LOWERING PRODUCTION COST BY INCREASING GROUP SIZE AND THE EFFECTS THEREOF ON PIG PERFORMANCE POST WEANING TO 70 DAYS

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DECLARATION

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously, in its entirety or in part, submitted it at any university for a degree.

Signature:

Date:

SUMMARY

The primary objective of today's pig producer is to maximize profit received per unit of pig space provided in a given facility. There are certain management strategies that a farmer can implement to ensure this. The goals of such strategies include maximizing performance and implementing proper pig flow schedules and to make sure current facilities are performing at maximum capacities or are better utilized. Labour in South Africa is still relatively inexpensive, but time is money. Feeding and cleaning small pens are time consuming and expensive to maintain (more feeders and water nipples, gates, walls and heating).

Proper management of facility space is vital to remain competitive in today's pig industry. The amount of floor and feeder space provided within an animal's environment could vastly influence pig performance and profitability. Crowding pigs has a negative effect on Average Daily Gain (ADG) and overall performance. Conversely, facility cost per pig increases as additional space is provided, therefore, in the interest of pen efficiency, the space that allows for maximum individual performance may not be optimal for maximizing profit. Factors such as cleaning and cleaning time also have an effect on profitability. Another concerning factor associated with maximizing performance and maintaining the pig flow of a facility is that of Body Weight (BW) variation. Having uniform pigs at 70 day, post-weaning has been a major goal to ensure maximum performance in finishers.

Numerous contradictions regarding the growth of piglets post-weaning (especially the effect of group size and floor space allowance) still exist in literature. Also, in South Africa, the majority of pig producers still believe that individual litters or small groups of pigs in the growers perform better and are the most economical production method.

Therefore, this trial was performed to investigate the raising of large groups (200-450 pigs/group) compared to small groups (10-20 pigs/group) on their performance until 70 days when they were moved to growers.

Over a period of two years, data was collected on a commercial 1200 sow unit in the Western Cape, South Africa. Crossbred pigs (n=14657; Landrace x Large White; both gilts and barrows) weaned at 19 to 24 days with average weaning weight of 5.11 kg were randomly divided into different group sizes. Groups of 10, 20, 200 and 450 were grouped together and were all given the same feed ration. The groups were housed in different buildings naturally ventilated with no artificial heating and with solid flooring.

Pelleted diets were formulated (Startrite followed after two weeks with Expresweaner) by Meadows Feed Mills (Paarl, Western Cape) for weaned piglets and fed to all the piglets. The animals received the diets and water *ad lib.* All the piglets were weighed before being placed into the different pens (initial weight). After 69 - 72 days the piglets were weighed again (final weight). The pigs were weighed as a group and not individually. The data was statistically analysed by determining averages and standard deviations for each house.

The results of this trial clearly indicate that raising piglets in larger groups does not negatively affect the performance of the piglet in terms of ADG and mortality. In larger groups, the less time (labour time) spent cleaning and the fewer feeders needed, also results in lower production costs. In today's economical environment, the producer that can lower his production cost while maintaining production standards has a significant advantage. Therefore, it is believed that by grouping pigs in larger groups, labor time (in terms of cleaning) can be reduced, and will lower production cost without reducing production standards.

OPSOMMING

Die hoofdoel van vandag se varkprodusente is om maksimum wins per eenheid vark spasie te maak. Daar is sekere produksietegnieke wat 'n produsent kan volg om dit te verseker. Die doel van die tegnieke is om te verseker dat maksimale produksienorme en doeltreffende vark vloei gehandhaaf word asook dat huidige fassiliteite optimum benut word. Arbeid is nog relatief goedkoop in Suid-Afrika (SA), maar tyd is geld. Die voeding en skoonmaak van klein hokke is tydrowend en duur om te onderhou (meer voerbakke, waternippels, hekke, mure en verhitting).

Om koste-effektief te boer, moet goeie bestuur van oppervlakte toegepas word. Die hoeveelheid oppervlakte en voerspasie beskikbaar, het 'n groot invloed op die produksievermoë en winsgewendheid van die varkies. Om te veel varkies per area aan te hou, het 'n negatiewe effek op die Gemiddelde Daaglikse Toename (GDT) en algehele prestasie. Soos die vloerspasie per varkie vergroot, neem die produksiekoste ook toe en is die area wat benodig word om varkies maksimaal te laat produseer, nie altyd die winsgewenste nie. Skoonmaak en skoonmaaktyd het ook 'n invloed op winsgewendheid. Die ideaal is om uniforme varkies op 70 dae te produseer. 'n Variasie in gewig is rede tot kommer, aangesien dit die produksie in die groeiafdeling beïnvloed.

Verskeie teenstrydighede aangaande die groei van varkies naspeen (veral die effek van goepgrootte en vloerspasie) bestaan steeds in die literatuur. In SA is die meeste produsente ook nog onder die indruk dat klein groepe varkies beter presteer as groot groepe en die mees ekonomiese metode is om te boer.

Daarom is 'n proef geloods om vas te stel hoe die produksie verskil tussen klein groepe (10 – 20 varkies per groep) teenoor groot groepe (200 – 450 varkies per groep) tot 70 dae ouderdom wanneer hulle na die groeiafdeling skuif.

Oor 'n periode van twee jaar is data gekollekteer op 'n kommersiële 1200 sog-eenheid in die Wes-Kaap, Suid-Afrika. Kruisgeteelde varke (n=14657; Landras x Groot Wit; beide beertjies en soggies) is gespeen tussen 19 en 24 dae, met 'n gemiddelde speen gewig van 5.11 kg en ewekansig verdeel in verskillende groepgroottes. Groepe van 10, 20, 200, en 450 varkies was saamgegroepeer en het almal dieselfde dieet ontvang. Die groepe is in verskillende

geboue gehuisves en al die geboue het soliede vloere gehad en was natuurlik geventileerd met geen kunsmatige verhitting nie.

'n Verpilde dieet is deur Meadows Voermeule (Paarl, Wes-Kaap) geformuleer (Startrite vir twee weke en dan Expresweaner vir die res van die proef). Die varke het die dieet en water *ad lib* ontvang. Al die varkies is geweeg voordat hulle in die verskillende hokke geplaas is (aanvangsmassa). Na 69 - 72 dae is die varkies weer geweeg (eindmassa). Die varkies is as 'n goep en nie individueel geweeg nie. Die data is statisties verwerk deur gemiddeldes en standaard-afwykings vir elke huis te bepaal.

Die resultate van hierdie proef het duidelik aangetoon dat die grootmaak van varkies in groter goepe nie die produksie van die varkies (i.t.v. GDT of mortaliteit) nadelig beïnvloed het nie. In groter goepe is minder tyd nodig om die hokke skoon te maak en is minder voerders nodig. Dit lei tot 'n verlaging in produksiekoste. Deesdae het die produsent wat sy produksie koste kan verlaag, sonder om produksiestandaarde in the boet, 'n aansienslike voorsprong. Die gevolgtrekking word dus gemaak dat deur varkies in groter groepe aan te hou, arbeid (in terme van skoonmaak) verminder kan word en dus kan produksiekoste verminder sonder dat produksie self afneem.

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CONTENTS

A) General Introduction

1. Introduction

As the technology of rearing weaned pigs has improved, producers have been able to wean pigs at progressively younger ages. In earlier years, when weaning age was reduced from 56 days to 28 days, there was a large and significant increase in pigs per sow per year (p/s/y). As some producers have moved from 28 days weaning down to 21 days weaning, and even down to 14 days (or younger) increase in sow productivity has not always been as evident (Stanislaw, 1996). Other advantages of weaning pigs at 12 - 18 days of age, are that their immunity from maternal antibodies is still high (Evans, 2000; Bernard, 2003) and the sow has not been milked down to the point that she loses body condition.

Average lactation length in the USA has decreased from approximately 25 days in 1990 to 18 days in 1999 and 72% of herds now have an average lactation length ≤ 22 days (PigCHAMP®, 2000). In South Africa (SA), weaning at an early age is still a relatively new management strategy to increase the litters/sow/year.

Modern pig farms are expensive to build and operate especially in South Africa (SA) where interest rates are high (12%) (ABSA Bank, Middleburg, personal communication, 2003); therefore, the primary objective of today's pig producer is to maximize profit received per unit of pig space provided in a given facility. There are certain management strategies that a farmer can implement to ensure this. The goals of such strategies include maximizing performance and implementing proper pig flow schedules and to make sure current facilities are performing at maximum capacities or are better utilized. Labour in SA is still relatively inexpensive, but time is money. Feeding and cleaning small pens are time consuming and expensive to maintain (more feeders and water nipples, gates, walls and heating).

