Postweaning growth check in pigs is markedly reduced by intermittent suckling and extended lactation

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ABSTRACT: The objective of this study was to determine whether intermittent suckling (IS) combined with an extended lactation can reduce postweaning growth check in pigs. Three weaning regimens (conventional weaning (CW), IS with 6-h separation intervals (IS6), and IS with 12-h separation intervals (IS12)) were compared. In CW (n = 17 litters), litters had continuous access to the sow until weaning (d 21, d 0 = farrowing). In IS6 and IS12, litters were separated from the sow for 12 h/d, beginning at d 14 and lasting until weaning (d 41 to 45). Litters were with the sow from 1400 to 2000 and from 0200 to 0800 (IS6, n = 14) or between 2000 and 0800 (IS12, n = 14). Litter size was standardized within 2 d after farrowing by crossfostering, resulting in an average litter size of 10.9 ± 1.8 piglets. Piglets had ad libitum access to creep feed from d 7 onward. One week after the onset of IS (d 20), creep feed intake was increased in litters from both IS groups compared with CW litters (P < 0.05). Both IS groups consumed considerable amounts of creep feed before weaning (d 41 to 45). Total feed intake before weaning was greater (P = 0.004) in IS12 (3,808 ± 469 g/piglet) than in IS6 (2,717 ± 404 g/piglet). In comparison, CW litters consumed 18 ± 9 g/piglet before weaning (d 21). Irrespective of weaning regimen, total feed intake of litters before weaning was highly correlated with postweaning feed intake (P < 0.001). Furthermore, in all treatment groups, total preweaning feed intake was correlated with postweaning growth (P < 0.10). Irrespective of treatment, piglets suckling anterior teats grew faster than piglets suckling middle or posterior teats during the first 2 wk of lactation. Body weights at the end of the experiment (d 55) were similar among weaning regimens. Onset of IS induced a growth check in both IS groups (34% for IS12 and 22% for IS6). Only a mild growth check was observed after weaning of IS litters (14% for both IS groups). However, a serious growth check (98%) was observed after weaning of CW litters. Results of the current study indicate that IS stimulated feed intake during lactation, providing a more gradual transition to weaning. Because the IS6 regimen did not prevent the growth check after the onset of IS and is rather laborious, we suggest that IS12 might be preferable for a practical implementation of IS.

Key words: feed intake, growth, intermittent suckling, lactation, pig, weaning

INTRODUCTION

In European, conventional pig husbandry, piglets are usually weaned at 3 to 4 wk of age. Weaning is associated with an abrupt dietary change, transport, altered housing, and mixing with unfamiliar pen mates. As a result, weaning is associated with reduced nutrient intake, reduced growth, and a greater susceptibility to diarrhea (van Beers-Schreurs et al., 1992; Nabuurs, 1998).

To familiarize piglets with creep feed before weaning, it is often provided during lactation. Piglets consuming an average of 610 g of creep feed during lactation had an improved performance after weaning (d 28) compared with control piglets without creep feed supplementation during lactation (English et al., 1980). However, creep feed intake during lactation is usually low and highly variable between and within litters (Pajor et al., 1991).

Intermittent suckling (IS, separation of sow and piglets during a fixed period of the day) stimulates creep
Animals, Housing, and Diet

In addition, IS mimics the increasing amount of time spent away from the piglets, when sows themselves can control contact with their piglets (Boe, 1991; Weary et al., 2002). Although creep feed intake during lactation is increased by IS, a total feed intake at weaning (d 25) of 600 g/piglet is accomplished in only a proportion (60%) of the litters (Kuller et al., 2004a). Onset of IS reduces piglet growth and results in lower weaning weights (Kuller et al., 2004a). In addition to IS, extending the lactation length might increase preweaning feed intake.

