Feed intake in group housed pigs – considerations for breeding programs

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Importance of feed intake

Feed costs account for a large proportion of the costs of pig production representing usually around 50% of the total costs (Aranda and Cleary, 2001). in the Australian pig industry this proportion has been much higher recently due to the shortage of feed resulting from the extensive drought. Selection for feed efficiency is always an important topic, independent of the current drought situation. Most pig breeders in Australia do not record feed intake and therefore have no records for feed efficiency. Instead, breeders have focussed on growth rate and backfat and considerable gains have been achieved using BLUP technologies. Selection for growth rate and backfat will indirectly improve feed efficiency but its effect on feed intake depends on the main selection emphasis. A high growth rate is genetically related to a high feed intake whereas a low backfat is genetically associated with a low feed intake. Whether feed intake has actually been reduced will depend on the magnitude of selection emphasis put on growth rate (higher feed intake) versus backfat and feed efficiency (lower feed intake). The Australian payment system warrants putting a high emphasis on backfat (Cameron and Crump, 2001), which together with selection emphasis on feed efficiency may have led to a reduction in the feed intake capacity of the pig. Rex Walters has outlined in the previous talk what the implications of a low feed intake capacity are. It is the aim of this paper to summarise some of the main findings of previous Australian research, which has focussed on the growing pig and to outline areas where additional information is required to explore this important topic further.

Selection for higher feed intake?

The classical approach of selecting for growth rate, backfat and feed conversion ratio (or feed intake) always puts a negative economic value on feed intake since higher feed costs reduce profit. As a result, breeding programs that have put a high emphasis on efficient lean meat growth have caused a reduction in the feed intake capacity of the pig (eg. Ellis et. al., 1983; Cameron, 1994). This reduced feed intake capacity may limit the actual lean meat potential of the pigs such that pigs are not able to eat enough food to maximise their lean meat growth potential.

Performance of pigs in commercial environments is often reduced in comparison to test and research environments and this has been extensively investigated in the 'Growth Gap Project" (Black et al., 2001). The various genetics projects conducted at AGBU in cooperation with QAF (Bunge) Meat Industries have also shown that *ad libitum* feed intake of the same genetic lines was approximately 200 grams lower per day in group-housed pigs (Project UNE20P) in comparison to single penning (Project UNE17P).

Therefore, the feed intake capacity of modern genotypes housed in commercial conditions may be insufficient to maximise lean meat growth.

Henman et al. (1999) investigated the relationship between energy levels in the feed and growth rate between 60 and 100 kg live weight at QAF Meat Industries for pigs housed in groups (Figure 1). The results showed that growth rate increased with increasing energy density. The authors commented that these findings are in contrast to the classical theory that increasing energy density would result in a consistent decline in feed intake and hypothesised that feed intake may be restricted more by physical or social effects than by physiological constraints.

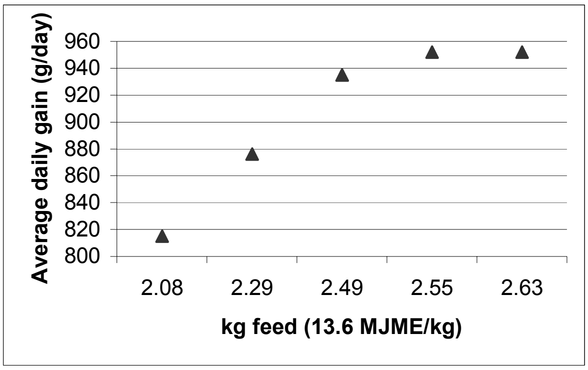


Figure 1 Average daily gain for different levels of feed intake for a QAF (Bunge) population published by Henman et al., (1999).

The relationship between growth rate and feed intake as presented by Henman et al. (1999) reflect the concept of the linear plateau model. This model assumes a linear increase in protein deposition until a plateau (maximum protein deposition) is reached. The concept of this model has been incorporated into many nutritional software packages including the AUSPIG model (Black et al., 1986). For genetic improvement it provides an avenue to directly select for the minimum feed intake capacity that is required to maximise lean meat growth and minimise feed conversion ratio (ie. Hermesch et al., 2003). It is important to note that incorporation of such a model into breeding programs requires further cooperation between geneticists and nutritionists.

