RESEARCH REPORT
ANIMAL WELFARE

Title: The Effect of Space Allowance and Season on the Welfare of Early Weaned Piglets Under Commercial and Experimental Transport Conditions - **NPB #03-147**

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Abstract: Six groups of forty eight Cotswold piglets were weaned at 17 ± 1 day of age and placed on trial in one of three seasons: summer, spring or winter. Piglets in each group were transported for 24 h at one of 3 densities: recommended (0.06 m^2/pig), 80 % of recommended (0.048 m^2/pig) or twice recommended (0.12 m^2/pig). During transport, air and bedding temperatures were collected in each density defined area. Behavioral data were collected using a VCR and 3 infra-red cameras. Piglet skin temperatures were recorded at the end of each 6 h period of transport. Following transport, piglets were placed in groups of 4, in weanling pens with free choice feed and water. Behavior was recorded for 4 days post transport using a VCR and low light level cameras. Body weights were recorded daily until 7 days post-weaning and again at 10 days post-weaning.

On average piglets dropped to 5.4 kg from a weaning weight of 5.9 kg, a weight loss of 7.8 %. Piglets reached their lowest average weight at 2.7 days post-weaning and recovered their weaning weight at 4.3 days post weaning. Piglets transported during the summer showed consistently poor production compared to winter and spring transport, with higher weight losses (9.6 % vs 6.9 % $P < 0.01$) and a longer growth check (4.9 d vs 4.0 d, $P < 0.01$). Behaviour also varied by season. Activity during transport was more prevalent in summer (25.6 %) and spring (25.2 %) than in winter (13.6 %; $P < 0.01$). Resting showed the opposite pattern with more resting during winter transport (85.7 %) than during summer (71.1 %) or spring (68.7 %; $P < 0.03$). Following winter transport resting was more frequent for 3 days, indicating a higher level of fatigue.

Serum cortisol levels were significantly higher following weaning irrespective of temperature or density during transport. Baseline serum cortisol levels averaged 42,601 picograms/ml the day before weaning and transport. After weaning/transport (24 h) cortisol levels had almost doubled to 82,915 picograms/ml. Twenty four hours later serum cortisol level had returned to baseline levels. Although temperature and density are likely to contribute to stress this was not measurable against the background of stress due to weaning.

The thermal microclimate of the piglets can be judged from 3 factors, truck temperature, piglet temperature, and thermoregulatory behaviour. Both bedding temperature and air temperature above the piglets varied with season. Average hourly air temperatures above the pigs ranged from 20.4 ^{0}C to 32.2 ^{0}C in summer, while winter air temperatures rarely exceeded 8.0 ^{0}C, with temperatures dropping to hourly averages of -9.8 ^{0}C. Spring temperatures tended to be intermediate ranging from 7 to 26 ^{0}C. Air temperatures in the truck followed environmental temperatures but were 10 to 15 ^{0}C higher in winter and spring and 5 to 10 ^{0}C higher in summer. Ear temperatures followed seasonal temperature with higher temperatures recorded in summer (35 ^{0}C) than winter (16.5 ^{0}C), with spring intermediate (29.6 ^{0}C). In the summer more piglets (81.3 %) spent 75-100% of the time in transport on top of bedding or other piglets ($P < 0.01$). In the winter piglets showed a preference for being underneath other piglets or bedding ($P < 0.01$) with only 8.6% exposed for greater than 75 % of the time in transport. 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.

Density affected air temperature, ear temperature and thermoregulatory behaviour of piglets. At high density air temperatures were higher (15.1 ^{0}C) than at low density (14.0 ^{0}C) with standard density intermediate (14.7 ^{0}C; $P<0.04$). Higher ear temperatures were also recorded at the high density (27.6 ^{0}C) when compared to standard (26.6 ^{0}C) or low density (26.9 ^{0}C; $P < 0.04$). The higher temperatures associated with high density were more likely to be detrimental during the summer heat. In addition the higher densities may have interfered with 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.

At the high density in summer piglets have a higher air temperature to contend with, which is reflected in higher ear temperatures. They also have more difficulty staying exposed to the air and run the risk of hyperthermia. Higher densities in winter were not as clearly detrimental possibly because the piglets tend to huddle irrespective of space available.

Introduction: Current Status of the Problem

The swine industry has adopted a segregated early weaning (SEW) management system, necessitating transport of piglets to a site separated from the breeding herd. This results in the transport of millions of piglets each year and problems affecting even a small percentage of the piglets can have a large economic and welfare impact.

The NPB Swine Care Handbook (2003) states that safety and comfort should be a primary welfare concern when transporting pigs, but specific requirements for SEW piglets are not well understood. Large numbers of piglets are now routinely transported in unheated trucks, irrespective of weather conditions. Operators have few guidelines and must use their experience and discretion to manage piglet welfare during transport by modifying parameters such as air flow, bedding, group size and stocking density. However, clear information is not available to the transporter or producer to make these decisions with confidence. The recommended stocking density for an early weaned piglet, typically of 4.5 - 5.5 kg in weight, is 0.06 m^2 (0.56 ft^2 / head) (CARC, 2001). However this value is based on extrapolated values from older piglets and not from published data for early weaned piglets. The ability of piglets to huddle is another confounding aspect in the assessment of an optimum stocking density under differing climatic conditions. Assessment of overcrowding of SEW piglets by veterinarians at the US/Canada border relies on the “startle response” (CARC, 2001). This involves startling piglets with an abrupt noise. The stocking density is considered adequate if 25 % of the floor is exposed when alerted piglets move away from the noise. Bedding with high insulating properties is a necessity during cold weather transport (NPB, Swine Care Handbook, 2003), but how piglets utilize bedding is not clear. Hence depth and type of bedding needs to be evaluated. Increased stocking density is often recommended during cold weather however piglets may not be able to reposition themselves in response to cold areas if stocking density is too high. Conditions such as these are likely to increase the risk of frostbite.

Current temperatures experienced by transported SEW piglets can vary greatly from the recommended comfort range of 26-32 C. Even a well ventilated trailer transporting piglets in the summer can exceed these recommended temperatures, while trailer temperatures rarely approach the lower value of the optimum range during the winter months (Berry and Lewis, 2001c). Stocking densities and the propensity for piglets to huddle can greatly influence the thermal microclimate at the level of the piglet. Typically piglets are highly active during the initial 4-6 hours of transport, which increases the temperatures recorded above the piglets (Lewis and Berry, 2003). Guidelines stating optimal stocking densities need to be developed based on studies assessing stocking density under a range of climatic conditions.

Objectives:

i To assess the impact of stocking density under different seasonal conditions on the performance, behavior and physiology of early weaned piglets using controlled transport conditions.

ii To validate the findings from the controlled trials under commercial transport conditions. (Held over until year 2 of the grant request).

iii To assess the effect of stocking density on the microclimate of the piglet during transport.

iv To develop guidelines for transporters and producers to ensure the welfare and future productivity of transported piglets.

