Eating and drinking activity of newly weaned piglets: Effects of individual characteristics, social mixing, and addition of extra zinc to the feed

L. Dybkjær,*2 A. P. Jacobsen,* F. A. Tøgersen,† and H. D. Poulsen*
*Department of Animal Health, Welfare and Nutrition, and †Department of Genetics and Biotechnology, Danish Institute of Agricultural Sciences, Research Center Foulum, Denmark

ABSTRACT: In production systems, piglets usually fast for a period after weaning, thereby increasing the risk of diarrhea and a reduction in growth. The low level of eating may relate to insufficient drinking activity, as solid feed intake must be accompanied by water intake. Mixing of newly weaned piglets is a well-known stressor and a common procedure in pig production. The effect of mixing on the temporal development of eating and drinking activity in newly weaned piglets has not been elucidated. High concentrations of zinc (Zn) in the feed improve the health and performance of piglets after weaning, but the underlying mechanisms are still obscure. One possibility is that Zn affects eating and drinking behavior. The effects of mixing 4 littermates from each of 2 litters and adding zinc oxide (ZnO; 2,500 ppm of Zn) to the feed were studied in a 2 × 2 factorial experiment using 123 piglets weaned at 27 d of age. Individual eating and drinking times during the initial 48 h after weaning were analyzed on 2 levels of aggregation, day and hour. The piglets spent less time eating on the first day after weaning compared with the second day (20 ± 5 vs. 98 ± 10 min, respectively; P < 0.001), whereas they spent more time drinking on the first day compared with the second day (13 ± 1 vs. 9 ± 0.5 min, respectively; P < 0.001). Eating and drinking times were positively associated (P < 0.001). Females ate for longer than males (61 ± 8 vs. 44 ± 7 min/24 h, respectively, P = 0.002), whereas sex did not affect drinking time. Drinking time increased (P = 0.003) and eating time decreased (P = 0.001) with increasing preweaning growth rate and weaning weight. Neither mixing nor addition of ZnO affected the daily eating time. However, nonmixed piglets given 2,500 ppm of Zn as ZnO in the feed spent more time drinking per day (12 ± 1 min) than did nonmixed piglets offered 100 ppm of Zn as ZnO (10 ± 1 min; P = 0.002). Mixing also affected the hourly distribution of the drinking activity (P < 0.05).

Key words: drinking behavior, eating behavior, mixing, piglets, weaning, zinc

INTRODUCTION

In pig production, piglets usually eat little during the first days after weaning (Bruininx et al., 2001, 2002). The low food intake disposes them to weaning diarrhea and weight loss (Madec et al., 1998; McCracken et al., 1999). Even though the intake of solid feed is related to the intake of water (Barber et al., 1989), the latter has received very little scientific attention to date.

Some of the variation in eating behavior between piglets after weaning (Fraser, 1978; Bruininx et al., 2001, 2002) can be attributed to the size (Bruininx et al., 2001) or the sex (Delumeau and Meunier-Salaün, 1995; Bruininx et al., 2001) of the piglet. But effects of these individual characteristics on the drinking behavior are largely unknown.

Mixing piglets at weaning is a common procedure causing physiological stress (Blecha et al., 1985) and increased aggression (Friend et al., 1983). The mixing may affect the temporal distribution of eating activity, as the peak number of fights associated with mixing coincides temporally with the major eating periods (Christison, 1996).

High concentrations of Zn in the feed reduce the incidence of weaning diarrhea and increase the performance of piglets after weaning (Poulsen, 1995) but the exact mode of action of the Zn is not fully known. Piglets may suffer from Zn deficiency at weaning (our unpub-
lished data). Zinc-deprived rats increase their feed intake within a few days if provided with a Zn-adequate diet (Reeves, 2003) and Zn-depleted chickens show a preference for diets containing Zn (Hughes and Dewar, 1971), suggesting that the effects of Zn on newly weaned piglets may be due to increased eating activity.

The objective of this study was to elucidate possible associations between eating and drinking activity of newly weaned piglets on an hourly as well as a daily basis, and to investigate the effects of sex, body weight, mixing, and dietary Zn concentration on the drinking and eating behavior.

