Title: Well-Being of Early Weaned Piglets During Transport: Assessment of Seasonal Effects on Performance and Behavior - **NPB #02-166**

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Date Received: January 5, 2004

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, winter or fall. Piglets in each group were transported for 6 h, 12 h or 24 h representing short, medium and long journeys. Data collected during and after transport were tested against non-transported (0 h) controls (CONT). During transport, temperature data were collected using a data logger with temperature probes in the air above the piglets, in the bedding and at the shell of the truck. Behavioral data were collected using a video recording system. As in commercial transport, feed and water were not available. Piglet skin and rectal temperatures were recorded at the end of each 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 3 days post transport using a VCR and low light level cameras. Body weights were recorded daily until 7 days post-weaning and again at 14 days post-weaning.

Behavior changed markedly after 12 h of transport. Standing ($P < 0.01$) and sitting ($P < 0.01$) decreased while resting ($P < 0.01$) and fighting increased ($P < 0.05$). The changes in standing ($P < 0.054$) and resting ($P < 0.01$) were most noticeable during winter and fall. Ear and rectal temperatures also began to drop after 12 h of transport ($P < 0.02$).

Behavior of the piglets in the first 3 days post transport showed a strong seasonal pattern. Standing ($P < 0.05$) and resting ($P < 0.05$), were less frequently observed while sitting ($P < 0.01$) and drinking ($P < 0.01$) were more frequently observed in the fall. As transport duration increased, the frequency of standing ($P < 0.01$) decreased while resting ($P < 0.01$) feeding ($P < 0.01$) and drinking ($P < 0.01$) increased post transport. Behavior also changed during the first 3 days after transportation. Standing ($P < 0.01$) and feeding ($P < 0.01$) increased and sitting ($P < 0.01$), resting ($P < 0.01$), drinking ($P < 0.01$) and fighting ($P < 0.01$) decreased with time.

Behavior during transport often indicates the immediate challenges imposed by transport and the coping strategies of the piglets. The cold temperatures during winter transport changed piglet behavior and physiology, encouraging lower levels of activity and decreased ear and rectal temperature. These changes were most apparent after 12 h of transport.

Post-transport behavior was also important for determining transport stressors. Behaviors which increase during long transportation, or which are more prevalent in transported than non-transported piglets are usually indicative of higher transport stress. In this study standing was observed less frequently and resting was more common, in transported piglets, indicating fatigue following transport. Feeding was observed more frequently in piglets transported for 12 or 24 h, reflecting an increased motivation to feed and possibly an increase in piglet age at the time of introduction to feed. Transported piglets drank more often due to lack of water availability during transport. Transported piglets, irrespective of duration of transport and season showed some behaviors associated with transport. Standing was less frequently observed while sitting, resting (day 1) and drinking (day 1) were more frequently observed in transported piglets and can be associated with transport stressors.

Season, was found to affect both behavior and performance. Standing was less frequent and sitting more frequent in the fall, which was associated with longer and therefore more stressful transport in this study. Average daily gain post recovery was lowest following winter transport. Most (76 %) piglets less than weaning weight after 7 days were also observed following winter transport, indicative that winter transport, in unheated trucks, was most detrimental to production. Piglets transported during the summer were observed to rest more frequently on day 1 and 2 post transport, indicting that hot summer transport induced fatigue. Transport in all seasons was found to affect behavior while winter transport also affected production. It is important to determine which stressors have the greatest impact in each season and develop strategies to reduce the effects of transport on welfare and production.

Introduction: Current Status of the Problem

The swine industry has progressively adopted a segregated early weaning (SEW) management system, necessitating the transport of piglets at 14 to 21 d of age. Transportation can be a severe stressor especially for young piglets, which show weight loss due to dehydration and food withdrawal (Robert et al., 1997, Berry and Lewis, 2001a,b). The responses and tolerances of SEW piglets to transport are not well understood. Most previous transport work focussed on slaughter hogs (Bergeron. and. Lewis, 1997). Weaning itself, especially at an early age, affects performance as piglets are slow to develop normal feeding patterns and consequently have a compromised feed intake (Gonyou et al., 1998). When weaning coincides with transport, the stressors are additive, increasing the detrimental effects on post-weaning performance. 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 occurs immediately after unloading. However Hicks et al., (1998) showed a journey of 4 h significantly increased weight loss over this period 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 (Warris and Brown 1994). Temperature can fluctuate rapidly in vehicles during transport (Tarrant and Grandin, 1993). 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 ^{0}C (Connor, 1993). However, temperatures as low as 15 ^{0}C can be tolerated by older piglets (23-26 d) for 12 h (Minton et al., 1988). Berry and Lewis (2001a,b) showed that transport temperatures of 35 ^{0}C and possibly 20 ^{0}C were detrimental to early weight gains 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 ^{0}C) and for extended durations. Therefore established recommendations for transport of SEW pigs are needed.

Objectives:

i) To further assess the impact of transport on the performance, behavior and physiology of SEW piglets using a transport apparatus designed to collect environmental temperature and humidity data and simultaneous behavioral data during transport.

ii) To assess the welfare / production impact of the current commercial practice of using unheated trucks during winter months.

iii) To construct a simple predictive model to identify transport conditions and animal factors that affect post transport performance. This model should form a useful basis for developing codes of practice.

Materials and Methods:

Piglets

Two hundred and eighty eight Cotswold piglets were weaned at 17 ± 1 day and placed on trial in one of three seasons: Summer (July), Winter (early March) and Spring/Fall (Oct.). 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 a transport duration in groups of 12. Each group contained piglets from different litters and of different sexes to mimic the mixing occurring during commercial weaning. 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).

