Behavior and performance of lactating sows and piglets reared indoors or outdoors.
A K Johnson, J L Morrow-Tesch and J J McGlone

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://www.journalofanimalscience.org/content/79/10/2571

American Society of Animal Science

www.asas.org

Behavior and performance of lactating sows and piglets reared indoors or outdoors[1]

A. K. Johnson*, J. L. Morrow-Tesch†[2], and J. J. McGlone*[3]

*Pork Industry Institute, Department of Animal Science and Food Technology, Texas Tech University, Lubbock, 79409 and †USDA-ARS, Texas Tech University, Lubbock, 79409

ABSTRACT: Two hundred eighty-seven lactating Newsham sows and their litters were used to determine the effects of intensive indoor (n = 147) and intensive outdoor (n = 140) production systems on sow and litter productivity and behavior. All sows were of contemporary age and fed a completely balanced sorghum-based diet. Behavior data were collected by live observation on 40 sows and litters (20 indoor and 20 outdoor) using a 5-min scan sample over a 4-h period in the afternoon (1400 to 1800). The durations of lying (90.0 vs 72.1 ± 2.76% of time observed) and drinking (4.42 vs 1.41 ± 0.6% of time observed) were higher ($P < 0.01$) among indoor than among outdoor lactating sows. Nursing interval and feeding and sitting behaviors were not different ($P > 0.05$) between production systems. Piglets spent more ($P < 0.05$) time walking (10.1 vs 5.2 ± 1.72% of time observed) and engaged in play activity (5.0 vs 1.7 ± 1.26% of time observed) when housed outdoors than indoors. Outdoor piglets had more ($P < 0.05$) nursing behaviors directed toward the sow (27.5 vs 20.3 ± 2.02% of time observed) but time spent in contact with the sow did not differ between environments (38.8 vs 39.2 ± 2.78% of time observed). Treatments did not influence ($P > 0.05$) any of the sow or piglet production parameters. In conclusion, outdoor-kept Newsham sows and their piglets showed a richer behavioral repertoire, but the diverse environments did not influence production parameters.

Key Words: Behavior, Environment, Performance, Piglets, Sows

Introduction

In recent years in the United States, there were 98,460 pig operations, with about 95% of the sows and piglets in modern swine systems housed intensively in gestation and farrowing crates (Bowman et al., 1996; NPPC, 2000). Farrowing crates in intensive indoor production systems are widely accepted because of the belief that the crate reduces piglet mortality and increases the total number of piglets weaned. However, this system has received increasing criticism due to potential detrimental effects it may inflict on the welfare of the sow by limiting her ability to make complete postural adjustments (Arey, 1999), the prevalence of decubital ulcers or sores in thin sows (Backstrom et al., 1980; Davies et al., 1996), and behaviors considered maladaptive, for example bar biting, polydipsia (Terlouw et al., 1991), and sham chewing (Haskell et al., 1996). One alternative to farrowing crates is to house sows intensively outdoors, in small, stable groups with a greater space allowance and less restriction to their movements (McGlone and Hicks, 2000). Recently, a number of studies have been conducted in outdoor swine production facilities to understand the behavior of the sow after parturition (Castren et al., 1989; Algers, 1994; Buckner et al., 1998) and how this behavior may impact productivity (McGlone and Blecha, 1987; Sarignac et al., 1997; Thodberg et al., 1999). However, few studies directly compare the behavior and productivity of contemporary sows and litters housed in the traditional indoor farrowing crate system and the intensive outdoor system.

The aim of this study was to directly compare the behavior and productivity of sows and piglets in farrowing crates vs outdoor farrowing huts over two consecutive parities using contemporary gilts and sows.

Table 1. Weather parameters for Lubbock County TX, from January to September 1999

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Air temperature, °C									
Min	−1.83	0.44	2.89	7.67	11.89	17.61	20.67	19.72	14.44
Max	14.72	19.50	16.89	23.22	26.11	30.67	33.11	35.17	27.72
Avg.	6.44	9.99	10.06	15.44	18.99	24.17	26.89	17.40	21.11
Total precipitation, cm	12.83	0.00	2.62	9.04	8.59	11.48	2.01	1.63	8.31
Wind velocity, km/h	17.22	20.92	21.56	25.10	21.40	21.08	18.34	13.52	16.73

Material and Methods

Animals

A total of 287 lactating sows (Newsham genotype, Colorado Springs, CO) and their litters were used over their first and second parities (defined as the number of litters carried by the sow). Gilts were obtained from a single source farm and were considered to have a high health status (negative for pseudorabies, brucellosis, porcine respiratory and reproductive virus, syndrome, and mycoplasmal hyopneumonia). The research location was situated in an area with a dry steppe climate producing mild winter temperatures near Lubbock, in west Texas (Table 1; National Weather Service, 1999).

Diets, Housing, and Husbandry

The research was conducted over a 9-mo period (January to September 1999). In each environment, sows remained entirely indoors or outdoors during breeding, gestation, and farrowing phases. Animals were housed and used in accordance with the *Guide for the Care and Use of Agricultural Animals Used in Agricultural Research and Teaching* (FASS, 1999) and the project was approved by the Texas Tech University Animal Care and Use Committee.

Indoor and outdoor sows were bred in eight groups consisting of 16 to 20 sows per group. All sows were artificially inseminated and pregnancy-checked 4 wk later. Sows that were confirmed pregnant were then moved into either a gestation crate or gestation paddocks. Both indoor- and outdoor-housed sows were transferred to farrowing facilities 5 d before scheduled farrowing.

Indoor sows were housed in conventional farrowing crates, measuring 2.1×0.6 m with a 2.1×0.46 m creep area. Flooring was woven wire, 5.5×1.0 cm with a lattice design. Waste fell into a pit and was removed 2 to 3 times/d by water flushing. Sows were fed once a day at 0800 with a completely balanced sorghum-based diet (CP 19.9%) in a metal trough. Depending on the stage of lactation, sows were fed the appropriate amount of feed (2 to 18 kg/d; NRC, 1998). A nipple drinker system supplied continuous water to both sows and piglets. Room temperature was kept between 27 and 29°C. Indoor piglets were provided a heat lamp the first 7 d and, at 14 d of age, a creep feeder containing a pre-starter/early wean diet (Metabalance 10/15 CP 22%, Consolidated Nutrition) was added to the pen. Iron shots were provided only to piglets housed indoors and were applied in the intramuscular region of the neck (Kleinbeck and McGlone, 1999).