MATERIALS AND METHODS

Experimental Design

The experiment was conducted as a 2 × 2 factorial, balanced block design with 8 replicates each containing the 4 combinations of the 2 experimental factors: 1) mixing, and 2) addition of extra ZnO to the feed.

Housing, Animals, and Management

The study was carried out at the Danish Institute of Agricultural Sciences, Research Center Foulum. All piglets were Danish Landrace × Yorkshire × Duroc crosses and were weighed at birth. Until weaning, they were housed in standard farrowing crates with free access to a circular feed trough and a drinking bowl. At weaning, the piglets were moved to a climate-controlled facility and 8 piglets were placed in each of 4 standard weaning pens (1.76 m × 1.60 m; 0.35 m² per piglet) situated next to each other. The front 0.4 × 1.6 m of the floor area was solid, and the remainder was slatted plastic floor. A feed trough (1.6 m long, 0.3 m wide, and 0.1 m deep) was placed in the front of the pen. Water was provided from 2 nipple drinkers, one at each side in the back of the pen. No straw was given. The windows were covered and artificial light was on from 0730 to 1500.

The piglets were weaned in 8 experimental blocks, each consisting of 4 litters (32 litters in total) according to the date of weaning. At weaning, the piglets were weighed and each litter was reduced to 8 randomly selected, clinically healthy piglets. When introduced to the weaning pens, piglets from 2 litters within each block were mixed into 2 pens with 2 sets of 4 littermates in each pen. The other 2 litters were not mixed and each was placed in their own pen. Before introduction to the weaning pens, 4 clinically healthy piglets from each pen (128 piglets in total) were randomly selected as focal animals; that is, individuals that were the focus of the behavior recordings during a particular sample period (Lehner, 1979); these piglets were individually marked with numbers on their backs.

Five piglets were subsequently deleted from the data set because the medical treatment records taken after the behavioral observations indicated that they suffered from subclinical illness during the observation period. The preweaning growth rate of the remaining 123 focal piglets was 239 ± 4 g/d, the weaning age was 27.2 ± 0.2 d (range: 24 to 30 d), the body weight at weaning was 8.0 ± 0.1 kg (range: 4.9 to 12.0 kg), and the proportion of males to females was 1.08.

The piglets had ad libitum access to creep feed before weaning (Table 1). At weaning, the composition of the diet was changed (Table 1). Half of the piglets were fed the basic diet (100 ppm of Zn as ZnO) and half of the piglets were fed the basic diet supplemented with extra zinc oxide (2,500 ppm of Zn as ZnO). The piglets had free access to the diets and fresh feed was added twice daily.

Data Collection

The behavior of the focal piglets was recorded by means of continuous time-lapse video recordings for 48 h, starting as soon as the last piglet was introduced into the weaning pen (a given time between 1000 and 1420). Infrared light was used to permit recording at night. From the videotapes, the duration of all eating and drinking bouts was recorded for each of the 4 focal animals per pen. Eating was defined as touching the feed with the snout and drinking was defined as touching the tip of the nipple drinker with the snout. Interruptions in eating or drinking lasting less than 10 s were considered as within-bout intervals (Lehner, 1979).

Daily feed consumption was recorded on the pen level by weighing and weighing back the feed. Because some spillage from the troughs was unavoidable, feed intake was reported as apparent feed intake (as suggested by Pluske and Williams, 1996).

Statistical Analyses

The eating and drinking activity of the focal piglets during the first 48 h after weaning was analyzed at 2

---

**Table 1.** Dietary ingredients in the creep feed and basic diets, % as fed

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Creep feed</th>
<th>Basic diet (after weaning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>31.95</td>
<td>33.00</td>
</tr>
<tr>
<td>Wheat</td>
<td>31.95</td>
<td>32.58</td>
</tr>
<tr>
<td>Soybean meal, toasted</td>
<td>14.03</td>
<td>17.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>12.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Animal fat</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>3.00</td>
<td>—</td>
</tr>
<tr>
<td>Monocalcium phosphate</td>
<td>0.56</td>
<td>0.90</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.49</td>
<td>0.59</td>
</tr>
<tr>
<td>Lysine, 40%</td>
<td>0.39</td>
<td>0.48</td>
</tr>
<tr>
<td>n-3-Methionine</td>
<td>0.05</td>
<td>—</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.18</td>
<td>0.25</td>
</tr>
<tr>
<td>Vitamin and mineral mixture&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0.40</td>
<td>0.20</td>
</tr>
</tbody>
</table>

