Designing production facilities for pig comfort in Argentinian conditions

Dr Mike Brumm
Brumm Swine Consultancy, Inc.
North Mankato, MN USA

The goal of pork production facilities is to provide an environment for the growing pig that allows the pig to perform at or near it's genetic potential for lean gain and feed conversion efficiency, all occurring within an economic framework.

Stocking Density

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. 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 formula $A = k * BW^{.67}$ can be used to express the relationship between space allowance (A) and body weight (BW) (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 when A is m^2/pig and BW is in kg (Gnyou et al, 2006). Body weight is the average pen weight on the day one or more pigs in the pen are first removed for slaughter. 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 the k value estimates of Gonyou et al (2006). For fully slatted facilities, each 3% decrease in space allocation results in a predicted 1% reduction in daily gain and daily feed intake for the entire grow-finish period. For partially slatted facilities, each 3% decrease in space allocation results in a predicted 1.5% reduction in daily gain and feed intake. These researchers were unable to determine a statistical correlation between space allocation and feed conversion efficiency. 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 et al, 2003; Brumm, 2004).

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.

The impact of space allocation on carcass backfat and percentage lean has only been reported in a few trials (Brumm and Miller, 1996; Brumm et al, 2003; 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.

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 ractopamine (Brumm et al, 2003).

In contrast, stocking densities during the growing phase greater than 110 kg/m^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, 110 kg/m^2 translates into a metric k=0.0435 which is considerably higher than the k = 0.0336 value which was the upper limit for an effect on daily gain (Gonyou et al, 2006).

In a recent experiment where the final metric "k" values ranged from 0.027 to 0.037, there was an increase in the average number of aggressions for k = 0.027 versus k = 0.034 and k = 0.037 (Anil et al, 2005). However, there was no difference in salivary cortisol associated with this increased aggression.

While the goal of pork production systems is to provide pigs an environment that promotes rapid and efficient gain, the decision on appropriate space allocation must include consideration of the economic tradeoffs of best pig performance and increasing facility costs as more space is provided to support best pig performance.

Recent survey results suggest the average stocking density for finishing facilities in the U.S. is 0.67 m^2/pig, with a range of 0.63 to 0.74 m^2/pig (Buhr et al, 2004). Results from this survey do not suggest any regional (i.e. Southwest versus Midwest) differences in stocking density, nor do they suggest any difference in density for full versus partial slats.

Group Size

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 United States swine 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 (Payne et al, 2001; 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. On the other hand, there was no interaction between group size and space allocation when comparing group sizes of 18 and 108 pigs per pen (Street and Gonyou, 2005).

Heat Production

Many producers make the mistake of thinking that because today's pigs are leaner than in previous years, the pigs need for assistance with heat removal is reduced. In fact the opposite has occurred.

Figure 1 is a chart of total heat production by growing pigs. Note that the data set used to produce the chart sorted the pigs according to pre-1988 and post-1988 genetics. This natural break in the data set also coincides with a major change in thinking by producers and their genetic suppliers. Around this time genetic selection for grow-finish traits began placing a major emphasis on high rates of lean gain. The last data set reviewed for this publication was published in 2001 (Brown-Brandl, et al, 2001). This suggests that with on-going genetic progress, pigs in production facilities in 2010 produce even more heat that must be dissipated than previously thought.

If one thinks about the physiology of growth, the increase in heat production by pigs with higher rates of lean gain should be expected. In the deposition of calories as fat, there is very little heat generated by the pig as relatively few metabolic processes are involved. On the other hand, when lean growth occurs, the cells mitochondria are very involved in the conversion of energy, amino acids, minerals, vitamins, etc. into muscle. This conversion process results in an increased amount of heat generation (Nienaber et al, 2009). The net consequence is that growing pigs today generate more heat that must be dissipated from swine facilities than previously dealt with.

