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The effect of floor type in farrowing crates on piglet welfare

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The effect on piglet welfare of different combinations of flooring in the sow and piglet areas of farrowing crates was examined. One hundred and three multiparous sows were housed, from one week pre-farrowing through farrowing and lactation to weaning, in farrowing crates with one of five flooring combinations: SS – slatted steel in both the sow and piglet areas of the crate; SP – slatted steel sow flooring and plastic-coated expanded metal for the piglets; AP – slatted steel (with a checker-plate panel) sow flooring and plastic-coated expanded metal for the piglets; CP – expanded cast iron sow flooring and plastic-coated expanded metal for the piglets; PP – plastic-coated woven wire sow flooring and plastic-coated expanded metal for the piglets. The number of litters assigned to SS, SP, AP, CP and PP were 27, 23, 17, 18 and 18, respectively. All piglet areas had a water-heated pad. Piglets were examined for lesions, scored from zero to three according to severity, at six locations on each foot and at seven locations on each limb during the suckling period. Addition of scores at each location yielded a foot and limb lesion score. In addition, the proportion of piglets in a litter affected by at least one injury was calculated for each of the following: the carpal joints, coronets, accessory digits, footpads. Piglet behaviour was recorded for 2 h, between 1330 and 1630, at 24 h after birth. Litters were weighed at birth and at weaning, and all deaths were recorded during the suckling period. SS litters had higher foot and limb lesion scores ($P < 0.001$). In addition, a greater proportion of piglets in SS litters were affected by at least one injury to the carpal joint, coronet, accessory digit and footpad ($P < 0.001$). SP piglets were active on the heatpad in more observations than AP piglets ($P < 0.05$). PP piglets were inactive in other areas of the pen in more observations than SS piglets ($P < 0.05$). There was no effect of treatment on piglet weight gain or mortality. It is concluded that the use of slatted steel in piglet areas of

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farrowing crates cannot be recommended because of injuries to piglets' feet and limbs. The combination of slatted steel in the sow area and plastic-coated expanded metal in the piglet area encourages use of the heatpad. However, use of plastic-coated woven wire in the sow area encourages piglets to use this area which puts them in danger of being overlaid by the sow.

Keywords: Farrowing crates; floors; limb lesions; piglet welfare

Introduction

There are numerous animal welfare disadvantages associated with slatted floors (Furniss *et al*., 1986; Phillips, Fraser and Thompson, 1996; Boyle, 1997), but they have one important management advantage. They are compatible with slatted slurry disposal systems that require less labour and so they are likely to persist in farrowing crates for the foreseeable future.

Slatted floors in farrowing crates present a dilemma because the needs of the sow differ from those of her piglets in a number of ways (Roach, 1981). Piglets require floors with low abrasive properties (Clark, 1983; Nilsson, 1988) as floor abrasiveness is a major cause of superficial injury in piglets in farrowing pens (Clark, 1985). However, breeding stock require access to an abrasive surface in order to prevent hoof overgrowth (MAFF, 1992). Indeed, attempts to provide a non-abrasive surface for piglets resulted in floors, which were too slippery for sows and gilts (Mitchell and Smith, 1977). Sows produce the bulk of faecal matter in farrowing pens (Baxter and Robertson, 1971), so it is important that the slats behind the sow are as near self-cleaning as possible. When slot width is greater than 10 mm there is a risk of injury to the piglets (Mitchell and Smith, 1977; Wells, 1979).

Wound development in suckling piglets is multi-factorial. The process by which a leg wound appears is a combination of abrasion and friction. When the leg is rubbed on the floor, sharp particles on the floor surface shear off particles of tissue. Concurrently, frictional forces generate heat as the leg is rubbed repeatedly, and the heat generated leads to deterioration in the structural integrity of the skin (Phillips, Fraser and Buckley, 1992). Floor properties such as surface temperature, surface roughness and coefficient of friction play a role in the development of wounds in piglets (Phillips *et al.,* 1992). Clark (1983) showed that injury occurred in 100% of piglets within 24 h of birth. More recently, Mouttotou and Green (1999) identified 61% of piglets with sole bruising within 24 h of birth. Leonard, O'Connell and Lynch (1996) found that piglets housed on metal floors had lower foot lesion scores but piglets housed on plastic floors had fewer skin lesions. This is in contrast to the findings of Quemere *et al.* (1988) and Navarotto *et al.* (1994) who found that iron mesh caused more lesions than plastic flooring. Similarly, Courboulay *et al.* (2000) found that piglets had a higher incidence of footpad lesions and knee injuries when housed on metal slats than on plastic slats, concrete or plastic-coated wire. Although most injuries heal by the time piglets are weaned (Mitchell and Smith, 1978; Brennan and Aherne, 1987; Mouttotou and Green, 1999), open wounds in young piglets may provide an entry point for infection (Penny, Edwards and Mulley, 1971) which can adversely affect performance later in the production cycle (Waddilove, 1995). Furthermore, even superficial injuries have welfare implications (de Koning, 1985).

European Union Council Directive 2001/88/EC was adopted into European law in October 2001. It lays down minimum standards for the housing of pigs. Farrowing crates can continue to be used due to the lack of viable alternatives with slatted slurry disposal systems. However, further information on the health and welfare implications of crates, including the impact of different floor types, is required for a report of the Scientific Committee on Animal Health and Welfare to be made by 1 January 2008.