Variation in feed intake

The PhD thesis by Pieter Knap (2000) is one of the most comprehensive examples of combining results from a number of disciplines in order to investigate the physiology of the growing pig. The aim of the thesis was to explore variation in maintenance requirements in growing pigs. Knap (2000) proposed that 40% of the variation in feed intake is related to production leaving 60% as 'residual feed intake' (Figure 2). A small proportion of the variance in feed intake (8%) is due to the requirements for composition of body growth (protein versus lipid deposition) leaving more than half of the variation in feed intake for maintenance requirements (52%). Only a small proportion of these maintenance requirements are related to body composition (3%). The author concluded that 49% of the variation in feed intake is related to 'other functions' which may include immune response, activity, thermoregulation and response to stressors. It will be the challenge of future research projects to better quantify some of these factors. However, these factors may provide the key to a better understanding of the driving forces that determine feed intake of individual pigs in commercial environments.

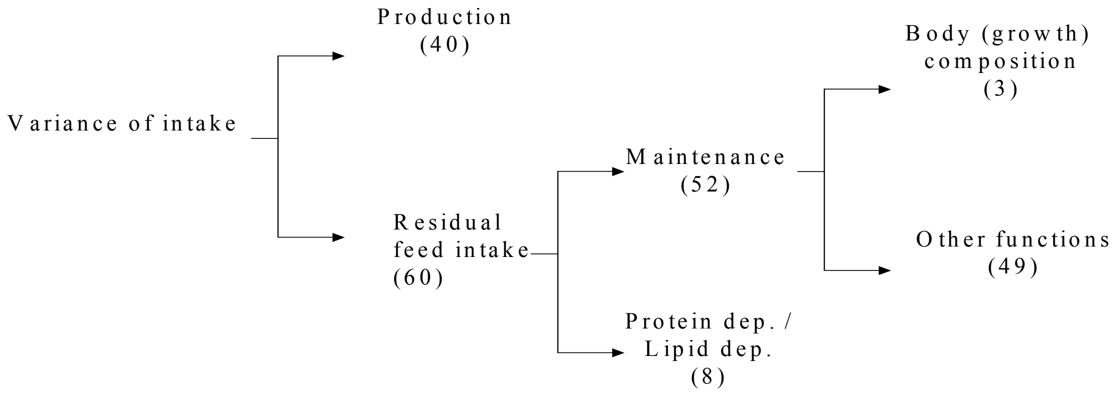


Figure 2 Proposed partitioning of within-population variance in *ad libitum* energy intake (Knap, 2000, p. 167).

Feed intake data from electronic feeders

The need to record feed intake in group housed pigs has led to the development of electronic feeders which provide a multitude of additional data that was previously available. Breeding programs should make best use of this additional data in order to explore social interactions between pigs (group dynamics) and their possible effects on performance. A starting point is the analysis of feeding behaviour traits as outlined in the work by McSweeny (2002). The first data set was used by Jodine to evaluate the functioning of the electronic feeders included three feeding levels. Pigs were either fed ad libitum, semi-restricted or restricted (also see Hermesch et al., 2002 for further details).

As discussed in the previous paper in this workshop, the daily feed allocation starts at midnight. The level of restriction influenced the feeding behaviour of pigs (Figures 3a, 3b, 3c). The largest proportion of feed was eaten during the day between 8 am and 4 pm for the *ad libitum* group. The semi-restricted group had a peak around 8 am and a larger proportion of feed was eaten in the early morning hours. Finally, the most restricted group were obviously the hungriest and were eating a large proportion of their feed after midnight and less and less feed was eaten during the day.

Pigs modified their feeding behaviour patterns in order to obtain their desired feed intake levels. It is also important to note that pigs on *ad libitum* feeding also had a higher feed intake level during the early morning hours. Pigs on different feeding levels were kept in the same pen and the activities of the restricted pigs shortly after midnight may have influenced the feeding activities of pigs on the *ad libitum* feeding regime. It is an indication that feeding activities of some pigs in the pen may influence feeding behaviour of other pigs in the group.