Materials and Methods:

<u>Piglets</u>

Two hundred and eighty eight Cotswold piglets were weaned at 17 ± 1 day of age and placed on trial in one of three seasons: Summer (June 28-29, July 01-02), Winter (Dec. 10-13) and Spring/Fall (April 16-17, 19-20). In each season two groups of 48 piglets were transported on separate days. Piglets were identified using permanent marker numbers on the back and randomly assigned to one of 3 transport densities in groups of 16. Each group contained piglets from different litters and of different sexes to mimic the mixing occurring during commercial transport. Piglets were transported for 24 h and, as in commercial transport, piglets did not have access to feed or water during this time. Following transport piglets were placed in weanling pens in groups of 4 with immediate access to feed and water. Care of piglets in this research project was conducted under CCAC guidelines (Canadian Council on Animal Care, 1993) and followed the Recommended Code of Practice for the Care and Handling of Farm Animals: Pigs (Connor, 1993).

<u>Transport Design</u>

Piglets were transported along a highway for 24 h at one of 3 densities; recommended 0.06 m^2/pig, 80% of recommended (0.048 m^2/pig) or twice recommended

(0.12 m^2/pig). A panel van, which allowed continuous access to the piglets, was used for transport. Inside the van, piglets were placed in a transport apparatus which allowed each group of 16 piglets to be held at one of the three experimental densities. The galvanized metal floor was deep bedded with straw (approximately 20 cm) in the winter and covered with shavings in the summer. A fan was used in summer and spring (when temperatures exceeded 25-30 ^{0}C) to simulate opening of the coroplast panels. The van allowed for normal daylight entry during the day but at night the piglets were in the dark as in commercial transport. Three UV cameras were mounted on the apparatus and behavior was recorded throughout each journey.

Post Transport Housing

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 m^2 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. The housing environment was kept at 30 ^{0}C for the first 7 days then dropped to 28 ^{0}C.

Performance Measures

Weight gain was recorded daily until 7 days post-weaning and again at 10 days post-weaning. Using this data the following measures were derived: the day at which the minimum weight was reached, the minimum weight, 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 d post weaning.

Physiological Measures

Skin temperatures were recorded remotely from the ear of a random sample of 5 piglets in each density every 6 h during transport. Skin temperatures were recorded using a Raytek Minitemp laser thermometer (630 – 670 nm) from less than 1 m.

Serum cortisol and hematocrit were measured using a separate experimental design. Piglets were placed in simulated transport, in groups of 4 for 24 h. Three groups of 4, one at each density, normal, 80 % of normal and twice normal, were placed in a temperature controlled room to simulate summer (8 h: 35 ^{0}C, 4 h: 30 ^{0}C and 12 h: 25 ^{0}C), spring (12 h: 30 ^{0}C, 12 h: 10 ^{0}C), and winter (24 h: 2 ^{0}C). Light dark cycles imitated each season; summer (18 L, 6 D), spring (12 L, 12 D) and winter (6 L, 18 D). Fans were used to simulate the opening of coroplast panels for cooling and were running at any time room temperature was 25 ^{0}C or above. Piglets were housed in wooden boxes bedded with either straw (winter and spring) or wood shavings (summer). Each box was divided into 3 compartments of different sizes to produce the three densities of the experiment. This was replicated for a total of 72 piglets sampled (4 pigs/density x 3 densities x 3 seasons x 2 replicates). A baseline blood sample was collected on the day prior to weaning for each piglet. Experimental blood samples were collected immediately post transport, 24 h and 48 h after entry to the weaning pens. Care was taken to sample at the same time of day. Blood was collected from the vena cava using 20 g vacutainer needles and 3 ml vacutainer tubes. Hematocrit was measured immediately using micro hematocrit tubes and a standard reader. Serum was frozen for cortisol analysis. When all blood samples had been collected serum samples were analyzed using the Cortisol Correlate EIA Kit[1]

[1] Assay Design Inc.

Behavioral Measures

Behavior was assessed both during transport and post transport using time lapse video recordings and scan sampling at 5 min. intervals. The following mutually exclusive behaviors were recorded during transport: active, sitting, resting, fighting and other (Table 1). One hour out of each 6 h time period during transport was used to study piglet movement within the group. During this period the number on the back of each visible piglet was recorded every 3 minutes as an assessment of position, either exposed or huddled under other piglets/bedding. The following mutually exclusive behaviors were recorded post transport: standing, sitting, resting feeding drinking, fighting playing oral manipulation and other (Table 1). Post-transport behavior was recorded for 4 days based on previous trials which showed that most piglets had regained their weaning weight by 4 days post weaning (Berry and Lewis, 2001a).

Environmental Measures

Temperature (^{0}C) was recorded every minute from six probes during transportation using a data logger (Campbell Scientific CR10X). Two probes were positioned in each density grouping, one in the bedding and one directly above the piglets (approximately 50 cm). Temperature measurements were averaged for each 10 min period during transportation and stored for further analysis.

Statistical Analysis

Piglet activities during transport were expressed as a proportion and analyzed using the Mixed procedure in SAS (SAS Inst. Inc., Cary, NC), with means tests (Bonferroni's) performed for significant effects. The experimental unit was the density group composed of 16 piglets. All behavioral data were subjected to an arcsine square root transformation to achieve a normalized distribution. The statistical model included effects of season (summer, winter, spring), transport density (normal, 80 % of normal and twice normal), transport group within season (1, 2) and interactions. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0. Fighting did not meet the criteria for use of parametric statistics and was therefore analyzed with a chi square analysis. Piglet visibility data was used to determine the number of piglets visible < 25 %, 25-50 %, 50 %-75 % and > 75 % of the observations in each hour. The 4 one hour periods were combined for a total possible n = 16 piglets/group x 2 groups / season x 4 observation periods = 128 in each season x density cell. Chi Square tests were used to determine differences between seasons and densities.

Piglet activities during the post-transport period were expressed as a proportion and analyzed using a Mixed Model procedure in SAS (SAS Inst. Inc., Cary, NC), with means tests (Bonferroni's) performed for significant effects. The unit of measure was the average of the 4 pigs in each pen. The statistical model for piglet behavior included effects of season (summer, winter, spring), transport density (recommended, 80 % recommended, twice recommended), transport group within season (1, 2), day (1, 2, 3, 4) and interactions. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0.

Daily weights were used to generate 5 variables: 1) the lowest body weight reached, 2) the percent weight loss, 3) the day at which this lowest weight was reached, 4) the time at which the weaning weight was regained (day of recovery) and 5) average daily gain from the day of recovery to 10 d after weaning. These performance measures were analyzed using the Mixed procedure (SAS Institute Inc., Cary, NC) with means tests (Bonferroni's) performed for significant effects. The experimental unit of measure was the average of the 4 piglets in each pen. The statistical model for piglet production included effects of season (summer, winter, spring), transport density (recommended, 80 % recommended, twice recommended), transport group within season (1, 2) and interactions. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0. Chi Square tests were used for analysis of data on “poor doers”, which did not meet the criteria for parametric statistics.