Outdoor sows during lactation were kept in the same social group as during gestation (16/group). Single-strand electric wire (7 to 12 A) surrounded the four 0.4-ha paddocks at a height of 59 cm from the ground. In each paddock, English-style arc farrowing huts (1.12 m height, 2.79 m width, and 1.65 m length) each with a wooden fender attached to the door (0.30 m height, 1.20 m width, and 1.20 m length) were used to house one sow and her litter (McGlone and Hicks, 2000). Short chopped wheat straw was used for bedding. Sows were fed once daily at 0800 in a designated strip area along one side of the perimeter fence. A continuous dewormer was added to the diet (Banminth 48, Pfizer, Lee Summit, MS). A clean supply of drinking water was provided to sows by way of a perforated PVC tube suspended over a wallow. Outdoor piglets were not provided with creep feed but did have access to ground cover. The predominate ground cover from March to late July was wheat (*Triticum aestivum*), buffalo grass (*Buchaloe dactyloides*), and Old World blue stem (*Bothriochloa bladhi*), which are native grasses. Vegetation provided continuous forage availability for the summer months. Every sow and her litter in both systems were checked twice a day for health, dead piglets, or farrowing problems. Each day new straw was provided to the outdoor farrowing hut.

Piglets in both environments were processed at 1 to 4 d of age. Processing included tail docking, ear notching, castration, and trimming of the needle teeth. Iron shots were given only to indoor piglets. Piglets were weaned from the sow once the average age was 21 d. Indoor piglets were weaned as a litter and were minimally mixed on the day of weaning. Outdoor litters were locked in the farrowing hut and sows were moved into a separate area adjoining the farrowing pasture. Each litter was removed from the hut and mixed into larger groups in a grower-finisher pen outdoors. All sows and piglets were weighed and checked for health problems, and sows were moved into either breeding crates (indoors) or paddocks (outdoors).

Behavior

Behavior data were collected on 40 sows and their litters, 20 indoor and 20 outdoor, by live observation,

using a 5-min scan sample over a 4-h period in the afternoon (1400 to 1800) when piglets were between 4 and 10 d of age (Arnold-Meeks and McGlone, 1986). Six sow behaviors were recorded: active (standing and walking), lying, sitting, drinking, feeding, and nursing interval. Nine piglet behaviors were recorded: standing, lying, sitting, walking, nursing, playing, out of sight, contact with the sow, and no contact with the sow. Standing behavior was defined as when the animal assumed or maintained an upright position on extended legs. Walking behavior included any actions while the animal was moving. Lying was considered to include lateral, semilateral, ventral, or sternal recumbency and involved contact of the body with the ground. Sitting behavior was when most of the animal's body weight and the posterior of the body trunk was in contact and supported by the ground. Drinking behavior was any contact between an animal's mouth and a water nipple or outdoor waterer, whereas feeding behavior involved voluntary oral ingestion of concentrates and(or) plant material. Nursing interval was defined as the period of time when the sow began grunting and when piglets responded through massaging the teat area until the next nursing cycle began. Nursing behavior for piglets was defined as when the piglet was massaging the teat area, had a teat within its mouth, or was receiving milk. Play behavior involved three areas that were grouped under one title as play. Piglets could firstly interact (pushing, biting, sniffing with snout) with any inanimate object, such as bars or nipple drinkers for indoor litters and straw or hut sides for piglets housed outdoors. Secondly, play could be directed toward one or more littermates, which included "mock combat" involving pushing or nudging and sudden leaping, two or more legs off the ground at any one time. Thirdly, play could be directed toward the sow, with a piglet climbing, nudging, or biting the sow (Dobao et al., 1984; Blackshaw et al., 1997). Out of sight was defined at the time of the scan if the observer could not visually assess one or more piglets. Contact and no contact were defined as the piglet physically touching or not touching any part of the sow's body at the time of the scan.

Production

A total of 147 indoor sows and their litters split over two parities (102 of Parity 1 and 45 of Parity 2) and 140 outdoor sows and their litters (89 of Parity 1 and 51 of Parity 2) were collected for production measures. Piglets were counted and weighed at birth and weaning. Total piglets per litter were divided further into piglets born alive, still-births, and mummies. Still-births were recorded as any piglet that was found dead during or shortly after farrowing and that had not breathed. Mummies were classified if they had one or more of the following characteristics: rubbery skeleton, bloated stomach, lack of hair, brown to black body color, sunken eyes, loose skin, or a bad odor. The days of lactation were calculated for each sow by subtracting the day

that she farrowed from the day that she was weaned. Preweaning piglet mortality was defined as any piglet that was born alive but died before weaning. Causes of death were mainly crushing of the piglet by the sow, starvation, and disease categorized by the stockperson through internal and external examination of the heart, lungs, stomach, and skin. The sow was weighed on the day she entered the farrowing facilities and on the day she returned to breeding after piglets were weaned.

Statistical Analysis

All analyses were performed using the GLM procedure in SAS (SAS Inst. Inc., Cary, NC) software for parametric data. The experimental unit was either the farrowing crate or the farrowing hut (containing one sow with their litter). All behavioral data were expressed as percentages and were subjected to a square root arc sine transformation process to achieve a normalized distribution. Transformed data were analyzed as a completely randomized design. The statistical model for sows and piglets included effects of environment. Behavioral data were collected in a single group of contemporary lactating sows.

A split-plot design was used to analyze production data (n = 7 contemporary groups). The statistical model main plot included environment and group and their interaction. The sub-plot included parity, environment × parity, and residual error. Three covariants (piglets born alive, days of lactation, and sow weight at farrowing) were also included in the model. The error term for environment effect (in vs out) was the environment × group interaction effect; otherwise, the residual error term was used.