Transport Design

Transport durations of 6 h, 12 h or 24 h representing short, medium and long journeys were tested against non-transport (0 h) controls (CONT). Drivers were instructed to transport piglets along highways between trips to the University for unloading and weighing. Piglets were transported in a panel van which allowed normal daylight entry and was lighted with a 7.5 watt bulb at night to facilitate observations. Piglets were placed in a transport apparatus inside the panel van and 12 pigs were removed at the end of 6, 12 and 24 h. Due to this design piglet numbers and transport duration are confounded. This apparatus allowed for alteration of square footage to reflect industry standards of 0.56 ft^2 (Connor, 1993). The galvanized metal floor was deep bedded with straw (approximately 20 cm) in the winter and covered with shavings in the summer. A low light level camera was mounted on the apparatus and behavior was recorded during each journey. As in commercial transport, feed and water were not available.

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 14 days post-weaning. Using this data, computer generated growth curves were calculated. The following measures were derived from these growth curves, the day at which the minimum weight was reached (Day of Minimum Weight), 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 14 d post weaning.

Physiological Measures

Skin temperatures were recorded on the ear, head, rump and back of each piglet at the time the piglets were removed from the truck after transport. Additionally, four random rectal temperatures were recorded for each group of 12 piglets. Skin temperatures were recorded using a Raytek Minitemp laser thermometer (630 – 670 nm) from less than 1 m distance and rectal temperatures were taken with a standard rectal thermometer.

Behavioral Measures

Behavior was assessed both during transport and post transport using time lapse video recordings. Post-transport behavior was recorded for 3 days based on previous trials which showed that most piglets had regained their weaning weight by 4 days post weaning (Berry and Lewis, 2001a). Scan sampling of the video recordings at 10 minute intervals allowed the assessment of mutually exclusive behaviors detailed in Table 1.

Table 1. Piglet behaviors assessed both during and after transportation from May 2002 through to October 2003 in Manitoba Canada.

Behavior	Definition
Standing	Piglet assumed an upright posture and was not engaged in appetitive or social behaviors
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.
Drinking	Piglet was in close proximity to the drinker and appeared to be drinking.
Fighting/Play	An active interaction between two piglets. As the frequency of this category follows a pattern typically seen in establishing a dominance hierarchy, it likely largely reflective of fighting.
Oral Manipulation	Chewing or in other ways manipulating objects with the mouth or nose. This may include ears of piglets or objects such as chains. Belly nosing was also included in this category of behavior.
Other	If a piglet was not engaged in one of the above behaviors it was recorded in this category. This included behaviors too infrequent for analysis.

Environmental Measures

Temperature (^{o} C) and relative humidity (%) were recorded every minute from three probes during transportation using a data logger (Campbell Scientific CR10X). Probes were positioned in the bedding, directly above the piglets (approximately 50 cm) and on the inside wall of the truck outside the area occupied by the piglets and approximately 50 cm above the floor. Temperature and relative humidity measurements were averaged for each 10 min period during transportation.

Statistical Analysis

Piglet activities during transport were expressed as a proportion and analyzed using the GLM procedure in SAS (SAS Inst. Inc., Cary, NC), with means tests (Turkey's). The experimental unit was the truck containing 12 to 48 piglets. All behavioral data were expressed as percentages and were subjected to a square root or arcsine square root transformation to achieve a normalized distribution. The statistical model included effects of season (summer, winter, fall), transport duration (0 h, 6 h, 12 h, 24 h), transport group within season (1, 2) and interactions (error = group within season). Fighting did not meet the criteria for use of parametric statistics and was therefore analyzed with a chi square analysis.

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 (Tukey's). The statistical model for piglet behavior included effects of season (summer, winter, fall), transport duration (0 h, 6 h, 12 h, 24 h), transport group within season (1, 2), day (1, 2, 3) and interactions (pen within season by transport duration by group). Following the mixed model criteria 2 and 3 way interactions were dropped from the analysis if their contribution was 0.

Growth curves were computer generated for each piglet based on the daily body weights. These growth curves were used to generate 4 variables: 1) the lowest body weight, 2) the time at which this lowest weight was reached, 3) the time at which the weaning weight was regained (day of recovery) and 4) average daily gain from the day of recovery to 14 d after weaning. This array of variables provided a good overview of the effect of transport on production. These performance measures were analyzed using the GLM procedure (SAS Institute Inc., Cary, NC) with weaning weight as a covariate. The statistical model for piglet behavior included effects of season (summer, winter, fall), transport duration (0 h, 6 h, 12 h, 24 h), transport group within season (1, 2) and interactions (error = pen within season by transport duration by group). Chi Square tests were used for analysis of data on "poor doers", which did not meet the criteria for parametric statistics.

Temperature data was averaged over each hour and graphed for use in evaluating effects of season and transport duration on behavior and production.

Results:

Performance Measures

On average piglets dropped to 5.9 kg from a weaning weight of 6.4 kg (S.D. 0.47 kg). They reached their lowest weight at 2.4 days post-weaning and recovered their weaning weight at 3.7 days post weaning (Figure 1). While performance measures post transport were not ($P < 0.05$) affected by duration of transport, season affected post-transport production in two ways. Poor doers, piglets which had not regained their weaning weight by 7 days post-weaning, were more common after winter transport. Seventeen piglets (5.9 %) were classified as "poor doers" and 76 % of these were observed following winter transport (n = 17, chi square = 12.0, 2 d.f. $P < 0.05 = 5.99$)

than during summer(1) and fall (3). Average daily gain for this trial was 0.38 kg. ADG, calculated as a percentage of weaning weight, was lower (P < 0.01) in winter (5.2 %) than during the fall (6.9 %) and summer (6.3 %) (Figure 2).

Physiological Measures

Head, back and rump temperatures did not differ (P > 0.05) with the duration of transport or the season. However, ear temperatures were more sensitive to ambient temperature changes. For transport durations of 6 h, season did not affect ear temperature. However, after 12 h and 24 h of transport, ear temperatures during the winter trial were lower (P < 0.01) than during summer (Table 2). Ear temperatures measured in the fall were midway between summer and winter temperatures. In summer and fall there was no (P > 0.05) drop in ear temperature after 6 h, 12 h or 24 h of transport. However, in winter, ear temperature dropped (P < 0.01) from a high of (33.8 ^{0}C) after 6 h of transport to 15.3 ^{0}C after 24 h of transport.

