# The Effect of Lactation Dietary Protein on the Reproductive Performance of Early and Conventionally Weaned Primiparous Sows

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## Introduction

The use of segregated early weaning to develop high health status pigs is becoming increasingly common in the swine industry. Based on 1995 USDA statistics, 31.4% of the pigs in the U.S. were weaned at 10 to 20 days of lactation (Swine '95). Early weaning (≤17 day lactation) provides health status benefits that result in improved pig growth performance, and also allows sows to be cycled through the production system faster (more litters/sow/year). However, early weaning can have some potential consequences in terms of reproductive efficiency of the sow. The incidence of increased weaning to estrus intervals, postweaning anestrus, decreased farrowing rate and decreased litter size become more frequent the earlier sows are weaned. These potential disadvantages need to be weighed against the potential increase in the number of litters/sow/year and improved health and growth rate of the pigs produced.

The objectives of this study were to determine the impact of two management practices: 1) weaning age and 2) lactation dietary crude protein level on sow feed intake, body weight change, backfat change, litter weaning weight, follicular development, uterine histology and hormone concentrations in the hypothalamus and pituitary.

## Materials and Methods

Forty-two European Landrace x (Duroc x Large White) first parity sows were fed either a high protein (HP, 21.5% crude protein and 1.2% lysine) or low protein (LP, 14.4% crude protein and 0.7% lysine) diet during lactation. The LP diet is an average protein diet, approximately meeting NRC requirements. Sows were either early weaned (EW, 8-17 days) or conventionally weaned (CW, 20-31 days). Sow lactation feed intake, weight change, 10th rib backfat change and litter weaning weights were recorded. Serum samples were collected at 2 day intervals postweaning via jugular venipuncture with the final sample being drawn preslaughter. Sows were slaughtered on either day 4, 6 or 8 postweaning (PW) and the hypothalamus, pituitary, adrenal glands, uterus and ovaries were recovered for examination. Four early weaned sows (15-17 day lactation) were slaughtered at 15 days postweaning (30-32 days postpartum) to serve as controls for comparisons in uterine histology between the early and conventionally weaned sows. Serum samples from the control sows were collected on days 6, 8, 11, 13 and 15 postweaning.

Ovaries were examined for corpora lutea, follicle numbers, and follicle sizes. Uteri were weighed, length was measured, and 3 samples per uterine horn were sectioned, stained and fixed for histological examination (slides are currently being evaluated). Hypothalami were homogenized and assayed for β-endorphin, corticotropin releasing factor (CRF) and gonadotropin-releasing hormone (GnRH). Concentration of progesterone in the serum samples was determined by radioimmunoassay.

## Results and Discussion

The effects of diet and weaning treatment on sow performance are given in Table 1. As expected, early weaning significantly reduced sow lactation weight loss (5.6 vs. 30.4 lb., P<.05), backfat loss (.04 vs. .15 in., P<.05), and litter weaning weight (76.9 vs. 138.4 lb., P<.05). Even though CW sows lactated for only about twice as long as EW sows (average lactation of 26 vs. 12 days), weight loss of CW sows was 5 times greater than EW sows. This indicates the majority of this weight loss occurred during the third and forth week of lactation for CW sows. Backfat loss was negatively correlated with lactation length (r = -.62, P<.01, Figure 1) and with litter weaning weight (r = -.64, P<.01, Figure 2). Lactation length was highly positively correlated with litter weaning weight (r = .85, P<.01, Figure 3). Thus, longer lactation lengths resulted in greater litter weights at the expense of increased sow body weight loss and backfat loss. However, even at long lactation lengths (28-31 days), the maximum backfat loss was only 0.24 inches. This suggests that diet nutrient density, sow feed intake and other management factors adequately prevented excessive body condition loss.

