Effects of Floor Area Allowance and Group Size on the Productivity of Growing/Finishing Pigs

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ABSTRACT: Six group sizes and three levels of floor area allowance were studied in a 6 × 3 factorial arrangement. Group sizes were 3, 5, 6, 7, 10, and 15 pigs per pen. Floor area allowances were 0.030, 0.039, and 0.048 m² × BW⁶⁶⁷. All pens were square and equipped with a single space feeder and nipple drinker near one corner. Pigs were fed a pelleted diet. Initial weights averaged 25.0 kg, and pigs remained on test for 12 wk. Pigs were weighed, feed intake was determined, and size of pens was increased at 2-wk intervals. Pen size was adjusted to provide the space required for the midpoint of each weigh period. Two replicates of the study were conducted. The ADG was reduced with increasing group size (899, 851, 868, 872, 857, and 821 g, SEM = 16.4, for 3, 5, 6, 7, 10, and 15 pigs, respectively; P < .05). Feed efficiency (gain/intake) was highest for group sizes of 7 and 10 pigs (0.381) and lowest for pens of three and five pigs (0.363; P < .05). The ADG and ADFI (832 g and 2.25 kg, respectively) for the most crowded space allowance were reduced compared to more spacious allowances (ADG and ADFI of 875 and 877 g, and 2.35 and 2.36 kg, for 0.039 and 0.048 m² × BW⁶⁶⁷, respectively; P < .05). Efficiency did not differ among space allowances. These results confirm previous studies reporting a negative effect of increasing group size on productivity, but our study suggests that gain and intake reach a plateau at less space allowance than previously reported.

Key Words: Pigs, Space Requirements, Group Size


Introduction

Space allowance is a critical factor in designing barns and accommodating the movement of pigs through the various phases of production. Most studies have investigated space allowance relative to a specific end point, such as market weight, but this approach limits the usefulness of the findings should that end point shift within the industry. A calculation of space allowance expressed in terms of body weight would allow one to plan, design, and manage pig flow and pen sizes more precisely. Previous investigators have proposed that space allowance should be based on body surface area, which is proportional to BW⁶⁶⁷ (Petherick and Baxter, 1981; Hurnik and Lewis, 1991), but it has not been demonstrated that the relationship between such space allocation and productivity is consistent over a range of body weights.

Group size is also an important determinant of barn design. Some studies have demonstrated a decrease in performance as group size increases (Petherick et al., 1989; Gonyou et al., 1992), but others have not (Randolph et al., 1981; Walker, 1991; McGlone and Newby, 1994). In addition, space allowance and group size may interact in their effects on performance (McGlone and Newby, 1994). Small group sizes that are not currently practical may become so if new technologies decrease penning costs, and should be considered in studies of group size. For example, Zhou and Stricklin (1992) reported that freedom of movement for simulated animals asymptoted at group size of approximately six when density was held constant.

The objectives of this study were 1) to determine the relationship of space allowance, based on BW⁶⁶⁷, on productivity and the consistency of this effect over a range of body weights; and 2) to determine the effect of group size on productivity over a range typical of experimental and small commercial pens.

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Materials and Methods

Six group sizes and three floor area allowances were evaluated in a 6 × 3 factorial arrangement, with two replicates over time. Group sizes studied were 3, 5, 6, 7, 10, and 15 pigs per pen. The group sizes selected in this study included groups typical of experimental studies (3 to 10 pigs) and small commercial groups (10 to 15 pigs). Within this range, an emphasis was placed on group sizes of 5, 6, and 7 pigs to support additional studies on spatial behavior. Zhou and Stricklin (1992) have reported that a group size of six animals may evidence unique spacing patterns.

Using the biological relationship between body weight and surface area, floor area allowances were calculated as \( k \times BW^{0.667} \), where BW is in kilograms and floor area allowance is in square meters (Petherick and Baxter, 1981; Edwards et al., 1988). The values for \( k \) used in the study were .030, .039, and .048. Pen sizes were adjusted at 2-wk intervals to reflect the requirements of the pigs at the midpoint of the subsequent 2-wk period, based on their expected body weights. The formula calculates the floor area allowance for an individual pig; we used the average weight of pigs in the pen for calculations. Floor area allowances for the first and final 2-wk periods averaged .295, .382, and .467 and .578, .761, and .942 \( m^2/pig \) for \( k \) values of .030, .039, and .048, respectively.

