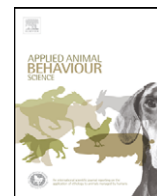




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Effects of exposing pigs to moving and odors in a simulated slaughter chute

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ABSTRACT

Pigs in the finishing stage are infrequently handled and can be difficult to handle when experiencing novel situations. This study sought to determine the effects of minimal training and a novel odor/taste reward on the ease of handling finishing pigs in a novel environment. Pigs were assigned to one of four treatments organized in a factorial arrangement: training and odor exposure at the barn or not (trained or non-trained, respectively) and provision or not of maple syrup in the simulated pre-stun area of a slaughter plant (reward or no reward, respectively). Trained pigs ($n = 14$ pens) were let out of their home pens and onto a trailer for 10 min/d for 10 d and could chew on maple syrup-soaked flags. Non-trained pigs ($n = 14$ pens) were not handled or exposed to maple syrup. After the 10 d, trained and non-trained pigs were transported, unloaded and then experienced a novel simulated pre-stun area. A maple syrup-soaked flag (reward) was dragged through the simulated pre-stun area and put in a simulated CO₂ stun box. Non-rewarded pigs were not exposed to maple syrup. Trained pigs unloaded the trailer and reached the resting pen faster ($P = 0.014$) than non-trained pigs. Trained pigs had fewer ($P = 0.02$) blood neutrophils and more ($P = 0.03$) lymphocytes than non-trained pigs. Rewarded pigs received fewer ($P = 0.02$) taps before reaching the simulated CO₂ stun box than non-rewarded pigs. Cortisol concentration increased ($P = 0.004$) when the total time to reach the simulated CO₂ stun box increased. Pigs that were allowed to exercise out of their home pen and were given access to an odor/taste reward moved faster and the neutrophil:lymphocyte ratio was decreased when exposed to a novel environment containing the same odor/taste reward.

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1. Introduction

Handling and loading at the farm, transport to the slaughter house and handling at the slaughter house are stressful events for livestock. Transport and conventional handling (which includes the use of electric prods and negative interactions with the pigs) may cause shifts in physiology associated with changes in glucose and lactic acid concentration which affect post mortem muscle

quality (Geverink et al., 1998b; Hemsforth et al., 2002; Bertol et al., 2005). In some cases distress is severe enough that some pigs become non-ambulatory (van der Wal et al., 1986; Hamilton et al., 2004; Ritter et al., 2006).

Pigs in the finishing stage of production may have few interactions with humans especially if automatic feeding and waste removal systems limit human caretaker time in the facility. One UK survey showed that the way pigs reacted to stressful situations in a slaughter house were influenced by previous life experiences including contact with humans, exercise and exposure to novel environments during post-weaning (Hunter et al., 1997).

Fear of novel situations, e.g., the intrusion of a human in a familiar environment (Hemsforth and Barnett, 1991) or introduction to a chute (Grandin and Curtiss, 1985), can be

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decreased if pigs are positively handled. For example, total and free plasma cortisol concentrations at rest and in response to intrusion of a human in a familiar environment were decreased when pigs were positively handled (Hemsworth et al., 1981; Hemsworth and Barnett, 1991). Pigs were less fearful and more explorative of a novel situation if they were raised in an enriched environment compared to a barren environment (Stolba and Wood Gush, 1980) and were less hesitant to approach a human if they were provided with toys for 31 d in their home environment compared to if they were not (Grandin et al., 1987). Therefore, non-negative daily human interactions or exposure to new stimuli could improve handling of pigs in novel situations. Active training also affected the behavior of pigs. Geverink et al. (1998b) regularly moved pigs out of their finishing home pens and to a mobile box. These authors found that pigs that were regularly trained and handled moved faster out of their pens and to the box than pigs that were naïve to handling, which resulted in time savings and welfare benefits because pigs that moved faster were less likely to be handled roughly.

Stockmen behavior can affect the behavioral response of pigs to handling and cause stress in pigs. Plasma cortisol concentrations and neutrophil:lymphocyte ratio are indicators of stress, as intracerebroventricular injections of corticotrophin-releasing hormone in pigs caused an increased plasma cortisol concentration and an increased neutrophil:lymphocyte ratios (Salak-Johnson et al., 1997). Transport also increased saliva cortisol concentrations in finishing pigs (Geverink et al., 1998a) and plasma cortisol concentrations in weaned pigs (Hicks et al., 1998).

