Acta vet. scand. 1991, *32,* 35–45.

Effect of Fractionated Weaning on Hormonal Patterns and Weaning to Oestrus Interval in Primiparous Sows

By *T. Rojkittikhun, S. Rojanasthien, S. Einarsson, A. Madej* and *N. Lundeheim*

Department of Obstetrics and Gynaecology, Department of Clinical Chemistry, and Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Rojkittikhun, T., S. Rojanasthien, S. Einarsson, A. Madej and N. Lundeheim: Effect of fractionated weaning on hormonal patterns and weaning to oestrus interval in primiparous sows. Acta vet. scand. 1991, 32, 35–45. – The effect of weaning the 4–5 heaviest piglets in the litter on day 33 of lactation and the remainder 2 days later (fractionated weaning) on plasma levels of prolactin, cortisol, oestradiol-17β (E_2), progesterone (P_4) and LH, as well as on the weaning to oestrus interval in primiparous sows was studied. Twelve crossbred sows were grouped into 6 pairs according to farrowing date and litter size. The litter of 1 sow in each pair (F) was weaned in 2 stages, and the other conventionally weaned at 35 days (C). Blood samples were collected via a permanent jugular vein catheter every 3 h from 9 a m to 9 p m daily throughout the experimental period, and intensively at 15 min intervals for 12 h on the day of first and final weaning and for 6 h on the day after each weaning. All sows were slaughtered following their first post-weaning oestrus and the reproductive organs were macroscopically examined.

Lactational oestrus was not observed in any of the sows. Sows from 5 out of 6 pairs showed oestrus within 8 days of weaning and post-mortem examination showed normal ovulation. There was a tendency for the F sows to have a shorter weaning to oestrus interval, as compared with the C sows (5 of 6 pairs, 4.8 days v 5.6 days). The plasma levels of prolactin around weaning were not significantly different between the 2 groups. Within 6 h after final weaning, the prolactin concentrations decreased gradually from 7.6 and 8.7 to 1.6 and 1.7 μg/l in the control and treatment groups, respectively. The plasma levels of cortisol, showing a diurnal rhythm (with the lowest level at 6 and/or 9 p m), did on no occasion differ between the 2 groups. On the day of final weaning, no diurnal rhythm was observed, with cortisol remaining high at 6 and 9 p m. The plasma levels of E_2 and P_4 were low until final weaning in both groups. After final weaning the E_2 levels rose faster in the F sows than in the C sows, to 44.3 and 34.8 pmol/l, respectively, on day 2 ($p < 0.01$). No significant differences in levels of plasma LH and the number of LH pulses were observed between the groups. After final weaning the average and base levels of LH and the number of LH pulse(s) increased significantly.

prolactin; cortisol; oestradiol-17β; LH.

Introduction

Sows are generally anoestrus during lactation (*Burger* 1952). After a lactation period of 4 to 8 weeks, oestrus usually occurs within 1 week of weaning. The weaning to oestrus interval is longer in primiparous sows than in multiparous sows (*Einarsson & Settergren* 1974, *Benjaminsen & Karlberg* 1981). The effect of suckling and weaning on reproductive performance and hormonal patterns in sows have been extensively studied. Suckling inhibits the synthesis and release of LH by suppressing the hypothalamic release of GnRH, thereby limiting follicular development (*Crighton & Lamming* 1969, *Stevenson et al.* 1981, *Cox & Britt* 1982a). Weaning results in a rapid decline of the blood concentrations of prolactin and in an increase in LH levels (*Edwards & Foxcroft* 1983, *Shaw & Foxcroft* 1985). However, recent studies have demonstrated that lactational oestrus or shorter weaning to oestrus intervals can be induced when the nursing patterns of pigs are altered or disrupted during lactation (e.g. *Britt & Levis* 1982, *Henderson & Hughes* 1984, *Newton et al.* 1987). Reducing the litter size several days before weaning (*Stevenson & Britt* 1981, *Stevenson & Davis* 1984), or weaning some of the heaviest piglets several days earlier (fractionated weaning) (*Cox et al.* 1983, *Kunavongkrit et al.* 1985, *Riley et al.* 1985) has been found to shorten the interval to oestrus after final weaning. *Cox et al.* (1983) were able to increase significantly the percentage of primiparous sows in oestrus within 10 days of weaning by weaning the heaviest half of the litter 2 days earlier than the rest of the piglets. *Kunavongkrit et al.* (1985) demonstrated that weaning the heaviest piglets first and leaving the 5 lightest piglets for 7 days, before final weaning on day 35 of lactation in primiparous sows, produced an increase in LH activity after the first weaning in 2 out of 4 sows and a tendency towards a shorter weaning to service interval. The knowledge of the influence of fractionated weaning on hormonal patterns and reproductive performance in primiparous sows is, however, very limited.

