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PREDICTION OF PERFORMANCE TEST TRAITS IN GROWING LANDRACE AND LARGE WHITE PIGS UNDER PHILIPPINE CONDITIONS

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ABSTRACT

Non-linear prediction equations (i.e. polynomial and power functions) were determined to investigate trends in performance test traits and body measurements of 80 Landrace (40 boars and 40 gilts) and 78 Large White (38 boars and 40 gilts) grown from 76 to 174 days old at a local swine breeding farm, Cabuyao City, Laguna. For boars, the proposed shift from 90 to 110 kg weight at the end of test (EOT) will result to older boars (+20.6 days), higher daily feed intake, DFI (+0.20 kg/day), higher average daily gain, ADG (+0.081 kg/day), lower feed efficiency, FE (+0.03 g/g), higher average backfat thickness, ABFT (+1.70 mm), body length, BL (+7.6 cm), shoulder height, SH (+2.98 cm), and rump height, RH (+3.95 cm). At 110 kg market weight, Landrace boars were older at EOT (+2.1 days) and had higher DFI (+0.03 kg/day) than Large White boars. At 110 kg market weight, performance tested gilts were older (+16.0 days), had higher DFI (+0.30 kg/day) and ADG (+0.056 kg/day), poorer FE (+0.31 g/g), higher ABFT (+1.12 cm), BL (+6.19 cm), SH (+2.72 cm), and RH (+3.35 cm). Landrace gilts were younger (-1.3 days) and had lower DFI (-0.03 kg/day) than Large White gilts.

Key words: Growth prediction models, Landrace and Large White boars and gilts, performance test traits

INTRODUCTION

Pig growth models are generally developed for two main purposes: (1) as a research and education tool to evaluate alternative management decisions and (2) to predict the actual performance of different groups of pigs managed under a range of conditions (de Lange *et al*., 2001).

When used in optimizing production systems, pig growth models may require a parameterization of animal growth. A model requires functions to deal with such parameters to allow for a proper fit of data measured in such environments and avoid biased estimates of the potential parameters. It may be an integration of our knowledge of the effects of genetic potential, nutrient intake, and environmental conditions on pig growth (Schinckel and de

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Lange, 1996). In a stressful or limiting environment, more parameters will be needed to describe the coping strategies of a particular genotype. For many deterministic applications, nonlinear mixed effects models allow a more precise evaluation of animal growth functions than the traditional fixed effects models. Mixed effects models can also reduce the impact of potential biases of selective sampling and provide an additional parameter that describes animal to animal variation (Knap, 2000).

In this study, linear and nonlinear (exponential, logarithmic, polynomial and power) prediction models were determined separately for Landrace and Large White boars and gilts for various performance test parameters in a local breeding farm in the Philippines. This study was conducted in anticipation of the proposed change in market weight from 90 kg to 110 kg, and its implications on the infrastructure requirements of a local performance testing program.

MATERIALS AND METHODS

A total of 80 Landrace (40 boars and 40 gilts) and 78 Large White (38 boars and 40 gilts) pigs were performance tested at the International Farm Corporation (INFARMCO) swine breeding farm at Barangay San Isidro, Cabuyao City, Laguna (approx. 14^{o} 14' 49.69" N, 121^{o} 8' 34.41" E). Pigs were at least 30 kg at 77±3 days old at the start of test. Boars were penned in groups of 3 with about 1.67 m^2 floor space allotted per head while gilts were tested in groups of 8 per pen with approximately 1.33 m^2 floor space per head. Both boars and gilts were given the same starter ration (i.e. 18-19% CP, 2300-2350 Kcal/kg NE) at the start of test for three weeks (i.e. 77 to 98 days old). Boars were then given a special performance test ration (i.e. 17-19% CP, 2100-2150 Kcal/kg NE) until the end of test (EOT). Gilts, on the other hand, were given grower ration for five weeks (i.e. 99 to 134 days old) and then gilt developer ration (i.e. 16-16.5% CP, 2200-2250 Kcal/kg NE) until EOT.

