The behaviour of early-weaned piglets following transport: Effect of season and weaning weight

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Received 4 July 2007, accepted 25 March 2008.

Wamnes, S., Lewis, N. J. and Berry, R. J. 2008. The behaviour of early-weaned piglets following transport: Effect of season and weaning weight. Can. J. Anim. Sci. 88: 357–367. Two groups of 48 Cotswold piglets were weaned at 17 ± 1 d of age and assigned to road or simulated transport during summer or winter. Following transport (0, 6, 12 or 24 h), piglets were grouped by weaning weight (light, medium and heavy) in pens of four. Piglet behaviour was recorded on days 1–4, 7 and 14 after weaning and transport. As transport duration increased, drinking behaviour increased (P < 0.05). Control (0 h) piglets fed less (1.5%) than transported piglets (3.1%) during the first 3 d in housing. Significant differences were observed on days 2 and 3 only (P < 0.02). Across season and transport treatment, heavy piglets spent more time fighting (P < 0.005) during the first day in housing, and less time feeding (P < 0.05) during the first 3 d in housing compared with light and medium piglets. During the first 3 d in weanling pens, piglets spent less time feeding following road transport (2.4%) than following simulated transport (2.9%, P < 0.05). Piglets transported by road also spent more time engaged in oral/nasal behaviour during the first 3 d in housing compared with simulated transport groups, although this reached significance on day 3 only (P < 0.05). These results suggest that transport of early-weaned piglets may exacerbate the stress of weaning through additional stress related to factors associated with truck movement, such as noise and vibration, and by imposing an increased risk of dehydration following long journeys (> 12 h).

**Key words:** Early weaning, transport, pigs, behaviour, season

Wamnes, S., Lewis, N. J. et Berry, R. J. 2008. Comportement des porcelets sevrés hâtivement après le transport : incidence de la saison et du poids au sevrage. Can. J. Anim. Sci. 88: 357–367. Deux groupes de 48 porcelets Cotswold ont été sevrés à 17 ± 1 jours et transportés par camion en été ou en hiver, ou ont subi une telle simulation. Après le transport (0, 6, 12 ou 24 h), les sujets ont été placés dans des enclos par groupe de quatre, selon leur poids (léger, moyen ou lourd). Les auteurs ont ensuite noté leur comportement 1–4, 7 et 14 jours après le sevrage et le transport. Les animaux boivent plus quand le transport se prolonge (P < 0.05). Au cours des trois premiers jours dans l’enclos, les témoins (0 h de transport) mangent moins (1,5 %) que les porcelets qui ont été transportés (3,1 %). On ne note de variation importante que les deuxième et troisième jours (P < 0.02). Peu importe la saison et la durée du transport, les porcelets lourds passent plus de temps à se battre (P < 0,005) la première journée et moins de temps à se nourrir (P < 0,05) les trois premiers jours, comparativement aux animaux de poids léger ou moyen. Durant les trois premiers jours dans l’enclos, les porcelets passent moins de temps à se nourrir après le transport routier (2,4 %) qu’après une simulation de ce dernier (2,9 %, P < 0,05). Les animaux transportés réellement consacrent aussi plus de temps aux comportements oraux/nasaux lors des trois premières journées dans l’enclos, comparativement à ceux dont on avait simulé le transport, mais cette différence n’est significative que le troisième jour (P < 0,05). Les résultats laissent croire que le transport des porcelets sevrés précocement pourrait exacerber le stress du sevrage en y ajoutant le stress lié aux mouvements du camion, tels le bruit et les vibrations, et en accroissant les risques de déshydratation au terme d’un long périple (> 12 h).

**Mots clés:** Sevrage précoce, transport, porcs, comportement, saison

Segregated early weaning (SEW) is currently a common piglet management practice in North America (Carroll et al. 1998; Worobec et al. 1999). Previous studies have shown that early weaning causes reduced post-weaning feed intake (Leibbrandt et al. 1975), weight loss (Lewis et al. 2005), increased levels of oral/nasal behaviour (Gonyou et al. 1998), and increased levels of vocalization (Weary et al. 1999). Therefore, early weaning is believed to cause significant stress to piglets. As SEW necessitates the transport of piglets to a separate production facility, millions of early-weaned piglets are transported across North America every year (Manitoba Pork Council, personal communication 2005). Transport is an additional stressor, involving mixing, crowding, feed and water deprivation, cold, heat, temperature fluctuations, vibration and noise, and is, therefore, a concern with respect to animal welfare. Studies involving transport of grower and slaughter pigs have shown that transport (simulated transport and road transport) may cause increased levels of stress hormones (McGlone et al. 1993; Bradshaw et al. 1996a,b; Hicks et al. 1998; Parrot et al. 1998), changes in behaviour (Hicks et al. 1998), fatigue (Lambooy 1988), and increased weight loss relative to controls (Lambooy et al. 1985). When weaning coincides