Truck temperatures were averaged over each 6 h period and analyzed using the Mixed procedure (SAS Institute Inc., Cary, NC) with means tests (Bonferroni’s) performed for significant effects. The statistical model included effects of season (summer, winter, spring), transport density (recommended, 80 % recommended, twice recommended), transport group within season (1, 2) and interactions. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0.

Serum cortisol levels and hematocrit were analyzed using the Mixed procedure (SAS Institute Inc., Cary, NC) with means tests (Bonferroni’s) performed for significant effects. The statistical model included effects of simulated season (summer, winter, spring), transport density (recommended, 80 % recommended, twice recommended), transport group within season (1, 2) and interactions. The unit of measure was pig within pen within season by transport density by group. Cortisol values were transformed to the log before analysis. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0.

Piglet ear and rectal temperatures were analyzed using the Mixed procedure (SAS Institute Inc., Cary, NC) with means tests (Bonferroni’s) performed for significant effects. The statistical model included effects of season (summer, winter, spring), transport density (recommended, 80 % recommended, twice recommended), transport group within season (1, 2) and interactions. Following the mixed model criteria random 2 and 3 way interactions were dropped from the analysis if their contribution was 0.

Results:

Performance

On average piglets dropped to 5.4 kg from a weaning weight of 5.9 kg, a weight loss of 7.8 %. Piglets reached their lowest average weight at 2.7 days post-weaning and recovered their weaning weight at 4.3 days post weaning (Figure 1). Piglets transported during the summer showed consistently poor production compared to winter and spring transport (Table 2). Piglets transported in summer had a higher % weight loss (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 the winter and spring. However % average daily gain and minimum weight did not differ between seasons. Production of piglets transported in winter tended to be worse than production of piglets transported in spring but this was not a significant difference.

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 %) (n = 53, chi square = 23.9, 2 d.f. $P < 0.01 = 9.21$). Morbidity however was not higher in summer and mortality (euthanasia) was < 3 % in all seasons (Summer: 3, 3.1 %, Spring 0, 0 %, Winter 2, 2.1 %). In this experiment density during transport did not affect production.

Physiological Measures

Ear temperatures were affected by both season and density during transport. Summer ear temperatures (35.0 ^{0}C) recorded were higher than ear temperatures recorded in winter (16.5 ^{0}C) with ear temperature during spring transport (29.6 ^{0}C) intermediate (P < 0.02). Density also affected ear temperature, with higher ear temperatures recorded in the piglets transported at the high density (27.6 ^{0}C) than the standard (26.6 ^{0}C) or low density (26.9 ^{0}C; P < 0.04). In this experiment duration of transport was not a significant factor in ear temperature.

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. Hematocrit levels (35.5 %) were all within normal values (Merck Veterinary Manual, 1998) and did not indicate clinical dehydration in any of the groups of pigs.

Piglets exposed to simulated transport at 35 ^{0}C and 80 % of standard 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). Temperatures were taken again 1.5 hours later, at which time the temperatures ranged from 40.2 to 40.8 ^{0}C (ave. 40.4 ^{0}C). At this point fans were placed over the piglets. Two hours later the temperatures of the piglets were again taken and the average temperature was still increasing (40.6). At this point the room temperature was reduced to 30 ^{0}C and the fans were left in place. 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 80 % of standard density (39.8 ^{0}C – 40.5 ^{0}C) also showed increased temperatures but did not appear to be heat stressed. Although the experiment was not designed to study body temperatures these numbers were indicative.

Behavior

During Transport: Piglets exhibited 3 basic behaviours during transport: activity (standing or moving; 21.5 %), resting (75.2 %) and sitting (3.3 %). The frequencies of these behaviours were affected by season and density and changed over the duration of the transport. Activity was higher in summer (25.6 %) and spring (25.2 %) than in winter (13.6%; P<0.01). Activity dropped with time during transport. In the first 12 h of transport, activity averaged 31.6% which dropped to 11.3% in the final 12 h (0-6: 35.2 %, 6-12: 28.1 %, 12-18: 8.9 %, 18-24: 13.7 %; P < 0.01). Resting tended to show a pattern opposite to that of activity. Resting was higher in winter (85.7 %) than in summer (71.1 %) and spring (68.7 %; P < 0.03). As transport duration increased resting became more frequent. In the first 12 h of transport, resting averaged 63.1 % which rose to 87.3 % in the final 12 h (0-6: 58.2 %, 6-12: 67.9 %, 12-18: 90.4 %, 18-24: 84.2 %; P < 0.01).

Sitting was affected by season, density and duration of transport. During summer and spring transport more sitting was observed at the high density, although this was significant for spring only (Table 3; P < 0.01). During winter, sitting was not affected by density of transport. At the highest density, when sitting was most common (Table 3; P < 0.01) a difference was apparent, in which the frequency of sitting was higher in spring (10.2 %), than winter (1.6 %; P < 0.03). Sitting during summer transport was intermediate in frequency (5.4 %) at the higher density. Sitting was observed more frequently in the first 6 h of transport and dropped thereafter. This pattern was significant for summer and spring (P < 0.01) but not for winter transport (Table 4). This pattern was also significant at high and standard densities (P < 0.01) but not at low density.

Fighting was more common during spring (112 piglets) than during winter (5 piglets) with an intermediate number of piglets (89) fighting in the summer (P < 0.01, chi square = 92.0, d.f. = 2, 9.2). Fighting was also more common at lower transport density (179 piglets) compared to standard density (22 piglets) and high density (5 piglets) (P < 0.01, chi square = 266.8, d.f. = 2, 9.2). As transport progressed fighting increased from 28 pigs in the first 6 h to 66 pigs in the next 6 h. However from 12-18 h in transport fighting dropped again to 27 pigs. In the last 6 h of transport fighting was highest at 85 piglets (P < 0.01, chi square = 48.3, d.f. = 3, 11.3).

In the summer more piglets were visible 75-100% of the time (158), than 50-75 % (30), 25-50 % (5) or 0-25 % (1; n = 194, chi square = 334.3, 2 d.f. P<0.01). In the winter piglets showed a preference for being underneath other piglets or bedding and therefore were less visible (75-100 %: 11, 50-75 %: 38, 25-50 %: 33, 0-25 %: 46; n = 128, chi square = 26.5, 2 d.f. P<0.01=9.21). At the highest density during summer 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 (n = 158, chi square = 5.4, 2 d.f. P < 0.05 = 5.99).

Post Transport: Piglets spent the greatest proportion of time resting (80.6 %). Standing was the next most frequent behavior recorded at 8.1 %. Feeding and drinking averaged 4.2 % and 2.2 % respectively with sitting, play, fighting and oral manipulation, representing a total of only 5.0% over the first four days after transport (Table 5).