Test animals were measured at the start of test and bi-weekly thereafter for 13 weeks or a maximum age of 174 days. Data were collected in 11 batches from July 30, 2016 to February 1, 2017. Performance test traits included pig weight (kg), daily feed intake (DFI, kg/day), average daily gain (cumulative ADG kg/day), feed efficiency (cumulative FE, g/g). Backfat thickness was also recorded using the RENCO© ultrasound backfat probe at the shoulder area directly above the point of the elbow, mid-back near the last rib, and ham area located at the last lumbar vertebra, all taken 5 cm off the midline on the right side of the pig. Average backfat thickness (ABFT, mm) was computed based on backfat measurements from the 3 sites. Body measurements included body length (BL, cm), shoulder height (SH, cm), and rump height (RH, cm). The number of observations for pig weight, daily feed intake, performance test parameters and body measurements per breed and per sex used in determining trendlines are given in Table 1.

The Pearson product-moment correlation coefficients were determined to measure linear relationships among performance test parameters for different breeds and sex using the CORR procedure of SAS (2009).

Linear, logarithmic, exponential, polynomial and power trendline functions were used to calculate the least square fit for a line or best-fit-curved line using the following equations:

Table 1. Number of records for performance test parameters, by breed and by sex.

Performance Test Parameters	Landrace (LDR)			Large White (LRW)			Grand Total
	Boars	Gilts	Total LDR	Boars	Gilts	Total LRW	
Pig weight	425	455	880	393	472	865	1745
Daily feed intake	308	351	659	283	360	643	1302
Average daily gain	362	400	762	346	411	757	1519
Feed efficiency	282	320	602	269	330	599	1201
Average BFT	336	351	687	305	368	673	1360
Body length	336	351	687	305	368	673	1360
Shoulder height	336	351	687	304	367	671	1358
Rump height	336	353	689	304	366	670	1359

Linear: $y = mx + b$, where m is the slope and b is the intercept.
Logarithmic: $y = c \ln x + b$, where c and b are constants, and ln is the natural logarithm function.
Exponential: $y = ce^{bx}$, where c and b are constants, and e is the base of the natural logarithm.
Polynomial: $y = b + c_1x + c_2x^2 + c_3x^3 + \ldots + c_6x^6$, where b and $c_1 \ldots c_6$ are constants.
Power: $y = cx^b$, where c and b are constants

The linear, exponential, logarithmic, power, or polynomial model that best fit the distribution of age to reach market weight [i.e. based on the highest computed coefficient of determination (R^2)] was chosen as the final prediction model. This was done separately for each breed and sex. Using the predicted age to reach 90 kg and 110 kg, prediction equations were then determined for pig weight at the end of test (EOT), DFI, performance test parameters (ADG, FE and ABFT), and body measurements (BL, SH and RH) at EOT. Scatter plot and trendline graphs were generated based on the final prediction models, with performance test parameters as the response (y) variable and age as the independent (x) variable, see Figures 1, 2, 3 and 4.

Differences in predicted values based on 90 kg and 110 kg market weight were used to quantify projected changes the same traits as a result of the proposed change in market weight from 90 kg to 110 kg.

RESULTS AND DISCUSSION

Table 2 shows that correlations of ADG were higher with pig weight (r = 0.79 to 0.81) than with daily feed intake (r = 0.29 to 0.54). Correlations of ADG with pig weight were similar between breeds and between sexes. Correlations of ADG with daily feed intake were higher with Landrace boars (r = 0.36) than in Large White boars (r = 0.29); and higher with Landrace gilts (r = 0.54) than with Large White gilts (r = 0.44). Feed efficiency was not significantly correlated with pig weight (P>0.05) while correlations of FE with daily feed

