Welfare Implications of Intensive Animal Systems with Effects on Production

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Introduction

There are a number of welfare concerns in intensive animal industries that have implications for growth and production. Broom (1994) for example, has listed a number of changes designed to improve the general economic efficiency of intensive animal production enterprises and the level of production efficiency per animal, and welfare problems reported for animals. Some production-welfare problems cited by Broom include increased stocking density and increased disease, fewer animal care staff and problems missed, and improved nutrition for energy partitioning and incorrect muscle-to-bone ratio. In addition, other welfare and ethical issues are being vigorously debated, particularly in Europe, as a consequence of transgenic procedures or administration of biotechnology products (Broom, 1993). While these are issues which must be addressed by the intensive animal industries, it is not our intention here to provide an exhaustive review of the literature on all relevant animal welfare issues. Such a review is beyond the scope of this paper. There are however, recent reviews in the literature for pigs (Bamett and Hutson, 1987; Baxter, 1989), layer hens and broilers (Hemsworth and Bamett, 1993) and dairy cows (Hemsworth *et al.*, 1995) that are detailed and specific. In addition, there are other welfare reviews in the literature of a general nature and others which present results across species (Broom, 1988, 199 1; van Putten, 1988; Appleby *et al.*, 1992) or on specific issues such as the human-animal relationship (Hemsworth *et al.*, 1993).

There is considerable debate on the objective assessment of welfare in animals. The first part of this review defines our approach to its assessment and provides some support for this approach. The second part concentrates on welfare-production issues in pigs, both housing for pigs and the human - animal relationship.

Objective Assessment of Welfare

Definitions of welfare include concepts such as "satisfactory state", "well-being", "suffering" or other subjective "feelings". Clearly these are abstract concepts that will impose difficulty when defining animal welfare, but the lack of ability to define welfare does not remove the need to take serious consideration of the real problems which animals may experience. It has been proposed that the most appropriate approach in assessing welfare is the "best estimate" approach using a range of indicators (Broom, 1986, 1991; Bamett and Hutson, 1987; Bamett and Hemsworth, 1990). This approach involves measurement of parameters that are arguably indicators of welfare, including stress physiology, behaviour, mortality, health and productivity (see Sybesma, 198 1; Baxter *et al.*, 1983; Aumaitre and Dantzer, 1984).

These criteria, which can be used to assess welfare, rely on showing some evidence of change. For example, changes associated with the stress responses have been widely used as physiological indicators of welfare (Dantzer *et al.*, 1983; Dantzer and Mormede, 1983; Moberg, 1985). Similarly, changes in behaviour, particularly the occurrence of abnormal behaviours, have been used as behavioural indicators of welfare (Broom, 1983; Wiepkema *et al.*, 1983). It is axiomatic that anything that reduces health will reduce welfare (Duncan and Dawkins, 1983); frequently used health indicators are disease, lameness, injuries and measures of immune function. The use of production variables as indicators of welfare is a contentious issue (see Duncan and Dawkins, 1983). However, if a chronic physiological stress response is considered as an acceptable indicator of welfare, then on the basis of the effects of chronic stress on growth and reproductive efficiency, there is justification in including production variables in the list of welfare indicators. There are numerous examples in the literature of substantial changes in stress physiology, indicative of poor welfare, associated with changes in productivity in a number of farm species (Flux *et al.*, 1954; Brush, 1960; Esbenshade and Day, 1980; Pesti and Howarth, 1983; Vamer and Johnson, 1983; Echtemkamp, 1984; Koelkebeck and Cain, 1984). Corticosteroids, which are considered to be a mediator of the stress response, are intimately involved in nitrogen balance (Imms, 1967; Ingle and Prestrud, 1949; Moreiras-Varela et *al.,* 1978) and there are other studies that indicate a negative relationship between stress and reproduction (Barb *et al.*, 1982; Esbenshade and Day, 1980; Moberg, 1985; Pollard, 1984; Ramaley, 1981; Rivier and Rivest, 199 1).