<sup>1</sup>Provided per kilogram of feed: zinc, 100 mg; iron, 50 mg; manganese, 27.7 mg; copper, 20 mg; iodine, 0.2 mg; selenium, 0.3 mg; vitamin E, 60 mg; vitamin K₃, 2.2 mg; vitamin B₁, 2.2 mg; vitamin B₂, 4 mg; vitamin B₆, 3.3 mg; d-pantothenic acid, 11 mg; niacin, 22 mg; biotin, 0.06 mg; vitamin A, 4,400 IU; vitamin D, 1,000 IU.
levels of aggregation, namely at the hour and day levels. The former illustrates the temporal distribution of the eating and drinking activity of piglets over the 48-h period. It carries more information and may reveal more subtle relationships between effects than data on daily aggregation. The areas under the curves presenting the hourly eating and drinking activities represent the eating and drinking activity on a daily basis.

Because the mean response per hour exhibits a cyclic pattern, it may be modeled as a sum of a sufficiently large number of corresponding sine and cosine terms of different frequencies (Körner, 1988). The effects of the experimental treatments mixing (variable MIX) and adding ZnO to the feed (variable ZNO) were tested by including MIX and ZNO, as well as interaction terms between these and the sinusoidal terms. The former accounts for different levels in responses related to treatment effects, and the latter accounts for different shapes of the curves. The different shapes of the curves for d 0 (first 24 h after weaning) and d 1 (25 to 48 h after weaning) were modeled by means of a day effect and its interaction with the sinusoidal terms.

Daily weight gain (kg/d) in the nursing period and the sex of the piglet were included in the model as systematic effects. The analyses were performed with and without eating activity (min/24 h) included as a covariate in the model testing the effects on drinking activity and vice versa. However, because the effects of the other explanatory variables did not differ between the models with and without these covariates, only the results from the models with the covariates included are presented.

Variation due to subject-specific effects is expected, giving different curves for different pigs. This was modeled by including random sine and cosine terms at the pig level. A random effect (interaction between MIX, ZNO, and block) was included to account for variation within the pen due to the social facilitation of eating (Hsia and Wood-Gush, 1984) and drinking behaviors. Tests of treatment effects were accordingly performed against variation within pen and not across pens. All random effects were assumed independent. Because responses were measured repeatedly over time for each piglet, a repeated effect was included in the model and estimated. A noticeable increase in variability from d 0 to d 1 was modeled by specifying different variances for the 2 d of all the random effects appearing in the statistical model. In the analysis on the day level, data included 2 additional random effects that were used to account for litter and block effects, respectively.

The hourly-basis data were subjected to analysis of variance by mixed model methods using random coefficient models (random regression, see Longford, 1995). The daily data were subjected to ordinary ANOVA by mixed model methods. Square root and logarithmic transformations were performed to make the data more eligible for standard statistical methods of linear normal theory. The analyses were performed using the MIXED procedure in SAS (SAS Inst., Inc., Cary, NC; Littell et al., 1996).

The start models on an hourly basis had 12 sinusoidal terms together with the treatment effects, the covariates, and their interactions, as mentioned above. Stepwise backward selection procedures with deletion of terms with \( P \) values > 0.05 or decreasing Akaike’s information criteria (Akaike, 1974) were used to identify the final models.

The statistical analyses showed that 5 sinusoidal terms were sufficient to model the systematic mean response curves for the eating and drinking activity (\( P < 0.001 \)). This number of terms was used throughout the analyses for both response variables. In addition, effect of day and terms of interactions between effect of day and the sinusoidal terms were highly significant (\( P < 0.001 \)).