The objective of the present study was to investigate the effect of fractionated weaning on reproductive performance and hormonal patterns in primiparous sows.

Materials and methods

Experimental animals

Twelve crossbred (Swedish Landrace × Swedish Yorkshire) primiparous sows were brought to the Department of Obstetrics and Gynaecology 3–4 weeks before expected farrowing and grouped into 6 pairs. Farrowing dates for sows within a pair did not differ by more than 1 week, and the litter size did not differ by more than 2 piglets, with a minimum of 8 piglets remaining at 4 weeks. The number of piglets nursing each sow was adjusted to uniform size within 24–48 h after birth. The sows were housed in individual pens, in the same stable as the boar pens, throughout the experimental period. The animals were fed according to the Swedish breeding stock standard (*Göransson* 1984). Jugular vein catheterization (*Rodriguez & Kunavongkrit* 1983) was performed under general anaesthesia during the fourth week of lactation. One sow from each pair was randomly allocated to treatment (F), which consisted of weaning the heaviest half of the litter (H) on day 33 (day-2) of lactation and the lighter piglets (L) 2 days later. Depending on the number of piglets (n) from the treatment sows, the number of piglets weaned at the first weaning was (n-1)/2 or n/2 in the odd or even-numbered litter, respectively. The 6 control sows (C) were conventionally weaned on 35 days (day 0). Sows were weighed on the third day after farrowing and again after all the piglets in their litters had been weaned. Starting after the first weaning, oestrous detection was performed in the presence of a boar twice daily. Ovarian status was examined by laparoscopy on day 14 after final weaning in sows which failed to show oestrus (*Wildt et al.* 1973, *Kunavongkrit et al.* 1984a). All sows were slaughtered following their first post-weaning oestrus, or 21 days after weaning if they had not shown oestrus by then. The reproductive organs were macroscopically examined 1 h after slaughter.

The weight of each piglet was recorded on the day before the first weaning (day-3) and on the seventh day after the final weaning (day 7). Piglet weight gain during 10 days after the first weaning was statistically evaluated.

Blood collection and hormonal analysis

Blood samples were collected daily at 9 a m, 12 a m, 3 p.m, 6 p m and 9 p m from day 30 of lactation until slaughter. Frequent blood sampling at 15 min interval was done for 12 h on the day of first and final weaning (6 h before and after weaning) and for 6 h on the day after each weaning and thereafter every 7 days throughout the experiment. During the period of standing oestrus, blood samples were collected every 3 h until the signs of oestrus subsided. All samples were collected in heparinized tubes which were immediately centrifuged and the plasma was stored in plastic tubes at –20°C until assay.

The blood samples taken 5 times daily were analysed for the concentrations of progesterone (P_4) (*Bosu et al.* 1976), oestradiol-17β (E_2) (*Boilert et al.* 1973) and cortisol (*Nyberg et al.* 1988). All samples were analysed for concentrations of LH (*Stupnicki & Madej* 1976) and prolactin (*Gromadzka-Ostrowska et al.* 1985, *Algers et al.* 1991). The methods used for P_4, E_2 and LH analysis have previously been validated in the porcine species (*Kunavongkrit et al.* 1983).

The sensitivity of the assay systems to P_4, E_2, cortisol, LH and prolactin were 1.0 nmol/l, 20.6 pmol/l, 4.5 nmol/l, 0.2 µg/l and 0.5 µg/l, respectively. The inter-assay variations for P_4, E_2, cortisol, LH and prolactin were 10.3 and 7.9, 16.9 and 18.6, 13.8 and 9.2, 16.5 and 12.6 and 26.2 and 10.6 %, respectively, for low and high assay controls. The intra-assay variations for E_2, cortisol, LH and prolactin were less than 10 % in the working ranges between 36.9–133.3 pmol/l, 38.9–110.0 nmol/l, 0.5–26.2 µg/l and 6.4–29.5 µg/l, respectively. The average LH level was defined as the mean of the values obtained from the frequent samples. The LH base level was defined as the mean plus one standard deviation of the values obtained from the frequent samples excluding the pulse(s) of LH. The LH pulse was defined as 2 or more consecutive values above the base level plus 1 standard deviation.

Statistical analysis

Data were analysed by least-squares analysis of variance using the General Linear Model procedure (*SAS Institute Inc.* 1985).

The statistical model for analysing the differences between treatment and control in average levels of LH, based on individual recordings (from 15-min samplings), included the following effects: Treatment (2 levels), sow within treatment (6+6 sows), period (six 6 h periods, 6 h before and after the first and the final weaning and 6 h on the day after each weaning), hours within period (6 h) and the interaction between treatment and period. The above model was also used for analysis of base levels of LH and number of LH pulse(s) during the 6 h periods after exclusion of the effect of sampling hour.