Resting changed in frequency over the first 4 days, with the pattern affected by both season and density during transport. On average resting was highest on the first 2 days post transport then dropped from to day 3 and again to day 4 (Table 6). This pattern varied by season (P < 0.01). In summer resting was lower on day 1 than on day 2 with the frequency of resting dropping back to day 1 levels on day 3 and 4. In spring resting was the same and high on days 1 and 2 and dropped to lower levels on days 3 and 4. In winter resting was higher for the first 3 days and dropped in frequency on day 4. If resting frequencies above the average of 80.6 % can be considered to be higher levels of resting then in summer resting was higher on day 2, in spring on day 1 and day 2 and in winter on day 1, day 2 and day 3. Resting patterns post transport also changed with transport density (P < 0.01). At high density resting was most frequent on day 2 and 3 with less frequent resting on day 1 and 4. Following transport at the recommended density resting was most often observed on day 1 and 2 with less resting on day 3 and 4. Following low density transport resting frequency dropped with time but this was not a significant difference.

The frequency of standing showed a pattern across the first 4 days post transport which was affected by the season (P < 0.01; Table 7). Following summer transport standing was higher on days 1, 3 and 4. In spring standing was more frequently observed on the first 2 days falling to lower levels on day 3 and day 4. In winter standing was highest on day 1 dropped on day 2 and was lowest on days 3 and 4. The average frequency of standing behaviour was 8.1 % consequently, higher than average levels of standing were observed in summer on days 1, 3 and 4, in spring on day 1 only and in winter on days 1 and 2.

Following summer and spring transport sitting showed an average daily pattern in which the highest frequency was observed on day 1 with a drop to days 2-4 (Table 8). However, following winter transport sitting did not vary across days and tended to be lower on the first day post transport. Piglets transported at high densities were observed to sit more often on day 1 than on subsequent days. However, piglets transported at standard and low densities showed the same level of sitting across days.

Feeding frequency increased from day 1 to day 4 (0.42 %, 3.2 %, 6.3 %, 6.8 %) with very low levels recorded on day 1 ($P<0.01$). Feeding frequency was lower in summer (2.9 %) than during winter (5.2 %) or spring (4.5 %; $P < 0.01$). This was consistent for each of the 4 days post transport (Table 9).

Drinking was most frequent on day 1 (4.0 %) dropping significantly ($P < 0.01$) on each day for the 4 days observed (2.1 %, 1.5 %, 1.3 % for days 2, 3, 4 respectively). Drinking frequency was higher in summer (5.2 %) and spring (4.6 %) than in winter (2.3 %; $P < 0.01$).

Play behaviour did not differ significantly with season or density of transport. The frequency of fighting on day 1was highest in summer (3.9 %) compared to spring (2.4 %) and winter 2.3 %; $P < 0.05$). In each season fighting was highest on day 1 post transport and dropped thereafter (summer day 1: 3.9 %, day 2: 1.9 %, day 3: 0.8 %, day 4: 0.4 %; $P < 0.01$) (spring day 1: 2.4 %, day 2: 0.8 %, day 3: 0.4 %, day 4: 0.3 %; $P < 0.01$) (winter: day 1: 2.3 %, day 2: 1.0 %, day 3: 0.5 %, day 4: 0.3 %; $P < 0.01$). Oral manipulation of other pigs was observed less frequently on the first day in the weanling pens with a subsequent increase after day 2 (day 1: 1.5 %, day 2: 3.0 %, day 3: 3.2 %, day 4: 3.1 % $P < 0.01$).

<u>Environmental Measures</u>

Both bedding temperature and air temperature above the piglets varied with season (Table 10). Summer air and bedding temperatures were significantly higher than winter air and bedding temperatures with spring temperatures intermediate ($P < 0.01$). Density affected air temperatures above the piglets but not bedding temperatures. At high density air temperatures were higher (15.1 ^{0}C) than at low density (14.0 ^{0}C) with standard density intermediate (14.7 ^{0}C; $P < 0.04$). There was a tendency for air temperatures to vary with transport duration ($P < .06$). Temperatures tended to be higher initially (0-6 h: 17.9 ^{0}C, 6-12 h: 16.0 ^{0}C) than after 12 h of transport (12-18 h: 12.1 ^{0}C, 18-24 h: 12.3 ^{0}C), following outside temperature (Fig. 2).

Discussion:

Objective 1: *To assess the impact of stocking density under different seasonal conditions on the performance, behavior and physiology of early weaned piglets using controlled transport conditions.*

Density and season affected production, serum cortisol levels and behaviour of early weaned piglets to different degrees. While performance was affected by season, density did not have a measurable effect on early production. Weight loss was the same in this experiment as in the last experiment (Lewis and Berry, 2004). On average piglets dropped to 5.4 kg in this trial from a weaning weight of 5.9 kg, a weight loss of 7.8%. In the previous trial piglets dropped to 5.9 kg from a weaning weight of 6.4 kg, also a weight loss of 7.8%. However the piglets in this trial reached their lowest weight at 2.7 days post-weaning and recovered their weaning weight at 4.3 days post weaning compared to 2.4 days and 3.7 days in the previous trial.

Piglets transported during the summer showed consistently poor production compared to winter and spring transport. Piglets transported in summer had higher % weight losses, took longer to reach minimum weight and longer to recover from the growth check than piglets transported in the winter and spring. Piglets which had not regained their weaning weight by 7 days post-weaning were most common after summer transport. Production of piglets transported in winter tended to be lower than production of piglets transported in spring but this was not a significant difference. It is not clear why summer transport had such a detrimental effect on performance. In a previous trial (Lewis and Berry, 2004) winter transport was more detrimental to production. 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 compared to 25% 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. It is also possible this summer farrowing produced poor pigs which did not gain well. However, morbidity was not higher in this summer group.

Serum cortisol levels were significantly higher 24 h after weaning irrespective of room temperature or density of transport. Baseline serum cortisol levels averaged 42,601 picograms/ml the day before weaning and transport, doubled following this stress and had returned to pre-weaning levels 24 h later. It is likely that the additional stress of transport, even at higher density, was not reflected in higher cortisol levels due to the high levels already present at weaning. Certainly the piglets in the simulated transport at 35 ^{0}C and 80 % of standard density were heat stressed as they exhibited heavy panting approximately 2 h into the simulated transport and body temperatures rose necessitating lowering of the room temperature and the use of fans placed over the piglets. This was not however, reflected in the cortisol levels. This is also a clear indication that piglets which are 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 may be harmful.

Behavior is a sensitive measure of acute stressors (Hicks et. al., 1998) and when observed during transport can provide indicators of the immediate challenges faced by piglets and how they cope with these challenges. Changes in the frequency or the presence or absence of a behavior can then be assessed in relationship to the transport environment, providing a measure of the impact of transportation. Piglets exhibited 3 basic behaviours during transport: activity (21.5 %), resting (75.2 %) and sitting (3.3 %). The frequencies of these behaviours were affected largely by season. Activity was higher in summer and spring than in winter while resting showed the opposite pattern. Activity dropped with time during transport, while resting increased, indicative of both fatigue and thermoregulatory behaviour in the cooler night temperatures (Lewis and Berry, 2004).