The 276 pigs used in the study were a cross of Canabred and C15 lines (Pig Improvement Canada). Because the pigs were videotaped for additional behavior studies that required paint markings, white pigs were preferred during initial selection of pigs for this experiment. Allotment to pens was based on weight within gender class (females and castrated males), with approximately equal numbers of males and females in each pen. When an odd number of pigs were assigned to a pen, all pens within that group size had the same gender ratio. None of the pens of three pigs contained littermate diads, and the proportion of such related diads in other group sizes varied between 2 (group size six) and 4% (group size seven). The pigs averaged 25.0 and 96.9 kg at the beginning and end of the 12-wk study, respectively.

Pigs were housed in a fully slatted, negatively ventilated room with ceiling inlets and an air recirculation duct. Thermostat settings were decreased in stages from 25 to 15°C during each replicate. Room temperatures exceeded settings by more than 5°C on 8 and 63 d in replicates 1 and 2, respectively. All pens were square and constructed of solid walls. Each pen was equipped with one single-space dry feeder and one nipple drinker. The feeder was incorporated into one wall, .5 m from a corner, so that the feeder was outside the pen. The drinker was mounted .25 m from the feeder. The close proximity of feed and water was intended to standardize the distance and simulate conditions of a wet/dry feeder without associated problems of weighing back wet feed. The pigs were given ad libitum access to pelleted complete diets based on wheat, barley, soybean meal, and canola meal, formulated to provide 3,260 and 3,200 kcal/kg of energy and 16.7 and 16.1% CP during the initial and final 6-wk periods, respectively.

Pigs were individually weighed on d 0 and at 2-wk intervals thereafter. Pen sizes were adjusted on the same day. Feed intake (disappearance) was summarized at 2-wk intervals using standard weigh-in and weigh-back methods. The ADG, ADFI, and feed efficiency (gain/intake) were analyzed for the periods 0 to 4, 4 to 8, 8 to 12, and 0 to 12 wk. Analysis of variance was performed using the General Linear Models procedure of SAS (1985), including gender ratio, replicate, group size, floor area allowance, and group size × floor area allowance in the model. Because the pen was the experimental unit, replicate nested within group size and floor area allowance was the error term. An F-protected LSD means separation test was used for main effects.

Results and Discussion

Of the variables studied, only ADG differed between replicates. Pigs in the second replicate gained 1.4 kg more during the course of the study than did those in the cooler first replicate. Because neither ADFI nor efficiency was affected, it is unlikely that the temperature difference between replicates was a significant factor in the experiment.

Floor Area Allowance. Decreasing the floor area allowance from a coefficient of .048 to .039 did not affect ADG, ADFI, or feed efficiency over 12 wk (Table 1). The additional decrease in floor area allowance to a coefficient of .030 resulted in a reduction of ADG (5%) and ADFI (4%) but had no effect on feed efficiency during this same period. This pattern of reduced gain and intake at the lowest floor area allowance was numerically true in each 4-wk period of the study and was significant for ADG between wk 4 and 8 and for ADFI during every period. Again, feed efficiency did not differ among floor area allowances during any 4-wk period. The CV for weight and ADG within a pen did not differ among floor area allowances, with means of 9.0 and 18.5%, respectively.

Commonly, studies on floor area allowance are designed so that pigs are provided a specific area throughout the experiment rather than adjusting the pens as the animals grow. Although this common experimental practice reflects commercial production, it results in the animals having abundant floor area early in the trial and only being crowded during the final few weeks of the study. As a consequence, traditional studies reveal the effects of the final few weeks of crowding but do not necessarily indicate when crowding begins or the effect of restricted floor
area allowance early in the study. The results of this study indicate that when floor area allowance is expressed on an allometric basis (related to body size) the effects of restriction are consistent throughout the growing period. Thus, we believe it is possible to extrapolate these results to market pigs of larger weights. It also provides a basis for managing floor area and pig flow based on actual requirements rather than published ranges. Under the conditions of this experiment, productivity was affected by crowding at a floor area allowance between coefficients of .030 and .039. Edwards et al. (1988), using a similar method of allometric sizing, reported that performance was reduced by any restriction below a coefficient of .034, their maximum allowance. Guidelines for floor area allowance should strike a balance between animal well-being as indicated by ADG, and efficiency of space use (gain per unit of floor area). The level for optimal efficiency of floor area use may be considerably lower than that for maximal individual weight gain (Edwards et al., 1988; Powell and Brumm, 1992).