Further proof that heat relief is a major concern for growing pigs is provided in Figure 2. This graph is the drinking pattern for finishing pigs in winter and summer. In thermal neutral conditions such as finishing facilities in the winter, growing pigs show a distinctive single daily peak in both eating and drinking behavior. However, when conditions in the pig zone are above their thermal neutral temperature, the pig changes its behavior in response to the need to reduce the impact of warmer temperatures on its well being. This response in behavior is accomplished by the pig eating and drinking earlier in the day, reducing activities associated with eating and drinking during the mid-day heat and resuming eating and drinking during later evening hours.

Figure 3 is a plot of both drinking activity and temperature in the pig zone in a facility in northeast Nebraska in late May, 2004. The top graph is a plot of air temperature as logged by the ventilation controller probes. The bottom graph is the drinking water usage for the facility. The vertical lines are the amount of water use logged every 15 minutes, while the horizontal lines within each feed and water graph are the 24 hour totals.

Note that prior to the 2 days in the middle of the time line when air temperatures in the pig zone were warmer than 80 F (26.6 C), the water pattern in the bottom graph was basically the single peak pattern, indicating that the pigs were in their thermal-neutral zone for temperature. On the first day of temperatures higher than 80 F (26.6 C), the water pattern changed to the double peak. Even when temperatures declined to the low to mid 70’s (21-24 C), note that the water pattern did not return to the single peak. When air temperatures returned to 80 F (26.6 C) or higher at the right side of the time line, the pigs drinking once again reverted to the double peak pattern.

This lack of return to the preferred single peak pattern suggests that the growing pig is more sensitive to high temperatures than many producers think. The pig is willing to adapt a non-preferred behavior (double peak pattern of drinking water usage) for several days after a heat event as a preventive measure in anticipation of another heat event.
This relatively recent on-farm data on altered behavior patterns in response to heat is in agreement with the very large number of studies suggesting that air temperatures above 26C in the pig zone for pigs heavier than 30-40 kg results in a reduction in daily gain and possible worsening of feed conversion efficiency. Brown-Brandl et al (2000) concluded that high-lean-gain growth pigs reared in hot environments deposit more fat and less protein than those raised in a thermoneutral environment and fed to a similar intake level.

All of this data suggests that producers need to be more aggressive in helping pigs deal with summer heat in confinement facilities. In the United States, the general recommendation is that pigs greater than 25-kg be provided moisture for evaporative heat loss. Providing water for the pig to evaporate from its skin surface has been demonstrated to be more effective than increasing the rate of air movement over the skin surface (Turner et al, 1997) The most common method is to have automated sprinklers linked to a thermostat that operate no more than 2 minutes out of every 15-20 minute period. The goal is to thoroughly wet the pig, and then let cooling occur by evaporative heat loss from the pig’s surface. Larger droplets of water are preferred versus a fine mist of water as the larger droplets are more likely to wet the surface of the pig, rather than to be evaporated and just cool the air.

Wean-Finish Facilities

The North American swine industry is rapidly moving towards wean-finish pig flow. In this system, 4-6 kg pigs (most often 17-21 days of age), are placed in fully slatted pens where they remain until slaughter at 115-120 kg. Research has suggested pig performance in this management system is similar to pigs placed in conventional weaned pig nurseries and moved to grower-finisher facilities at 25-30 kg (Brumm et al, 2002b; Wolter et al, 2002).

The main reasons cited by producers for adoption of wean-finish pig flow is labor savings, both from one less pig movement and one less facility to clean per growth cycle. Lenders have encouraged the move to wean-finish production facilities as they perceive more options being available in the event of a loan default with wean-finish facilities versus more traditional nursery and grow-finish facilities. It is estimated that over 90% of the new production facilities constructed in the upper Midwest region of the United States from 2001-2009 were wean-finish.

Typical modifications to traditional fully-slatted grow-finish facilities that producers make to accommodate wean-finish include:

- Supplemental zone heating such as heat lamps or infrared brooders.
- Mats under the supplemental zone heating area for 3-5 weeks.
- Wean-finish feeders or modified grow-finish feeders. These generally have solid dividers between spaces to prevent pigs from sleeping in the feeder and becoming trapped as they grow.
- Modified gating. Gating rods can be no more than 50 mm apart for weaned pigs, and gating must come within 35-50 mm of the floor so weaned pigs don't get their heads caught.
- Cup drinkers must be no more than 100 mm off the floor so weaned pigs can drink readily.