Results

Behavior

Duration of sow lying and drinking behavior was different ($P < 0.01$) between treatments (Table 2). Indoor sows spent a greater percentage of their time lying and drinking than outdoor sows. Feeding and sitting

Table 2. Least squares means and standard errors for behaviors performed by Parity-2 Newsham sows indoor vs outdoor from January to March 1999

Behavioral measures	Environment		SE	P-value[a]
	Indoor	Outdoor		
Number of sows	20	20		
Active, %	9.1	27.9	2.76	<0.001
Lying, %	90.9	72.1	2.76	<0.001
Sitting, %	3.2	1.9	0.66	0.34
Drinking, %	4.42	1.4	0.60	0.004
Feeding, %	1.4	3.0	0.92	0.09
Nursing interval, min	40.1	42.2	2.47	0.30

[a]P-value for comparison of indoor- and outdoor-housed lactating sows. P-values are based on analysis of transformed data.

Table 3. Least squares means and standard errors for behaviors performed by Parity-2 Newsham piglets indoor vs outdoor from January to March 1999

Behavior measures	Environment		SE	P-value[a]
	Indoor	Outdoor		
Number of litters	20	20		
Standing, %	15.7	22.1	2.38	0.23
Lying, %	72.2	68.1	3.11	0.19
Sitting, %	3.3	3.4	0.64	0.94
Walking, %	5.2	10.1	1.72	0.02
Nursing, %	20.3	27.5	2.02	0.03
Playing, %	1.7	5.0	1.26	0.046
Out of sight, %	0.21	0.74	0.26	0.08
Contact with sow, %	38.8	39.2	2.78	0.94
No contact with sow, %	61.0	60.0	2.86	0.84

[a]*P*-value comparing indoor- and outdoor-reared piglets. *P*-values are based on the analysis of transformed data.

behaviors were not different ($P > 0.05$) between treatments. In addition, nursing interval (minutes) showed no differences ($P > 0.05$) between sows housed indoors and those housed outdoors.

Piglet behavior was influenced by treatment (Table 3). Indoor piglets spent less time ($P < 0.05$) engaged in nursing activities compared with outdoor piglets. Outdoor piglets spent more time engaged in play activity ($P < 0.05$) than indoor-reared piglets. Piglet behaviors not influenced ($P > 0.05$) by production system were the percentages of time spent standing, lying, sitting, out of sight, and in contact with the sow.

Production

Treatment (indoor vs outdoor) did not influence ($P > 0.05$) the number of piglets born per litter, number of piglets born alive per litter, number of still-births and mummies per litter, days of lactation, total number of piglets weaned per litter (Figure 4), mortality, litter birth and wean weights, and sow starting weight on the day she entered lactation and her ending weight on the day of weaning. However, sows entering the farrowing paddock tended to be heavier ($P = 0.08$) than their indoor contemporaries and litter wean weights for piglets born indoors also tended to be heavier ($P = 0.08$) compared with those born outdoors (Table 4).

There was a significant parity × treatment interaction for number of piglets born per litter ($P < 0.04$) with more piglets born in Parity 2 indoors (10.9 piglets born per litter) compared with Parity 2 outdoors (10.3 piglets born per litter; Figure 1). Number of piglets still-born was different between treatments with a greater number of still-births in Parity 2 indoor piglets ($P < 0.04$) compared with Parity 2 outdoor litters (Figure 2). Parity 1 outdoor litters had a higher ($P < 0.02$) percentage of piglets that died preweaning compared with all other groups (Figure 3).

Discussion

Behavior

Baxter (1982) suggested that confined sows must face an unresolvable conflict between restraint, their comfort requirements, and motivation for high levels of activity. Furthermore, Whatson and Bertram (1982) observed that sows in a crate over time became an increasing focus point for the litter. Sows can be exposed to piglets chewing their teats, ears, snout, bristles, tail, scabs, and vulva. The sow can be seen to snap or bite at the piglets in response to piglet behavior. In comparison, outdoor sows can move in and out of the farrowing hut at will and can spend increasing time away from the litter. Csermely (1994) reported that during the first 2 d after farrowing the feral sow spent 76% of her time lying in her nest, but from d 3 until weaning decreased her lying time to 42% and reached a greater distance (> 10 m) away from the nest. Jensen (1994) supported this finding for sows kept in a seminatural environment. Sow behavior significantly changed during the first 4 wk of nursing: foraging and locomotion increased whereas lying, nursing, and contact with piglets decreased. The authors suggested that the sow finds the older piglets increasingly stressful and in a natural setting would choose to spend more time away from her litter. Our experiment conducted in a production-related outdoor environment confirms these observations. Intensively housed outdoor sows were more active (standing and walking) than indoor sows, and outdoor-born and reared-piglets spent less time in contact with the sow beginning on d 4 postpartum. Additionally, although both indoor and outdoor piglets did not differ in the amount of contact they had with the sow, the distance between the sow and her litter differed between the environments. In a crate situation, the piglets are never more than 1 m away, but a sow in an outdoor environment can be at varying distances from her litter at any given time. Once piglets are approximately 12 d old, they become strong enough to jump over the wooden fender partition into the farrowing paddock, and then piglets commingle with other piglets and sows. Keeping sows and piglets in social groups may prevent the social trauma associated with the abrupt mixing of unfamiliar, weaned piglets, which reduces the aggressive encounters and benefits the piglet throughout the production cycle (Edwards and Mauchline, 1993; Jensen, 1994; Sarignac et al., 1997). In our study, piglets were young and had not cleared the fender or left the "nest" but it would be of interest to continue the production comparisons up to slaughter and determine whether the early birthing environment had a positive effect on productivity or behavior.

