Synthetic maternal pheromone stimulates feeding behavior and weight gain in weaned pigs[1]

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ABSTRACT: One hundred and forty-four pigs were used to determine the effects of a putative synthetic maternal pheromone on behavior and performance of weanling pigs. Each pen of weaned pigs contained three pigs that were given free access to water and feed. Pigs were videotaped in time lapse for 48 h after weaning and weekly body weights and feed disappearances were recorded for 4 wk. Treatments included: a) control (vehicle applied), b) 30 mL of synthetic pheromone applied to the feeder, or c) 10 mL of synthetic pheromone applied to each of three pigs' snouts. Pigs exposed to the synthetic pheromone spent more ($P < 0.05$) time with their heads in the feeder and less ($P < 0.05$) time drinking, lying down, or engaged in agonistic behaviors than control pigs. Pigs exposed to the synthetic pheromone were more ($P < 0.05$) active during the 48-h period of video taping than control pigs. Pigs exposed to the synthetic pheromone (either on the feeder or their snout) had increased ($P < 0.01$) average daily gain (ADG) and better ($P < 0.01$) feed:gain ratio than control pigs over the 28-d postweaning period. In conclusion, the putative synthetic pheromone, applied once at weaning, stimulated apparent feeding behaviors, and reduced fighting and apparent drinking behaviors during the first 48 h after weaning. ADG and feed:gain ratio were improved by application of the putative synthetic pheromone either directly on the feeder or when painted on the pigs' snouts. Olfactory signals can modulate adaptation to the postweaning environment in ways that may improve pig performance and welfare.

Key Words: Behavior, Pheromones, Pigs

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Introduction

Pigs have a highly developed olfactory system and probably have many pheromones that regulate their behavior and physiology. Pheromones are compounds secreted by one animal that have an effect on the physiology or behavior of other animals (Halpern, 1987). Pheromones also signal individual, gender, or other modes of recognition. Morrow-Tesch and McGlone (1990a,b) provided evidence that maternal pheromones regulate nursing pig behaviors. They found that pigs would not nurse when odors were washed from the skin of lactating sows using a solvent, and that piglets were attracted to and could discriminate among maternal odors found in feces and other biological fluids. Consequently, Pageat (2001) isolated skin secretions of mammals and developed a fatty acid mixture that was similar in composition to sow skin secretions. This formulation was thought to contain the essential elements of a possible maternal pheromone. Pageat and Teissier (1998) reported preliminary results suggesting pig aggressive biting was reduced by the use of this synthetic pheromone when piglets were mixed after weaning.

The objective of this project was to determine the effects of applying a synthetic maternal pheromone on pig weight gain, efficiency of feed utilization, and behaviors. The hypothesis for this study was that the synthetic maternal odor might help weanling pigs eat dry feed more quickly and in greater quantities during the difficult few hours after weaning, and that this might influence postweaning pig performance and behavior.

Materials and Methods

A three-pig bioassay was used to evaluate the efficacy of the candidate pheromone. This bioassay was previously published (McGlone and Morrow, 1988; McGlone et al., 1993) for the evaluation of treatments among weanling pigs. Briefly, the model involves placing three pigs in a weanling pig pen while recording them on time-lapse videotape. Postweaning behavior was collected during the period in which dry feed consumption and dominance order formation was taking

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place. Pig postweaning performance was recorded for 4 wk.

Piglets were weaned at either 3 or 4 wk of age. A total of 12 complete blocks were weaned at 3 wk of age. An additional four complete blocks were weaned at 4 wk of age. Weaning ages were first considered different trials at the start of the work. Because data analyses revealed no interactions among weaning age and treatments, weaning age was dropped from subsequent analyses.

Weaned pigs were provided a pen measuring 1.2 m^2. The floor was galvanized steel woven wire. Feed (19% crude protein, sorghum-soybean meal) and water were available ad libitum. Feed provided nutrients consistent with NRC (1998) recommendations. Rooms were held at about 30°C for the first week after weaning and lowered 2°C per week. Two rooms with separate ventilation were used. One room served as a control and another room was used for pheromone applications. Rooms were randomized among odor treatments over successive block replications. Because two pheromone treatments were in one room, they were housed at opposite ends of the room to avoid the differently treated pigs from influencing each other's behavior.