The effects of diet and weaning treatment on sow reproductive parameters are given in Table 2. Uterine weights of CW sows decreased at a greater rate and to a lower weight by day 8 postweaning than EW sows (Figure 4, P<.02). When uterine weights are plotted by day postpartum, the reason for this difference is evident (Figure 5). CW sows had more time for uterine involution during lactation and had lighter uteri than EW sows postweaning. Uterine weight was negatively correlated with lactation length (r = -.35, P<.02). Most uterine weight loss occurred during the first 7 days postpartum and then continued slowly to about 28 days postpartum. Total uterine length was correlated with uterine weight (r = .63, P<.01), but not with lactation length (r = -.23, P=.13).

Involution of the uterus of the sow, which requires approximately 18 to 21 days to be completed, is a gradual process that is necessary to provide a receptive endometrium for implantation of the blastocysts and for the proper levels of uterine secretory proteins to be present in the uterine fluid. It has been suggest that incomplete uterine involution may result in a ‘patchy’ uterus that has a limited area suitable for implantation. This would limit the space available for implantation, causing increased embryonic/fetal mortality and a subsequent reduction in litter size. However, embryonic survival may be more complex. Pope et al. (1990) has suggested that some embryos get a developmental head start and create a uterine microenvironment which spreads and results in the death of the less developed blastocysts. This diversity in developmental state may be partially due to the fact that ova are ovulated asynchronously.

There were no diet or weaning treatment effects on average follicle size (P>.27). Sows EW tended to develop fewer (16.4 vs. 19.1) total follicles compared to CW sows (P<.17). Increased dietary crude protein during lactation tended to increase the number of follicles (P<.18) and had a greater impact on CW (17.2 vs. 22.2) than on EW (15.8 vs. 16.5) sows. Sows on the HP diet had more total follicles than those on the LP diet (18.1 vs. 16.3), but this trend was reversed for EW sows on day 6. Previous studies have found no significant effect of lactation length on ovulation rate.

However, Tonn et al. (1994) found that sows weaned at 5 to 11 days had lower ovulation rates as compared to sows weaned at 23 to 31 days of lactation (15.9 vs. 24.0 ova). Our preliminary data also support a potential negative effect of short lactation lengths on the number of follicles developed by primiparous sows. However, since most of our sows were slaughtered prior to ovulation, we cannot confirm an effect of lactation length on ovulation rate. Early weaning may affect final follicular maturation (which is luteinizing hormone (LH) dependent), since 10 to 21 day lactations versus 35 day lactations have been shown to result in decreased amplitude of preovulatory LH surges (Kirkwood et al., 1984).

During most of lactation, the endocrine system of the sow is in a refractory state in which the ability of the hypothalamus (part of the brain) to secrete GnRH is reduced. This results in low levels of the gonadotropins, luteinizing hormone and follicle stimulating hormone, and suppression of follicular growth and ovulation. This refractory state is gradually overcome and pre-ovulatory sized follicles begin to develop. Sows weaned during the early stages of this refractory state will often have a prolonged anestrus period, decreased fertility and smaller litters. Current research involving hormonal treatments to avoid the problems associated with weaning during this refractory feedback period has yielded some promising results (Britt et al., 1997).

Dietary crude protein had no effect (P>.40) on hypothalamic GnRH concentration. However, early weaning tended to extend the time to peak GnRH concentrates by 2 days postweaning compared to CW sows (d 6 vs. d 4 PW, P<.13). The concentration of GnRH in the hypothalamus during lactation remains constant, and only the rate of secretory granule synthesis, transport and secretion changes. GnRH concentration in the hypothalamus begins to increase within 2.5 days postweaning and builds prior to ovulation (Cox and Britt, 1982). Conventionally weaned sows may have recovered more from the refractory feedback state since they had increased GnRH concentrates more quickly postweaning than EW sows.

