BEHAVIOURAL OBSERVATIONS OF PERI-PARTURIENT SOWS AND THE DEVELOPMENT OF ALTERNATIVE FARROWING ACCOMMODATION: A REVIEW

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A number of alternative farrowing systems have recently been developed, some of which have been more successful at improving welfare and productivity than others. It is argued that for a system to be successful it should meet with the behavioural requirements of the sow at this time. A number of studies have been carried out to observe the natural behaviour patterns of the peri-parturient sow in a wide range of environmental conditions. These studies have shown that during each phase of peri-parturient behaviour there are a number of key environmental features and conditions which are important to the sow. These include the social environment, shelter, nesting material and offspring interaction. This information can be useful in the design of farrowing systems. A review of the literature indicated that the more these conditions are met, the more readily the sow can adapt to the system, leading to improvements in maternal behaviour and piglet production.

Keywords: *animal welfare, behaviour, farrowing sow, housing, preference*

Introduction

The farrowing-crate system for housing sows and piglets has received increasing criticism because of the detrimental effect that it has on the welfare of the sow (Hafez & Signoret 1969; Baxter 1982a; Kilgour & Dalton 1984; Vestergaard & Hansen 1984; Lammers & de Lange 1986; Cronin *et al* 1991; Lawrence *et al* 1994). The development of alternative accommodation for the farrowing sow has therefore attracted a certain amount of research (Phillips & Fraser 1993). A number of long-term studies have been carried out in extensive outdoor enclosures to determine the natural peri-parturient behaviour of the sow and the causal and functional mechanisms underlying these activities. These studies have indicated that there are certain environmental features and patterns of social organisation which may be important to sows at farrowing. This information has generated a number of hypotheses which have been tested under experimental conditions. The results of these experiments have in turn given rise to design criteria which have been used in the development of alternative farrowing systems for sows.

Some systems have been designed to house sows individually: such as turn-round crates (McGlone & Blecha 1987); 'Ottawa' crates (Fraser *et al* 1988); ellipsoid crates (Lou & Hurnik 1994); sloped-floor pens (Collins *et al* 1987); and farrowing boxes (Schmid 1991). More recently, there has been increased interest in group systems where animals share

communal areas which contain individual nests (Van Putten & van de Burgwal 1990; Baxter 1991; Houwers *et al* 1992; Götz & Troxler 1993; Rudd *et al* 1993; Bøe 1994; Arey 1995; Rantzer *et al* 1995; Cronin *et al* 1996; Wechsler 1996). Although the overall aim has been to improve the welfare of the sow, a number of behavioural problems still occur. Also, any perceived benefits to the sow need to be balanced against disbenefits to piglets, cost or practical management (Edwards & Fraser 1996). The aim of this paper is to review the development of alternative farrowing systems in relation to the information which has been gathered on the natural peri-parturient behaviour of the sow.

Pre-parturient behaviour

Both wild *Sus scrofa* and domestic sows usually leave the family group prior to farrowing and become less tolerant of group members (Gundlach 1968; Jensen 1986). In semi-natural enclosures, farrowing sites were generally located in areas furthest away from the communal nest (Stolba & Wood-Gush 1984). Jensen *et al* (1987) suggested that sows are motivated to seek isolation prior to farrowing for which there may be a number of advantages: reduced risk of piglets being crushed, trampled or infected; increased mutual recognition; reduced likelihood of inadvertently adopting piglets from other sows and reduced predator attraction.

This motivation to seek isolation can lead to sows becoming aggressive particularly during the pre-parturient phase (Götz & Troxler 1993). Aggression can be reduced in group-farrowing systems by modifying pens to provide more isolation and avoidance potential but it is also important that the sows are familiarized with each other before this time (Arey *et al* 1992a). Keeping sows together in familiar groups in order to minimize aggression has been addressed in a number of systems. In integrated systems, sows remain together in one large group and are given access to specific nesting areas from farrowing until weaning (Bøe 1994). In family systems, small groups of sows remain together in one pen with their offspring (Stolba & Wood-Gush 1984; Kerr *et al* 1988; Arey 1995; Wechsler 1996).