Rectal temperatures were significantly (P < 0.01) lower in winter (38.6 ^{0}C) and fall (38.7 ^{0}C) than in summer (39.1 ^{0}C). Rectal temperatures were also (P < 0.01) lower after 24 h of transport (38.4 ^{0}C) than after 6 h (39.1 ^{0}C) or 12 h (38.9 ^{0}C) of transport during the winter.

Behavioral Measures

During Transport

Standing decreased in frequency as transport duration increased (P < 0.01). Standing was most commonly observed (35.9 %) in the first 12 h of transportation. In the final 12 h standing dropped in frequency to 7.4 % of total time observed. This pattern was apparent in all three seasons but tended to be less defined in summer (P < 0.054). Resting showed the opposite pattern (P < 0.01) with less resting occurring in the first 12 h (59.8 %) than in the second 12 h period (91.5 %). This pattern was strongest in fall and winter whereas in summer resting tended to be spread more evenly throughout transport (P < 0.03) (Table 3). Increased sitting was observed during the first 12 h of transport (P < 0.01) during the fall season (P < 0.05) (Table 4). More (P < 0.01, chi square = 32.7, d.f. = 2, 9.2) 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. Fighting varied (P < 0.01 chi square = 72.98, d.f. = 3, 11.34) between time periods. During the first 6 h only 2 piglets were observed fighting, 17 in the second 6 h, 29 in the third period and 12 in the final 6 h of transport.

Post Transport

Piglets spent the greatest proportion of time resting (80.3 %). Standing was the next most frequent behavior recorded at 8.0 %. Feeding and drinking averaged 3.0 % and 2.0 % respectively with sitting, play/fighting and oral manipulation, representing a total of only 4.7 % over the first three days after transport (Table 5).

There was a seasonal pattern in which the behavior of piglets during the fall differed from behavior observed in the winter and summer (Table 6). Standing was less (P < 0.01) common during the fall than during the summer and winter while sitting was observed more frequently (P < 0.05). Resting was more frequent during the summer and winter than in the fall but this was apparent only on day 1 (P<0.01). In the fall resting remained the same across days (1: 78%, 2: 80%, 3: 77.4%) (P < 0.05). During summer, resting was higher on the first 2 days then dropped (1: 82.2%, 2: 82.2%, 3:

78.7%). During winter, resting tended to remain high across all three days (1: 81.2%, 2: 82.1%, 3: 80.6%). This can be visualized in Figure 3.

Transport duration affected a number of post-transport behaviors (Table 7). CONT piglets stood more (P<.01) than transported piglets, although increasing transport duration did not further reduce the frequency of standing. Resting was more frequently observed (P<.01) in transported piglets on day 1. However, by day 2 transport had no effect on resting behavior. Feeding was infrequent (0.5 %) for CONT and transported piglets on the first day in the weanling pens. On day 2 piglets transported for 12 h and 24 h spent more time feeding (P<.01). This difference had disappeared by day 3. Piglets transported for 24 h were 1 day older when placed on feed than CONT piglets. When the feeding behavior of piglets the same age (19 ± 1 day of age) was compared, CONT 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 CONT piglets (6.6 %). In both comparisons the CONT piglets were feeding more frequently than their transported littermates, however they had been on feed an additional day. Drinking frequency on the first day after transport increased as duration of transport increased (P < 0.01). On day 2 (1.8%) and 3 (1.4%) there were no differences due to transport duration.

Behavior changed markedly over the first 3 days in the weanling pens Standing was less frequently observed (P < 0.01) on day 1 than on day 2 and 3 (Table 8). However this was apparent only during the fall. In summer (9.9 %) and winter (8.5 %) standing did not change across days. Sitting was most frequently observed (P < 0.01) on day 1 (Table 8). The frequency of feeding was low (P < 0.01) on the first day following transport and increased on day 2 and day 3 (Table 8). Higher (P < 0.01) drinking frequencies were observed on day 1 in summer (2.1 %) and winter (3.0 %) and on day 1 (3.7 %) and 2 (2.3 %) in the fall. Subsequently drinking levels dropped to an average of 1.4 %. Fighting was highest on day 1 but decreased (P < 0.01) on day 2 and day 3.

<u>Environmental Measures</u>

Truck temperatures vary across the time of day with the higher temperatures recorded during the day (Figure 4). In summer the average bedding temperatures during each 6 hour period ranged from 31.8 ^{0}C in the hottest 6 h of the day to 25 ^{0}C in the coolest 6 h of the day. Air temperature above the pigs averaged 2.7 degrees lower and truck shell temperature 3.7 ^{0}C lower than bedding temperatures. In the fall average bedding temperatures ranged from 14 ^{0}C to 7 ^{0}C. Air temperature above the pigs averaged 1.8 ^{0}C below the bedding temperature but during the early morning air temperature was higher. Truck shell temperatures average 7 ^{0}C below bedding temperatures. In the winter, bedding temperatures ranged from 0 ^{0}C to -10.8 ^{0}C during the 4 6-h periods of transport. Air temperature above the pigs averaged 4.7 ^{0}C higher than bedding temperatures and shell temperatures were 3.4 ^{0}C lower.

Discussion:

Objective 1: To further assess the impact of transport on the performance, behavior and physiology of SEW piglets using a transport apparatus designed to collect environmental temperature and humidity data and simultaneous behavioral data during transport.