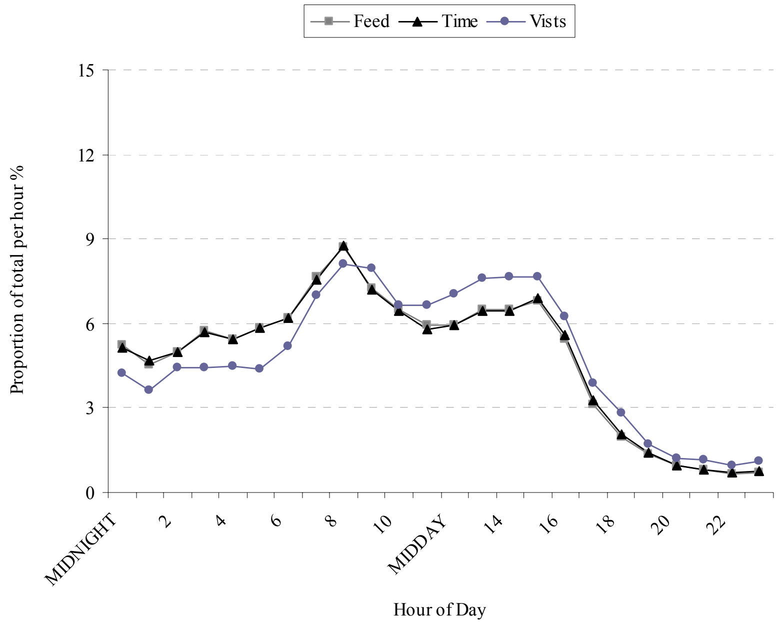


Figure 3a Percentage of total feed, time and visits per hour in proportion to the whole day – Ad libitum group (based on DATA1 from McSweeny, 2002).

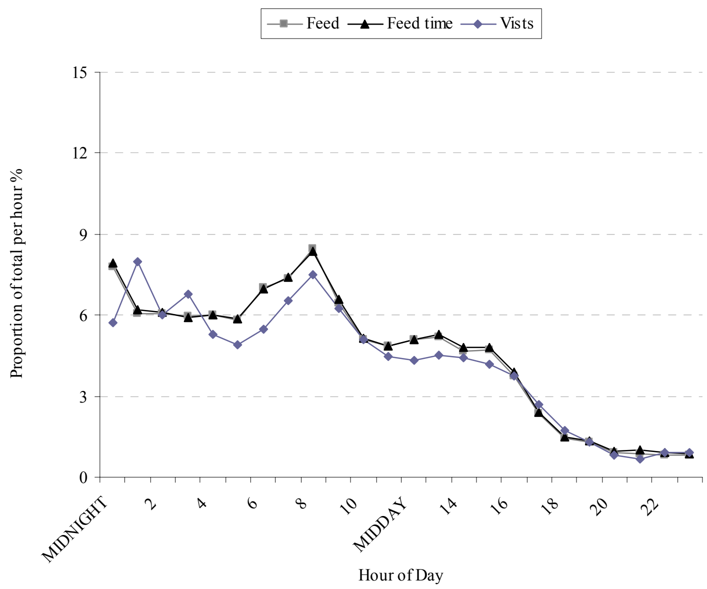


Figure 3b Percentage of total feed, time and visits per hour in proportion to the whole day – Semi-Restricted group (based on DATA1 from McSweeny, 2002).