The search for a nest site begins approximately 1–2 days before farrowing. This takes 4–6 hours, during which time the sows in outdoor enclosures may cover up to 6.5km (Jensen 1986). Sows appear to be strongly motivated to perform locomotive behaviour at this time (Hafez & Signoret 1969; Haskell & Hutson 1994) and still cover large distances even when housed individually in straw-bedded pens (Baxter 1982a). According to Baxter (1991), sows need to be able to walk around their farrowing environment rather than simply having enough space to turn around as is the case in some individual pens without crates (Collins *et al* 1987; McGlone & Blecha 1987; Fraser *et al* 1988; Lou & Hurnik 1994). It is not known whether this ambulatory behaviour is internally motivated or whether it can be reduced by providing an optimum nest site in an isolated location. Hesse (1992) found that sows with greater freedom were more active and showed higher levels of maternal behaviour. However, in relatively confined conditions Heckt *et al* (1988) found that pre-partum behaviour in gilts was largely unaffected by pen size. It may be that the quality of the space is more important than the amount of space per se.

Sows choose nest sites which afford a view of the surrounding area. In semi-natural conditions most nests were found on open ridges or on the borders of wooded areas (Stolba & Wood-Gush 1984). In a group-farrowing system which housed four to six sows, there was a tendency for the first farrowing sow to choose the pen closest to the building entrance from where the stockperson would normally approach (Arey unpublished data). Van Putten & van

de Burgwal (1990) reported that the sow's requirements could be met in a group system by arranging the pens in a circle so that each animal had a certain degree of privacy whilst still being able to survey the whole house.

Stolba & Wood-Gush (1984) also found that most nests were established in sheltered sites. Out of 100 nests, 40 per cent were at least partially covered by the branches of trees or bushes and 89 per cent were sheltered on at least one side. Sows were observed gathering larger branches and placing them around the side of the nest. Indoor sows also avoid open spaces preferring to build nests in enclosed areas, which may partly explain the low rate of occupancy found for nest boxes which provide little vertical protection (Fisher 1990). Sows choose to farrow in areas enclosed by three or four walls (Hunt & Petchey 1989) or between two close parallel walls (Petchey 1991). Preference for enclosed spaces was found to be reduced when open-bar fences were used (Haskell & Hutson 1994). Baxter (1991) found that walls were even more attractive when they sloped inwards at the bottom because they aided the sow during her lying down movements.

One of the difficulties with group-farrowing systems is determining the right size for the nest areas. Van Putten & van de Burgwal (1990) were of the opinion that nest areas should be large enough to allow the sow to turn round. However, this can create difficulties because of the large size difference between sows and gilts. Too much restriction may discourage sows while too much space can lead to pen sharing, particularly by gilts (Arey *et al* 1992a; Arey 1995). Pens designed with two entrances can overcome this problem as space can be minimized because the sow does not need to turn around. Pens with two entrances were equally attractive to sows as pens with one entrance (Cooke 1995) but were more difficult to manage (Arey 1995). Piglet restraint barriers (200mm step) were not found to discourage sows from using nest areas (Cooke 1995).

Although sows kept outdoors may prefer some overhead cover, sows kept inside do not show a preference for roofed farrowing areas (Sancha & Arey 1995). However, farrowing areas with roofs were preferred by sows farrowing for the first time. Similarly, Phillips *et al* (1991) found that younger sows (2nd or 3rd parity) showed a clear preference for fully enclosed, solid-sided crates whereas preference in older sows (4th–9th parity) was unaffected by whether the crates were covered. Primiparous sows are generally more fearful and agitated at farrowing than older, more experienced sows (Cronin & van Amerongen 1991). They may therefore prefer more enclosure because it provides a greater feeling of security and isolation. Preference for shelter can also be affected by the prevailing environmental conditions. In very cold weather sows choose more sheltered sites (Jensen 1989) and may forgo their preference for isolation in favour of protection from the weather (Jensen *et al* 1993).

The selection of a nest site is therefore affected by a number of factors. Choice may be influenced by the location of the feeder and drinker (Haskell & Hutson 1994). Provision of an adequate water supply and areas in which sows can cool down are also important considerations (Arey 1992). Feeding sows within their farrowing areas was considered to contribute significantly to the high rate with which sows used the pens at farrowing (Arey 1994). Systems in which sows are fed outside the pens appear to be less successful at attracting the sow (Houwers *et al* 1992). Perhaps one of the main determinants in nest site selection is the availability of materials with which sows can build a nest.