**Abbreviations:** SEW, segregated early weaning; SEM, standard error of mean
with transport, the stressors may be additive, increasing the detrimental effects of early weaning. Temperature and duration of transport are believed to be two primary factors affecting early-weaned piglets’ responses to transport (Berry and Lewis 2001). While the duration of journeys within Canada typically falls within the range of 4–20 h, transport across the US border may extend beyond 24 h. Currently the two Canadian codes of practice state different duration allowances, 12 h [Canadian Agri-Food Research Council 2001 (CARC)] and 24 h (CARC 2003). Information on the stress associated with 12 and 24 h of transport is needed to resolve this discrepancy. Compromised welfare due to increased levels of stress may be detected through piglet behaviour, often before any differences in performance parameters appear. The objectives of this experiment were to study the behaviour and performance of early-weaned piglets as affected by (1) the duration of transport, (2) season of transport, (3) weaning weight, and (4) the general effects of road transport, including noise, vibration, movement and fluctuating temperatures. Production variables have been addressed in a previous paper (Wamnes et. al. 2006).

MATERIALS AND METHODS

Animals and Housing
One hundred and ninety-two Cotswold (Cotswold Canada Inc.) piglets, with a mean initial body weight of 6.28 kg were weaned at 17 ± 1 d of age and immediately placed on trial. Following weaning and transport, piglets were housed in a temperature-controlled room, which was maintained at 30°C for the first week, and then gradually reduced by 0.5°C every second day to 28°C. Piglets were fed a commercial medicated weaner diet that was replaced daily. Feed and water were available ad libitum.

Piglets were assigned, in groups of four, to raised weaner pens. Each pen measured 1.06 × 1.72 m, which allowed 0.43 m² per pig. Individual pens were equipped with one water nipple, adjusted to piglet shoulder height, one free-flow stainless steel pellet feeder designed for weanlings, and a plastic-coated expanded metal floor. A chain was hung from the mid point of the longest side as an enrichment device. Animal care was conducted in accordance with the Canadian Council on Animal Care Guidelines (CCAC 1993) and Recommended Code of Practice for the Care and Handling of Farm Animals: Pigs (CARC 1993).

Experimental Design
The experiment was carried out in two seasons, winter and summer. In each season, two groups of 48 piglets were exposed to transport, one group to road transport and the other to simulated transport. In order to control for loading and handling, each group (including control piglets) were transported (<20 min) from the farrowing unit to the research facility. This transport occurred in the van described for road transport and at a density of 0.625 m² per pig. Simulated transport occurred 2 d after road transport. This was necessary in order to process the temperature data from the road transport that was utilized in the simulation. On arrival, all piglets were weighed. Control (0 h) piglets were removed from the truck and placed directly into weanling pens. The piglets assigned to simulated transport were removed from the truck and placed in simulated-transport boxes in temperature-controlled rooms in the weanling facility. The piglets assigned to road transport remained on the truck for the assigned duration of transport. At 6, 12, and 24 h all piglets (in weanling pens, simulated and road transport) were checked and weighed to ensure piglet welfare. Two days prior to weaning, piglets within each transport type (road or simulated) were ranked from 1 to 48 according to their relative weight. Piglets were then categorized and marked as heavy (1–16), medium (17–32) or light (33–48) according to their weight rank. This resulted in three different (P < 0.01) weight groups, based on weight at weaning, heavy (7.38 kg), medium (6.17 kg) and light (5.26 kg; SEM 0.11). Within the weight groups (16 pigs), four piglets, from different litters, were randomly assigned to either 0, 6, 12 or 24 h of transport, representing control groups (0 h), short, medium and long journeys, respectively. Mixing litters was given priority over mixing sexes, resulting in one single-sex pen in trial 1 (winter) and one single-sex pen in trial 2 (summer). A black non-toxic permanent marker was used to identify individual animals during transport and later in their housing pen. Handling during weighing and removing of piglets at the weaning housing should be considered additional to that which would normally occur during commercial transport. However, this was necessary for accurate weights for this study and was consistent across all treatment groups.

Road Transport
Road transport was carried out using a 1-ton cube-van. Daylight entered the cargo area through a translucent skylight, but no artificial light was supplied at night. The vehicle was not equipped with controlled ventilation for the cargo compartment. In accordance with commercial transport practices, piglets received no feed or water while in transit, and no supplemental heat was provided during winter transport. Piglets were transported as a single group of 36 pigs and, due to the removal of piglets, 12 at each time period, space allowance ranged from 0.085 (0–6 h) to 0.125 (6–12 h) to 0.25 m²/piglet (12–24 h). This adhered to the recommended minimum 0.085 m²/piglet up to 9 kg (CARC 2001) and the commercial transport recommendations of allowing more space per pig during long journeys (more than 4 h in transit). Straw (approx. 20 cm) and shavings (approx. 1 cm) were provided as bedding material during the winter trial, while dry shavings were used during the summer trial. Two electronic temperature
Probes (Campbell Scientific CS500-L, Edmonton, AB) were used to obtain internal van temperatures every minute; one along a side wall and the other immediately above the piglets. Temperature data were averaged over 10 min and stored on a data logger (Campbell Scientific CR10X, Edmonton, AB). Average temperatures recorded above the piglets during road transport in winter were 8.4, 7.1 and -0.15°C during 0–6, 6–12 and 12–24 h of transport, respectively. Corresponding temperatures in summer were 23, 25.7 and 17.4°C. Graphed temperatures can be found in Wamnes et al. (2006). Driving was predominantly along highways and was initiated between 0900 and 0930 each day of transport.