The aim of the current study was to determine whether combining IS with an extended lactation results in a less severe growth check at weaning. Intermittent suckling was applied in 2 regimens, with separation intervals of 6 or 12 h, both with a total separation time of 12 h/d, and compared with a conventional weaning regimen. It was anticipated that dividing the total separation time over 2 intervals might prevent the reduced growth normally seen after the onset of IS, while still stimulating creep feed intake.

MATERIALS AND METHODS

Animals, Housing, and Diet

The Ethical Committee of Wageningen University and Research Center approved the experimental design, including all procedures involving animals.

The experiment was conducted in 3 batches, between March and December 2004, at De Haar Research Farm (Wageningen University and Research Centre, the Netherlands). Forty-seven multiparous sows (TOPIGS 40-line, TOPIGS, the Netherlands) were used in 3 batches, consisting of 15, 15, and 17 sows. Sows were randomly selected from a breeding farm and had a parity ranging from 3 to 9. Sows were mated at the experimental farm and individually housed in the same room during gestation. One litter in batch 1 was omitted from data analysis due to the sow’s low milk production, which resulted in severe weakness of the piglets in the second week of lactation. Another sow, in batch 2, was weaned within 2 d after farrowing, also because of low milk production, and her piglets were distributed across other litters of that batch. This resulted in a final number of 14, 14, and 17 sows in batches 1, 2, and 3, respectively.

Three weeks before farrowing, pregnant sows were individually housed in farrowing pens (2.15 × 2.25 m), consisting of 4.39 m² of concrete floor and 0.45 m² of slatted floor. Two weeks before the expected day of farrowing, sows were provided with an intravascular catheter for another study under local (batch 1) or general (batch 2 and 3) anesthesia. From a few days before farrowing until weaning, sows were placed in farrowing crates (2.15 × 1.00 m) within the farrowing pen to prevent crushing of the piglets. Each morning, the pen was cleaned and enriched with wood shavings. A heated area was provided for the piglets by an infrared light from birth until d 10, and by floor heating. Artificial lighting was provided between 0800 and 2000 and was dimmed during the night.

Litter size at birth varied from 4 to 18 live piglets and was standardized within 2 d after farrowing by crossfostering within each batch, resulting in an average litter size of 10.9 ± 1.8 piglets. One day after farrowing, piglets had their BW determined and were given an ear tattoo. Within 3 d of farrowing, piglets received an i.m. iron injection (Prevan 200, Eurovet Animal Health, Bladel, the Netherlands). Males were not castrated. Within each batch, the beginning of the experimental procedure (d 0) was designated as the day on which most of the litters were born. Litters were born from 2 d before to 3 d after d 0.

All piglets were offered creep feed ad libitum from d 7 onward. Creep feed was offered in a piglet feeder, with 2 feeding places (d 7 to 13, 7 cm/feeding place; d 13 onward, 15 cm/feeding place). From d 7 until 29, a milk-based commercial creep feed was offered (11.44 MJ of NE/kg; 19% milk products; CP, 17.8%; 1.25% Lys, as-fed basis; Speen Select, Rijnvallei, the Netherlands). From d 31 until the end of the experiment on d 55, a commercial creep feed for weaner pigs was offered (9.94 MJ of NE/kg; 5% milk products; CP, 17.9%; 1.16% Lys, as-fed basis; Babybiggenkorrel®, Rijnvallei, the Netherlands). During a 2-d transition period (d 29 to 31), the 2 diets were mixed (1:1) to produce a gradual transition to the new diet. During the entire experiment, piglets had ad libitum access to drinking water, which was provided by 1 nipple per pen. Sows were fed an increasing amount of feed after farrowing until reaching the maximal allowance of 1% of BW plus 0.5 kg per piglet on d 11.

Treatments

Sows in each batch were allocated according to parity and BW to 1 of 3 weaning regimens: conventional weaning (CW), IS with 12-h intervals (IS12), and IS with 6-h intervals (IS6); litters receiving different treatments were housed in separate rooms.

