Feed intake, growth and feed utilization patterns of pigs highly divergent in growth rate

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Received 18 December 1986; accepted 23 October 1987

A group of slow-growing Landrace and a group of fast-growing Large White boars were used to study their patterns of feed intake, growth rate and feed utilization. The pigs were fed *ad libitum* on a high-energy diet of a high protein content and quality. The data show no difference in mean daily feed intakes between the two groups. Mean daily live mass gain was, however, 174 g/day (20,5%) more for the Large White boars and feed conversion 16,5% better (both statistically significant at $P \leq 0,01$). The fast-growing pigs also had only 15,7 mm of P_2 backfat, 40% less than the 26,1 mm of the Landrace pigs at 86 kg live mass. Distinct intake and growth patterns were also established not only between the two pig groups, but also between individual pigs. Hence it is concluded that the absolute amount and pattern of feed intake is dictated by the animal's growth rate, its pattern of body protein and fat accretion, and the amount of food used for maintenance.

'n Groep stadiggroeiende Landrasbere en 'n groep vinniggroeiende Grootwitbere is gebruik om hul patroon van voerinname, groei en voerverbruik te bestudeer. Die varke is *ad libitum* op 'n hoë-energiedieet met 'n hoë proteïeninhoud van 'n hoë kwaliteit gevoer. Die data toon dat gemiddelde daaglikse voerinnames nie tussen die twee groepe verskil het nie. Die Grootwitbere het gemiddeld 174 g/dag (20,5%) meer in lewende massa toegeneem en hul voedsel 16,5% beter benut (beide statisties hoogs betekenisvol by $P \leq 0,01$). Ook het die vinnigroeiende varke 'n P_2-rugspekmaat van slegs 15,7 mm gehad, 40% minder as die 26,1 mm van die Landrasbere op 'n massa van 86 kg. Duidelike inname- en groeipatrone is ook gevind, nie slegs tussen die twee varkrasse nie, maar ook tussen individuele varke. Gevolglik is tot die gevolgtrekking gekom dat beide die absolute hoeveelheid en patroon van voerinname deur die dier se groeitempo, patroon van proteien- en vetneerlegging en die hoeveelheid voer vir onderhoud benodig, bepaal word.

Keywords: Feed intake, growth rate, feed utilization, pigs

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Introduction

In a review on feed intake regulation by growing pigs Henry (1985) concluded that feed or energy intake is closely related to the potential for muscular growth and the capacity of fat deposition.

According to Whittemore (1985), daily lean tissue gains increase linearly as food intake increases, up to a point at which the intrinsic maximum or plateau for a specific pig is reached. Feed consumed in excess of that required to maximize lean tissue gain is therefore excessive, resulting in surplus fat deposition. Pigs of higher merit will, therefore, have higher potentials for daily lean tissue growth rate, the plateau will be raised, and the point at which it will be reached will relate to a higher feed supply.

Siebrits (1984) quantified daily gains of protein and fat in genetically lean and obese pigs, and showed that feed intake is allometrically related to growth rate, as well as to the rate at which protein and fat are deposited in the body. Hence feed intake and growth rates increased curvilinearly to reach a maximum, only to decline subsequently' but at different rates for each type of pig. As a consequence the pattern of energy retention may be dictated by the pattern of energy intake. The apportionment of consumed energy towards protein and fat is, however, genetically and sexually controlled, depending on the propensity of the pig to deposit protein, with the proviso that an adequate diet is fed.

Different growth rates in *ad libitum* fed pigs are not necessarily associated with differences in feed intake. The pig with a high potential for daily lean tissue growth rate will be a more efficient converter of dietary energy and protein. Therefore, it will deposit more lean and less fat than its fat counterpart and thus have a higher potential for growth rate on the same amount of feed.

The availability of data on feed intake and growth of pigs highly divergent in growth rate afforded the opportunity to study the pattern of both feed intake and feed conversion of these pigs when fed *ad libitum* on a high-energy diet of a high protein content and quality.

Experimental procedures

The data of 14 Landrace and 15 Large White boars were used in this study. The pigs were obtained from two piggeries, with all the pigs of a specific breed coming from the same piggery. The Landrace boars arrived at the Testing Station when 74,0 ± 2,5 days old and 22,9 ± 3,6 kg in live mass. The Large White boars were 64,5 ± 4,5 days old and 23,0 ± 3,9 kg in live mass.

Pigs were individually penned in indoor pens (1,22 m × 3,05 m) fitted with a self-feeder and an automatic water nipple. Feed intake and live mass were recorded every 4 days. Feed and water were not withdrawn before mass determinations were done. The trial ended when the pigs were 87,3 ± 1,2 kg in live mass. Pigs had *ad libitum* access to the diet (pelleted) used for boar testing in South Africa (Table 1). Backfat, measured at P_2, was corrected to a live mass of 86 kg using the method described by Rossouw & Coetzer (1982).

