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Variation in Piglet Weights: Weight Gains in the First Days After Birth and Their Relationship with Later Performance

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KEYWORDS

piglet, body weight, suckling behavior, agalactia, mortality

ABSTRACT

Piglets from 42 litters of Yorkshire sows were weighed 0, 1, 2, 3, 4, 5, 7, 10, and 14 d after farrowing in order to explore the highly variable weight gains during the first 2 wk after birth. All litters were adjusted to 10-12 piglets by fostering. Litters differed greatly in average gain per piglet during the first 3 d after farrowing, with litter means ranging from 5 to 227 g d^{-1} per piglet for the 3-d period. Gains during days 0-3 tended to be somewhat lower if the sow had a high body temperature during these days, but the correlation was not high ($r = -0.35$; $P < 0.05$). Compared to litters with high average gains during days 0-3, litters with low gains during this period continued to have lower average gains during days 3-14 ($P < 0.05$) and had higher within-litter variation in gain ($P < 0.01$). On a within-litter basis, weight gain during the first days after farrowing was only weakly correlated with the day 14 weight of individual piglets. Low average gain by a litter in the first 3 d after birth is probably due to low initial milk yield by the sow, and likely indicates a poor start to the sow's lactation. Early identification of litters with low initial gains might allow remedial action to reduce the problems of high mortality and low, variable gains later in lactation.

In a previous study (Thompson and Fraser 1986), we noted that piglet weight gains are highly variable in the first and, to a lesser extent, the second week after birth. During the first week, for example, some piglets more than doubled their birth weights, while others gained only negligible amounts. These early gains were virtually uncorrelated with birth weight.

However, in later weeks of lactation, rate of gain became more and more closely correlated with a piglet's body weight at that time. During the fifth week, for example, most piglets gained about 30% of the weight they had reached by the end of the fourth week; consequently, a 10-kg piglet tended to gain about twice as much as a 5-kg piglet. At this stage, the established differences in body weight, which resulted from differences in birth weight coupled with the large variation in gain during the first 2 wk, simply became more pronounced. We concluded, therefore, that much of the variation in piglet weight gains is associated with events occurring in the first 2 wk after birth.

In the present study, we examined in more detail the weight gains of piglets in the important first 2 wk. By weighing piglets each day in the first days after farrowing, we describe the early development of variation in weight gain and its relationship with gains to day 14.

MATERIALS AND METHODS

The study was part of a larger data collection which included a comparison of four farrowing crate designs. The entire collection, of which 42 litters were used here, consisted of 78 farrowings by Yorkshire sows from the Animal Research Centre's minimum-disease herd.

The farrowing crates are described in detail by Fraser et al. (1988). Briefly, in the first type of crate, the two sides consisted of four straight, horizontal rails, leaving an internal width of 560 mm. In the second type, the lowest rail on each side was flared outward from the sow, giving an internal width of 750 mm at the sow's lying height, and 430 mm at standing height. The third type of crate followed a design by Gadd (1982) with nearly vertical prongs angling down and slightly outward away from the sow. The fourth type allowed the sow more freedom of movement; the side walls were spaced 1150 mm apart at the sow's standing height, but angled inward near the floor to restrict the sow's lying area to a width of 750 mm.

Each crate was installed in a farrowing pen of 3.5-3.9 m^2 with a plastic-coated, expanded-metal floor raised 0.3 m above the floor of the room. The sow's area was covered by a mat of rubber with enough texture to provide extra traction. Each pen was equipped with a 250-W heat lamp suspended 0.6 m above the raised floor of the crate, a piglet water bowl accessible to the piglets from the time of farrowing, and a two-hole piglet supplementary feeder accessible to the piglets from 10 d of age.

Sows were moved into the crates about 5 d before farrowing was due. They received about 2 kg of feed per day before farrowing. After farrowing, feed was available ad libitum, with the feed trough being refilled daily. Sows had continuous access to water from a nipple-drinker installed 0.6 m above the floor of the crate. Routine management of the piglets included ear notching and clipping the needle teeth on the first day after birth; iron injection on days 3 and 10; and castration of males on day 10. The rectal temperature of each sow was recorded using a mercury thermometer twice daily (at about 10:00 and 15:00 h) on the first 5 d after farrowing. Sows and litters remained in the pens until the piglets were 14 d old.