In countries where slatted systems are used, crates were traditionally furnished with one type of slatted floor. However, in an effort to meet the differing needs of the sow and her piglets the effects of five flooring combinations on piglet welfare in farrowing crates were assessed.

Materials and Methods

Animals

The experimental work was carried out at Moorepark Research Centre, Fermoy, Co. Cork where weekly farrowing is practised. One hundred and three F1 (Large White × Landrace) sows and gilts (Hermitage AI, Co. Kilkenny) were used in five treatments. Parity number ranged from zero to nine (mean 3.73, s.d. 2.32). The experimental data were obtained over a 15-month period (December 2000 to February 2002 inclusive). The animals were maintained to high welfare standards under veterinary supervision.

Piglets were ear-notched for identification purposes after birth. In addition, an experienced stockperson clipped the piglets' teeth to the gum line using a standard side-cutter clippers and docked their tails. Piglets were injected with 1 ml Iron Dextran and 1 ml *Mycoplasma hypopneumoniae* vaccine 3 days after birth. They were also injected with 2 ml *Mycoplasma hypopneumoniae* vaccine at weaning. This was generally at 28 days of age but some large piglets were weaned 1 week earlier at 21 days of age.

Housing and diet

All the sows farrowed previously in standard farrowing crates with slatted steel floors, which had a non-slip section and slat and slot widths of 10 mm.

Six days pre-partum the sows were moved to the farrowing accommodation. This consisted of two mechanically-ventilated, thermostatically-controlled rooms (farrowing rooms A and B) each containing 10 farrowing pens. The farrowing pens measured 2.30 m × 1.65 m. Each pen contained a farrowing crate constructed of steel bars, situated in the centre of the pen and measuring 2.3 m × 0.5 m (O'Donovan Engineering, Coachford, Co. Cork). Room temperature was maintained at 24 °C during the pre-partum period. On the day after parturition the temperature was reduced to 22 °C and from the second week post-partum to the time of weaning the room temperature was maintained at 20 °C. Lighting was provided by overhead fluorescent strips and was turned on manually from 0800 to 1645 each day. Sows were fed a standard lactating sow diet (3.3:1 water:solid liquid feed) twice daily. The diet contained (g/kg) 158 crude protein, 9.1 lysine, 56 fat, 35 crude fibre and 46 ash. Digestible energy concentration was 14.2 MJ/kg. Sows had continuous access to water via a nipple drinker (Aratowerk, Köln, Germany) in the feed trough. Piglets also had continuous access to water via a piglet-dedicated nipple drinker (Monoflo GmBh, Heppenheim, Germany). Solid feed (Startrite 88, SCA

Nutrition Limited, Co. Kildare) was introduced when the piglets were two weeks old.

Treatments

The floors (Nooyen Roosters BV, Deurne, The Netherlands) used in the sow areas of the farrowing crates were:

S: slatted steel (Tribar® with Soft-Grip®) with slat and slot widths of 10 mm. Over a surface area of 1.47 m × 0.60 m the slatted steel had a series of indentations. This was to provide a non-slip surface for the sow (U-Noslip®).

A: as for S, but with a solid metal checker-plate panel (0.61 m × 0.59 m) in the anterior part of the crate (under the sternum and forelegs).

C: Expanded cast iron. The dimensions of each opening were 99 mm × 10 mm. The width of the cast iron bars was 12 mm.

P: Plastic-coated woven wire (Supercoated Ecoline®) with a slatted steel section at the rear of the crate to facilitate dung removal (comprising slatted steel with slat and slot widths of 10 mm, employed over a surface area of 0.56 m × 0.6 m) and three solid plastic-coated panels (Shoulderplates®) (each panel covered a surface area of 0.15 m × 0.40 m) in the anterior part of the crate (under the sternum and forelegs). The dimensions of the diamond-shaped openings in the floor were 49 mm × 11 mm. The width of the bar surrounding each diamond-shaped opening was 10 mm.

In the piglet areas of the farrowing crates the floors (Nooyen Roosters BV, Deurne, The Netherlands) were either:

S: slatted steel (Tribar® floor) with slat and slot widths of 10 mm and a checker-plate (solid non-slip) water-heated pad (1.2 m × 0.45 m) situated on both sides of the centrally-positioned crate.

P: plastic-coated expanded metal (Super-coated Ecoline® floor), with a solid plastic-coated water-heated pad (1.25 m × 0.25 m) situated on both sides of the centrally-positioned crate. The dimensions