Two statistical models were used for analysing the differences within pair of sows (treatment-control), including the following effects: One model for E_2, cortisol and prolactin: pair of sows (6 pairs), date (8 days, day-5 to day 2), sampling hour (9 a m and 9 p m for E_2; 9 a m, 12 a m, 3 p m, 6 p m and 9 p m for cortisol and prolactin) and the interaction between date and sampling hour. The other model for prolactin collected every 15 min: pair of sows (6 pairs), date (2 days, day-2 and day 0), sampling hour (four 1-h periods, 1 h before and 3 h after each weaning).

The statistical model for analysing the differences between the weights of the piglets from the different treatment sows included the following effects: pair of sows (6 pairs), treatment (2 levels), weight group of piglets (2 levels, heaviest 50 % and lightest 50 % within litter) and the interaction between treatment and group.

Results

Reproductive performance

The clinical data for the sows are shown in Table 1. None of the sows showed oestrus during lactation. Sows from 5 out of 6 pairs exhibited their first oestrus within 8 days of the final weaning. The mean number of corpora lutea were 18.2 and 17.0 in the F and C sows, respectively. The sows submitted to fractionated weaning tended to have a shorter weaning to oestrus interval than the control sows (5 of 6 pairs, 4.8 days v 5.6 days), but the differences were not statistically compared because of the small number of sows. In 1 pair of sows, no signs of oestrus were seen within 21 days of final weaning and laparoscopic examination at 2 weeks after weaning only revealed growing follicles in their ovaries.

Hormonal patterns

Prolactin. The peripheral plasma concentrations of prolactin from the daily samplings and from the frequent samplings are presented in Fig. 1 and Fig. 2 A & 2 B, respectively. Plasma prolactin concentrations during late lactation (d-5 to d-3), around the first weaning (d-2 to d-1) and the final weaning (d 0 to d 1), were not significantly different between the groups. Within 6 h of

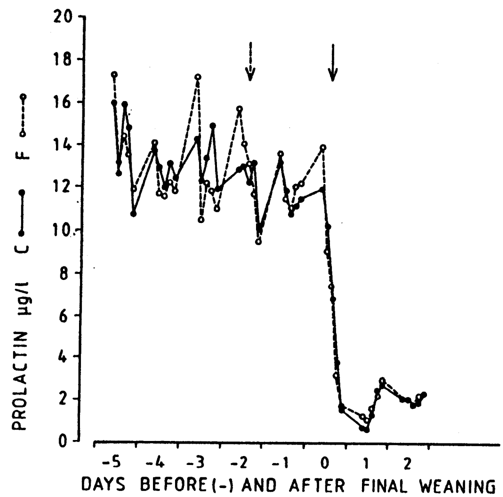

Figure 1. Peripheral plasma concentrations of prolactin around weaning in the F (○---○) and C (●——●) groups. Samples were collected 5 times daily. Arrows indicate first (dashed arrow) and final (solid arrow) weaning.

Table 1. Effect of fractionated weaning on the reproductive performance of the sows.

Group	F*	C*
No. of sows	6	6
No. of weaned piglets	9.7 (8–11)	9.5 (8–12)
Weaning to oestrus interval (days)**	4.8 (3–8)	5.6 (4–8)
No. of corpora lutea per sow**	18.2 (16–20)	17.0 (14–22)
Weight loss during lactation (kg)	17.0 (6–47)	26.2 (10–40)

* F = Fractionated weaning, C = Conventional weaning.

** One pair of sows was excluded as none of the sows had shown signs of oestrus by day 21 after weaning.

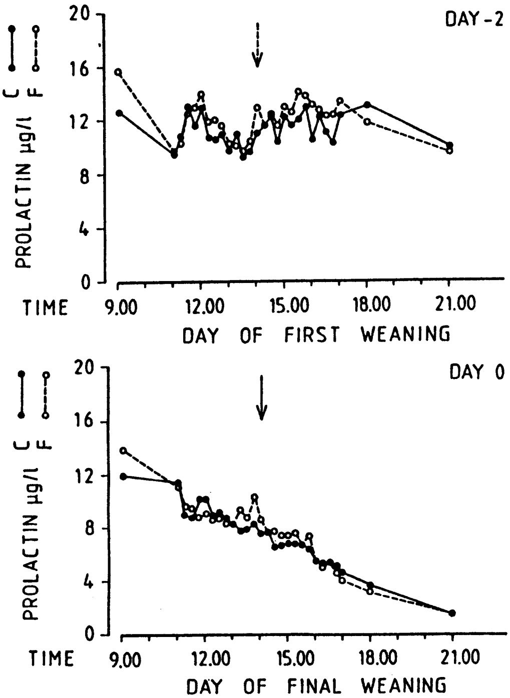

Figure 2 (A-B). Peripheral plasma concentrations of prolactin around weaning on day –2 and day 0 in the F (○- - -○) and C (●——●) groups. Samples were frequently collected at 15 min intervals. Arrows indicate first (dashed arrow) and final (solid arrow) weaning.