Proper management of facility space is vital to remain competitive in today's pig industry. The amount of floor and feeder space provided within an animal's environment can vastly influence pig performance and profitability. Crowding pigs has a negative effect on Average Daily Gain (ADG) and overall performance (Kornegay and Notter, 1984). Conversely, facility cost per pig increases as additional space is provided, therefore, in the interest of pen efficiency, the space that allows for maximum individual performance may not be optimal for maximizing profit (Powell and Brumm, 1992). Factors such as cleaning and cleaning time will also have an effect on profitability. Another concerning factor associated with maximizing performance and maintaining the pig flow of a facility is that of Body Weight (BW) variation. Having uniform pigs at 70 day, post weaning has been a major goal to ensure maximum performance in finishers. Research has shown that weaning weight has a very important influence on pig performance.

Some of the problems that develop with the early weaning of piglets, as well as the factors that influence growth post weaning, will be discussed in more detail in the next few pages.

2. Problems associated with early-weaned piglets

Usually, pigs weaned at 3 to 4 weeks of age will go through an adjustment period (Worobec *et al.*, 1999). In many cases, newly weaned pigs will just maintain their body weight for the first week after weaning. Severe growth depression may result from poor ventilation, poor sanitation and poor diet selection. Although the starter diet can significantly improve performance, environmental factors can easily overshadow the benefits of a good diet.

It is beneficial to review some of the reasons why problems often develop shortly after weaning.

- There is physical stress at weaning time. The diet changes from a liquid to a dry diet and consists of complex starch compared to the highly digestible milk they used to consume. In addition, there is a physical change between liquid and dry feed, although some dry feeds can yield the same performance as liquid feeds (Pluske and Williams, 1996).
- The piglet has a relatively underdeveloped digestive tract at 3 weeks of age and must adjust to dietary changes (Swine Nutrition Guide, 2002).
- The piglet has a limited ability to produce antibodies, which it primarily obtained from its mother during lactation.
- With a sparse hair coat and relatively little body fat, the piglet has a limited heat regulating mechanism.
- Piglets are forced to make a social adjustment – going from the security of their dam to new environments with new pen mates (Pluske and Williams, 1996).

Once the piglet is successfully weaned, there are also a lot of other factors influencing growth and they will be discussed in the next few pages.

3. Factors influencing post weaning growth in piglets

The weaning of piglets places them under stress and it has a very negative effect on their post weaning performance. In order to understand the reason for this and to make sure that the amount of stress is minimized one need to understand the different factors that lead to stress.

3.1 Weaning age and weight

Weaning is the major stress period for piglets followed by a period of underfeeding due to the inability of the piglet to adapt to the new environment and change of feed composition (Heugten, E. 2002). Birth weight and weaning weight are two very important factors in rearing pigs commercially.

The rapid implementation of Segregated Early Weaning (SEW) worldwide has posed some new challenges to the health of piglets and those caring for them. Many problems stem from imposing strict maximum ages at weaning, regardless of piglet body weight, to prevent disease transmission and to achieve the eradication of certain endemic infections during the growing life of the pig (i.e. *Actinobacillus pleuropneumoniae*) (Duran, 1998). In addition, early weaning will increase labour and feed costs due to more care of these smaller and younger piglets in the nursery (O'Connell, N.E., Beattie, V.E., and Weatherup, R.N., 2003). Newly weaned pigs tend to have a reduced feed intake following the weaning process due to the post weaning stress. This "growth check" post weaning can be a reduction in ADG from 300g/day pre-wean, to 100g/day post weaning. This growth check has been shown to affect the lifetime performance and carcass quality of the pig (Hutton, 1989 as cited by O'Connell *et al.*, 2003). It also has a negative effect on the time pigs spend in the expensive nursery accommodation. It lowers the weaner piglet's physiological development and results in the animals being more susceptible to diseases (Partridge, 1989 as cited by O'Connell *et al.*, 2003).

In the study of Worobec *et al.* (1999), there were marked differences in the behaviour of the piglets weaned at different ages (7, 14 and 28 days). Piglets weaned at 7 days spent more time belly-nosing, showed more escape behaviour and spent less time interacting with neighbours, feeding and nosing and chewing objects compared to piglets weaned at 14 or 28 days. Piglets weaned at 14 days exhibited more belly-nosing behaviour and spent less time feeding directly following weaning than did those weaned at 28 days. They also spent more time nosing and chewing pen-mates than did the piglets weaned at either

7 or 28 days. Times spent engaged in aggressive behaviour and aggression at the feeder and drinker and lying down were similar in piglets across weaning age. At 6 weeks of age, the piglets weaned at 14 and 28 days were significantly heavier than piglets weaned at 7 days. Worobec *et al*. (1999) concluded that weaning piglets on or before 14 days of age may result in reduced performance and the development of behaviour patterns that either cause, or are indicators of, reduced welfare. Mixing during lactation reduced aggression post-weaning without detrimentally affecting growth. Mixing earlier in lactation reduced the number and severity of lesions. By using this method of grouping in lactation aggression may be reduced throughout the pig's life by maintaining them in larger groups from an earlier age that minimizes fighting when grouped later in production. There is an indication that mixing in lactation too early (7 days old) or too close to weaning (21 days old) has less effect on improving post-weaning performance than when mixed at 14 days age. Mixing piglets at 14 days tends to increase growth rates when analyzing the long-term effects post weaning (Allen *et al.*, 2000). Increasing floor space, enriching the post-weaning environment or pre-mixing piglets prior to weaning may also decrease aggression levels (Held & Mendl, 2000; Swinkels, et al., 2000).

Managing the newly weaned pig is considered the most difficult task within a pig production unit. Nutritional and behavioral changes are reasons why pigs under-perform and ADG decreases (See, 2003). While suckling, piglets satisfy both their hunger and thirst simultaneously, but as soon as they are weaned, they need to satisfy these needs individually. The sow also calls them, which encourages them to suckle in a group. When weaned, they have to distinguish between the physiological drives of hunger, thirst and how to satisfy it with water and dry feed.

These disruptions in their feeding and drinking behaviour results in the piglets becoming dehydrated and weak due to the lack of energy reserves in their bodies. It also has significant effects on the structure and function of the digestive tract (Brooks *et al.,* 2000).

The maintenance of gut health in the young post weaned piglet is of paramount importance if the young growing animal is to achieve its full genetic potential for growth. At weaning, there is immediate withdrawal of the passive protection afforded by the IgA class antibodies from the sow's milk and the piglets own active immunity processes are still under development. Furthermore, because of the stress of the weaning event itself, the ability of piglets to mount effective immune responses to antigenic challenges is further compromised. Under commercial conditions, weaned piglets are moved to new accommodation and mixed with new pen mates. This process leads to rapid changes in the microflora on the gut wall and is especially damaging to the microvilli and to the enterocytes themselves (Baynes *et al.*, 2000).

Commercially for many years, it has been the perceived wisdom to use in-feed agents that will promote good gut health post weaning. Amongst these agents are the antimicrobial growth promoters (AGP's), copper sulphate, zinc oxide, probiotics, pre-biotics, herbal extracts and spices, and immunostimulants. Copper and zinc are still widely used in the UK and in many other countries around Europe and further afield. The AGP's have similarly been widely used to good effect (Baynes *et al.*, 2000).

One of the potential pitfalls in the prolonged use of mild antibiotics is that every time they are used they are applying a genetic selection pressure on the population of non-pathogenic gut bacteria normally resident in the gut lumen and bound onto the enterocytes. Over time, this selection pressure will favour those bacterial genotypes that are better able to survive the antibiotic environment. Over long time spans there is the possibility that extremely virulent pathogenic strains will arise out of this forced evolution and the antibiotics will no longer work in killing the bacteria. If this scenario exists, then presumably the antimicrobial product would also most likely lose their ability to enhance digestion and growth (Baynes *et al.*, 2000).

There are alternatives to the use of antibiotic growth promoters for creating conditions where animals can exploit their full genetic potential for growth. If conventional antimicrobials were to be precluded from use in the animal industries then there may be a significant increase in demand for such products (Baynes *et al.*, 2000).

Successful outcomes in the nursery are dependent upon a well-conceived production system, careful planning of pig flow, the appropriate feeding program and stockpersons with good stock skills performing the necessary procedures and daily routines correctly and on time (Evans, 2000). The role of the stockperson cannot be emphasized enough. He has to make sure that the pigs perform to their potential by making sure the environment in which the piglets are kept are favourable to maximizing the growth performance of the animal.

3.2 Air quality and ventilation

Ventilation is the replacement of air within the building with fresh air from without and thereby controlling the microenvironment of the pig. There are several reasons why effective ventilation is important:

1. Controlling the temperature in the building

2. Controlling the humidity in the building
3. Supplying the pigs with fresh air
4. Removing any harmful gasses, dust and pathogens in the building.