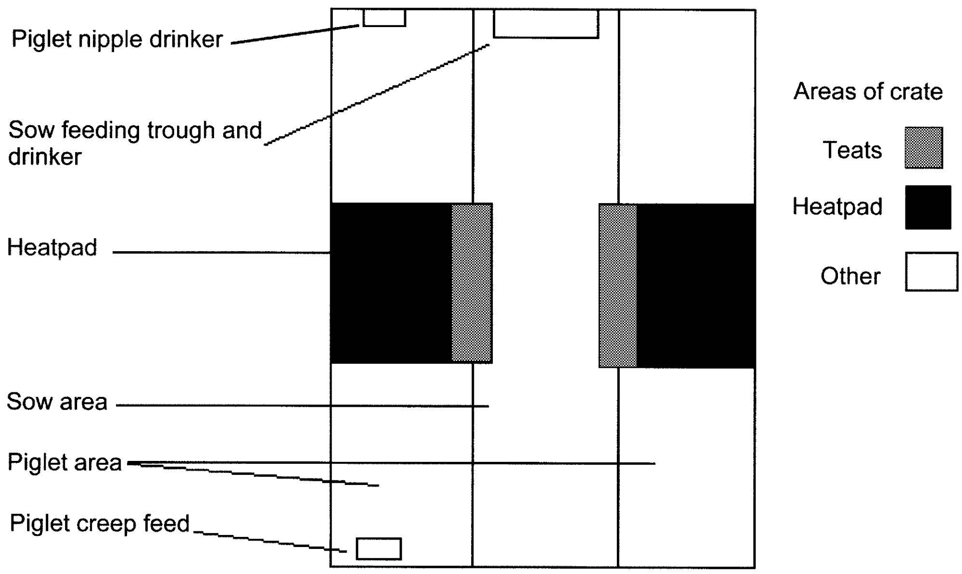

Figure 1: Areas of farrowing crate used in 2-h scan sample of piglet behaviour carried out 24 h after birth.

of the diamond-shaped openings were 25 mm × 13 mm. The width of the plastic-coated expanded metal bar was 9 mm.

The locations of the sow and piglet areas in the farrowing crate are shown in Figure 1.

Five flooring combinations were evaluated. These were (1) slatted steel under the sow and slatted steel in the piglet areas (SS), (2) slatted steel under the sow and plastic-coated expanded metal in the piglet areas (SP), (3) slatted steel with a checker-plate panel under the sow and plastic-coated expanded metal in the piglet areas (AP), (4) expanded cast iron under the sow and plastic-coated expanded metal in the piglet areas (CP) and (5) plastic-coated woven wire under the sow and plastic-coated expanded metal in the piglet areas (PP). The number of litters used in SS, SP, AP, CP and PP were 27, 23, 17, 18 and 18, respectively. Sample size differences between treatments were due to different numbers of farrowing crates equipped with the five flooring combinations. Farrowing room A contained 4 SS farrowing crates. Farrowing room B contained 4 SP farrowing crates and two each of AP, CP and PP farrowing crates. Each room was used approximately once every 6 weeks as part of the normal farrowing routine. Approximately 12 sows farrowed each week. Within each weekly group, sows were assigned at random from within parity to the treatments.

Piglet lesions

Piglets were inspected for lesions at approximately 24 h post-partum and again on days 8 and 15 post-partum. Lesions were categorised by the methodology of Penny, Osborne and Wright (1963) and de Koning (1985) and were assigned a severity score from 0 to 3 (Table 1). Lesions were assessed at six individual locations on each foot

Table 1. Lesion types and associated severity scores used in assessing piglet foot and limb lesions[1]

Lesion	Score	Foot lesion	Limb lesion
Bruise, severity 1 (least severe)	1	√	
Burn	1		√
Callus	1		√
Scab	1	√	√
Swelling	1	√	√
Peeling	1	√	√
Redness	1	√	√
Alopecia	1	√	√
Redness and Alopecia	1	√	√
Bruise, severity 2 (intermediate)	2	√	
Wound	2	√	√
Severe burn	2		√
Severe callus	2		√
Severe scab	2	√	√
Severe swelling	2	√	√
Bruise, severity 3 (most severe)	3	√	
Severe wound	3	√	√
Cracked	3	√	
Erosion	3	√	
Amputated	3	√	
Infection	3	√	

[1]Applicable scores indicated by √.

(Figure 2a) and at seven individual locations on each limb (Figure 2b). Addition of scores at the six locations on each of the four feet yielded a foot lesion score. Addition of scores at the seven locations on each of the four limbs yielded a limb lesion score. The proportion of piglets in a litter with at least one lesion was determined for the coronets, accessory digits, footpads and carpal joints. Data on a small number of litters were not collected on two inspection days due to time constraints.