**Simulated Transport**

The comparison between road and simulated transport was used to evaluate the composite effect of noise, vibration, temperature fluctuation and other variables associated with the movement of the truck during road transport. Consequently, the simulated transport reproduced only confinement, duration and average temperature. Transport was simulated using high-sided wooden boxes (0.9 m W x 1.25 m L x 0.75 m H) placed in a temperature-controlled room. Piglets were transported in groups of 12 due to the size restriction of the simulated transport boxes. This resulted in a difference in group size (36 vs. 12 piglets) between road and simulated transport. This difference was considered following analysis of results, but was not considered to have a substantial effect. Due to the removal of piglets, space allowance ranged from 0.094 (0–6 h), to 0.14 (6–12 h) to 0.28 m²/piglet (12–24 h), above the recommended minimum 0.085 m²/piglet (CARC 2001). Space allowance was not restricted, allowing a full range of thermoregulatory behaviour. Transport boxes were bedded with dry shavings in the summer and shavings (approx. 1 cm) and straw (approx. 20 cm) during the winter trial. The light schedule followed that observed on the day of road transport (summer: 0500 to 2200, winter: 0900 to 1630). Temperatures recorded above the piglets during the first 6, 6–12 and 12–24 h of road transport were averaged and reproduced in the simulated transport. Winter temperatures were 8.4±1°C, 7.1±1°C and 2.5±1°C for 0–6, 6–12 and 12–24 h, respectively. Summer temperatures were 23.0±1°C, 25.7±1°C and 19.0±1°C for 0–6, 6–12 and 12–24 h, respectively. All temperatures in the simulated transport rooms were within 3°C of the average recorded road temperature.

**Behavioural Observations**

Piglet activities were recorded using six low-light level black and white video cameras (Panasonic WV-BP 134), a multiplexer (Panasonic WJ-FS 216) and a time-lapse video recorder (Panasonic AG 6720A). In order to accommodate this video recording, 24 h lighting in the weanling room was utilized. Video recording occurred on days 1–4, 7 and 14 post-weaning and transport. Two methods were used to sample data from the tapes. Continuous sampling was used to record the interval between piglet entry to the nursery pen and the time of the first observation of drinking and feeding (drinking and feeding latency). In addition, continuous sampling was used to record occurrence, duration and frequency of individual feeding and drinking bouts in 2 h blocks over the first 3 d following introduction to the nursery pen: 0–2 h, 6–8 h, 12–14 h, 18–20 h, 24–26 h, 30–32 h, 36–38 h, 42–44 h, 48–50 h, 54–56 h, 60–62 h and 66–68 h. All values in the text are for 8 h d⁻¹.

In order to study general activity, instantaneous scan sampling was performed at 10-min intervals on days 1–4, 7 and 14. The following mutually exclusive behavioural categories were recorded: (1) Standing idle: Piglet was standing still without performing any other apparent behaviour. (2) Lying: Piglet was lying down with head in raised or lowered position, sleeping or awake. (3) Sitting: Piglet was supported on its hind quarters with front legs extended. (4) Drinking: Piglet was holding the drinking nipple in its mouth or appeared to be drinking water resulting from another pig activating the drinking nipple. (5) Feeding: A pig was considered feeding if its head was inside the feeder and it was apparent that the pig was not resting. (6) Playing: Low intensity, non-aggressive interactions with pen-mates or neighbouring piglets. (7) Fighting: High intensity, aggressive interactions between two or more piglets. Fighting included head and body contact, consistent with aggressive encounters. (8) Orally manipulating chain: Nibbling on or chasing the provided chain. (9) Orally manipulating piglet: Biting or nibbling on any body-part of pen-mates irrespective of posture. (10) Belly-nosing: When a piglet was using its snout to repeatedly push or massage a pen-mate. (11) Other: Behaviours that did not fit into any of the other behaviour categories including, but not limited to, walking, exploring and rooting.