In USA slaughter houses, there is a confined space in the pre-stun area, consisting of two corridors running side by side (the 'irons'), where pigs move one by one towards the electric or CO₂ stun area. The irons are where most rearing, backflows and prodding happen as pigs are encouraged to enter the stun area (Grandin, 1982). Slaughter houses train their employees to handle pigs gently; however the electric prod is still used in the irons area. The use of the electric prod and the paddle caused finishing pigs to rear, turn back, back up, and delayed pig movement forward when they were handled in a chute or alley (McGlone et al., 2004). If pigs were motivated to move forward voluntarily, the frequency of tapping/touching with the paddle or the electric prod may decrease, which would decrease the relative distress experienced by pigs and potentially decrease the rate of non-ambulatory pigs at the slaughter plant (Benjamin et al., 2001). If pigs moved voluntarily, time efficiency at loading, unloading and at the plant may also be improved.

The objectives of this experiment were to reduce the time needed for pigs to unload from a trailer and move through a novel environment and to reduce the use of paddles at loading, unloading and during movement to a simulated pre-stun area. Pigs were either trained (or not) to the novel odor/taste reward of maple syrup during the late finishing period and then exposed (or not) to this reward at the simulated slaughter house. The first hypothesis was that pigs that had been trained to a novel odor/taste in the finishing barn would be motivated by the same reward when present in a novel environment, move

faster and be tapped less. The second hypothesis was that the plasma cortisol concentration and neutrophil:lymphocyte ratio would be decreased in trained/rewarded pigs compared to non-trained/non-rewarded pigs following exposure to a novel environment.

2. Materials and methods

2.1. Animals and procedures

Texas Tech University Animal Care and Use Committee approved all experimental procedures. The experiment was conducted in May 2006 and July 2006. Pigs were housed on slatted floors, in a building with natural ventilation and were offered feed and water ad libitum. Daily temperatures ranged between 15 °C minimum (in the early morning) and 40 °C maximum.

Ten days prior to the testing day, 280 pigs (100–120 kg, PIC Camborough, USA) were organized in pens of 10 pigs and balanced for weight and sex. The pen was the experimental unit. One complete set of treatments or block (four pens of 10 pigs) was examined each day, for 7 d (28 pens in total). Within a block, each of the four pens of 10 pigs was randomly assigned to one of four treatments according to a 2 × 2 factorial arrangement: training at the barn (trained or non-trained) and treatment at the plant (odor/taste reward or no reward). Treatments were: (1) non-trained/non-rewarded, (2) trained/rewarded, (3) non-trained/rewarded, and (4) trained/non-rewarded. Maple syrup was chosen as the odor/taste reward as it has a strong, novel smell, known palatability (Frederick and van Heugten, 2002) and rewarding properties (Salak-Johnson et al., 1997).

2.2. Training procedures

'Training' refers to physical exercise and exposure to maple syrup odor in the finishing barn. Trained pigs were let out of their home pens and gently pushed with beaded paddles and boards (13 KP48, Wiggins & Associates Inc., Gresham, OR, USA) up a ramp in the aisle of the finishing barn, and onto a trailer. The ramp had a 30% (17°) slope, was 1.22 m in length and had cleats spaced at 20 cm to prevent slipping. A maple syrup-soaked flag made of 100% cotton which pigs were allowed to occasionally taste, was dragged in front of the pigs. Once the pigs had reached the maple syrup flags in the trailer, they were allowed to go freely back and forth up the ramp and in and out of the trailer for 10 min a day for 10 consecutive days. Non-trained pigs stayed in their home pen: they were neither handled nor exposed to maple syrup.

On the testing day, pigs were taken out of their home pens as pen groups. They were pushed with boards and fiberglass beaded paddles to the same trailer used for training. The pigs were weighed on the trailer and transferred to a different four-compartment trailer. Each compartment was 5.3 m² for 8–10 pigs. Once the pigs were loaded, they were transported for 70 min on a paved road. The departure time varied between 05:30 h and 05:45 h. The trip included 14 corners and the speed was kept at approximately 80 km/h. The same driver drove throughout the entire experiment.