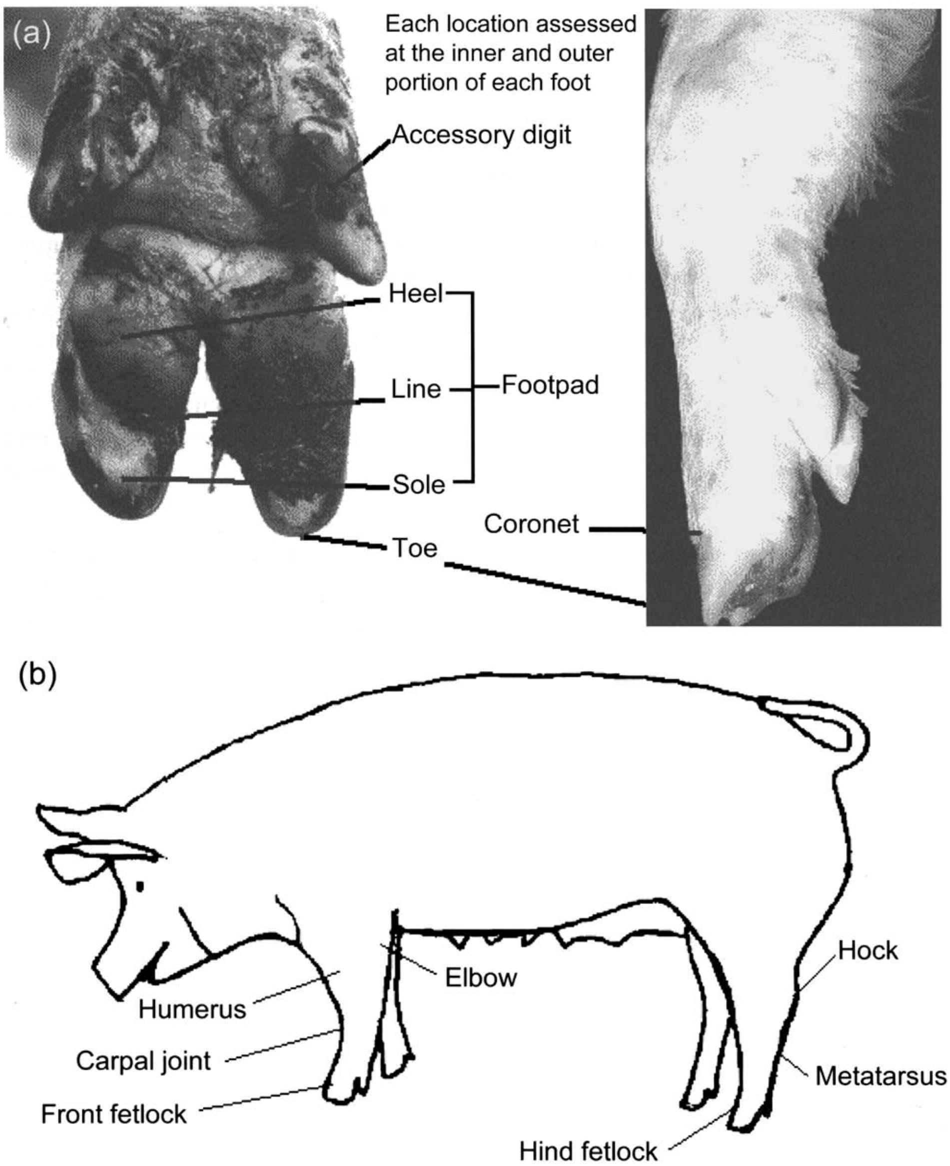

Figure 2: Locations on the feet (a) and limbs (b) inspected for lesions.

Piglet behaviour

Piglet behaviour was recorded at 24 h post-partum using instantaneous scan sampling techniques during a 2-h period between 1330 and 1630. Every 5 min the number of piglets in each litter that were active and inactive on the heatpad, at the teats and in any other part of the pen was counted (Figure 1). This time of day was previously identified as one of high activity in piglets (Beattie, 1994).

Production records

Litter weight was recorded at birth and at weaning. Causes of mortality throughout the suckling period were also recorded. These were crushing, low viability, starvation, splay legs, meningitis, diarrhoea and other.

Statistical methods

Procedures of the Statistical Analysis System (SAS, 1999) were used to analyse the data with litter as the experimental unit. Production data were analysed by one-way analysis of variance using PROC GLM of SAS. Data on piglet behaviour were also analysed by using PROC GLM. The proportion of piglets in a litter that had at least one lesion to the coronets, accessory digits, footpads and carpal joints, and piglet foot and limb lesion scores, were analysed using PROC MIXED. The model included fixed effects of treatment, day and their interaction. Tukey's Test was used to evaluate pairwise differences between treatments on each individual observation day.

Results

Piglet lesions

There was an effect of treatment on the foot and limb lesion scores ($P < 0.001$; Table 2). In all instances the lesion scores of SS litters were greater than those of litters on each of the other four floor combinations ($P < 0.01$).

There was an effect of treatment on the proportion of piglets in a litter that had at least one carpal, coronet, accessory digit and footpad lesion ($P < 0.001$; Table 3). A higher proportion of piglets in SS litters were affected by at least one carpal and accessory digit lesion than on all other floor combinations ($P < 0.01$). A greater proportion of piglets in SS than in PP and AP litters had at least one coronet lesion and a greater proportion of piglets in SS than in CP litters had at least one footpad lesion ($P < 0.01$; Table 3).

Table 2. The effect of five flooring combinations used in farrowing crates on foot and limb lesion scores (least squares mean ± s.e.) of piglets during the suckling period

Lesion area	Piglet age (days)	Flooring combination[1]					F-test
		SS	SP	AP	CP	PP	
Feet	1	24.6 ± 1.0^a	16.0 ± 1.1^b	16.6 ± 1.2^b	15.1 ± 1.2^b	16.3 ± 1.2^b	***
	8	22.6 ± 1.0^a	15.8 ± 1.1^b	14.5 ± 1.2^b	14.7 ± 1.2^b	15.8 ± 1.2^b	***
	15	20.1 ± 1.0^a	10.8 ± 1.1^b	10.0 ± 1.2^b	9.4 ± 1.2^b	12.2 ± 1.2^b	***
Limbs	1	1.3 ± 0.2^a	0.4 ± 0.2^b	0.8 ± 0.2^b	0.4 ± 0.2^b	0.5 ± 0.2^b	***
	8	2.2 ± 0.2^a	1.0 ± 0.2^b	1.3 ± 0.2^b	1.1 ± 0.2^b	1.0 ± 0.2^b	***
	15	2.5 ± 0.2^a	1.1 ± 0.2^b	1.3 ± 0.2^b	1.4 ± 0.2^b	1.3 ± 0.2^b	***

[1]SS: slatted steel under the sow and slatted steel in piglet areas, SP: slatted steel under the sow and plastic-coated expanded metal in piglet areas, AP: slatted steel with a solid panel under the sow and plastic-coated expanded metal in piglet areas, CP: cast iron slats under the sow and plastic-coated expanded metal in piglet areas, PP: plastic-coated woven wire under the sow and plastic-coated expanded metal in piglet areas.