**Statistical Analysis**

Data were analyzed using a general linear model with a split-plot in time design (repeated measures) (SAS Institute, Inc. 2001). The main plot included pens within transport treatments and the sub-plot included days of observation. All data were analyzed on a pen basis. All main effects (season, transport type, transport duration and weight grouping), and all two-way interactions in this model were considered fixed effects. Three and four-way interaction mean squares in the analysis of variance were used to provide an estimate of error (Cochran and Cox 1957) as a true replication was not possible. Behaviour data were expressed as a ratio averaged over 8 h (continuous sampling) or 24 h (scan sampling). Variables that did not meet the criteria for normality and homogeneity of variance were transformed before analysis (Steel et al. 1997). A log transformation was used for feeding and drinking frequency and bout length. An arcsine square root transformation was used for behaviours calculated as percentages. Back
transformed means and 95% confidence limits are provided for all transformed values. Pair-wise differences between treatment means were tested using Bonferroni inequality tests. The category “oral/nasal manipulation” was composed of three different behavioural elements, which were directed to the piglet’s physical and social surroundings (orally manipulating a chain, orally manipulating pen mates and belly nosing). Due to their relatively low individual expression, these related behaviours were grouped for the purpose of analysis and discussed as one behavioural element.

RESULTS

Drinking Behaviour

The percentage of time spent drinking during the first 24 h in the pen (day 1) increased from 0 h transport groups (0.5%; 0.4–0.6) to pigs transported for 6 h (1.0%; 0.9–1.2), 12 h (2.0%; 1.7–2.2) and 24 h (3.2%; 2.9–3.5; P < 0.05). Drinking latency was significantly longer for 0 h transport groups (16.1 min; 12.4–20.7) than for 12 h (2.9 min; 2.1–4.1) and 24 h (1.5 min; 1.0–2.2) transport groups (P < 0.05). Drinking latency for the 6-h transport group (5.2 min; 3.9–6.9) was intermediate. By day 2, there were no significant differences in drinking behaviour between piglets in different transport groups. Control (0 h transport) groups expressed a low and consistent level of drinking behaviour (0.5%; 0.4–0.6) during the first 3 d in housing. Piglets transported for 6 h spent more time drinking on day 1 (1.0%; 0.9–1.2) relative to days 2 and 3 (average 0.7%; 0.6–0.9), but the difference was not significant. However, piglets transported for 12 h and 24 h spent significantly more time drinking on day 1 (12 h: 2.0%; 1.7–2.2; 24 h: 3.2%; 2.9–3.5) relative to days 2 and 3 in housing (12 h: 0.6%; 0.5–0.7; 24 h: 0.7%; 0.6–0.8, P < 0.001). Increased drinking on the first day in housing was a result of an increase in the frequency of drinking bouts for 6-h transport groups [day 1: 25.5 (22.5–28.8) vs. 2 and 3: 19.0 (16.8–21.5), 12-h transport groups [day 1: 43.1 (31.2–48.6) vs. 2 and 3: 15.9 (14.1–18.1)] and 24-h transport groups [day 1: 53.5 (47.4–60.3) vs. days 2 and 3: 19.8 (17.5–22.4), P < 0.02]. Piglets transported for 24 h also increased drinking bout duration (day 1: 16.5 s; 14.6–18.6 vs. days 2 and 3: 9.8 s; 8.7–11.2, P < 0.001).

Season affected both drinking bout frequency and duration during the first day in housing, although total drinking time was not affected. Piglets transported during summer had significantly less frequent, but longer, drinking bouts (P < 0.01) than piglets transported during winter (Table 1). Both summer and winter groups spent more time drinking and expressed a significantly higher frequency of drinking bouts on day 1 than on days 2 and 3 post transport. Summer groups expressed significantly longer drinking bouts on day 1 than on days 2 and 3 (P < 0.005). Winter groups expressed longer drinking bouts on day 1 relative to day 2 (P < 0.01) but similar to day 3 (Table 1).

Feeding Behaviour

The proportion of time spent feeding increased significantly over the first 3 d in housing. Piglets spent 0.2% (0.3–0.5) of the time feeding on day 1. By day 2, feeding increased to 1.5% (1.1–1.9) and reached 5.4% (4.7–6.2) by day 3 (P < 0.001). Control (0 h) groups spent less time feeding than transported piglets during the first 3 d in housing. This reached significance on day 2, when 0 h transport groups fed significantly less than groups transported for 12 and 24 h, and on day 3, when 0 h transport groups fed significantly less than all other transport groups (Table 2). Increased feeding on the second day in housing was a result of an increase in the frequency of feeding bouts for all transported groups relative to controls, and an increase in feeding bout length in piglets transported for 24 h. On day 3, both feeding bout frequency and length were increased, but were not statistically different (Table 2).

