Evaluation of the growth parameters of six commercial crossbred pig genotypes 2. Under ideal temperature conditions in chambers

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Abstract

To test whether animals grown under ideal temperature conditions would have different growth parameters to animals grown in more conventional housing, 60 Large White x Landrace male pigs from three genotypes were housed in six temperature-controlled chambers. The results were compared with data from a similar trial, with the same three genotypes, conducted in an open-sided house. Estimates of mature size (as measured by mature protein weight (P_m)), rate of maturing (B) and levels of inherent fatness (LPR_m) were obtained from serial slaughtering four pigs per genotype at 30, 40, 70, 80 and 90 kg live weight. The results indicate that for commercial crossbred male pigs there were no significant differences in the growth parameters between genotypes grown under ideal temperature conditions (Controlled), nor were there any differences between similar genotypes grown in Controlled *vs.* commercial conditions (Uncontrolled). The rate of maturing was also similar for all three genotypes and for all components. Mean estimates of P_m, B and LPR_m determined from both Controlled and Uncontrolled conditions can be combined to give values of 40.4±1.62 kg, 0.0114±0.0005 per day, and 1.67±0.153 kg/kg, respectively. Furthermore, controlling temperature had minimal effect on the allometric relationships between protein and the remaining body components for different genotypes. The determination of growth parameters for commercial crossbred pig genotypes can, therefore, be accomplished when the animals are grown individually in an open-sided house.

Keywords: Pigs, protein growth, temperature, Gompertz parameters
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Introduction

The possible adverse affects of the environment, especially temperature, on feed intake and subsequently growth are well known (Verstegen *et al*., 1973; Rinlado & Le Dividich, 1991; Ferguson *et al*., 2000a;b). To allow animals the opportunity to achieve their genetic potential they must be grown in an ideal environment and fed a non-limiting diet (Emmans & Oldham, 1988) The purpose of this study was to determine the genetic parameters of the various genotypes and, therefore, preference should be given to eliminate or reduce the adverse affects of the environment and particularly ambient temperature. It is most likely that temperatures in open-sided housing facilities are not ideal, given that the animals are exposed to variable ambient temperatures and could, therefore, affect the accuracy of the growth parameters (Ferguson & Gous, 1993). For example, Kyriazakis & Emmans (1991) observed a significant improvement in protein growth in the same genotype of pig when the animals were housed at cooler temperatures. The aim of this study was to test whether environmental temperatures do affect the accuracy of predicting the growth parameters of commercial genotypes of pigs. In addition comparisons will be made between the growth parameters determined from pigs grown in an environment where temperatures are controlled with those grown in uncontrolled, open-sided housing facilities.

Materials and Methods

A total of 60 pigs (20 per genotype) from the three genotypes, Genotypes 4, 5 and 6, as described in the previous paper (Ferguson & Kyriazis, 2003) were simultaneously housed in six temperature-controlled chambers. For ease of comparison the same genotype numbering, as in the previous paper, will apply. The chambers were approximately 6 m long, 3 m wide and 3 m high, which gave a floor space of close to 18 m^2. The chambers were able to maintain the temperature to within 0.5 °C of the required temperature setting. Ten pigs per genotype were randomly allocated to a chamber and were allowed to move freely within these chambers. The floors were covered with interlinking hard plastic-rubber mats with holes that allowed urine and faeces to pass through to steel grooves beneath the mats. Two fans were set to ventilate every minute for a minute to provide sufficient fresh air but still maintain the set temperature.

Four pigs were slaughtered per live-weight group according to the methods described in the previous paper (Ferguson & Kyriazis, 2003). The weight groups were 30, 40, 70, 80 and 90 kg live weight. As the genotypes used in the chambers were the same as those in the uncontrolled pens, it was not necessary to slaughter additional pigs at four and 14 days, respectively, and, therefore, the same estimates of body composition at four and 14-days, as reported in the previous paper, were used.