Independent of environmental condition, a minimum amount of fresh air (depending on the number and class of animals housed) is required in a building to remove water vapour, carbon dioxide, ammonia, airborne dust, bacteria and odors. This minimum ventilation rate will reduce the temperature in the building and insulating the roof and walls will reduce heat loss by conduction. Draught proofing will reduce uncontrolled air change (Casey, 2003).

By increasing the airflow through the piggery many airborne particles, which include clumps of microorganisms, will be removed. This will improve the air quality inside the building reducing the risk of respiratory diseases. Bad ventilation can also lead to high humidity and poor air quality, resulting in bad dunging patterns, reducing the level of hygiene. Overcrowding especially in hot humid weather also lowers hygiene (Cargill, 2003).

3.3 Food and water availability

The management of the water and feed of pigs is one of the most important factors in the production of pigs but it is important that this form part of the other factors that one must give attention to and not lose focus of others. The adequate provision of food and water are essential to the survival and productivity of pigs. Inadequate feeding space can increase the amount of feeder related aggression and reduce the growth rate of growing pigs (Spoolder *et al.*, 1999). Moreover, the number of pigs that can be accommodated per feeder space affects the relative feeder cost per pig and the group size of the pen. Therefore, the appropriate feed and water provisions needed to maximize performance must be determined to establish the appropriate stocking level of a pen.

Traditional recommendations have suggested less than 10 and as few as 3 pigs per feeder space are necessary to maximize growth performance (Baxter, 1984), but recent results have indicated that as many as 20 or 30 pigs can be fed from a single space feeder and still maintain acceptable performance (Walker, 1991; Nielsen *et al.*, 1995). There are numerous factors determining how many pigs can adequately perform on a given feeder space. The quantity, dimension, and placement of the feeding spaces as well as the animals' selection preferences are important components to consider maximizing pig performance during all phases of growth.

Many studies have compared the provision of dry and wet/dry feeders and have generally concluded that the availability of water within the feeder increases feed intake and daily weight gain of pigs (Anderson *et al.*, 1990; Walker, 1990; Gonyou and Lou, 2000). However, providing feed and water together may also reduce carcass lean weight (Walker, 1990; Gonyou and Lou, 2000), therefore, Gonyou and Lou (2000) suggest that diet formulation should be modified for wet/dry feeders taking into account increased feed consumption. Little information is available on the benefits of providing a supplemental water source, other than in the feeder, in pens containing wet/dry feeders. Some research suggests that an additional water source is unnecessary and may increase water wastage (Walker, 1990).

Researchers have also evaluated feeder placement within a pen in an attempt to optimize accessability and identify selection preferences (i.e., animals' choice to use one feeding space compared to another). Morrow and Walker (1994) found no difference in growth performance between groups of 20 pigs with single space feeders placed either side by side or separately. Moreover, Wolter and co-workers (2000b) provided multiple, single feeding locations to groups of 100 pigs, and reported no difference in growth performance. Therefore, based on the limited amount of information, we can conclude that positioning feeders apart or together has little effect on pig performance.

The size of the animal also affects their eating space both dimensionally and quantitatively. The width, height and depth of a given feeding space must consider the physical size of an animal during all phases of growth. Baxter (1984) determined that the width of a given feeding space should reflect the shoulder width of the animal and can be predicted from the equation: width (cm) = 6 x liveweight (kg)$^{0.33}$. According to this equation pigs weighing 20 or 120 kg require feeding spaces of 16 and 29 cm, respectively. Another means of predicting minimum feeder space results from determining the relationship between shoulder width (mm) and the weight (kg) of the pig as 61 (mm)$W^{0.33}$ (Petherick, 1983). Another potential limiting factor determining the number of pigs that efficiently utilize one feeding space is the total duration of eating time which is dependent on intake and eating speed. Researchers have reported that pigs fed from a single- compared to a multiple-space feeder were able to maintain intake by increasing eating speed (Gonyou and Lou, 2000) and altering the circadian feeding pattern (Walker, 1991). The total duration of eating time (Walker, 1991; Hyun *et al.*, 1997; Gonyou and Lou, 2000) and number of meals (Walker, 1991) decrease as pigs continue to grow.

The level of feeder related aggression has also been reported to increase in pigs provided inadequate feeding space (McBride, 1964; Petherick and Blackshaw, 1987; Nielsen *et al.*, 1995; Spoolder *et al.*, 1999). In a review of the literature, Petherick and Blackshaw (1987) suggested that feeder-related aggression can be minimized by *ad libitum* feeding, providing barriers between pigs during feeding, and by having regular feeding times. Additional research is needed to establish the effects of specific feeder design features and feeder-space allowances on pig aggression and pig performance during all phases of growth.

When it comes to pig production, producers often underestimate the value of managing water and watering devices (See, 2001). Pigs require water for a variety of reasons, including most metabolic functions, adjustment of body temperature, movement of nutrients into the body tissues, removal of metabolic waste, production of milk and for growth and reproduction (Almond, 2002). Eighty percent of the empty body weight of a newborn pig and about 50% of a market pig consists of water. An animal can loose practically all its fat and over half of its protein and yet live, while a loss of one-tenth of its water results in death (Almond, 2002). The amount of water consumed depends upon factors such as environmental temperature, diet, frequency with which water is provided, housing and stress (Almond 2002).

Environmental temperature influences the pig's water requirements because pigs use water to help reduce body heat. When the environmental temperature rises from 15°C to 35°C, the water requirements of a 34 kg pig can increase by 57% (See, 2001).

In general, the water requirements of grower-finisher pigs is related to feed intake and expressed as a ratio of water:feed. This ratio usually range form 2:1 to 3.5:1. These values are based on the requirements of pigs in a thermoneutral environment and under ideal condition (Almond, 2002). According to Almond (2002), nursery piglets (up to 27 kg body weight) require 2.8l of water/pig/day or 2.5l of water/kg of feed consumed.

Water systems should be checked regularly for any signs of contamination. The quality of the water may affect intake, nutrient digestibility and pig performance. The mineral content and microbial safety of the water source should be routinely monitored.

Watering devices should be checked and maintained frequently to prevent leaks. The recommended flow from a nipple drinker is 70 ml/min for a growing pig and 1000 ml/min for a finishing pig (See, 2001).

According to Freese (1996) pigs prefer drinking from bowls or cups; however they also have a strong preference for drinking from a clean water source. When a cup is contaminated by feed residue, pigs will select a nipple drinker over a cup drinker.

3.4 Photoperiod

If piglets are exposed to a period of underfeeding after weaning, this leads to villous atrophy in the small intestine (McCracken, B.A., Spurlock, M.E., Roost, M.A., Zuckermann, A., and Gaskins, H., 1995; Pluske and Williams, 1996). Villous atrophy is considered a predisposing factor for post weaning health problems (Diarrhea and mortality). Weaning stress also leads to increased energy requirements for maintenance (Sijben, J.W.C., P.N.A. van Vugt, J.W.G.M. Swinkels, H.K. Parmentier, and J.W. Schrama,1998).

Bruininx and co-workers, 2002 demonstrated that the majority of weanling pigs did not start eating during the dark periods of the day. Based on this observation Bruininx *et al.* (2002) hypothesized that a prolonged photoperiod within the nursery may stimulate a early start and development of feed intake in pigs during the first days after weaning. Although the first visit to the feeder and the moment of the first feed intake were not affected by lighting schedule, it did strongly affect the performance of the weaning pigs.
A prolonged photoperiod (23 h vs. 8 h within a 24 hour period) resulted in an increase in feed intake, metabolizability of energy and average daily gain and a decrease in the energy requirements for maintenance, especially during the second week after weaning.

3.5 Group Size

Numerous studies have reported that the number of animals per group influences pig performance in both the nursery and grow-finish phases (NCR-89, 1984; Meunier-Salaun *et al.*, 1987; Spicer and Aherne, 1987; Petherick *et al.*, 1989). Large group sizes (i.e., ≥ 100 pigs) have been advocated in an attempt to reduce equipment costs (Verdoes *et al.*, 1998), but a concern exists that increasing group sizes may negatively affect growth (Wolter *et al.*, 2000a). In a previous review of the literature, Kornegay and Notter (1984) demonstrated that pigs in the early stages of growth (i.e., nursery) respond more adversely to increases in-group size compared to pigs in later stages of growth (i.e., grow-finish). Experiments have been conducted more recently that further support the previous conclusion that the response to group size differs depending on the stage of production.