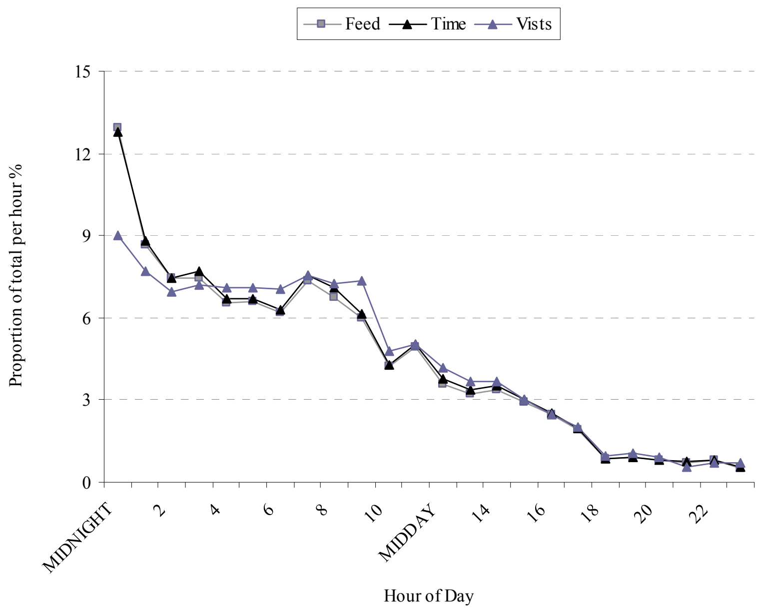


Figure 3c Percentage of total feed, time and visits per hour in proportion to the whole day – Restricted group (based on DATA1 from McSweeny, 2002).

Despite these changes in feeding patterns during the day, some pigs on restricted feeding were not able to eat all of their feed allocation (Figure 4). The restrictions have reduced the variation in feed intake but did not fully eliminate variation in feed intake. In contrast, it was possible to eliminate variation in feed intake in selection experiments based on single pen feeding (McPhee et al., 1988). The reasons why the feed intake of some pigs is reduced to such an extent in such a commercial group-housing environment are unknown. One explanation may be the dominance of some pigs preventing other pigs from eating. For example, Muir et al. (2002) demonstrated in poultry that selection for fast growing efficient animals increased competition between animals. Competitive effects may impair the performance of some pigs in the group and these effects and their implication for pig breeding programs need to be explored further.

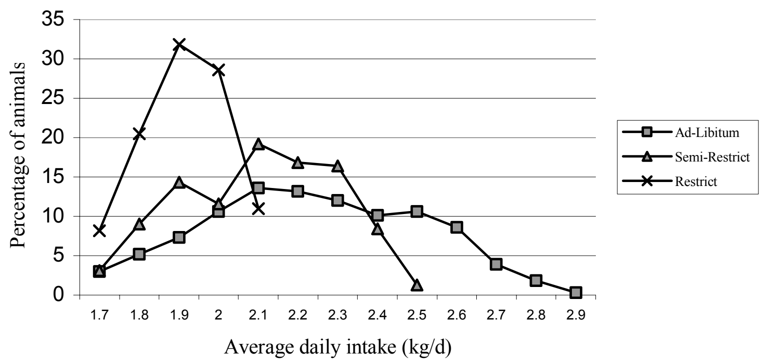


Figure 4 Percentage of animals in each feeder group for different average daily feed intake levels (Data described in Hermesch et al., 2002).

Pathways of genetic improvement – can we avoid a reduction in feed intake?

Selection for improved efficient lean meat growth can be achieved along different pathways (Fowler *et al*., 1976; Table 1). A selection strategy based on ad libitum feeding where variation in feed intake is fully expressed in combination with a selection emphasis on lean meat growth and feed conversion ratio will increase lean meat deposition, reduce fat deposition and reduce feed intake. In contrast, a selection strategy based on restricted feeding with the aim of improving lean meat growth will maximise lean meat growth and ultimately increase feed intake.

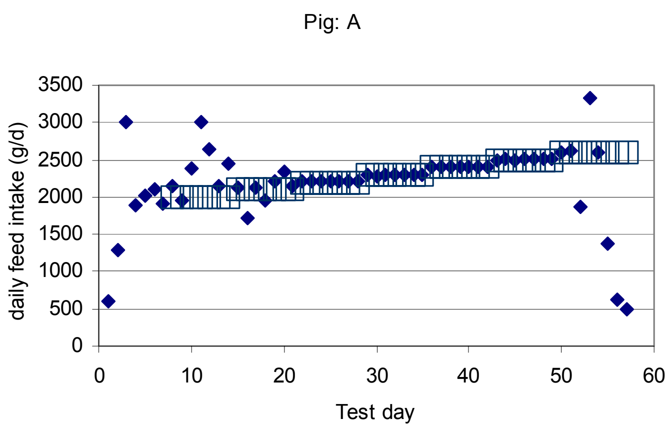
Table 1 Summary of pathways for genetic improvement of efficient lean meat growth (adapted from Fowler et al., 1976)