Details of the diets, choice feeding system, slaughter methods, sampling and carcass composition analyses, as well as statistical analyses are the same as described by Ferguson & Kyriazis (2003). The pigs were weighed weekly and the chambers were cleaned and serviced twice a week. The only difference in the feeding system between the chambers and the conventional pens was that the feeder bins in the chambers were fitted for wet feeding by means of a nipple drinker at the side of the bowl. This was the only water source for the pigs.

The ambient temperature within the chambers was controlled according to a proposed optimum temperature scheme for growth (Whittemore, 1998). At the start of the trial, when the pigs were between 15 and 20 kg and the temperatures of the chambers were set at 27 °C. As the average weight of the pigs in each chamber reached 25 kg, the temperature was dropped to 24 °C. From 30 kg body weight the temperature was dropped one degree for every 10 kg gain in average body weight per chamber until the final temperature was 17 °C for the pigs weighing 90 kg.

The fit-non-linear procedure in Genstat 5 (1997) and the allometric function, $Y = aX^b$ (Huxley, 1924), as described in the previous paper, were used to determine the Gompertz parameters, the allometric relationships between body components and the lipid, water and ash to protein ratios at maturity (LPR_m, $WAPR_m$, and APR_m, respectively). Comparisons of the growth parameters and allometric coefficients between and within genotypes were done by means of the Student t-test using pooled estimates of standard error of the difference of means to determine significant differences. Similar tests were conducted to compare the differences between (1) similar genotypes (Genotype 4, 5, and 6) grown in temperature-controlled conditions (Controlled) *vs.* those grown in open pens (Uncontrolled), and (2) all genotypes (Genotypes 1, 2, 3, 4, 5 and 6) in Uncontrolled conditions *vs.* pigs in Controlled conditions (Genotypes 4, 5 and 6).

Results

Data for the same genotypes tested in this paper, but grown in individual pens in an open-sided house (Uncontrolled) were obtained from the previous paper (Ferguson & Kyriazis, 2003). The results of fitting the Gompertz function to the data from pigs grown in the temperature-controlled chambers (Controlled) to estimate the mature component weight and rate of maturing (B), are shown in Table 1. There were no significant differences in growth parameters between genotypes, nor in the B value between components within a genotype. However, there was considerable variation within genotypes such that the coefficient of variation (CV) for all mature component weights exceeded 20%, with lipid having the highest (CV = 40.6%) while the CV's for the rate of maturing were between 11.9 and 13.3%.

Table 1 Estimates of the mature weights and B values for protein (P_m, $B_{protein}$), lipid (L_m, B_{lipid}), water (W_m, B_{water}) and ash (A_m, B_{ash}) in pig Genotypes 4, 5 and 6

	Protein		Lipid		Water		Ash	
Genotype	P_m	$B_{protein}$	L_m	B_{lipid}	W_m	B_{water}	A_m	B_{ash}
4	48.6	0.0110	56.2	0.0116	130.2	0.0116	11.5	0.0101
5	36.5	0.0123	62.0	0.0106	132.5	0.0115	9.9	0.0101
6	38.5	0.0118	60.1	0.0115	158.6	0.0102	7.4	0.0112
Pooled s.e.[#]	11.4	0.0014	23.8	0.0015	30.1	0.0013	3.46	0.0013
CV[¶]	27.6	11.9	40.6	13.3	21.4	11.6	36.1	12.4

[#]To test for significant differences between genotypes, pooled s.e. of the difference between means (= Pooled s.e. x √2 (t=2.145 for P=0.05) was used.
[¶] CV - Coefficient of variation (%)

The LPR_m, $WAPR_m$ and ash APR_m of the three genotypes grown in Controlled housing are shown in Table 2. No test for significant differences was conducted on these ratios at maturity because they were calculated from the values in Table 1.

Table 2 The lipid (LPR_m), water ($WAPR_m$) and ash (APR_m) to protein ratios at maturity in Genotypes 4, 5 and 6, and the mean (s.e.) of all genotypes housed in controlled chambers[#]

Component	Genotype 4	Genotype 5	Genotype 6	Mean (s.e.)
LPR_m	1.16	1.70	1.56	1.47 (0.163)
$WAPR_m$	2.68	3.63	4.12	3.48 (0.422)
APR_m	0.24	0.27	0.19	0.23 (0.023)

[#] Estimates of variation not provided as values are calculated and not means

Table 3 shows the predicted allometric constants and coefficients for the three genotypes tested. There were no significant ($P > 0.05$) differences in allometric coefficients between genotypes grown in the chambers, except for the allometric constant for water (a_{water}) where Genotype 4 had a significantly ($P < 0.05$) higher estimate than the other genotypes.