Table 1 Diet fed *ad lib.* in a pelleted form to both Landrace and Large White boars

Ingredients	%
Maize meal	67,00
Wheaten bran	10,44
Molasses	3,00
Fish meal	12,50
Soyabean oilcake	5,46
Feedlime	0,37
Monocalcium phosphate	0,23
Fine salt	1,00
Mineral and Vitamin mixture	Added
Composition:	
Dry matter, %	89,2
Protein, %	21,8
DE, MJ/kg[a]	14,88

[a] Determined in a digestion trial as described by Kemm & Ras (1971)

Statistical analyses

The allometric autoregressive (AA) growth model, as described by Roux (1976) and subtantiated in pig studies by Roux & Kemm (1981) and Siebrits (1984), was used to describe growth rate, feed intake and feed conversion in the present study.

The procedures followed in the application of the model to the data in this study were exactly as described by Siebrits (1986). Autoregressions of ln(cumulative DE intake) were calculated for each individual pig by correlating the ln of cumulative DE intake at time (t-1) as X with ln(cumulative DE intake) at time t as y. The relationships between ln(cumulative DE intake) and ln(mass) was then used to calculate feed and DE conversion for each pig for the live mass interval 35 – 85 kg. Because of the breakpoint in growth identified at an age of approximately 81 days (see Siebrits 1986) the equations were calculated with the data point on or before 81 days as a first data point, hence the choice of a 35 – 85 kg live mass interval for data presentation. The statistical parameters, tabulated in Table 2, were used to fit the curves in Figure 1. For the graphs in Figure 2 the parameters individually derived for each of two pigs selected on their diversity in growth rate were used.

Table 2 Growth parameters of the allometric autoregressive model

Growth parameters	Landrace boars (Mean ± *SD*)	Large White boars (Mean ± *SD*)
ρ^1	0,948 ± 0,009	0,952 ± 0,012
α^2	9,049 ± 0,272	9,281 ± 0,467
a^3	-1,747 ± 0,220	-2,140* ± 0,394
b^4	0,770 ± 0,033	0,834* ± 0,055
μ^5	6,620 ± 0,172	6,877 ± 0,143

ρ^1 slope of autoregression
α^2 asymptote of cumulative DE intake
a^3 mean intercept of ln(live mass) - ln(cumulative DE) regressions
b^4 mean slope of ln(live mass) - ln(cumulative DE) regressions
μ^5 mean initial ln(cumulative DE intake) value
* Statistically highly significant ($P \leq 0,01$)
The means of the coefficients of determination (r^2) of the autoregressions and the ln(cumulative DE intake) - ln(live mass) regressions were 0,999 and 0,998 respectively, indicating a very close fit

Results and Discussion

The individual growth parameters of each pig were used to calculate the mean feed intake, growth rate and feed conversion data for the growth interval 35 – 85 kg live mass presented in Table 3. The data indicate that there was no difference in mean daily feed intake between the two groups. The mean daily live mass gain was, however, 174 g/day (20,5%) more for the Large White boars and feed conversion ability 16,5% better, differences that proved to be statistically highly significant ($P \leq 0,01$). The fast-growing Large White pigs not only utilized their feed more efficiently but also had only 15,7 mm of P_2 backfat, 40% less than the 26,1 mm of the Landrace boars. Obviously differences in the partitioning of feed nutrients into lean and fatty tissues in the body must, therefore, have played a major role in the big differences in growth rate and feed conversion between pigs that consumed a similar daily amount of the same diet during the same live mass interval.

The measurement of feed intake and live mass at regular intervals for each pig also allowed the autoregressive model to be used to study the pattern of feed intake, growth rate and feed conversion, both on an individual and a group basis.

The patterns of feed intake, growth rate and feed conversion for the two pig breeds over the experimental period, calculated with the parameters in Table 2, are presented in Figure 1. Although the two pig groups consumed the same mean daily amount of feed to grow from 35 – 85 kg in live mass (Table 3), the data in

Table 3 Means ± *SD* for feed intake, growth rate and feed conversion data calculated for the growth interval 35 – 85 kg live mass and P_2 backfat corrected to 86 kg live mass

Measurement	Landrace boars (n = 14)	Large White boars (n = 15)
Feed intake, g/day	2419 ± 244 (100)	2428 ± 190 (100,3)
Live mass gain, g/day	850 ± 66 (100)	1024* ± 95 (120,5)
Feed conversion, kg/kg gain	2,85 ± 0,26 (100)	2,38* ± 0,23 (83,5)
P_2 backfat, mm	26,1 ± 4,8 (100)	15,7* ± 2,2 (60,2)

* Statistically highly significant ($P \leq 0,01$)