The synthetic pheromone contained lipid-soluble compounds found in skin secretions of sows using a formula described by Pageat (2001). The synthetic pheromone was supplied as a microemulsion containing 20% (wt/vol) of the pheromonal fraction in an alcohol solution (placebo). The control solution was the same vehicle as that which contained the synthetic pheromone. The synthetic pheromone was a proprietary product (Suilence, Ceva Sante Animale, Libourne, France).

Within each block, nursing pigs of a given sex from three different sows were weaned and placed in one of three treatments. Treatments included the following liquids applied immediately after weaning: a) 10 mL of placebo applied to the snout of each of three piglets per pen, b) 30 mL of synthetic pheromone applied to the feeding trough and lip of the feeder using a camel-hair paint brush, or c) 10 mL of pheromone applied to the snout of each of three piglets per pen (using a camel-hair paint brush). Different people applied the control and experimental substances to avoid cross contamination. However, control and treated pigs were collected, weighed, moved, and treated simultaneously.

Behavior Data Summary. Pigs were videotaped in time lapse for 48 h after regrouping, at a tape speed of 0.8 frames/s. Tapes were viewed, with observers blind to experimental treatments.

A scan sample was used to summarize standing, lying, feeding, drinking, and agonistic behaviors. Behavior definitions were provided in McGlone et al. (1993). Lying down was recorded when pigs were either near the feeder (within one body length) or far from the feeder. Total lying down was the sum of the two lying behaviors. Active, nonfeeding, nonagonistic behaviors were the sum of standing and walking. Agonistic behaviors included bite, push, and thrusting against each other as previously described (McGlone, 1986).

For the scan sample, each pigs' behavior was recorded each 15 min for 48 h. Data were expressed as a percentage of time pigs were engaged in each behavior.

Pig Performance. Pigs were randomly selected from litters based on weaning weights. Pigs were weighed at weaning and each week for up to 4 wk after weaning or until a common end point of 7 wk of age. Pigs weaned at 3 wk of age were weighed for 4 wk, whereas pigs weaned at 4 wk were weighed for 3 wk. Feed disappearance was determined for each weigh period. Average daily gain, apparent feed intake, and feed:gain ratio were calculated for each pen.

Statistical Analyses. For all measures, the pen was the experimental unit. Because pigs of both sexes (females and castrated males) were used, a preliminary analysis showed no sex effects or interactions with treatment (gender has few effects on pig performance or behavior at this age); therefore, pig gender was dropped from the model. A total of 16 complete blocks (replicates) were examined per treatment. Two blocks experienced a power failure, and thus, behavior data were lost (14 complete blocks remained for behavioral measures). Data were analyzed as a completely randomized block design. Scan sample data were percentage data. For these percentage data, the raw data were transformed by the square root arc sine procedure (for normalization of percentage data) prior to analyses. All data were analyzed using GLM procedures of SAS (SAS Inst., Inc., Cary, NC). Linear contrasts were used to evaluate control (placebo) vs the combined pheromone treatments (pheromone applied to the feeder and pheromone applied to the snout).

Results

A summary of pig behavior is presented in Table 1 and Figures 1 and 2. Pigs given the pheromone treatment on the feeder spent more ($P < 0.05$) time feeding and standing/walking, less time drinking and lying down, and less time engaged in agonistic behaviors than pigs in the control group. Pigs given the pheromone treatment on the snout showed behaviors largely similar to the pigs given the pheromone on the feeder (Table 1).

Only two behavioral measures showed a significant ($P < 0.05$) time × treatment interaction. Presented in Figure 1 are data for lying-down behaviors. During the first 4 h after weaning, pigs exposed to the pheromone spent more ($P < 0.05$) time lying down compared to control pigs. After the first 4-h period, the control pigs generally lay down in the pen, whereas pheromone-treated pigs did not lie down, but actively explored their new environment and feed. Standing and walking also were elevated among pheromone-treated pigs after the initial 4-h period compared with control pigs.