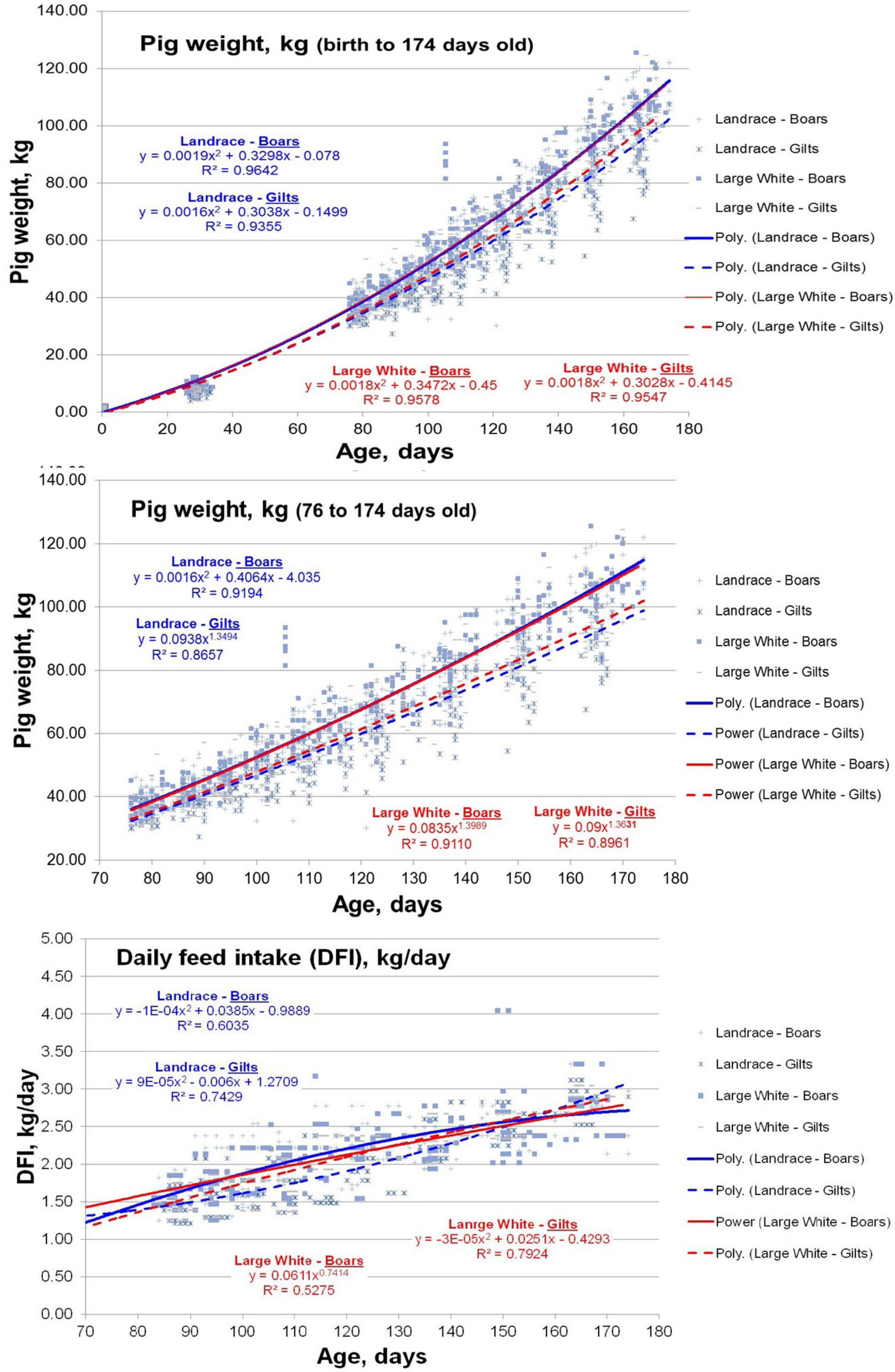

Figure 1. Scatter plot and trends for pig weight (birth to 174 days old and 76 to 174 days old) and daily feed intake (DFI, kg/day).