3.5.1 Effect of group size on pig performance during the nursery period

A summary of studies investigating the effects of group size on pig performance during the nursery period is presented in Table 1. Wolter *et al.* (2000a) evaluated the effects of pigs given a constant floor-space allowance (0.17 m^2) grouped in 20 or 100 pigs per pen for 9 weeks post weaning (5.3 to 40 kg) and found that 20 pigs per pen had 6.0% higher average daily gain and 6.4% higher feed intake compared to 100 pigs per pen. Increased BW variation was also detected within larger groups of pigs. McConnell et al. (1987) also found that pigs given a constant floor-space allowance (0.21 m^2) grouped in 16 and 24 pigs per pen for 35 days post weaning (6.4 to 18 kg) had 8.0 and 12.4% lower average daily gains and 11.6 and 12.8% lower feed intakes respectively, compared to pigs housed in groups of 8 pigs per pen. However, a higher gain: feed ratio was reported in favour of pigs housed in-group sizes of 16 and 24 compared to groups of 8. Moreover, in two nursery trials conducted from weaning to 37 days post weaning, Jensen and co-workers, (1966) found that pigs penned in groups of 8, 16 or 24 that were given a constant floor-space allowance (0.30 m^2) possessed similar average daily gains but lower feed intakes as group size per pen increased. A third trial was conducted by Jensen and co-workers, (1966) that evaluated pigs (9.5 kg) in groups of three, 5 or 7 at a constant floor-space allowance (0.21 m^2) for 39 days post weaning. The results of this trial indicate that group sizes of five and seven pigs per pen had a 10.5 and 17% lower daily feed intake and a 2 and 17% reduction in daily gain, respectively, when compared to the group size of three. The data further support the evidence provided by Kornegay and Notter (1984) in that weaned piglets show reduced growth performance with increases in group size.

3.5.2 Effect of group size on pig performance during the grow-finish period

A summary of studies investigating the effects of group size on pig performance during the grow-finish period is presented in Table 2. Results of experiments conducted during the grow-finish stage generally show that the reduced performance found in larger group sizes in the nursery may not be as pronounced during subsequent growing periods. Spoolder *et al.* (1999) observed a lower daily weight gain in growing pigs (35 to 65 kg of BW) penned in larger groups (80 vs. 40 vs. 20 pigs/pen), whereas, during the finishing period (65 to 85 kg of BW) growth performance was similar among group sizes. Wolter *et al.* (2001) compared group sizes of 25, 50 and 100 pigs (6 to 116 kg BW) in a wean-to-finish building from weaning to market. From weaning to week 8 pigs in larger group sizes had reduced growth rates, however, from week 8 to market and for the overall period no difference in growth performance among group sizes was detected. However, Petherick and co-workers, (1989) observed a lower daily weight gain in growing pigs (20 to 60 kg of BW) housed in groups of 36 compared to 16 or 8 pigs per pen. Similarly, in studies evaluating smaller group sizes, Gehlbach and co-workers (1966) comparing groups of 4, 6 and 8 and Randolph and co-workers, (1981) comparing 5 vs. 20 pigs per pen found no difference in growth performance during the finishing period. Conversely, Gonyou and Strickland (1998) found daily weight gain and feed intake reduced as group size increased (i.e., 3, 5, 6, 7, 10 and 15 pigs per pen) during the grow-finish phase (25 to 97 kg BW). These experiments also support the findings of Kornegay and Notter (1984), in that as pigs increase in weight and age they appear to be less affected by increasing group size (i.e., nursery pigs > growing pigs > finishing pigs).

Generally, historical research discussed here suggests that low feed intake levels are the primary reason for the reduction in daily weight gain observed in large group sizes. Kornegay *et al.*, (1985) and Safranski and Zulovich (2003) speculated that the reduction in feed intake found in large group sizes may be caused by an increase in social pressure in larger compared to smaller groups. Wood-Gush and Csermely (1981) reported that pigs can be stimulated to eat if they view other penmates feeding. Therefore, the potential may exist for large groups to exhibit greater social pressure at feeding, thereby, causing increased competition at the feeder resulting in reduced feed intake levels. To that end, Penny (2000) attempted to reduce social pressure in large groups by providing two feeding locations in groups of 135 weanling pigs. Results showed that the provision of two feeding locations within a large group can increase the growth performance of pigs compared to pigs in large groups given one feeding location. However, Wolter and co-workers, (2000b) provided multiple feeding locations compared to a single feeding location in pens with group sizes of 100 weanling pigs, but failed to increase the growth performance of the group. More data is needed to better understand feeder access and its effect on increasing feed intake in large groups of pigs.

Another factor involved in better understanding the effects of large groups sizes on feed intake and growth is the varying responses given by pigs in different production stages. Perhaps, the differential growth responses elicited by light and heavy weight pigs to increasing group size can be explained by work conducted by Hyun and co-workers, (1997) and Nielsen and co-workers, (1995). Hyun and co-workers, (1997) evaluated the effect of group size (2, 4, 8 and 12 pigs per pen) during both the growing (26 to 48 kg of

BW) and finishing (84 to 112 kg of BW) periods on feed intake patterns. The results showed that finishing pigs had the ability to change their feeding patterns, and thus maintain daily feed intake, whereas pigs in the growing period were unable to adapt and consequently consumed less feed and grew at a slower rate in the larger groups. More specifically, Hyun and co-workers, (1997) reported that finishing pigs in larger groups decreased the number of feeder visits per day, but maintained consumption levels by increasing both feeder occupation time and feed consumption rate per visit. In addition, Nielsen and co-workers, (1995) evaluated groups of 5, 10, 15 and 20 pigs (34 kg of BW) for 29 days and also found that pigs kept in groups of 20 made fewer but longer visits to the feeder and consumed more feed at a higher rate per visit than pigs penned in smaller groups. More research is needed to characterize feeding behaviour in large groups of nursery, growing, and finishing pigs to better understand the contributing factors involved in feed intake reduction.

3.6 Floor-Space Allowance

It has been widely established that insufficient space allocation can result in dramatic decreases in pig performance. Optimizing space utilization is difficult to accomplish because the amount of space required to maximize pig performance is inversely related of that needed to minimize building costs. Space is not a simple term to describe or account for, but rather a complex variable that is categorized into several components such as resting space, functional space, and social space (Baxter, 1984). Hurnik and Lewis (1991) suggested using an allometric equation to determine the floor-space allowance based on the relationship between the live weight and surface area of the pig. To determine this relationship **Practical Pig Production** offer the equation $k \times BW^{0.667}$, where k is constant, BW is measured in kilograms, and floor space is measured in square meters. Kornegay and Notter (1984) predicted that performance would increase if coefficients greater than 0.030 were used. More recently, Gonyou and Strickland (1998) demonstrated that the relationship between floor space and growth performance is relatively constant throughout the growing period. Moreover, these authors reported a significant reduction in growth performance as space was reduced from coefficients of 0.039 to 0.030. Edwards and co-workers, (1988) also reported decreased weight gains in pigs that were provided less than the coefficient 0.034.

3.6.1 Effect of floor-space allowance on pig performance during the nursery period

A previous review of the literature (Kornegay *et al.*, 1985) reported that as floor space was reduced in groups of nursery pigs their daily feed intake and weight gains were decreased, while no effect on BW variation was reported. However, the studies evaluated in that review generally reduced floor-space allowance by increasing the number of pigs per pen, thereby confounding floor space by group size. Studies that are more recent have evaluated the independent effects of floor-space allowance on nursery pig performance by maintaining group size across treatments; a summary of these studies is presented in Table 3. Kornegay and co-workers, (1993a; 1993b) evaluated weanling pigs housed at 0.28 or 0.14 m^2/pig and reported that pigs housed at the reduced space consumed 21 and 12% less and grew 18 and 12% slower, for studies 1993a and 1993b, respectively. Other research evaluating the effect of floor-space allowance on weanling pig performance also reported decreased growth rates as floor space was reduced (NCR-89, 1984; Yen and Pond, 1987; Wolter *et al.*, 2000a). Previous research has generally concluded that a reduction in feed intake is the primary factor associated with decreased weight gains in pigs housed at reduced floor-space allowances (Kornegay and Notter, 1984; Kornegay *et al.*, 1985). However, in other similar studies conducted with nursery pigs, researchers concluded that the reduction in weight gain in pigs housed with reduced floor-space allowances was caused by lower feed efficiencies not reduced feed intakes (Yen and Pond, 1987; Wolter *et al.*, 2000a).