The major debate arises over interpretation of these changes. Change per se is not an indicator of a change in welfare as the animal's behaviour and physiology are continually being adjusted to maintain homeostasis and the animal is obviously not in a continual state of changing welfare because of these continued adjustments (see Baxter, 1989). The important question for animal welfare is "at what level of change (for example, in physiology and behaviour) is welfare at risk?" Our current state of knowledge does not allow this question to be adequately answered, however several authors have proposed some provisional answers (Barnett and Hutson, 1987; Barnett and Hemsworth, 1990; Mendl, 1991). In this review we will utilise evidence of significant change in these so-called best indicators of welfare, as a consequence of management or environmental changes, as evidence that welfare of the animal may be at risk.

Housing - Welfare and Production of Pigs

Individual housing around mating and during gestation

There have been several studies attempting to relate housing system and reproductive performance in pigs. However, the data are equivocal. More than half of the 15 studies conducted between 1969 and 1984 (see reviews by Hemsworth, 1982 and Lynch *et al.,* 1984) suggest that reproductive performance is better (on the basis of mating, conception or pregnancy rates) in groups (two or more pigs), while only four studies suggest it is better in individual housing (cage-stalls, tether-stalls or pens). One of the reasons for these equivocal results may be that the design of the housing system was not considered. For example, initial research on tether housing indicated that community concerns about the welfare of pigs in this system was substantiated on the basis of evidence of a chronic stress response (Barnett *et al.,* 1985, 1987a, 1987b), increased gluconeogenesis and lower immunological reactivity (Bamett *et al.,* 1987a), an increased metabolic rate (Cronin *et al.,* 1986), reduced reproductive performance (Barnett *et al.,* 1991) and increased incidence of skin lesions (de Koning, 1985). Another study also showed a chronic stress response in tethers, on the basis of increased responsiveness to adrenocorticotrophic hormone (von Bore11 and Ladewig, 1989). Other studies (Becker *et al.,* 1985; Friend *et al.,* 1988) have shown evidence of acute responses to tethering, although the latter study found no long-term effects of different housing systems. The mechanism for some of the chronic physiological changes appears to be a behaviourally induced chronic stress response which can be alleviated by modifying the design of the tether-stall to minimise aggressive interactions between adjacent pigs (Barnett *et al.,* 1987b). Thus, if the tether stall divisions, which in the above studies by Barnett *et al.* were of vertical bars, are covered with mesh, the physiological responses of tethered pigs are similar to group housed pigs. Thus, these data indicate that it is the design of the tether stall that is important to welfare rather than housing in tethers per se. Similarly, with individual (cage) stall housing it is the design of the stall divisions that are important to welfare (i.e. stall divisions should be of vertical rather than horizontal bars; Bamett *et al.,* 1991). Another study that has implications for production is one that showed that individual housing in stalls adversely affected bone strength / leg problems (Marchant and Broom, 1994), which may have consequences on culling rates and the profitability of the farm enterprise.

One study by Bamett and Hemsworth (1991) compared reproductive performance in individual housing of a design that was known to result in a chronic stress response (tether stalls with vertical bars) and group housing. Housing pigs in tether-stalls during the mating/gestation period had adverse effects on oestrus detection rates, successful copulations and conception rates which in combination resulted in an overall reduction in pregnancy rate (65 vs. 86% for tether and group housed pigs, respectively).

A criticism of conventional stall housing for adult pregnant pigs is that pigs are unable to turn around. There have been some recent innovations that have resulted in a design of stall that allows pigs to turn around (McFarlane *et al.,* 1988; Johnson *et al.,* 1990). In the commercial design of the "turn-around-stall" the divisions are hinged about 60 cm from the front so that the back two-thirds of the divisions can move sideways and thus pigs can "borrow" space at the rear of the stall to allow them to turn around. Commercial experience indicates that pigs quickly learn to use the stalls and an experiment by J.L. Bamett and I.A. Taylor (unpublished data) showed that on average pigs turned around 66.3 times during the first 12 h after entry and 21.5 times for a similar time period 43 days later and that there were similar cortisol concentrations to group housed pigs. The production consequences of this system have not been determined, although turn-around-stalls are in commercial use in both Australia and the USA and there is anecdotal evidence of improved conception rate and stillbirth rate (I.A. Taylor, personal communication).