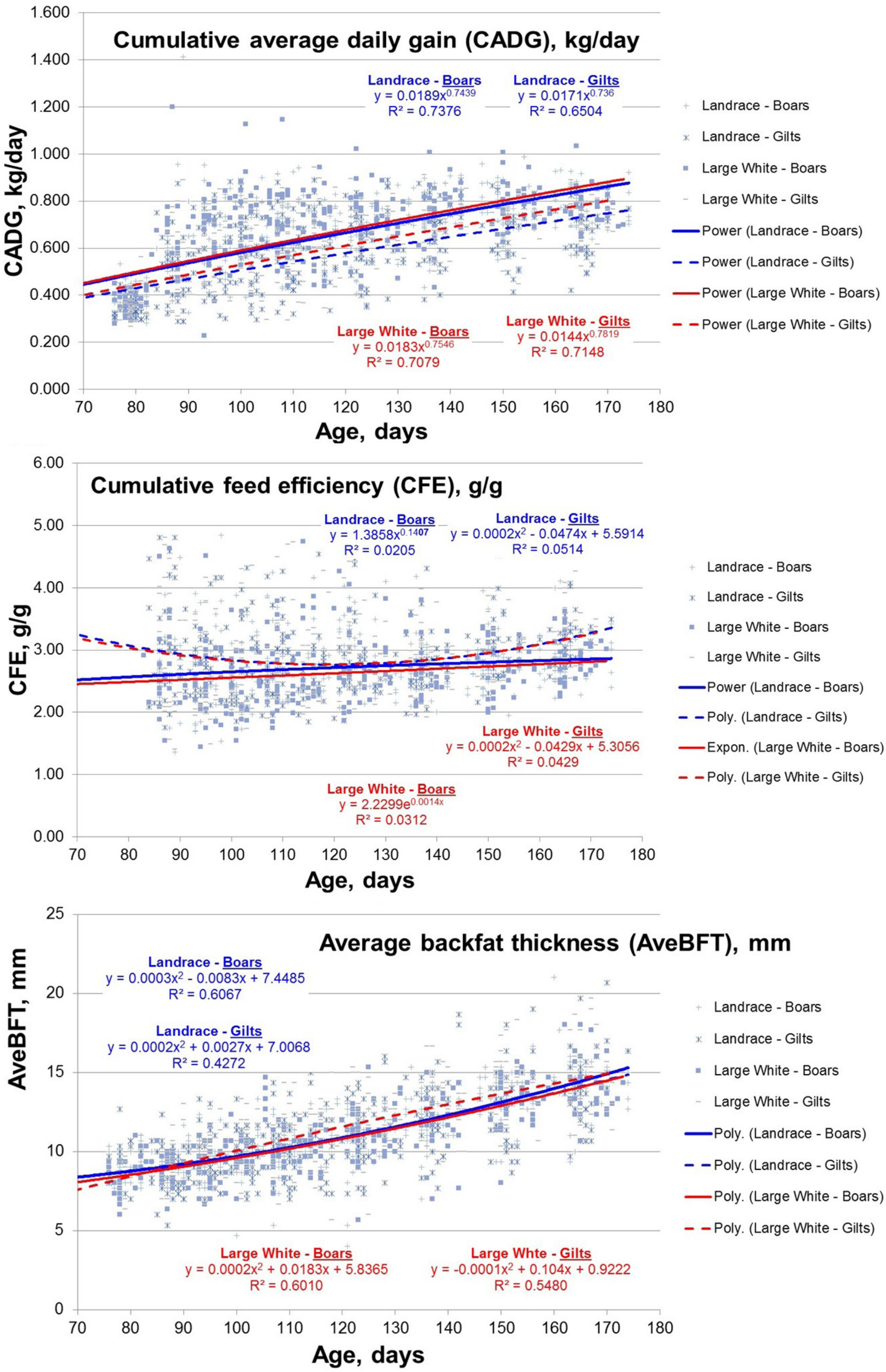

Figure 2. Scatter plot and trends for average daily gain (ADG, kg/day), cumulative feed efficiency (FE, g/g), and average backfat thickness (AveBFT, mm).

