# OPERANT HEAT DEMAND OF PIGLETS HOUSED ON FOUR DIFFERENT FLOORS

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Four groups of six 28-d-old piglets (three male, three female) were assigned in a Latin
square design to each of four floors, bedded concrete, bare concrete, perforated metal
or raised rubber-coated metal. Each pen was equipped with a microswitch which, when
pushed, turned on three 250-W infrared lamps suspended 42 m above the floor. Each
group of piglets remained on each floor for 48 h and the same groups were used for
a second replicate. This approach was repeated with different groups of piglets at temperatures of 14, 16, 18, 20, 22 and 24°C. Behavior regarding activation of the
microswitch was monitored by the use of a video cassette recorder. Light at 180 lx
was provided continuously. On bedded concrete, piglets demanded approximately 3 min
less heat per hour ($P < 0.05$) than on any other floor and on perforated metal demanded
approximately 3 min more heat per hour ($P < 0.05$) than on any other floor. Supplemental
heat on bare concrete was similar to that of raised rubber-coated metal. From the results
it was established that the effective environmental temperature on bedded concrete is
3°C warmer than that for bare concrete or raised rubber-coated metal and 6°C warmer
than perforated metal. Piglets showed diurnal variation in heat demand.

Key words: Piglets, operant, thermal regulation

[Commande du chauffage par des porcelets élevés sur quatre types de sols différents.]
Titre abrégé: Chauffage à commande par les porcelets.
Quatre groupes de six porcelets de 28 jours (trois mâles, trois femelles) ont été répartis selon un dispositif en carrés latins sur quatre types de sols différents: béton recouvert d'une litière, béton nu, métal perforé ou métal surélevé à revêtement de caoutchouc.
Chaque enclos était équipé d'un micro-contact qui commandait l'allumage de trois lampes
infrarouges de 250 W suspendues à 420 mm au-dessus du plancher. Chaque groupe
de porcelets a été laissé sur chaque type de sol pendant 48 h et les mêmes groupes
ont été réutilisés pour une seconde expérience identique. Cette méthode a été répétée
avec des groupes différents de porcelets à des températures de 14, 16, 18, 20, 22 et
24°C. Le comportement des porcelets (utilisation du micro-contact) a été surveillé à
l'aide d'une caméravideo. On assurait un éclairage de base permanent de 180 lux. Sur
le béton recouvert d'une litière, les porcelets ont demandé environ trois minutes de
chaleur de moins par heure ($P < 0.05$) que sur n'importe quel autre type de plancher
et sur le métal perforé, ils en ont demandé environ trois minutes de plus par heure
($P < 0.05$). La demande en chaleur supplémentaire des porcelets sur sol de béton nu
était semblable à celle des porcelets gardés sur un plancher surélevé en métal à revêtement de caoutchouc. Les résultas obtenus nous ont permis d'établir que la température
ambiante effective des enclos à plancher de béton recouvert de litière est supérieure
de 3°C à celle des enclos à plancher de béton nu ou à plancher surélevé fait de métal
à revêtement de caoutchouc et supérieure de 6°C à celles des enclos à plancher de
métal perforé. La demande de chaleur par les porcelets laissait voir une variation diurne.

Mots clés: Porcelets, commande par les porcelets, régulation thermique

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The thermal environment experienced by the pig is not well described by air temperature as measured by a dry bulb thermometer. Factors which determine thermal sensation and therefore thermal response include air movement, humidity, type of floor, number of pigs in the group and temperature of the surrounding walls, floor and ceiling. The effective environmental temperature is the composite of all factors which constitute the environmental heat demand and, in this work, was established for the piglets by the operant procedure. Mount (1975) calculated the equivalent standardized environmental temperature for pigs in the body weight range of 20–50 kg for a variety of environmental conditions. He estimated that pigs in straw would have a lower critical temperature 9°C lower than comparable pigs on concrete slats and over 10°C lower than pigs on wet concrete. Bruce and Clark (1979) calculated that the lower critical temperature of pigs housed on straw was approximately 4°C lower than that of pigs on bare concrete. Verstagen and van der Hel (1974) reported the effective critical temperature of 40-kg pigs was 11.5–13°C on straw, 14–15°C on asphalt and 19–20°C on concrete slats. Baldwin and Ingram (1968) and Curtis and Morris (1982) used an operant procedure to allow piglets to select their preferred environmental temperature. The purpose of the work reported herein was to use an operant procedure to determine the response of piglets to a series of environmental temperatures when housed on four different floor types.