Nest building behaviour

Nest building behaviour has been described in detail for wild sows (Gundlach 1968); domestic sows in semi-natural environments (Stolba & Wood-Gush 1984; Jensen 1986); and domestic sows housed in straw pens (Baxter 1982a; Arey *et al* 1991). The selected area is hollowed out by rooting movements of the snout. The sow then collects nest material such as leaves and twigs and uses this material to line the hollow. Scattered material is scraped round the edge of the nest by pawing movements of the forelegs. The edge of the nest is further built-up with larger twigs and branches to give solidity to the structure. The sow makes repeated entrances into the nest to readjust material and finally gives birth to the piglets.

Sows therefore show a preference for floor surfaces which can be rooted. In a choice between concrete and sand floors (room temperature 15°C) all 12 sows were observed to build a nest and farrow on the sand (Arey *et al* 1991). Sows which had free access to an earth-floored pen (room temperature 20°C) all dug a nest and farrowed in it (Hutson & Haskell 1990). However, use of the earth pen was interrupted when the sows had to lift a lever to gain access to the pen but this may have been caused by the uncertainty created by the opening and closing of the gate.

The gathering of nest material and manipulation phases of nest building are also seen in domestic sows (Baxter 1982a). In semi-natural environments sows line their nests with grass, leaves and twigs (Stolba & Wood-Gush 1989; Jensen 1989). The amount of material gathered depends on experience, with older sows gathering more bedding (Jensen 1989). When offered straw ad libitum from a dispenser, it was found that sows removed approximately 23kg of straw which they deposited in and around the nest hollow (Arey *et al* 1991). In another experiment, sows were trained to lift a lever 10 times in order to gain access to 2kg of straw (Hutson 1992). Lifts made for straw were no greater than those made for the control (an empty box), suggesting sows were not highly motivated to obtain the nesting material. However, when food was compared with a pen containing 18kg of straw, as the cost of access in panel presses for the two was increased, the number of panel presses made for both commodities declined at a similar rate (Arey 1992). As the sows approached farrowing, panel presses for straw increased significantly but not for food. This indicated that straw is a highly valued commodity to sows approaching farrowing and highlighted the importance of the methodology used in operant techniques. Even sows confined in crates would appear to benefit from the provision of bedding prior to farrowing (Edwards & Furniss 1988). Cronin *et al* (1993) found that the duration of parturition, the number of stillborn piglets and the number of piglets overlaid were reduced by providing sawdust to young sows in farrowing crates. Unfortunately, the relative benefits of bedding and freedom of movement have been confounded in most studies and information is still needed to determine the stress levels of confined farrowing sows kept with and without bedding (English 1993).

Baxter (1982b) proposed that nest building behaviour may be controlled by a negative feedback mechanism which might involve the sow's udder. He speculated that a nest which provided comfort for the udder might 'switch off' the motivation to nest build. However, later work showed that when sows were presented with a pre-formed nest, they gathered less nest material but the total amount of nest building behaviour was not reduced (Arey *et al* 1991). Similarly, when pre-formed nest features were presented to sows there was no significant preference for either a nest containing a hollow, a mattress or a built-up rim

though all were chosen in preference to a control with no nest feature (Arey *et al* 1992b). In subsequent trials, sows were offered the same choices except straw bedding was supplied in the 1.5m^2 control area at varying amounts. All the sows chose to farrow in the bedded area when it contained at least 4.5kg of straw but at 2.25kg of straw some sows moved the straw to enhance the pre-formed nests and farrowed there instead.

Straw is a preferred nesting material because it can be manipulated by the sow. If nest material such as cloth tassel is fixed, sows will pull and tear at it but less so if straw is also available (Widowski & Curtis 1990). Cronin *et al* (1996) found that all sows farrowed in designated areas which contained rice hulls. In a group-farrowing system (Arey 1995), sows were given the choice of nesting in pens containing either 7.5kg of straw or 7.5kg of wood-shavings. Out of 17 sows, 15 farrowed on straw and two farrowed on wood-shavings after bringing in straw from other pens (Arey unpublished data). A sufficient amount of straw bedding allows sows to perform most of their nest building activities and thereby may be used to attract sows to a designated farrowing area. However, even when bedding and other factors are taken into consideration, nest occupancy at farrowing in group systems may still be unacceptably low (Houwers *et al* 1992). One way round this is to use deep straw-bedding over the whole floor area as in the 'Thorstenssen system' so that it is less important where the sow farrows (Algers 1991). The provision of bedding can be a problem in smaller farrowing pens designed to allow the sow to turn round because fully-slatted floors are required to rid the lying area of the animals' dung. This can be overcome in larger pens with separate areas for lying and dunging (Schmid 1991).

