the clearance of progesterone in the early weaned sow, and follow the recovery of pulsatile luteinizing hormone (LH) secretion after progesterone administration.

IV. Procedures :

The University of Missouri Animal Care and Use Committee approved all procedures utilized throughout the current research. Thirty-eight Yorkshire x Landrace crossbred sows with a parity distribution ranging from one to eight were used for this study. A balanced corn-soybean meal based diet was fed ad libitum during lactation. Sows were weaned at approximately 9:00 between d 9 and 14 of lactation with litter sizes ranging from 5 to 14 pigs. Sows were distributed over two farrowing groups; 17 sows in February, 1998 and 21 in March, 1998.

All sows were given up to 3.65 kg of lactation diet daily post weaning. Water was provided ad libitum. All sows were checked twice daily for return to estrus at 6:00 and 18:00 h starting on d 3 postweaning using the back pressure test in the presence of a mature boar.

At the time of weaning sows were randomly allocated to one of two treatments. Sows were either injected with 8 ml of sesame seed oil or 8 ml of a progesterone/sesame seed oil solution at a concentration of 50 mg/ml. Injections were given intramuscularly in two sites of the neck 30 minutes before weaning.

At weaning seven sows from each group were moved directly to gestating crates at the Swine Research Center. The remaining 10 sows from the first group and 14 from the second were transported to the Animal Sciences Research Center and individually penned. At 13:00 sows were nonsurgically fitted with indwelling jugular vein cannulas (Almond and Dial, 1990). This allowed blood samples to be taken without disturbing the sows at each sampling. One sow from the first group, after several failed attempts to keep the cannula in place, was removed from the blood sampling portion of the study, but remained in the WEI data set. Several sows had to be recannulated with no apparent effect on the blood sampling. After the initial two or three samples sows did not appear to be disturbed by the presence of the person doing the sampling.

Blood samples (8 ml) for progesterone were collected every 4 h, starting at 17:00, (8 h after weaning) for 6 d or until expression of estrus. Blood samples (8 ml) were collected daily for LH at 20-min intervals for 6 h starting at 11:30 the day after weaning until sows returned to estrus or until d 8 post-weaning. Samples were stored at room temperature to clot, then refrigerated at 4°C for 12 to 18 h prior to centrifugation at 1,500 x g for 20 min. The serum was decanted and frozen at –20°C until assayed for concentrations of progesterone and LH by radioimmunoassay. Analysis for progesterone concentration was performed using a Coat-A-Count progesterone kit (TKPG5, Diagnostic Products, Los Angeles, CA). Plasma concentrations of LH were measured with a double-antibody radioimmunoassay for porcine LH. The standard curve points were .195, .39, .78, 1.56, 3.12, 6.24, 12.5, 25, 50, and 100 ng/ml.

Statistical analyses were run using GLM procedures of SAS (1990). The model for WEI included lactation length, treatment, sow parity, number of pigs weaned, blood sample, and lactational length x treatment interaction. Blood sample was included in the model to account for variation due to bleeding and differences in housing between the sows which were bled and those that were not. The model for progesterone and LH analyses contained treatment, sow number within treatment, time, and treatment x time interaction. Sow number by treatment served as the error term to help eliminate the variation caused within treatment.

V. Results:

The concentration of progesterone was higher ($P < 0.05$) for the treatment group as expected (Figure 1). The difference was statistically significant and remained so for approximately 30 h following the injection. The progesterone concentration dropped to control levels following this initial 30 h except for occasional rises which were believed to be the result of remaining progesterone solution being released from the fat deposits in the neck.

The WEI was similar between treatments ($P > 0.1$; Table 1). The WEI ranged from 3 to 14 d, with two of the progesterone treated sows anestrus beyond d 15 post-weaning. One of the two sows was found to have 27-mm cysts encompassing both ovaries as determined by real time ultrasound. Cystic follicles have been found to occur more frequently as the lactation length was shortened (Svajgr et al., 1974; Hays et al., 1978). Ulberg et al. (1951) found the effect of progesterone injections to vary with dose. In gilts, a 25 mg dose resulted in a partial depression of LH resulting in overgrowth of the follicles with ovulation; however, the 50 mg dose depressed luteinizing activity to the point of an irreversible cystic state. The mean WEI in this study was lower than that previously reported in other studies with early weaned sows. Svajgr et al. (1974) showed a decrease ($P < 0.01$) in WEI as the number of days from farrowing to weaning increased from 2 to 13, 24, or 35 d, with an average WEI of 10.1, 8.2, 7.1, and 6.8 d, respectively.

Ulberg et al. (1951) and Baker et al. (1954) injected progesterone to gilts as a tool to control estrous cycle length as well as synchronize estrus. Liu et al. (1998) found a single 400 mg injection sufficient to increase ($P < 0.05$) progesterone levels above 1 ng/ml for a period of 3 d. The 400-mg injection administered in the present study was intended to be sufficient to block estrus for 3 to 5 d. This delay was intended to simulate a 16 to 18 d lactation and achieve the benefits of early weaning for the piglets, while at the same time diminishing the undesired reproductive performance associated with short lactations. The progesterone levels were higher in the sows treated with progesterone as expected, but only significantly so for approximately 30 h.

