Transportation of Early Weaned Piglets: production and welfare aspects
N.J. Lewis, R.J. Berry and S. Wamnes
Dept. Animal Science, University of Manitoba.

1. Introduction

The swine industry in North America has adopted a segregated early weaning (SEW) management system, necessitating the transport of early weaned piglets. Transportation is a stressor and food/water withdrawal can produce weight loss and dehydration (Robert et al., 1997, Berry and Lewis, 2001a). The requirements of SEW piglets in transport are not well understood. Most previous transport work has focussed on older hogs often for immediate slaughter (Bergeron and Lewis, 1997). Weaning itself, especially at an early age, affects behaviour as piglets are slow to develop normal feeding patterns and consequently have a compromised feed intake (Metz and Gonyou, 1990; Gonyou et al., 1998). When weaning coincides with transport, the stressors are additive, increasing the detrimental effects on post-weaning welfare (Berry and Lewis, 2001a).

Journey duration is a primary factor. With longer durations, the feed and water deprivation increases and fatigue can become a factor (Lambooy, 1988). Brumm et al., (1987) found that pigs (20 kg) were able to cope, measured by performance, with journeys of 15 h if provision of feed and water occurred immediately after unloading. Hicks et al. (1998) showed a journey of 4 h significantly increased weight loss in weanling pigs (28 d) compared to equivalent (heat and cold stressed) non-transported piglets.

Temperature is also a crucial factor governing the amount of stress an animal experiences during transportation (Warriss and Brown, 1994). Temperature can fluctuate rapidly in vehicles during transport (Tarrant and Grandin, 2000). At present, specific
recommendations for optimum transport temperatures for weaned piglets are not available. The recommended comfort zone of early weaned piglets (4-7 kg) is between 24 and 34 °C (CARC, 1993). However, temperatures as low as 15 °C can be tolerated by older piglets (23-26 d) for 12 h (Minton et al., 1988). Berry and Lewis (2001a) showed that transport temperatures of 35 °C and possibly 20 °C were detrimental to early recovery when combined with a 24 h transport. The seasonal and geographic features present across North America result in piglets being transported through a wide temperature range (40 °C) and for extended durations.

The swine industry transports millions of early weaned (SEW) piglets each year. Problems affecting even a small percentage of the piglets can have a large economic and welfare impact (Bergeron and Lewis, 1997). The Recommended Code of Practice for the Care and Handling of Farm Animals – Transportation (CARC, 2001) and The Recommended Code of Practice for the Care and Handling of Farm Animals: Pigs, Addendum early weaned piglets (CARC, 2003), recognizes the SEW piglet as having special needs. However, the specific requirements for SEW piglets are not well understood. Our laboratory has been attempting to study some of the parameters of transport which will enhance production and welfare of the early weaned piglet.

2. Methodology

2.1 Transportation

2.1.1 Simulated Transport: A simulated transport model was used to control transport variables which were difficult to keep at a constant level during real transport, such as temperature. In this model 17 ± 1 day old piglets were held in a high sided, open
topped wooden box (1.2 x 1.2 x 1 m), in a temperature controlled room (± 1 °C). The
floor of the box was loosely bedded with straw to a depth of 10 cm. As in commercial
transport, feed and water were not available.

2.1.2 Real Transport: A transport apparatus was designed to be placed in a panel
van during transport studies. Barred pen dividers allowed the area occupied by the piglets
to be modified. The galvanized metal floor was deep bedded with straw (approximately
20 cm) in the fall and winter, and covered with shavings in the summer. The apparatus
included cameras and video recording equipment. Temperature probes were placed
within the bedding and directly above the piglets with a data logger to record these
values. Fans were used to simulate opening of the coroplast panels and sunlight entry
occurred via a sunroof. The van was driven along highways local to the University. A
total of 12 journeys, 576 pigs, have been video taped over two years and the data is
presented as an amalgamation of these studies.