In spite of randomization, pigs in the pheromone treatments were lighter ($P = 0.03$) at weaning (pretreat-

Table 1. Effects of application of a putative synthetic maternal pheromone or a control odor on weaned pig behavior[a]

	Treatments					
Measure	Control	Pheromone feeder	Pheromone snout	SE[b]	*P*-value[b]	*P*-value contrast[b]
No. of pigs	42	42	42	—	—	—
No. of replicates	14	14	14	—	—	—
Scan sample, % of observations						
Feeding (head in feeder)	1.33[y]	3.06[z]	2.54[z]	0.29	0.0007	0.0003
Drinking (mouth on waterer)	0.67[y]	0.30[z]	0.27[z]	0.11	0.02	0.007
Lying close to feeder	18.2	9.21	9.25	4.06	0.21	0.08
Lying far from feeder	65.1	69.9	71.8	4.66	0.58	0.32
Lying (total)	83.2[y]	79.1[z]	81.0[yz]	1.32	0.10	0.06
Stand and walk (active)	12.9[y]	16.1[z]	13.0[z]	0.92	0.03	0.14
Agonistic behaviors	1.52[y]	0.82[z]	0.96[yz]	0.24	0.11	0.04

[a]Table values are raw data and SE of raw data. Analyses were performed on transformed data and the *P*-values represent those for the transformed data.
[b]*P*-value refers to the treatment effect while the *P*-value contrast refers to a linear contrast comparing control with the combined pheromone treatments.
[y,z]Means with a different superscript differed $P < 0.05$.

ments) than control pigs. As a supplemental analysis, pig body weight data were subjected to a covariate analysis to equalize the time-zero (weaning) weights. Introduction of this covariate to equalize time- zero body weights did not change the observed effects. Therefore, the covariate analysis was not considered further.

At the end of the nursery phase, pheromone-treated pigs in both treatment groups were about 1 kg heavier ($P < 0.05$) than control pigs. Over the entire 4-wk post-weaning period, ADG was 19 and 27% higher for pigs with synthetic pheromone applied to the feeder or snout, respectively, than for control pigs. The synthetic pheromone-induced improvement in ADG without a significant change in feed intake resulted in improved ($P < 0.05$) feed:gain ratio for pigs exposed to the synthetic pheromone. The pheromone also improved ($P < 0.01$) feed:gain ratio by 17 and 26% over the entire growth period for synthetic pheromone applied to the feeder or snout, respectively (Table 2), compared to control-treated pigs.

Discussion

Odors are perceived by nonprimate mammals through either their main olfactory epithelium or

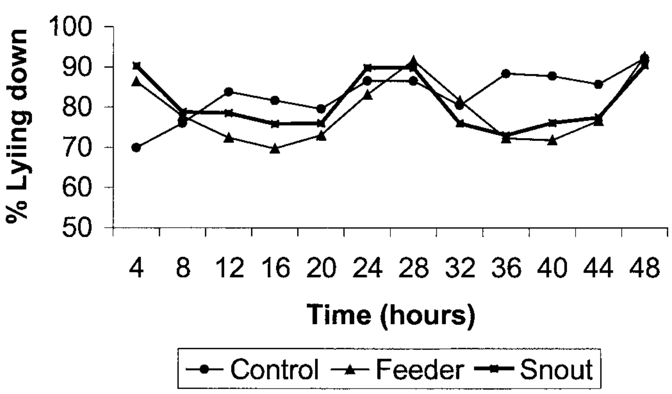

Figure 1. Percentage of time pigs spent lying down over time. The time points on the x-axis represents the time at the end of the period (e.g., 4 represents 0 to 4 h). Control pigs = ●, pheromone applied to the feeder = ▼, and pheromone applied to the snout = ×. The time × treatment interaction was significant ($P < 0.05$) for lying behavior. These data represent 48 h after weaning. A clear diurnal pattern of behavior was not yet established. SEp = 1.6 %. N = 14 pens per data point. Control pigs differed ($P < 0.05$) from pheromone treatments at 4, 36, and 40 h after weaning.