During the first 3 d in weanling pens, piglets subjected to road transport spent less time feeding (2.1%; 1.6–2.7) than piglets subjected to simulated transport (2.7% (2.0–3.4), P < 0.05). This reduced feeding behaviour

<table>
<thead>
<tr>
<th>Variable</th>
<th>Summer (n = 48 pens)</th>
<th>Winter (n = 48 pens)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D 2</td>
</tr>
<tr>
<td>Total drinking*</td>
<td>1.5b</td>
<td>0.7a</td>
</tr>
<tr>
<td>Confidence interval</td>
<td>1.4–1.7</td>
<td>0.6–0.7</td>
</tr>
<tr>
<td>Frequency*</td>
<td>25.6b</td>
<td>17.4a</td>
</tr>
<tr>
<td>Confidence interval</td>
<td>23.5–27.9</td>
<td>15.9–19.0</td>
</tr>
<tr>
<td>Bout length*</td>
<td>14.0e</td>
<td>10.3a</td>
</tr>
<tr>
<td>Confidence interval</td>
<td>12.8–15.3</td>
<td>9.4–11.2</td>
</tr>
</tbody>
</table>

*Percentage of observed time drinking (8 h d⁻¹ pig⁻¹).

1Average daily observed visits to the drinker (8 h d⁻¹ pig⁻¹).

2Average duration (seconds) of a visit to the drinker.

a–c Values with different letters within a row indicate statistical differences (P < 0.05).
Table 2: Feeding behaviour in piglets during the first 3d (D) following transport of various durations

<table>
<thead>
<tr>
<th>Transport duration</th>
<th>0h (n = 12 pens)</th>
<th>6h (n = 12 pens)</th>
<th>12h (n = 12 pens)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
</tr>
<tr>
<td></td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
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<td>Transport duration</td>
<td>0h (n = 12 pens)</td>
<td>6h (n = 12 pens)</td>
<td>12h (n = 12 pens)</td>
</tr>
<tr>
<td></td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
</tr>
<tr>
<td>Total feeding*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>0.76 (0.47)</td>
<td>0.40 (0.26)</td>
<td>0.60 (0.45)</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>Interven interval</td>
<td>1.0 (1.0)</td>
<td>1.0 (1.0)</td>
<td>1.0 (1.0)</td>
</tr>
<tr>
<td>Bout length</td>
<td>6.3 (6.1)</td>
<td>9.5 (9.5)</td>
<td>11.4 (11.4)</td>
</tr>
<tr>
<td>Confidence</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
</tbody>
</table>

*Values with different letters within a row indicate statistical differences (P<0.05).

was a reflection of significantly less-frequent [8.3 (6.2–11.2) vs. 10.6 (7.8–14.1) bouts d⁻¹, P<0.05] and shorter feeding bouts [36.4 (26.7–49.3) vs. 47.1 (34.9–63.7) s bout⁻¹, P<0.05]. Also, road transport produced a significantly longer feeding latency in large piglets [road transport: 542.9 (337.2–873.84) min vs. simulated transport: 84.6 (52.2–136.6) min, P<0.05], but not in medium [road transport: 349.0 (216.6–561.8) min vs. simulated transport: 95.9 (59.3–154.9) min] or light piglets (road transport: 129.5 (80.1–208.9) min vs. simulated transport: 295.3 (183.2–475.5) min). The proportion of time spent feeding increased progressively from groups of large (1.3%; 0.9–1.7) through medium (1.7%; 1.3–2.2) and small (2.3%; 1.8–2.8) piglets, but was different between groups of large and small piglets only (P<0.05). All piglets reached a relatively uniform level of feeding behaviour by day 3 (average 5.5%; 4.2–7.0). This level was maintained throughout the remaining experimental period.

General Behaviour

Daily Time Budget

Piglets were observed lying in 77.2% of scan observations. In 7.2% of the observations piglets were feeding and in another 3.7% piglets were observed engaging in oral/nasal manipulation of pen mates or objects. Piglets were observed standing idle 2.9% of the time and spent 1.7% of the time drinking. Piglets spent, on average, 1.5% of their time engaged in play behaviour. Fighting was infrequent following the first day in weanling pens and was, on average, observed only 0.6% of the time. Piglets spent 5.2% of the day in other behaviours, such as walking, exploring and rooting.

Transport Duration

Frequency of lying was significantly affected by transport duration on days 1 and 2 in the weanling pens. Transported piglets [6h: 79.3% (77.8–80.8), 12h: 79.8% (78.2–81.2), 24h: 79.1% (77.6–80.6] spent more time lying than 0h piglets [75.2% (73.7–76.7), P<0.01] (Fig. 1). On day 2, 0h piglets (81.4%; 79.9–82.9) were observed lying more frequently than transported groups [6h: 79.9% (77.8–80.8), 12h: 78.3% (76.8–79.8), 24h: 76.6% (75.1–78.1)]. However, the difference reached significance between 0 h, and 12 h (P<0.05) and 24 h (P<0.05) groups only. By the third day in housing all piglets spent similar amounts of time lying (average 78.5%; 77.0–80.0). Although 0 h groups were observed lying significantly less on day 1 (75.2%; 73.7–76.2) than on day 2 (81.4%; 79.9–82.9; P<0.001), there were no significant differences between transported groups on any given day or between days (Fig. 1).