Ambient temperature in the room was generally kept at 20-24°C by supplementary heating and cooling equipment, but extremes of 17 and 29°C were recorded over the 20-mo duration of the study.

To minimize the effects of litter size, all litters were adjusted to 10-12 piglets by the time of the weighing on day 1. Piglets were removed if they had physical abnormalities or weighed < 800 g. Large litters were then reduced to 12 by removal of randomly-chosen piglets. Small litters were increased to 10 by adding foster litter-mates which increased to 10 by adding foster litter-mates which were within the weight range of the recipient litter and differed in age by no more than 36 h. Because of their different genetic make-up and the possible effects of fostering on early weight gain, the fostered animals were not included in the analysis.

Piglets were weighed to the nearest 5 g on days 0, 1, 2, 3, 4, 5, 7, 10 and 14 after birth. All weighing was done between 10:00 and 12:00 h daily, so that daily weight gains would cover a period close to 24 h. However, this meant that some litters were as much as 24 h old when weighed for the first time. In order to reduce variation due to age at first weighing, the analysis was restricted to 42 litters that farrowed between 16:00 h (the latest time when sows were routinely checked during the day) and 08:00 h the next morning.

Analyses of variance were applied to the weight gain data, partitioning the total variation into between-litter and within-litter variation. The variance components (Snedecor and Cochran 1967) in Table 1 were estimated from these analyses. Using the same partitioning, an analysis of covariance was applied to the day 14 weights, with day 0 weights as the covariate. The regression coefficient obtained from the analysis was used to obtain adjusted weights, that is,

$$\text{Adj. day 14 wt} = \text{day 14 wt} - 2.23 \times (\text{day 0 wt} - \text{mean day 0 wt})$$

when the influence of initial weight was to be removed from the day 14 weights. In comparing parameters from those litters which gained the most and those that gained the least during the first 3 d after farrowing, we felt that assumptions of normality were difficult to justify. Hence, Wilcoxon's Rank Sum Test (Hollander and Wolfe 1973) was used. Stepwise regression was used to examine the effectiveness of different variables for predicting day 14 weight. In each case, weight on day 0 was introduced as the first step, and then weight gain during a specified period was included as the second step (Snedecor and Cochran 1967, p. 413). Litter size was ignored in all analyses based on litter means.

Of the 457 piglets, 17 were omitted from the analysis of body weights because they died before day 14, and 49 were omitted because they had been added by fostering. This left 391 piglets from the 42 litters in the analysis. Mortality was ignored in the analyses for two reasons: (1) the level of mortality was very low and (2) aside from one litter which was reduced to five piglets, those litters in which piglets died remained of comparable size with those with no mortality. Preliminary analyses showed no differences owing to sex so this factor was also ignored throughout.

RESULTS

Between-litter Differences in Early Gains

Litters varied greatly in the amount and timing (over days) of their weight gains during the first few days after birth. Figure 1 shows two examples, both involving litters of 10 piglets. In litter 52, the piglets gained at a fairly steady rate of 200 g d^{-1} for the first 4 d, with somewhat higher rates on days 4-14. In litter 19, all piglets lost weight (10-65 g) on the first day; several continued to lose on the second day; and it was not until the fourth day that all piglets had begun to gain. Other patterns were seen occasionally: some litters had little or no gain on the first day, and then normal gains thereafter; others had sizeable gains on the first day but considerably lower gains on the second or third. These sudden changes in average daily gain, as well as the very low average values of < 50 g d^{-1} (Table 1), were generally confined to the first 3 d after birth, with most litters following more uniform trends on the fourth and subsequent days. There was no evidence that poor performance was associated with the number of foster piglets added to the litter.

Analysis of variance showed highly significant differences between litters ($P < 0.001$) in gain during all periods studied, but no significant differences ($P > 0.05$) attributable to farrowing crate type, litter size, or the interaction. Between-litter differences 'accounted for 55.5% of total variance in gain on the first day, 28.4% on the second day, and less than 25% during the next 3 d (Table 1). The relative importance of between-litter variation increased again in the second week (Table 1).

The distribution of average daily gains on days 0-3 approximated the normal distribution (Fig. 2), and was negatively correlated with the maximurn body temperature recorded for the sow during the same days ($r = -0.35$, $P < 0.05$). However, the relationship was far from clear-cut (Fig. 2). For example, of the four litters whose dam registered a body temperature of > 41°C at least once, only one was among the 10 litters with the lowest 0-3 day gains.