After transport, the pigs were unloaded as pen groups and remained in four shaded resting pens for 2 h (approximately 07:15–09:15 h). The resting pens were located near the simulated pre-stun area (Fig. 1) and were 7.62 m² with one drinker per pen. A misting system was turned on when the temperature reached or exceeded 28 °C. After the 2-h rest period, the pigs from one pen were taken out and moved through the simulated pre-stun area (Fig. 1). Only half the pigs (five pigs on average) were allowed to simultaneously go through the gate leading to the irons. The second half of the group was waiting by the gate until the first half had exited the simulated CO₂ stun box then was run through the irons. Pigs were moved through the irons into the simulated CO₂ stun box (enclosed box, 2.40 m long × 0.86 m large × 1.04 m high, with a light inside—approximately 640 lx at 0.5 m above the ground). Two handlers were standing on each side of the irons and used fiberglass beaded paddles to push the pigs through. The gates into the irons were operated by two other handlers who also managed possible backflows. People performed the same tasks in order to avoid variation among experimental units. For behavioral observations, the irons were divided into two portions: the first part was the section between the first and second gate and the second part was from the second gate to the entrance of the simulated CO₂ stun box (Fig. 1). On exiting of the simulated CO₂ stun box, one pig (barrow or

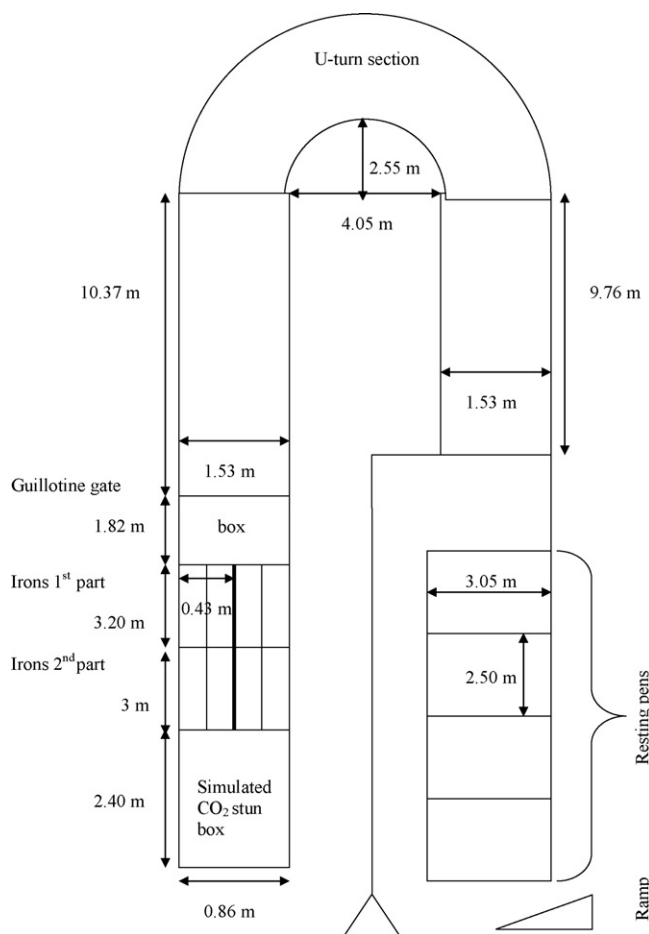


Fig. 1. Diagram of the simulated slaughter plant holding, pre-stun, and stun areas. Pigs were loaded at a finishing site, transported for 70 min, unloaded, held for 2 h in the shaded resting pens, then moved through chute, pre-stun area (called the “irons”) and into a simulated CO₂ stun box.

gilt) was randomly chosen and immobilized using a snare. A 20 mL blood sample was collected over EDTA (ethylenediaminetetraacetic acid) via jugular venipuncture. The same procedure was repeated for the second half of the same experimental unit for a gilt or a barrow so that in each experimental unit, a blood sample was collected from one barrow and one gilt. Blood samples were therefore collected between 2 h and 2 h 40 min after entrance in the resting pens.

Rewarded pigs were exposed to the maple syrup-soaked flag throughout the simulated pre-stun area. A person walked outside the simulated pre-stun area and dragged the flag at a variable speed to maintain the flow of pigs. Pigs were allowed to occasionally nibble and taste the flag. The simulated CO₂ stun box also contained four maple syrup-soaked flags on the exit doors of the box to provide the smell of maple syrup when its door was open. Fresh flags were provided for each experimental unit. There were no flags for the non-rewarded pigs. Though this could induce a bias, to evaluate the objectives, for odor research it is important that the control treatment group have no chance to smell even a very small amount of the reward odor. Hence, rewarded pigs were tested after the non-rewarded pigs.