3.6.2 Effect of floor-space allowance on pig performance during the grow-finish period

Adverse performance responses to reduced floor-space allowance have also been documented in grow-finish pigs. A summary of studies investigating the effect of floor-space allowance on grow-finish pigs is presented in Table 4. The data in Table 4 depict reductions in daily weight gain by as much as 14.3% and feed intake as great as 11.9% for pigs housed in lower space allowances (0.56 vs. 0.78 m^2/pigs) during the grow-finish period (McGlone and Newby, 1994). Much like the results of the effects of floor-space allowance on nursery pig performance there is contradicting evidence with respect to space allocation and feed efficiency in the grow-finish pig. Some studies suggest that the reduction in weight gain is largely associated with lower feed intake levels (Gehlbach *et al.*, 1966; Jensen *et al.*, 1966; Kornegay and Notter, 1984; McGlone and Newby, 1994) while others indicate that reduced feed efficiency is a major factor (Krider *et al.*, 1975; Harper and Kornegay, 1983). Regardless of the factors contributing to the reduced weight gains, it is apparent in this review that providing insufficient space in nursery and grow-finish pigs adversely affects growth performance. Moreover, the reduction in BW gain appeared uniform within a pen with all pigs reacting similarly, thus not affecting the coefficient of variation of weight within a pen (Kornegay *et al.*, 1985).

McGlone and Newby (1994) evaluated groups of 10, 20 and 40 pigs/pen and determined that more 'free space' (i.e. total floor space not occupied by any pig at any particular time) is available in larger group sizes. Consequently, the authors hypothesized that, as group size increases, pigs may be housed at lower floor-space allowances without compromising growth. McGlone and Newby (1994) evaluated removing 100, 50 or 0% of the calculated free space in a group of 20 finishing pigs. Results indicated that removing 100% of the free space negatively impacted growth while removing 50% of the free space had no effect. Wolter *et al.* (2000a) supported results of McGlone and Newby (1994) reporting that when groups of 20 and 100 nursery pigs were provided spaces that were adequate (i.e., space allowance was similar between group sizes) and a 50% reduction in free space (i.e., groups of 100 pigs were given 13% less space than groups of 20 pigs) the group of 100 pigs performed similarly to the group of 20. This indicates that larger groups of pigs may be housed at lower space allowances.

A number of approaches have been examined in an attempt to combat the reduction in growth performance incurred by housing pigs at low space allowances. Approaches employed have included increasing dietary lysine (Kornegay *et al.* 1993a), energy and lysine (NCR-42, 1993; Brumm and Miller, 1996), amino acids and protein levels (Hahn *et al.*, 1995; Edmonds *et al.*, 1998), and vitamin C (Yen and Pond, 1987). In addition, the effect of dietary antibiotics have been evaluated (Harper and Kornegay, 1983; NCR-89, 1984). However, none of these approaches has produced any improvement in growth performance in pigs housed at low floor-space allowances.

Another important factor to consider when evaluating floor-space allowance is the levels of aggression and pig mortality that may be associated with reduced space housing. Experiments evaluating the effect of floor space on aggression have shown differential results. McBride and James (1964) and Ewbank and Bryant (1972) suggested that aggression will increase as stocking rate increases due to the animals' desire to maintain spacing between themselves and their pen mates. These studies decreased floor space by increasing group size so the independent effects of group size and floor-space allowance could not be separated. Bryant and Ewbank (1972) evaluated the independent effects of group size and floor-space allowance on pig aggression and reported no differences among floor-space allowance or group size treatments; however, it appeared that as group size increased pigs were more likely to retreat faster compared to pigs in smaller groups. In more recent studies, researchers have reported that crowding pigs by decreasing the available floor space in a standard sized group will result in increased aggressive behaviour in pigs (Kelley *et al.*, 1980; Randolph *et al.*, 1981). However, Kornegay *et al.* (1993b) reported that pigs housed with restricted floor space fought less frequently and had less injuries (i.e., bruises, lameness) than pigs housed with adequate floor space.

There are concerns about the effects of increasing group size on productivity and welfare. Previous studies have yielded conflicting results, with some researchers reporting reduced productivity and increased aggression when group size is increased (Spoolder *et al.*, 1999), and others finding no effect on productivity and reduced aggression when group size is increased (Nielsen *et al.*, 1995). A key concern with large groups is the welfare of smaller pigs, which may have difficulty gaining access to resources such as the feeder. However, the greater choice of feeding spaces in larger groups and the increase in available or free space (McGlone and Newby, 1994) may benefit small pigs in particular by allowing them to escape from, and feed away from, larger animals.

It is important to note that the majority of data collected utilized relatively small group sizes (≤ 20 pigs/pen) compared to what is generally being used in modern commercial production units. In addition, these data were collected during specific stages (i.e., nursery or grow-finish) of a multi-phase system.

3.7 Temperature

According to Casey (2003), there is a certain temperature range in which pigs will obtain optimum growth. This thermoneutral zone has an upper limit (Evaporative Critical Temperature (ECT)) and a lower limit (Lower Critical Temperature (LCT)). If the surrounding temperature drops below the LCT or rises above the ECT the animal has to try and regulate its body temperature in order to grow. The Upper Critical Limit (UCL) is the highest tolerable temperature (± 6-8°C) above ECT and if the surrounding temperature raises above this level, the pigs are in a stressful environment and cannot grow. It may even prove fatal, if not altered immediately.

The ECT and LCT vary with the weight of the pig. Pigs will generally show their discomfort with less ideal temperatures by either huddling and eating more, or by avoiding body contact, not eating, panting and fouling more. As pigs age, they are more tolerable to the LCT.

Directly after weaning, the pig has a limited amount of body fat (12-18%) (Brumm and Reese, 2003). Body fat at weaning primarily serves as insulation and an energy reserve. During the weaning process, the piglet changes from a wet, high fat, highly digestible food to a dry, complex starch feed and therefore eat less. The piglet goes into a negative energy balance, since more energy is needed to support life than can be supplied by the reduced amount of food. The shortage of energy has to be supplied by the animal's own body fat and therefore the insulation layer is depleted thereby hampering the ability of the pig to adjust to changing ambient temperatures. The pig is now more vulnerable to low temperatures.

Temperature fluctuations of more than 2.8°C lead to poor performance and scouring. It is important to note that the temperatures at the pig's level are significantly different from the temperatures at the human's eye level (Brumm and Reese, 2003) and therefore temperature measurement should always be taken close to the floor. The major cause of chilling is due to draughts. A scarcely noticeable air speed of 9.15 m per minute chills a pig as much as a 3.92°C drop in air temperature. A draft of 27.45 m per minute (3.2186 km/h and common in many housing situations) is equivalent to a 10.08°C drop in temperature. Solid pen partitions in the desired sleeping area are recommended if draft control is a problem (Brumm and Reese, 2003).

Wet floors also can increase chilling and can equal a 5.6 to 8.4°C drop in temperature as the pig uses body heat to dry itself. Straw bedding of 2.5cm on solid floors is comparable to increasing the temperature as much as 3.92°C (Brumm and Reese, 2003).

Due to the information and research that has been done, the general perspective is that small groups are the most cost effective production method to grow weaner pigs in South Africa. It was felt to do a trail using large groups (200 to 400 pigs) to compare the performance of these large groups to that of small groups (10 to 20 pigs). The research was done on a commercial pig farm in the Western Cape and due to the practicality reasons: The mortality, percentage sick pigs and average weight at 70 days age was compared between the treatment groups. ADG and FCR were not used due to the practical limitations.

Table 1. Summary of literature evaluating the effect of group size on the growth performance of weanling pigs.

Author, year	Weight Range (kg)	Group Size	Floor-space allowance[a]		Feeder-space allowance	CV (%)	ADG (g)	ADFI (g)	G:F	Mortality (%)
			m^2	*k* value						
Wolter *et al.*, 2001	5.9 - 33.9	100	0.68	0.065	8 pigs/hole	-	498	821	0.61	1.0[b]
	5.9 - 33.9	50	0.68	0.065	8 pigs/hole	-	499	818	0.61	1.5[b]
	5.9 - 34.8	25	0.68	0.065	8 pigs/hole	-	512*	815	0.63*	3.0[b]
Wolter *et al.*, 2000a	5.3 - 14.8	100	0.17	0.027	5 pigs/hole	15.0	337	465	0.73	<1.0
	5.3 - 15.4	20	0.17	0.027	5 pigs/hole	14.5	361*	498*	0.73	<1.0
McConnell *et al.*, 1987	6.4 - 17.5	24	0.21	0.029	2 pigs/hole	-	318	586	0.56	-
	6.4 - 18.0	16	0.21	0.029	2 pigs/hole	-	331	594	0.56	-
	6.4 - 19.1	8	0.21	0.029	2 pigs/hole	-	363	672	0.53	-
Gehlbach *et al.*, 1966	NA - 45.0	16	0.36	0.028	-	-	590	-	-	-
	NA - 45.0	12	0.36	0.028	-	-	640	-	-	-
	NA - 45.0	8	0.36	0.028	-	-	645*	-	-	-
Jensen *et al.*, 1966	10.0 - 24.0	24	0.30	0.035	-	-	400	870	0.46	-
	10.0 - 24.7	16	0.30	0.035	-	-	420	950	0.45	-
	10.0 - 25.1	8	0.30	0.035	-	-	430	940	0.47	-
Jensen *et al.*, 1966	9.5 - 26.7	7	0.21	0.022	-	-	440	1030	-	-
	9.5 - 29.8	5	0.21	0.022	-	-	520	1110	-	-
	9.5 - 30.2	3	0.21	0.022	-	-	530	1240	-	-

[a] Floor-space allowance per pig determined by square meters (m^2) and coefficients determined from $k \times BW^{0.667}$ (*k* values).
[b] Mortality rates were figured for the entire growing period (5.9 to 116 kg).
* Significance ($P < 0.05$) was detected among treatments within study.
G:F = ADG/ADFI

Table 2. Summary of literature evaluating the effect of group size on the growth performance of grow-finish pigs.