Relationships between early and later gains were studied by comparing the 10 litters with the highest gains on days 0-3 ("fast-start" litters) and the 10 litters with the lowest gains during this period ("slow-start" litters). Two main differences were apparent (Fig. 3).

Table 1. Average daily gain of piglets (g d^{-1}), showing overall mean, range of litter means, and variance structure, based on 42 litters during successive periods in the first 14 days after birth

Period (d)	Mean	Range of litter means: lowest	Range of litter means: highest	Total† variance	% variance‡ between-litter
0-1	86	–136	233	8181	55.5
1-2	146	–11	265	6930	28.4
2-3	157	18	236	6289	18.6
3-4	183	53	319	8034	24.9
4-5	207	121	366	6956	20.1
5-7	217	116	309	4619	26.9
7-10	223	76	298	4809	37.5
10-14	224	88	301	5120	41.4

†The sum of the between- and within-litter variance components, that is, the variance of an individual piglet measurement.

‡The percentage of the total variance represented by the between-litter component.

First, the fast-start litters were only slightly heavier at birth than the slow-start litters ($P > 0.10$), but were substantially heavier by day 14 ($P < 0.01$). This was due partly to the large differences in early gains, but also to a persistent difference in rate of gain on days 3-14 ($P < 0.05$).

Second, the slow-start litters were significantly more variable in their day 14 weights ($P < 0.01$, based on adjusted day 14 weights), even though the slow- and fast-start litters did not differ in their degree of within-litter variability at birth (Fig. 3).

There were only two deaths (one each in two litters) among the fast-start litters, but 10 piglets died in the slow-start litters. These included one litter with seven deaths, one with two deaths, and one with a single death. The litter with seven deaths had the second lowest 0 to 3 day gain recorded in the experiment.

The relationship between early weight gain and later within-litter variation was studied more closely using the entire set of 42 litters. Standard deviation in day 14 weight was negatively correlated with the litter's mean weight gain during days 0-3 ($r = –0.45$, $P < 0.01$, using day 14 weights adjusted for initial weight).

The relationship between the litters' early weight gains and mean day 14 weights was also studied using the entire 42 litters. Regression analysis was applied to the litter means, using mean day 14 weight as the dependent variable. Weight on day 0 was included in the model first, accounting for 40.3% of the between-litter variation. The total gain from day 0 to a particular day was then added to the model as the second step. As shown by the broken line in Fig. 4, much of the variation in the litters' mean day 14 weights could be explained by the gain during day 0-2. Using longer periods of time provided additional explanatory power, but only slowly.

Early Gains and Within-litter Differences

Regression analysis was also applied to determine how effectively early weight gains helped to predict later body weights of individual piglets. The analysis was done on a within-litter basis (i.e., after first introducing litter differences into the model), with day 14 weight as the dependent variable. Weight on day

0 was included first, and explained 41.8% of the within-litter variation in day 14 weight. The gains from day 0 to each measurement date were then added; the results are shown by the solid lines in Fig. 4. Compared to the analysis based on litter means, the within-litter analyses indicated that the gains on the first 2 d were much less effective in predicting the day 14 weights. Gains later in the 14-d period were much more closely related to the final weights. For example, day 14 weights (adjusted for day 0 weights) were strongly correlated with gain during days 7-10 (*r* = 0.85) and days 10-14 (*r* = 0.82), but only weakly correlated with gain on day 0-1 (*r* = 0.36).

Fig. 1. Mean (± SEM) daily gain per piglet in litters 52 and 19 which had among the highest and lowest weight gains, respectively, during days 0-3 after farrowing. Gains are shown for individual days after farrowing, where "day 1" refers to the gain between day 0 and day 1, and so on.