β-endorphin and CRF are compounds made in the hypothalamus that are often released in response to stress. Both of these compounds are known to have negative effects on the reproductive system of the sow. The concentrations of β-endorphin and CRF in the hypothalami of EW and CW sows were highly variable and showed no clear relationship with respect to day postweaning. Early weaned sows did not have greater concentrations of β-endorphin or CRF postweaning compared to CW sows. This suggests early weaning was not a long term stressor. CRF concentration in the hypothalamus was positively correlated with β-endorphin concentration (r = .50, P<.01) and was negatively correlated with total number of follicles (r = -.40, P<.01). However, high concentrations of GnRH were positively correlated with high concentrations of β-endorphin postweaning (r = .60, P<.01).

Progesterone levels did not differ (P>.30) between the two weaning treatments on any day postweaning. Sows with greater than 0.6 ng/ml of serum progesterone consistently had ovulation points on some of their follicles upon examination of their ovaries. Even though there were fewer CW than EW sows (12 vs. 26), a higher percentage of CW sows had ovulated prior to slaughter (33.3% vs. 11.5%, respectively). This may reflect a greater level of recovery of the hypothalami of CW sows from the refractory state and a quicker return to final follicular maturation and subsequent ovulation postweaning.

## Application

Increased dietary crude protein during lactation increased the total number of follicles and early weaning tended to reduce total follicles by approximately 2, indicating both management practices can potentially affect sow reproductive performance. Conventional weaning resulted in a greater sow weight and backfat loss but also greater litter weaning weights. CRF and β-endorphin levels in the hypothalamus postweaning did not suggest that early weaning was a long term stressor. A more rapid increase in GnRH concentrations postweaning in CW sows suggests they may have been better prepared to resume follicular maturation and subsequent ovulation. The potential loss in reproductive efficiency of the early weaned sow should be weighed against the benefits in pig output when choosing a weaning age.

## Acknowledgments

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Table 1. Effect of lactation dietary crude protein concentration and weaning age on sow performance.

| | EW | | CW | | ANOVA[a,b] |
|---|---|---|---|---|---|
| | LP | HP | LP | HP | |
| No. of Sows | 13 | 13 | 6 | 6 | |
| Days Lactation | 12.2±3.5 | 11.7±3.1 | 26.5±3.7 | 26.2±3.9 | Wean[a] |
| No. of Pigs Nursed | 10.0±1.5 | 9.5±1.3 | 10.0±1.1 | 10.5±2.4 | ns |
| Sow Weight Change (lb) | -7.1±26.3 | -3.1±17.8 | -35.0±14.4 | -26.0±9.3 | Wean[a] |
| Sow Backfat Change (in) | -0.03±0.04 | -0.06±0.08 | -0.15±0.04 | -0.15±0.02 | Wean[a] |
| Sow Backfat Postweaning (in) | 0.79±0.21 | 0.70±0.19 | 0.65±0.10 | 0.56±0.06 | Wean[a], Diet[a] |
| No. of Pigs Weaned | 8.9±1.8 | 9.1±1.4 | 9.5±1.0 | 8.8±1.3 | ns |
| Litter Weaning Weight (lb) | 74.6±26.9 | 78.4±14.9 | 150.5±7.6 | 124.3±27.9 | Wean[a] |
| ADFI Week 1 (lb) | 9.0±1.7 | 9.0±1.6 | 11.2±1.7 | 9.5±1.2 | Wean[b] |
| ADFI Week 2 (lb) | 13.0±1.8 | 12.6±1.9 | 12.5±4.5 | 10.7±1.5 | ns |
| ADFI Week 3 (lb) | | | 13.7±1.2 | 12.2±2.1 | ns |
| ADFI Week 4 (lb) | | | 14.1±2.1 | 12.2±3.5 | ns |
| Lysine Intake (g/day) | 30.7±5.3 | 58.6±9.0 | 40.9±5.5 | 60.7±6.3 | Diet[a] |

[a] These effects were significant at P<.05.

[b] These effects were trends at P<.10.

