

# The Effect of Environmental Manipulation on Behavior, Salivary Cortisol, and Growth of Piglets Weaned at 14 Days of Age

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Environmental enrichment can be a useful tool to reduce belly nosing behaviors in early weaned piglets. The aim of this study was to assess the effect of environmental enrichment on behavior, salivary cortisol, and productivity of piglets weaned at 14 days of age. The study assigned 112 piglets (line Camborough 22 of PIC<sup>TM</sup>) into 2 treatments, control and enriched, and observed them for 192 hr in 3 periods: 14 to 28 days of age (Phase 1), 28 to 42 days of age (Phase 2), and 42 to 54 days of age (Phase 3). The study obtained saliva samples in each phase from 56 piglets selected randomly from each group for cortisol determination. Comparisons between both treatments and phases included the following: proportion of time belly nosing, latency of approaching a person, average levels of salivary cortisol, and daily weight gain. Belly nosing was higher and latency of approaching a person lower in the control group than in the enriched one ( $p < .05$  and  $p < .01$ ). Belly nosing was lower in Phase 3 ( $p < .05$ ); latency of approaching a person was higher in Phase 1 with respect to Phase 2, and this was higher with respect to Phase 3 ( $p < .01$ ). There were no differences in salivary cortisol levels between treatments or phases. Weight gain was higher in the enriched group ( $p < .001$ ). Environmental enrichment in piglets weaned at 14 days of age resulted in a reduced proportion of time nosing, reduced latency of response to humans, and better growth than piglets in barren environments.

Early weaning of piglets (10 to 21 days old) is a practice carried out to control the vertical transmission of infectious diseases and improve the sanitary state of the herd (Alexander, Thornton, Boon, Lysons, & Gush, 1980; Harris & Alexander, 2000). However, this management procedure is related to several behavior and welfare problems (Weary, Appleby, & Fraser, 1999; Worobec, Duncan, & Widowski, 1999). On the other hand, several studies have shown that salivary cortisol measurements in pigs can be a useful, noninvasive tool to assess welfare problems (Blackshaw & Blackshaw, 1989; Ekkel, Savenije, Schouten, Wiegant, & Tielen, 1997; Jarvis et al., 1998; Mendl, Zanella, & Broom, 1992; Parrott, Misson, & Baldwin, 1989; Ruis et al., 1997). However, to date there is no information on salivary cortisol of piglets weaned at 14 days of age. In previous studies in which environmental enrichment has been assessed in adult pigs, some positive results have been obtained—an increase of activity, decrease in aggression with the use of physical barriers (Waran & Broom, 1993), reduction in belly nosing (Beattie, Walker, & Sneddon, 1996; Grandin & Curtis, 1984; Pearce, Paterson, & Pearce., 1989), growth rates (Beattie, O'Connell, & Moss, 2000), and ease of handling (Day, Spooler, Burfoot, Chamberlain, & Edwards, 2002). Considering this, the aim of this study was to assess the effect of environmental manipulation with hanging ropes and tires on behavior, salivary cortisol, and productivity of piglets weaned at 14 days of age.

## MATERIALS AND METHOD

### Subjects and Housing

This study was carried out on a commercial farm with a production system of three sites. A total of 112 pigs (56 males and 56 females, line Camborough 22 of PIC™) weaned at 14 days old were selected randomly, forming 2 groups of 56 animals each, divided in 4 pens of 14 pigs each. Each pen was 3 m × 1.5 m with woven wire flooring and a separating fence of 1 m high of the same material. The pigs were assigned to a control group and to an enriched group with a hanging rope and a rubber tire tube hanging from a height of 1 m from the level of the floor of the pen with an initial length of 0.9 m. The ropes and tubes were shortened at 0.6 m at 4 weeks of age.

### Procedure for Obtaining Data

The study was divided into three phases to obtain information on behavior, salivary cortisol, and weight gain in different stages of the weaning period: Phase 1 was 14 to 28 days of age; Phase 2 was 28 to 42 days; and Phase 3 was 42 to 54 days, at which time the pigs were transferred to the growing facilities of the farm.