References:

AAFC. 1993. Recommended Code of Practice for the Care and Handling of Farm Animals: Pigs. Agriculture and Agri-Feed Canada Publication 1898/E, Ottawa.

Anil, L., S.S. Anil and J. Deen. 2005. Effect of stocking density on average daily gain and welfare of grow finish pigs. Proceedings Allen D. Leman Swine Conference, Univ. Minnesota, St. Paul. Pp 252-254.

Brown-Brandl, T.M., J.a. Nienaber, L.W. Turner, and J.T. Yen. 2000. Manual and thermal induced feed intake restriction on finishing barrows. I: Effects on growth, carcass composition and feeding behavior. Trans. ASAE 43(3):987-992.

Brown-Brandl, T.M. R.A. Eigenberg, J.A. Nienaber and S.D. Kachman. 2001. Thermoregulatory profile of a newer genetic line of pigs. Livestock Prod. Sci. 71:253-260.

Brown-Brandl, T.M., J.A. Nienaber, H. Xin and R.S. Gates. 2004. A literature review of swine heat production. Trans. ASAE 47(1):259-270.

Brumm, M.C. and P.S. Miller. 1996. Response of pigs to space allocation and diets varying in nutrient density. J. Anim. Sci. 74:2730-2737.

Brumm, M.C., M. Ellis, L.J. Johnston, D.W. Rozeboom, D.R. Zimmerman and the NCR-89 Committee on Swine Management. 2001. Interaction of swine nursery and grow-finish space allocations on performance. J. Anim. Sci. 79:1967-1972.

Brumm, M. C., A. K. Baysinger, R. W. Wills and R. C. Thaler. 2002. Effect of wean-to-finish management on pig performance. J. Anim. Sci. 80:309-315.

Brumm, M.C., P.S. Miller and R.C. Thaler. 2003. Do crowded pigs respond to Paylean? Nebraska Swine Report EC03-219, University of Nebraska, Lincoln. pp 15-18.

Brumm, M.C. 2004. The effect of space allocation on barrow and gilt performance. J. Anim. Sci. 82:2460-2466.

Buhr, B., D. Holtkamp, M. Brumm and J. Kliebenstein. 2004. Economics of pig space; analysis of production systems and marketing impacts. Final report NPB Project 01-177, National Pork Board, Des Moines, IA.

Chambers, C., L. Powell, E. Wilson and L.E. Green. 1995. A postal survey of tail biting in pigs in south west England. Vet. Rec. 136:147-148.

Ekkel, E.D., H.A.M. Spoolder, I. Hulsegge and H. Hopster. 2003. Lying characteristics as determinants for space requirements in pigs. Appl. Anim. Behav. Sci. 80:19-30.

European Council. 2001. Council directive 2001/88/EC of 23rd October 2001 amending directive 91/630/EEC laying down minimum standards for the protection of pigs. Off. J. Eur. Comm. L316 (2001/12/01).

Fritschen, R.D. and A. Hogg. 1983. Preventing tail biting in swine (anti-comfort syndrome). NebGuide G75-246(Rev 83). University of Nebraska, Lincoln.

Fritschen, R.D. and A.J. Muehling. 1986. Space requirements for swine. Pork Industry Handbook No. 55, Purdue University, West Lafayette, IN.

Gonyou, H.W., M.C. Brumm, E. Bush, J. Deen, S.A. Edwards, T. Fangman, J.J. McGlone, M. Meunier-Salaun, R.B. Morrison, H. Spoolder, P.L. Sundberg and A.K. Johnson. 2006. Application of broken-line analysis to assess floor space requirements of nursery and grower-finisher pigs expressed on an allometric basis. J. Anim. Sci. 84:229-235.

Huynh, T.T.T., A.J.A. Aarnink, M.W.A. Verstegen, W.J.J. Gerrits, M.J.W. Heetkamp, B. Kemp, and T.T. Canh. 2005. Effects of increasing temperatures on physiological changes in pigs at different relative humidities. J. Anim. Sci. 83:1385-1396.