In CW litters (n = 17 litters), piglets had continuous access to the sow during a lactation period of 3 wk (d 0 to 21); CW litters were weaned on d 21, but the piglets remained in the farrowing pen until d 41. In IS litters, piglets had continuous access to the sow during the first 2 wk of lactation (d 0 to 14), and intermittent access from d 14 until weaning. In both IS groups, piglets had access to the sow for a total time of 12 h/d, but the distribution of these hours differed: in IS12 litters (n = 14), access to the sow was during a continuous period from 2000 to 0800; in IS6 litters (n = 14), access to the sow was from 1400 to 2000 and from 0200 to 0800. During separation from the litter, sows were housed individually in a different room. At night, during the return of IS6 sows to their litter, lights were on in all rooms. Weaning of IS litters occurred between d 41 and 45 of lactation (d 43 ± 1 on average).
At weaning (IS) or on d 41 (CW), each litter was moved from their farrowing pen to a fattening pen with a 2.63-m² slatted and 2.45-m² concrete floor. Litters remained in the fattening pens until the end of the experiment (d 55). Two IS litters were weaned earlier than scheduled; 1 IS12 litter due to a rectal prolapse of the sow on d 27 and 1 IS6 litter due to mastitis of the sow on d 37. For both of these litters, all data were included in the data analysis, except for the data obtained after weaning for the litter weaned at 27 d.

Measurements

All piglets were weighed 1 d after farrowing, and on d 7, 13, 16, 20, 23, 27, 34, 41, and 55 of the experiment. Piglets in the IS treatments were also weighed at weaning (W), and at 2 d (W2) and 6 d (W6) after weaning. Piglets in the CW treatment were moved to fattening pens at d 41, and weighed 2 (W2) and 6 d (W6) after moving. Creep feed residuals were determined simultaneously with BW of the piglets and on d 29 before transition of the creep feed diet. In case of moisture in creep feed residuals, DM percentage of the residuals was determined and creep feed intake was calculated.

During the first 2 wk of lactation, teat order was assessed for each litter because it might affect weight gain of piglets during lactation. Furthermore, we hypothesized that IS might have various effects on growth of the piglets with a different teat order. Therefore, teat order was used as a covariate during statistical analysis. In accordance with Kim et al. (2000), teat order was defined as the specific teat (pair) nursed by each piglet with respect to the anatomical location of the nursed mammary gland. Piglets were marked with a number on the back, and the position at the udder was recorded for each piglet during 3 suckling bouts on each of d 6 and 9 (6 observations total). Based on the preferred teat pair suckled by the piglets, a distribution of teat order in 3 classes was made: anterior (teat pairs 1 and 2), middle (teat pairs 3, 4, and 5), and posterior (teat pairs 6 and 7).

Calculations

Cumulative feed intake at each time was calculated by summing the total feed intake of the previous times. Missing values (<2.5% of observations, and all before d 29) were estimated based on interpolation of the ADFI of the litter at the previous and next time. This estimation resulted in a deviation of 4.3 ± 3.2% when differences between estimated and observed values on d 27 were expressed as a percentage of the total feed intake on d 29. Cumulative feed intake was analyzed using the procedures described below for daily feed intake.

Growth check was defined as the reduction in ADG directly after the beginning of IS (d 14) or weaning. The growth check was calculated 2 d after the beginning of IS (d 14) and after weaning (d 41 to 45) in IS litters, and 2 d after weaning (d 21) in CW litters. The relative growth check (%) was calculated as: 100[(ADGbefore − ADGafter)/ADGbefore].

Statistics

Unless stated otherwise, data are presented as means ± SE. Normally distributed data were analyzed using the GLM procedure (SAS Inst. Inc., Cary, NC). Although litter was considered to be the experimental unit, all data were expressed per piglet. Effects were considered significant if P < 0.05; for posthoc testing, Bonferroni’s procedure was used.