Season

Time spent lying was affected by season during the first 4d in housing, when piglets transported in summer (79.8%; 79.3–80.4) spent significantly more time lying...
than piglets transported in winter (77.3%; 76.8–77.9; P < 0.05). There was no difference between seasons by day 7 (average 75.6%; 74.5–76.7). Play behaviour was low and similar for all piglets during the first 4 d in housing (average 0.7%; 0.5–0.9). By day 7, play had increased to 1.0% (0.8–1.1; P < 0.001) and remained at this level throughout the trial period. Piglets spent more time playing, on average, in winter (1.1%; 1.0–1.3) than in summer (0.9%; 0.7–1.0; P < 0.05).

Weaning Weight
Heavy piglets fought significantly more (3.0%; 2.4–3.6) than light (1.7%; 1.2–2.1) and medium (1.6%; 1.2–2.0) sized piglets during the first day in the weanling pens (P < 0.005) (Fig. 2), but not on subsequent days. Although all piglets expressed reduced aggression with time, the pattern of reduction varied by weight group. While groups of light and heavy piglets fought significantly less on day 2 (small: 0.7%; 0.40–1.0, large: 1.3%; 1.0–1.8) than on day 1 (small: 1.7%; 1.2–2.1; P < 0.002; large: 3.0%; 2.4–3.6; P < 0.0005), medium sized piglets did not express a significant reduction in fighting behaviour until day 3 (day 1: 1.6%; 1.2–2.0, day 3: 0.6%; 0.4–0.9, P < 0.002). Weaning weight did not affect the percentage of time piglets were observed fighting on days 3 or 4 (Fig. 2).
Transport Type

Piglets transported by road spent more time engaged in oral/nasal behaviour during days 2–4 compared with simulated transport groups, but the difference reached significance on day 3 only (road: 2.8% (2.2–3.4) vs. simulated: 1.1% (0.8–1.5); \( P<0.05 \)) (Fig. 3). Piglets subjected to road transport spent significantly less time engaged in oral/nasal manipulation during the first day in housing [0.7% (0.4–1.0) than on days 2–4 (average 2.5% (2.0–3.3); \( P<0.01 \)]. Piglets subjected to simulated transport did not differ significantly between days, and spent on average 1.4%; 1.0–1.9 of the time engaged in oral/nasal manipulation of pen mates and objects (Fig. 3).

DISCUSSION

Drinking increased significantly with increased transport duration on the first day following weaning and transport. As water was not available during transport, drinking was expected to increase in proportion to the period of deprivation. Similar results have been reported by Lewis and Berry (2006). In an earlier study, hematocrit values were also shown to increase with transport duration. However, 0 h transport groups also showed increased hematocrit values, indicating piglets with access to water may not be drinking adequate quantities of water (Berry and Lewis 2001). Becker et al. (1989) found higher hematocrit values in slaughter hogs subjected to transport (11 h) and feed withdrawal (48 and 72 h) than in hogs subjected to feed withdrawal only, indicating that increased dehydration may be associated with other transport variables such as noise, vibration, fluctuating temperature and acceleration/deceleration. This effect may be further exacerbated in early-weaned piglets, based on their dependency on a liquid diet and higher surface to volume ratio relative to adult pigs (Bergeron and Lewis 1997). In the current study, transported piglets increased drinking by increasing bout frequency. This increase was expressed as a linear trend relative to transport duration and reflected the relative need to recoup water loss and re-establish homeostasis. Piglets transported for 24 h also increased drinking bout length, which may be a natural behavioural response to the increased water requirement.

The observation that initial (days 1–3) feeding frequency increased with increased transport duration was in agreement with findings reported by Lewis and Berry (2006). While all transported piglets exhibited significantly more frequent feeding bouts than 0 h groups, 24 h groups also expressed significantly longer feeding bouts. Feed withdrawal for 24 h has been shown to increase feeding motivation in 17- to 18-d-old piglets (Lee et al. 1999) as well as in older pigs (Farmer et al. 2001). The duration of feed withdrawal (in transit) in the current study may similarly have increased piglet appetitive behaviour during the first 3 d in housing. Weaning age has been shown to affect piglet consumption of dry feed immediately following weaning (Metz and Gonyou 1990; Gonyou et al. 1998; Worobec et al. 1999). Also, McCracken et al. (1995) reported rapid post-weaning gut maturation in SEW piglets (19 d of age), including significant growth of the small intestine during the first 5 d following weaning. This rapid process of gut maturation may partially explain the pattern of initial feed intake observed in the current study. Observation of post-transport behaviour necessarily began at the end of the transport period; consequently, groups transported for 6, 12, and 24 h were 0.25, 0.5 and 1 d older than the 0 h piglets on any given day in housing. Therefore, the difference in feeding behaviour between treatment groups on day 2 in housing may have been influenced.