Breeding objective	Testing scheme	Results of selection
Lean meat growth and feed conversion ratio	*Ad libitum*	Increased lean meat deposition Reduced fat deposition Reduced feed intake
Lean meat growth	*Ad libitum*	Increased lean meat deposition Increased feed intake Less efficient than restr. feeding Accurate measurement of lean meat required
Lean meat growth	Restricted	All pressure on increased lean meat deposition Increased feed intake

These principles have been confirmed in selection experiments (McPhee et al., 1988; Cameron and Curran, 1995) as well as in a study based on commercial data (Hermesch et al., 1999). Those results were presented at the 2000 Pig Genetics Workshop concluding that restricted feeding favoured selection for lean meat growth rate. In contrast, *ad libitum* feeding was superior for a breeding objective focussing on feed efficiency and leanness, which was achieved by a reduction in feed intake. However, differences in genetic parameters were not as profound as results presented by McPhee et al., (1988) and Cameron and Curran (1995), which may be due to the remaining variation in feed intake of restricted pigs in commercial conditions.

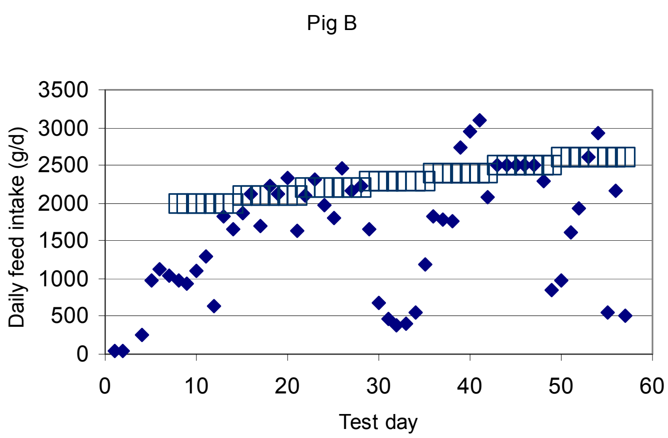
Feed intake over the growth trajectory

In addition to feeding behaviour traits, electronic feeders provide data on daily feed intake levels and the variation in feed intake from one day to the next. Figures 5a, 5b and 5c provide examples of the daily feed intake patterns of three pigs. These pigs were tested on a restricted feeding regime and the boxes in each graph indicate the maximum feed allowance during each week. Pig A had a high feed intake capacity and low variation in daily feed intake. It was able to eat all feed most of the time. Pig B was able to eat its allocations in the fifth and sixth week but showed much larger variation in feed intake from day to day. Finally, Pig C has a lower feed intake capacity in this environment and was not able to eat its allocations during test. It should be explored whether this variation is a heritable trait and is genetically related to any performance levels.



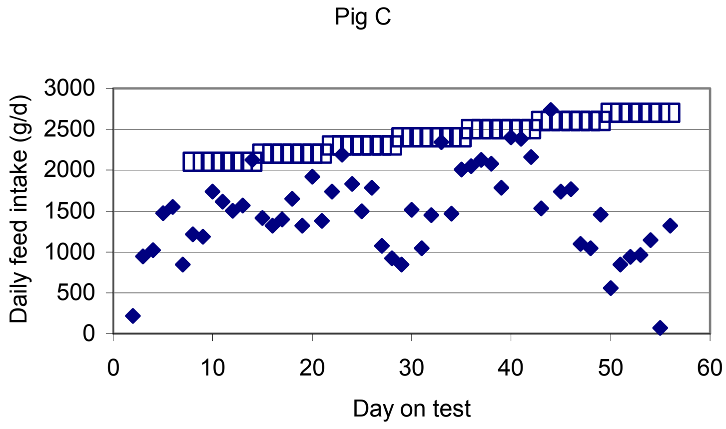
(◆) feed intake on specific day; □ maximum allocation

Figure 5a Daily feed intake patterns over test – Pig A.