Behavior 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. In this study resting was the most common behavior. In the first 12 hours, 60 % of the piglets were resting. In the final 12 h of transport resting had increased to 92 %. When not resting, piglets were most likely to be standing or sitting. More fighting was observed later in the transport process, with only 2 piglets observed fighting in the first 6 h. As fighting is usually initiated within 30 minutes of mixing piglets (D’Eath, 2002), this was indicative that transport was stressful enough to delay establishment of a dominance hierarchy. As transport progressed, resting was observed more frequently with the change occurring after 12 h of transport. This pattern was consistent with fatigue as described by Lambooy (1988). High levels of resting post transport tend to support this hypothesis. However other factors may also be affecting this behavior such as colder temperatures at night.

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. For this reason the effects of transportation were more difficult to detect. Behaviors which increased during long transportation or which were more prevalent in transported than CONT piglets were considered to be indicative of higher transport stress. In this study four behaviors were affected by transport. Standing decreased while resting, feeding and drinking increased following transport. Increases in resting post transport were indicative of fatigue in transported piglets. As the duration of transport increased, drinking on day 1 increased. Although hematocrit values could not be measured in this study, hematocrit has been shown to rise to high normal levels following longer transport (Berry and Lewis, 2001) indicating that transportation was a risk factor for dehydration in SEW piglets. The pattern that emerged in this trial was that stressed piglets were observed standing less, drinking and resting more post transport.

Feeding was considered an important behavior indicating recovery from the stress of weaning and transport as well as an important pointer to recovery from the growth check. On the first day following transport, feeding was similar, and low, in all pens including the CONT pens. This indicated that weaning had a greater effect on feed consumption than transportation. On the second day following transport piglets transported for 12 h and 24 h spent more time feeding than piglets transported for 0 h or 6 h. Feeding frequency on day 2 was a reflection of both weaning, which caused an initial drop in feed consumption, and fasting during transport, which increased the motivation to feed but exacerbated the problems of early weaning. While feeding increased as transport duration increased, it was not clear that this was a direct result of the transport as piglet age at the time of introduction to the feed was necessarily confounded with transport duration. During day 3, feeding behavior did not differ between CONT and transport groups.

Transported piglets, because of the period of fasting and the additional requirements for energy to provide heat and for muscle movement were expected to lose more weight, take longer to reach their minimum weight and longer to regain their weaning weight as transport duration increased. Longer or more stressful transport was expected to exacerbate these loses. In this trial duration of transport did not significantly affect any of the production parameters.

A seasonal comparison showed that piglets transported in the fall stood less, sat more often and exhibited higher than normal drinking levels for 2 days, indicative of higher stress levels in fall transport. However, piglets transported in summer and winter rested more post transport indicating a higher level of fatigue. Winter transport had the greatest effect on production. Transport, irrespective of season, was an additive stress following early weaning.

Objective 2: To assess the welfare / production impact of the current commercial practice of using unheated trucks during winter months.

This objective was best assessed by comparing the behavior and performance of pigs in winter compared to summer and fall transport. In summer, resting tended to be spread more uniformly throughout transport while in winter and fall, piglets were observed to rest more frequently in the last 12 h of transport. As the greatest difference between summer and fall/winter transport was the colder night temperatures, the piglets may have rested as a method of conserving heat. Following winter transport resting remained high for 3 days indicating substantial fatigue during winter transport. The lower level of fighting in the winter (3 pigs compared to 39 in summer) was also indicative of the need to huddle for warmth, a more immediate necessity than establishing a dominance hierarchy.

While skin temperatures on the trunk of the piglets did not vary with season, ear temperature was lower in winter and lower as transport duration increased. As core temperature begins to drop blood flow to the extremities, like the ears, is decreased in order to conserve core temperature. With lower blood flow, skin temperatures drop. In this study the drop in ear temperature in winter was indicative that the piglets needed to conserve heat to maintain body core temperature in the last 12 hours of transport. Rectal temperatures, which were a better indication of core temperature, but also more prone to vary with handling, also dropped as duration of winter transport increased and were lower in fall and winter than in summer.

Performance was also affected by winter transport. A larger proportion (76 %) of poor doers, piglets which did not regain their weaning weight by 7 days post-weaning, were transported in the winter. Average daily gain post recovery to 14 d was also significantly lower in winter.

The cold temperatures in winter change piglet behavior, physiology and production, encouraging lower levels of activity, reduced ear and rectal temperature, more poor doers and lower early average daily gains.

Objective 3: To construct a simple predictive model to identify transport conditions and animal factors that affect post transport performance. This model should form a useful basis for developing codes of practice.

Growth curves were computer generated based on daily body weights. These growth curves were used to calculate four important production variables: 1) the lowest body weight, 2) the time at which this lowest weight was reached, 3) the time at which the weaning weight was regained (Day of Recovery) and 4) average daily gain from the day of recovery to 14 d after weaning. This array of variables can provide a good assessment of early post weaning growth. The time to reach the lowest body weight and the lowest weight reached were a measure of how much of the piglets reserves were used during the weaning process and to compensate for losses during transport. The Day of recovery reflects the ability of the piglet to recover from these losses and the post recovery average daily gain reflects longer term affects on growth and performance. On average, piglets lost 0.45 kg body weight over 2.4 days. The Day of Recovery averaged 3.7 days and average daily gain from Day of Recovery to 14 d was 0.38 kg. Lower average daily gains post recovery in piglets transported in winter indicate that these piglets have a longer recovery period, at least 14 days than would have been indicated by the other production measures.

References:

Bergeron, R., and N. J. Lewis. 1997. Farm Animal Transportation, Health and Welfare; Farm Animal Welfare in Canada: new technologies, research and world trade. The Lennoxville Symposium, Lennoxville Quebec, June 6, 1997.

Berry, R. J., and N. J. Lewis. 2001a. The effect of duration and temperature on simulated transport upon the performance of early weaned piglets. Can. J. Anim. Sci. 81:199-204.

Berry R. J., and N. J. Lewis. 2001b. Response of early weaned piglets to simulated transport duration and temperature. *Proc. of the VI[th] I.L.E.S,* Louisville, Kentucky (May 2001) pp 527-534.