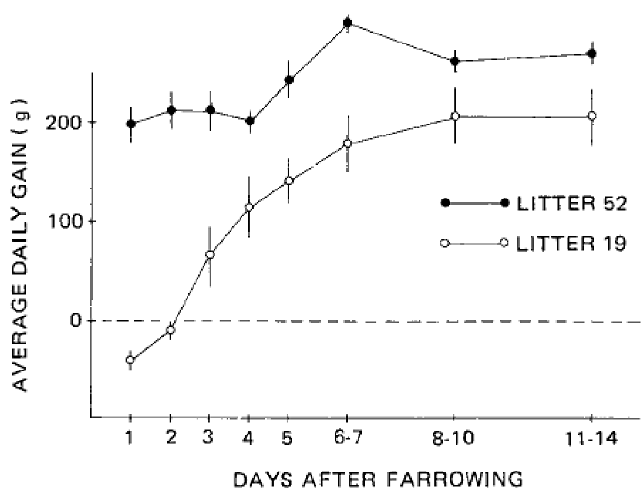


Fig. 2. Frequency distribution of the 42 litters, divided according to the average daily gain per piglet on days 0-3 after farrowing. Cross-hatching indicates that the sow's maximum body temperature recorded on these days was at least 41.1°C; vertical shading indicates a maximum between 40.6 and 41.0°C.

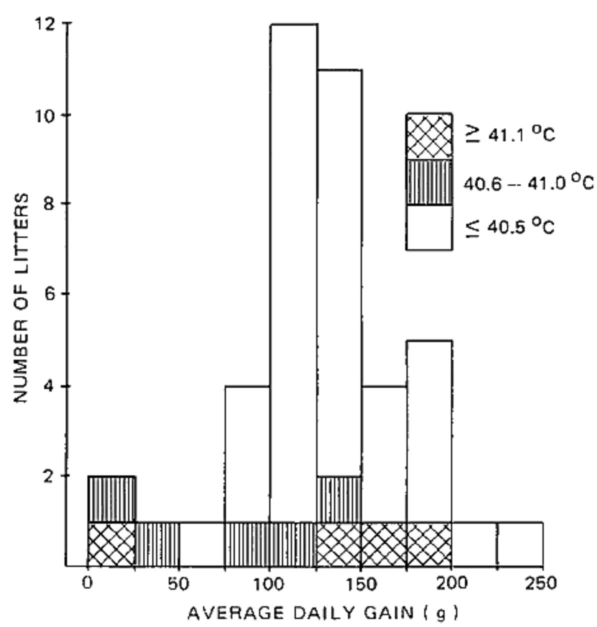


Fig. 3. The litter means and standard deviations of day 0 and day 14 body weights (adjusted for day 0 weights) and the litter means of gains during days 0-3 and days 3-14 for the 10 "slow-start" and the 10 "fast-start" litters. The arrows indicate the means of the means and standard deviations.