Table 2. Effect of lactation dietary crude protein concentration and weaning age on sow reproductive parameters.

| | EW | | CW | | ANOVA [a,b,c] |
|---|---|---|---|---|---|
| | LP | HP | LP | HP | |
| Total No. of Follicles | | | | | |
| d4 PW | 17.0±1.8 | 23.5±2.9 | 19.0±2.8 | 26.5±3.5 | |
| d6 PW | 16.2±8.2 | 11.6±5.2 | 14.0±0.0 | 17.0±0.0 | |
| d8 PW | 14.3±1.5 | 15.8±5.6 | 18.5±3.5 | 20.5±10.6 | |
| Mean | 15.8±5.0 | 16.5±6.7 | 17.2±3.2 | 22.2±7.0 | DPW[a],<br>Diet*DPW[a] |
| Number of Follicles of Each Size (mm), for d4, d6, and d8 Postweaning Combined | | | | | |
| 4 mm | 4.3±3.8 | 6.2±6.2 | 9.0±0.0 | 5.0±4.0 | ns |
| 5 mm | 6.3±4.6 | 6.0±5.5 | 3.4±3.4 | 16.7±10.7 | DPW[a],<br>Wean* DPW[a] |
| 6 mm | 2.0±1.4 | 2.4±1.9 | 2.7±1.2 | 2.8±1.5 | ns |
| 7 mm | 2.3±1.6 | 2.0±1.4 | 4.3±3.9 | 2.3±2.3 | ns |
| 8 mm | 4.5±4.3 | 3.5±2.8 | 3.5±3.0 | 3.5±2.1 | ns |
| 9 mm | 6.0±7.1 | 8.5±3.5 | 5.0±1.4 | 3.0±0.0 | ns |
| Weighted Mean Follicle Size | 5.9±1.5 | 5.9±1.4 | 6.6±1.2 | 5.5±1.1 | Wean*DPW[b] |
| Uterus Weight (g) d4, d6, d8 Postweaning | | | | | |
| d4 PW | 614±48 | 659±106 | 609±94 | 711±239 | |
| d6 PW | 644±220 | 560±193 | 525±140 | 287±176 | |
| d8 PW | 407±105 | 524±79 | 346±95 | 433±212 | |
| Mean | 587±173 | 579±141 | 493±148 | 477±252 | Wean[a], DPW[a] |
| GnRH Conc. (pg/g) d4, d6, d8 Postweaning | | | | | |
| d4 PW | 56.5±40.4 | 38.5±28.6 | 85.8±12.0 | 82.5±98.3 | |
| d6 PW | 86.3±48.6 | 62.4±25.4 | 31.5±6.4 | 72.5±41.7 | |
| d8 PW | 52.8±25.2 | 54.7±38.7 | 45.5±21.9 | 36.5±10.6 | |
| Mean | 65.2±38.8 | 52.5±29.1 | 54.2±27.6 | 63.8±52.6 | ns |
| CRF Conc. (pg/g) | 4.3±1.6 | 3.71±1.5 | 5.0±1.8 | 3.8±2.7 | ns |
| β-Endorphin Conc. (pg/g) | 13.4±4.0 | 12.8±3.0 | 14.0±3.7 | 14.0±6.9 | ns |

[a] These effects were significant at P <.05.

[b] These effects were trends at P <.10.

[c] DPW = Days postweaning.

