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The science behind the space allocation decision for nursery and grow-finish facilities

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Investment in nursery and grow-finish facilities represents the most capital-intensive portion of modern pork production systems. It also is the investment most likely to have the lowest asset turnover ratio as a measure of financial return to investment. Thus, the decision on how many pigs to stock a facility with has major economic impacts. Not only must a decision be made regarding the number of pigs to put into a facility each time it is stocked, during the construction of the facility decisions must be made regarding the number of pens per facility and hence, the number of pigs per pen.

The basic decision

Stocking density, in terms of floor area, has traditionally been expressed as area per pig (Fritschen and Muehling, 1986), or when a pen of known area is used, as pigs per pen. Under conventional management systems, pigs remain in the same pen for several weeks, and space allowance is based on the maximum space required during that time period. For pigs that are removed from the pen as a group, such as when pigs are moved from a nursery to a growing-finishing barn, the maximum space requirement occurs on the day of all pigs leaving the pen. For finishing pigs, the maximum space requirement usually occurs the day that the first pig from a pen is removed for market.

Results from numerous research trials (Kornegay and Notter, 1984) make it clear that as nursery and growing-finishing pigs are provided less space per pig, feed intake decreases, with a decrease in daily gain. The impact on feed conversion efficiency is less predictable.

In the past, space allocation recommendations were weight specific (Fritschen and Muehling, 1986). The challenge in these recommendations is that they were often considered as absolute values within a given weight range, rather than as a continuum of values relating to pig growth.

Space allowance can be expressed as an allometric relationship between body weight and body dimensions. The relationship between space allowance (A) and body weight (BW) can be expressed as $A/BW^{.67}=k$ (Petherick, 1983). A recent summary of research studies suggests that the maximum growth rate for the entire grow-finish period will be achieved at a coefficient (k) of 0.0336 (Gonyou et al., 2005), when A is m^2/pig and BW is in kg. This converts to a coefficient (k) of 0.2145 when A is in ft^2/pig and BW is in pounds.

The metric $k = 0.0336$ is very close to the $k = 0.0339$ as the predicted average space occupation for 50 kg lying pigs and the $k = 0.035$ as the predicted average space occupation for 100 kg lying pigs in pens that were 40% slatted (Ekkel et al., 2003).

Table 1 lists the space allocations predicted to have no impact on daily gain and the space allocations predicted to reduce daily gain 5% based on these k values and the allometric equation. For fully slatted facilities, each 3% decrease in space allocation resulted in a 1% reduction in daily gain and daily feed intake for the entire grow-finish period (Gonyou et al., 2005). These researchers were unable to determine a statistical correlation between space allocation and feed conversion efficiency. However, crowding has not been demonstrated to increase the variation in weight within a pen at slaughter (Kornegay et al., 1985; Brumm et al., 2001; Brumm, 2004; Brumm et al., 2004b).

Table 1: Predicted adequacy of space (in ft^2/pig) allocation for fully slatted facilities based on Gonyou et al. (2005).

Weight, lb	Adequate space	5% reduction in ADG
50	2.9	2.5
100	4.6	3.9
150	6.1	5.2
200	7.3	6.2
250	8.5	7.2

Space allowance and codes of practice

The Swine Welfare Assurance Program of the National Pork Board uses the Swine Care Handbook (NPB, 2002) as the basis for assessing the space allocation adequacy of swine facilities. The Handbook currently uses the recommendations of Fritschen and Muehling (1986) as the basis for its recommendations. The current recommendation is 8 ft^2/pig from 150 pound BW to slaughter. This recommendation is at or above the space allocation predicted to be adequate for maximum performance up until 227 pounds BW (**Table 1**).

The European Council (2001) specifies space allowances for several weight ranges of pigs that approximate k values of 0.028 for grow-finish pigs when using metric units in the allometric equation to assess space. On the other hand, the Canadian Code of Practice (AAFC, 1993) recommends a metric k of 0.035 for pigs on fully slatted floors.

Current industry practices

Recent survey results suggest the average stocking density for finishing facilities in the U.S. is 7.2 ft^2/pig, with a range of 6.8 to 8.0 ft^2/pig (Brumm et al., 2004a). Results from this survey do not suggest any regional (Southwest versus Midwest) differences in stocking density, nor do they suggest any difference in density for full versus partial slats.

Impact on carcass merit

The impact of space allocation on carcass backfat and percentage lean have only been reported in a few trials (Brumm and Miller, 1996; Hamilton et al., 2003; Brumm et al., 2004b; Brumm, 2004). In all trials, the leanest carcasses and the carcasses with the smallest backfat depth were those in pigs given the lowest space allocation treatment. From the limited data available, it is not possible to predict the impact of space allocation on carcass traits, other than to state that the effect is a slight improvement in carcass lean and a slight decrease in carcass backfat depth as space is restricted with a resulting decrease in daily feed intake.

Interaction of group size and space allocation

In general, pigs use their sense of smell to locate peers with a social group (Meese and Baldwin, 1975). As long as the social group is limited to 20-25 pigs, pigs can rely on these olfactory clues and form stable social hierarchies (Meese and Ewbank, 1972). When group sizes become larger than this, an unstable social grouping occurs. Unstable groups are characterized by 1-5 dominant pigs in the social group, 1-5 submissive pigs in the group, and the remainder unsure of their social ranking. This instability is demonstrated by frequent social disruptions (fighting), resulting in slight reductions in performance.