Group housing of sows during gestation

Indoor group housing is a common housing system for pregnant pigs and, while some attention has been given to factors such as space allowance and group size (Jensen *et al.,* 1970; Ford and Teague, 1978; Kuhlers *et al.*, 1985; Barnett *et al.*, 1986; Hemsworth *et al.*, 1986), particularly for reproductive performance, little consideration has been given to other factors such as social contact / dominance order and design features in pens that may affect welfare. A common criticism of individual housing systems for pigs is that social contact is disrupted. However, the effects of social rank on reproductive success of group-housed sows indicates potential problems for certain animals. For example, Nicholson *et al.* (1993) reported that, compared with dominant and submissive sows in the same group, socially intermediate sows showed specific signs of stress (elevated cortisol and reduced natural killer activity), had lower far-rowing rate and smaller litter size. Other factors such as space allowance are also likely to be involved. Recommendations for space requirements for adult pigs are few, probably based on current practice and are in the range of 1.4-1.8 m^2/pig (Cale, 1979; Anon, 1983a, 1994). There is clear evidence of a chronic stress response and reduced reproductive performance if space allowance is insufficient (e.g. 1 m^2/pig; Hemsworth *et al.*, 1986; < 1 m^2/pig; Barnett *et al.*, 1992). While the same study indicated that there may be reproductive performance advantages by housing at 3 m^2/pig than 2 m^2/pig the physiological criteria indicated no differences between these space allocations. None of the recommendations take into account the amount of additional "free space" available to pigs kept in large groups and the potential to reduce space allocation pig in such group pens and this aspect warrants research.

There are no recommendations on group size for adult pigs in Codes of Practice relating to welfare (Anon., 1983a, 1983b, 1994). Nevertheless, this management factor may vary widely in commercial practice and may affect both welfare and sexual behaviour. Studies by Bamett *et al.* (1984, 1986) found that sexually mature gilts housed in pairs were chronically stressed compared to similar gilts housed in groups of 4-8. Both large group size (24 vs. 8 pigs) and small group size (3 vs. 9, 17 or 27 pigs) may have detrimental effects on oestrus expression (Christenson and Ford, 1979; Christenson and Hruska, 1984), while increasing group size and concomitantly decreasing space allowance may have detrimental effects on oestrous expression (Cronin *et al.*, 1983).

Alternative group housing indoors

Because of the intense criticism of individual housing of pigs, considerable effort has been directed to the development and promotion of alternative group housing systems in Europe. In addition to the types of developments for conventional group penning, indicated above, a number of systems, based around electronic feeding stations (EFS) are being "trialed" and recent emphasis has been directed more to overcoming practical problems inherent to group housing than to the resulting level of well-being actually afforded to the sow. Thus, reliable production information for sows in alternative housing systems is scarce. While Rousseau (1989) reported no difference compared with the national average, in reproductive performance for 61 units using an EFS, de Koning *et al.* (1990) in the Netherlands reported slightly reduced productivity in group housing with ESF compared with individual stall housing.

The farrowing /lactating sow

Since the 1960's, there has been a strong trend in the pig industry to house the farrowing / lactating sow in farrowing crates (Phillips and Fraser, 1994). This practice has at least partly contributed to a general reduction in the level of piglet mortality (English and Morrison, 1985). However, the restrictive nature of intensive farrowing accommodation, with its explicit function of restraining the sow and controlling her movements (Baxter, 1984), has attracted the opposition of animal welfare groups' which have moved for a ban or at least limitation on the use of crates in some European countries.

It is paradoxical, that while piglet mortality levels have declined with increased level of intensive housing, it has also been reported that sows housed in crates perform less maternal behaviour (Baxter, 1982; Cronin *et al.*, 1992a and b; Cronin *et al.*, 1994). Clearly, the sow's behaviour is modified by environmental conditions in the pre-farrowing period, but the significance of this for sow welfare is disputed. On the one hand, Baxter and Petherick (1980) and Vestergaard and Hansen (1984) have speculated, on the basis of behavioural observations of pre-parturient sows, that restriction on the sow's pre-partum behaviour would induce a short-term stress response, prolonging far-rowing and increasing stillbirths. Cronin *et al.* (199 1) and Lawrence *et al.* (1994) both reported a significantly greater cortisol response from gilts in crates compared to straw-bedded pens during the first few hours after entry to the far-rowing accommodation. Within 4 hours of placing the gilts in the different farrowing treatments, there were no differences in circulating cortisol concentrations, suggesting that the cortisol response was a short-term response to a new environment. During the 24 h pre-partum and during the period of parturition, gilts in the crate treatment showed a greater increase in free cortisol concentration than gilts in straw-bedded pens, suggesting the crate environment induced a greater stress response in pre-partum gilts. However, there was no evidence of a difference in cortisol response on the day following parturition nor during the first three weeks of lactation.