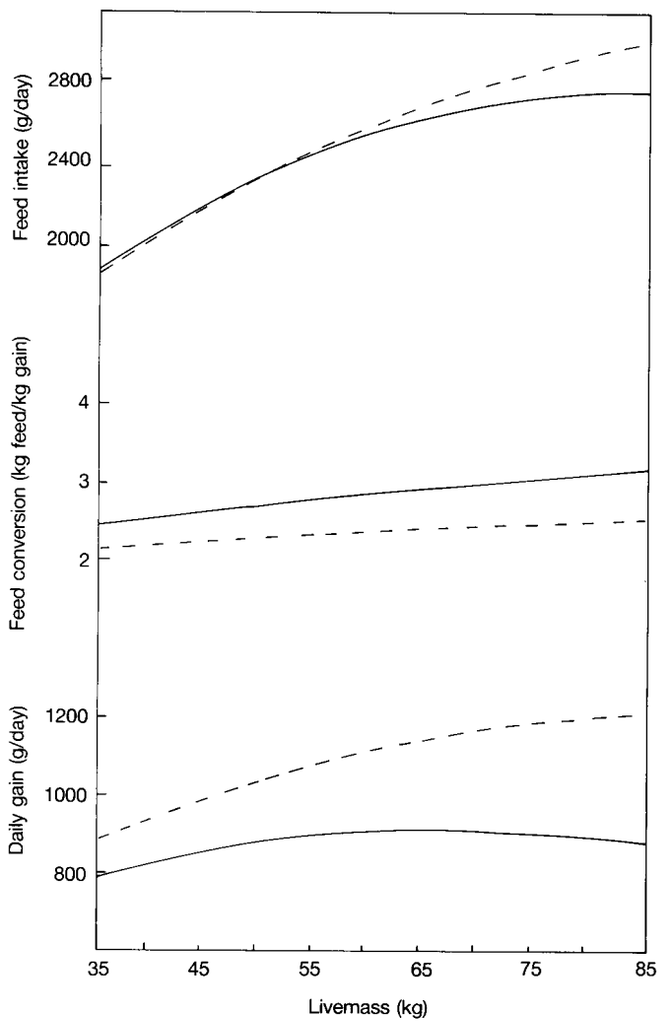

Figure 1 Daily live mass gains, feed conversion and daily feed intakes for Landrace (—) and Large White (- - -) boars

Figure 1 show a difference in intake pattern. Initially the Landrace pigs consumed slightly more feed per day (1898 vs 1872 g) at 35 kg live mass with very little difference in intake between the two breeds up to a live mass of about 55 kg, whereafter the Large White boars consumed progressively more feed per day up to the end of the trial period (3070 vs 2807 g/day at 85 kg). The rate of intake of the Landrace boars, however, tended to increase at a declining rate as they approached 85 kg live mass. The biggest difference in intake between the two groups (263 g/day) therefore occurred at 85 kg.

The amount of feed required by the Landrace group per unit of live mass gain (Figure 1) increased from 2,44 to 3,18 kg, an increase of 30%. For the Large White group the corresponding requirements were 13 and 20% less, increasing from only 2,13 kg at 35 to 2,54 kg at 85 kg live mass.

It is also important to note that the feed requirements per unit of live mass gain of the Large White pigs increased by only 20% compared to the 30% increase for the Landrace group.

The growth rate (Figure 1) of the Landrace boars increased from 778 g/day at 35 kg live mass to maximize at about 908 g at a live mass of 70 kg, only to decline subsequently to 883 g at 85 kg live mass. Large White boars, however, continued to grow at a faster rate throughout the trial period from an initial 880 g/day at 35 kg to 1210 g/day at 85 kg live mass.

Absolute values at different live masses (Table 4) and

Table 4 Feed intake, feed conversion and growth rate data computed at preselected live masses for the two pigs with the worst, Landrace No 109, and best, Large White No 12, feed conversion ability

	Live mass, kg						Mean	
	35		70		85		35 - 85	
Pig No	109	12	109	12	109	12	109	12
Feed intake, g/day	2170	1741	2887	2495	2748	2678	2711	2262
Feed conversion, kg/kg gain	2,81	1,93	3,70	2,00	4,00	2,02	3,46	1,98
Live mass gain, g/day	772	903	780	1250	688	1328	785	1144
P_2 backfat, mm					26*	14*		