Brumm, M. C., G. W. Jesse, H. F. Mayes, G. M. Zinn, and E. T. Clemens. 1987. Effects of feed and water restriction and receiving diet crude protein on feeder pig performance J. Anim. Sci. 64:1606-1611.

Canadian Council on Animal Care., 1993. Guide to care and use of experimental animals: Vol 1. E. D Olfert, B. M. Cross and A. A. McWilliam eds. Canadian Council on Animal Care. Ottawa, Ontario. ISBN:0-919087-18-3.

Connor, M. L. 1993. Recommended code of practice for the care and handling of farm animals: Pigs. Agriculture and Agri-food Canada. Publication 1898/E. Ottawa.

D'Eath, R.B. 2002. Individual aggressiveness measured in a resident intruder test predicts the persistence of aggressive behaviour and weight gain of young pigs after mixing.

Gonyou, H. W., E. Beltranena, D. L. Whittington, and J. F. Patience. 1998. The behaviour of weaned pigs at 12 and 21 days of age from weaning to market. Can. J. Anim. Sci. 78:517-523.

Hicks, T. A., J. J. McGlone, C. S. Wishant, H. G. Kattesh, and R. L. Norman. 1998. Behavioural, endocrine, immune and performance measures for pigs exposed to acute stress. J. Anim. Sci. 76:474-483.

Lambooy, E. 1988. Road transport of pigs over a long distance: some aspects of behavior, temperature and humidity during transport and some effects of the last two factors. Anim. Prod. 46:257-263.

Minton, J. E., D. A. Nichols, F. Blecha, R. B. Westernman, and R. M. Phillips. 1988. Fluctuating ambient temperatures for weaned pigs: effects on performance and immunological and endocrinological functions. J. Anim. Sci. 66:1907-1914.

Robert, S., D. Weary, and H. W. Gonyou. 1997. Segregated early weaning and welfare of piglets p 133-138 In. S. Robert ed. Lennoxville Symposium. Farm Animal Welfare in Canada: new technologies, research and world trade. Lennoxville, QC.

Tarrant, V., and T. Grandin. 1993. Cattle Transport. P109-126 In. T Grandin ed. Livestock Handling and Transport. CAB International, Wallingford, UK.

Lay Interpretation:

Impact of transport: Behavior during transport provides us with indicators of the immediate problems faced by piglets during transport and the coping strategies of the piglets. We can look at each behavior and assess the reasons underlying the change in frequency in relationship to the transport environment. This provides us with a method for judging the impact of transportation. Establishment of the dominance hierarchy, as indicated by fighting, was considerably delayed during transport indicating some stress associated with early transport, probably related to weaning and the new environment of the truck. Behavior changed markedly after 12 h of transport. Active behaviors such as standing and sitting decreased while resting increased indicative of fatigue. However since the changes in standing and resting were most noticeable during winter and fall some of the increased resting may have been associated with cold temperatures. Ear and rectal temperatures also began to drop after 12 h of transport. At this time outside temperatures were also dropping. Piglets may have reduced other activities and rested in order to conserve body temperature.

Behavior post-transport also provides us with information to assess the stress of transport. Piglets which start to feed early, become hydrated rapidly and show normal behavior patterns can be said to have recovered well from transport and weaning. Behaviors which increase during long transportation or which are more prevalent in transported than non-transported piglets are usually indicative of higher transport stress. Such behaviors include resting, associated with fatigue and drinking, associated with dehydration. In this study standing was observed less frequently and resting was more common, in transported piglets, indicating fatigue following transport. This was most apparent following winter transport (3 d) but was also observed following summer transport (2 d). Feeding was observed more frequently in piglets transported for 12 or 24 h, reflecting an increased motivation to feed and possibly an increase in piglet age at the time of introduction to feed. Transported piglets drank more often, although this was not significantly different until piglets had been transported for 24 h.

There was also a strong seasonal pattern in which the behavior of piglets during the fall differed significantly from behavior in winter and summer. Standing was less frequently observed and sitting was more frequently observed in the fall, indicating a higher stress level in this season. Higher drinking frequencies were extended into day 2 in the fall indicating that the piglets were not able to meet their needs on day 1, unlike piglets observed in other seasons. Transported piglets, irrespective of duration of transport and season showed some behaviors associated with transport. Standing was less frequently observed while sitting, resting (day 1) and drinking (day 1) were more frequently observed in transported piglets and can be associated with transport stressors.

Impact of winter transport without supplemental heat: The cold temperatures during winter transport changed piglet behavior and physiology, encouraging lower levels of activity and decreases in ear and rectal temperature. These changes were most apparent after 12 h of transport. Higher levels of resting, indicative of fatigue, were noted for 3 days post-transport. Average daily gain (post recovery) was lowest in winter and 76 % of “poor doers” (less than weaning weight after 7 days) were observed in the winter. Transported pigs irrespective of season show some signs of stress and it is important to determine which stressors are most important in each season in order to provide an environment favorable to high welfare and short growth checks but this is especially important for winter transport where production and therefore welfare is compromised up to 14 days after transport.

Performance Measures: Growth curves were computer generated based on daily body weights. These growth curves were used to calculate 4 important production variables: 1) the lowest body weight, 2) the time at which this lowest weight was reached, 3) the time at which the weaning weight was regained (Day of Recovery) and 4) average daily gain from the day of recovery to 14 d post weaning. This array of variables provided a comprehensive assessment of early post weaning growth. The time to reach the lowest body weight and the lowest weight reached were a measure of how much of the piglets reserves were used during the weaning process and to compensate for losses during transport. The Day of recovery reflects the ability of the piglet to recover from these losses and the post recovery average daily gain reflects longer term affects on growth and performance. On average piglets lost 0.45 kg body weight over 2.4 days. The Day of Recovery averaged 3.7 days and average daily gain from Day of Recovery to 14 d was 0.38 kg. Lower average daily gains post recovery in piglets transported in winter indicate that these piglets have a longer recovery period, at least 14 days, than would have been indicated by the other production measures.