2.3. Behavioral measures

Behavioral data in the resting pens were recorded by a single observer who stood still in the same place, 4 m in front of the resting pens while observing the pigs in the four resting pens. In each pen, the number of pigs standing, lying and sitting (as defined by Hurnik et al., 1995) was recorded at 5-min intervals over the 2-h resting period. Activity behaviors were fighting behaviors (i.e. two or more pigs engaged in an aggressive or

submissive encounter, biting the ears, head and neck area, attempting to bite and/or retreating/turning; McGlone and Curtis, 1985).

The mean of the individual time to unload the pigs and push them into their resting pen was recorded as a measure of speed of moving after transport. The time to enter the irons (from the time the last pig had passed the guillotine gate to the time the last pig entered the irons, Fig. 1), the time to enter the simulated CO₂ stun box (from the time the last pig had entered the irons to the last pig entered the simulated CO₂ stun box) and the total time from the resting pen to the simulated CO₂ stun box were recorded per group, then averaged depending on the number of pigs to have individual measures of timing (s/pig).

The movement of the pigs throughout the simulated pre-stun area was recorded using time-lapse VCRs (Panasonic TL 500, Yokohama, Japan, 2-h mode), overhead cameras (Panasonic wv-BP70 and Panasonic wv-CP412, Yokohama, Japan) and a digital camera (Canon DC230, Japan). The individual frequency of touching/tapping pigs with the paddle in the first and second part of the irons and the percentage of time lost in backflows were recorded. A backflow occurred when a pig was in the simulated CO₂ stun box, came out before the gates of the box were closed, and had to be pushed back inside the CO₂ stun box. The time spent backflowing (starting when the first pig came back out and ending when the last pig was back inside the simulated CO₂ stun box) was divided by the total time needed for all pigs to be in the simulated CO₂ stun box (starting when the first pig was in the box for the first time and ending when the last pig was in the box) to obtain the percentage of time lost in backflows.

In the reward treatment, four flags were soaked in maple syrup and attached to the exit door and to the far end sides of the simulated CO₂ stun box. The time spent not chewing any flag was subtracted from and

divided by the total time spent in the simulated CO₂ stun box by the group of pigs to obtain the percentage of time spent chewing the reward.

2.4. Immune and cortisol measures

Whole blood was analyzed using a Cell Dyn-3700 (Abbott labs, Santa Clara, CA, USA) and the following measures were obtained: total white blood cells, total red blood cell count, hemoglobin, hematocrit and percentage of neutrophils, lymphocytes, monocytes, eosinophils and basophils. The neutrophil:lymphocyte ratio was calculated. The remainder of the blood sample was centrifuged at 1800 rpm for 15 min. Plasma was removed and frozen at -80 °C until cortisol analysis was performed. Plasma cortisol concentrations were measured using a Coat-a-count kit (Diagnostic products, Los Angeles, CA, USA). The intra-assay variation was 5.4%.

2.5. Statistical analyses

All data were checked for normality using the Minitab[®] software (Minitab Inc., State College, PA, USA) and equality of variances was checked using Levene's test in SAS (SAS Inst. Inc., Cary, NC, USA, Version 9.1, 2002–2003) prior to statistical analyses. The timing data (in s) and the cortisol concentrations were log-transformed to reach normality.

The behavioral data collected in the resting pens and inside the simulated CO₂ stun box and the time to unload and reach the resting pen were analyzed using the general linear model procedure in SAS. Training at the barn (trained or non-trained) and block were included as main effects in the model with training at the barn by block as the experimental error.

Other timing data, percentage of time lost in backflows, tapping/touching frequencies and immune data were analyzed using the general linear model procedure in SAS. The model included block, training at the barn and treatment at the plant as main effects and their interaction. Block by treatment at the plant served as the experimental error. Pair-wise comparisons for training at the barn or treatment at the plant were assessed using the least squares means and *t*-tests if a significant ($P < 0.05$) treatment effect was detected.

The correlation procedure in SAS was used to assess correlations between timing data, immune data, plasma cortisol concentrations and tapping/touching frequency.