* Measured ultrasonically and corrected to 86 kg live mass

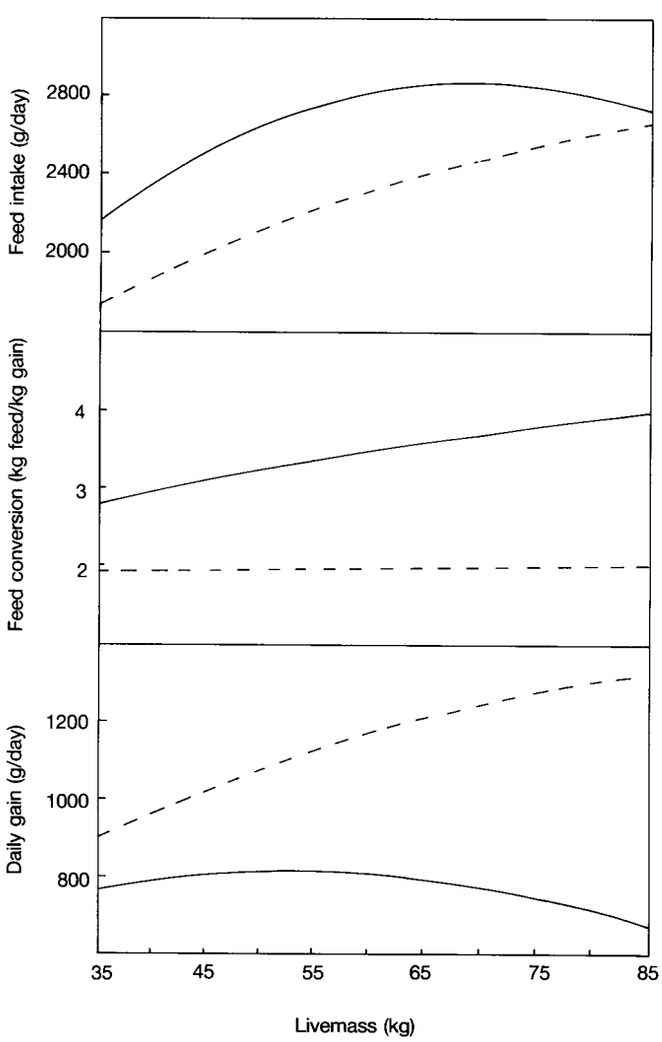

Figure 2 Daily live mass gains, feed conversion and daily feed intakes for Landrace boar No 109 (—) and Large White boar No 12 (- - -)

patterns (Figure 2) of feed intake, growth rate and feed conversion for the two pigs with the best (Large White boar No 12) and the worst (Landrace boar No 109) feed conversion ability are depicted in Figure 2.

Over the experimental period, pig No 109 consumed 20% more feed per day than pig No 12 (2711 vs 2262 g/day), had a 75% worse feed conversion ability (3,46 vs 1,98 kg/kg live mass gain) and a mean daily live mass gain which was 31% less (785 vs 1144 g/day).

The data presented in Table 4 and Figure 2 also show big differences between the two pigs in their patterns of feed intake, growth rate and feed conversion. Pig No 12 continued to consume greater amounts of feed per day over the entire experimental period, whilst the daily feed intake of pig 109 dropped from a maximum intake of 2887 g/day at a live mass of 70 kg to 2748 g/day at 85 kg. Consequently the initial difference of 24,6% in intake between the two pigs at 35 kg live mass decreased to only 2,6 % at 85 kg.

The data on feed conversion are most informative. The feed conversion ability of pig No 12 deteriorated only slightly from 1,93 to 2,02 kg/kg gain over the entire experimental period, with a period mean of 1,98. For pig No 109 the corresponding values were 2,8l at 35 kg live mass and 4,0 at 85 kg, with a mean value of 3,46 for the entire growth period.

The sustained ability of pig No 12 to utilize the continuously increasing amount of feed it consumed efficiently resulted in an accelerated growth rate over the entire period of study, from an initial 903 g/day at 35 kg live mass increasing to 1328 g/day at 85 kg. Pig No 109 grew at an appreciably slower rate and to a vastly different pattern (Figure 2). Its daily gain increased from 772 g/day at 35 kg live mass to peak at 822 g/day when the pig had a live mass of 50 kg whereafter there was a rapid decline in its rate of gain to only 688 g/day at 85 kg live mass.

In conclusion it is suggested that the pig has an intrinsic limit to both lean (protein) and fat growth as well as a specific pattern of growth. The absolute amount and pattern of feed intake may therefore to a large extent be dictated by its growth rate and maintenance requirements. Growth rate in turn is dependent on, *inter alia*, genetic potential for protein deposition and its maximum capacity for lipid growth, which has been shown by Siebrits (1984) to take place in a specific pattern for each of the two pig types studied. Future work will, therefore, be directed at attempts to increase feed intake in the fast-growing lean pig to levels higher than those achieved by its fatter slow-growing counterpart in an attempt to test the validity of the above suggestion.

The content and dietary balance of feed nutrients, such as protein (amino acids) supplied in excess of the animals requirements may alter *ad libitum* feed intake. Hence there is a need to also study the effect of dietary nutrient content on the pattern of feed intake.

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