RESULTS

The eating and drinking activity of the focal piglets during the first 2 d after weaning was characterized by a high frequency of short eating and drinking bouts (Figure 1). There was large variation among the 123 focal piglets in total daily eating and drinking times (Figure 2). On the first day after weaning, approximately one-third of the piglets spent less than 14 min eating. Total eating time ranged from 0.2 to 132 min on the first day after weaning and from 0.3 to 246 min on the second day. Total drinking time ranged from 4.3 to 35 min and from 3.2 to 26 min on the first and second days, respectively.

Effects of Day After Weaning

Apparent feed intake was affected by day (\( P < 0.001 \)), with an average feed consumption of 47.5 ± 48.8 g/piglet on the first day and 171.3 ± 42.5 g/piglet on the second day after weaning.

The total eating time per day was lower on the first day after weaning compared with the second day (20 ± 5 min vs. 98 ± 10 min/piglet; \( P < 0.001 \)), whereas the total drinking time was higher on the first day compared with the second day (13 ± 0.6 vs. 9 ± 0.4 min/piglet; \( P < 0.001 \)).

The hourly distributions of eating and drinking during the first 48 h after weaning are shown in Figure 3 for each of the 4 combinations of experimental treatments. Across treatments, eating activity was low during the first approximately 20 h and then increased and followed a diurnal pattern for the rest of the 48 h. Drinking activity was more constant over the 48 h, but was slightly increased during the first hours after weaning and again from around 20 to 30 h and around 45 to 48 h after weaning.

Association Between Eating and Drinking

Total eating time and total drinking time were significantly associated (regression coefficient = 0.19, SE =
0.04; \( P < 0.001 \)), so that the longer the piglet spent eating, the longer it spent drinking. Time spent eating and drinking did not differ during the first 20 h \( (P = 0.18) \), whereas more time was spent eating than drinking after the first 20 h postweaning \( (P < 0.001; \text{Figure 3}) \).

**Effects of Sex of Piglets**

The proportion of males to females did not differ between treatments. Total daily eating time was higher in females than in males \((61 \pm 8 \text{ vs. } 44 \pm 7 \text{ min/piglet}; \ P = 0.002)\), and the hourly distribution of eating differed according to the sex of the piglet \( (P < 0.02) \), with females eating for a consistently longer time but with a similar distribution of eating time as the males over the 48-h period. Sex of the piglet, however, affected neither the total daily drinking time, nor the hourly distribution of drinking.

**Effects of Preweaning Growth Rate and Body Weight at Weaning**

Neither the preweaning growth rate, the body weight at weaning, or the distribution of body weights within pens differed between treatments. The total daily
Figure 3. Distribution of eating and drinking activity during the first 48 h after weaning in piglets exposed to 4 combinations of mixing piglets and adding Zn to the feed. Time spent eating and drinking did not differ until after the first 20 h after weaning ($P < 0.001$).

Eating time was negatively correlated with the growth rate of the piglet in the nursing period (regression coefficient = $-14.8$, SE = 4.3; $P = 0.001$). Piglets with low growth rates ate for a longer time during the first 48 h after weaning compared with piglets with higher pre-weaning growth rates, a finding confirmed by the analysis on an hourly basis ($P < 0.03$). The eating activity curves in Figure 4 (piglets divided into 4 categories for illustration purposes only) show that the lower the growth rate, the longer the eating time, but with the same distribution of eating activity over the whole 48-h period regardless of preweaning growth rate.

In contrast, total daily drinking time was positively associated with preweaning growth because piglets with high growth rates in the nursing period spent more time drinking during the first 48 h after weaning than piglets with lower preweaning growth rates (regression coefficient = 2.19, SE = 0.54; $P = 0.003$). The preweaning weight gain tended ($P < 0.06$) to affect the drinking pattern, but the distribution of drinking activity seemed very similar for piglets with different preweaning growth rates (Figure 5).

The body weight at weaning was positively correlated with the preweaning growth rate ($r = 0.87$, $P < 0.001$).