Sows housed indoors showed synchronization in their nursing behavior. When one sow began to nurse her litter and the piglets began to squeal, it stimulated the remaining sows and their litters to also begin nursing. This synchronization may be based on learning by pig-

Table 4. Least squares means and standard errors for production measures of
Newsham sows and piglets indoor vs outdoor over two parities
from January to September 1999

| Production measures	Indoor	Outdoor	P-value[a]
Number of sows and litters	147	140	
Pigs born, No./litter	10.8 ± 0.10	10.5 ± 0.11	0.15
Pigs born alive, No./litter	9.4 ± 0.49	9.4 ± 0.44	0.95
Still-births	0.9 ± 0.10	0.7 ± 0.11	0.15
Mummies, No./litter	0.0048 ± 0	0.0039 ± 0	0.73
Days of lactation	23.8 ± 0.47	22.2 ± 0.48	0.10
Piglets weaned, No./litter	8.4 ± 0.41	7.6 ± 0.37	0.33
Mortality, %	11.0 ± 1.61	11.8 ± 1.74	0.76
Litter birth wt, kg/litter	19.7 ± 1.35	21.1 ± 1.48	0.22
Piglet birth wt, kg/pig	1.9 ± 0.14	2.1 ± 0.15	0.29
Litter wean wt, kg/litter	58.4 ± 2.96	53.3 ± 3.24	0.08
Sow start wt, kg[b]	216.4 ± 6.47	227.3 ± 6.79	0.08
Sow end wt, kg[b]	190.6 ± 3.59	186.1 ± 3.91	0.15

[a]P-value comparing indoor- and outdoor-reared piglets.
[b]Weight of sow on the day she entered the farrowing facilities and on the day she returned to breeding after piglets were weaned.

lets, an effect also noted by Wechsler and Brodmann (1996). The treatments did not affect the nursing interval between d 4 and 10 and when the outdoor sow was present for nursing; her piglets displayed significantly more nursing behaviors than indoor piglets.

Interestingly, indoor-housed sows displayed a higher percentage of their time drinking compared with sows housed outdoors. Possible theories for this are that outdoor sows have further to walk for water and so they may prioritize their motivational hierarchy to drink efficiently, whereas indoor sows have the drinker available continuously at their snout. Sows housed individually in the farrowing crate can perform repetitive activities, for example excessive drinking or polydipsia (Fraser, 1975; Appleby and Lawrence, 1987; Terlouw et al.,

1991) or may be redirecting oral behaviors toward the nipple without ingesting water. Robert et al. (1993) concluded that sows fed a restricted diet with additional fiber showed a decrease in stereotypies and adjunctive drinking behaviors. Feed was provided once a day at 0800 to both treatments and was identical in nutritional content. Behavioral observations were completed in the afternoon and by that time all the indoor sows had consumed most of their feed ration, but outdoor sows still had the ability to forage, root, and consume pasture. This foraging activity could provide increased fiber and bulk to their diet throughout the day and may provide an opportunity for oral behaviors on an alternative substrate (vegetation) compared with sows housed indoors.
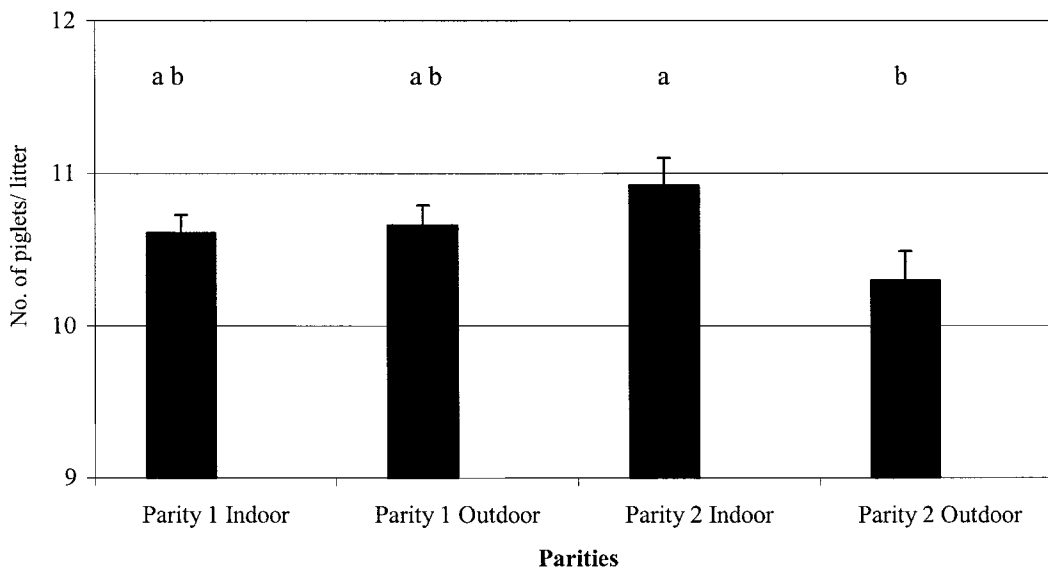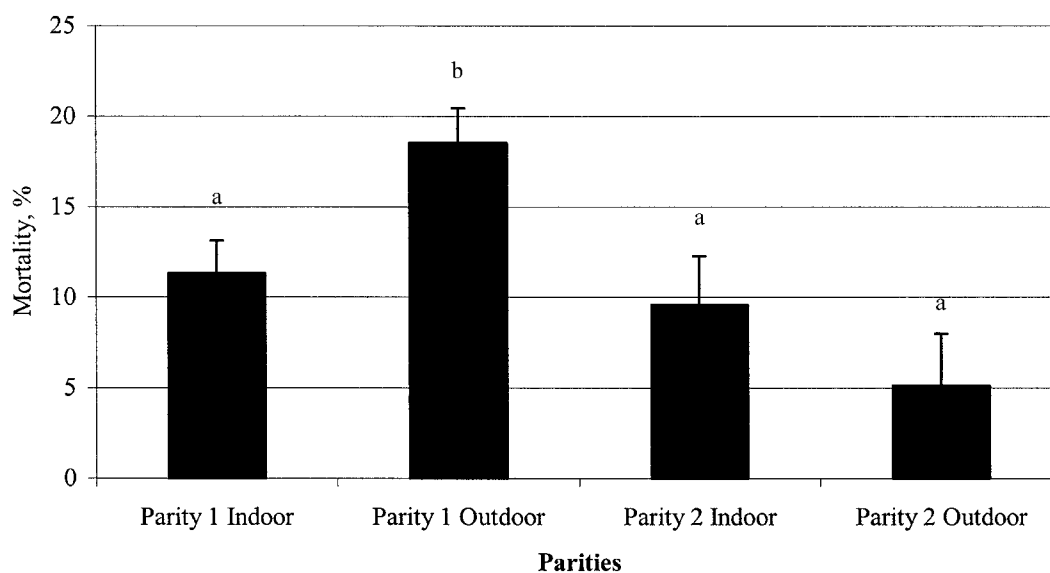