Because feed intake in the first 3 wk (i.e., until d 23) were not normally distributed, they were analyzed using a nonparametric Kruskal-Wallis test. When this test detected an overall treatment effect, treatments were compared pairwise. From d 27 onward, feed intake was normally distributed and was analyzed using the following model:

\[ Y_{ijk} = \mu + T_i + B_j + A_k + BW_1 + LS27 + e_{ijk}, \]

where \( Y_{ijk} \) = ADFI per piglet in a weighing interval, \( \mu \) = the overall mean, \( T_i \) = treatment, \( B_j \) = batch, \( A_k \) = age on d 0, \( BW_1 \) = BW 1 d after farrowing, \( LS27 \) = litter size on d 27, and \( e_{ijk} \) = residual error.

Data for BW and growth before weaning (IS) or moving (CW) were analyzed using the following model:

\[ Y_{ijklmn} = \mu + T_i + B_j + S_k(T_i \times B_j) + A_L + G_m + TO_n + BW1 + e_{ijklmn}, \]

where \( Y_{ijklmn} \) = piglet BW or ADG in a weighing interval, \( \mu \) = the overall mean, \( T_i \) = treatment, \( B_j \) = batch, \( S_k(T_i \times B_j) \) = sow nested within treatment and batch, \( A_L \) = age on d 0, \( G_m \) = sex, \( TO_n \) = teat order, \( BW1 \) = BW 1 d after farrowing, and \( e_{ijklmn} \) = residual error. The effect of treatment was tested against \( S_k(T_i \times B_j) \) as the error-term.

Piglet BW and ADG from weaning (IS) or moving to fattening pens (CW) onward were analyzed using the following model:

\[ Y_{ijkl} = \mu + T_i + B_j + S_k(T_i \times B_j) + G_1 + WA + BW1 + e_{ijkl}, \]

where \( Y_{ijkl} \) = piglet BW or ADG in a weighing interval, \( \mu \) = the overall mean, \( T_i \) = treatment, \( B_j \) = batch, \( S_k(T_i \times B_j) \) = sow (nested within treatment and batch), \( G_1 \) = gender, \( WA \) = age at weaning, \( BW1 \) = weight 1 d after farrowing, and \( e_{ijkl} \) = residual error. The effect of treatment was tested against \( S_k(T_i \times B_j) \) as the error-term.

Correlations were calculated with Pearson correlation coefficients using SAS.

RESULTS

Feed Intake

Creep feed intake in the second week of lactation, before onset of IS, was negligible. One week after the
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Figure 1. Average daily feed intake of piglets per treatment until (A) and after (B) d 27 of the experiment. a–cWithin each experimental period, differences between treatments ($P < 0.05$) are indicated with different superscripts above the bars. The experiment began on d 0; intermittent suckling began on d 14. The conventional weaning (CW) litters were weaned on d 21, and intermittent suckling (IS) litters were weaned between d 41 and 45. IS12 = intermittent suckling with 12-h intervals; IS6 = intermittent suckling with 6-h intervals; W = Weaning of the IS treatments; W2 = 2 d after moving (CW, d 41) or weaning (IS); W6 = 6 d after moving (CW, d 41) or weaning (IS). Note differences between vertical scales between (A) and (B).

beginning of IS (d 20), creep feed intake was greater in IS than in CW litters (Figure 1A; $P < 0.05$). Weaning (d 21) increased feed intake in CW litters and resulted in a greater feed intake compared with IS litters from

1 wk after weaning CW (d 27) until weaning (d 41 to 45) of IS litters (Figure 1A and 1B; $P < 0.01$). Feed intake was greater for IS12 litters than IS6 litters, but this difference only became significant just before weaning (d 41; Figure 1B; $P < 0.001$) lasting until just after weaning (W2, $P = 0.006$).

Cumulative feed intake was variable among litters, regardless of weaning regimen (Figure 2). In the CW treatment, cumulative feed intake before weaning (d
Figure 3. Cumulative feed intake before weaning, in relation to average daily feed intake (g piglet$^{-1}$d$^{-1}$) after weaning for conventional weaning (CW; A, □) and IS (B, ▲ for IS6 and △ for IS12) litters. IS12 = intermittent suckling with 12-h intervals; IS6 = intermittent suckling with 6-h intervals.