Table 3 Estimates of the allometric constant and exponent for lipid (a_{lipid}, b_{lipid}), water (a_{water}, b_{water}) and ash (a_{ash}, b_{ash}) in relation to protein weight in pig Genotypes 4, 5, 6 and mean (s.e.) of all genotypes housed in controlled facilities

	Lipid		Water		Ash	
Genotype	a_{lipid}	b_{lipid}	a_{water}	b_{water}	a_{ash}	b_{ash}
4	0.705	1.139	5.286[a]	0.856	0.174	1.033
5	0.697	1.101	5.197[b]	0.860	0.174	1.020
6	0.713	1.128	5.189[b]	0.858	0.175	1.019
Pooled s.e.[#]	0.071	0.036	0.020	0.010	0.058	0.017
CV[¶]	10.0	3.2	0.4	1.2	33.4	1.7

[ab] Values within a column with different superscript differ significantly ($P < 0.05$)
[#]To test for significant differences between genotypes, Pooled s.e. of the difference between means (= Pooled s.e. x $\sqrt{2}$ ($t = 2.145$ for $P = 0.05$) was used
CV - Coefficient of variation (%)

There were no significant differences in any parameter or allometric coefficient between the three genotypes grown in Controlled *vs.* Uncontrolled facilities. Likewise, when comparing the differences between the mean of all genotypes (Genotype 1, 2, 3, 4, 5 and 6) grown in Uncontrolled housing facilities with the mean of the three genotypes kept in the Controlled facilities, there were no differences in mean estimates of B, P_m, LPR_m and only the allometric constant for lipid (a_{lipid}) was significantly ($P < 0.05$) different.

Discussion

The results in this paper indicate that there are no significant differences in the estimated growth parameters (B, P_m, LPR_m) between genotypes grown in temperature-controlled chambers. However, the lack of significance may be attributed to the high variation within genotypes, masking the real differences between genotypes. The causes of the high variation would likely be the same as discussed in the previous paper. From Table 1 it would appear that Genotype 4 had a higher P_m value and Genotype 6 a higher W_m value. Nevertheless, the remaining estimates are similar, despite the high CV. The mean parameter values estimated from pigs grown in Controlled and those in Uncontrolled housing, are shown in Table 4. There

were no significant differences in any parameter or component between genotypes grown in either Controlled or Uncontrolled facilities, irrespective if the comparison was based on the three similar genotypes or all six genotypes . On this basis mean estimates of the growth parameters would appear to be acceptable in describing the commercial crossbred male genotype pig grown in South Africa.

Table 4 Mean (s.e.) mature weights (kg) and rate of maturing (B, day^{-1}) of protein, lipid, water and ash estimated for Genotype 4, 5 and 6 pigs grown either in temperature-controlled housing (Controlled) or in open-sided housing (Uncontrolled 1) for all genotypes in open-sided housing (Uncontrolled 2) and the mean (s.e.) estimates for commercial pig genotypes

	Controlled		Uncontrolled 1[#]		Uncontrolled 2[¶]		Mean
Component	Mature weight (kg)	B (/day)	Mature weight (kg)	B (/day)	Mature weight (kg)	B (/day)	Mature weight (kg)
Protein	41.2 (3.74)	0.0117 (0.0006)	39.1 (3.20)	0.0118 (0.0009)	40.0 (1.86)	0.0116 (0.0003)	40.4 (1.623)
Lipid	59.4 (2.96)	0.0112 (0.0005)	64.9 (8.15)	0.0110 (0.0012)	69.1 (6.35)	0.0114 (0.0010)	65.9 (4.43)
Water	140.4 (9.11)	0.0111 (0.0008)	125.6 (8.23)	0.0116 (0.0009)	126.2 (4.13)	0.0115 (0.0004)	130.9 (4.43)
Ash	9.6 (1.18)	0.0105 (0.0006)	9.1 (0.82)	0.0104 (0.0007)	8.6 (0.46)	0.0103 (0.0006)	9.0 (0.47)
Mean		0.0113 (0.0003)		0.0113 (0.0003)		0.0114 (0.0004)	0.00114 (0.0005)