Piglets were identified using permanent marker numbers on the back and
randomly assigned to transport treatments (season or density). Each group contained
piglets from different litters and of different sexes to mimic the mixing occurring during
commercial weaning. Care and handling of piglets in all experiments followed the
Recommended code of practice for the care and handling of farm animals: Pigs (CARC,

2.2 Behaviour

Following transport piglets were placed, in groups of 4, in weanling pens.
Weanling pens were 1.06 x 1.72 m with plastic coated expanded metal floors. Feed and
water were freely available from a single water nipple set at a height of 0.2 m and one free-flow pellet feeder utilizing 0.1 m² of pen area. A chain was hung from the midpoint of the longest side as an enrichment device. Feed was checked daily and consisted of a standard medicated commercial starter diet. Temperature was held at 30 °C for the first 7 days then dropped to 28 °C. Behavior was assessed post transport using scan sampling (10 min. intervals) of time lapse video recordings. A total of 14 journeys, 1,152 pigs were recorded over three years and the amalgamated data is presented.

2.3 Production

Weight gain was recorded daily until 7 days post-weaning and again at 10-14 days post weaning. Using this data the following measures were derived for all piglets: the day at which the minimum weight was reached, minimum weight and weight loss. The number of piglets which had not regained weaning weight by day 7 (poor doers) was recorded and these piglets were removed from the data set. The following measures were then derived: the day at which the piglet returned to its weaning weight (day of recovery) and the average daily gain, as a percentage of weaning weight, from day of recovery to 10-14 d post weaning. A total of 14 journeys, 1,152 pigs have been assessed over three years and the amalgamated data is presented.

3. Results and Discussion

3.1 Behaviour During Transport

Behaviour during transport can be used to assess the stresses placed on piglets during transport and the coping strategies of the piglets. Resting occupied 75 % of the
time in both experiments and activity (standing/moving) occupied 21-22% of the time in transit. These were the most prevalent behaviours observed during transport. Activity dropped and resting increased with duration of transport (P < 0.01). Activity averaged 33.8% and resting 61.5% in the first 12 h of transport. In the second 12 h of transport resting frequency rose to 89.4% while activity dropped to 9.4%. This pattern was indicative of fatigue, also described by Lambooy et al. (1985).

Fighting was low in the first 6 h of transport (P < 0.01) in both experiments. During the first 6 h only 2 piglets were observed fighting in the first experiment indicative that transport was stressful enough to delay establishment of the dominance hierarchy. Sitting was more common in the first 12 h of transport (16.9%) than in the second 12 h (2.1%; P < 0.01). Increases in resting, reduction in sitting and establishment of the dominance hierarchy later in transport may indicate that piglets became less, rather than more stressed as transport continued.

3.2. Post Transport Behaviour

Piglets which have recovered well from transport should begin feeding and drinking early, which will be reflected in normal feeding and drinking patterns and a low frequency of behaviours related to stress during transport. Because transport occurred in conjunction with weaning which is a highly stressful period for the piglets some of the behaviours observed post transport will be related to the stress of weaning. In order to determine which behaviours are associated with weaning stress rather than transport stress it is important to study the differences in behaviour between non-transported and transported piglets and piglets transported for short and long journeys.
Piglets spent the greatest proportion of time resting (80%) in the first 3-4 d post transport. Standing was also a frequently observed behavior in all studies although the frequency varied (21.6% vs 8.0% vs 4.5%). Feeding and drinking frequency averaged 3.7% and 2% respectively. Sitting (0.28), play (0.8), fighting (1.6), and oral manipulation (2%) represented a total of only 4.7%

3.2.1 Feeding and Drinking: Feeding was infrequently observed (0.4%) on day 1. Since this occurred in both control and transported piglets, it was largely due to early weaning. However, transported piglets in most studies consumed more feed on the second day in the pens. Continuous observations showed this increase was due to increased feeding bout frequency (7 bouts/day vs 13.1 bouts/day) and a tendency toward an increase in feeding bout length (35.3 sec./bout vs 59.5 sec/bout). However, in all studies piglets transported for 24 h were 1 day older when placed on feed than control piglets. When the feeding behavior of piglets the same age (19 ± 1 day) was compared, control piglets were observed to feed more frequently (1.3%) than piglets transported for 24 h (0.57%). The same comparison can be made at 20 ± 1 day of age. Piglets transported for 24 h fed less frequently (4.3%) than control piglets (6.6%) of the same age. However the control piglets had been on feed an additional day, making this comparison difficult to assess. A study to separate the effects of age and transport has been planned to determine the contribution of age and increased motivation to these differences in feed consumption.

In all studies drinking frequency was highest on the first day post transport and increased as duration of transport increased (P < 0.01). Continuous observations showed
that the increase in drinking frequency was due to an increase in drinking bout frequency.