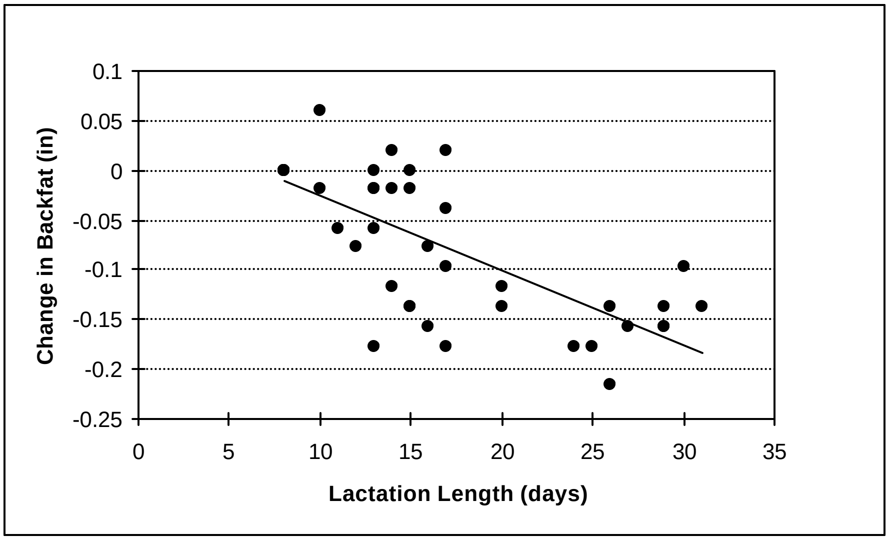

Figure 1. Change in 10th rib backfat vs. lactation length.

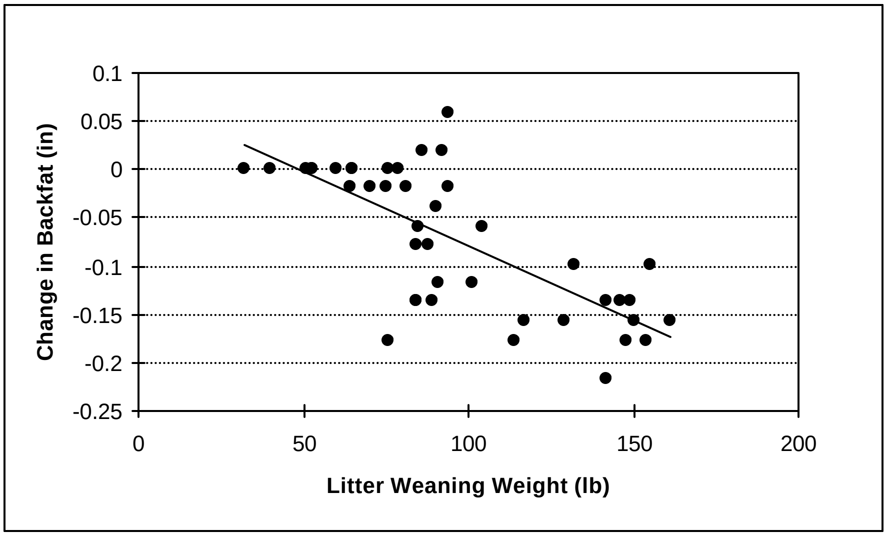

Figure 2. Change in 10th rib backfat vs. litter weaning weight.

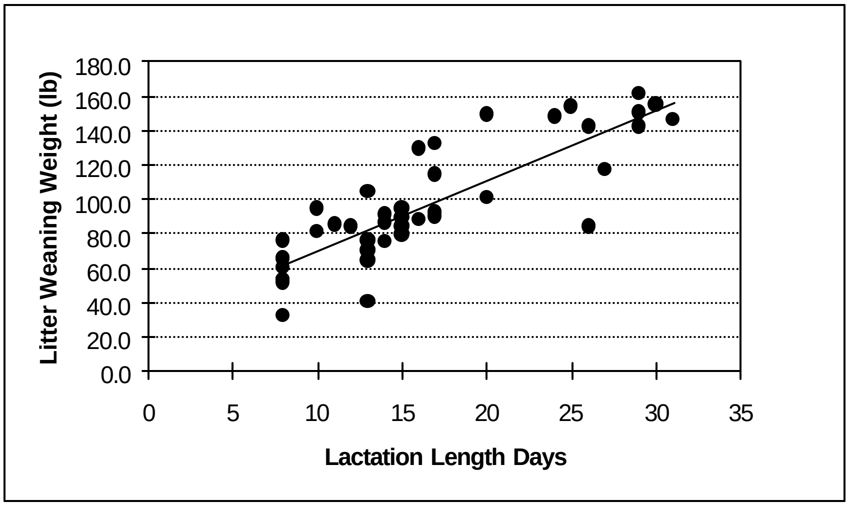

Figure 3. Litter weaning weight vs. lactation length.