[a,b] Within rows, means without a common superscript differ significantly ($P < 0.05$).

Table 3. The effect of five flooring combinations used in farrowing crates on the proportion of piglets in a litter with at least one lesion to the coronet, accessory digit, footpad or carpal joint (least squares mean ± s.e.) during the suckling period

Anatomical site	Piglet age (days)	Flooring combination[1]					F-test
		SS	SP	AP	CP	PP	
Coronet	1	0.44 ± 0.04^{a}	0.33 ± 0.04^{ab}	0.22 ± 0.04^{b}	0.32 ± 0.04^{ab}	0.26 ± 0.04^{b}	***
	8	0.16 ± 0.04^{a}	0.13 ± 0.04^{ab}	0.07 ± 0.04^{b}	0.17 ± 0.04^{ab}	0.05 ± 0.04^{b}	***
	15	0.21 ± 0.04^{a}	0.05 ± 0.04^{ab}	0.03 ± 0.04^{b}	0.05 ± 0.04^{ab}	0.03 ± 0.04^{b}	***
Accessory digit	1	0.31 ± 0.03^{a}	0.14 ± 0.03^{b}	0.22 ± 0.03^{b}	0.17 ± 0.03^{b}	0.16 ± 0.03^{b}	***
	8	0.11 ± 0.03^{a}	0.03 ± 0.03^{b}	0.03 ± 0.03^{b}	0.05 ± 0.03^{b}	0.08 ± 0.03^{b}	***
	15	0.09 ± 0.03^{a}	0.01 ± 0.03^{b}	0.01 ± 0.03^{b}	0.01 ± 0.03^{b}	0.02 ± 0.03^{b}	***
Footpad	1	1.00 ± 0.01^{a}	0.98 ± 0.02^{ab}	0.99 ± 0.02^{ab}	0.98 ± 0.02^{b}	0.98 ± 0.02^{ab}	***
	8	1.00 ± 0.01^{a}	0.99 ± 0.02^{ab}	0.99 ± 0.02^{ab}	0.95 ± 0.02^{b}	0.98 ± 0.02^{ab}	***
	15	0.99 ± 0.01^{a}	0.96 ± 0.02^{ab}	0.95 ± 0.02^{ab}	0.88 ± 0.02^{b}	0.94 ± 0.02^{ab}	***
Carpal	1	0.35 ± 0.05^{a}	0.20 ± 0.05^{b}	0.11 ± 0.06^{b}	0.12 ± 0.06^{b}	0.14 ± 0.06^{b}	***
	8	0.63 ± 0.05^{a}	0.41 ± 0.05^{b}	0.37 ± 0.06^{b}	0.37 ± 0.06^{b}	0.32 ± 0.06^{b}	***
	15	0.77 ± 0.05^{a}	0.46 ± 0.05^{b}	0.46 ± 0.06^{b}	0.53 ± 0.06^{b}	0.51 ± 0.06^{b}	***

[1]See footnote Table 2.
[a,b]Within rows, means without a common superscript differ significantly ($P < 0.05$).

Piglet behaviour

Treatment affected the proportion of observations in which piglets were active on the heatpad (P < 0.05; Table 4). SP piglets were active on the heatpad in a greater proportion of observations than AP piglets (P < 0.05). There was also an effect of treatment on the proportion of observations in which piglets were inactive in other areas of the pen (P < 0.05; Table 4). PP piglets were inactive in other areas of the pen in a greater proportion of observations than SS piglets (P < 0.05).

Production

There was no effect of treatment on any of the production parameters recorded (P > 0.05; Table 5).

Discussion

In agreement with previous research findings (Furniss *et al.,* 1986; Leonard *et al.,* 1996; Courboulay *et al.,* 2000) the use of plastic-coated expanded metal in the piglet area significantly reduced limb damage, compared to steel flooring. Mouttotou, Hatchell and Green (1999) identified the repeated rubbing on the floor while piglets kneel during suckling as the main cause of damage to piglets limbs, particularly the forelimbs. Hence, our finding that injury to the piglets limbs was more likely due to the flooring used in the piglet area than in the sow area of the crate is not surprising. The finding of carpal lesions in 1-day-old piglets on all floors raises concern for their welfare but is not unusual (Penny *et al.,* 1971; Furniss *et al.,* 1986). It was likely due to the intense scrambling that goes on at the udder to establish a teat order soon after birth (Hartsock and Graves, 1976). Skin abrasions were usually superficial. The importance of wounds to the carpal joint and other areas of the limb is that they may

Table 4. The effect of five flooring combinations used in farrowing crates on the proportion of observations on 1-day-old piglets that were classified as active or inactive in different parts of the farrowing crate (mean proportion of time ± s.e.)