Piglets transported for 24 h also increased drinking bout length.

**3.2.2 Other Behaviour:** Transported piglets rested more than control piglets in both studies on day 1 (P < 0.01), indicating that fatigue was a stressor in transportation. Sitting was most frequent (P < 0.01) on day 1 in two studies, then diminished in frequency. Fighting decreased in frequency (P < 0.01) across days in all three studies.

**3.2.3 Production:** Production traits were useful for assessing both production and welfare. Early weaned piglets which start feeding early have a higher level of welfare and also higher weight gains, consequently early weight gains are a measure of early feed consumption and good welfare. The percent weight loss and day of minimum weight were used as a reflection of the time required for the piglets to learn to feed and a measure of the end of the loss of body reserves. In our studies the percent weight loss for the three studies averaged 7.1 % and was not higher for transported than non-transported piglets. The day of minimum weight averaged 2.4 in the three studies. The day of recovery (3.8 d), return to weaning weight, was used as a measure of the growth check and an indication of the return to normal feed consumption and growth. Average daily gain as a percentage of weaning weight averaged 5.6 % for the three studies. Poor doers were defined as piglets which had not regained their weaning weight by 7 days post-weaning. The percentage of piglets in this category was 5.9 % and 18.4 % in the two studies in which this was determined. Preliminary observation of these piglets indicated that they were not learning to eat solid feed. These piglets represent a significant production loss if they do not recover and represent an important welfare issue, as they may continue to deteriorate if not given individual care.
3.4 Season of Transport

The most important difference between season of transport was temperature. In our early work using simulated transport a combination of long transport (24 h) at high temperatures 35 °C was found to reduce the rate at which piglets regained weaning weight (Berry and Lewis, 2001a). The industry was also using unheated trailers for the transport of early weaned piglets (Berry and Lewis, 2001b) a move away from well heated transport. It was clear that truck temperature was an important factor. However truck temperature and the microclimate of the piglets were not necessarily highly correlated. The thermal microclimate of the piglets was judged based on 3 factors, truck temperature, piglet temperature, and the thermoregulatory behaviour of the piglets.

3.4.1 Truck Temperature: Both bedding temperature and air temperature above the piglets varied with season. Summer air (26.5 °C) and bedding (28.9 °C) temperatures were significantly higher than winter air (0.9 °C) and bedding (4.8 °C) temperatures with spring/fall temperatures (air: 16.4 °C, bedding: 20.7 °C) intermediate (P < 0.01). Average hourly air temperatures above the pigs ranged from 20.4 °C to 32.2 °C in summer, while in winter air temperatures rarely exceeded 8.0 °C, with temperatures dropping to hourly averages of -9.8 °C. Spring temperatures tended to be intermediate ranging from 7 to 26 °C. The air temperature in the truck was higher than the ambient temperature by 4 - 10 °C in summer, 9 to 15 °C in spring/fall and 10 to 20 °C in winter.

Temperatures were measured on 3 or more commercial journeys in each season and were similar to those recorded in the experimental trucks (Berry and Lewis, 2001b). During winter transport the average minimum air temperature fell to -6.7 °C and average
highs ranged from 12.2 °C to 16.2 °C. Temperature during summer travel averaged 25.8 °C and averages ranged from 17.3 °C to 28.3 °C. Humidity averaged 56.4 %, well within the comfort zone for piglets. Temperatures recorded in the fall were typically low during the early morning (1.4 °C) but rose rapidly during the day to highs of 31.2 °C. Some of the highest temperatures recorded were during fall journeys. Transporters in this instance were likely restricting air flow into the trailer to negate morning chilling, but the consequence of this was that the trailer temperature rose during the afternoon.

3.4.2 Piglet Temperature: Ear temperatures in summer (36.2 °C, 35.0 °C) were significantly higher (P < 0.01) than ear temperatures in spring/fall (27.0 °C, 29.6 °C) and winter (23.1 °C, 16.5 °C). Rectal temperatures were also higher (P < 0.01) in summer (39.2 °C) than in fall (38.7 °C) and winter (38.6 °C). Lower ear temperatures in winter and high ear temperatures in summer were indicative that blood was being shunted away from or to the ears to conserve or disseminate body heat. Although rectal temperatures were not outside of the normal range, core temperature was rising and falling with the truck temperature indicative that the piglets were working to maintain core temperature.