## Behavioral Measurements

A combination of scan and behavior sampling was used to record information on individual and social behavior of the piglets in the three phases of the weaning period (Martin & Bateson, 1986). In total, the piglets were observed directly by only one observer for 192 hr distributed over 24 days, divided into three separate observation periods. Each observation period consisted of 64 hr distributed over 8 days. In each observation day, the piglets were observed during 8 hr, from 0900 to 1300 and from 1400 to 1800. Each pen was observed for 30 min during the morning and 30 min during the afternoon, which corresponded to 4 hr of behavior sampling in each experimental group in each day, with the aim of collecting information on the frequency of interactive behaviors in each treatment. In addition, scan sampling was used every 15 min in all pens to obtain information on the average proportion of time each piglet was involved in belly nosing other piglets in the group.

The following day, the observation of the pens started in progressive order to avoid beginning always at the same hour in the same pen. The behavioral measurements included time belly nosing that were expressed as proportion of time calculated as the number of observations of a behavior/total number of scan samplings.

In addition, the reactivity to the human presence was assessed by calculating the time latency of approaching the person who collected the saliva samples in each of the sampling days (see next). This was measured by counting the time a piglet voluntarily made contact with the person in the pen during the first minute after the person's leaning inside the pen in front of the piglets. This was always the same person, who leaned in the same posture and at the same distance from the limits of the pen. To control these types of distractions, beige clothing was worn on all occasions, and there was no talking.

## Salivary Cortisol Measurements

A total of 28 pigs (14 female and 14 male), of each treatment were selected randomly for saliva samples ( $n = 56$ ). A saliva sample from each of those piglets was taken at 28, 42, and 54 days of age. When sampled, each pig was held and lifted by the abdomen, and a cotton web was introduced in the sublingual area for 35 to 40 sec. The samples always were taken at the same time (0900) and in the same order, alternating group to control for temporal changes related to sampling period. An average cortisol level in each group of each sampling day was obtained. At the end of the experiment, 168 samples (56 piglets sampled in three phases) were obtained and kept at  $-26^{\circ}\text{C}$  until protocol measurement by radioimmunoassay (RIA) for cortisol determination. A cortisol antibody was used (3-CMO of Chemicon). The antibody was characterized by being of high

specificity and crosses 3.3% with corticosterone, 5.1% with 11-Deoxycortisol, 0.7% with cortisone, and 36.8% with prednisone. The tracer was  $^3\text{H}$ -Hydrocortisone ([1,2,6,7- $^3\text{H}$ (N)] 70–100 Ci/mmol, 1 mCi/ml Ethanol, NEN Life Science products, Inc.). The standard curve was accomplished with Hydrocortisone (200, 100, 50, 25, 12.5, 6.25 ng/ml of saliva). The saliva was used directly for cortisol determination and the intra- and interassay coefficient of variation (CV) were 5.52% and 9.64%, respectively.

### Live-Weight Gain

All pigs were weighed 4 times in each of the days that coincided with the collection of the saliva samples taken from the piglets selected for cortisol analysis—at arrival to the farm (14 days of age) and at days 28, 42, and 54 of age. The daily weight gain then was calculated as: daily weight gain = final weight (54 days) – initial weight (14d)/days of test.

### Statistical Analysis

Box-Cox transformations were obtained for behavior and salivary cortisol variables. The model used on weight gain analysis included the effects of the treatment and the initial weight as a covariate. For the behavior and cortisol variables, the model included the effects of the treatment and the time samples as repeated measurements and the two-way interaction between them. The variables were analyzed using an analysis of variance and multivariate tests through the use of the statistical package JMP (SAS Institute, Cary, NC). Multiple comparisons among means were made using Tukey's range procedure (Lentner & Bishop, 1993).

## RESULTS

Overall, the piglets in the enriched group spent  $9.5\% \pm 3.1\%$  of time manipulating the enrichment devices. The means ( $\pm SD$ ) of time spent manipulating the ropes and tubes during the experiment were  $5.5\% \pm 2.3$  and  $4.0\% \pm 2.3$ , respectively.