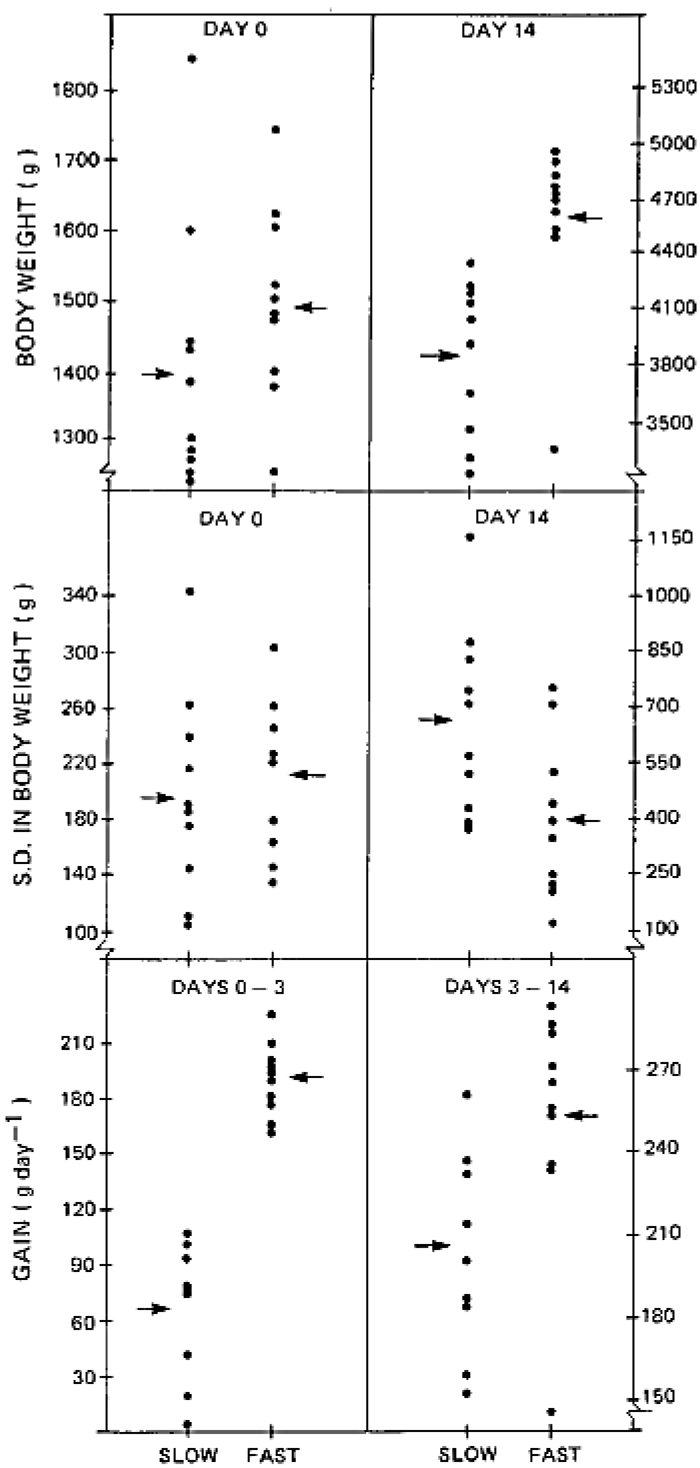
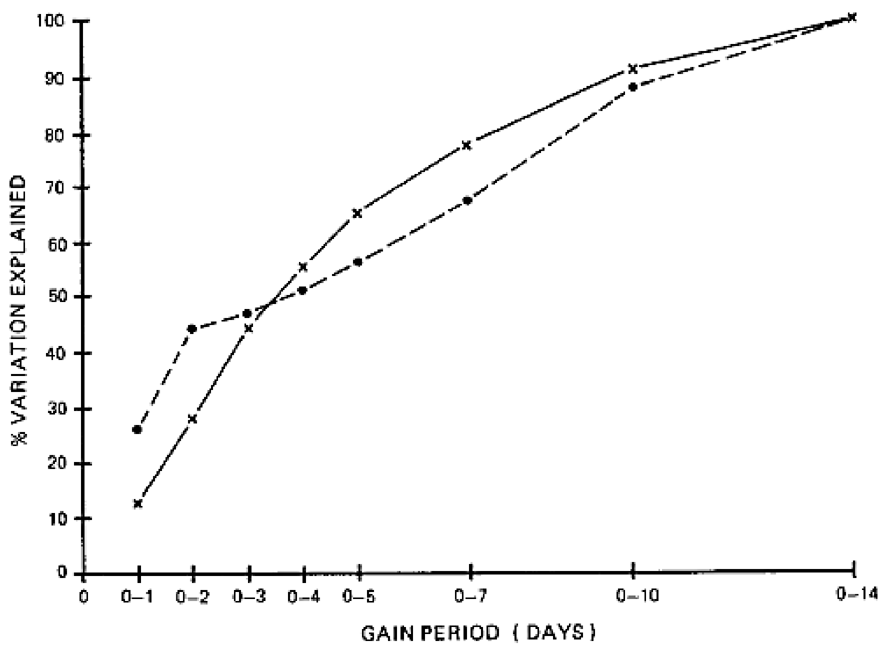


Fig. 4. Change with age in the percentage variation in day 14 weights (adjusted for initial weight) explained by the total gain to a particular date. x-----x represent the within-litter analyses, .-----. the between-litter analyses.



Toward the end of the 14 d, a piglet's weight gain during a given period was highly correlated with its weight at the beginning of the period (Table 2). For example, gain during days 10-14 was highly correlated (r = 0.62) with body weight on day 10. This relationship, however, was much weaker in the first few days after birth, especially for the litters with low initial weight gains (Table 2). By about day 4, both groups had developed a clear tendency for heavier piglets to gain faster than light piglets.

DISCUSSION

In this study, daily weighing of piglets revealed remarkably large differences between litters in weight gains during the first few days after farrowing. Since much of the variation applied to litters as a whole, it probably indicates large differences between sows in the early availability of milk. Evidently, some sows were capable of supporting a high rate of piglet weight gain starting on the first day after farrowing, while others supported low or erratic gains for up to 3 d.