The function of the nest would appear to be protection for the piglets from both climatic conditions and predators. Jensen (1989) found that out of 49 nests built outdoors, all contained enough nest material to completely cover the piglets and 15 contained enough to cover the sow as well. In winter, sows gather more nest material than in summer (Jensen 1989). As a result, temperatures measured within the nests were unaffected by external temperatures which ranged from 7°C to minus 17°C (Algers & Jensen 1990). In South Carolina, USA, where July temperatures average 27°C, the nests of feral pigs consisted of simple scrapes containing pine straw (Kurz & Marchinton 1972). Buss (1972) suggested that protection from the weather may be the reason why the nest building behaviour of sows kept inside is modified.

Nest building in pigs is a complex behaviour which is dependent on both internal and external causal factors. The first phase of preparation of the nest site would appear to be largely triggered by internal factors, eg hormone levels (Arey *et al* 1992b; Jensen *et al* 1993). The second phase of gathering and arranging the nest material would appear to be under the control of negative feedback from external stimuli, eg the nest (Arey *et al* 1991; Jensen 1993). Sows housed without access to nesting materials are observed to perform the first part of nest building only, which includes rooting and pawing (Lammers & de Lange 1986; Jensen 1993).

There is a significant rise in the plasma concentrations of prolactin at the same time as nest building starts (Taverne *et al* 1979; Meunier-Salaün *et al* 1991), suggesting that prolactin has a significant role in initiating nest building behaviour. This effect is less well-mediated in gilts farrowing for the first time and concentrations of prolactin may increase with parity (Lawrence *et al* 1994). Castrén *et al* (1993) also found that straw gathering correlated positively with progesterone concentrations and negatively with somatostatin

concentrations indicating that the second phase of nest building may also be under the influence of endocrine control. The cessation of nesting activities and the onset of labour were found to coincide with an increase in oxytocin release (Castrén *et al* 1993).

Parturient and post-parturient behaviour

Sows are still intolerant of other group members at farrowing and may attack other sows which encroach too closely (Stolba & Wood-Gush 1989). Disturbance at this time, particularly from dominant sows, can lead to piglets being trampled or even savaged by their mothers. Jensen (1989) showed a tendency for higher piglet mortality the more sows were congregated at farrowing and disturbance from other sows was found to put piglets at greater risk in outdoor paddocks (Head *et al* 1995; Higgins & Edwards 1996). Similarly, Bøe (1991, 1993) reported that sows housed in individual pens tended to rear more piglets than those housed in groups. Evidence suggests that sows are more likely to farrow in the nest areas, resulting in improved piglet survival when housed in smaller groups (Götz & Troxler 1995) than in larger groups (Houwers *et al* 1992). Ebner (1993) found that groups of 10–12 sows performed better than groups of 16–20 sows.

Behaviour at parturition has been described in detail for wild sows *(Sus scrofa)* (Gundlach 1968; Graves 1984) and domestic sows (reviewed in Hurnik 1985). During the birth process wild sows lie on their sides and may change position several times, which can help to free the piglets from their umbilical cords. Sows may sniff at their new-born piglets but otherwise little assistance is given to them at birth. Sows spend most of the first 24 hours nursing their piglets, which begin suckling almost immediately from birth. Group-housed sows (Arey & Sancha 1996; Cronin *et al* 1996) and sows with access to straw (Cronin & Smith 1992) spend more time nursing their piglets which may lead to higher piglet growth rates. Group-housed sows are also more responsive to piglet alarm vocalizations than sows confined in farrowing crates (Arey & Sancha 1996). In contrast to confined sows, loose sows take greater care when lying down; rooting through the bedding to disturb the piglets before lying (Baxter 1984). Although these maternal behaviours have an important role in more natural environments, there is little evidence that they improve piglet survivability in a restricted indoor environment (Cronin *et al* 1994; Cronin *et al* 1996). Very little work has been carried out on the study of mother/offspring behaviour in outdoor production systems.