Author, year	Weight Range (kg)	Group Size	Floor-space allowance[a]		Feeder-space allowance	CV (%)	ADG (g)	ADFI (g)	G:F	Mortality (%)
			m^2	*k* value						
Wolter *et al.*, 2001	33.9 - 116.2	100	0.68	0.029	8 pigs/hole	9.8	733*	2231	0.33*	1.0
	33.9 - 116.1	50	0.68	0.029	8 pigs/hole	9.6	708	2206	0.32	1.5
	34.8 - 116.4	25	0.68	0.029	8 pigs/hole	9.4	716	2232	0.32	3.0
Spoolder *et al.*, 1999	36.2 - 85	80	0.55	0.028	10 pigs/hole	-	758	-	-	-
	36.2 - 85	40	0.55	0.028	10 pigs/hole	-	759	-	-	-
	36.2 - 85	20	0.55	0.028	10 pigs/hole	-	773	-	-	-
Randolph *et al.*, 1981	21.6 - 89.5	20	1.64	0.082	2.5 pigs/hole	-	714	2120	0.34	-
	21.6 - 89.5	5	1.64	0.082	2.5 pigs/hole	-	720	2050	0.34	-
	21.6 - 89.5	20	0.82	0.041	2.5 pigs/hole	-	695	2110	0.33	-
	21.6 - 89.5	5	0.82	0.041	2.5 pigs/hole	-	679	2030	0.33	-
Gehlbach *et al.*, 1966	45.0 - 90.0	8	0.72	0.036	-	-	760	-	-	
	45.0 - 90.0	6	0.72	0.036	-	-	770	-	-	
	45.0 - 90.0	4	0.72	0.036	-	-	770	-	-	

[a] Floor-space allowance per pig determined by square meters (m^2) and coefficients determined from $k \times BW^{0.667}$ (*k* values).
* Significance ($P < 0.05$) was detected among treatments within study.
G:F = ADG/ADFI

Table 3. Summary of literature evaluating the effect of floor-space allowance on the growth performance of weanling pigs.

Author, year	Weight Range (kg)	Group Size	Floor-space allowance[a] m²	*k* value	Feeder-space allowance	CV (%)	ADG (g)	ADFI (g)	G:F	Mortality (%)
Wolter *et. al.*, 2000a	5.0 - 15.0	100	0.17	0.027	4 cm/pig	14.6	356*	484	0.74*	-
	5.0 - 15.0	100	0.13	0.021	4 cm/pig	15.0	342	478	0.72	-
	5.0 - 15.0	20	0.17	0.027	4 cm/pig	14.6	356*	484	0.74*	-
	5.0 - 15.0	20	0.15	0.025	4 cm/pig	15.0	342	478	0.72	-
Kornegay *et al.*, 1993a	8.4 - 32.1	4	0.28	0.028	11 cm/pig	-	565*	1053*	-	0.0
	8.4 - 27.8	4	0.14	0.014	11 cm/pig	-	464	835	-	0.0
Kornegay *et al.*, 1993b	7.0 - 18.8	4	0.28	0.038	11 cm/pig	15.2	381*	675*	0.57	0.0
	7.1 - 20.4	4	0.14	0.019	11 cm/pig	14.4	335	597	0.56	0.0
Yen and Pond, 1987	7.6 - 19.5	8	0.25	0.034	1.6 pigs/hole	-	335*	671	0.50*	-
	7.6 - 17.8	8	0.13	0.018	1.6 pigs/hole	-	292	636	0.46	-
NCR-89, 1984	8.1 - 17.1	-	0.23	0.035	2.5 pigs/hole	-	332*	622*	0.53*	1.0
	8.1 - 17.1	-	0.14	0.021	2.5 pigs/hole	-	304	588	0.51	2.0

[a] Floor-space allowance per pig determined by square meters (m²) and coefficients determined from $k \times BW^{0.667}$ (*k* values).
* Significance ($P < 0.05$) was detected among treatments within study.
G:F = ADG/ADFI

Table 4. Summary of literature investigating the effect of floor-space allowance on the growth performance of grow-finish pigs.

Author, year	Weight Range (kg)	Group Size	Floor-space allowance[a] m²	Floor-space allowance[a] *k* value	Feeder-space allowance	CV (%)	ADG (g)	ADFI (g)	G:F	Mortality (%)
Brumm and NCR-89, 1996	55 - 137	7,12,16	1.20	0.045	≤5 pigs/hole	6.4	865	3221	0.27	-
	55 - 137	7,12,16	0.93	0.035	≤5 pigs/hole	6.0	857	3227	0.27	-
	55 - 137	7,12,16	0.65	0.024	≤5 pigs/hole	8.0	836	3101	0.27	-
NCR-89, 1993	53 - 114	≥10	0.93	0.039	≤4 pigs/hole	6.6	720*	2770*		-
	53 - 114	≥10	0.74	0.031	≤4 pigs/hole	7.3	690	2670	0.26	-
	53 - 114	≥10	0.56	0.024	≤4 pigs/hole	7.8	640	2590	0.25	-
Moser *et al.*, 1985	55 - 100	9	0.74	0.034	2.3 pigs/hole	-	710*	2510		-
	55 - 100	9	0.66	0.031	2.3 pigs/ hole	-	700	2430	0.29	-
	55 - 100	9	0.56	0.026	2.3 pigs/ hole	-	660	2400	0.28	-

[a] Floor-space allowance per pig determined by square meters (m²) and coefficients determined from $k \times BW^{0.667}$ (*k* values).
* Significance ($P < 0.05$) was detected among treatments within study.
G:F = ADG/ADFI

4. Aim of this study

Numerous contradictions regarding the growth of piglets post weaning (especially the effect of group size and floor space allowance) still exist in literature. Also, little research has been done in South Africa to evaluate the appropriate space allocation to maximize individual pig performance or to optimize economic performance of the entire group.

Therefore, the objectives of the research described in this thesis were as follows:

1) to evaluate the effects of group size/floor-space allowance on pig performance in a commercial farm with a 21 day weaning system
2) to evaluate the provision of feeder space and water space on weaner group size and health
3) to evaluate the grouping of over 200 weaner pigs per pen on ADG and general health at 70 days of age.

5. References

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B) LOWERING PRODUCTION COST BY INCREASING GROUP SIZE AND THE EFFECTS THEREOF ON PIG PERFORMANCE POST WEANING TO 70 DAYS

Abstract

Over a period of two years, data was collected on the effect of group size and post weaning performance from a commercial 1200 sow unit. Crossbred pigs weaned at 19 to 24 days with average weaning weight of 5.11 kg, were randomly divided into different group sizes. Groups of 10, 20, 200 and 450 were grouped together and were all given the same feed ration *ad lib*. After being divided into groups, the pigs were weighed as a group (initial weight). After 69 - 72 days, the piglets were weighed again as a group (final weight). The results of this trial clearly indicated that raising piglets in larger groups does not negatively affect the performance of the piglet in terms of average daily gain (ADG) and mortality. In larger groups, less time is spent cleaning and fewer feeders are needed, resulting in lower production costs.

Key words: weaned piglets, group size, floor space allowance, cost/pig.

Introduction

Modern pig farms are expensive to build and operate especially in South Africa (SA) where interest rates are high (12%; ABSA Bank, Personal Communication, 17 October 2003). Therefore, the primary objective of today's pig producer is to maximize profit received per unit of pig space provided in a given facility. Numerous studies have reported that the number of animals per group influences pig performance in both the nursery and grow-finish phases (NCR-89, 1984; Petherick *et al.*, 1989). Large group sizes (i.e., $\geq$100 pigs) have been advocated in an attempt to reduce equipment cost but a concern exists that increasing group sizes may negatively affect growth (Wolter *et al.,* 2000). In a previous review of the literature, Kornegay and Notter (1984) demonstrated that pigs in the early stages of growth (i.e. nursery) respond more adversely to increases in group size compared to pigs in later stages of growth (i.e. grow-finish).