Location in crate	Behaviour	Flooring combination[1]					F-test
		SS	SP	AP	CP	PP	
Teats	Active	0.24 ± 0.02	0.24 ± 0.02	0.26 ± 0.02	0.23 ± 0.03	0.24 ± 0.02	
	Inactive	0.08 ± 0.01	0.10 ± 0.02	0.12 ± 0.02	0.15 ± 0.04	0.10 ± 0.02	
Heatpad	Active	0.08 ± 0.01^{ab}	0.10 ± 0.01^{a}	0.06 ± 0.01^{b}	0.08 ± 0.01^{ab}	0.06 ± 0.01^{ab}	*
	Inactive	0.50 ± 0.03	0.42 ± 0.03	0.43 ± 0.04	0.43 ± 0.04	0.42 ± 0.04	
Other areas	Active	0.04 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	
	Inactive	0.04 ± 0.01^{a}	0.08 ± 0.02^{ab}	0.07 ± 0.02^{ab}	0.05 ± 0.01^{ab}	0.12 ± 0.03^{b}	*

[1]See footnote Table 2.

[a,b]Within rows, means without a common superscript differ significantly (P < 0.05).

Table 5. The effect of five flooring combinations used in farrowing crates on production variables (least squares mean ± s.e.)

Variable	Flooring combination[1,2]				
	SS	SP	AP	CP	PP
Number born live (piglets/litter)	10.43 ± 0.57	11.16 ± 0.49	11.00 ± 0.64	11.30 ± 0.78	10.47 ± 0.49
Number stillborn (piglets/litter)	0.93 ± 0.32	0.70 ± 0.18	1.73 ± 0.42	1.22 ± 0.32	1.06 ± 0.31
Number born mummified (piglets/litter)	0.19 ± 0.12	0.13 ± 0.07	0.65 ± 0.26	0.44 ± 0.19	0.17 ± 0.09
Litter birth weight (kg)	16.31 ± 0.97	16.96 ± 0.72	16.68 ± 0.95	16.49 ± 1.32	16.19 ± 0.55
Number weaned (piglets/litter)	9.36 ± 0.22	9.65 ± 0.30	9.47 ± 0.40	9.95 ± 0.22	9.53 ± 0.39
Litter weaning weight (kg)	71.18 ± 1.94	78.05 ± 2.74	73.79 ± 3.36	79.30 ± 2.92	77.06 ± 3.65
Weight gain per piglet (kg)	6.02 ± 0.11	6.57 ± 0.18	6.46 ± 0.51	6.49 ± 0.21	6.55 ± 0.22
Mortality due to crushing (proportion of litter)	0.02 ± 0.01	0.02 ± 0.01	0.04 ± 0.01	0.02 ± 0.01	0.04 ± 0.01
Total mortality (proportion of litter)	0.05 ± 0.02	0.07 ± 0.03	0.07 ± 0.02	0.08 ± 0.02	0.07 ± 0.02

[1]See footnote Table 2.
[2]There were no significant differences among flooring combinations.

become infected resulting in joint swellings, abscess formation and lameness (Smith and Mitchell, 1976; Gardner *et al.*, 1990; Phillips, Fraser and Pawluczuk, 1995). In addition, injuries sustained in farrowing crates are implicated in injury and performance later in life (Waddilove, 1995). Irrespective of effects on performance, a high frequency of injured piglets or the presence of piglets with severe injuries indicates reduced welfare (Ekesbo, 1981; Webb and Nilsson, 1983).

Slatted steel in the piglet areas also had a negative effect on piglet foot lesions relative to the plastic-coated expanded metal. This supports the findings of other studies (Kornegay, Thomas and Bryant, 1981; Navarotto *et al.,* 1994; Courboulay *et al.,* 2000). Many studies have highlighted problems associated with piglets' feet passing through the perforations in the floor, which can lead to accessory digit, coronet and footpad lesions (Mitchell and Smith, 1978; Van Veen, Vellenga and Hoogerbrugge, 1985; Vellenga, van Veen and Hoogerbrugge, 1983). Piglets' feet were probably less likely to get caught in the diamond-shaped openings of the plastic-coated expanded metal floor. If they did get caught the plastic coating reduced the injurious chaffing and rubbing associated with freeing the trapped foot (Mitchell and Smith, 1978). The type of sow flooring used in combination with the plastic-coated piglet floor had no consistent influence on piglet foot lesions.

Behaviour was recorded when the piglets were approximately 1-day-old because at that age they can show a strong preference for certain floor types (Farmer and Christison, 1982). This preference is best indicated by lying behaviour (Pouteaux, Christison and Stricklin, 1982). It is preferable that piglets lie on the heat-pad, as they are less at risk of crushing or chilling there than if they lie elsewhere in the crate (Cronin and Cropley, 1991). The observation that piglets were inactive in areas of the crate other than on the heatpad when the combination of plastic-coated flooring in both the sow and piglet areas was used is consistent with the finding that plastic-coated expanded metal is consistently preferred by piglets over other types of slatted floors (Marx and Schuster, 1980, 1982; Pouteaux *et al.,* 1982). Hence, when it covered the entire crate floor the piglets did not have to restrict their lying to the heatpad. The more time piglets spend off the heatpad the greater the danger from being close to the sow. Consequently, use of plastic-coated type flooring in the sow area of farrowing crates cannot be recommended. On the other hand, use of the slatted steel floor in the sow area in combination with the plastic-coated floor in the piglet area encouraged piglets to use the heatpad. This was probably because the slatted steel was uncomfortable for piglet activity. Unfortunately, slatted steel floors are more injurious to sows than plastic-coated floors (Leonard *et al.,* 1996), which emphasises the difficulty in reconciling the needs of the sow with the needs of her piglets in farrowing crates.