Figure 1. Number of piglets born per litter indoors vs outdoors for Parity 1 and 2 Newsham sows from January to September 1999. Least squares means with a different letter differ (environment × parity $P \leq 0.05$) (n = 287 litters).
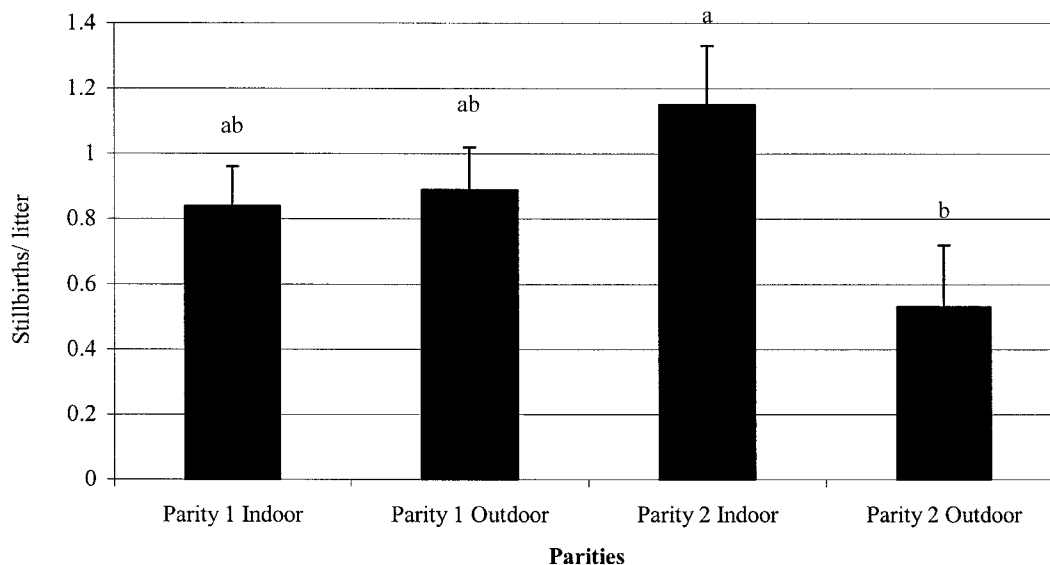
Figure 2. Number of still-births indoors vs outdoors for Parity 1 and 2 Newsham sows from January to September 1999. Least squares means with a different letter differ (environment × parity $P = 0.03$) (n = 287 litters).

Webster (1997) compared the behavior of six outdoor-born and six indoor-born piglets from birth to weaning and reported that outdoor piglets at d 15 spent less time in contact with the sow and more time directing their rooting toward the soil, plants, and straw available in the pasture. Our experiment agreed with Webster's findings that outdoor piglets engaged in a significantly higher percentage of their time walking. Furthermore, play activities, which involved, hop, toss head, and pivot in circles was greater among outdoor-kept piglets. Many theories have been proposed as to why animals play, what restricts play, and what is the

purpose of this behavior. It has been proposed that play in young animals is important and, if restricted through the early housing environment or allowed to develop abnormally, then this abnormal play behavior can continue through the animal's life and can be seen in the behavior of the adult. Play may allow the piglet to coordinate its movements, develop bone and muscle, understand threatening situations, and avoid conflict later in life. Perhaps the most important reason to play is to form and display flexible behavior (Blackshaw et al., 1997; Bekoff and Byers, 1998). Newberry and Wood-Gush (1988) and Newberry et al. (1988) reported that,

Figure 3. Piglet mortality expressed as a percentage, indoors vs outdoors for Parity 1 and 2 Newsham sows from January to September 1999. Least squares means with a different letter differ (environment × parity $P = 0.01$; n = 287 litters).
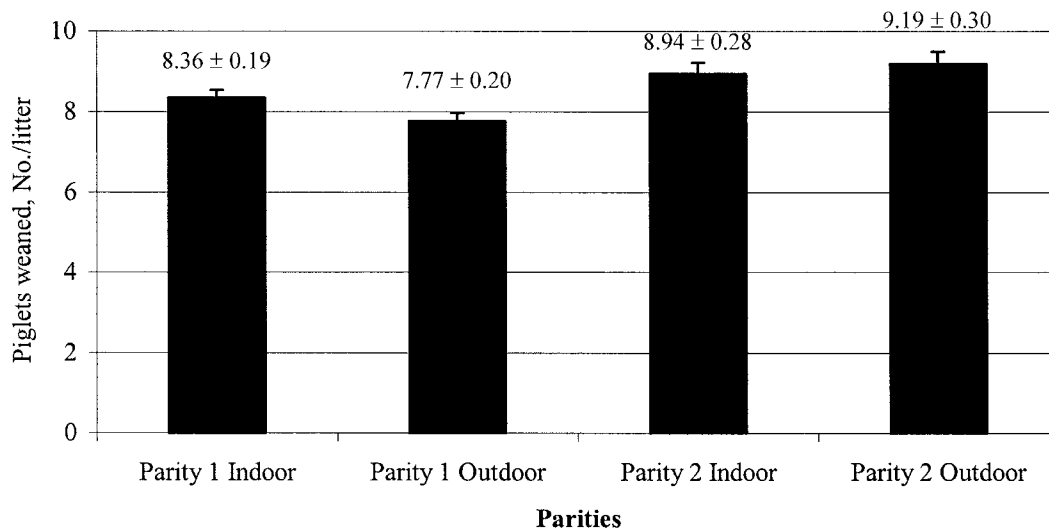
Figure 4. Number of piglets weaned per litter, indoors vs outdoors for Parity 1 and 2 Newsham sows from January to September 1999. Means were not different ($P > 0.05$).