### Comparison of Behavior Variables Between Groups

Overall, the proportion of time piglets spent belly nosing was significantly higher in the control group than in the enriched one. The average proportion of

time in that behavior for the control and the enriched groups respectively were 9.3% and 6.6%,  $F(111) = 8.55$ ,  $p < .01$ . In addition, the average latency of piglets approaching the person in the pen during the first minute was also significantly higher in the control group,  $F(111) = 519.6$ ,  $p < .01$  than in the enriched one. The average latency of approximation in the two groups was as follows: control = 23.2 sec, enriched = 8.3 sec.

### Comparison of Behavior Across the Weaning Period

The proportion of time pigs spent belly nosing changed across time,  $F(111) = 19.1$ ,  $p < .01$ . In the control group, the proportion of time in that behavior was lower in the third phase (see Table 1) with respect to the first and second phases ( $Q = 2.86$ ,  $p < .05$ ;  $Q = 2.86$ ,  $p < .05$ ), whereas in the enriched group the values for the second and third phases were significantly lower with respect to the first phase ( $Q = 2.86$ ,  $p < .05$ ;  $Q = 2.86$ ,  $p < .05$ , respectively).

In the two groups the latency of approaching the person sampling the piglets was significantly lower in Phase 3 (see Table 1) than in the other two phases,  $F(111) = 3.59$ ,  $p < .001$ .

### Comparison of Salivary Cortisol Levels

Basal salivary cortisol levels (14 days) for the control and enriched groups were  $3.22 \text{ ng/ml} \pm 1.37$ , and  $2.93 \text{ ng/ml} \pm 2.06$ , respectively. The overall average salivary cortisol levels were not different between groups or in each phase of the

TABLE 1  
Comparison of the Average Proportion of Time Belly Nosing and Latency of Making Contact With a Person in the Two Groups

| Group | Behavior                        | Phase 1                    | Phase 2                   | Phase 3                  | Average                    |
|-------|---------------------------------|----------------------------|---------------------------|--------------------------|----------------------------|
| T1    | Belly nosing <sup>a</sup>       | 0.11 ± 0.06 <sub>a</sub>   | 0.09 ± 0.08 <sub>a</sub>  | 0.08 ± 0.07 <sub>b</sub> | 0.093 ± 0.07 <sub>1</sub>  |
|       | Latency of contact <sup>b</sup> | 31.96 ± 14.49 <sub>a</sub> | 22.3 ± 14.42 <sub>b</sub> | 15.3 ± 8.18 <sub>c</sub> | 23.19 ± 12.36 <sub>A</sub> |
| T2    | Belly nosing                    | 0.08 ± 0.05 <sub>a</sub>   | 0.06 ± 0.06 <sub>b</sub>  | 0.06 ± 0.06 <sub>b</sub> | 0.066 ± 0.06 <sub>2</sub>  |
|       | Latency of contact              | 14.07 ± 3.13 <sub>a</sub>  | 6.93 ± 1.33 <sub>b</sub>  | 3.77 ± 1.16 <sub>c</sub> | 8.26 ± 1.88 <sub>B</sub>   |

*Note.* Differences noted by lower case subscript letters between columns represent significant differences between phases ( $p < .05$ ). Different subscript numbers and capital letters between treatments in the average values column represent statistical difference between groups for belly nosing and latency of contact, respectively. Phase 1 = 14 to 28 days of age; Phase 2 = 28 to 42 days of age; Phase 3 = 42 to 54 days of age; T1 = control; T2 = ropes/rubber tubes.

<sup>a</sup>Average proportion of belly nosing given in percentages. <sup>b</sup>Latency of making contact with a person is given in seconds plus or minus standard deviations.

weaning period, 28, 42, and 54 days,  $F(53) = .013$ ,  $p > .05$ . The average values for each group were as follows: control = 1.54 ng/ml, enriched = 1.51 ng/ml (see Table 2).