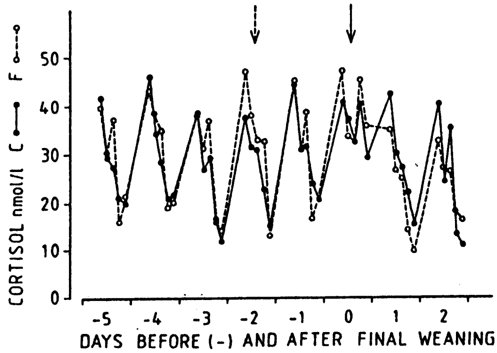

Figure 3. Peripheral plasma concentrations of cortisol around weaning in the F (○- - -○) and C (●——●) groups. Arrows indicate first (dashed arrow) and final (solid arrow) weaning.

weaning, the plasma prolactin concentrations gradually decreased from 7.6 and 8.7 to 1.6 and 1.7 µg/l in the control and treatment groups, respectively.

Cortisol. The plasma levels of cortisol showed a diurnal rhythm and the concentrations did on no occasion differ between the 2 groups (Fig. 3). On the day of final weaning, no diurnal rhythm was observed, with cortisol levels remaining high at 6 and 9 p m (4 and 7 h after final weaning, respectively).

Progesterone. The progesterone concentrations were low until final weaning in both groups of sows (Fig. 4).

Oestradiol-17β. Before final weaning the E_2 concentrations were low and did not differ significantly between the groups (Fig. 4). After final weaning, the E_2 concentrations in the F group rose faster, and was significantly higher on day 2 ($p < 0.01$), than in the C group.

LH. The average and base levels of LH and the number of LH pulse(s)/6 h from the frequent samplings are presented in Table 2. There were no significant differences in plasma LH levels and number of pulses between

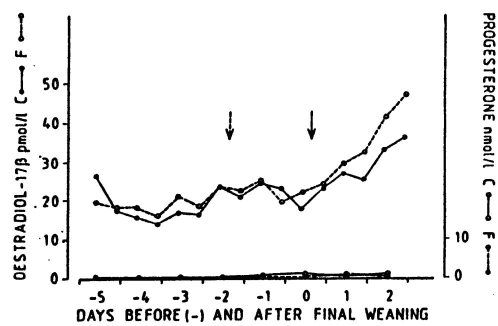

Figure 4. Peripheral plasma concentrations of oestradiol-17β and progesterone around weaning in the F (○- - -○) and C (●——●) groups. Arrows indicate first (dashed arrow) and final (solid arrow) weaning.

Table 2. Average and base levels of LH and number of LH pulse(s)/ 6 h obtained from frequent samples taken for 6 h periods (P). P1 and P2 = 6 h periods before and after the first weaning, P3 = 6 h period on the day after the first weaning (W_{first}), P4 and P5 = 6 h periods before and after the final weaning (W_{fin}), P6 = 6 h period on the day after the final weaning.

	6 h P1	W_{first} 6 h P2	6 h P3	6 h P4	W_{fin} 6 h P5	6 h P6
	D-2		D-1	D 0		D 1
			Average LH level (µg/l)			
F	0.69^{a}	0.71^{ab}	0.70^{a}	0.68^{a}	0.74^{b}	0.82^{c}
C	0.70^{a}	0.72^{a}	0.65^{b}	0.56^{c}	0.73^{ade}	0.77^{e}
			Base level of LH (µg/l)			
F	0.66^{ab}	0.65^{ab}	0.67^{ab}	0.65^{a}	0.68^{ab}	0.77^{b}
C	0.67^{ab}	0.67^{ab}	0.64^{ab}	0.57^{a}	0.68^{ab}	0.75^{b}
			No. of LH pulse(s)/6 h			
F	1.5^{a}	1.8^{a}	2.2^{a}	1.5^{a}	2.5^{ab}	3.3^{b}
C	1.5^{a}	2.0^{a}	1.7^{a}	1.5^{a}	2.3^{a}	3.7^{b}

Values within rows without a common superscript are significantly different.

the groups around weaning. Marked increase of the levels and in the number of pulses was detected 1 day after final weaning in both groups.

Piglet body weight changes

The body weight of the piglet recorded on the day before the first weaning (W1) and on the seventh day after the final weaning (W2) is presented in Table 3. The mean initial

Table 3. Effect of fractionated weaning on piglet weight changes within 10 days of the first weaning.