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

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Table 3: The effect of season (summer, winter and fall) on the percentage of time spent resting by groups[t] of piglets (17 ± 1 d) during transportation periods of 6, 12 or 24 h from Oct. 02 to July 03.

Resting Behavior %					
Season	**Transport Duration, h**				
	0 – 6 **n = 216**	**6 - 12** **n = 144**	**12 – 18** **n = 72**	**18 – 24** **n = 72**	**P** [tt]
Fall	45.1 [a]	51.0 [a]	91.2 [b]	96.6 [b]	< 0.05
Winter	55.3 [a]	63.3 [a]	91.6 [b]	98.3 [b]	< 0.05
Summer	71.0 [a]	72.8 [a b]	81.6 [a b]	89.8 [b]	< 0.05

Behavior was recorded on time lapse video with natural light during the day and a 7.5 watt bulb utilized during the dark period. Temperature above the piglets averaged 25.6 ^{0} C in summer, 7.8 ^{0} C in fall and – 0.4 ^{0} C in winter.
[tt] Initial group size was 48 piglets, 12 were controls, and 36 piglets were transported. At the end of each transport duration 12 piglets were moved into weanling housing. This was repeated twice in each season.

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

[a.b] Means within rows comparing season of transport over 0, 6, 12 and 24 h differ according to superscript (p<0.05).

Table 4: The effect of duration of transport and season on the time spent sitting[t] by groups[t] of piglets (17 ± 1 d) during transportation periods of 6, 12 or 24 h

Sitting Behavior %				
Transport Duration, h				
0 – 6 **n = 216**	**6 - 12** **n = 144**	**12 – 18** **n = 72**	**18 – 24** **n = 72**	**P** [tt]
33.2 [a]	23.7 [a]	2.8 [b]	2.7 [b]	< 0.01
Season				
Fall	**Winter**	**Summer**	**P**	
2.1 [a]	1.6 [a b]	1.0 [b]	< 0.05	

Behavior was recorded on time lapse video with natural light during the day and a 7.5 watt bulb utilized during the dark period. Temperature above the piglets averaged 25.6 ^{0} C in summer, 7.8 ^{0} C in fall and – 0.4 ^{0} C in winter.

[t] Initial group size was 48 piglets, 12 were controls, and 36 piglets were transported. At the end of each transport duration 12 piglets were moved into weanling housing. This was repeated twice in each season.

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

[a.b] Means within rows comparing season or duration of transport differ according to superscript.

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Table 5: The average behavior[t] of piglets during the first 3 days in the weanling pens [tt].

Behavior %			
Measure	Frequency	Measure	Frequency
Standing	8.0	Drinking	2.0
Sitting	0.36	Play / Fighting	1.9
Resting	80.3	Oral Manipulation	2.4
Feeding	3.0	Other Behaviors	1.9

[t] Behavior was recorded on time lapse video with 24 h lighting. Lease squares means, before transformation, are presented.

[tt] The group of piglets studied included non-transported controls and piglets transported during the summer, winter or fall.

Table 6: The effect of the season in which the piglets were transported on behavior in the weanling pens for the first 3 days after weaning/transport

Behaviour %				
	Season			
Measure	Summer n = 96	Winter n = 96	Spring/Fall n = 96	P [t]
Standing [tt] (days 1 – 3)	9.9 [a]	8.5 [a]	5.5[b]	< 0.01
Sitting [tt] (days 1 – 3)	0.29 [a]	0.27 [a]	0.52[b]	< 0.05
Resting [tt] (day 1)	82.2 [a]	81.2 [a]	78.0 [b]	< 0.01
Drinking [tt] (day 1) (day 2)	2.1 [a] 1.3 [a]	3.0 [a] 1.7 [a b]	3.7 [b] 2.3 [b]	< 0.05

The frequency of these behaviors was analyzed after transformation, the original percentages are presented in this table. Behavior was recorded on time lapse video with 24 h lighting. Transport groups (Cont, 6, 12 or 24 h) entered the weanling housing at different times. Day 1 is defined as the first 24 h in the weanling pens.

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

[tt] Significant differences were observed only on the days indicated.

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

Table 7: The effect of the duration of transport, 0, 6, 12 or 24 h, on the time spent standing, resting, feeding and drinking by piglets during the first 3 days after weaning/transport

Behavior %					
Activity	Transport Duration, h				
	0 n = 72	6 n = 72	12 n = 72	24 n = 72	P [t]
Standing [tt] (day 1 – 3)	9.7 [a]	7.5 [b]	7.3 [b]	7.4 [b]	< 0.01
Resting [tt] (day 1)	77.5 [a]	80.2 [a b]	82.2 [b]	81.9 [b]	< 0.01
Feeding [tt] (day 2)	1.3 [a]	1.1 [a]	3.0 [b]	4.3 [b]	< 0.01
Drinking [tt] (day 1)	2.4 [a]	2.7 [a]	3.0 [a]	3.7 [b]	< 0.01

Piglet behavior was recorded on time lapse video with 24 h lighting. Transport groups (Cont, 6, 12 or 24 h) necessarily entered the weanling housing at different times. Day 1 is defined as the first 24 h in the weanling pens.

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

[tt] Significant differences were observed only on the days indicated.

[a.b] Means within rows comparing duration of transport differ according to superscript.

Table 8: The effect of day post-transport on the behavior of weaned / transported piglets.