A problem with using an allometric relationship to experimentally establish floor area requirements is the difficulty one encounters when comparing results with traditional studies. Recent reports have indicated that maximum gains are achieved when pigs are provided, throughout the grow/finish period, floor areas equivalent to .040 (NCR-89, 1993), .029 (McGlone and Newby, 1994), and between .032 and .038 (Brumm et al., 1996) $m^2 \times BW(kg)^{.667}$ at final test weight. It should be noted that the estimate of floor area allowance from McGlone and Newby (1994) may be low, because they reported only the weight at which pigs were marketed, and not the average weight for the pen when the first pigs were removed. Using the minimal coefficient at which we obtained maximum gain (.039) as a criterion for crowding, the fastest growing treatments were crowded for approximately 0 (NCR-89, 1993), 56 (McGlone and Newby, 1994), 42, and 23 d (Exp. 1 and 2, respectively; Brumm et al., 1996) in these previous studies. The number of days of crowding required to produce a significant reduction in gain is not known but may be considerable.

Kornegay and Notter (1984), using previously published material, calculated that gain is maximized when final floor area allowance is approximately .048 $m^2 \times BW(kg)^{.667}$, a value considerably greater than that suggested by our results. Part of the reason for this discrepancy may be our use of single space feeders. Such feeders require less floor area to be used primarily for feeding, compared with multiple space feeders (see Gonyou, 1994). Our pens also placed the drinker adjacent to the feeder, which could also reduce space required for individual movement (Gonyou et al., 1997).

**Group Size.** During every 4-wk period, the ADG and ADFI of pigs in groups of three exceeded that of pigs in larger groups, and those of pigs in groups of 15 were reduced compared to those of pigs in smaller groups (Table 2). Overall, ADG of pigs in groups of 3 exceeded that of pigs in groups of 5, 6, 7, or 10 by 4.3%, which in turn exceeded that in groups of 15 by 4.9%. This reduction in ADG averaged 1.1 and .6% per pig increase in group sizes between groups of 3 and the midsized groups (5 to 10 pigs/pen) and between the midsized groups and groups of 15, respectively. The CV for ADG did not differ among group sizes (mean = .185). The ADFI was 8% greater
in groups of 3 than in the midsized groups and 4.3% greater in midsized groups than in groups of 15. Feed efficiency peaked for groups of 7 or 10 and was poorest for groups of 3 or 5 (P < .05). The cause of poorer feed efficiency for the smaller groups is unclear. A greater lipid/protein deposition ratio for the small groups would explain the results, but carcass data were not collected.

Previous studies on group size have yielded inconsistent results. Petherick et al. (1989) reported a decrease in gain for large groups (36 pigs/pen) compared to smaller groups (8 and 16 pigs/pen) during a 22-d trial. However, Randolph et al. (1981) reported no differences between group sizes of 5 and 20, and Walker (1991) reported no difference among 10, 20, and 30 pigs per group even when feeder space was held constant. McGlone and Newby (1994) reported no difference in productivity among group sizes of 10, 20, and 40 pigs. Kornegay and Notter (1984) calculated reductions of .3 and .16% per pig increase in group size, for grower and finisher pigs, respectively, based on their review of literature. Gonyou et al. (1992) reported a substantial reduction in gain and intake for pigs in groups of five, compared with individually penned pigs. In a subsequent study, increasing group size to 15 resulted in a further, but smaller, reduction in ADG and ADFI (Gonyou et al., unpublished data). These reductions in gain were attributed to a reduction in intake.

With ADFI and ADG decreasing as group size increases, it is usually hypothesized that the decrease in gain is due to the reduction in intake. Gonyou et al. (1992) reported that pigs in groups avoided eating while another pig was using the two-holed feeder and suggested that this behavior may result in decreased intake. In the current study the use of a single space feeder would be expected to magnify this problem, particularly as group size increased from 10 to 15 pigs/pen. However, the greatest effect of increasing group size occurred between very small groups (3 pigs per pen) and middle sized groups (5 to 10 pigs per pen), neither of which should have been greatly restricted by access to the feeder. Indeed, groups of 20 and even 30 pigs have been reported to maintain intake and growth when fed from a well-designed single space feeder (Walker, 1991). Associated with increasing group size is increasing pen size, which results in greater distances between resources (feed, water, dunging, and resting areas) within the pen, and the greater cost of moving to resources may reduce their
The effect of increased group size on productivity should be considered when comparing results from experimental studies using small (< 10 pigs) or large (> 10 pigs) groups.

**Literature Cited**