In detailed observations of a semi-natural environment, domestic sows remained in the nest for 90 per cent of the 48 hours after farrowing (Stangel & Jensen 1991). They found that sows abandoned the nest at 6–7 days, after gradually spending longer periods away from the nest. This behaviour may cause problems for group-farrowing systems. In group systems nest abandonment may occur earlier, leading to higher piglet mortality, particularly if the nest area is restrictive (Rudd *et al* 1993). In sow-controlled systems where the sow (but not the piglets) is able to leave the nest area, the litter may become abandoned so early as to reduce growth rates and survivability (Bøe 1993; Rantzer *et al* 1995). In systems where piglets are not confined to the nest, control of piglet movement is important. Restricting piglets to the nest for the first week reduces milk stealing and allows bonding between mother and offspring (Van Putten & van de Burgwal 1990). Once the sow starts to abandon the nest it is necessary to remove this restriction of piglets. In group systems, this should be done gradually as sudden mixing can lead to problems with cross-suckling (Hatet *et al* 1994; Arey 1995).

After one to two weeks, sows and their litters in outdoor enclosures begin to integrate with other members of the herd (Jensen & Redbo 1987). In group systems sows may begin to intrude into other nest areas. This can be overcome by using electronic gates (Buré & Houwers 1989) but was not considered to be a problem by Bøe (1994). After four weeks, spatial and nasal contact between mother and offspring is significantly reduced (Jensen 1988). The frequency of nursing bouts gradually becomes lower with the sow initiating fewer and terminating more bouts (Jensen 1988). Finally the piglets are weaned between 9 and 17 weeks (Newberry & Wood-Gush 1985; Jensen & Récen 1989). In sow-controlled systems weaning occurs much earlier. In these systems, half the sows kept in individual pens had weaned their piglets by week 10 (Bøe 1991) and half of the sows in group systems by week 5 (Bøe 1993). In a group-housed system where piglets were able to follow their mothers, sows began to wean their piglets after eight weeks though suckling behaviour was still observed at 12 weeks (Arey 1995).

It would appear that in restricted systems, sows suffer as a result of not being able to escape the demands of their piglets (Ladewig *et al* 1984; Passillé de & Robert 1989; Cronin *et al* 1991). One way to overcome this problem is to confine sows at farrowing and then after two weeks release both sows and piglets into a multi-suckling system. However, this may lead to cross-suckling which can be highly stressful and can affect performance (Petchey *et al* 1978), though recent research has shown that this can be reduced by better management (Wattanakul *et al* 1996).

Productivity

In farrowing systems which do not confine the sow, the number of piglets which are overlaid or crushed tends to be higher compared with farrowing crates. However, in the largest survey carried out to date, there was no significant difference in overall mortality between crates and individual pens (Gustaffson 1982) (reviewed in Arey 1993). Mortality of liveborn piglets in farrowing crates for the UK national herd ranges between 11.7 per cent (Meat and Livestock Commission (MLC) 1996) and 12.2 per cent mortality (Pig Improvement Company (PIC) 1996). In pens which allow the animal to turn only, mortality figures range between 8.7 per cent (Fraser *et al* 1988) and 15.4 per cent (Lou & Hurnik 1994). Figures for sloped-floor pens range between 9.1 per cent (McGlone & Morrow-Tesch 1990) and 12.4 per cent (Collins *et al* 1987). In slightly larger individual pens mortality figures range between 11.5 per cent (Schmid 1991) and 14.5 per cent (Bøe 1991).

For integrated systems, a mortality rate of 11.3 per cent was achieved in an experimental study (Buré & Houwers 1993) though the average mortality rate from a survey of Norwegian herds was 16.3 per cent (Bøe 1994). Piglet mortality in group systems has been recorded at 13 per cent (Algers 1991); 20.7 per cent (Arey 1995); 12 per cent (Baxter 1991); 23.9 per cent (Götz & Troxler 1993); 26 per cent (Kerr *et al* 1988); 22.7 per cent (Marchant *et* al 1996); and 25 per cent (Rudd *et al* 1993). It is not clear why integrated systems should generally perform better than ordinary group systems, except that in some integrated systems sows may be locked in their pens five days prior to farrowing until a few days after (Houwers *et al* 1992; Bøe 1993).