Sitting was observed more frequently at the highest density in summer, tended to be higher in spring but was the same in winter. This behaviour clearly follows the theoretical stress level imposed at higher density. In summer when temperatures are higher high densities are more likely to impose a temperature stress as seen in the simulated transport study. In spring when temperatures are lower the stress should be less and in winter when high densities may be beneficial for thermoregulatory behaviour the high density may not have been detrimental. Sitting was more prevalent earlier in transport with the highest frequencies observed in the first 12 h. This may be indicative that the first 12 h of transport were the most stressful for the piglets.

Fighting was more common during spring than during winter with an intermediate number of piglets fighting in the summer. This is likely a response to temperature. In summer fighting increases the heat load and in winter thermoregulatory behaviour overrides dominance hierarchy establishment. Fighting was also more common at lower transport density compared to standard density and high density. This may have been simply a result of the space restriction or may reflect a high stress level and a consequent delay of hierarchy formation.

Behavior post-transport can be used to assess the level of stress during transport. Piglets which started feeding and drinking early, and exhibited normal behavior patterns were considered to have recovered well from transport and weaning. Weaning is a stressful period for piglets and many of the behavioral changes noted in this study were due to weaning. Transportation tends to be an additive stressor, exacerbating the effects of weaning.

Resting post transport is an important indicator of fatigue during transport. On average resting was highest on the first 2 days post transport then dropped to day 3 and again to day 4 indicating fatigue during transport. However, this pattern of resting varied with season. If resting frequencies above the average of 80.6 % can be considered to be higher levels of resting then in summer resting was higher on day 2, in spring on day 1 and day 2 and in winter on day 1, day 2 and day 3 indicating higher fatigue levels in winter followed by spring and summer. Resting patterns post transport also changed with transport density. After high density transport resting was most frequent on day 2 and 3 with less frequent resting on day 1 and 4. Following transport at the recommended density resting was most often observed on day 1 and 2 with less resting on day 3 and 4. Following low density transport resting frequency dropped with time but this was not a significant difference. Both summer transport, which showed the poorest production and the highest density showed higher resting on day 2. However it is not clear why this would happen. This was not an artifact of higher resting levels in a summer high density pen.

Piglets transported at high densities were observed to sit more often on day 1 than on subsequent days. However, piglets transported at standard and low densities showed the same level of sitting across days. Following summer and spring transport sitting showed the highest frequency on day 1 with a drop to days 2-4. However, following winter transport sitting did not vary across days and tended to be lower on the first day post transport. Combining these two observations would lead to the conclusion that the higher level of sitting on day 1 resulted from higher sitting on day 1 in spring and summer but not winter. Sitting thus appears to be a reflection of more stressful transport at high densities in summer and spring. Higher densities during winter transport were considered to be less likely to result in stress.

Feeding frequency increased from day 1 to day 4 with very low levels recorded on day 1. This was most likely a reflection of weaning with transport as an additive factor as this low level of feeding is common in non-transported weaned piglets (Berry and Lewis, 20001b, Gonyou et. al., 1998). Drinking was most frequent on day 1 dropping significantly on each day for the 4 days observed. Drinking frequency was higher in summer and spring than in winter when higher water losses would be expected. However, drinking behaviour was not significantly affected by density during transport.

Fighting followed a typical pattern associated with establishment of the dominance hierarchy but was not affected by season or density. Play and oral manipulation did not vary with season or density.

Seasonal patterns in this experiment were similar to those in the previous experiment with higher levels of resting in winter and more activity in spring and summer during transport. Sitting, sometimes indicative of stress, was again more frequent during spring/fall transport. Higher levels of resting were also observed for longer in winter than in spring and summer indicating higher levels of fatigue. Production however in this trial was not affected as detrimentally in winter as in summer.

While behavioural differences were noted at high densities, production, hemaotocrit and serum cortisol levels were not measurably affected, possibly due to the high concurrent levels of stress and the growth check caused by early weaning. Lambooy also found no difference in hematocrit in slaughter hogs transported for similar times (Lambooy et. al., 1985). McGlone et. al. (1993) found higher serum cortisol values in grower pig following transport however these pigs did not have high concurrent stress levels caused by weaning. While the pattern of resting altered with density this change was not a useful basis for judging stress or coping strategies at higher densities. Sitting was more common during, and the day after, transport at high densities in spring and summer. Fighting was less frequently observed at higher densities during transport however this may have been a reflection of the limited space as much as transport stress. It appears that sitting may be the best measure of transport stress at higher densities.

Objective 2: To validate the findings from the controlled trials under commercial transport conditions. (Held over until year 2 of the grant request).

Objective 3: To assess the effect of stocking density on the microclimate of the piglet during transport.

The thermal microclimate of the piglets can be judged from 3 factors, piglet temperature, truck temperatures and the thermoregulatory behaviour of the piglets. Both bedding temperature and air temperature above the piglets varied with season. Average hourly air temperatures above the pigs ranged from 20.4 ^{0}C to 32.2 ^{0}C in summer, while in winter air temperatures rarely exceeded 8.0 ^{0}C, with temperatures dropping to hourly averages of -9.8 ^{0}C. Spring temperatures tended to be intermediate ranging from 7 to 26 ^{0}C. Air temperatures in the truck followed ambient temperatures but were 10 to 15 ^{0}C higher in winter and spring and 5 to 10 ^{0}C higher in summer. Lambooy (1988) also found a correlation between truck and outside temperatures (.54-.88). Density also affected air temperatures above the piglets but not bedding temperatures. At high density air temperatures were higher, providing a better microclimate for the piglets in winter but in summer a worse microclimate. There was tendency for air temperatures to decrease with increasing transport duration. Temperatures tended to be higher initially and during the day with lower temperatures recorded at night. As the temperature in the truck tended to follow ambient air temperatures it was assumed that ambient temperature rather than transport duration resulted in these lower temperatures. The increase in piglet resting behaviour in winter may also have contributed to a drop in air temperature as the piglets huddled together losing less heat to the atmosphere.

Ear temperatures provided a good indication of how well the piglets were coping with the truck temperatures. Ear temperatures varied with both season and density during transport. Ear temperatures followed the seasonal temperature with higher temperatures recorded in summer when the piglets were trying to lose heat compared to winter when body heat was being conserved. Higher ear temperatures recorded in the piglets transported at the high density indicates higher body temperatures, a benefit in winter but not in summer. In this experiment duration of transport was not a significant factor in ear temperature even though truck temperatures dropped at night.