[#] Mean values for only Genotypes 4, 5 and 6 in Uncontrolled housing
[¶] Mean values for all Genotypes (1, 2, 3, 4, 5 and 6) in Uncontrolled housing

The purpose of growing the pigs in the temperature-controlled chambers was to allow individual animals to express their potential protein growth by eliminating the possible adverse effects of too high ambient temperatures. However, the similarities in parameters between each genotype grown in different housing facilities suggest that (1) the conventional facilities were not as limiting as anticipated; or (2) the environment within the chambers was not ideal, either because of social constraints or poor air quality; or (3) for the commercial genotypes tested, temperature was not a limiting factor. The current experiment was carried out during late summer in South Africa, and during this time there were no periods of sustained heat, or extreme cold. Maximum temperatures in the Uncontrolled facility seldom exceeded 28 °C, and with insulated ceilings the fluctuations in temperature were decreased and, therefore, temperature could have exerted less of an effect on the performance of the pigs.

The lack of an improved performance shown by the pigs kept in the chambers could also be due to the fact that the commercial male genotypes used in this experiment had a maximum rate of protein growth of approximately 170 g/d, as calculated by Ferguson *et al*. (1994). An improved performance as a result of lower temperatures could possibly have been expected if the genotypes used, had been high lean-growing genotypes, as was shown by Kyriazakis & Emmans (1991). Emmans & Kyriazakis (1999) suggested that a "moderate of '98" male genotype would have a maximum rate of protein growth of 206 g/d. Such animals, with a higher potential protein growth rate produce more heat and, therefore, to facilitate the increased heat production, the environmental heat demand must increase and this is best done by decreasing the ambient temperature. From the results presented in this paper and those of Ferguson & Kyriazis (2003) it appears that commercial crossbred genotypes used in South Africa are able to maximise protein growth when grown in warm ambient temperatures.

The high variability of the lipid fraction (CV = 30%) reported by Ferguson & Kyriazis (2003) was still present between similar genotypes grown in the chambers (CV = 40%). With environmental temperature

controlled, it was expected that the effect of temperature on the lipid fraction would be minimised. However, there was a similar amount of variation between the two housing facilities, which supports the idea that the interaction between the genotypes and the choice feeding strategy was responsible for the variation in the lipids. The similarities in growth and carcass composition between the pigs subjected to the two different environments suggest that temperature did not significantly affect the determination of the growth parameters for these commercial crossbred pigs.

Similar to the results of Ferguson & Kyriazis (2003) the estimates of B for each component within a genotype did not significantly ($P > 0.05$) differ from each other. This supports the fundamental assumption made in simulation modelling that B is constant across all body components (Emmans, 1981).

With Genotypes 4, 5 and 6 having similar growth parameters, irrespective of growing conditions, it is not unreasonable to assume that they have a similar mature state with regards the composition of the body at maturity. Table 5 presents the mean LPR_m, $WAPR_m$ and APR_m ratios between pigs reared in the different housing facilities. There were no significant ($P > 0.05$) differences in the mean estimates of LPR_m, $WAPR_m$ and APR_m between housing facilities, although there was a 15% reduction in the LPR_m ratio when pigs of a similar genotype were grown in a cooler environment (1.47 *vs* 1.72 kg/kg, respectively). The mean estimates of B, P_m and LPR_m (0.0113 (/day), 41.2 (kg), 1.47 (kg/kg), respectively) are not significantly different to those reported in the previous paper, and, therefore, B, P_m and LPR_m can be estimated as 0.0114 (/day), 40.4 (kg) and 1.67 (kg/kg), respectively.