Treatment[1]	Group[2]	n	Piglet body weight, kg[3,4] W1	Piglet body weight, kg[3,4] W2	Weight gains by 10 days after the 1st weaning, kg[3,4]
F	H	27	9.8 ± 0.2^{a}	13.1 ± 0.3^{a}	3.3 ± 0.2^{a}
F	L	31	8.0 ± 0.2^{b}	11.7 ± 0.3^{b}	3.7 ± 0.2^{a}
C	H	27	11.0 ± 0.2^{c}	14.6 ± 0.3^{c}	3.6 ± 0.2^{a}
C	L	30	9.2 ± 0.2^{d}	12.7 ± 0.3^{a}	3.5 ± 0.2^{a}

1) F = Fractionated group, C = Control group.
2) H = Heavy group, L = Light group.
3) LS mean ± standard error.
4) Values within column with different superscript differ significantly.
W_1 = weight on the day before the first weaning.
W_2 = weight 10 days after the first weaning.

weight was significantly higher for the piglets from C sows than from F sows, for both heavy and light groups. The heavy piglets gained as much weight as the light piglets in both groups of sows.

Discussion

The present study demonstrated that weaning the heaviest half of the litter 2 days before final weaning on day 35 of lactation in primiparous sows resulted in a tendency towards a shorter weaning to oestrus interval in the F sows, compared with the C sows. The absence of an obvious shortening of the interval from weaning to oestrus in fractionated sows, as found here, is inconsistent with results found in some earlier studies (e.g. *Cox et al.* 1983, *Stevenson & Davis* 1984). This discrepancy may be due to any of the following factors.

Number of remaining piglets: *Stevenson & Britt* (1981) found that sows nursing 3 piglets during the last 5 days before weaning showed oestrus approximately 3 days earlier than sows nursing either 8 or 13–14 piglets. Reducing the litter size to 2–4 piglets 5 days before weaning at 2, 3 or 4 weeks resulted in 44 % of the sows showing oestrus on the day of weaning and more sows were in oestrus in 0–3 days after weaning, compared to control sows weaned at 5 weeks (*Stevenson & Davis* 1984). *Kunavongkrit* (1984) also reported that primiparous sows nursing 2–4 piglets during a 5-week lactation period had a shorter interval from weaning to oestrus than sows nursing 7 or more piglets. It therefore seems likely that the number of remaining piglets (4–6) in our study was still large enough to provide sufficient suckling stimulus to inhibit the onset of cyclic ovarian activity.

Length of lactation. From the study of *Stevenson & Davis* (1984), reducing the litter 5 days before final weaning after 2 or 3 weeks of lactation tended to improve the oestrous response, compared with the same treatment at 4 weeks. *Riley et al.* (1985) also demonstrated that the interval from weaning to service remained similar in the fractionated group, but decreased in the control group as the lactation period went on for more than 21 days. A contributing factor to the small difference in weaning to oestrus interval between the C and F sows in the present study may thus be the length of the lactation period (5 weeks) which resulted in a short weaning to oestrus interval in the C sows.

Time interval between initial and final weaning: *Kunavongkrit et al.* (1985) were not able to demonstrate a significant reduction in the interval from weaning to service by weaning the heaviest piglets (2–8 piglets) 7 days before the 5 remaining piglets on day 28 of lactation. *Cox et al.* (1983) reported that weaning half of the litter 2 days before final weaning increased the percentage of primiparous sows in oestrus within 10 days of weaning (77 %), compared with 5 days (58 %) and 0 days (51 %). Our results did not show a clear reduction of the post-weaning oestrus interval in the F sows compared with the C sows. It seems likely that for a 5-week lactation period, weaning half of the litter either 7 days or 2 days earlier does not reduce the post-weaning oestrus interval in primiparous sows, compared to conventional weaning. The optimum time between the 2 weanings that could potentially reduce the interval from weaning to oestrus is still to be determined.

The prolactin concentrations did not change after the first weaning, but gradually decreased to basal levels within 6 h of the final weaning in both the control and the treatment group. The decline in prolactin after final weaning confirms the results of previous studies (*van Landeghem & van de*

Wiel 1978, *Kirkwood et al.* 1984, *Shaw & Foxcroft* 1985). Weaning some of the heaviest piglets a few days before final weaning thus had no influence on the pattern of plasma prolactin. This indicates that the remaining 4–6 piglets were enough to stimulate the release of prolactin during lactation. The peripheral prolactin concentrations did not decrease even in lactating sows showing ovulatory oestrus when given GnRH in pulsatile administration during the fourth week of lactation (*Rojkittikhun et al.* 1991). Prolactin does not seem to interfere with the action of exogenously administered GnRH on the pituitary gland, as evidenced by LH release or on the subsequent ovarian response, as lactating sows can ovulate following GnRH treatment (*Bevers et al.* 1981, *Cox & Britt* 1982b, *Rojanasthien et al.* 1987, 1988). The role of prolactin in the hypothalamus as a factor evoking lactational anoestrus in sows remains to be considered.