There are no overall differences between average cortisol measurements across time in each of the groups,  $F = .08$ ,  $p > .05$ .

### Comparison of Live-Weight Gain

When comparing the weight gain between groups, it was found that the enriched group had a significantly higher weight gain than did the control group,  $F(111) = 4.15$ ,  $p < .001$ . The least square means ( $\pm SE$ ) for the control and enriched groups were  $0.285\text{kg} \pm 0.009$  and  $0.317\text{kg} \pm 0.009$ , respectively. The simple means ( $\pm SD$ ) for live weight at 14 days and 54 days for the control and enriched groups were as follows: control =  $5.21\text{kg} \pm 0.6$  and  $17.26\text{kg} \pm 2.15$ , respectively; enriched =  $4.07\text{kg} \pm 0.35$  and  $15.54\text{kg} \pm 2.76$ , respectively.

## DISCUSSION

Some of the negative effects of early weaning include the increase of aggression and belly nosing (Li & Gonyou, 2002; Worobec et al., 1999). This study confirms that the presence of hanging objects in the pen can reduce the proportion of time nosing. Piglets can direct nosing and chewing behaviors to hanging pendulous objects (Blackshaw, Thomas, & Lee, 1997) instead of redirecting those behaviors to group mates.

That piglets in the enriched groups approached the person handling them faster and habituated more easily to subsequent handling than did the piglets in the control group supports the idea that pigs under greater sensorial stimulation can reduce their fear response to humans and approach people with more confidence, making it easier to handle them (Day et al., 2002).

The existing data on salivary cortisol of pigs include the effects of transportation (Parrott & Misson, 1989), isolation (Ruis et al., 1997), regrouping (Ekkel et

TABLE 2  
Mean Salivary Cortisol Levels

| Group | Phase 1         | Phase 2         | Phase 3         | Average         |
|-------|-----------------|-----------------|-----------------|-----------------|
| T1    | $1.69 \pm 1.12$ | $1.31 \pm 0.34$ | $1.61 \pm 1.25$ | $1.54 \pm 0.90$ |
| T2    | $1.76 \pm 0.63$ | $1.45 \pm 0.46$ | $1.33 \pm 0.43$ | $1.51 \pm 0.50$ |

*Note.* Levels ng/ml  $\pm SD$  at 28, 42, and 53 days of age of piglets in the two groups. No differences were found between groups or phases ( $p > .05$ ). Phase 1 = 14 to 28 days of age; Phase 2 = 28 to 42 days of age; Phase 3 = 42 to 54 days of age; T1 = control; T2 = ropes/rubber tubes.

al., 1997), social behavior (Mendl et al., 1992), or changes of the physical environment (de Jong et al., 2000; Gilbert, Boulton, Forsling, Goode, & McGrath, 1997; Jarvis et al., 1998). However, no data on the effect of enrichment on salivary cortisol of piglets weaned at 14 days of age is available. As in those previous studies, this less invasive technique of measuring adrenal activity appears to be a useful indicator of the way these individuals cope with their environment (Broom, 1986) and helps to understand better the development of adrenal activity in growing pigs.

The results presented here suggest that the weight gain in piglets weaned at 14 days of age could be better under enriched environments in comparison to barren environments. This coincides with Schaefer, Salomons, Tong, Sather, and Lepage (1990) and Beattie et al. (2000). The former mentions that pigs in enriched environments (chains and tires) grew 4% more than those pigs without environmental manipulation; the latter reports a growth rate of finishing pigs in enriched environments better than their counterparts from barren environments. However, to be able to relate productivity of piglets weaned at 14 days of age with behavior, more detailed studies, with larger samples, should be carried out, considering food conversion and food efficiency measurement. In this study, no individual consumption measurements could be made.

## CONCLUSIONS

In conclusion, these results indicate that environmental enrichment in piglets weaned at 14 days of age results in less anomalous behaviors, reduced fear response to humans, and better growth. This information is useful in understanding better how piglets weaned at that age cope with their environment and in investigating further this type of manipulation on a larger scale to reduce welfare problems and improve productivity on commercial farms.

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