as piglets matured, considerable time walking, with peaks in trotting, scampering, and play activity, increased in an experimental seminatural environment and these behaviors peaked between 2 and 6 wk. The authors suggested that space was an important factor for the development of walking. Blackshaw et al. (1997) also found an increase in play behaviors, leveling off between 26 and 30 d. Rushen (1993) suggested that increased play may also arise from the increase in available space, but Wood-Gush and Vestergaard (1993) reported that there was no evidence showing that frequency of play is dependent on space availability. Clearly in our study, outdoor pigs had considerably more space and freedom of movement and engaged in more play behavior. The early developmental environment had immediate and possibly long-term effects on piglet behavior in our study. Other work has shown that pig developmental environment may influence muscle development (Petersen et al., 1998) and pig brain structure (Jarvinen et al., 1998).

Production

All the Parity 2 sows farrowed as gilts in this study. Fewer Parity 2 sows were collected for production data in both environments because two separate experiments were being conducted at the same facility and the majority of sows that had farrowed once were allocated to this research. Concerns were raised over the possibility of an effect on both behavior and productivity of sows that had undergone additional trials, and, therefore, data were not included for this study.

Few reports have documented the productivity of the intensive indoor compared with the intensive outdoor system, and at times the reports are confusing and contradictory. Berger et al. (1997) studied 76,578 litters outdoors and 867,719 litters indoors. They concluded

that number of piglets born was the same, but piglet mortality was higher outdoors (21.1% outdoors vs 17.4% indoors), which influenced the average number of piglets weaned per sow per year. In addition, Mortensen et al. (1994), Van der Steen (1994), and PIC (1998) have all reported that a well-run outdoor unit can equal that of a well-run indoor unit for annual sow production. In agreement with Mortensen et al. (1994), Van der Steen (1994), and PIC (1998), production parameters were similar between treatments in our controlled experiment.

Mortality in any system is of unchallenged importance for the productivity of the farrowing system. Of all piglets born, between 4 and 8% are born dead and up to 25% of those born alive may die before weaning (Arey et al., 1992). A large proportion of piglet preweaning deaths occur during farrowing and in the first 72 h after parturition (Glastonbury, 1976; Edwards et al., 1994; Yeske et al., 1994). Crushed piglets not only represent one of the most important factors that limits sow productivity, but also presents a great obstacle in any attempt to improve animal welfare (Arey and Sancha, 1996). Researchers have estimated that preweaning mortality for piglets born in traditional farrowing crates can range between 4.8 and 18% (English and Smith, 1975; Svendsen et al., 1986). One aim of the traditional farrowing crate, which has influenced its overall design, has been to restrict the sows' movement to reduce preweaning mortality attributable to crushing. An observation by Edwards and Malkin (1986) and Marchant et al. (1996) showed that posterior crushing (when the sow changes from a standing to sitting position and traps piglets under her back legs) is one of two major movements performed by the sow that kills piglets. The other occurs when sows lie from a sitting position and piglets are trapped beneath her thorax.

A variety of farrowing huts and other technologies are used in outdoor systems, and preweaning mortality

can range from less than 10% to well over 20%. In our study, preweaning mortality rate was 11 and 11.8%, respectively, for indoor- and outdoor-housed litters, with all outdoor litters housed in the English-style arc farrowing huts. This is slightly higher than the averages reported for farrowing crates but far lower than many reports for outdoor systems. McGlone and Hicks (2000) reported litters farrowed in English-style huts weaned 1.5 more piglets per sow (because of a lower preweaning mortality) than did litters in the American-style huts.

The continuous failure in addressing the problem related to the still-born piglet may be through the numerous uncertainties surrounding the issue: the assumption that the piglet died in utero before the onset of parturition (Stanton and Carroll, 1974; Blackwell, 1987; Dyck and Swierstra, 1987), that the piglet was weak, that it "desired" to die, or that it was a consequence of the birth process (Randall, 1972b). Additionally, the impact of the housing environment may influence the number of still-born piglets, with sows confined in a farrowing crate often enduring a prolonged labor (Randall 1972a; Bille et al., 1974; English and Morrison 1984), which can result in a higher incidence of still-borns. Although in this study no differences were observed for the number of piglets born and the occurrence of still-births per litter for Parity 1 sows, a production system difference was noted for Parity 2. Outdoors, fewer piglets were born, but there were also fewer still-born piglets per litter. Consequently, at weaning, the number of piglets was not different for the two production systems. Furthermore, sows housed outdoors in their first parity had a higher preweaning mortality rate compared with their second parity. Reasons why this occurred are speculative, but the experience of birthing by the gilt would have made her familiar with the huts, pasture, and the stockperson. During the first parity, a new stockperson had been employed to run the outdoor operation and, although well-trained indoors, had not worked on an outdoor swine unit. The decrease in preweaning mortality from Parity 1 to 2 outdoors may be partially explained by the experience gained. Additionally, outdoor sows are less interacted with during the day, and disturbances in the outdoor paddock by people are minimal. Conflicting theories are published on the importance of the stockperson being present at the time of parturition on the survival rates of the piglets. To support the presence of the stockperson at parturition, Sovljanski et al. (1972) stated that 30% of apparently still-born piglets could be revived after the stockperson cleared excessive mucus and fluids from the upper respiratory tract and in some cases provided artificial respiration. Friendship et al. (1986) suggested that death rates declined for intensive indoor piglets by about one pig per litter when sows were assisted during the perinatal period. However, Caugant (1993) reported that, for the outdoor sow, the percentage of losses increased from 18.2% when the stockperson did not watch to 21.2% when they were present.

Lawrence and O'Connor (1992) reported that delivery could be delayed by major disturbances to the sow at parturition.