3. Results

3.1. Behavioral measures

Training in the finishing barn did not affect sitting ($3.7\% \pm 0.62$; $F = 1.42$, d.f. = 1, $P = 0.26$), standing ($33.1\% \pm 2.29$; $F = 0.68$, d.f. = 1, $P = 0.42$) lying ($60.0\% \pm 2.74$; $F = 1.50$, d.f. = 1, $P = 0.24$) and fighting ($0.13\% \pm 0.10$; $F = 1.01$, d.f. = 1, $P = 0.33$) behaviors in the resting pens.

When applicable, transformed means will be reported followed by back-transformed means, in parentheses or in Table 1. Trained pigs unloaded and reached the resting pen faster ($F_{(1,5)} = 7.36$, $P = 0.01$) than non-trained pigs (1.6 ± 0.2 (5.6 s/pig) vs. 2.4 ± 0.23 (13.8 s/pig), respectively). There was a block effect ($F_{(1,6)} = 140.26$, $P = 0.0009$) for the time to unload

and reach the resting pen (range: 4.7–23.0 s/pig). The average time to unload and reach the resting pen for blocks 1–7 was 1.13 (13.6 s/pig), 0.93 (8.5 s/pig), 1.36 (23.1 s/pig), 1.01 (10.3 s/pig), 1.30 (19.8 s/pig), 0.75 (5.6 s/pig) and 0.74 (5.5 s/pig) ± 0.005 , respectively. Trained pigs entered the irons faster ($F_{(1,5)} = 22.21$, $P = 0.003$) than non-trained pigs (1.2 ± 0.07 (4.2 s/pig) vs. 1.7 ± 0.07 (7.0 s/pig), respectively) (Table 1). Rewarded pigs entered the irons slower ($F_{(1,5)} = 9.52$, $P = 0.02$) compared to non-rewarded pigs (1.7 ± 0.12 (7.2 s/pig) and 1.2 ± 0.12 (4.0 s/pig), respectively) (Table 1). There was a significant interaction between training and providing the reward to enter the simulated CO₂ stun box ($F_{(1,5)} = 6.62$, $P = 0.04$); trained/rewarded pigs entered the simulated CO₂ box faster ($P < 0.05$) than trained/non-rewarded pigs (2.0 ± 0.2 and 2.6 ± 0.2 , respectively) (Table 1). The differences on the total time from unloading to the simulated CO₂ stun box were not statistically significant ($P > 0.19$) (Table 1).

In the second part of the irons, rewarded-pigs received less ($F_{(1,5)} = 11.18$, $P = 0.02$) taps (reward: 0.039 ± 0.008 taps/pig/s; non-reward: 0.074 ± 0.0051 taps/pig/s) and had fewer ($F_{(1,5)} = 6.48$, $P = 0.05$) backflows compared to non-rewarded-pigs (reward: $0.082\% \pm 0.68$; non-reward: $2.43\% \pm 0.68$). No significant interaction between training at the farm and providing the reward at the plant ($P > 0.53$) was found for touching/tapping frequency in the second part of the irons. However, in the first part of the irons, non-trained/non-rewarded pigs received fewer ($F_{(1,2)} = 29.58$, $P = 0.03$) taps (0.00 taps/s/pig ± 0.0015) than the trained/rewarded pigs (0.015 taps/s/pig ± 0.0015), the trained/non-rewarded pigs (0.012 taps/s/pig ± 0.0015) or the non-trained/rewarded pigs (0.012 taps/s/pig ± 0.0015).

Regardless of previous exposure to maple syrup, the percentage of time spent chewing on the reward inside the simulated CO₂ stun box was not affected ($P > 0.05$) ($46.9\% \pm 7.59$).

3.2. Immune and cortisol measures

Trained/non-rewarded pigs tended ($F_{(1,2)} = 4.69$, $P = 0.07$) to have a higher white blood cell count ($19,700 \mu\text{L}^{-1} \pm 780$) than trained/reward ($17,700 \mu\text{L}^{-1} \pm 780$), non-trained/reward ($17,800 \mu\text{L}^{-1} \pm 780$) and non-trained/no-reward pigs ($17,000 \mu\text{L}^{-1} \pm 780$). Trained pigs had lower ($F_{(1,5)} = 10.66$, $P = 0.02$) percentage of neutrophils than non-trained pigs ($41.1\% \pm 1.4$ vs. $47.6\% \pm 1.4$) and a greater ($F_{(1,5)} = 8.27$, $P = 0.03$) percentage of lymphocytes than non-trained pigs ($51.2\% \pm 1.73$ vs. $44.2\% \pm 1.73$). The N:L ratio was

Table 1

Least squares means for time required to move through the simulated pre-stun area and human touching of pigs with a handling device ($n = 7$ blocks per treatment). Means with different superscripts differ, $P < 0.05$.