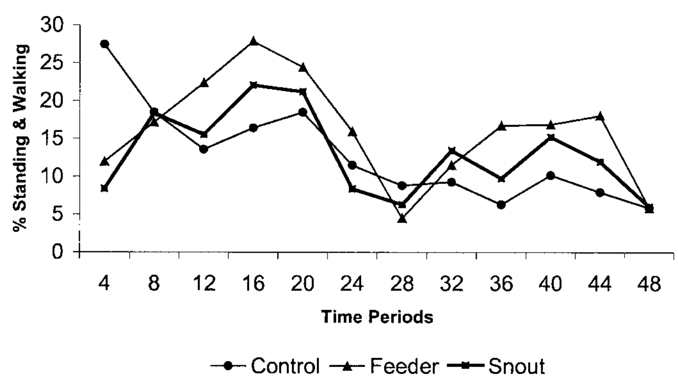

Figure 2. Percentage of time pigs spent in active behaviors (standing and walking) over time. The time points on the x-axis represents the time at the end of the period (e.g., 4 represents 0 to 4 h). Control pigs = ●, pheromone applied to the feeder = ▼, and pheromone applied to the snout = ×. The time × treatment interaction ($P < 0.05$) for active, nonfeeding behaviors included standing and walking. Standing and walking and investigating the environment tended to be lower for control pigs (except for the first 4-h period). SEp = 1.3%. N = 14 pens per data point. Control pigs differed from pheromone-treated pigs at 4, 36, and 44 h after weaning.

Table 2. Effects of application of a putative synthetic maternal pheromone or a control odor on weaned pig weight performance

	Treatments					
Measure	Control	Pheromone Feeder	Pheromone Snout	SE	*P*-value	*P*-value contrast[a]
Number pigs	48	48	48	—	—	—
Number replicates	16	16	16	—	—	—
Wean weight, kg	6.07[y]	5.07[z]	5.71[yz]	0.13	0.09	0.03
End of nursery, kg	10.6[y]	11.6[z]	12.0[z]	0.35	0.02	0.01
ADG, kg/d						
0 to 7 d	0.09	0.12	0.11	0.015	0.36	0.16
7 to 14 d	0.16	0.15	0.18	0.015	0.36	0.95
14 to 21 d	0.29[y]	0.32[yz]	0.36[z]	0.02	0.098	0.08
21 to 28 d	0.30	0.36	0.40	0.03	0.42	0.24
0 to 28 d	0.198[y]	0.236[z]	0.253[z]	0.01	0.004	0.001
Feed intake, kg/d						
0 to 7 d	0.17	0.19	0.18	0.01	0.61	0.38
7 to 14 d	0.45	0.45	0.46	0.017	0.90	0.78
14 to 21 d	0.63	0.63	0.64	0.028	0.95	0.80
21 to 28 d	0.95	0.98	1.00	0.03	0.12	0.07
0 to 28 d	0.52	0.51	0.54	0.01	0.45	0.25
Feed:gain ratio[b]						
0 to 7 d	0.24	1.98	0.39	1.40	0.61	0.58
7 to 14 d	7.66	1.57	4.91	1.57	0.37	0.83
14 to 21 d	2.51	2.44	2.02	0.25	0.26	0.25
21 to 28 d	3.75[y]	3.25[yz]	2.47[z]	0.42	0.11	0.09
0 to 28 d	2.65[y]	2.22[z]	1.95[z]	0.13	0.005	0.002

[a]*P*-value refers to the treatment effect, whereas the *P*-value contrast refers to a linear contrast comparing control with the combined pheromone treatments.

[b]Feed:gain ratios were highly variable due to feed wastage especially during the first week postweaning.

[y,z]Means with a different superscript differed ($P < 0.05$).

through the vomeronasal organ (**VNO**; Halpern, 1987). The main olfactory epithelium quickly habituates to odors whereas the VNO neurons do not habituate under prolonged stimulus exposure (Holy et al., 2000). In general, odorants that bind the main olfactory epithelium are volatile compounds, whereas the chemical signals that bind the VNO may be less volatile or liquid. Stimulation of the VNO by a biologically relevant chemical signal would be expected to cause sustained VNO activation.

We are not certain if pig maternal pheromones have their effect through the main olfactory or VNO systems. The VNO is most likely the primary site of reception of mammalian pheromones, including maternal neonatal pheromones (Wysocki and Lepri, 1991). If the putative maternal pheromone was perceived primarily through the VNO, then touching the liquid to the pig snout would be required. Direct application of pheromones on the mouth or snout may be better to facilitate access to VNO, but it is not likely to be mandatory. Even if not very volatile, pheromones may be perceived when present in the environment, in particular through snout and mouth movements during flehmen behavior. Dorries et al. (1997) described the vomeronasal ducts, showing communications between VNO and mouth and snout in pigs. Furthermore Dorries et al., (1997) showed that the VNO was not systematically involved in pheromone perception in pigs. The methodology used here did not allow us to ascertain the site of action (VNO vs main olfactory epithelium). To assure a route of administration that stimulated the VNO, pigs were painted on their snout as one treatment. Another treatment, considered more practical, was to paint the feeder with the putative synthetic pheromone. The synthetic pheromone had similar effects when it was painted on the snout or on the feeder.