The importance that the role of the stockperson, whether it be indoors or outdoors, has long been underestimated and plays a pivotal role in the productivity of the unit, yet the effects of the production system and how it influences the behavior of the sow around the time of parturition are not clearly understood and future research in this area must be conducted. In the present study, apparently well-managed indoor and outdoor production systems yielded similar preweaning mortality and consequently overall productivity was also similar.

Implications

Outdoor sows and piglets were more active and showed a richer behavioral repertoire than indoor-housed sows and piglets. Although the behavior of sows and piglets differed in each production system, productivity was similar for the two systems. Northern European countries have already integrated this outdoor farrowing system into existing management practices, and even though interest in the United States is still very low, opportunities exist for its expansion. Areas in the United States that could successfully operate such a unit would include the panhandle of Texas or the drier parts of the western Midwest, which have flat and suitable land, low rainfall, and few people. Merits for an intensive outdoor system, including lower capital costs per pig, producing a product appropriate for niche markets, and addressing the concerns over animal well-being are important considerations for the future success of this industry.

Literature Cited

Algers, B. 1994. Health, behaviour and welfare of outdoor pigs. Pig News Info. 15:113N–115N.

Appleby, M. C., and A. B. Lawrence. 1987. Food restriction as a cause of stereotypic behaviour in tethered gilts. Anim. Prod. 45:103–110.

Arey, D. S. 1999. Time course for the formation and disruption of social organization in group-housed sows. Appl. Anim. Behav. Sci. 62:199–207.

Arey, D. S., A. M. Petchey, and V. R. Fowler. 1992. Farrowing accommodation and piglet mortality. Farm Build. Prog. 107:5–7.

Arey, D. S., and E. S. Sancha. 1996. Behaviour and productivity of sows and piglets in a family system and in farrowing crates. Appl. Anim. Behav. Sci. 50:135–145.

Arnold-Meeks, C., and J. J. McGlone. 1986. Validating techniques to sample behavior of confined young pigs. Appl. Anim. Behav. Sci. 16:149–155.

Backstrom, L., J. Connors, W. Price, R. Larson, and A. Morkoc. 1980. Mastitis, meritis, agalactia (MMA) in the sow: A field survey of MMA and other farrowing disorders under different gestation and farrowing housing conditions. Univ. of Illinois, Urbana, IL.

Baxter, M. R. 1982. The nesting behaviour of sows and its disturbance by confinement at farrowing. In: Bessai (ed.) Disturbed Behaviour in Farm Animals. p 101. Eugen, Ulmer, Stuttgart, Germany.

Bekoff, M., and J. A. Byers. 1998. Animals at Play. Cambridge University Press., Cambridge, UK.

Berger, F., J. Dagorn, M. Le Denmat, J. P. Quillien, J. C. Vaudelet, and J. P. Signoret. 1997. Perinatal losses in outdoor pig breeding.

A survey of factors influencing piglet mortality. Ann. Zootech. 46:321–329.

Bille, N., N. C. Nielsen, J. L. Larsen, and J. Svendsen. 1974. Pre-weaning mortality in pigs. II. The perinatal period. Nord. Vetmed. 26:294–313.

Blackshaw, J. K., A. J. Swain, A. W. Blackshaw, F. J. M. Thomas, and K. J. Gillies. 1997. The development of playful behaviour in piglets from birth to weaning in three farrowing environments. Appl. Anim. Behav. Sci. 55:37–49.

Blackwell, T. E. 1987. Predicting stillbirth problems. Swine Protection Manage. F371:371–373.

Bowman, G. L., S. L. Ott, and E. J. Bush. 1996. Management effects on pre-weaning mortality: a report of the NAHMS National swine survey. Swine Health Prod. 4:25–32.

Buckner, L. J., S. A. Edwards, and J. M. Bruce. 1998. Behaviour and shelter use by outdoor sows. Appl. Anim. Behav. Sci. 57:69–80.

Castren, H., B. Algers, and P. Jensen. 1989. Occurrence of unsuccessful sucklings in newborn piglets in a semi-natural environment. Appl. Anim. Behav. Sci. 23:61–73.

Caugant, A. 1993. La limitation des pertes avant le sevrage, le savoir-faires des meilleurs eleveurs. J. Truie 18–21.

Csermely, D. 1994. Maternal behaviour of free ranging sows during the first 8 days after farrowing. J. Ethol. 12:53–62.

Davies, P. R., M. Morrow, D. C. Miller, and J. Deen. 1996. Epidemiological study of decubital ulcers in sows. J. Am. Vet. Med. Assoc. 208:1058–1062.

Dobao, M. T., J. Rodriganez, and L. Sills. 1984. Choice of companions in social play in piglets. Appl. Anim. Behav. Sci. 13:259–266.

Dyck, G. W., and E. E. Swierstra. 1987. Causes of piglet death from birth to weaning. Can. J. Anim. Sci. 67:543–547.

Edwards, S. A., and S. J. Malkin. 1986. An analysis of piglet mortality with behavioral observations. Anim. Prod. 42:470 (Abstr.).

Edwards, S. A., and S. Mauchline. 1993. Designing pens to minimize aggression when sows are mixed. Farm Build. Prog. 113:20–23.

Edwards, S. A., W. J. Smith, C. Fordyce, and F. Macmenemy. 1994. An analysis of the causes of piglet mortality in a breeding herd kept outdoors. Vet. Rec. 135:324–327.

English, P. R., and V. Morrison. 1984. A review of survival problems of the neonatal pig. Proc. Pig. Vet. Soc. 11:39–55.

FASS. 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st ed. Federation of Animal Science Societies, Savoy, IL.

Fraser, D. 1975. The effect of straw on the behaviour of sows in tether stalls. Anim. Prod. 21:59–68.

Friendship, R. M., M. R. Wilson, and M. I. McMillan. 1986. Management and housing factors associated with piglet preweaning mortality. Can. Vet. J. 27:307–311.

Glastonbury, J. R. W. 1976. A survey of preweaning mortality in the pig. Aust. Vet. J. 52:272–276.

Haskell, M., F. Wemelsfelder, M. T. Mendl, S. Calvert, and A. B. Lawrence. 1996. The effect of substrate-enriched and substrate-impoverished environments on the diversity of behaviour in pigs. Behaviour. 133:741–761.