Pre-weaning mortality in systems such as used in this study is normally about 9% and so is an important economic problem (Martin, 2002). Although there was no effect of treatment on mortality in this study, nor in a previous study at Moorepark Research Centre (O'Connell, Leonard and Lynch, 1996), Hoofs (1996) did show that mortality was lower in farrowing crates with plastic slats than with metal slats. In agreement with several studies elsewhere, there was no effect of floor type on piglet weight gain (e.g. Navarotto *et al.,* 1994). However, Elst-Wahle *et al.* (1992) reported that piglets on a fully slatted soft-coated Tribar® floor had a higher rate of gain than piglets on a conventional slatted Tribar® floor or a part-slatted Tribar® floor.

It is concluded that plastic-coated expanded metal should be used in preference to slatted steel in the piglet area of farrowing crates and that piglets are encouraged to use the heatpads when the sow area of the crate has a slatted steel floor. The latter should reduce the risk of accidental mortality due to being overlaid by the sow.

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References

Baxter, S.H. and Robertson, A.M. 1971. Slatted floors in farrowing and rearing pens. *Farm Building Progress* **26:** 27–36.

Beattie, V.E. 1994. The effects of environmental enrichment on the domestic pig. *PhD Thesis*, The Queen's University of Belfast, Northern Ireland.

Boyle, L.A. 1997. Skin lesions, overgrown hooves and culling reasons in sows housed individually. *MAgrSc Thesis,* National University of Ireland, Dublin, Ireland.

Brennan, J.J. and Aherne, F.X. 1987. Effect of floor type on the severity of foot lesions and osteonchrondrosis in swine. *Canadian Journal of Animal Science* **67:** 517–523.

Clark, M. 1983. Biomechanical aspects of piglet foot development. *PhD Thesis,* University of Aberdeen, Aberdeen, Scotland.

Clark, M. 1985. Farrowing pen floor abrasiveness measured using a rubber–block drag test. *Farm Building Progress* **80:** 29–32.

Council Directive 2001. Council Directive 2001/88/EC of 23 October 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs.

Courboulay, V., le Roux, A., Collin, F., Dutertre, C. and Rousseau, P. 2000. Incidence du type de sol en maternite sue le confort de la truie et des porcelets. *Journees Recherche Porcine en France* **32:** 115–122.

Cronin, G.M. and Cropley, J.A. 1991. The effect of piglet stimuli on the posture changing behaviour of recently farrowed sows. *Applied Animal Behaviour Science* **30:** 167–172.

De Koning, R. 1985. On the well-being of dry sows. *PhD Thesis,* University of Utrecht, Utrecht, The Netherlands.

Ekesbo, I. 1981. Method for the assessment of the environment from the point of view of animal welfare. *Proceedings of 32nd Annual Meeting of the European Association for Animal Production* IV-4 1–1.

Elst-Wahle, E.R. ter, Hoofs, A.I.J., Vermeer, H.M. and van Rooy, A.M.A. 1992. Effect of floor type in the farrowing crate on the productivity of sows. Proefsverlag Proefstation voor de Varkenshouderij, P1.82, 24 pages.

Farmer, C. and Christison, G.I. 1982. Selection of perforated floors by newborn and weanling pigs. *Canadian Journal of Animal Science* **62:** 1229–1236.

Furniss, S.J., Edwards, S.A., Lightfoot, A.L. and Spechter, H.H. 1986. The effect of floor type in farrowing pens on pig injury. I. Leg and teat damage of suckling piglets. *British Veterinary Journal* **142:** 434–440.

Gardner, I.A., Hird, D.W., Sullivan, N.M. and Pierce, R.J. 1990. Clinical, pathologic and microbiologic findings of foot abscesses in neonatal pigs. *Journal of the American Veterinary Medicine Association* **196:** 1791–1794.

Hartsock, T.G. and Graves, H.B. 1976. Piglet fighting behaviour, nursing order and growth. *Journal of Animal Science* **43:** 209 (Abstract).

Hoofs, A.I.J. 1996. The value of several types of plastic slat in farrowing pens with a fully slatted floor with a solid part for the piglets. Varkensproebedrijf "Zuid-en West-Nederland" Proefsverlag nummer P 1.127.

Kornegay, E.T., Thomas, H.R. and Bryant, K.L. 1981. Flooring materials, pigs per cage and use of oats in starter diets for pigs housed in triple deck nurseries. *Journal of Animal Science* **53:** 130–137.

Leonard, F.C., O'Connell, J.M. and Lynch, P.B. 1996. Skin and foot lesions in sows and piglets on different farrowing house floor types. *Irish Journal of Agricultural and Food Research* **35:** 67 (Abstract).

MAFF (Ministry of Agriculture, Fisheries and Foods) 1992. Lameness in pigs, action on animal welfare booklet. MAFF Publications, London SE99 7TP, Ref.: 1148.