## MATERIALS AND METHODS

A total of 144 newly-weaned pigs (28 d old) were used for this experiment. Each group contained three male and three female newly weaned piglets, averaging about 6 kg. These groups were randomly assigned to pens 1.17 × 2.44 m. Each pen was equipped with a feeder, nipple drinker and a microswitch which was located 0.3 m above the floor. All the pens were built in an environmental chamber in which temperature and humidity were controlled. The characteristics of this room allowed the assumption that there were no time treds existing in the conduct of the experiment. This room was part of a research barn in which normal

activities take place between 0730 and 1700 h. The microswitch was protected by a curved piece of plexiglass which, when lifted or pushed, activated the microswitch. The floor of the pen was either bedded concrete, bare concrete, perforated metal or raised rubber-coated metal. The concrete floors contained styrofoam insulation throughout, with an RSI value of 2.1. The bedding used was wheat bran at a depth of approximately 2.5 cm.

Activation of the microswitch turned on three 250-W infrared heat lamps suspended 0.42 m above the floor and immediately above the microswitch. The supplementary heat remained on for 4 min during the learning phase, and for 10 min during the experimental phase. Timing of the supplementary heat and recording of the number of times the microswitch was activated was controlled by an IBM PC Jr microcomputer. Activation of the microswitch during supplementary heat delivery was recorded but did not alter the amount of heat delivered.

Following the learning phase, which lasted 24 h, each group of piglets was on each floor for 48 h, according to a Latin-square design (Table 1) and the same group was used for a second replicate, at any given environmental temperature. This approach was repeated with different groups of piglets at temperatures of 14, 16, 18, 20, 22 and 24°C. The number of minutes of supplemental heat demanded by the piglets was used to determine the effective environmental temperature.

The environmental chamber used allowed placement of one of the pens (perforated metal) over a deep gutter. The gutter was contained within the chamber, hence no drafts, exterior to the room, influenced the effective environmental temperature. Behavior of the piglets was monitored continuously for 24 h over the period of 48 h, by the use of two television cameras and a time-lapse video cassette recorder. The data regarding activation of the microswitch were analyzed to establish variation in supplemental heat demand among pigs. Light was provided at a level of 180 lx on a 24 h per day basis. Each piglet was numbered on the back for identification.

Table 1. Latin-square design

| Floor† | | | |
|---|---|---|---|
| B | BC | PM | RRC |
| BC | RRC | B | PM |
| PM | B | RRC | BC |
| RRC | PM | BC | B |

†B = bedded concrete; BC = bare concrete; PM = perforated metal; RRC = raised rubber-coated metal.

Table 2. Minutes of supplemental heat demanded per hour at six temperatures over all floors

| Temperature (°C) | Minutes of heat |
|---|---|
| 14 | 20.1 |
| 16 | 15.6 |
| 18 | 12.7 |
| 20 | 10.5 |
| 22 | 11.0 |
| 24 | 6.8 |

Standard error of the mean = 0.6

Table 3. Minutes of supplemental heat demanded per hour on four floors, over all temperatures

| Floor | Minutes of heat |
|---|---|
| Bedded concrete | 9.4c |
| Bare concrete | 12.7b |
| Perforated metal | 16.2a |
| Raised rubber-coated metal | 12.9b |

Standard error of the mean = 0.05.
a–c Means with different letters differ ($P < 0.05$).