Kornegay, E. T. and D.R. Notter. 1984. Effects of floor space and number of pigs per pen on performance. Pig News Inform. 5:23-33.

Kornegay, E.T., D.R. Notter, H.S. Barlett and M.D. Lindemann. 1985. Variance of body weights and daily weight gains of weaner pigs housed at various stocking densities in confinement. Anim. Prod. 41:369-373.

Kritas, S.K. and R.B. Morrison. 2004. An observational study on tail biting in commercial grower-finisher barns. J. Swine Health Prod. 12:17-22.

Petherick, J.C. 1983. A biological basis for the design of space in livestock housing. In: S.H. Baxter, M.R. Baxter and J.A. SC. MacCormack (ed.) Farm Animal Housing and Welfare. Martinus Nijoff, Boston. Pp 103-120.

Meese, G. B., and R. Ewbank. 1972. A note on instability of the dominance hierarchy and variations in level of aggression within groups of fattening pigs. Anim. Prod. 14:359-362.

Meese, G. B. and B. A. Baldwin. 1975. The effects of ablation of the olfactory bulbs on aggressive behaviour in pigs. Appl. Anim. Ethology 1:251-262.

McGlone, J.J. and B. E. Newby. 1994. Space requirements for finishing pigs in confinement: behavior and performance while group size and space may vary. Appl. Anim. Sci. 39:331-338.

Moinard, C., M. Mendl, C.J. Nicol and L.E. Green. 2003. A case study of on-farm risk factors for tail biting in pigs. Appl. Anim. Behav. Sci. 81:333-355.

Nienaber, J.A., J.A. DeShazer, H. Xin, P.E. Hillman, J.T. Yen and C.F. Ferrell. 2009. Chapter 4: Measuring energetic of biological processes. In: Livestock Energetics and Thermal Environmental Management, J.A. DeShazer (ed). Amer. Soc. Agri. and Biological Eng., St Joseph, MI. pp 72-112.

Payne, H., M. Brumm, M. D'Antuono, B. Mullan, J. Pluske and I. Williams. 2001. Review of group size effects on performance. PRDC Project 1749 Research Report. Dept. Agric, Perth, AU.

Petherick, J.C. 1983. A biological basis for the design of space in livestock housing. In: S.H. Baxter, M.R. Baxter and J.A. SC. MacCormack (ed.) Farm Animal Housing and Welfare. Martinus Nijoff, Boston. Pp 103-120.

Schmolke, S. A. and H. W. Gonyou. 1999. Effect of increasing group size on grower-finisher pigs. Annual Research Report, Prairie Swine Centre, Saskatoon, Saskatchewan.

Street, B.R. and H.W. Gonyou. 2005. The effects of housing grow-finish pigs at two different group sizes and space allocation. J. Anim. Sci. 83(suppl 2):38 (abstr).

Turner, L.W., H.J. Monegue, R.S. Gates, and M.D. Lindemann. 1997. Fan, sprinkler, and sprinkler plus fan systems for cooling growing-finishing swine. ASAE Paper 974076. Amer. Soc. Ag. Eng., St. Joseph, MI.

Turner, S. P., D. J. Allcroft and S. A. Edwards. 2003. Housing pigs in large social groups: a review of implications for performance and other economic traits. Livestock Prod. Sci. 82:39-51.

Wolter, B.F., M. Ellis, S.E. Curtis, M.R. Augspurger, D.N. Hamilton, E.N. Parr and D. M. Webel. 2001. Effect of group size on pig performance in a wean-to-finish production system. J. Anim. Sci. 79:1067-1073.

Wolter, B. F. M. Ellis, J. M. DeDecker, S. E. Curtis, G. R. Hollis, R. D. Shanks, E. N. Parr and D. M. Webel. 2002. Effects of double stocking and weighing frequency on pig performance in wean-to-finish production system. J. Anim. Sci. 80:1442-1450.

Table 1. Predicted adequacy of space allocation for fully slatted facilities (based on Gonyou et al, 2006).