In both groups of sows, cortisol concentrations showed a diurnal rhythm except for the day of final weaning. The diurnal rhythm found in this study is similar to the one described in boars (*Edqvist et al.* 1980) and also corresponds to the pattern observed in lactating sows (*Kunavongkrit et al.* 1984b). The lack of a diurnal rhythm on the day of final weaning, which to our knowledge has not been reported earlier, may reflect physiological and/or psychic stress in the sows due to distended udders and/or the emotional effect of the absence of their piglets. Weaning half of the litter did not seem to affect the sows, as the diurnal rhythm did not change after the first weaning.

The plasma concentrations of E_2 were low in both groups until final weaning, thereafter they rose faster in the F sows than in the C sows. The faster increase of E_2 levels after final weaning indicates a comparatively faster follicular development in these sows. Measurement of E_2 levels in utero-ovarian blood (*Rojanasthien* 1988), might have revealed an occurrence of follicular development following the first weaning in the F sows.

The peripheral LH concentrations and the number of LH pulses were low before final weaning and increased significantly 1 day after final weaning in both groups of sows. The low LH activity during lactation found in this study is in agreement with previous studies (*Shaw & Foxcroft* 1985, *Foxcroft et al.* 1987, *Rojanasthien* 1988). Reducing the number of suckling piglets 2 days before weaning had no significant effect on the average and base levels of LH or the number of LH pulses. *Kunavongkrit et al.* (1985), on the other hand, demonstrated an increase in LH activity after the first weaning in 2 out of 4 sows submitted to fractionated weaning. The fast-rising E_2 levels and a tendency towards a shorter weaning to oestrus interval in the treatment group in the present study were not preceded by any changes in LH levels after the first weaning. However, a longer period of frequent blood collection after the first weaning might have revealed changes even in the LH pattern.

It can be concluded that the fractionated weaning technique, as performed in this experiment, resulted in a small difference in the interval from weaning to first oestrus compared with conventional weaning. No differences in prolactin, cortisol, progesterone or LH patterns were observed between the F and the C sows. Oestradiol-17β rose faster after weaning in the F sows than in the C sows.

Acknowledgements
This work was supported by grants from the Swedish Council for Forestry and Agricultural Research. NIDDK and NHPP, University of Maryland, School of Medicine, USA, are acknowledged for providing USDA-pLH-I-1 and USDA-pPRL-

I-1. The authors wish to thank Prof. Lars-Erik Edqvist for fruitful discussion and criticism and the Faculty of Veterinary Medicine, Kasetsart University, Thailand, for granting T. Rojkittikhun study leave and salary.

References

Algers B, Madej A, Rojanasthien S, Uvnäs-Moberg K: Quantitative relationships between suckling-induced teat stimulation and the release of prolactin, gastrin, somatostatin, insulin, glucagon and VIP in sows. Vet. Res. Comm. 1991 (accepted for publication).

Benjaminsen E, Karlberg K: Postweaning oestrus and luteal function in primiparous and pluriparous sows. Res. vet. Sci. 1981, *30,* 318–322.

Bevers MM, Willemse AH, Kruip ThAM, van de Wiel DFM: Prolactin levels and the LH-response to synthetic LH-RH in the lactating sow. Anim. Reprod. Sci. 1981, *4,* 155–163.

Boilert B, Edqvist L-E, Johansson EDB, Lindberg P, Martinsson K: The influence of conjugated oestrogens in radioimmunoassays using different antibodies against oestradiol-17β. Steroids 1973, *22,* 891–894.

Bosu WTK, Edqvist L-E, Lindeberg P, Martinsson K, Johansson EDB: The effect of various dosages of lynestrol on the plasma levels of oestrogens and progesterone during the menstrual cycle in the rhesus monkey. Contraception 1976, *13,* 677–684.

Britt JH, Levis DG: Effect of altering suckling intervals of early-weaned pigs on rebreeding performance of sows. Theriogenology 1982, *18,* 201–207.

Burger JF: Sex physiology of pigs. Onderstepoort J. vet. Res. 1952, *25* (Suppl. 2), 3–218.

Cox NM, Britt JH: Relationships between endogenous gonadotropin-releasing hormone, gonadotropins, and follicular development after weaning in sows. Biol. Reprod. 1982a, *27,* 70–78.