Experiments that have been conducted more recently (Bernard, P. 2003, Wolter *et al.,* 2000) further support the previous conclusion that the response to group size differs depending on the stage of production. It has been widely established that insufficient space allocation can result in dramatic decreases in pig performance.

Optimizing space utilization is difficult to accomplish, because the amount of space required to maximize pig performance is inversely related to that needed to minimize building cost. Space is not a simple term to describe or account for, but rather a complex variable that is categorized into special components such as resting space, functional space and social space (Baxter, 1984).

The adequate provision of food and water is essential to the survival and productivity of pigs. Inadequate feeding space can increase the amount of feeder-related aggression and reduce the growth rate of the growing pigs (Spoolder *et al.,* 1999). Moreover, the number of pigs that can be accommodated per feeder space affects the relative feeder cost per pig and the group size of the pen. Therefore, the appropriate feed and water provisions needed to maximize performance must be determined to establish the appropriate stocking level of a pen.

The general practice in SA is to group one or two litters together after weaning (i.e. small groups of 10 to 20 pigs/pen). This requires small pens and each pen requires one or two water nipples (10 pigs per nipple) and a self-feeder. This practice is believed to lead to better-feed conversion and ADG and less aggression post-weaning due to mixing.

The objective of this study is to evaluate the effect of group size and floor-space allowance on pig performance, ADG and general health of weanling pigs in a commercial piggery.

Material and methods

Over a period of two years, data was collected on a commercial 1200 sow unit in the Western Cape, South Africa. Crossbred pigs (n=14657; Landrace x Large White; both gilts and barrows) weaned at 19 to 24 days with average weaning weight of 5.11 kg were randomly divided into different group sizes. Groups of 10, 20, 200 and 450 were grouped together and were all given the same feed ration. The groups were housed in different buildings naturally ventilated with no artificial heating and with solid flooring.

1. House A had 24 pens (1.2 m x 3 m) behind farrowing crates. Each pen had one water nipple and one self-feeder (0.5 m x 0.15 m x 0.10 m). There were 10 pigs per pen (0.36 m^2/piglet) and they were littermates. A total of 1554 piglets were raised in House A.

2. House B had 36 pens (1.4 m x 4.2 m) with one self-feeder (1.2 m x 0.15 m x 0.10 m) and two water nipples per pen. There were 20 pigs (two litters mixed) per pen and therefore 0.294 m^2 per pig. A total of 1565 piglets were raised in House B.
3. House C had 46 pens (1.4 m x 3.7 m) with one self-feeder (0.5 m x 0.15 m x 0.10 m) and two water nipples per pen. There were 20 pigs per pen and therefore 0.259 m^2 per pig (two litters mixed). A Total of 4001 piglets were raised in House C.
4. House D had 66 pens (1.6 m x 3.6 m) with one self-feeder (0.50 m x 0.15 m x 0.10 m) and one water nipple per pen. There were 10 pigs per pen (one litter) and therefore 0.396 m^2 per pig. A total of 5027 piglets were raised in House D.
5. House E (137.78 m^2) had 450 piglets. Therefore, there were 0.306 m^2 per pig. There were 10 lean machines (BD 20453900 – Big Dutchman) (40 to 50 pigs per pen) and 8 water nipples. All water nipples had water troughs (4 nipples per trough) to reduce spillage and to ensure that any water medication would not be wasted. Every lean machine also had two water nipples to wet the feed and provide the pigs with water. A total of 1782 piglets were raised in House E.
6. House F (67.2 m^2) had 200 pigs (0.336 m^2 per pig) and 4 lean machines (50 pigs per feeder) with 8 water nipples. All water nipples had cups to reduce spillage and to ensure that any water medication would not be wasted. Every lean machine had an additional two water nipples to wet the feed and provide the pigs with water. A total of 728 piglets were raised in House F.

Pelleted diets were formulated (Startrite followed after two weeks with Expresweaner) by Meadows Feed Mills (Paarl, Western Cape) for weaned piglets and fed to all the piglets. The animals received the diets and water *ad lib*. All the piglets were weighed before being placed into the different pens (initial weight). After 69-72 days the piglets were weighed again (final weight). The pigs were weighed as a group and not individually. The data was statistically analysed by determining averages and standard deviations for each house.

Results and discussion

In order to obtain realistic data, achievable in practice, this trial was performed on a commercial pig production unit. Existing buildings and pen spaces were used and therefore a difference in area/pig was unavoidable. The trials were also performed, without manipulating the routine on the farm (i.e. the amount of piglets weaned on a given week determined the amount of piglets placed in the different houses). The pig flow of the buildings was maintained and due to the number of piglets weaned a direct comparison could not be achieved between buildings. For the same reasons, individual feed intake and feed conversion could not be measured. The aim of this trial was simply to determine what the effect of group size would be on the performance of weaned pigs, under SA conditions.

The different houses, areas and feeder and water spaces are given in Table 1. Table 2 indicates the growth parameters, ADG and mortality of the piglets.

Table 1. Number of pigs per pen, area per pig, feeder space and nipples provided in the different houses.

House	A	D	B	C	E	F
Number of pigs/pen	10	10	20	20	450	200
Area (m^2)	3.60	3.96	5.88	5.18	137.78	67.20
Area/pig (m^2)	0.360	0.396	0.294	0.259	0.306	0.336
Feeders	1	1	1	1	10	4
Feederspace (m)	0.50	0.50	1.20	1.20	12.88	5.15
Feederspace/pig (m)	0.050	0.050	0.060	0.060	0.029	0.026
Nipples	1	1	2	2	28	16
Pigs/nipple	10	10	10	10	16	13

Due to the use of a converted building (milking stable), there was only one building available to house large groups of 200 and 450. Since piglets were weaned and moved to the nursery on a Thursday and from the nursery to the finishing pens on a Monday or Tuesday, variation in weaning age and days in nurseries did occur. Weaning age varied between 20 and 24 days and days spent in the different nursery houses varied between 44 and 47 days. Therefore ADG was used to compare growth between the different groups.

Building C had the lowest ADG (0.390 kg/day/pig). This could be the result of building design and inadequate floor space (0.259 m^2). Another reason could be aggression at the feeder, due to the mixing of two litters and the restructuring of the pecking order. Various authers (McBride, 1964, Petherick and Blackshaw, 1987, Nielsen *et al.*, 1995 and Spoolder *et al.*, 1999 reported that inadequate feeding space could increase the amount of feeder-related aggression and reduce the growth rate of growing pigs. However, although aggression was also observed in the groups of 200 and 450 during the first 2 days, it did not seem to affect their growth. In fact, the group of 450 pigs had the highest ADG.

Table 2. Growth parameters of the weaned piglets (Average and Standard Deviation)

House	A		B		C		D		E		F	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Initial weight (kg)	5.22	0.46	4.96	0.33	5.03	0.33	4.97	0.69	4.84	0.32	4.76	0.63
Final weight (kg)	24.46	1.94	23.85	1.42	22.54	1.42	24.80	2.21	26.29	2.40	24.07	2.48
Initial age (days)	21.50	0.55	21.15	1.36	22.56	1.36	22.46	1.51	22.00	1.63	21.50	1.00
Final age (days)	66.39	4.27	67.43	3.92	67.33	3.92	69.95	4.67	68.70	1.70	68.50	3.11
Days in house	44.89	3.86	46.28	3.84	44.77	3.84	47.49	4.80	46.70	2.82	47.00	3.56
ADG (kg/day)	0.43	0.03	0.41	0.03	0.39	0.03	0.42	0.04	0.46	0.07	0.41	0.04
Mortality (%)	1.92	0.40	2.02	1.24	1.88	1.24	2.04	0.94	1.48	0.36	1.60	0.22

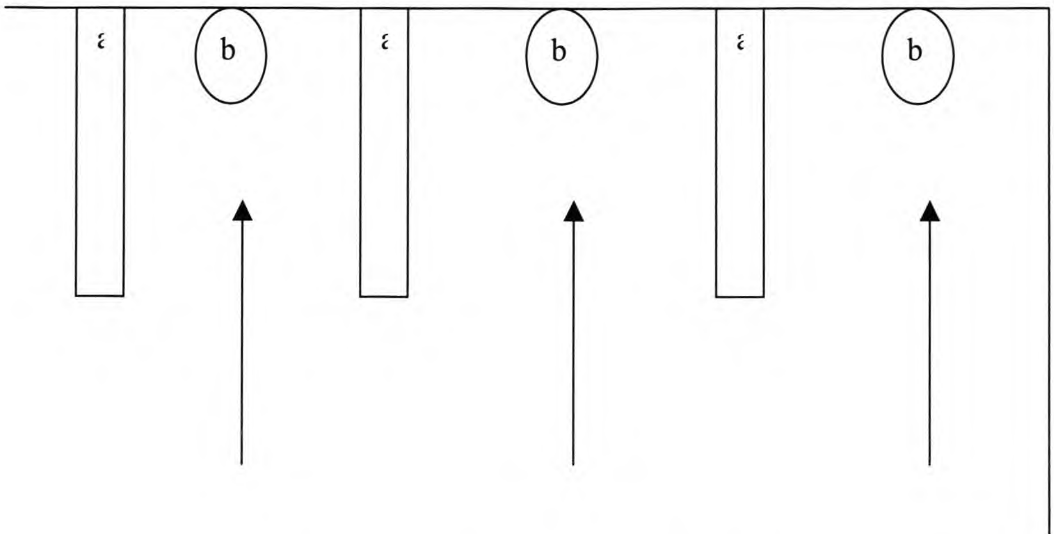
In a review of the literature, Petherick and Blackshaw (1987) suggested that feeder-related aggression could be minimized by *ad lib* feeding. The pigs in Group E were also housed in a new building, which therefore had less pathogens, this could also be a reason why the larger groups did not have a higher mortality rate. The mortality in general was low and could be due to added care with more time spent by personal to do the trail.