Variable measured	At farm (at plant)				SE	P-values		
	Non-trained (no reward)	Non-trained (reward)	Trained (no reward)	Trained (reward)		Training at farm	Reward at plant	Interaction
Time to enter the irons (s/pig)	5.4	8.7	2.6	5.7	0.74	0.003	0.02	0.71
Taps second part irons (number/s/pig)	0.062	0.039	0.086	0.039	0.01	0.52	0.02	0.53
Time to enter the simulated CO ₂ stun box (s/pig)	10.8 ^{a,b}	12.7 ^{a,b}	15.3 ^b	8.19 ^a	1.8	0.74	0.26	0.04
Average of the total individual time from resting pen to the simulated CO ₂ stun box (s/pig)	80.2	76.4	69.4	60.5	11.3	0.19	0.33	0.81

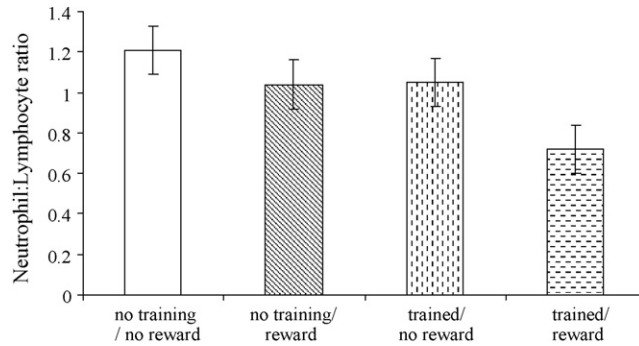


Fig. 2. Additive effect of the training at the farm (allowed out of their home pen and exposed to maple syrup or not) and the treatment at the plant (presented with a maple syrup reward in a novel simulated pre-stun area or not) on neutrophil:lymphocyte (N:L) ratio ($n = 7$ blocks/treatment).

also lower ($F_{(1,5)} = 13.40, P = 0.01$) among trained pigs (0.9 ± 0.05) compared to non-trained pigs (1.1 ± 0.05). No significant interaction between training at the farm and treatment at the plant was found ($F_{(1,2)} = 0.47, P = 0.52$), but the individual main effects of training or reward were additive (Fig. 2). Compared to non-trained/non-rewarded pigs, trained or rewarded pigs showed a similar, incremental decrease in the N:L ratio. Adding together the magnitude of the training effect

and the reward effect, among trained/rewarded pigs yielded a further incremental and additive decrease in the N:L ratio (Fig. 2).

Differences were not statistically significant for the number of red blood cells ($7130 \mu\text{L}^{-1} \pm 150, P > 0.64$), hemoglobin ($13.4 \text{ g/dL} \pm 0.21, P > 0.51$), hematocrit ($37.9\% \pm 0.63, P > 0.62$), percentage of monocytes ($5.33\% \pm 0.31, P > 0.26$), eosinophils ($1.03\% \pm 0.08, P > 0.27$), basophils