(◆) feed intake on specific day; □ maximum allocation

Figure 5b Daily feed intake patterns over test – Pig B.



(◆) feed intake on specific day; □ maximum allocation

Figure 5c. Daily feed intake patterns over test – Pig C.

These repeated feed intake as well as repeated weight measurements were analysed by Abe Huisman applying a random regression model (Huisman, 2002, chapter 4 and chapter 6). This model allows heritability and genetic correlation estimates to be obtained over an age or weight trajectory. Heritability estimates increased from 0.05 to 0.17 over the weight trajectory from 62.5 kg to 117.5 kg for daily gain and did not vary substantially for feed intake (results from Huisman, 2002 are summarised in Figure 6). Genetic correlations for each trait over the weight trajectory were essentially one for daily gain and above 0.90 for the fast majority of daily intake data points. These high genetic correlations show that daily gain, daily feed intake and feed efficiency were genetically the same trait over the weight range analysed.

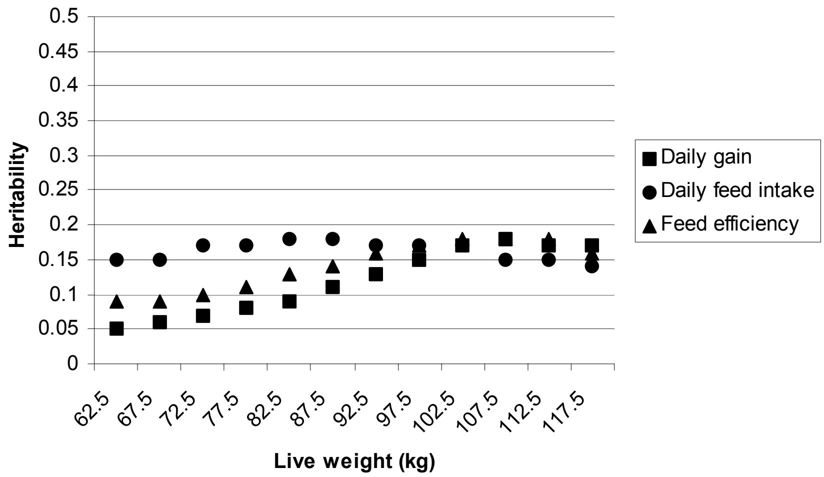


Figure 6 Heritability estimates for daily gain, daily feed intake and feed efficiency over live weight (estimates from Huisman, 2002).

Summary and outlook

The feed intake capacity of modern genotypes housed in certain commercial environments (eco-shelters were not considered in this paper) may limit the lean meat growth potential of pigs. Breeders need to understand the implications of selection strategies on feed intake. These strategies may include the use of growth models in breeding programs, which requires a close collaboration of nutritionists and geneticists.

A large part of the variation in feed intake is due to 'other functions' (Knap, 2000), which are unrelated to production and maintenance requirements for growth and body composition. These other functions may include immune response, physical activity, thermoregulation and response to stressors that prevail in a group. The complexity of these issues again highlights the importance of a cooperative research approach by scientists from a number of disciplines.

Electronic feeders provide a range of additional information that should be explored further. A trait of specific interest may be variation in daily feed intake.

On-farm measurements?

Breeders may look for on-farm measurements which give a better evaluation for the feed intake capacity of their pig in relation to the protein and lipid deposition. In the growing pig, repeated weight and backfat measurements can be used in growth models to better predict the body composition of pigs along with the feed intake capacity of the pig (Schinckel et al., 1996).

Rex Walters has highlighted the importance of a high feed intake during lactation in the previous paper. Feed intake in the lactating sow is labour intensive to measure but does not require large capital investments. An initial project should explore whether it is sufficient to only record daily feed intake on specific days during lactation rather than every day. In addition, the weight and backfat of the sow at farrowing and at the end of lactation would have to be recorded along with the litter weight at birth and at weaning (or 21 days of age). This type of data would provide us with a much better understanding of the genetic background of sow feed intake during lactation.

Acknowledgements

The preparation of this manuscript was supported by the Australian Pork Limited (Project No. 11711). Provision of data by QAF Meat Industries and support by Brian Luxford and Colin Bennett are gratefully acknowledged.

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