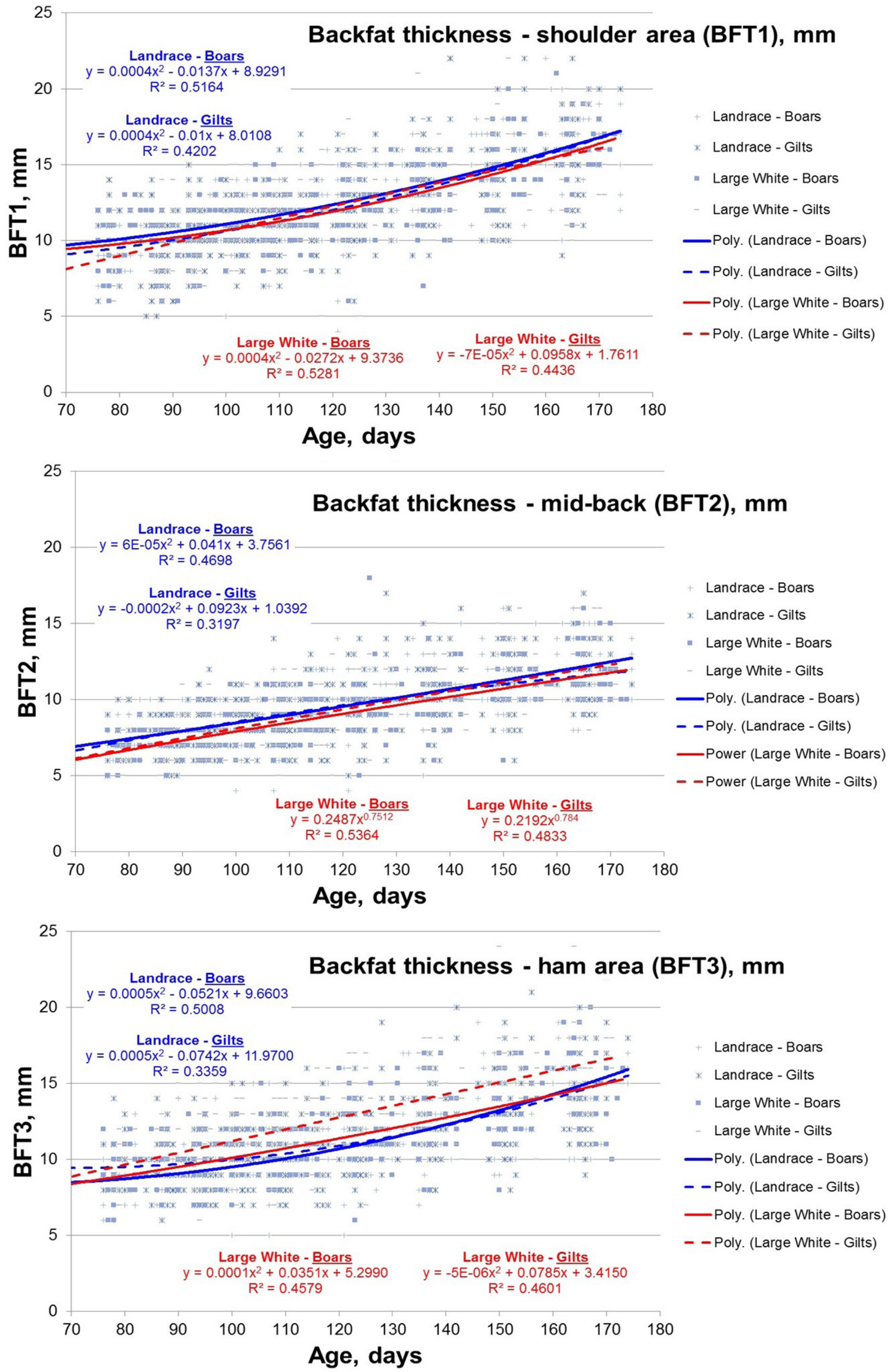

Figure 3. Scatter plot and trends for average backfat thickness (shoulder area - BFT1, mm; loin area - BFT2, mm; ham area - BFT3, mm).

Table 2. Pearson correlation coefficients among performance test records of Landrace and Large White boars (upper off-diagonals) and gilts (lower off-diagonals).