## RESULTS AND DISCUSSION

Since there was no significant ($P > 0.05$) interaction between floor types and temperatures, the minutes of supplemental heat were averaged over all temperatures (Table 2) and all floor types (Table 3). The piglets responded to increased temperatures by decreasing the amount of supplemental heat demanded (Table 2). A fitted linear regression (supplemental heat = 35.21–1.18 [°C], Fig.1) indicates that for each 1°C change in environmental temperature the supplemental heat was altered by 1.18 min h$^{-1}$. Over all temperatures, piglets demanded approximately 3 min less heat ($P < 0.05$) on bedded concrete than on any of the other floors (Table 3), while pigs on perforated metal demanded approximately 3 min more heat ($P < 0.05$) than on any other floor. Supplemental heat demanded on bare concrete and raised rubber-coated metal was similar. It should be noted that the first replicate for each given temperature consisted of pigs 28 d old, while the second replicate involved the same pigs, 8 d older. Given this age difference it was found that the demand for supplemental heat from the younger pigs was consistently higher on all floors and at all temperatures than the demand of older pigs. Nevertheless, the trends across floors and across temperatures were similar for both groups and it is these trends that were used to assess the effective environmental temperatures on different floor types and at different temperatures.

Inasmuch as each degree Celsius altered supplemental heat by 1.18 min h$^{-1}$ it is possible to calculate the difference in effective environmental temperature between the floors (Table 4). Bedded concrete was perceived as being warmer by approximately 3°C compared with bare concrete or raised rubber-coated metal and 6°C compared with perforated metal. Although a linear relationship was used to calculate the effective environmental temperature, it should be noted that changes in demand for supplemental heat were not strictly linear across all temperatures. In effect, at lower (14°C) and higher (20–24°C) temperatures, the changes were more drastic than at intermediate temperatures (16–18°C). However, the significant linear trend observed across all temperatures provided an adequate evaluation of the effective environmental temperatures.

The calculated effective environmental temperature for bedded concrete compared with bare concrete agrees closely with the results of Bruce and Clark (1979). It differs considerably from the calculations of Mount (1975). The smaller difference in effective environmental temperature found in this work may reflect a difference between wheat bran, used in these trials and straw used in Mount's estimates.

These data emphasize that, as far as the piglet is concerned, differences as great as 6°C exist between bedded concrete and perforated metal. Considering that dampness and air movement are important factors determining effective environmental temperature, it is possible for piglets to feel differences of 10–15°C in environments with the same dry bulb temperature.

The daily average of supplemental heat was 12.52 min h$^{-1}$ (SD = 4.87). Based on the distribution of supplementary heat demanded
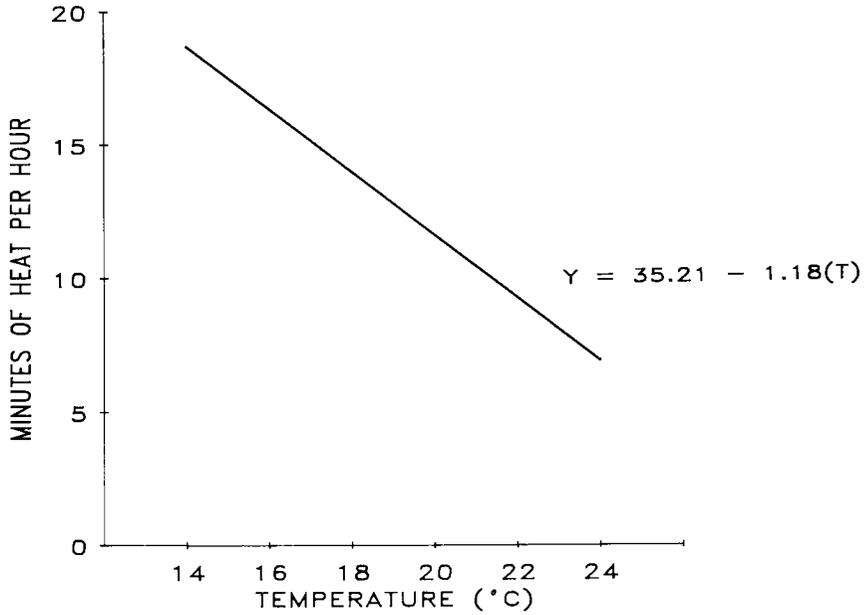
Fig. 1. Regression line indicating relationship of heat demand to temperature.
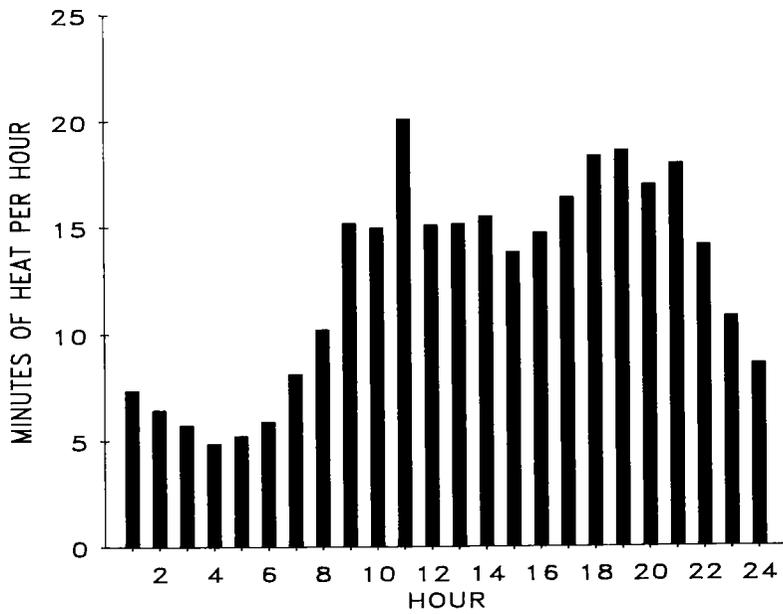
$$Y = 35.21 - 1.18(T)$$