Thus, it is likely that restraining the primiparous sow at farrowing and/or denying access to bedding material may induce an acute stress response. By the end of the fourth week of lactation, Cronin *et al.* (199 1) reported increased cortisol concentrations for animals in crates and straw-bedded pens, compared with previous two weeks of lactation, suggesting that animals in both treatments were beginning to experience chronic stress responses. It was suggested that the chronic stress response was associated with the persistent attention of the litter and the increased magnitude of the cortisol response for the gilts in crates compared with straw-bedded pens was probably associated with the smaller area available to the litters in the different environments. Further, on the basis of this finding, it may be a valid comment that 4 weeks is the "natural" age of weaning for sows in intensive far-rowing accommodation.

The critical measure of success for farrowing accommodation however, is whether piglet survival (a fundamental measure of piglet welfare) and growth are maximised. While the use of full confinement farrowing crates has assisted with reducing piglet mortality levels, it is apparent that there are at least some effects on the sow which may limit piglet survival. Investigations of the role of pre-far-rowing behaviour by sows (Cronin *et al.,* 1993) suggest that pre-partum nesting behaviour may be associated with the duration/process of parturition, in turn, affecting incidence of intrapartum stillbirths and therefore piglet viability. Generally, investigations of the incidence of stillbirths suggest a greater effect of the gestation than far-rowing environment of the sow. Svendsen and Andreasson (1980) and Vestergaard and Hansen (1984) reported a longer duration of parturition and increase in stillbirths for sows housed in stalls compared to loose accommodation during gestation and crates for farrowing. On the other hand, Cronin and Simpson (1993) found gilts that were loose-housed in gestation and crate-house for farrowing had a higher incidence of stillbirths than gilts that were housed in cage stalls for gestation, but the difference between the last study and the two previous ones may have been related to the parity age of the animals involved. This suggestion therefore has at least two implications. 1) Previously unrestrained gilts may be acutely stressed at parturition in farrowing crates, as suggested by Lawrence *et al.* (1994), with consequences for piglet viability and survival. 2) Older parity sows, particularly those housed in cages stall systems for gestation, may be less fit, have longer fat-rowing times and therefore higher incidence of stillbirths. Ferket and Hacker (1985) forced sows to exercise during gestation and reduced their mean duration of parturition compared to non-exercised sows, however, sows do not appear to exercise voluntarily. The importance of level of sow activity, even while in the far-rowing crate, for stillbirths / piglet viability, is also suggested by the studies of Arey *et al.* (1992) and Cronin *et al.* (1993), where treatments which induced higher levels of activity amongst preparturient sows were also associated with a reduction in stillbirths.

Housing and growth performance

Most studies on stocking density, which includes aspects of both group size and space allowance, are related to the maximum growth performance of young pigs. It is widely accepted that a group size of less than 10 or 12 growing pigs has little or any affect on growth performance (see reviews by Syme and Syme, 1969; Petherick *et al.,* 1989; Komegay and Notter, 1984) or aggressive behaviour (Bryant and Ewbank, 1972). Nevertheless, there is compelling evidence that group housed young pigs do not perform as well as individually housed pigs (see review by Chapple, 1993). This issue warrants further research from the production viewpoint alone, notwithstanding any consequences for welfare.

The Human-Animal Relationship - Welfare and Production

Comprehensive research on the influence of human-animal interactions on farm animals has been conducted in the pig industry and this research has indicated that these interactions may have some serious consequences for both the productivity and the welfare of pigs. Commercial pigs may be highly fearful of humans (Hemsworth and Bamett, 1987) and research on both experimental and commercial pigs has shown that high levels of fear of humans by pigs may markedly reduce the growth and reproductive performance of pigs (Gonyou *et al.,* 1986; Hemsworth *et al.,* 198 1 a and b, 1986, 1987, 1989; Hemsworth and Bamett, 1991). The mechanism involved appears to be a chronic stress response, because, in a number of experiments, pigs which were fearful of humans had a sustained elevation of free corticosteroid concentrations with consequent adverse effects on nitrogen balance and reproduction (Bamett *et al.,* 1983; Hemsworth *et al.,* 198 la, 1986, 1987). Furthermore, the results of studies on commercial pigs in the Netherlands and Australia (Hemsworth *et al.,* 198 1 b, 1989) indicate that high levels of fear of humans may be an important factor in intensive pig production limiting the reproductive performance of commercial pigs. For example, in one of the studies, fear of humans accounted for 20% of the variation between farms in reproductive performance (Hemsworth *et al.,* 1989): In general, reproductive performance was low at farms in which pigs were highly fearful of humans. Fear of humans may also have important implications for the welfare of commercials pigs if, as seen in experimental pigs, commercial pigs that are highly fearful of humans experience a chronic stress response.