Piglet Performance

The number of piglets treated for illness was similar in all treatments. Piglet mortality was greatest during the first 2 wk of the experiment, before the beginning of the treatments. A small percentage of the total piglet loss consisted of piglets, which were euthanized because of severe locomotor failure or BW loss. Piglet loss from d 14 until the end of the experiment (d 55) was greater in the CW treatment (9%) than in the IS6 treatment (2%; \( P = 0.01 \)); and intermediate in the IS12 treatment (4%). Most of these piglets died between d 13 and 20 with 73, 100, and 67% for CW, IS12, and IS6, respectively.

Piglet BW and growth were similar in all 3 treatments during the first 2 wk of the experiment. However, IS resulted in a reduced growth (d 16) in both IS treatments compared with the unweaned CW litters (Figure 4A; \( P < 0.001 \)). From d 16 to 20, growth of IS litters was still lower than in the unweaned CW litters (\( P < 0.001 \)), and lower in IS12 than in IS6 litters (\( P = 0.04 \)). This decreased growth after IS resulted in a lower BW at d 20 for IS12 and IS6 than for CW (Table 1, \( P < 0.005 \)). However, the relative growth check after the beginning of IS (d 16) (34% for IS12; ranging from 4 to 78%, and 22% for IS6; ranging from −18 to 60%) was much less severe than that observed after (at d 23) weaning of CW litters (98%; ranging from 13 to 170%; \( P < 0.001 \)). In all treatments, the observed growth check was positively correlated with piglet growth in the preceding period (\( r = 0.57, 0.53, \) and 0.48 for IS12, IS6, and CW, respectively; \( P < 0.001 \)); piglets with a greater growth in the preceding period before IS or weaning (CW) suffered a more severe growth check than did piglets with a lower growth.

At the end of lactation (d 41), piglet BW of IS litters did not differ (\( P = 0.25 \)) from that of CW litters (Table 1). Weaning of IS litters resulted in a small growth
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Figure 4. Average daily gain of piglets per treatment until (A) and after (B) d 27 of the experiment. a,b Within each experimental period, differences between treatments (P < 0.05) are indicated with different superscripts above the bars. The experiment began on d 0; intermittent suckling (IS) began on d 14. The conventional weaning (CW) litters were weaned between d 41 and 45. IS12 = intermittent suckling with 12-h intervals; IS6 = intermittent suckling with 6-h intervals; W = Weaning of the IS treatments; W2 = 2 d after moving (CW; d 41) or weaning (IS); W6 = 6 d after moving (CW; d 41) or weaning (IS). Note differences between vertical scales between (A) and (B).

Teat order affected piglet growth only until d 16 of the experiment. In general and regardless of treatment, piglets suckling anterior teats had a greater growth rate than piglets suckling the middle or posterior teats (P < 0.001); piglets suckling the middle teats had a greater growth rate than piglets suckling the posterior teats (P < 0.02). Piglet growth in the second week of lactation was 263.4 ± 6.3, 236.5 ± 5.9, and 211.3 ± 10.8 g/piglet/d for piglets suckling anterior, middle, or posterior teats, respectively. On d 16, piglet growth remained greater for piglets suckling anterior teats (213.8 ± 7.9 g/piglet/d) compared with piglets suckling posterior teats (185.0 ± 14.2 g/piglet/d; P = 0.012). Regardless of treatment, the growth check after IS or weaning (CW) of piglets suckling anterior teats was greater than that of piglets suckling middle teats (P = 0.04).