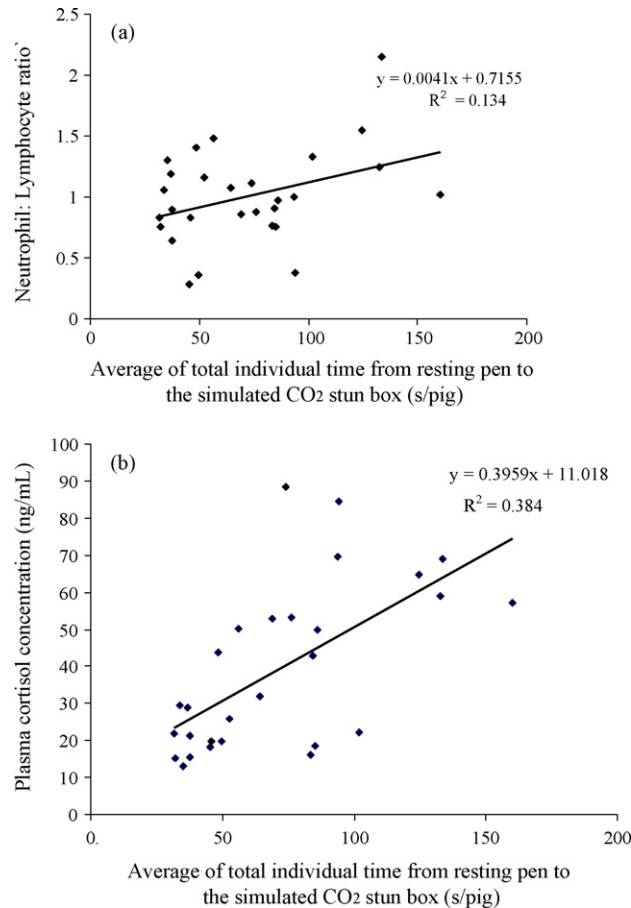


Fig. 3. Relationships between pig movement times, neutrophil:lymphocyte ratio and plasma cortisol measures. (a) Relationship between average of total individual time from resting pen to the simulated CO₂ stun box (s/pig) and neutrophil:lymphocyte ratio ($n = 26, P = 0.055$). (b) Relationship between average of total individual time from resting pen to the simulated CO₂ stun box (s/pig) and plasma cortisol concentrations (ng/mL) ($n = 28, P = 0.0004$).

($1.57\% \pm 0.15$, $P > 0.17$) and plasma cortisol concentration (1.59 ± 0.48 (39.4 ng/mL), $P > 0.11$). However, there was a block effect on plasma cortisol concentration ($F_{(1,2)} = 10.76$, $P = 0.0054$). The average plasma cortisol concentration for blocks 1–7 in was 1.74 (55.5 ng/mL), 1.80 (63.5 ng/mL), 1.82 (66.3 ng/mL), 1.37 (23.4 ng/mL), 1.37 (23.6 ng/mL), 1.39 (24.7 ng/mL) and 1.27 (18.8 ng/mL) ± 0.0049 , respectively. The average plasma cortisol concentration of the final four blocks (conducted in July) was therefore lower than that of the first three blocks conducted 2 months earlier.

3.3. Correlations

As the total individual time to go through the simulated pre-stun area increased, both the N:L ratio ($r = 0.37$, $P = 0.055$; Fig. 3a) and mean plasma cortisol concentrations increased ($r = 0.62$, $P = 0.0004$; Fig. 3b).

4. Discussion

The first question that this study addressed was 'does training at the farm help improve time efficiency in a novel environment?' The block effect on the time to unload the trailer and reach the resting pen may simply reflect the expected variability among experimental units. The use of experimental blocking removes variation and allows a more sensitive evaluation of treatment effects, e.g., trained pigs were unloaded from the trailer and reached the resting pens 8 s/pig faster than non-trained pigs, which was twice as fast. This suggests that pigs familiar with moving out of their home pen were either more willing or more able (or both) to move when taken to a new environment. Our results are consistent with the findings of other studies involving training pigs at the farm. For example, Abbott and Hunter (1994) moved pigs for 2 min weekly for 3 weeks prior to slaughter and found that pigs exited the home pen twice as fast as non-handled pigs. Geverink et al. (1998b) allowed pigs to move freely out of the home pen for 8 min (and 2 min in a mobile box) twice a week from week 15 to week 23 of age and found that pigs moved faster out of their home pen and into the box at age 25 weeks. Based on our example, if pigs were unloaded by groups of five at the slaughter house, the time saving would be 8 s per group and 288 s on a truck of 180 pigs. If unloading were to take 30 min (as is common in this area), the turnover of trucks at the slaughter house could be increased by 16%. More rapid unloading may also reduce truck waiting time at the slaughter house, which is a risk factor for pig deaths especially during periods of warm weather (Sutherland et al., 2008). Not only did trained pigs unload and reach the resting pens faster, they also entered the irons 1.7 times faster (2.8 s/pig) than non-trained pigs. This demonstrates that letting pigs move freely out of their home pen for 10 min/d for 10 d reduced the time required to move them in a novel setting.