Figure 4. Distribution of eating activity during the first 48 h after weaning in piglets divided into four categories (for illustration purpose only) according to daily growth rate in the nursing period (< 200 g/d, 200–240 g/d, 240–270 g/d, > 270 g/d). Slow growing piglets ate for more time compared with faster growing piglets ($P < 0.03$).
and when the former was included in the models instead of the preweaning growth, weaning weight also affected the total daily duration of eating and drinking ($P = 0.002$ and $P < 0.001$, respectively) in opposite directions in that the larger the weaning weight, the less time the piglet spent eating and the more time it spent drinking.

**Effects of Mixing and Zinc**

Apparent feed intake was not affected by experimental treatments ($P = 0.80$). Neither mixing piglets nor addition of Zn to the feed affected the total daily eating time (MIX: $P = 0.34$; ZNO: $P = 0.59$) or the hourly distribution of eating (MIX: $P = 0.98$; ZNO: $P = 0.37$).

However, there was an interacting effect of mixing and Zn on the total daily drinking time ($P = 0.02$). Nonmixed piglets with an extra 2,500 ppm of Zn as ZnO in their feed spent more time drinking (12 ± 1 min/piglet) compared with nonmixed piglets with no extra ZnO in their feed (10 ± 1 min/piglet). The ZnO concentration did not affect the total drinking time in the mixed piglets ($P = 0.22$).

Most of the interactions between mixing and the sinusoidal terms were significant ($P < 0.05$), indicating that mixing affects the drinking activity pattern. A visual inspection of the group mean curves for mixed and nonmixed piglets (Figure 6) indicates that the mixed piglets spent less time drinking during the first approximately 3 h and from approximately 24 to 26 h after weaning, whereas they spent more time drinking at around 20 to 22 h and again 44 to 46 h after weaning.

**DISCUSSION**

The current study reveals strong associations between the eating and drinking behavior of the individual piglets. The individual characteristics affected behavior, with females eating for longer than males, and with the large or fast-growing piglets eating for less and drinking for more time than their smaller littermates. The temporal distribution of drinking seemed to be influenced by mixing, whereas eating time was unaffected by the 2 external factors, mixing and addition of Zn as ZnO.

When piglets are weaned abruptly at 4 wk of age, most individuals experience a sudden and complete transition from getting all (or the majority) of the nourishment as milk from a teat to having feed and liquid offered separately from 2 different facilities. The low duration of eating observed on the first day after weaning may be due to the piglets spending much time exploring their new environment and having difficulties adapting to the unfamiliar source of feed (Bark et al., 1986). It can take 50 h or more after weaning before all individuals have started eating (Bruininx et al., 2001, 2002), and increases in feed intake and eating time from the first to the second day after weaning, as found in the current study, are generally observed (Bark et al., 1986; Metz and Gonyou, 1990; Morgan et al., 2001; Mason et al., 2003).

The hourly distribution of eating and drinking over the 48 h after weaning showed strong similarities to the distributions observed by Christison (1996), except for the first few hours, in which eating activity was lower in the current study. This difference may be because the light was turned off within a few hours after the piglets were introduced into the weaning pen in the current study, whereas Christison exposed the piglets to constant illumination. During the second day, eating activity followed a diurnal pattern with a peak in the daytime (about 20 to 27 h after weaning) and a smaller peak in the afternoon (32 to 36 h after weaning). Similar
diurnal patterns of eating behavior with 2 maxima per day have been reported in older pigs (De Haer and Merks, 1992; Bornett et al., 2000).

Little is known about the water intake of piglets around weaning. One reason for this is the lack of suitable noninvasive methods for measuring the real water ingestion in newly weaned piglets. Drinking time from a bowl drinker is highly correlated with individual water consumption in 1- to 2-d-old piglets (Phillips et al., 1990). However, it is not known whether a high correlation also exists in newly weaned piglets drinking from a nipple drinker. In order to quantify the water intake of group-housed weaned piglets, usually the water release from facilities or the drinking time is reported (Brooks et al., 1984; Algers et al., 1990). Brooks et al. (1984) found higher water release on the second day after weaning compared with the first day, whereas McLeese et al. (1992), in accordance with our results regarding drinking activity, recorded higher water intake on the first day after weaning compared with the following days. Algers et al. (1990) found significantly longer drinking times on the first day after weaning compared with the last day before weaning. High drinking activity, as found in the current study in the first days after weaning, may be due to the piglets trying to achieve a feeling of satiety by drinking water as suggested for older pigs (Yang et al., 1981; Vargas Vargas et al., 1987), but may also be due to the piglets exploring their new postweaning environment by sucking and biting the nipple drinker.