Thermoregulatory behaviour is also an indicator of the coping strategy of piglets in both the heat of summer and the cold of winter. The propensity for piglets to huddle or spread out and the bedding quality influence the thermal microclimate of the piglet. 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. At the higher density fewer piglets were able to maintain this exposed position although, this difference failed to reach significance. In winter only 8.5 % of the piglets fell in the 75-100% group, showing piglets actively burrowed under companions/bedding for warmth. 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.

At the higher density in summer piglets have a higher air temperature to contend with, which is reflected in higher ear temperatures. They also have more difficulty staying exposed to the air and run the risk of hyperthermia. Higher and lower densities in winter are not as clearly detrimental possibly because the piglets tend to huddle irrespective of space available.

Objective 3: *To develop guidelines for transporters and producers to ensure the welfare and future productivity of transported piglets.*

Both season of transport and density are important indicators for subsequent production. In this trial piglets transported during summer exhibited the longest and most severe growth check as indicated by a longer growth check and more poor doers. Behavior was shown to be more sensitive to differences in density than production or serum cortisol levels, possibly due to the high growth check and stress levels associated with weaning. In spite of signs of hyperthermia observed in simulated transport at high density this was not reflected in higher serum cortisol levels. However, based on the transport simulation trial where high body temperatures and panting were observed and treated, densities higher than the Code of Practice guidelines (Connor, 1993) are an added risk factor for hyperthemia in summer. Higher densities during winter do not seem to be as detrimental. The frequency of sitting may be a useful behaviour for judging stress during transport however, a practical guideline will have to be developed. At high and standard densities truck temperatures can be estimated from ambient temperature by adding 5 to 10 ^{0}C in summer and 10 to 15 ^{0}C in spring/fall and winter. This is a preliminary finding and will need to be checked against temperature differences in commercial vehicles.

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Lay Interpretation:

Experimental Design: Six groups of forty eight Cotswold piglets were weaned at 17 ± 1 day of age and placed on trial in one of three seasons: summer, spring or winter. Piglets in each group were transported for 24 h at 3 densities: recommended (0.06 m^2/pig), 80 % of recommended (0.048 m^2/pig) or twice recommended (0.12 m^2/pig). During transport, temperature data were collected using a data logger with temperature probes in the air above the piglets and in the bedding for each density. Behavioral data were collected using a VCR and 3 infra-red cameras. Piglet skin temperatures were recorded at the end of each 6 h period of transport. Following transport, piglets were placed in groups of 4, in weanling pens with free choice feed and water. Behavior was recorded for 4 days post transport using a VCR and low light level cameras. Body weights were recorded daily until 7 days post-weaning and again at 10 days post-weaning. Density and season of transport were studied for affects on production, stress levels and behaviour of early weaned piglets.

Average Production: On average piglets dropped to 5.4 kg from a weaning weight of 5.9 kg, a weight loss of 7.8 %. Piglets reached their lowest average weight at 2.7 days post-weaning and recovered their weaning weight at 4.3 days post weaning.

Stress Levels: Serum cortisol levels showed a significant effect of weaning irrespective of season or density of transport. Baseline serum cortisol levels averaged 42,601 picograms/ml the day before weaning and transport. Following weaning and twenty four hours of simulated transport cortisol levels had doubled to 82,915 picograms/ml. Twenty four hours later serum cortisol level had returned to baseline levels.

Season: Piglets transported during the summer showed consistently poor production compared to winter and spring transport. Piglets transported in summer took longer to reach minimum weight and longer to recover from the growth check than piglets transported in the winter and spring. Piglets which had not regained their weaning weight by 7 days post-weaning were most common after summer transport. Production of piglets transported in winter tended to be lower than production of piglets transported in spring but this was not a significant difference. It is not clear why summer transport had such a detrimental effect on performance. In a previous trial (Lewis and Berry, 2004) winter transport was found to be more detrimental to production. Feeding behaviour, which has a direct affect on feed consumption, was also lowest during summer. In this trial 100% of the piglets were transported for 24 compared to 25 % 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. It is also possible this summer farrowing produced poor pigs which did not gain well. However, morbidity was not higher in this summer group.

Behaviour also varied by season. Activity during transport was higher in summer (25.6 %) and spring (25.2 %) than in winter (13.6 %; $P < 0.01$). Resting showed the opposite pattern with more resting during winter transport (85.7 %) than during summer (71.1%) or spring (68.7 %; $P < 0.03$). This was similar to the previous trial and appears to be a function of the increased necessity for thermoregulatory behaviour in winter coupled with fatigue. Thermoregulatory behaviour can be quantified as time spent exposed to the air or hidden. In the summer more piglets were visible 75-100 % of the time (156), than 50-75 % (30), 25-50 % (5) or 0-25 % (1; $P < 0.01$). In the winter piglets showed a preference for being underneath other piglets or bedding and therefore were visible for less time (75-100 %: 11, 50-75 %: 38, 25-50 %: 33, 0-25 %: 46; $P < 0.01$). 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. Drinking was most frequent on day 1 dropping significantly on each day for the 4 days observed. Drinking frequency was higher in summer and spring than in winter when higher water losses would be expected. However, drinking behaviour was not significantly affected by density during transport. If resting frequencies above the average of 80.6 % can be considered to be higher levels of resting then in summer resting was higher on day 2, in spring on day 1 and day 2 and in winter on day 1, day 2 and day 3 indicating higher levels of fatigue following winter transport. This is corroborated by the findings in the previous trial (Lewis and Berry, 2003). Fighting was more common during spring (112 piglets) than during winter (5 piglets) with an intermediate number of piglets (89) fighting in the summer ($P < 0.01$). Although fighting is not a desirable behaviour, establishment of the dominance hierarchy is normal and is usually initiated in the first few hours following mixing. Delays in fighting as seen during transport are likely to be an indicator of stress. This delay was longest in piglets transported in winter.

Density: Density affected environmental temperature which was reflected in both ear temperature and behavior. At high density air temperatures were higher (15.1 ^{0}C) than at low density (14.0 ^{0}C) with standard density intermediate (14.7 ^{0}C; $P < 0.04$). Ear temperature was higher in the piglets transported at the high density (27.6 ^{0}C) than the standard (26.6 ^{0}C) or low density (26.9 ^{0}C; $P < 0.04$). This is beneficial in winter but not during summer as seen by the tendency of piglets to pant and show increased body temperature in the simulated trial. At the highest density during summer fewer piglets were able to stay exposed to the air for 75-100 % of the time (high: 39, standard: 58, low: 61). Although this did not meet the criteria for significance, it may indicate why piglets could not maintain comfortable body temperatures at high density. During summer (tendency) and spring ($P < 0.01$) transport, more sitting was observed at the high density. This behaviour may be useful for measuring the effect of density during transport. Fighting was also more common at lower transport density (179 piglets) compared to standard density (22 piglets) and high density (5 piglets) ($P < 0.01$).