Unfortunately, most of the studies made on alternative systems have been small-scale and little can be concluded until these systems have been tested under fully commercial conditions. There is evidence that piglet mortality may improve as a result of sows and

stockpersons becoming more experienced with loose-housed farrowing systems (National Agricultural Centre 1994; Wechsler 1996). The number of piglets raised in UK outdoor systems, which are almost entirely dependent on the maternal behaviour of the sow, are very similar to the numbers raised in farrowing crates with mortality rates between 11.2 per cent (MLC 1996) and 13.3 per cent (PIC 1996).

Productivity aside, there are a number of factors which make loose-housed systems less economic than farrowing crates, including the need for more space. Loose-housed systems, particularly group systems, are more labour intensive and require different husbandry skills. One of the main problems with group systems is cross-suckling which leads to piglet injuries and poor performance (Götz & Troxler 1993). The management of dung can also be a major, practical difficulty. In group-farrowing systems sows will use each others nest areas for dunging once the nests have been abandoned for one week (Van Putten & van de Burgwal 1990). Even with designated dunging areas, eliminative behaviour still occurs in other parts of the pen which may be more difficult to clean (Wechsler 1996). A further problem in loose-housed farrowing systems is that some sows may be very protective towards their piglets and as a result become aggressive towards stockpersons.

Summary and animal welfare implications

Sows begin to get highly active around one to two days before farrowing. The aim of this activity is to find a suitable nest site away from other pigs. It is not known how much space is required by sows. It is possible that the need for space is reduced where sows are kept apart, though the need for isolation does not appear to be predominant. If housed together in groups, sows should be well-acquainted and be able to avoid each other in order to minimize aggression and thus improve welfare.

Sows usually select a nest site which provides both an open view of the surroundings and a certain degree of cover. Areas designated for farrowing should allow the sow to see the approach of other animals and stockpersons. They should also provide some degree of enclosure with three or four solid walls, particularly where they are used by gilts or younger sows. Roofs over indoor farrowing pens do not appear to have any great effect on sow preference, though again they may be of benefit to gilts. Step-over barriers designed to prevent piglet escape do not appear to deter sows. Feeding sows within the nesting areas encourages pen usage at farrowing.

Nest building is highly motivated behaviour which is dependent on both internal and external factors. Substrates which allow these activities to be performed are highly valued by sows. The provision of adequate straw acts as a key stimulus in allowing most of these nest building activities to be performed thereby attracting sows to use a designated farrowing area. Approximately 4.5kg of straw over 1.5m^2 would seem to be sufficient. Other substrates such as wood-shavings or earth floors appear to be less attractive. Artificial nest sites, particularly those which cannot be manipulated by the sow have even less effect on sow preference. More information is required on the combined effects of space and bedding on the welfare of sows, as the two factors have been confounded in most studies.

Sows are very sensitive to disturbance at farrowing, particularly from other sows and piglet survival is improved when sows are isolated at this time. Sows do not usually congregate with other group members until several days after giving birth and may become increasingly protective of their young. Studies of outdoor systems indicate that maternal

behaviour has an important role in piglet survival though it may have less of an effect in more restricted environments. The provision of isolation, freedom of movement and bedding all appear to improve nursing behaviour and the welfare of both sows and piglets. Sows should be able to get away from their piglets and this becomes increasingly important after around 10 days when sows would normally leave the nest. However, sows may abandon their offspring completely if the piglets are unable to follow their mother.

In terms of piglet survival, the most successful systems would appear to be at either end of the spectrum – either complete control of the sow (as in farrowing crates) or minimal control (as in outdoor systems). The problem with systems between these extremes appears to be that they have difficulty in accommodating the large variation in sow behaviour which occurs at this time and leads to greater demands on the stockperson. The tendency for individual pens to work better than group systems could also be a reflection of this fact. Individual pens would also appear to be better for the welfare of the sow because they eliminate aggression. More work is needed to study the behaviour and welfare of sows in outdoor systems.

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