Jarvinen, M. K., K. Morrow-Tesch, J. J. McGlone, and T. L. Powley. 1998. Effects of diverse developmental environments on neuronal morphology in domestic pigs (*Sus scrofa*). Dev. Brain. Res. 107:21–31.

Jensen, P. 1988. Maternal behaviour and mother-young interactions during lactation in free-ranging domestic pigs. Appl. Anim. Behav. Sci. 20:297–308.

Jensen, P. 1994. Fighting between unacquainted pigs—effects of free-ranging domestic pigs. Appl. Anim. Behav. Sci. 41:37–52.

Kleinbeck, S. N., and J. J. McGlone. 1999. Intensive indoor versus outdoor swine production systems: genotype and supplemental iron effects on blood hemoglobin and selected immune measures in young pigs. J. Anim. Sci. 77:2384–2390.

Lawrence, A. B., and C. E. O'Connor. 1992. Behavioural aspects of neonate survial. Brit. Soc. Anim. Prod. 15:35–46.

Marchant, J. N., D. M. Broom, and S. Corning. 1996. The effects of sow maternal behaviour on piglet mortality in an open farrowing system. Anim. Sci. 62:675.

McGlone, J. J., and F. Blecha. 1987. An examination of behavioral, immunological and productive traits in four management systems for sows and piglets. Appl. Anim. Behav. Sci. 18:269–286.

McGlone, J. J., and T. A. Hicks. 2000. Farrowing hut design and sow genotype (Camborough—15 vs 25% Meishan) effects on outdoor sow and litter productivity. J. Anim. Sci. 78:2832–2835.

Mortensen, B., Ruby, V., Pedersen, B. K., Smidth, J., and Larsen, V. A. 1994. Outdoor pig production in Denmark. Pig News Info. 15:117N–120N.

National Weather Service. 1999. Monthly climate summary: Lubbock. Available at: *http://www.srh.noaa.gov/lub/climate/LBB.Climate/1999/clidoc.htlm*. Accessed Jan. 18, 2001.

Newberry, R. C., and D. G. M. Wood-Gush. 1988. Development of some behaviour patterns in piglets under semi-natural condition. Anim. Prod. 46:103–109.

Newberry, R. C. D. G. M. Wood-Gush, and J. W. Hall. 1988. Playful behaviour of piglets. Behav. Process 17:205–216.

NPPC. 2000. Pork facts: 2000/2001. Available at: http://www.nppc.org/NEWS/newsmain.html. Accessed Nov. 9, 2000.

NRC. 1998. Nutrient Requirements of Swine. 10th ed. National Research Council, National Academy Press, Washington, DC.

Petersen, J. S., P. Henckel, N. Oksberg, and M. T. Sørensen. 1998. Adaptations in muscle fibre characteristics induced by physical activity in pigs. Anim. Sci. 66:733–740.

PIC. 1998. Pig Management Yearbook. Pigs Improvement Corporation, Abingdon, UK.

Randall, G. C. B. 1972a. Observations on parturition in the sow. II. Factors influencing stillbirth and perinatal mortality. Vet. Rec. 90:183–186.

Randall G. C. B. 1972b. Studying stillbirths. Pig Farm. 53:55.

Robert, S., J. J. Matte, C. Farmer, C. L. Girard, and G. P. Martineau. 1993. High-fibre diets for sows: effects on stereotypies and adjunctive drinking. Appl. Anim. Behav. Sci. 37:297–309.

Rushen, J. 1993. Exploration in the pig may not be endogenously motivated. Anim. Behav. 45:183–184.

Sarignac, C. N., J. P. Signoret, and J. J. McGlone. 1997. Sow and piglet performance and behavior in either intensive outdoor or indoor units with litters managed as individuals or as small social groups. J. Rech. Porcine Fr. 29:123–128.

Sovljanski, B., S. Milosavljevic, V. Miljkovic, M, Stankov, G. Trbojevic, and B. Radovic. 1972. Dependence of the occurrence of stillborn piglets upon the body postion of the piglets at farrowing. Acta Vet. (Belgr.) 22:77–80.

Stanton, H. C., and J. K. Carroll. 1974. Potetnial mechanisms repsonsible for prenatal and perinatal mortlaity or low viability of swine. J. Anim. Sci. 38:1037–1044.

Svendsen, J., A. C. H. Bengtsson, and L. S. Svendsen. 1986. Occurrence and causes of traumatic injuries in neonatal pigs. Pig News Info. 7:159–170.

Terlouw, E. M. C., A. B. Lawrence, and A. W. Illius. 1991 Relationship between agonistic behaviour and propensity to develop excessive drinking and chain manipulation in pigs. Physiol. Behav. 50:493–498.

Thodberg, K., K. H. Jensen, M. S. Herskin, and E Jørgensen. 1999. Influence of environmental stimuli on nest building and farrowing behaviour in domestic sows. Appl. Anim. Behav. Sci. 63:131–144.

Van der Steen, H. A. M. 1994. Genotypes for outdoor production. Pig News Info. 15:129N–130N.

Webster, S. 1997. Behavioural effects of outdoor and indoor rearing of pig: Observations on commercial units. Cambac JMA Research, U.K.

Wechsler, B., and N. Brodmann. 1996. The synchronization of nursing bouts in group-housed sows. Appl. Anim. Behav. Sci. 47:191–199.

Whatson, T. S., and J. M. Bertram. 1982. Some observations of mother-infant interactions in the pig (*Sus scrofa*). Appl. Anim. Ethol. 9:253–261.

Wood-Gush, D. G. M., and K. Vestergaard. 1993. Inquisitive exploration in pigs. Anim. Behav. 45:185–187.

Yeske, P., S. L. Ott, and H. S. Hurd. 1994. Facility effects on preweaning mortality: a report of the NAHMS. Swine Health Prod. 2:11–18.

Citations

This article has been cited by 8 HighWire-hosted articles:
http://www.journalofanimalscience.org/content/79/10/2571#otherarticles