The synthetic pheromone was not very volatile and had little odor to the human investigators (beyond the alcohol base). One investigator could discriminate between the placebo and the product, but another could not discriminate based on odor. In any case, the synthetic pheromone caused behavioral changes in the test pigs, and thus, the signal was received by the pigs. Pigs of both synthetic pheromone treatment groups responded in terms of behavioral changes and increased growth to the synthetic pheromone.

The synthetic pheromone caused significant changes in the behavior of weanling pigs. Application of the maternal odor on the feeder or on the snout of the pigs caused an increase in the percentage of scan samples in which pigs were observed with their head in the feeder. This behavior does not mean that the pigs were actually eating. In fact, feed intake data indicated that treatments groups had a similar feed disappearance. Weanling pigs spend considerable time playing with and rooting in their dry feed as they learn to consume dry feed. This behavior causes considerable variation in apparent feed intake. This added variation may explain the lack of difference in apparent feed intake.

Control pigs spent more time apparently drinking than pheromone-treated pigs (Table 1). Control pigs may have spent more time attempting to use the nipple waterer in pseudonursing behavior than pheromone-exposed pigs. The behavioral data for apparent feeding and drinking behaviors indicated that weanling pigs in the control treatment were exploring the waterer, whereas pheromone-treated pigs were exploring the feeder. When the synthetic pheromone was applied to the feeder, pigs spent less time lying or engaged in agonistic behavior and more time exploring than control pigs. The pigs with the pheromone applied to their snout were intermediate in these behavioral effects. These results may indicate that the pheromone applied to the feeder modulated the weanling pigs' behavior in a more desirable manner—that is, causing more feeder exploration, less playing with the waterer, and less agonistic behavior compared to control pigs. The lower level of agonistic behaviors shown by pigs exposed to the synthetic pheromone agrees with the preliminary report by Pageat and Teissier (1998).

Pig performance was improved by both pheromone treatments relative to the control treatment. During the first week after weaning, the pig feed intake was approximately one-half of the predicted values given in NRC (1998). However, by the last week (21 to 28 d post weaning), pig feed intakes were similar to those given in NRC (1998). The maternal pheromone seemed especially effective in this study when feed intake and weight gains were low during the immediate postweaning period. One plausible hypothesis is that the maternal pheromone reduced the stressfulness of weaning, and in this manner, may have improved the welfare of the weanling pigs.

Pigs started the study slightly lighter in the pheromone-feeder treatment group compared with the control pigs. However, both synthetic pheromone treatments resulted in a heavier pig weight by 28-d postweaning compared with the control pigs. Although apparent feed intake was similar in each treatment, pigs had variable amounts of feed wastage. The feed wastage is apparent when one examines the variable feed:gain ratios during the first 14 d after weaning. Pigs were observed playing with feeders and wasting a variable amount of feed. Some pen groups wasted more feed than others, with no apparent relationship to treatment. With improvements in ADG and no differences in apparent feed intake, there was an improved feed:gain ratio among pigs exposed to the synthetic pheromone. To have such an effect would require some metabolic mechanism that would more efficiently utilize feed consumed. Although a metabolic mechanism (ex., improved nutrient absorption or systemic endocrine effect) might be responsible for the synthetic pheromone effects on ADG and feed:gain ratio, we think this is an unlikely explanation of the observed effects. Rather, it is possible that the synthetic pheromone caused an increase in actual feed intake and less feed wastage compared with the control pigs that might have wasted more feed relative to the amount they consumed. These possibilities need to be tested in future studies. In conclusion, for overall performance effects, the putative synthetic pheromone applied to the feeder or the snout had positive effects on pig weight gain and apparent efficiency of feed utilization.

Implications

A putative synthetic pheromone had significant effects on the behavior and performance of weaned pigs. The putative synthetic pheromone stimulated apparent feeding behaviors, and reduced fighting during the first 48 h after weaning. Control pigs spent more time drinking than did pigs treated with the synthetic pheromone. Average daily gain and feed:gain ratio were improved by the application of the putative synthetic pheromone either directly on the feeder or the pigs' snouts. Olfactory signals can modulate adaptation to the postweaning environment and may contribute to the improved performance and welfare of the weaned pig.

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