Cox NM, Britt JH: Pulsatile administration of Gonadotropin Releasing Hormone to lactating sows: Endocrine changes associated with induction of fertile estrus. Biol. Reprod. 1982b, *27,* 1126–1137.

Cox NM, Britt JH, Armstrong WD, Alhusen HD: Effect of feeding fat and altering weaning schedule on rebreeding in primiparous sows. J. Anim. Sci. 1983, *56,* 21–29.

Crighton DB, Lamming GE: The lactational anoestrus of the sow: The status of the anterior pituitary-ovarian system during lactation and after weaning. J. Endocr. 1969, *43,* 507–519.

Edqvist L-E, Einarsson S, Larsson K, Lundström K: Diurnal variations in peripheral plasma levels of testosterone, androstenone and cortisol in boars. Acta vet. scand. 1980, *21,* 451–453.

Edwards S, Foxcroft GR: Endocrine changes in sows weaned at two stages of lactation. J. Reprod. Fert. 1983, *67,* 161–172.

Einarsson S, Settergren I: Fertility and culling in some pig breeding herds in Sweden. Nord. Vet.-Med. 1974, *26,* 576–584.

Foxcroft GR, Shaw HJ, Hunter MG, Booth PJ, Lancaster RT: Relationships between luteinizing hormone, follicle-stimulating hormone and prolactin secretion and ovarian follicular development in the weaned sows. Biol. Reprod. 1987, *36,* 175–191.

Gromadzka-Ostrowska J, Madej A, Barcikowski B: Peripheral plasma prolactin concentrations during oestrus cycles in different types of primitive gilt. J. Reprod. Fert. 1985, *73,* 159–164.

Göransson L: Förslag till ny utfodringsnorm till suggor. (Feeding recommendation for sows). Fakta Husdjur, Sveriges Lantbruksuniversitet, Sweden, 1984, No. 3.

Henderson R, Hughes PE: The effects of partial weaning, movement and boar contact on the subsequent reproductive performance of lactating sows. Anim. Prod. 1984, *39,* 131–135.

Kirkwood RN, Lapwood KR, Smith WC, Anderson IL: Plasma concentrations of LH, prolactin, oestradiol-17β and progesterone in sows weaned after lactation for 10 and 35 days. J. Reprod. Fert. 1984, *70,* 95–102.

Kunavongkrit A: Clinical and endocrinological studies in primiparous post partum sows: Effect of lactation length and litter size. Acta vet. scand. 1984, *25,* 260–279.

Kunavongkrit A, Kindahl H, Andersson A-M: Laparoscopy in post partum sows with special emphasis on the effects of uterine manipulation on the release of prostaglandin $F_{2\alpha}$. Res. Vet. Sci. 1984a, *36,* 66–70.

Kunavongkrit A, Kindahl H, Madej A: Clinical and endocrinological studies in primiparous zero-weaned sows: 2. Hormonal patterns of normal cycling sows after zero weaning. Zbl. Vet. Med. A 1983, *30,* 616–624.

Kunavongkrit A, Madej A, Einarsson S: Plasma levels of cortisol in zero-weaned and lactating sows during the first two weeks post partum. Dom. Anim. Endocr. 1984b, *1,* 217–223.

Kunavongkrit A, Rojanasthien S, Ogle RB: Effect of fractionated weaning on hormonal patterns and weaning to oestrus interval in sows. Swedish J. agric. Res. 1985, *15,* 39–44.

Newton EA, Stevenson JS, Minton JE, Davis DL: Endocrine changes before and after weaning in response to boar exposure and altered suckling in sows. J. Reprod. Fert. 1987, *81,* 599–609.

Nyberg L, Lundström K, Edfors-Lilja I, Rundgren M: Effect of transport stress on levels of cortisol, corticosteroid binding globulin (CBG) and glucocorticoid receptors in pig with different halothane genotypes. J. Anim. Sci. 1988, *66,* 1201–1211.

Riley JE, Edwards SA, Simmins PH, Shepherd CM, Brade MA: The effects of fractionated weaning on sow productivity. Proc. 2nd Int. Conf. Pig. Reprod. 1985, Columbia, U.S.A. (Abstract), p. 71.

Rodriguez H, Kunavongkrit A: Chronic venous catheterization for frequent blood sampling in unrestrained pigs. Acta vet. scand. 1983, *24,* 318–320.

Rojanasthien S: LH-patterns in jugular plasma and oestradiol-17β and progesterone levels in utero-ovarian and jugular plasma of primiparous sows around weaning. J. vet. Med. 1988, *35,* 498–505.

Rojanasthien S, Einarsson S, Kindahl H, Edqvist L-E, Lundeheim N: Clinical and endocrine responses to pulsatile administration of Gonadotropin-releasing Hormone (GnRH) treatment during lactation in primiparous sows. Anim. Reprod. Sci. 1988, *177,* 123–140.