Behavior %				
Activity	Day 1 n = 288	Day 2 n = 288	Day 3 n = 288	P [t]
Standing (Fall) [tt]	4.6 [a]	5.9 [b]	5.9 [b]	< 0.01
Sitting	0.49 [a]	0.35 [b]	0.23 [b]	< 0.01
Resting	80.5 [a]	81.4 [a]	78.9 [b]	< 0.01
Feeding	0.5 [a]	2.4 [b]	6.9 [c]	< 0.01
Drinking	2.9 [a]	1.8 [b]	1.4 [c]	< 0.01
Play / Fight	2.4 [a]	1.9 [b]	1.3 [c]	< 0.01

Piglet behavior was recorded on time lapse video with 24 h lighting. Transport groups (Cont, 6, 12 or 24 h) necessarily entered the weanling housing at different times. Day 1 was defined as the first 24 h in the weanling pens.

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

[a.b,c] Means within rows comparing day differ according to superscript.

[tt] Significant differences between days in percentage of time spent standing were observed only in the fall. Differences between days in subsequent behaviors listed were observed in all seasons.

Table 2. The effect of the season of transport on ear temperature measured by infra red thermometer at the end of each period of transport (6 h, 12 h, 24 h) in each season (summer, fall, winter).

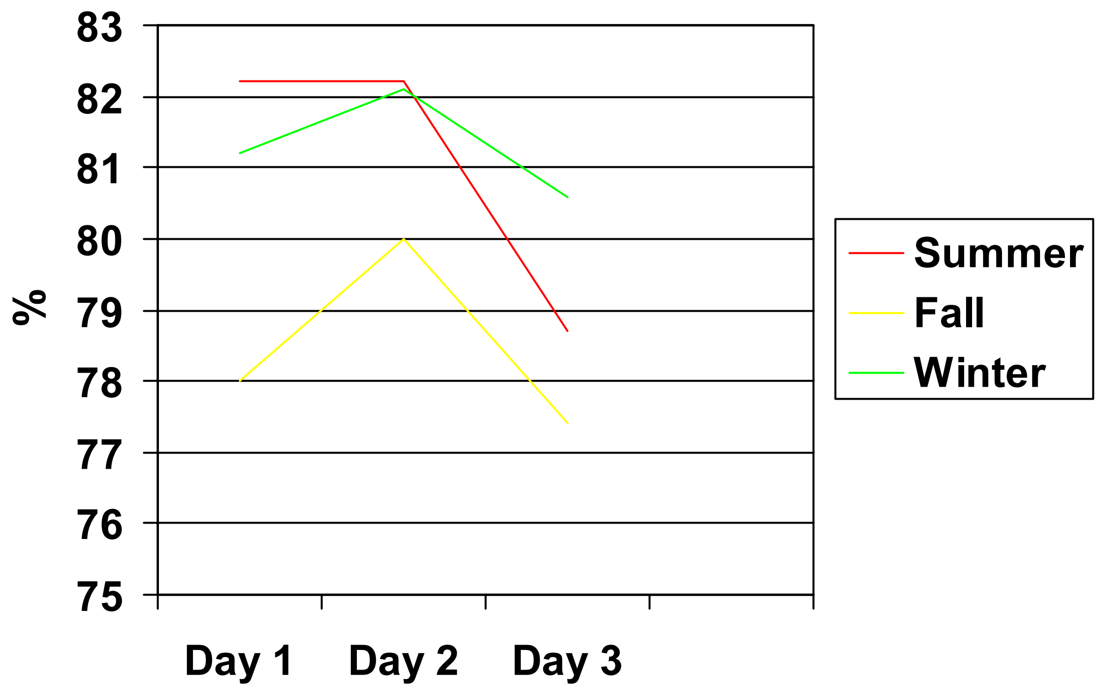
Ear Temperature ^{0}C				
Transport Duration (h)	Season			
	Summer n = 72 [t]	Fall n = 72	Winter n = 72	P
6	38.5 [a]	36.4 [a]	33.8 [a]	<0.01
12	31.1 [a]	26.3 [ab]	23.5 [b]	<0.01
24	26.9 [a]	21.3 [ab]	15.3 [b]	<0.01

The temperature above the piglets averaged 25.6 ^{0} C in summer, 7.8 ^{0} C in fall and – 0.4 ^{0} C in winter.

[a.b] Lease squares means within rows comparing season within transport duration (6 h, 12 h, 24h) differ according to superscript.

[t] Each of 6 groups, 3 seasons x 2 replicates, started with 36 piglets. After 6, 12 and 24 h of transport the ear temperature of 12 piglets were recorded and the piglets were moved into weanling housing.

Figure 3: The effect of the season of transport on the proportion of time spent resting during the first 3 days in the weanling pens by 96 pigs housed in groups of 4.



The temperature above the piglets averaged 25.6 ^{0} C in summer, 7.8 ^{0} C in fall and – 0.4 ^{0} C in winter.

The frequency of resting was analyzed after transformation, the original percentages are presented in this figure. Piglet behavior was recorded on time lapse video with 24 h lighting.

Figure 1: Average growth curve for 288 piglets exposed to 0, 6, 12 or 24 h of transportation over three seasons – spring, summer or fall in Manitoba, 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.