The exact mechanism which triggered the onset of estrus is unknown. Serum progesterone concentrations remained above 1 ng/ml in the progesterone treated sows for 112 h; so one hypothesis is that the progesterone threshold necessary to prevent estrus in early weaned sows is higher than the 1 ng/ml previously reported in gilts (Liu et al., 1998). Another hypothesis is that the rapid rate of clearance of progesterone, rather than absolute concentration, triggered the onset of estrus. Serum concentrations of progesterone averaged 28.77 ng/ml beginning 8 h after progesterone injection, and dropped to an average of 7.2 ng/ml at 30 h post injection.

There were no significant interactions between treatment and time for any of the above parameters. There were no significant differences between treatments nor interactions for number of peaks in a 6h period, average peak amplitude, or average baseline LH. From these physiological measurements, we concluded that progesterone at a single 400 mg dose failed to alter the estrous cycle in any way.

Parvizi et al. (1976) hypothesized that lactation somehow interferes with steroid-LH interactions, preventing a cyclic release of LH. However, lactation does not result in an absolute block of LH secretion (Edwards and Foxcroft, 1983). Stevenson et al. (1981) and Crighton and Lamming (1969) both showed with ovariectomized versus intact sows that the low level of LH secretion during lactation was due to suckling. Luteinizing hormone levels appear to be suppressed during early lactation, with increases in LH concentration as lactation progresses (Stevenson and Britt, 1980; Stevenson et al., 1981). Stevenson and Britt (1980) measured serum LH concentrations on d 7 and 21 and found concentrations of .20 and .37 ng/ml respectively ($P < 0.01$). Results from Stevenson et al. (1981) showed similar LH concentrations between the ovariectomized and intact sows throughout lactation, but LH was higher ($P < 0.02$) from d 21 until weaning than during the first 20 d. In the present study the mean LH ranged from .16 to .21 ng/ml in the controls, and .18 to .25 ng/ml in the progesterone treated sows during the WEI. The difference was not statistically significant.

Kirkwood et al. (1984) found the area under the peak and the peak LH values also differed significantly for two groups of lactating sows (35 versus 10 d lactations). These results support that poorer reproductive performance of sows after short lactations is at least partly due to reduced LH release at the first post-weaning estrus. Kirkwood et al. (1984) concluded that the prolonged weaning to remating interval experienced following short lactations may be due to a slower recovery of the hypothalamic/pituitary unit in terms of GnRH and LH stores and/or to a lower sensitivity/responsiveness of the hypothalamic/pituitatary unit.

Progesterone concentrations in the progesterone treated sows were as high as 1.5 ng/ml at estrus, whereas the control sows all had progesterone levels below 1 ng/ml. This indicates that the level of progesterone needed to delay the onset of estrus may need to be maintained at a higher threshold than anticipated for the 3 to 5 d period. The delivery method may also need to be evaluated in order to provide a sustained P4 release. A single injection appears to be incapable of sustaining an anestrous state, nor was it able to alter levels or patterns of LH secretion.

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Table 1. Effect of Treatment on WEI (d)

Treatment	LS Mean WEI (S.E.)	WEI Range	WEI Mode	Number Anestrous
P_4	6.74 (0.70)	4-12	4	2
Control	6.05 (0.66)	3-14	7	0

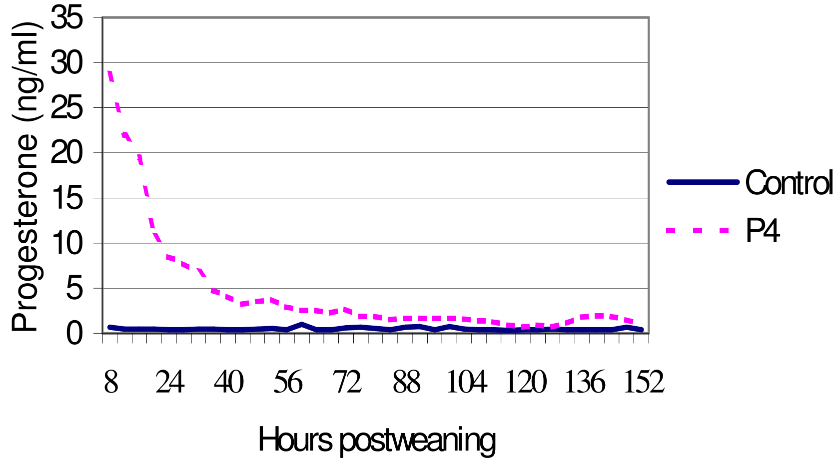

Figure 1. Mean Serum Progesterone Concentration by Treatment Over Time