![Fig. 3. Mean percentage of time piglets were observed engaged in oral/nasal manipulation of pen-mates or objects on days 1–4 following weaning and road or simulated transport. Error bars represent 95% confidence intervals. Bars with different letters differ significantly (\( P<0.05 \), \( n = 24 \) pens).](image-url)
by piglet age as well as the effects of transport duration. Comparing 0 h transport groups from day 2 (18 d of age) with 24 h transport groups from day 1 (18 d of age) did not show a significant difference in feeding behaviour. Furthermore, no difference was found between 0 h transport groups on day 3 (19 d) and 24 h transport groups on day 2 (19 d), indicating that piglets spent the same amount of time feeding relative to age, regardless of duration of transport. Increased feeding motivation observed in piglets transported for 24 h in the present study may, therefore, be caused by a combination of hunger and relative age of the piglets at the time when feed becomes available to them.

Resting time was not significantly different across the 4 d in the transport groups and days 3 and 4 in the 0 h transport groups. These times were similar to those observed in other studies involving early-weaned piglets (Metz and Gonyou 1990; Worobec et al. 1999; Li and Gonyou 2002; Lewis and Berry 2006). A lower frequency of resting followed by an apparent compensatory increase in resting behaviour by the 0 h transport groups was an unusual finding. Metz and Gonyou (1990) weaned piglets at 2 or 4 wk of age and reported an increase in resting after weaning, but no increase from day 1 to day 2 post weaning. Lewis and Berry (2006) found that transported piglets rested more frequently on day 1 than 0 h transport groups. However, this was attributed to fatigue in the transported piglets. No compensatory rise in the frequency of resting behaviour in 0 h transport groups was observed on day 2 in that study.

Short lying time and high levels of activity may be indicative of piglets experiencing a higher level of stress (Boe 1993). Gardner et al. (2001) found that “known stressors”, such as increased stocking density and mixing, reduced lying time in piglets weaned at 12–14 d of age. Gonyou et al. (1998) reported a negative relationship between high activity and growth in pigs weaned at 12 and 21 d of age. A study of the performance of the piglets in the current study (Wamnes et al. 2006) found control (0 h) piglets lost more weight and recovered their weaning weight later than piglets transported for 6 h, but consistent with piglets transported for 12 and 24 h. These results indicate that these piglets were not feeding adequately on day 1 post-weaning, and supported stress as a cause for lower levels of resting in the 0 h transport groups. Using resting behaviour as an indicator of the level of stress experienced by the piglets, it appeared that the 0 h transport groups experienced more stress than the transported groups on the first day in weanling housing. However, the piglets’ behaviour during transport in the current study was not observed, making it difficult to directly compare treatment groups during the first day post-weaning. Studies involving long-distance transport of slaughter hogs (Lamboom 1988; Lamboom et al. 1985) and 24 h transport of early-weaned piglets (Lewis and Berry 2006) have shown that pigs spend most of the time in transit lying down, presumably resting. Even if this “resting behaviour” during transport is induced as a coping mechanism against fatigue, it may affect the piglets’ requirement for rest during subsequent days.

Season had a direct effect on the frequency of drinking during the first day in housing. Piglets transported in summer exhibited less frequent, but significantly longer drinking bouts than piglets transported in winter. Theoretically, the higher temperatures experienced during the summer trial resulted in a higher level of water loss and increased motivation to drink following summer transport. This was reflected in longer bout length rather than more frequent drinking bouts. However, total drinking time was not significantly different between seasons, possibly due to the competition at the drinker. Water consumption was not measured, consequently this cannot be confirmed.

Piglets transported in winter were observed lying less frequently with a concurrent increase in the frequency of playing. Increased activity has been suggested to be indicative of a higher level of stress (Boe 1993; Metz and Gonyou 1990; Gonyou et al. 1998; Worobec et al. 1999). However, increased play behaviour has been suggested to be an indication of reduced levels of stress and, therefore, an indication of increased welfare (Lawrence and Appleby 1996; Kelly et al. 2000; Donaldson et al. 2002). Since these measures of welfare are contradictory, and because higher temperatures are known to reduce activity, it is most likely that these observed changes in behaviour were the result of seasonal temperature differences rather than transport stress.

Groups of heavy piglets were observed fighting more frequently than groups of light and medium piglets during the first day in housing. This continued as a trend on day 2 and had disappeared by day 3. Olesen et al. (1996) found total skin lesions and weight to be positively correlated, indicating that fighting between heavier pigs is more severe than fighting between lighter pigs. Since body weight is an indirect indicator of social rank within the group (Rushen 1987; Jensen and Yngvesson 1998; Andersen et al. 2000), it may be expected that large piglets are more motivated to initiate fights and to reciprocate when challenged. Groups of high pigs of similar weight and age may, therefore, have more difficulty establishing a stable dominance hierarchy due to their previous experience as “winners” in social conflicts with smaller littermates. In contrast, light and medium piglets may be better at evaluating their relative fighting ability based on different outcomes from previous conflicts (D’Eath 2002). As a result, in the present study, less overall aggression was observed in these medium- and light-weight groups.