Martin, M. 2002. Technical efficiency in pig production, how does Ireland rate? Pig Farmers Conferences (21– 23 October), Kanturk/Kilkenny/ Cavan, Ireland, pages 49–57.

Marx, D. and Schuster, H. 1980. Ethologische Wahlversuche mit fruhabgesetzten Ferkeln wahrend der Flatdeckhaltung. 1. Mitteilung: Ergebnisse des ersten Abschnitts der Untersuchungen zur tiergerechten Fussbodengestaltung. *Deutsche Tierartzliche Wochenschrifte* **87:** 369–375.

Marx, D. and Schuster, H. 1982. Ethologische Wahlversuche mit fruhabgesetzten Ferkeln wahrend der Flatdeckhaltung. 2. Mitteilung: Ergebnisse des zweiten Abschnittes der Untersuchungen zur tiergerechten Fussbodengestaltung. *Deutsche Tierartzliche Wochenschrift* **89:** 313–318.

Mitchell, C.D. and Smith, W.J. 1977. Slotted materials in farrowing pens: what to look for. *Farm Building Progress* **49:** 13–14.

Mitchell, C.D. and Smith, W.J. 1978. Slatted and slotted floors in farrowing pens. *Farm Buildings Digest* **13:** 15–17.

Mouttotou, N. and Green, L.E. 1999. Incidence of foot and skin lesions in nursing piglets and their association with behavioural activities. *Veterinary Record* **145:** 160–165.

Mouttotou, N., Hatchell, F.M. and Green, L.E. 1999. The prevalence and risk factors associated with forelimb skin abrasions and sole bruising in preweaning piglets. *Preventative Veterinary Medicine* **39:** 231–245.

Navarotto, P.L., Heinzl. E.L., Giuliani, M.G. and Lanzani, D. 1994. Comparison of farrowing boxes for sows with different types of flooring. *Proceedings of the XII World Congress of Agricultural Engineering, Milan, Italy,* pages 705–712. CIGR General Secretariat: Merelbeke, Belgium.

Nilsson, C. 1988. Floors in Animal Houses. Dissertation, Swedish University of Animal Sciences, Lund, Sweden.

O'Connell, J.M., Leonard, F.C. and Lynch, P.B. 1996. Effect of floor type on the behavioural activity of sows in the farrowing house. *Irish Journal of Agricultural and Food Research* **35:** 66 (Abstract).

Penny, R.H.C., Edwards, J.M. and Mulley, R. 1971. Clinical observations of the skin of suckling piglets. *Australian Veterinary Journal* **47:** 529–537.

Penny, R.H.C., Osborne, A.D. and Wright, A.I. 1963. The causes and incidence of lameness in store and adult pigs. *Veterinary Record* **75:** 1225–1235.

Phillips, P.A., Fraser, D. and Buckley, D.J. 1992. Simulation tests on the effect of floor temperature on leg abrasions in piglets. *Transactions of the American Society of Agricultural Engineers* **35:** 999–1003.

Phillips, P.A., Fraser, D. and Thompson, B.K. 1996. Sow preference for types of flooring in farrowing crates. *Canadian Journal of Animal Science* **76:** 485–489.

Phillips, P.A., Fraser, D. and Pawluczuk, B. 1995. Effects of cushioned flooring on piglet leg injuries. *Transactions of the American Society of Agricultural Engineers* **38:** 213–216.

Pouteaux, V.A., Christison, G.I. and Stricklin, W.R. 1982. Perforated floor preference of weanling pigs. *Applied Animal Ethology* **11:** 19–23.

Quemere, P., Degroote, G., Degroote, S., Stoffaes, J. and Willequet, F. 1988. Types de sol et lesions podales chez les truies et les porcelets. *Journees Recherche Porcine en France* **20:** 123–132.

Roach, B. 1981. Sussing out pig comfort. *Pig Farming* **29:** 47–48 (February).

SAS 1999. The SAS system for windows V8. SAS Institute Inc., Cary, NC 27513, USA.

Smith, W.J. and Mitchell, C.D. 1976. Observations on injuries to suckled pigs confined on perforated floors with special reference to expanded metal (2073f). *The Pig Journal* **1:** 91–104.

Van Veen, H.M., Vellenga, L. and Hoogerbrugge, A. 1985. Mortality, morbidity and external injuries in piglets housed in two different housing systems. II. Rearing period of weaned piglets (age 5.5–10 weeks). *Veterinary Quarterly* **7:** 127–132.

Vellenga, L., van Veen, H.M. and Hoogerbrugge, A. 1983. Mortality, morbidity and external injuries in piglets housed in two different housing systems. I. Farrowing house. *The Veterinary Quarterly* **5:** 101–106.

Waddilove, A.E.J. 1995. Septic feet in weaners. *The Pig Journal* **34:** 126–128.

Webb, N.G. and Nilsson, C. 1983. Flooring and injury, an overview. In: 'Farm Animal Housing and Welfare' (ed. S.H. Baxter, M.R. Baxter and J.A.C. MacCormack), Boston, Martin Nijhoff Publishers, The Hague, pages 226–261.

Wells, G.A.H. 1979. Genetic, physiological and anatomical factors in baby pigs contributing to foot and limb disorders and other injuries attributable to floors. *Pig Veterinary Society Proceedings* **1:** 91–104.

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