Truck Temperatures: Both bedding temperature and air temperature above the piglets varied with season. Average hourly air temperatures above the pigs ranged from 20.4 ^{0}C to 32.2 ^{0}C in summer, while in winter air temperatures were rarely above 8.0 ^{0}C, with temperatures dropping to hourly averages of -9.8 ^{0}C. Spring temperatures tended to be intermediate ranging from 7 to 26 ^{0}C. Air temperatures in the truck followed ambient temperatures but were 10 to 15 ^{0}C higher in winter and spring and 5 to 10 ^{0}C higher in summer.

Conclusions: Early weaning is a stressful period as reflected by high serum cortisol levels. Transport can add to this stress. In winter, cold environmental temperatures result in cold truck temperatures, lower ear temperatures and fatigue. Piglets try to cope with the lower truck temperatures by huddling and reducing other activities such as establishing the dominance hierarchy. 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. At the higher density in summer piglets have higher air temperatures to contend with, which is reflected in higher ear temperatures. They also have more difficulty staying exposed to the air and run the risk of hyperthermia. Production was also lowest in summer in this trial compared to winter in the previous trial.

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Table 1. Piglet behaviors assessed both during and after transportation from Dec. 2003 through to July 2004 in Manitoba, Canada.

Behavior	Definition
Active	Piglet was standing or moving on the truck. (Transport behavior only).
Standing	Piglet assumed an upright posture and was not engaged in appetitive or social behaviors. (Included in Active for transport behavior).
Sitting	The piglet assumed a sitting posture with the hind legs folded and the front legs extended. This is often described as dog sitting.
Resting	Piglet was lying in lateral or sternal recumbency, asleep or awake.
Feeding	The piglet had its head in the feeder and was active i.e. not sleeping in the feeder. (Post transport only)
Drinking	Piglet was in close proximity to the drinker and appeared to be drinking. (Post transport only)
Fighting	An active interaction between two piglets which involved biting and pushing. Differentiated from play by repeated active head contact and from oral manipulation by the high activity level of both participants.
Play	Pulling or manipulating chains. An active interaction between two piglets which involves locomotion without head contact. Differentiated from fighting by low levels of head contact. (Included in Other for transport behaviour)
Oral Manipulation	Chewing or in other ways manipulating other pigs (e.g. ears) with the mouth or nose in a quiet manner. Belly nosing was also included in this category of behavior. Differentiated from fighting by the low general activity level of both participants. (Included in Other for transport behaviour)
Other	If a piglet was not engaged in one of the above behaviors it was recorded in this category. This category included behaviors too infrequent for analysis.

Table 2: The effect of the season (summer, spring or winter) of transport on production of early weaned (17±1 d) piglets transported for 24 h.

	Season			
Measure [t]	Summer n = 288	Winter n = 288	Spring n = 288	P
Minimum Weight (kg)	5.3	5.5	5.5	ns
Percent Weight Loss (%)	9.6 [b]	7.1 [a]	6.7 [a]	< 0.01
Day of Minimum Weight	3.7 [b]	2.5 [a]	1.9 [a]	< 0.01
Day of Recovery	4.9 [b]	4.2 [a]	3.8 [a]	< 0.03
Average Daily Gain (%)	5.2	4.7	4.2	ns

[t] Daily body weights were used to calculate the production parameters. Minimum weight was the lowest weight reached by the piglets prior to beginning to regain weight. Percent weight loss was the same measure as a percentage of the weaning weight. Day of minimum weight was the length of time during which the piglet was not consuming enough feed to meet physiological requirements and therefore was loosing weight. Day of recovery was the day at which the weaning weight was regained and the represented the end of the growth check. Average daily gain was calculated from the day of recovery to 10 days after entry to the weaning pens as a percentage of the weaning weight.

Table 3. The effect of season (summer, spring or winter) and density (high, standard or low) on the frequency of sitting during a 24 h transport of early weaned (17 ± 1 d) piglets.

Sitting Behavior (%)				
	Density During Transport [t]			
	High n = 96	Standard n = 96	Low n = 96	P [tt]
Average	5.8 [b]	3.1 [a]	1.2 [a]	< 0.01
Summer	5.4	2.3	1.0	ns
Spring	10.2 [b]	4.8 [ab]	2.0 [a]	< 0.01
Winter	1.6	2.0	0.7	ns

Behavior was recorded on time lapse video using infra red cameras and ambient lighting.

[t] Piglets were transported at one of 3 densities: standard density (0.06 m^2), high density (80% of standard, 0.48 m^2) or low density (twice standard, 0.12 m^2).

[tt] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[a.b] Means within rows comparing density during transport differ according to superscript.

Table 4: The percentage of time spent sitting by early weaned (17 ± 1 d) piglets during transport showing the average frequency of sitting for each 6-h period and the effect of season (summer, spring or winter) and density (high, standard or low)[t] on this pattern.

Sitting Behavior (%)					
	Period During Transport (h)				
	0-6 n = 288	6-12 n = 288	12-18 n = 288	18-24 n = 288	P[tt]
Average	6.5 [c]	4.0 [b]	0.9 [a]	2.0 [a]	< 0.01
Summer	4.4 [a]	4.3 [ab]	0.4 [b]	2.7 [b]	< 0.01
Spring	11.8 [b]	6.2 [a]	2.0 [a]	2.7 [a]	< 0.01
Winter	3.5	1.4	0.2	0.7	ns
High	10.4 [b]	7.8 [b]	1.2 [a]	3.6 [a]	<0.01
Standard	6.3 [b]	3.2 [ab]	1.0 [a]	1.9 [a]	<0.01
Low	2.9	1.0	0.4	0.6	ns

Behavior was recorded on time lapse video using infra red cameras and ambient lighting.

[t] Piglets were transported at one of 3 densities: standard density (0.06 m^2), high density (80% of standard, 0.48 m^2) or low density (twice standard, 0.12 m^2).

[tt] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[a.b] Means within rows comparing periods during transport differ according to superscript.

Table 5: The average behavior of piglets during the first 4 days in the weanling pens following 24 h transport at one of three densities; high, standard or low.

Behavior %			
Measure	Frequency	Measure	Frequency
Standing	8.1	Play	0.77
Sitting	0.20	Play / Fighting	1.3
Resting	80.6	Oral Manipulation	2.7
Feeding	4.2	Other Behaviors	0.1
Drinking	2.2	Total	100.1

Behavior was recorded on time lapse video with 24 h lighting. Least squares means, before transformation, are presented.

Piglets were transported at one of 3 densities: standard density (0.06 m^2), high density (80% of standard, 0.48 m^2) or low density (twice standard, 0.12 m^2).

Table 6: The percentage of time spent resting by early weaned (17 ± 1 d) piglets over the first 4 days post transport (24 h) showing the average frequency of resting for each day and the effect of season (summer, spring or winter) and density (high, standard or low) on the 4 day pattern.