Research in the pig industry has shown strong correlations between the attitude and the behaviour of the stockperson and the level of fear of humans and reproductive performance of commercial pigs (Hemsworth *et al.,* 1989). Consequently it has been proposed that, because a stockperson's behaviour towards animals is largely under voluntary control, this behaviour is strongly influenced by the attitudes and beliefs that the stockperson holds about the animals (see Hemsworth *et al.,* 1994). Furthermore, it is the stockperson's behaviour which is an important determinant of the animal's fear of humans. Thus in situations in which the animal is fearful of humans, there is the opportunity for the animal to experience an acute or a chronic stress response. It is the occurrence of a stress response, particularly a chronic stress response, that places both the animal's productivity and welfare at risk.

The implications of this research are most obvious to the breeding pig, since this class of animal receives regular and, at times, very intense contact with humans. Thus in situations in which the behaviour of the stockpersons is poor, the productivity and welfare of animals under the care of these stockpersons will be at risk. The implications for the piglet and growing pig are less obvious and clearly research is required under commercial conditions to quantify the risks to these classes of pigs. However a recent study under commercial conditions (Hemsworth *et al.*, unpublished data) found highly significant and positive between-unit correlations between the withdrawal response of lactating sows at days 2-4 of lactation to an approaching experimenter and the stillbirth rate of sows in the unit. Units in which lactating sows were most fearful of humans had a higher stillbirth rate than those units in which a lower fear response was displayed. The variable 'the percentage of sows withdrawing in the close presence of the experimenter' accounted for about 28% of the variance in stillbirth rate in the farrow ing units.

In addition to these direct relationships between human attitude and behaviour and pig behaviour (fear) and productivity, it is possible and indeed likely, particularly in the long term, that these human factors may have indirect effects on the productivity and welfare of pigs. The attitude of the stockperson towards pigs may influence other important human factors which may directly affect the work performance of the stockperson, such as work ethic, job satisfaction, and motivation to acquire new knowledge about pigs. For example, stockpersons obviously need to have high standards of technical skill and knowledge to properly care for and manage pigs, but stockpersons also need to be highly motivated to apply these attributes. These skills and knowledge may not be fully translated into improved work performance if the stockperson's work ethic is poor. Stockpersons are required to work closely and frequently with animals and thus a poor attitude towards the animal may result in a deterioration in the work ethic of the stockperson. Therefore the attitude and behaviour of the stockperson may affect other important human factors which may impact on the productivity and welfare of pigs. These effects clearly have implication for the productivity and welfare of growing pigs. Recent research has indicated that training programmes, designed to improve the attitudinal and behavioural profiles of stockpersons, can be successfully employed in the pig industry to improve animal productivity and welfare (Hemsworth *et al.*, 1994).

Conclusions

The data presented in this paper indicate that the behavioural, physiological and production responses of pigs can be affected by manipulating physical, social and human influences. Some of the responses can be interpreted in terms of changes to welfare, whereas the interpretation of other changes for welfare will be disputed. It is the role of the scientist to continue the development of methodologies to assess animal welfare, and to apply these to evaluating the consequences of the design and management of whole systems, aspects of systems and husbandry techniques. In addition, the pig industry needs to recognise there are legitimate community concerns over some aspects of the housing and husbandry of pigs, and be prepared to adopt design and management improvements. There is an obvious appeal of 'welfare-friendly' pig production within the modem intensive climate and the overriding consideration must be the welfare of animals. Whether the benefits to animal welfare are real or perceived, there are potential effects on community attitudes and it is this that may ultimately affect Government regulation of pig housing and husbandry.

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