Table 5 The mean (s.e.) lipid (LPR_m), water ($WAPR_m$) and ash (APR_m) to protein ratios at maturity of Genotypes 4, 5 and 6 housed either as a group in a temperature-controlled chamber (Controlled) or individually in an open-sided house (Uncontrolled 1), for all genotypes in open-sided housing (Uncontrolled 2) and the mean (s.e.) estimates for commercial pig genotypes

Component	Controlled	Uncontrolled 1[#]	Uncontrolled 2[¶]	Mean
LPR_m	1.47 (0.163)	1.72 (0.357)	1.77 (0.0213)	1.67 (0.153)
$WAPR_m$	3.48 (0.422)	3.23 (0.140)	3.17 (0.097)	3.27 (0.146)
APR_m	0.23 (0.023)	0.23 (0.010)	0.22 (0.011)	0.22 (0.010)

[#] Mean values for only Genotypes 4, 5 and 6 in Uncontrolled housing
[¶] Mean values for all Genotypes (1, 2, 3, 4, 5 and 6) in Uncontrolled housing

Table 6 Mean (s.e.) allometric constants and exponents for lipid (a_{lipid}, b_{lipid}), water (a_{water}, b_{water}) and ash (a_{ash}, b_{ash}) in relation to protein weight, of Genotypes 4, 5 and 6 housed either as a group in a temperature-controlled chamber (Controlled) or individually in an open-sided house (Uncontrolled 1), for all genotypes in open-sided housing (Uncontrolled 2), and the mean (s.e.) estimates for commercial pig genotypes

	Lipid		Water		Ash	
Housing	a_{lipid}	b_{lipid}	a_{water}	b_{water}	a_{ash}	b_{ash}
Controlled	0.705[a] (0.005)	1.123 (0.011)	5.224 (0.031)	0.858 (0.002)	0.174 (0.001)	1.024 (0.004)
Uncontrolled 1[#]	0.633[ab] (0.043)	1.189 (0.047)	5.022 (0.119)	0.881 (0.008)	0.185 (0.007)	0.995 (0.013)
Uncontrolled 2[¶]	0.583[b] (0.030)	1.183 (0.021)	5.030 (0.063)	0.875 (0.005)	0.189 (0.004)	0.970 (0.015)
Mean	0.624 (0.028)	1.163 (0.017)	5.095 (0.053)	0.869 (0.004)	0.184 (0.003)	0.988 (0.014)

[a-b] Values within a column with different superscript differ significantly ($P < 0.05$)
[#] Mean values for only Genotypes 4, 5 and 6 in Uncontrolled housing
[¶] Mean values for all Genotypes (1, 2, 3, 4,5 and 6) in Uncontrolled housing

Most of the allometric relationships between protein weight and lipid, water and ash weight were similar between genotypes grown in Controlled facilities (Table 3) and, therefore, genotypes were combined to provide mean estimates (Table 6). The only significant difference ($P < 0.05$) was in the allometric constant, a_{water}, between Genotype 4 and Genotype 5 or 6.

There were no significant differences in the allometric coefficients between any group of pigs. Only the allometric constant for lipid (a_{lipid}) of pigs in a Controlled environment was significantly ($P < 0.05$) higher than the mean of all genotypes kept in Uncontrolled facilities (Table 6). The overall mean estimate of b_{water} (0.869) was higher than the 0.855 proposed by Emmans & Kyriazakis (1995), while the estimate from pigs grown in temperature-controlled chambers (0.858) was almost the same. Despite this discrepancy it would appear that a single set of allometric coefficients could be applicable across most commercial genotypes.

Conclusion

The aim of the comparison between pigs grown in controlled temperature environments and those in conventional facilities was to observe whether environmental influences would affect the determination of the growth parameters. The results suggest that, for the genotypes tested, there was no temperature constraint on the growth of the animals when housed in an Uncontrolled environment. It can, therefore, be concluded that using individually penned animals in an open-sided house to determine growth parameters, required for nutritional models, will give statistically similar results as if they were housed in a temperature-controlled chamber. Controlling temperature also had little effect on the allometric relationships between protein and the remaining body components, except for a possible effect on body water relative to protein.

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