Resting Behavior %					
	Day Post Transport				
	1 n = 288	2 n = 288	3 n = 288	4 n = 288	P^{t}
Average	80.9^{bc}	81.6^{c}	80.0^{ab}	79.7^{a}	< 0.01
Summer	79.0^{a}	82.0^{b}	79.8^{a}	78.9^{a}	< 0.01
Spring	81.1^{b}	81.1^{b}	78.7^{a}	80.1^{ab}	< 0.01
Winter	82.5^{b}	81.7^{ab}	81.5^{ab}	80.2^{a}	< 0.01
High Density [t]	80.0^{a}	82.3^{b}	81.1^{ab}	80.4^{a}	< 0.01
Standard Density	81.1^{b}	81.0^{b}	78.6^{a}	79.0^{a}	< 0.01
Low Density	81.5^{a}	81.4^{a}	80.4^{a}	79.8^{a}	< 0.01

Behavior was recorded on time lapse video with 24 h lighting.

[t] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[tt] Piglets were transported at one of 3 densities: standard density (0.06 m^2), high density (80% of standard, 0.48 m^2) or low density (twice standard, 0.12 m^2).

[a.b] Means within rows comparing days post transport differ according to superscript.

Table 7: The percentage of time standing by early weaned (17 ± 1 d) piglets over the first 4 days post transport (24 h) showing the average frequency of standing for each day and the effect of season (summer, spring or winter) on the 4 day pattern.

Standing Behavior %					
	Day Post Transport				
	1 n = 288	2 n = 288	3 n = 288	4 n = 288	P^{t}
Average	9.0^{b}	7.9^{a}	7.6^{a}	7.7^{a}	< 0.01
Summer	8.4^{b}	7.2^{a}	8.7^{b}	9.0^{b}	< 0.01
Spring	8.7^{b}	8.1^{ab}	7.4^{a}	7.1^{a}	< 0.01
Winter	10.0^{c}	8.4^{b}	6.8^{a}	7.0^{a}	< 0.01

Behavior was recorded on time lapse video with 24 h lighting.

[t] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[a.b] Means within rows comparing days post transport differ according to superscript**.**

Table 8: The percentage of time spent sitting by early weaned (17 ± 1 d) piglets over the first 4 days post transport showing the average frequency of sitting for each day and the effect of season (summer, spring or winter) and density (high, standard or low) on the 4 day pattern.

Sitting Behavior (%)					
	Day Post Transport				
	1 n = 288	2 n = 288	3 n = 288	4 n = 288	P [t]
Average	0.28 [b]	0.19 [a]	0.16 [a]	0.15 [a]	< 0.01
Summer	0.31 [b]	0.18 [a]	0.13 [a]	0.13 [a]	< 0.01
Spring	0.43 [b]	0.20 [a]	0.17 [a]	0.15 [a]	< 0.01
Winter	0.09 [a]	0.18 [a]	0.17 [a]	0.16 [a]	ns
High Density [tt]	0.41 [b]	0.19 [a]	0.11 [a]	0.11 [a]	< 0.01
Standard Density	0.20 [a]	0.23 [a]	0.21 [a]	0.20 [a]	ns
Low Density	0.21 [a]	0.14 [a]	0.14 [a]	0.13 [a]	ns

Behavior was recorded on time lapse video with 24 h lighting.

[t] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[tt] Piglets were transported at one of 3 densities: standard density (0.06 m^2), high density (80% of standard, 0.48 m^2) or low density (twice standard, 0.12 m^2).

[a.b] Means within rows comparing days post transport differ according to superscript**.**

Table 9: The percentage of time spent feeding by early weaned (17±1 d) piglets in each season (summer, spring or winter) over the first 4 days post transport.

Feeding Behaviour (%)				
	Season			
Day	Summer	Spring	Winter	P [t]
1	0.08 [a]	0.45 [ab]	0.74 [b]	<0.01
2	1.7 [a]	4.3 [b]	3.6 [b]	<0.01
3	4.2 [a]	8.2 [c]	6.3 [b]	<0.01
4	5.5 [a]	7.6 [b]	7.2 [b]	<0.01

Behavior was recorded on time lapse video with 24 h lighting.

[t] *P*-values are based on the analysis of transformed data. Least squares means, before transformation, are presented.

[a.b] Means within rows comparing season differ according to superscript.

Table 10 Affect of season (summer, spring or winter) on air temperature above the piglets and bedding temperature during transport for 24 h.

Temperature ^{0}C			
	Season		
	Summer n = 72	Spring n = 72	Winter n = 72
Air Temperature	26.5 ^{a}	16.4 ^{ab}	0.9 ^{b}
Bedding Temperature	28.9 ^{a}	20.7 ^{ab}	4.8 ^{b}

Air and bedding temperature were measured using 6 probes, 2 in each density designated area, one in the air above the piglets and one in the bedding. Data were collected each minute, averaged and stored for each 10 min. period. Prior to analysis the temperature data was averaged over each 6 h period.

Figure 1: Average growth curve for 288 piglets weaned at 17 $\pm$ 1 day and transported for 24 h in Manitoba during 3 seasons (summer, spring or winter) and at one of 3 densities (recommended 0.06 m^2/pig, 80% of recommended (0.048 m^2/pig) or twice recommended (0.12 m^2/pig) computer generated from daily piglet weights (kg). Minimum weight reached, the time post-weaning at which the minimum weight was reached, return to weaning weight and subsequent weight gain for transported piglets were calculated as a measure of production efficiency post weaning.

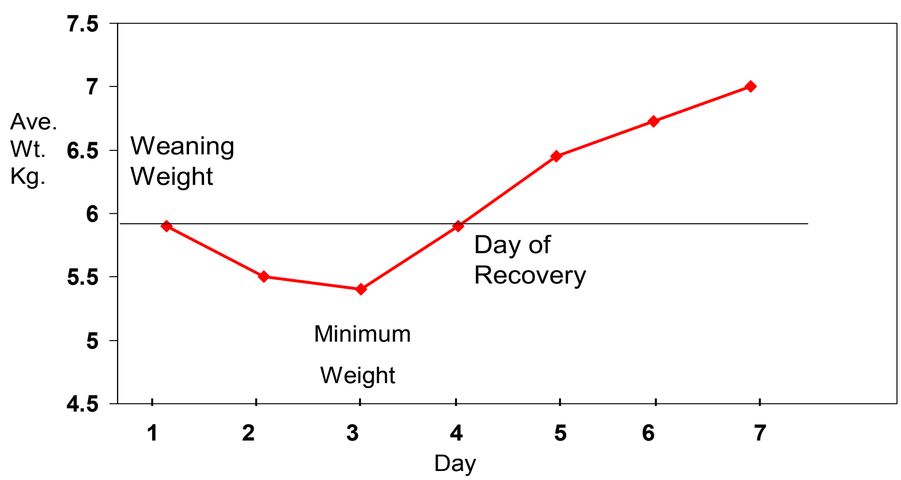

Figure 2: Ambient Outside Temperature (Airport Readings) and inside truck temperatures measured by temperature probes in the air above the piglets and at the floor level in the bedding.