Rojanasthien S, Madej A, Lundeheim N, Einarsson S: Luteinizing hormone response to different doses of synthetic gonadotropin-releasing hormone during early and late lactation in primiparous sows. Anim. Reprod. Sci. 1987, *13,* 299–307.

Rojkittikhun T, Rojanasthien S, Edqvist L-E, Einarsson S: Plasma prolactin during pulsatile administration of GnRH and oestrus in lactating sows. Anim. Reprod. Sci. 1991, *24,* 355–360.

SAS Institute Inc.: SAS User's Guide. SAS Institute Inc., Cary, N. C. 1985, pp. 433–506.

Shaw HJ, Foxcroft GR: Relationships between LH, FSH and prolactin secretion and reproductive activity in the weaned sows. J. Reprod. Fert. 1985, *75,* 17–28.

Stevenson JS, Britt JH: Interval to oestrus in sows and performance of pigs after alteration of litter size during late lactation. J. Anim. Sci. 1981, *53,* 177–181.

Stevenson JS, Cox NM, Britt JH: Role of the ovary in controlling luteinizing hormone, follicle stimulating hormone, and prolactin secretion during and after lactation in pigs. Biol. Reprod. 1981, *24,* 341–353.

Stevenson JS, Davis DL: Influence of reduced litter size and daily litter separation on fertility of sows at 2 to 5 weeks postpartum. J. Anim. Sci. 1984, *59,* 284–293.

Stupnicki R, Madej A: Radioimmunoassay of LH in blood plasma of farm animals. Endokrinologie 1976, *68,* 6–13.

van Landeghem AAJ, van de Wiel DFM: Radioimmunoassay for porcine prolactin: Plasma levels during lactation, suckling and weaning and after TRH administration. Acta endocr. 1978, *88,* 653–667.

Wildt DE, Fujimoto S, Spencer JL, Dukelow WR: Direct ovarian observation in the pig by means of laparoscopy. J. Reprod. Fert. 1973, *35,* 541–543.

Sammanfattning

Effekten av fraktionerad avvänjning på hormonmönstret och intervallet från avvänjning till brunst hos ungsuggor.

Effekten av avvänjning av de 4–5 tyngsta smågrisarna i kullen på dag 33 av diperioden och de återstående 2 dagar senare på blodplasmakoncentrationerna av prolaktin, kortisol, 17β-östradiol (E_2), progesteron (P_4) och LH samt intervallet från avvänjning till brunst studerades hos ungsuggor. Tolv korsningssuggor grupperades i 6 par efter grisningsdatum och kullstorlek. Kullen till en sugga i varje par (F) avvandes i 2 etapper och kullen till den andra suggan på konventionellt sätt på dag 35 (C). Blodprov togs via permanent jugularven dagligen var 3:e timme från kl. 09.00 till kl. 21.00 under hela experimentperioden, var 15:e minut under 12 timmar dag 33 och dag 35 samt under 6 timmar dag 34 och dag 36. Suggorna slaktades efter första brunsten och könsorganen obducerades.

Ingen sugga visade brunst under diperioden. Alla suggor i 5 av 6 par visade brunst och ovulerade inom 8 dagar efter avvänjningen. Det fanns en tendens till kortare intervall hos F-suggorna än hos C-suggorna (5 av 6 par; 4,8 respektive 5,6 dagar). Prolaktinkoncentrationerna var inte signifikant skilda mellan de 2 grupperna. De sjönk från 7,6 och 8,7 till 1,6 och 1,7 ug/l i C- respektive F-gruppen inom 6 timmar efter avvänjningen. Kortisolkoncentrationen visade en signifikant dygnsvariation (lägst koncentration kl. 18.00 och/eller kl. 21.00). Avvänjningsdygnet (dag 35) observerades ingen dygnsvariation av kortisol. E_2 och P_4 var låga fram till avvänjningen (dag 35) i båda grupperna. Efter avvänjningen steg E_2-koncentrationen snabbare hos F- än hos C-suggorna (44,3 och 34,8 pmol/l på dag 2 hos F- respektive C-suggorna, $p < 0,01$). Inga signifikanta skillnader påvisades i LH-nivåerna eller antalet LH-peakar mellen de 2 suggrupperna. Efter avvänjningen steg såväl basala LH-nivåerna som antalet LH-peakar signifikant.

(Received February 6, 1990; accepted March 19, 1990).

Reprints may be requested from: T. Rojkittikhun, Department of Obstretrics and Gynaecology,
P. O. Box 7039, Faculty of Veterinary Medicine,
Swedish University of Agricultural Sciences, S-750 07 Uppsala, Sweden.