In the current study, the eating behavior of the piglets was unrestricted as all the piglets had free and simultaneously access to the feed in a long trough. The feed intake of piglets in the first days after weaning has been measured in several studies, using feeding equipment that did not allow all piglets to eat simultaneously (Pajor et al., 1991; Bruininx et al., 2001, 2002, 2004; Mason et al., 2003). Synchronization of eating behavior is common in pigs (Wood-Gush and Csermely, 1981), and eating can be stimulated by the presence of conspecifics that eat (Hsia and Wood-Gush, 1984; Appleby et al., 1991; Morgan et al., 2001). This may explain why limited feeding space can reduce eating time as well as feed consumption (Appleby et al., 1991, 1992; Georgsson and Svendsen, 2002). The feed trough in the present study, however, hindered the measurement of the exact amount of feed eaten by each individual; instead, eating time was used to describe eating behavior, as has been reported before (De Passillé et al., 1989; Appleby et al., 1991, 1992; Fraser et al., 1994) as an acceptable measure of individual feed intake, even though it may not always completely reflect the actual feed intake (see Appleby et al., 1991).

In accordance with others (Fraser, 1978; Bruininx et al., 2001, 2002), we observed large variations among individuals in eating activity during the first 2 d after weaning. Our finding that female piglets ate for longer time than males is in agreement with the results of Delumeau and Meunier-Salatn (1995) and Bruininx et al. (2001). However, a later study by Bruininx et al. (2004) showed no effect of sex on feed intake during the initial 4 d after weaning. In the present study, effects of sex on duration of eating were not due to differences in preweaning growth rate or weaning weights, as these did not differ between sexes.

In the current study, preweaning growth rate correlated negatively with eating behavior, showing that piglets with low growth rates before weaning (and low weaning weight) spent more time eating after weaning compared with the larger, faster growing piglets. Bruininx et al. (2001) also found that lighter piglets had higher initial feed intake and shorter latency to eat after weaning than did their heavier penmates. These results seem to fit with the “fast-food hypothesis” proposed by Jensen and Recén (1989), which suggested that differences in intake of solid feed between lit-
termates relate to the milk production of the specific teat occupied by the piglet, as the piglet will optimize its foraging behavior by ceasing to suckle, and compensate by eating solid feed once its nutritional demand can no longer be met by the milk from its teat. In accordance with this, Algers et al. (1990) found a negative correlation between the preweaning weight gain from third to fourth week after birth and eating time on the last day before and on the first day after weaning at 6 wk of age. Mason et al. (2003) analyzed vocalizations of piglets at weaning and suggested that heavy piglets experience more nutritional deprivation than lighter piglets.

Other studies, however, do not support this hypothesis as they found that faster growing piglets consume or show most interest in creep feed (De Passillé et al., 1989; Pajor et al., 1991; Bruininx et al., 2004) or that body weight and creep feed consumption is not related (Bruininx et al., 2004). The discrepancies between studies may partly be due to methodological differences or, as pointed out by Pajor et al. (1991) and Appleby et al. (1992), the mechanisms may not be strict alternatives but can act at different times of the nursing period. More studies are needed to resolve this discrepancy.

A corresponding theoretical foundation does not exist with regard to the drinking behavior of piglets. We found that piglets with high preweaning weight gain (and high weaning weight) spend more time drinking during the first 2 d after weaning than the smaller piglets. Similar to a few other studies, Algers et al. (1990) included drinking behavior in their study, and found that weight gain from the third to fourth week after birth was significantly negatively correlated with time spent drinking water on the last day before weaning at 6 wk of age, but did not correlate with drinking time on the first day after weaning. Restricting access to feed may stimulate pigs to drink water in an attempt to suppress hunger (Yang et al., 1981; Vargas Vargas et al., 1987). We suggest that the larger, fast-growing piglets showed more interest in the nipple drinkers after weaning than did the smaller piglets in an attempt to compensate for the lack of milk and reach satiation by swallowing a liquid from a facility that has some similarities to a teat, rather than eat the solid feed.