Pig wt, kg	No impact of space on daily gain m^2/pig	5% reduction in daily gain m^2/pig
23	0.27	0.23
45	0.43	0.36
68	0.56	0.48
91	0.68	0.57
114	0.79	0.67
136	0.89	0.76

Figure 1. Metabolic heat (sensible plus latent) production by growing pigs (Brown-Brandl et al, 2004).

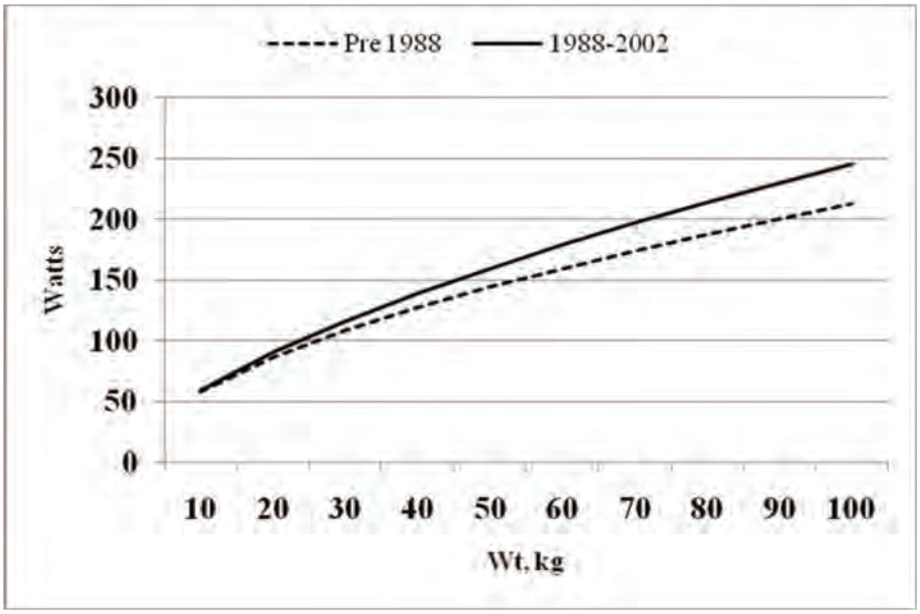

Figure 2. Drinking patterns in finishing pigs by season of the year in a 1200-hd room. Data courtesy dicamusa.com.

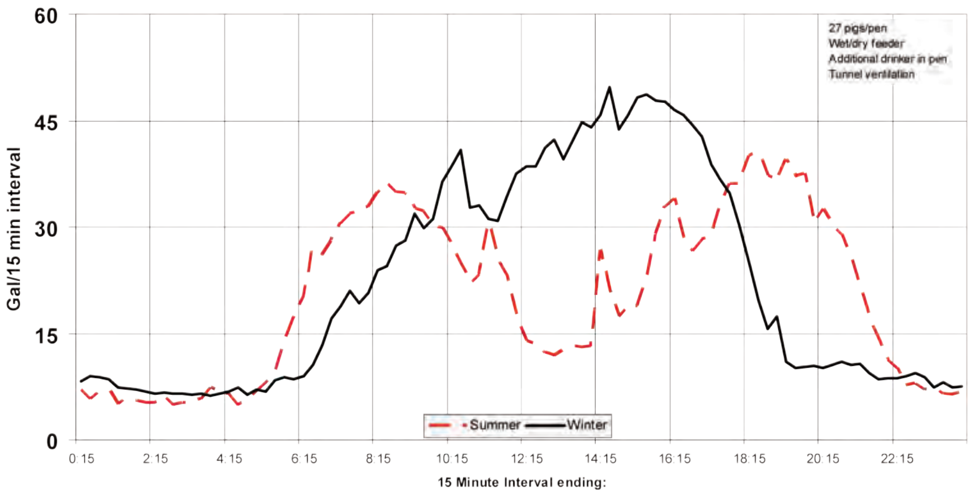

Figure 3. Plot of temperature, fan run time, feed auger run times and drinking water disappearance in a finisher facility. Data courtesy dicamusa.com.