Traditional recommendations have suggested less than 10 and as few as 3 pigs per feeder space are necessary to maximize growth performance (Baxter, 1984), but recent results have indicated that as many as 20 or 30 pigs can be fed from a single-space feeder and still maintain acceptable performance (Walker, 1991; Nielsen *et al*., 1995). There are numerous factors determining how many pigs can adequately perform on a given feeder space. The quantity, dimension, and placement of the feeding spaces as well as the animal selection preferences are important components to consider in order to maximize pig performance during all phases of growth. Since the lesser feed-space per piglet in houses E and F did not negatively influence the piglets growth, it might indicate that the Lean Machines are a very economical feeding system. It was also quite interesting to observe the feeding behaviour of the pigs. They seemed to prefer certain Lean Machines to others, although the reasons for this are unknown.

Many studies have compared the provision of dry and wet/dry feeders and have generally concluded that the availability of water within the feeder increases feed intake and daily weight gain of pigs (Anderson *et al*., 1990; Walker, 1990; Gonyou and Lou, 2000). However, providing feed and water together may also reduce carcass lean weight (Walker, 1990; Gonyou and Lou, 2000), therefore, Gonyou and Lou (2000) suggest that diet formulation should be modified for wet/dry feeders taking into account increased feed consumption. Little information is available on the benefits of providing a supplemental water source, other than in the feeder, in pens containing wet/dry feeders. Some research suggests that an additional water source is unnecessary and may increase water wastage (Walker, 1990).

The two larger groups in this trial had more pigs/nipple drinker, but that did not seem to affect their performance. At no given time were overcrowding at the nipples drinkers of any groups observed.

An interesting observation in House E and F was that the first two groups of pigs defecated in the watering cups, which had to be cleaned continuously. To avoid this problem every water cup (b) was isolated by means of low walls (a), which forced the pigs to enter head first in order to obtain water (see picture below).



The low wall was 400mm high and 200mm apart. In the centre between walls were cupdrinkers. The pigs had to enter the comparment from the front to drink.

The use of cup drinkers enabled the workers to medicate the water in House E and F. The first three days the pigs were given Stresspac with Coliprim and Phenominovite to reduce the effect of moving the pigs from nursery to weaner housing. This might also have improved the performance of the pigs in the larger groups. The other houses only had nipple drinkers and no cups to prevent wastage. These pigs were also medicated but water medication was given in bowls during the last few days in the nursery.

Another aspect that warrants attention in any housing system is the cost involved in maintaining cleanliness and a healthy environment. The smaller the group size, the more pens are needed, resulting in more walls that need to be cleaned and disinfected. Every pen also needs a feeder and water nipple. A comparison was made between building C as it is currently functioning and same building was converted from small groups to large groups.

In House C there are 46 feeders and 92 nipple drinkers and the total floor area is 238.28 m^2. At 0.36 m^2 per piglet, this area can hold 662 piglets. With 46 pens you have a total of 707.48 m^2 to clean and disinfect (walls are 1 m high and every pen has gate made of round iron. If this building were only divided into two pens, each pen would have 296.94 m^2 of floor space (825 pigs at 0.36 m^2 per pig). This alone increases the capacity of the building by 163 pigs. Two pens would result in a surface area of 401.24 m^2 to be cleaned and disinfected. Using Lean Machines and two pens, one would need 21 Lean Machines and 41 water nipples (at 10 pigs per water nipple). Using self-feeders one would need 83 water nipples and 41 self-feeders (1.2 m wide). If one would assume the average person takes 5 minutes to clean and disinfect 1 m^2 it will result in 25.52 hours of extra cleaning time. More time spent cleaning also leads to more water usage and results in more waste material to be disposed of. Running time and wear on the pressure-washer, as well as added electricity costs should also be taken into account. Soaps and disinfectants also add to the cost of cleaning.

The construction of small pens is also more expensive, since more dividing walls need to be built. These walls also take up more space, which could have been used for pigs. This results in a higher cost per pig produced.

One disadvantage of raising pigs in larger groups is that it is difficult to catch and treat sick piglets. Compared to smaller pen sizes, it is more difficult to distinguish between resting space, functional space and social space in larger pen sizes. Since solid floors were used in this trial, it leads to more frequent removal of faeces. Slated floors would have raised the cost of production, but would have been easier to clean and would probably be cheaper in the long run.

This trial was only performed on piglets between 24 and 70 days of age. It will be interesting to see the effect of larger group size on the wean-to-finish-growth phase.

Conclusions

The results of this trial clearly indicate that raising piglets in larger groups does not negatively affect the performance of the piglet in terms of ADG and mortality. Future trials could be more specific in order to establish FCR of large groups compared to small groups. The optimum floor space requirement for large groups and ideal group size (100, 200, 400?) can also be investigated. In larger groups, the less time (labour time) spent cleaning and the fewer feeders needed, will result in lower production costs. The result of reducing the cost of raising piglets is a more profitable production unit. Genetic improvement of feed conversion and sow production is a slow process. Time and labour is and will in the future be an integral part of production cost. In today's economical environment, the producer that can lower his production cost while maintaining production standards has a significant advantage. Therefore, it is believed that by grouping pigs in larger groups labor time in terms of cleaning can be reduced production cost will decrease without reducing production standards.

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C) General Conclusions

Modern pig farms are expensive to build and operate especially in South Africa (SA) where interest rates are high (12%); therefore, the primary objective of today's pig producer is to maximize profit received per unit of pig space provided in a given facility. There are certain management strategies that a farmer can implement to ensure this. The goals of such strategies include maximizing performance and implementing proper pig flow schedules and to make sure current facilities are performing at maximum capacitys or are better utilized. Labour in SA is still relatively inexpensive, but time is money. Feeding and cleaning small pens are time consuming and expensive to maintain (more feeders and water nipples, gates, walls and heating).

Proper management of facility space is vital to remain competitive in today's pig industry. The amount of floor and feeder space provided within an animal's environment could vastly influence pig performance and profitability. Crowding pigs have a negative effect on average daily gain (ADG) and overall production performance. Conversely, facility cost per pig increases as additional space is provided, therefore, in the interest of pen efficiency, the space that allows for maximum individual performance may not be optimal for maximizing profit. Factors such as cleaning and cleaning time also have an effect on profitability. Another concerning factor associated with maximizing performance and maintaining the pig flow of a facility is that of body weight (BW) variation. Having uniform pigs at 70 day, post-weaning has been a major goal to ensure maximum performance in finishers.

Numerous contradictions regarding the growth of piglets post weaning (especially the effect of group size and floor space allowance) still exist in literature. Also, in SA, the majority of pig producers still believe that individual litters or small groups of pigs in the growers perform better and are the most economical production method.

Therefore, this trial was performed to investigate the raising of large groups (200 - 450 pigs/group) compared to small groups (10 - 20 pigs/group) on their performance until 70 days when they were moved to the growing facility.

The results of this trial clearly indicate that raising piglets in larger groups does not negatively affect the performance of the piglet in terms of ADG and mortality. In larger groups, the less time (labour time) spent cleaning and the fewer feeders needed, will result in lower production costs. The result of reducing the cost of raising piglets is a more profitable production unit. Genetic improvement of feed conversion and sow production is a slow process. Time and labour is and will in the future be an integral part of production cost. In today's economical environment, the producer that can lower his production cost while maintaining production standards has a significant advantage. Therefore, it is believed that by grouping pigs in larger groups labour time can be reduced in terms of cleaning, and will reduce production cost without reducing production standards.