Relation Between Piglet Feed Intake and Growth

In both IS treatments, feed intake and growth were correlated after the beginning of IS (r = 0.81, P < 0.001 for IS12 and r = 0.54, P = 0.05 for IS6). Interestingly, after onset of IS, the correlation between feed intake and piglet growth was consistently high for IS12 litters (r ranging from 0.81 to 0.93), but lower for IS6 litters during the first 2 wk of IS (r ranging from 0.40 to 0.67) and increased thereafter (r ranging from 0.77 to 0.92). For piglets weaned conventionally, feed intake and growth were highly correlated immediately after weaning (r = 0.90, P < 0.001). Furthermore, the weaning induced growth check of CW litters was negatively correlated to feed intake immediately after onset of IS. Total cumulative feed intake during lactation was correlated to piglet growth directly after weaning both in CW litters (r = 0.59, P = 0.02) and in IS litters (r = 0.83 and P = 0.01 for IS12; r = 0.69 and P = 0.06 for IS6).

| Table 1. Body weight of piglets during lactation and after weaning1 |
|----------------------|-------|-------|-------|-------|
| Day | CW | IS12 | IS6 | SE |
| 13  | 4,011 | 4,135 | 4,111 | 98 |
| 16  | 4,838 | 4,599 | 4,670 | 110 |
| 20  | 6,097 | 5,364 | 5,582 | 109 |
| 27  | 6,736 | 6,981 | 7,426 | 130 |
| 41  | 11,812 | 12,823 | 12,789 | 264 |
| 55  | 21,842 | 23,059 | 22,364 | 479 |

a,bWithin a row, means without a common superscript letter differ (P < 0.05).
1Both IS regimens began on d 14, and IS litters were weaned between d 41 and 45. The CW litters were weaned on d 21.
2CW = Conventional weaning (n = 17); IS12 = intermittent suckling with 12-h intervals (n = 14); IS6 = intermittent suckling with 6-h intervals (n = 14).
3The SE of the mean BW until d 27 was based on 14 litters (IS treatments); on d 41 and 55, it was based on 13 litters (IS12).
The objective of this study was to determine whether IS during extended lactation reduces the postweaning growth check in pigs. This study demonstrates that IS treatment combined with extended lactation, using 6- or 12-h separation intervals, increases feed intake within 1 wk, prevents a severe growth check at weaning, and results in piglet BW at 55 d similar to conventional weaned pigs. In the current study, effects of IS and extended lactation were compared with conventional weaned litters. However, CW litters might have been exposed to less severe stressors at weaning than under practical conditions. For instance, piglets were not mixed or transported at weaning, and transition to the weaner diet occurred only 1 wk after weaning. So, effects of weaning on piglet performance might be even more pronounced under practical conditions than observed in piglets of the CW litters.

Under natural conditions, the weaning process may take 8 to 12 wk. During this period, young piglets make a gradual transition from a diet based on sow’s milk to a nonmilk diet, ultimately achieving nutritional independence from the sow (for review, see Miller and Slade, 2003). This transition coincides with profound changes in intestinal function (for review, see Cranwell, 1995), enabling digestion and absorption of novel food sources. In European conventional pig husbandry, weaning generally takes place around 3 to 4 wk of age. The abrupt change of diet, together with the stressful events associated with weaning, result in a reduced nutrient intake and growth. This leads to dramatic changes in intestinal morphology and function (Hampson and Kidder, 1986; Nabuurs et al., 1993; van Beers-Schreurs et al., 1998) and predisposes piglets to an increased morbidity and mortality. Increased feed intake levels before weaning partially prevented the degeneration of the structure (Nabuurs et al., 1993) and the impaired functioning of the gut (Nabuurs et al., 1996; Kuller et al., 2004b) that are normally associated with weaning. Consistent with previous studies, preweaning feed intake in all treatments of the current study was quite variable (Barnett et al., 1989; Pajor et al., 1991) and highly correlated to postweaning feed intake (Bruininx et al., 2002). Conventional weaned piglets, however, had a very low creep feed intake before weaning, and they suffered from a severe growth check after weaning. In contrast, all IS litters consumed a considerable amount of creep feed before weaning and showed only a mild growth check after weaning. In fact, the preweaning feed intake level of IS litters was correlated to postweaning performance directly after weaning, which is in line with previous findings (Kuller et al., 2004a). The importance of preweaning feed intake has also been reported by English et al. (1980), who observed that a substantial creep feed intake (610 g/piglet) during a 28-d lactation improved growth and feed intake levels after weaning compared with control piglets without supplementary feeding during lactation. Indeed, in the current study this threshold was amply exceeded during lactation (d 41) by all IS litters, except for 1 IS6 litter. Our results suggest that IS during an extended lactation provides both a trigger to stimulate feed intake and a gradual transition to weaning.