3.4.3 Thermoregulatory Behaviour: Thermoregulatory behaviour, the propensity for piglets to huddle or spread out, was also used as an indicator of the coping strategy of piglets in both the heat of summer and the cold of winter. In order to quantify this, piglets were classified as exposed or covered by other piglets or bedding. In summer 81 % of the piglets spent 75-100 % of their time exposed. In winter only 8.5 % of the piglets fell in the 75-100 % group. Theoretically, the most desirable situation in winter was to be exposed to the environment a minimum amount of time (< 25 %). This was achieved by 35.9 % of piglets. Piglets exposed for 50-75 % and 25-50 % represented 29.7
% and 25.8% of the piglets and indicated room for improvement with changes in density or bedding type and depth. We will be continuing to study thermoregulatory responses to various density and bedding combinations.

The pattern, in which piglets progressed from standing to resting as transport lengthened, was apparent in all three seasons but was less defined in summer indicating that resting was related not only to fatigue but also to thermoregulation. More (P < 0.01) fighting was observed during the summer (39 piglets). Eighteen piglets were observed fighting during fall transport and only 3 piglets were observed to be fighting during winter transport, indicative that in the colder environment of the truck in winter and to some extent in the fall social behaviours such as establishing the dominance hierarchy were reduced or suspended.

6.4.4 Resting: Winter transport appeared to be more fatiguing for piglets as higher levels of resting (81.6%) extended to 3 days post transport in both trials (P < 0.05). This additional resting occurred post transport in spite of a higher level of resting during transport in winter. In summer and spring/fall resting was more variable with high levels of resting lasting for 1 or 2 days post transport.

3.4.5 Production: In the trial comparing season at various durations of transport winter was found to be most detrimental to production based on the number of poor doers, piglets which had not regained weaning weight by 7 days post-weaning. Seventeen piglets (5.9%) were classified as poor doers and 76% of these (13) were observed following winter transport (P < 0.05), more than during summer (1) and fall (3).

In the second trial, comparing density during a 24 h transport, summer was found to be most detrimental to production. Piglets transported during the summer showed
consistently poor production compared to winter and spring transport. Piglets transported in summer had higher % weight losses (9.6 % vs 6.9 %: P < 0.01), took longer to reach minimum weight (3.7 d vs 2.2 d; P<0.01) and longer to recover from the growth check (4.9 d vs 4.0 d; P<0.03) than piglets transported in winter and spring. Feeding frequency was also lower in summer (2.9 %) than during winter (5.2 %) or spring (4.5 %; P < 0.01).

Poor doers, piglets which had not regained their weaning weight by 7 days post-weaning, were most common after summer transport. Fifty three piglets (18.4 %) were classified as poor doers. Most poor doers were observed in the summer group (34: 64.2 %), less were observed in the winter group (13: 24.5 %) and least following spring transport (6: 11.3 %) (P < 0.01). Morbidity however was not higher in summer and mortality (euthanasia) was < 3 % in all seasons.

It is not clear why summer transport had such a detrimental effect on performance in the second study. Poor doers were similar in number in winter (17 vs 13) and spring (1 vs 6) between the two experiments but were much higher in summer (34 vs 1). Feeding behaviour, which has a direct affect on feed consumption, was also lowest during summer. In this trial all of the piglets were transported for 24 h compared to 25 % of the piglets in the previous trial. Since transport for 24 h at high temperatures has been shown to reduce performance (Berry and Lewis, 2001a) a combination of these factors may have produced these lower values for production traits. One third of the piglets were also transported at high density which is more detrimental in summer than winter.

3.5 Density During Transport
Density has a direct effect on piglet welfare through effects on temperature and ability to exhibit thermoregulatory behaviour. In summer higher densities predispose piglets to hyperthermia but in winter higher densities may be beneficial. Three densities were studied on journeys of 24 h, low density (0.12 m$^2$/piglet), standard density (0.06 m$^2$/piglet) and high density (0.048 m$^2$/piglet).