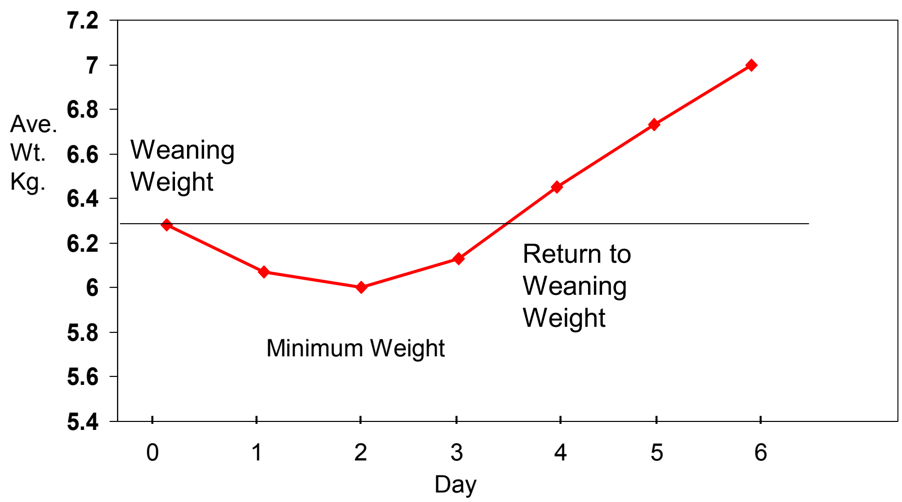
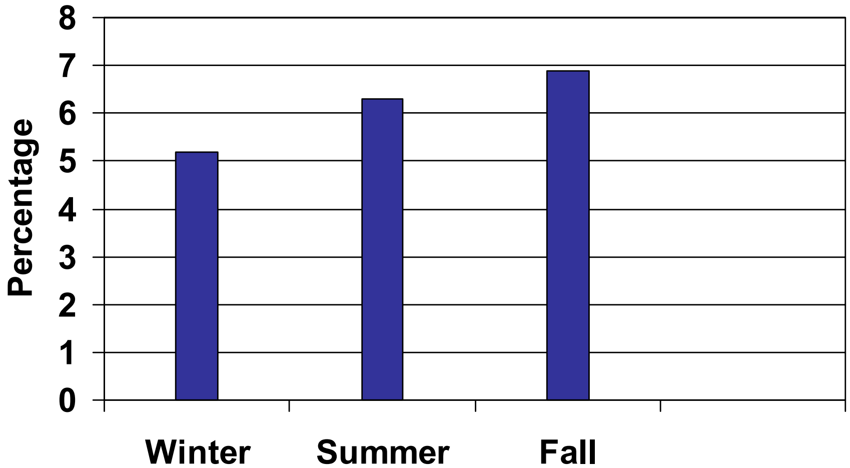
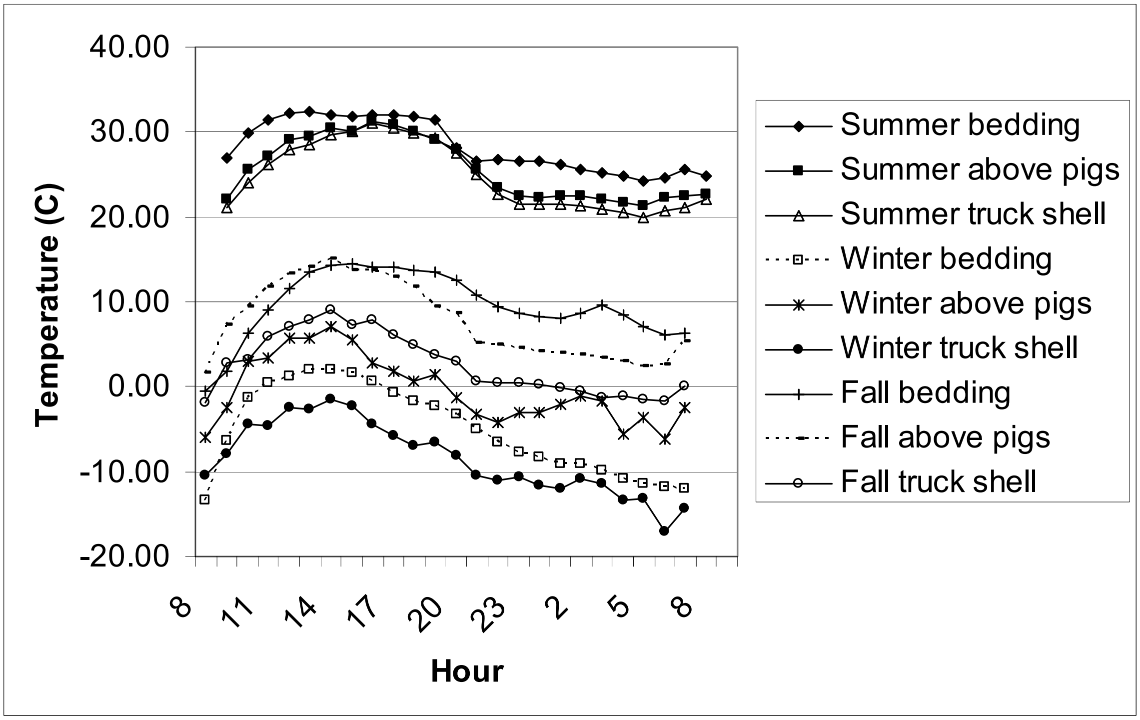


Figure 2: The effect of season on average daily gain from day of recovery of weaning weight to 14 days after entering weanling housing for 288 piglets exposed to 0, 6, 12 or 24 h of transportation over three seasons – spring, summer or fall in Manitoba.



Average daily gain, as a percentage of initial body weight was calculated for the period of time from day of recovery of weaning weight until 14 days after entering weanling housing.

Figure 4. Average of truck temperatures recorded each minute in the bedding, above the piglets and at the truck shell, using a data logger.



Temperature was recorded every minute, averaged and stored for each 10 min. period throughout transport using a data logger (Campbell Scientific CR10X). Probes were positioned in the bedding, in the air directly above the piglets and 2 feet above the floor of the truck along the outside wall.

Average temperatures for each 6 h period are presented below.

Probe		Temperature ^{0}C			
Season	Position	0-6 h	6 – 12 h	12 – 18 h	18 – 24 h
Summer	Bedding	29.6	31.8	26.8	25.0
	Air	26.0	30.3	24.0	22.1
	Shell	25.0	30.0	23.3	20.8
Fall	Bedding	7.0	14.0	9.6	7.7
	Air	9.6	12.8	5.3	3.4
	Shell	4.1	6.5	0.8	- 1.0
Winter	Bedding	- 2.9	0.0	- 6.7	- 10.8
	Air	1.6	3.2	- 2.8	- 3.5
	Shell	- 5.4	-4.6	- 10.7	- 13.4

Average temperatures for each 6 h period were calculated as an aid to interpretation of the graph.