Within the range of 5 to 30 pigs per pen, summaries of research suggest that for each additional pig within a pen, assuming adequate space allocation, daily gain decreases .004 lb/day during the grower phase and .003 lb/day during the finisher phase (Kornegay and Notter, 1984).

Recently, the industry has begun using large pen facilities for wean-to-finish, nursery, and finishing facilities. The evidence available to date suggests that housing newly weaned pigs in large groups (upwards of 100 pigs per pen) results in a depression in daily gain and feed intake for the first 6-8 weeks post-weaning (Wolter et al., 2001). However, there does not appear to be any negative long-term effect on performance when housing growing-finishing pigs in large groups (Wolter et al., 2001; Turner et al., 2003).

The above discussion centered on the independent effects of space allocation and number of pigs per pen. In production systems where pen size is fixed, space decisions are confounded with the number of pigs per pen. That is, as the number of pigs per pen increases and pen size remains the same, the space per pig decreases.

A key component of the impact of this confounding is the issue of ‘free space’. Free space is defined as the space within a pen not directly occupied by a pig (McGlone and Newby, 1994). Free space includes space necessary for such activities as dunging, drinking, eating, sleeping, and movement. As group sizes increase, the amount of total pen space devoted to dunging and movement areas doesn’t increase in proportion. Thus, the effective space needed per pig may decrease with no change in expected performance (McGlone and Newby, 1994). On the other hand, Street and Gonyou (2005) reported no interaction between group size and space allocation when comparing group sizes of 18 and 108 pigs per pen.

Interaction of diet and space allocation

The most predictable response to decreased space allocation is a decrease in daily feed intake and daily gain (Kornegay and Notter, 1984; Gonyou et al., 2005). It would seem logical to explain the decrease in daily gain as due to a decrease in dietary nutrient intake as a result of the decrease in daily feed intake. That is, if feed intake is decreased, the intake of nutrients such as energy, amino acids, etc. is decreased, resulting in a slower rate of gain. A logical reaction to this would be to suggest that the decrease in daily gain can be alleviated by increasing the nutrient density of the diet.

However, research does not support this logic. The addition of fat, lysine, soybean meal, or fat plus lysine to control diets had no effect on overcoming the depression in performance associated with space allocation reductions (Kornegay et al., 1993; Brumm and Miller, 1996, Edmonds et al., 1998). Stocking density has not been shown to have an effect on diet nutrient digestibilities (Leek et al., 2004). Research results also suggest that pigs do not respond differently to growth promoting dietary antimicrobials when space is restricted (Hale and Utely, 1985; Moser et al., 1985; NCR-89 Committee on Confinement, 1986; Zimmerman, 1986; Yen and Pond, 1987).

One suggested mechanism for the lack of response to dietary modifications is that when pigs are crowded, their potential for lean growth is decreased, resulting in a decrease in feed intake (Chapple, 1993; Ferguson et al., 2001). Thus, it is not recommended that the nutrient composition of growing-finishing diets be modified when space allocation is restricted.

Interaction of nursery and grow-finish space allocation

Research evidence suggests that the response to space allocation during the grow-finish phase may depend in part on whether the pigs are resorted into new social groups upon movement from the nursery facility (Brumm et al., 2001). Pigs which remain in the same social group (no remixing of pen mates) from weaning to slaughter don't react as negatively to a reduction in space allocation as pigs which are remixed upon a move from the nursery to the grower-finisher facility.

Research results suggest that the space allocation for pigs moved to growing-finishing facilities from nursery facilities may differ from that of wean-to-finish pigs who are in the same pen with the same pen mates from weaning to slaughter. In two recently reported wean-to-finish experiments, daily gain decreased 1% for each 7% decrease in space allocation (Brumm, 2004) and 1% for each 4.5% decrease in space allocation (DeDecker et al., 2005). Both of these reductions in daily gain are less than the prediction equations of Gonyou et al., (2005).

Interaction of sex and grow-finish space allocation

There is no evidence to suggest that barrows and gilts respond differently to space allocation (Hamilton et al., 2003; Brumm, 2004). Nor is there evidence that space restrictions during growth affect age at puberty or other reproductive traits of replacement gilts (Jensen et al., 1970; Ford and Teague, 1978). However, Kuhlers et al., (1981) suggest that pen density should be considered in performance testing schemes and in the evaluation of sire breed-dam breed combinations, suggesting a genetic line component in the response to space allocation

Space allowance and behavior

Crowding has been cited as a common cause of tail biting (Fritschen and Hogg, 1983). Two surveys of pork producers regarding tail biting and various management practices reported no association between stocking density and the incidence of tail biting (Chambers, et al., 1995; Kritas and Morrison, 2004). There was no effect of crowding on the severity of tail biting in a research trial investigating the possible interaction of space allocation and response to Paylean (Brumm et al., 2003).

In contrast, stocking densities during the growing phase greater than 22.4 lb/ft^2 increased the risk of tail biting (odds ratio = 2.7) on 92 pig farms in England (Moinard et al., 2003). As a point of reference, 22.4 lb/ft^2 translates into a metric k=0.0435 which is considerably higher than the 0.0336 value of Gonyou et al. (2005) which was the upper limit for an effect on daily gain.

Space allowance and health

In an experiment designed to examine the possible interaction of space allocation and fineness of grind of dietary ingredients, there was no effect of space restriction on stomach morphology (Eisemann and Argenzio, 1999) or the incidence of ulcers (Handlin et al., 1972). Crowding of nursery pigs had no effect on thymus, spleen or adrenal weights (Yen and Pond, 1987) or serum haptoglobin (Francisco et al., 1996).

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