Low yield of milk in the first days after farrowing is a well-known problem with sows, often associated with high rectal temperature, lack of appetite, inflammation of the mammary glands, and microbial infections (Martin and McDowell 1975; Ross et al. 1981; Bäckström et al. 1984). However, the differences between litters in piglet weight gains cannot be explained based on a simple distinction between sick and healthy sows. Early weight gains formed a nearly normal distribution, were far from perfectly correlated with the sows' rectal temperatures, and were not associated with any obvious mastitis. Where there was no obvious ill health, low piglet weight gains may have resulted from subclinical illness of the sow or from some different mechanism such as inadequate hormonal stimulation of milk production.

In this study, we used the first 3 d after farrowing as a measure of early gains. The exact choice of period was somewhat arbitrary. However, the very low average weight gains (< 50 g d^{-1}), the lack of correlation between gain and initial weight (Table 2), and the sudden declines in a litter's mean daily gain were all confined to the first 3 d. In addition, days 0-3 is commonly recognized as the period when most piglet deaths occur (e.g., Fahmy and Bernard 1971; Pettigrew et al. 1986).

Table 2. Pooled estimates of within-litter correlation coefficients, relating gain during a particular period with body weight at the beginning of the period

Period (d)	All 42 litters	10 fast-start litters	10 slow-start litters
0-1	0.18	0.33	0.06
1-2	0.24	0.21	0.16
2-3	0.26	0.40	0.22
3-4	0.40	0.42	0.39
4-5	0.55	0.43	0.60
5-7	0.63	0.54	0.62
7-10	0.68	0.57	0.70
10-14	0.62	0.68	0.66

Low initial weight gains were related to several important aspects of performance. First, low initial gains were followed by low gains during the remainder of the 14-d study period. Perhaps sows that have low initial milk production tend to have low yields later on; alternatively, litters debilitated by poor initial intake may be less able to stimulate high milk production later in the lactation.

Second, litters with lower initial gains tended to have more variable gains during days 3-14 and, consequently, more variable body weights at day 14 (Fig. 3). Previous work (Thompson and Fraser 1986) showed that differences established by day 14 are likely to be perpetuated and even enhanced during the remainder of a 5-wk lactation. In other words, low initial gains will likely predispose litters to highly variable weaning weights. Similarly, Hoy and Hörügel (1984) noted increased variability of weaning weights accompanying reduced average weight gains in litters with disease or disruptive fostering. Much variation in piglet weight gains is apparently due to competition among litter-mates (Fraser et al. 1979; Thompson and Fraser 1986). Perhaps the effects of such competition are more drastic when total milk intake is low.

Finally, low weight gains by litters in the first few days may increase the likelihood of piglets dying. In this study, there were few deaths, presumably because of the minimum-disease conditions and the controlled, hygienic environment. Nonetheless, the one litter with numerous deaths had one of the lowest average gains during days 0-3. Pettigrew et al. (1986) found that litters with four or more deaths had abnormally low average weight gains in the first week. De Passillé (1987) weighed piglets on days 0, 3 and 10, and noted low average gains during days 0-3 in litters with high mortality. Danielsen (1974) also noted high piglet mortality in litters reared by sows with low initial milk production. These three studies, done under more typical commercial conditions than our own, suggest that many piglet deaths occur in litters with low average weight gains early in lactation.

Although a litter's early gains provided a useful indication of later performance, the gains of individual piglets on the first 2 d did much less to predict their subsequent gains relative to their litter-mates. For example, gains on day 0-1 were very poorly correlated with within-litter differences in day 14 weight, whereas gains in later periods (days 7-10 and days 10-14) were much more closely correlated with day 14 weight. One reason for this result is arithmetic: the early gains are smaller than the later ones and hence contribute less to the final weight. In addition, the piglets' gradual increase in teat fidelity likely plays a role. During the first days after birth, piglets tend more and more to return to the same teat or teat pair (e.g., Hemsworth et al. 1976) and their suckling becomes more orderly (Mattwei et al. 1979). With the increased orderliness, the piglets establish individual differences in rate of gain which tend to persist for the rest of the lactation (Thompson and Fraser 1986). The earliest gains, before these developments have taken place, may involve additional variation associated with disorderly suckling and inconsistent choice of teats, and are not very useful indicators of within-litter differences in later performance.

These findings require some additional development and testing before they can be applied to piglet management. A simple weighing or inspection regime could perhaps be developed to identify litters with poor initial gains so that intervention, in the form of fostering, provision of supplementary nutrients, and attention to the sow's health, can be directed to the litters that would benefit most from such treatment.

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