Fig. 2. Diurnal variation in heat demand.

over 24 h (Fig. 2), it is apparent that the piglets drastically reduced their demand for supplementary heat between 2400 and 0500 h. This agrees with work of Baldwin (1968) and Curtis and Morris (1982) who showed that piglets housed in groups rarely turned on a heat source during nighttime hours. Even when housed at 14°C piglets elected to huddle rather than use supplementary heat. The reason for the peaks at 1000 h and from 1600 to 2000 h is not known. These times cannot be related to human activity in the barn or feeding schedule. Piglets seem to prefer a cyclic pattern of heat.

While this diurnal pattern in heat demand has resulted in some producers reducing the dry bulb temperature in pig nurseries during the night hours, published data are unavailable with regard to the effect of such action on growth, feed efficiency, mortality and incidence of disease.

At all temperatures, each piglet in a group exercised its ability to activate the heat source.

There was, however, significant ($P < 0.05$) variation between piglets illustrated by only one or two piglets operating the heat source in excess of 50% of the time. Table 5 provides a typical distribution of heat demand by individual piglets at 14°C.

Table 4. Calculated difference in effective environmental temperature between floors

| Floor comparisons[†] | Difference in supplemental heat (min h$^{-1}$) | Difference in effective environmental temperature (°C) |
|---|---|---|
| BC-B | 3.3 | 2.8 |
| PM-B | 6.8 | 5.8 |
| RRC-B | 3.5 | 3.0 |
| PM-BC | 3.5 | 3.0 |
| RRC-BC | 0.2 | 0.2 |
| PM-RRC | 3.3 | 2.8 |

[†]BC-B = bare concrete vs. bedded concrete; PM-B = perforated metal vs. bedded concrete; RRC-B = raised rubber-coated metal vs. bedded concrete; PM-BC = perforated metal vs. bare concrete; RRC-BC = raised rubber-coated metal vs. bare concrete; PM-RRC = perforated metal vs. raised rubber-coated metal.

Table 5. Sample data of rewarded strikes of the microswitch by individual piglets over four floors at 14°C

| Pig number | B[†] | BC[†] | PM[†] | RRC[†] | Total |
|---|---|---|---|---|---|
| 1 | 4 | 10 | 17 | 12 | 43 |
| 2 | 5 | 1 | 8 | 4 | 18 |
| 3 | 4 | 13 | 33 | 19 | 69 |
| 4 | 4 | 2 | 1 | 1 | 8 |
| 5 | 3 | 1 | 3 | 6 | 13 |
| 6 | 2 | 2 | 0 | 0 | 4 |

Each cell represents the total rewarded strikes over a 24-h period.
[†]B = bedded concrete; BC = bare concrete; PM = perforated metal; RRC = raised rubber-coated metal.

## ACKNOWLEDGMENTS

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