Intermittent suckling had already increased feed intake 1 wk after onset of IS compared with continuously suckled litters, and diminished the number of low uptake piglets, as demonstrated previously (Kuller et al., 2004a). The effect of IS on feed intake before weaning has been studied previously and resulted either in an increased (Smith, 1960; Thompson et al., 1981; Kuller et al., 2004a) or unaltered (Chapple et al., 1989) feed intake. The absence of a positive effect of IS in the latter study might have resulted from low palatability of the creep feed diet (Chapple et al., 1989). Cumulative feed intake of IS12 litters observed in the first 2 wk after IS was in agreement with a previous study (Kuller et al., 2004a) in which IS (12 h/d) was applied during the last 2 wk of a 28-d lactation period. Although the 2 wk with IS increased preweaning total feed intake in the latter study, only 60% of the litters exceeded 600 g/piglet. Extending the lactation period in the current study resulted in a gradual increase of this percentage in IS12 litters to 79% at 5 wk and up to 100% at the end of lactation. Moreover, feed intake levels shortly after weaning (d 41 to 45) were comparable with those of CW litters that had been weaned for 3 wk at that time. These results suggest that IS during a lactation period of 5 wk might be sufficient to improve adaptation to the postweaning situation for the majority of IS12 litters.

In the current study, IS increased feed intake of litters within 1 wk after onset compared with continuously suckled litters. Furthermore, high levels of feed intake were observed in all IS litters before weaning. However, caution must be used to attribute the beneficial effects on postweaning performance in the IS litters entirely to the limited time for sucking. Weaning age itself might also have affected performance after weaning. Pluske et al. (2003) demonstrated that piglets weaned at 2 wk of age have a less developed gastrointestinal tract compared with piglets weaned at 4 wk of age. Moreover, development of the gastrointestinal tract of 2-wk-old weaned piglets might proceed differently after weaning to that of piglets weaned at an older age. Furthermore, 3-wk-old weaned piglets appeared to have a greater reduction in villus height (65%) compared with 5-wk-old weaned piglets (27%), and postweaning recovery to an equivalent villus height took much longer (21 vs. 7 d; Cera et al., 1988). So, the older age at weaning of IS litters compared with CW litters might have resulted in a more advanced development of the gastrointestinal tract at weaning and might have diminished the detrimental effects of weaning on intestinal morphology and function, ultimately leading to a better postweaning performance. Conversely, the beneficial effects observed in this study cannot solely be ascribed to a longer lactation. The difference in feed intake be-
tween IS6 and IS12 litters demonstrates that the IS regimen, and thus limited suckling, also contributed to increased feed intake.