The relationship between eating and drinking time at the individual piglet level was strongly significant in the current study. Little attention, however, has been paid to relationships between intake of feed and water. At the group level, positive relationships between feed intake and water intake have been reported (Friend and Cunningham, 1966; Barber et al., 1989). Vargas Vargas et al. (1987) suggested that finishing pigs may be partially satiated by drinking water, and thus, may eat less food, but this was not confirmed by the current study in newly weaned piglets. More studies are needed to elucidate the causal relationships between intake of feed and water in pigs.

Even though mixing of piglets at weaning is a well-known stressor leading to elevated cortisol levels (Blecha et al., 1985) and increased aggression (Friend et al., 1988; McGlone and Curtis, 1985), we found no effects of mixing on daily feed intake, total daily duration of eating, or hourly distribution of eating behavior. Ample space at the trough and the small group size in our study may be part of the explanation, but Puppe et al. (1997) suggested that even 6-wk-old piglets have more problems coping with an unfamiliar housing system at weaning than coping with unfamiliar piglets. Merlot et al. (2004) suggested that the lack of effects of mixing at weaning may not reflect an absence of stress, but rather that the effects of dietary changes are more important to the piglets and mask the effects of mixing at the time of weaning.

A visual inspection of the temporal hourly distribution of the drinking activity indicated that the mixed piglets spent less time at the drinker during the first hours after weaning and again about 24 h later. Knowledge regarding the effects of mixing on drinking activity in pigs is very sparse, but the apparent pattern with mixed piglets drinking for shorter time immediately after weaning and drinking earlier in the morning than nonmixed piglets on the following 2 mornings may have a biological explanation related to the social environment. This observation needs further elucidation.

There are reasons to believe that piglets suffer from Zn deficiency at weaning (our unpublished data). The Zn status of rats can affect the pattern of feed intake over a 24-h period with a reduction in appetite in Zn-deficient rats (Chesters and Quarterman, 1970; Rains et al., 1998). Zinc-deprived rats, however, increase their feed intake within a few days if provided with a Zn-adequate diet (Reeves, 2003). Zinc-depleted chickens show a clear preference for a diet containing Zn compared with a diet without Zn within 24 h of presentation of the diet (Hughes and Dewar, 1971). Assuming that our piglets were generally Zn-deprived at weaning, we expected the piglets to increase their feed intake within the first 2 d after weaning when fed 2,500 ppm of Zn as ZnO, but they did not do so. Because it can take more than a day before piglets start eating the feed in the weaning pen (Bruininx et al., 2001, 2002), the 2-d observation period might not have been sufficient to reveal the positive feedback mechanisms involved in increased eating activity when offered high concentrations of Zn. As such, the positive effects of Zn on the health and growth performance of weaned piglets (Poulsen, 1995; Carlson et al., 1999, 2004) do not seem to be related to very early changes in eating behavior or feed consumption after weaning.

The addition of Zn slightly increased the total daily drinking time in the nonmixed piglets, indicating that high concentrations of Zn may increase thirst. This association was, however, depressed in the mixed piglets, where social factors may have reduced the drinking activity.

In conclusion, our results provide new insight into the eating and drinking activity of newly weaned piglets. The individual weaning weight and preweaning
growth rate strongly affected eating and drinking behavior as the larger piglets within the litter showed little interest in the feed and more interest in drinking. This suggests that within a litter, the larger piglets may not necessarily be as ready for weaning as their smaller littermates. The current study indicates that eating and drinking are strongly associated, but that drinking behavior is more easily influenced by external factors than is eating behavior. Attempts to increase feed intake before and after weaning should therefore include ways to optimize water intake in order to establish a balance between feed and water intake as soon as possible after weaning. Finally, the results indicate that the effects of mixing and addition of Zn on the physiology of the piglets do not involve changes in eating and drinking activity on the first 2 d after weaning.

**LITERATURE CITED**