Heavy piglets in the current study expressed longer feeding latencies and lower feeding frequencies than light and medium piglets. Small piglets also showed better feed conversion efficiency and average daily weight gain, as a percentage of weaning weight, relative to heavy piglets during the first 14 d following weaning.
and transport (Wamnes et al. 2006). Bruinix et al. (2001) found similar results when weaning 27-d-old piglets. While early-weaned piglets typically have a very low motivation to consume dry feed immediately following weaning (Metz and Gonyou 1990; Worobec et al. 1999), large piglets, in particular, are believed to have developed a strong dependency on a pure milk diet, making them poorly prepared for abrupt weaning (Weary and Fraser 1997; Weary et al. 1999). Large differences in teat quality during the pre-weaning period may drive piglets on poor producing teats to consume alternative food sources (Mason et al. 2003). Piglets on these teats are often individuals of smaller relative size. Fraser et al. (1988) found that newborn piglets with low milk intake expressed increased drinking behaviour and water usage. Consequently, it may be hypothesized that the smaller piglets in the current study had more experience with dry feed and in using a water nipple, and were, therefore, better prepared to start feeding and drinking. Alternatively, delayed and low feeding behaviour in groups of heavy piglets relative to light and medium piglets may have been due to the high frequency of aggressive interactions in the former groups, possibly disrupting normal feeding patterns. Although these results show that heavy piglets exhibit behavioural characteristics that are different from those of light and medium piglets, the differences did not appear to be directly related to transport stress.

Comparisons between road and simulated transport were used as a preliminary method of studying the effect of the combined factors of road transport, other than duration and temperature. These factors, including noise, vibration, temperature fluctuation, and acceleration/deceleration, are difficult to simulate, but are believed to add to the stress of transport. Conclusions drawn from differences between road and simulated transport were considered to be a preliminary assessment of the importance of these variables compared with duration and temperature. Results from continuous observation periods showed that piglets exposed to simulated transport spent more time feeding than piglets exposed to road transport during the first 3 d in housing. This decreased feeding behaviour following road transport was expressed through a decrease in both the frequency and duration of feeding bouts. Furthermore, heavy piglets delayed initial feeding after exposure to road transport, but not to simulated transport. Wamnes et al. (2006) found piglets exhibited a longer growth check following road transport than following simulated transport. Other studies have found increased levels of stress hormones and expression of motion sickness in pre-pubertal grower pigs following transportation (Bradshaw et al. 1996a,b; Randall and Bradshaw 1998; Parrott et al. 1998). When trained to operate a switch, pigs have been shown to turn off vibration and noise in a transport simulator (Stephens and Perry 1990) indicating these effects of transport are aversive to pigs. It is, therefore, possible that factors such as vibration and noise, present during road transport, act in synergy with weaning-induced stress responses, temporarily reducing feeding motivation compared with early-weaned piglets subjected to simulated transport.

Piglets exposed to road transport in the current study expressed more oral/nasal behaviour than simulated transport groups on days 2–4, suggesting that some elements of road transport (noise, vibration, acceleration/deceleration or fluctuating temperatures) caused more stress than simulated transport. Dybkjær (1992) found an increased occurrence of oral/nasal manipulation in 4-wk-old piglets subjected to social “stressors” such as mixing and crowding. However, the category oral/nasal manipulation in the present study was composed of three different behavioural elements, which were directed to the piglet’s physical and social surroundings (orally manipulating a chain, orally manipulating pen mates and belly nosing). As suggested by others (Dybikjær 1992; Petersen et al. 1995), it may be that these elements have different motivation and are released by different stimuli. Therefore, not all aspects of oral/nasal behaviour observed in the current study were necessarily stress related, making direct comparisons with other research difficult. Nevertheless, our results suggest that road transport has a transient effect on the temporal pattern of oral/nasal behaviour in early-weaned piglets. By day 4 in housing, piglets appeared to have overcome the adverse effects of road transport, as feeding and oral/nasal behaviour no longer differed between treatment groups.

CONCLUSION

The results in this paper are indicative that transport is stressful for early-weaned piglets, but do not clearly indicate whether 12 h or 24 h of transport should be considered the maximum for transport of early-weaned piglets. However, increasing duration of transport was shown to impose an increased risk of dehydration with a qualitative difference in drinking between piglets transported for 12 h and 24 h. Transport stress may be exacerbated through factors associated with truck movement, such as noise and vibration, and this should be given careful consideration when planning transport of early-weaned piglets. Due to increased fighting, delayed initiation of feeding and lower feeding levels, heavy piglets rather than lighter piglets, may be at a greater risk following weaning and should be observed closely.

ACKNOWLEDGEMENTS

The authors thank the Manitoba Pork Council, Agri-Food Research and Development Initiative (ARDI) and National (US) Pork Board for funding this project. The authors also thank staff at the University of Manitoba for their assistance and for providing high quality animal care.


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