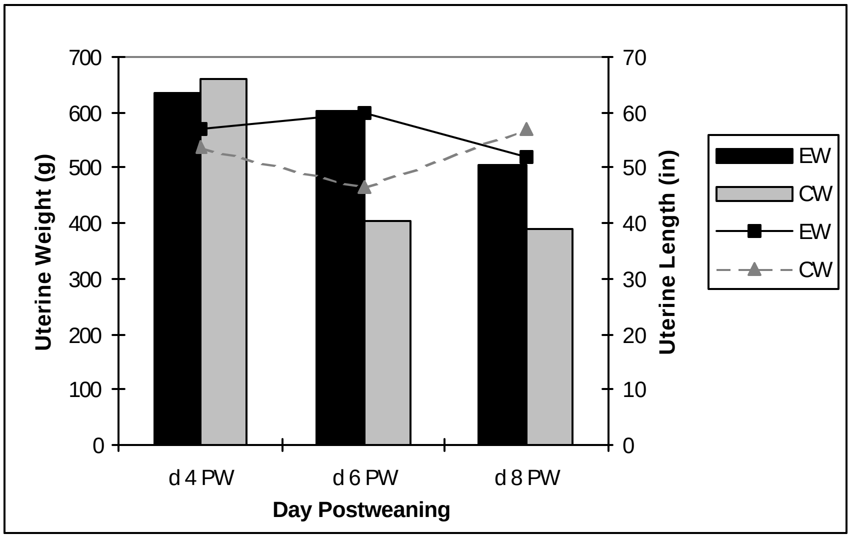

Figure 4. Uterine weight (bars) and uterine length (lines) by day postweaning.

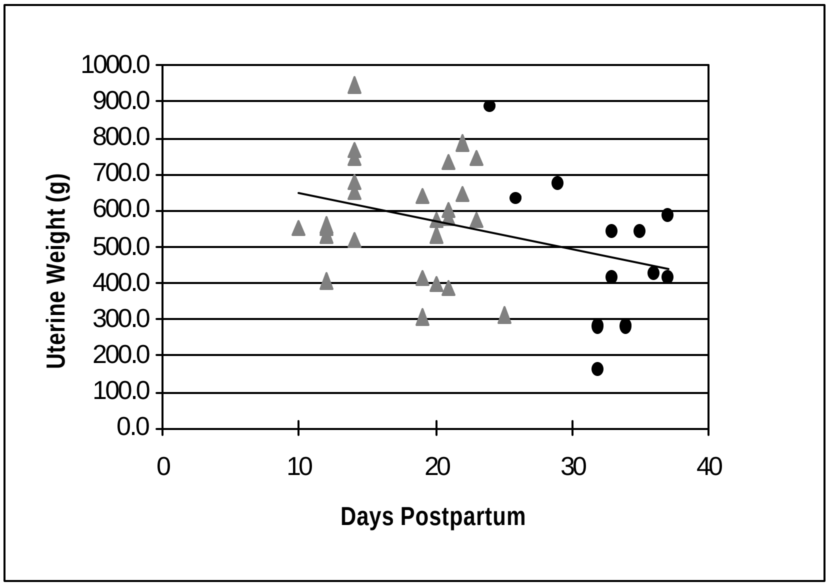

Figure 5. Uterine weight of early weaned (triangles) and conventionally weaned (circles) sows by day postpartum.