	PWt	DFI	ADG	FE	ABFT	BL	SH	RH
Landrace								
PWt	-	0.76**	0.81**	ns	0.84**	0.96**	0.96**	0.96**
DFI	0.88**	-	0.36**	0.20**	0.59**	0.76*	0.75**	0.74**
ADG	0.81**	0.54**	-	-0.68**	0.58**	0.63**	0.63**	0.61**
FE	ns	ns	-0.72**	-	-0.13*	ns	ns	ns
ABFT	0.82**	0.72**	0.71**	-0.26**	-	0.82**	0.80**	0.82**
BL	0.96**	0.86**	0.60**	ns	0.78**	-	0.93**	0.95**
SH	0.96**	0.87**	0.61**	ns	0.75**	0.93**	-	0.98**
RH	0.96**	0.89**	0.62**	ns	0.76**	0.95**	0.98**	-
Large White								
PWt	-	0.71**	0.80**	ns	0.85**	0.97**	0.96**	0.96**
DFI	0.87**	-	0.29**	0.21**	0.56**	0.72*	0.70**	0.69**
ADG	0.79**	0.44**	-	0.71**	0.57**	0.59**	0.62**	0.63**
FE	ns	0.22**	-0.74**	-	ns	ns	ns	ns
ABFT	0.80**	0.70**	0.54**	ns	-	0.81**	0.83**	0.83**
BL	0.96**	0.84**	0.55**	ns	0.72**	-	0.94**	0.95**
SH	0.96**	0.88**	0.68**	ns	0.74**	0.94**	-	0.98**
RH	0.96**	0.87**	0.68**	ns	0.73**	0.95**	0.98**	-

Note: ns - Correlation coefficient (r_{XY}) is significantly different from zero, *P*<0.05.
* - Correlation coefficient (r_{XY}) is significantly different from zero, *P*<0.05.
** - Correlation coefficient (r_{XY}) is significantly different from zero, *P*<0.01.

intake were similar in boars of different breeds (r = 0.20 to 0.21) and Large White gilts (r = 0.22). However, there was no significant correlation (i.e. r = 0) between FE and DFI in Landrace gilts. Correlations of ABFT with pig weight (r = 0.80 to 0.85) were higher than correlations of ABFT with daily feed intake (r = 0.56 to 0.72). Correlations of body measurements with pig weight (r = 0.96 to 0.97) were higher than correlations of body measurements with daily feed intake (r = 0.69 to 0.89). The correlations above imply that pig weight is a better predictor for average backfat thickness and body measurements than daily feed intake.

Prediction models and equations (mostly polynomial and power functions), predicted values for Landrace and Large White boars and gilts at 90 and 110 kg market weight for days to reach market weight, PWt, and DFI, for performance test measures (ADG, FE, ABFT), and for body measurements (BL, SH, RH) are given in Tables 3, 4 and 5, respectively.

For boars, the proposed shift from 90 to 110 kg weight at EOT will result to older boars (+20.6 days), higher DFI (+0.20 kg/day), higher ADG (+0.081 kg/day), lower FE (+0.03 g/g), higher ABFT (+1.70 mm), BL (+7.6 cm), SH (+2.98 cm), and RH (+3.95 cm). At 110 kg market weight, Landrace boars were older at EOT (+2.1 days) and had higher DFI (+0.03 kg/day), higher ADG (+0.010 kg/day), poorer FE (+0.60 g/g), higher ABFT (+0.10

Table 3. Predicted values for days to reach market weight and pig weight and daily feed intake based on 90 kg and 110 kg market weight.