Air temperatures above the piglets but not bedding temperatures were affected by stocking density. Air temperatures were higher (15.1 $^0$C) when stocking density was high than when stocking density low (14.0 $^0$C) with standard density intermediate (14.7 $^0$C; P < 0.04). Higher ear temperatures were recorded in piglets transported at the high density (27.6 $^0$C) than at the standard (26.6 $^0$C) or low density (26.9 $^0$C; P < 0.04). Piglets exposed to simulated transport at 35 $^0$C and high density were observed to be panting heavily approximately 2 h into the simulated transport. Body temperatures at this time ranged from 39.5 (normal) to 40.3 (fever). In spite of the placement of fans, body temperature continued to rise and the temperature in the room was reduced. Piglets were no longer exhibiting signs of thermal stress one hour later. This is a clear indication that piglets transported at temperatures of 35 $^0$C, even with the sides of the truck open will be exposed to a degree of thermal stress which is detrimental. Piglets exposed to 35 $^0$C at standard density (40.1 $^0$C – 40.3$^0$C) and 30 $^0$C at high density (39.8 $^0$C – 40.5 $^0$C) also showed increased temperatures but were not panting. Although the experiment was not designed to study body temperatures these numbers were indicative.

At high density it was also more difficult for piglets to exhibit thermoregulatory behaviour. At the high density fewer piglets were able to stay exposed for 75-100 % of
the time (high: 39, standard: 58, low: 61) although this did not meet the criteria for significance.

3.6 Serum Cortisol

Serum cortisol levels were significantly higher 24 h after weaning irrespective of season or density of transport. Baseline serum cortisol levels averaged 42,601 picograms/ml the day before weaning and transport. Twenty four hours after weaning and following transport cortisol levels had doubled to 82,915 picograms/ml. After 48 h (45,548 picograms/ml) and 72 h (46,024 picograms/ml) post weaning serum cortisol level had returned to baseline levels.

4. Conclusions and Recommendations

Weaning, especially early weaning, is a stressful period for piglets. High serum cortisol levels 24 h after removal of the piglets from the sow coincided with this period. Lower cortisol levels at the end of day 2 follow the day of minimum weight (2.4) and an increase in feed consumption but precede the day of recovery. The low levels of feeding behaviour observed on day 1 appeared to be largely due to weaning. Transportation tended to be an additive stressor, exacerbating the effects of weaning.

Transport up to 24 h does not appear to be more detrimental for piglets than early weaning as both transported and non-transported piglets lose similar body reserves and recover at the same time. However, if temperatures during transport are high (35 °C) recovery may be delayed. Piglets transported for longer durations (12 h, 24 h) spend more time drinking and are therefore at higher risk for dehydration than non-transported
controls. Fatigue during and after transport is a common feature of all durations of transport. Initially transport is stressful enough to delay hierarchy establishment, but this may diminish with time.

Following early weaning piglets lose an average of 7% of their body weight and recover weaning weight at 3.8 days. Poor doers (6%), piglets which don’t regain weaning weight by 7 days post transport, are an important exception to these averages. Preliminary examination indicates these are piglets which do not learn to feed appropriately. Stressful transport can increase the number of these piglets. More work needs to be done to determine how these piglets can be managed to reduce the effects on production and welfare.

The microclimate of the piglet during winter transport is important. Air temperature in unheated trucks ranged from -10 to $16^\circ$ C, well below thermal comfort levels. Ear and rectal temperatures rose and fell with the air temperature indicating active physiological thermoregulation was taking place to maintain body temperature in these cold trailers. Active behavioural thermoregulation also took place. In winter, piglets seek to be under bedding or other piglets and 35.9% of piglets achieved this for 75-100% of the time. Transport environments could be improved by modifying conditions (density/bedding) to increase this percentage. Winter transport also delayed establishment of the dominance hierarchy and increased fatigue, probably due to the necessity to keep warm. Poor doers have also been shown to increase following winter transport.

Summer transport, especially at high density, was shown to affect production with more poor doers, higher weight losses, delayed day of recovery and decreased feeding. At the higher density in summer piglets had a higher air temperature to contend with, which
was reflected in higher ear temperatures. They also had more difficulty staying exposed to the air. These piglets are thus at higher risk for hyperthermia.

5. Acknowledgements

The authors would like to thank the National Pork Board (US), Manitoba Pork Board and ARDI for funding these projects. The authors also wish to thank staff at the University of Manitoba for their assistance and for providing high quality animal care.

6. References


Lewis N.J. and S. Wamnes. 2004. The effect of space allowance and season on the welfare of early weaned piglets under commercial and experimental transport conditions. NPB Final Reprt 03-147