The second question that this study addressed was 'does training at the farm help decrease pig stress?' where an increased number of hits with the paddle was considered a precursor of stress (Hemsworth et al., 2002), while an increased neutrophil:lymphocyte (N:L) ratio (Salak-Johnson et al., 1997) and an increased plasma

cortisol concentration (Hemsworth et al., 2002) were considered indicators of stress. The effects of the training at the farm did not carry over to pig behavior in the resting pen. However, when exposed to the simulated stun area, trained pigs moved faster and had a lower N:L ratio compared to non-trained pigs and these variables were positively correlated (Fig. 3a). This is of considerable importance from an animal welfare point of view as high N:L ratio is a predictor of the rate of non-ambulatory, non-injured (NANI) pigs (Sutherland et al., 2008). Despite the noticeable beneficial effects of training on the N:L ratio, no significant effect was found on plasma cortisol concentration. This finding is consistent with the results of Geverink et al. (1998a) who showed no handling-induced increase in salivary cortisol concentration after the pigs had been transported and rested. In our experiment, the average plasma cortisol concentration of the final four blocks (conducted in July) was lower than that of the first three blocks conducted 2 months earlier. Though we suspect the higher levels were due to the heat stress, other factors, such as handler experience, cannot be excluded. The change in N:L ratio may be due to the timeline of blood collection, as the N:L ratio changes at a different rate compared to plasma cortisol concentrations (Salak-Johnson and McGlone, 2007). The reduction in physiological signs of stress were minimal and transient, as the N:L ratio was lower in trained pigs compared to non-trained pigs, but the plasma cortisol concentration was not improved. However, the requirement to take only one blood sampling (to avoid sampling method-induced stress hormone changes) meant we could not completely sample blood over time. A more complete sampling over time, perhaps with catheterized animals (to avoid sampling bias) might clarify the magnitude of the stress reduction. Furthermore, training did not have the expected effects on decreasing the number of touches/taps with the paddle. Indeed, trained pigs received more taps than non-trained/non-rewarded pigs. It is possible that trained pigs received more taps because training had made them less fearful of people. In this case, pigs would not move away from people, but would stop when people were adjacent to them in the simulated chute. When trained pigs would not move away from people, more taps were administered. We concluded that 10 consecutive days of training made the pigs overly tame. This hypothesis would agree with the results of Hemsworth et al. (2002) who found that pigs that were less fearful of humans on the farm were tapped more at the slaughter plant, and of others who showed that regularly handled pigs were not easier to move than pigs that were naïve to handling (Grandin, 1987; Geverink et al., 1998b). Based on the reduction of the N:L ratio, training at the farm decreased pig stress. However, the optimal training schedule remains to be determined to limit the number of taps with the paddle while still decreasing the N:L ratio and moving time.

The third question that this study addressed was 'does providing a reward at the plant increase time efficiency and improve welfare?' Rewarded pigs entered the irons 1.8 times slower (3.2 s/pig) than non-rewarded pigs, regardless of their familiarity with maple syrup (through training). However, among trained pigs (familiar with

the smell of maple syrup), the presence of the reward inside the simulated CO₂ stun box made them move twice as fast compared to if there was no reward. This suggests that the presence of the reward acted differently depending on where it was placed and on how familiar it was to pigs. When present at the iron entrance, regardless of the familiarity of pigs to it, maple syrup may have been distracting, hence the slower motion. However, once the pigs had entered the irons, it acted to promote movement towards the simulated CO₂ stun box, especially if pigs were familiar with it. Moreover, the presence of the reward decreased backflows because pigs were occupied chewing on the flags inside the simulated CO₂ stun box. Therefore, training pigs to a reward and providing the reward at the plant improved time efficiency. In addition to this, though this method failed to decrease the overall number of touches/taps with the paddle (probably due to pigs being too tame), it had additive effects on decreasing the N:L ratio. Therefore, training pigs to a reward and providing them the reward at the plant improved welfare.

5. Conclusion

Allowing finishing pigs to exercise and move outside of their home pen while exposing them to an odor/taste exposing them to an odor/taste at the farm ('training') improved time efficiency in moving them and reduced stress (as measured by the N:L ratio), and more so if pigs were familiar with the odor and were presented with it in the novel environment. However, it is unclear if the effects were due to the exercise or to the odor exposure. Furthermore, with this specific training method, the number of touches/taps with the paddles was not reduced in trained pigs. Therefore, the most efficient training method, schedule, number of sessions, interval between sessions, duration of sessions and age to start training, are factors that remain to be determined. Ultimately, this method of training could decrease the rate of non-ambulatory, non-injured pigs, which is of considerable interest from a welfare and economic point of view.

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