Distributing the total separation time (12 h/d) over two 6-h periods (IS6) resulted in lower feed intake levels during lactation compared with a 12-h period of separation per day (IS12). Despite a lower feed intake, ADG of IS6 litters was greater compared with IS12 litters 1 wk after onset of IS (d 20). These differences were maintained, although not significantly, for up to 3 wk after IS began. This finding suggests that IS6 litters had a greater milk intake compared with IS12 litters. Previous research (Newton et al., 1987a,b) already demonstrated that piglets subjected to IS are capable to compensate for the resulting milk intake deficit in the remaining hours with access to the sow. We estimated (data not presented above) the percentage of feed-derived and milk-derived ADG for IS litters in each weighing interval, using the average gain-to-feed ratio of CW litters between d 27 to 55. Although the percentage of milk-derived ADG decreased gradually during lactation for both IS treatments, it remained greater for IS6 (64%) compared with IS12 (55%) at the end of lactation (d 41), suggesting a greater dependency on milk for IS6 litters compared with IS12 litters. This is also in line with the lower correlation between feed intake and growth in the IS6 litters during the first 2 wk after onset of IS. The correlation between feed intake and growth in IS6 litters became stronger and more comparable to IS12 litters later in lactation. This suggests that the IS6 litters gradually became less dependent on milk intake for their growth, concomitant with a decrease in milk production of the sow as seen in a natural weaning process. In conclusion, distributing the total separation time (12 h/d) over two 6-h periods per day attenuated but did not prevent the decreased growth after onset of IS. Furthermore, IS6 litters remained more dependent on milk intake for their growth, which probably caused the lower feed intake levels during lactation.

Weaning induces a disruption of nutrient intake and thus luminal nutrition, with some piglets beginning to eat dry creep feed not before 50 h postweaning (Bruininx et al., 2001). A continuous supply of nutrients after weaning has been shown to prevent crypt hyper trophy and the decrease of villus height associated with weaning, but only in case this supply was sufficiently high, i.e., by gastric intubation every 3 h (Kelly et al., 1991a,b) or 4 h (van Beers-Schreurs et al., 1998). Because the onset of IS disrupts the continuous supply of nutrients to the small intestine as with weaning, one might suggest that IS also negatively affects intestinal structure or function. Hartke et al. (2005) observed no detrimental effects on intestinal morphology, after a single short-term (6 or 12 h) fasting, but IS piglets in the current study were subjected to repeated nonsuckling periods. Nabuurs et al. (1996), however, demonstrated that 2 wk of IS (8 h/d) without supplementary feeding did not induce changes of intestinal structure or net fluid absorption of the small intestine at weaning (around d 30) in the small intestinal segment perfusion test. Furthermore, in the current study, negative effects of IS (12 h/d) on growth were very mild and short lasting compared with conventional weaning. Interestingly, 2 wk of IS (8 h/d) with supplementary feeding (Nabuurs et al., 1996) resulted in a reduced villus height and net fluid absorption at weaning (around d 30) but partially protected piglets from the decrease in villus height and intestinal net absorption 4 d after weaning compared with piglets from continuously suckled or IS litters without supplementary feeding. Altogether, it appears that IS does not per se negatively affect intestinal structure or function. Moreover, IS with supplementary feeding partially prevents negative effects of weaning on intestinal structure and function.

Weaning age has been reduced to 3 or 4 wk in European conventional pig husbandry. As a result, weaning is associated with reduced nutrient intake, reduced growth and a greater susceptibility for diarrhea (van Beers-Schreurs et al., 1992; Nabuurs, 1998). We demonstrated that extending lactation length in combination with IS (12 h/d) resulted in increased feed intake before weaning, prevented a severe growth check at weaning, and resulted in similar piglet BW at d 55 compared with conventional weaned piglets. This suggests that the combination of IS and extended lactation results in a more gradual transition to weaning. However, practical implication of an extended lactation can only be profitable when the number of litters per sow is not diminished, which requires the onset of cyclicity before weaning. Recent studies demonstrated that IS can induce lactational estrus (Gerritsen et al., 2005a; Langendijk et al., 2005) without affecting pregnancy rate and early embryonic survival at d 23 of gestation (Gerritsen et al., 2005b). Hence, combining IS and extended lactation might be a practical management strategy (improving piglet postweaning performance without compromising sow reproductive performance). Distributing total separation time (12 h/d) over two 6-h separation intervals had no added value; and considering this together with the fact that the IS6 regimen is rather laborious, we conclude that IS12 is the most practical for implementation.

LITERATURE CITED