Breed	Sex	Model type	Prediction Equation	R^2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Days to reach market weight							
Landrace	Boars	Polynomial	$y = -0.0019x^2 + 1.4355x + 31.240$	0.9182	145.0	166.10	22.1
Landrace	Gilts	Polynomial	$y = -0.0075x^2 + 2.2198x + 14.956$	0.8675	153.0	168.40	14.4
Large White	Boars	Power	$y = 0.7.6808x^{0.6512}$	0.9110	143.9	164.00	20.1
Large White	Gilts	Polynomial	$y = -0.0051x^2 + 1.9039x + 21.961$	0.9062	152.0	169.70	17.7
			Boar average	144.5	165.0	20.60	
			Gilt average	153.0	169.0	16.00	
			Overall average	148.7	167.0	18.30	
Pig weight, kg							
Landrace	Boars	Polynomial	$y = -4.0350x^2 + 0.0016x + 0.4064$	0.9194	88.55	107.64	19.09
Landrace	Gilts	Power	$y = 0.0938x^{1.3494}$	0.8567	83.95	94.71	10.76
Large White	Boars	Power	$y = 0.0835x^{1.3969}$	0.9111	86.34	103.63	17.29
Large White	Gilts	Power	$y = 0.0900x^{1.3631}$	0.8961	84.79	98.50	13.72
			Boar average	87.44	105.63	18.19	
			Gilt average	84.37	96.60	12.24	
			Overall average	85.91	101.12	15.21	

Table 3. Continuation...

Breed	Sex	Model type	Prediction Equation	R^2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Daily feed intake, kg/day							
Landrace	Boars	Polynomial	$y = -0.9889x^2 - 0.0001x + 0.0385$	0.6035	2.49	2.65	0.16
Landrace	Gilts	Polynomial	$y = 1.2709x^2 + 0.0001x - 0.0060$	0.7429	2.48	2.81	0.33
Large White	Boars	Power	$y = 0.0938x^{1.3494}$	0.5275	2.43	2.68	0.25
Large White	Gilts	Polynomial	$y = -0.4293x^2 - 0.0000x + 0.0251$	0.7924	2.69	2.97	0.27
			Boar average	2.46	2.66	0.20	
			Gilt average	2.59	2.89	0.30	
			Overall average	2.52	2.78	0.25	

Table 4. Predicted values for performance test traits based on 90 kg and 110 kg market weight.

Breed	Sex	Model type	Prediction equation	R^2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Average daily gain, kg/day							
Landrace	Boars	Power	$y = 0.0189x^{0.7439}$	0.7376	0.766	0.848	0.082
Landrace	Gilts	Power	$y = 0.0170x^{0.7360}$	0.6504	0.693	0.740	0.047
Large White	Boars	Power	$y = 0.0183x^{0.7546}$	0.7079	0.778	0.858	0.081
Large White	Gilts	Power	$y = 0.0144x^{0.7819}$	0.7148	0.732	0.797	0.066
			Boar average	0.7720	0.853	0.081	
			Gilt average	0.7120	0.769	0.056	
			Overall average	0.7420	0.811	0.069	
Feed efficiency g/g							
Landrace	Boars	Power	$y = 1.3858x^{0.1407}$	0.0205	2.79	2.85	0.060
Landrace	Gilts	Polynomial	$y = 5.5914x^2 + 0.0002x - 0.0474$	0.0514	3.03	3.28	0.220
Large White	Boars	Power	$y = 2.2299x^{0.0014}$	0.0312	2.25	2.25	0.000
Large White	Gilts	Polynomial	$y = 5.3056x^2 + 0.0002x - 0.0429$	0.0429	3.41	3.78	0.380
			Boar average	2.52	2.55	0.03	
			Gilt average	3.22	3.53	0.31	
			Overall average	2.87	3.04	0.17	

Table 5. Predicted values for body measurements based on 90 kg and 110 kg market weight.

Breed	Sex	Model type	Prediction equation	R^2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Body length, cm							
Landrace	Boars	Polynomial	$y = 56.1950x^2 + 0.0001x + 0.3510$	0.8464	108.36	116.16	7.80
Landrace	Gilts	Polynomial	$y = 81.0510x^2 + 0.0015x - 0.0634$	0.8455	106.86	112.91	6.05
Large White	Boars	Polynomial	$y = 52.1730x^2 - 0.0001x + 0.3871$	0.8829	106.63	114.03	7.40
Large White	Gilts	Polynomial	$y = 64.6430x^2 + 0.0005x + 0.1978$	0.8654	106.26	112.60	6.34
			Boar average	107.49	115.10	7.60	
			Gilt average	106.56	112.75	6.19	
			Overall average	107.03	113.93	6.90	
Shoulder height, cm							
Landrace	Boars	Polynomial	$y = 13.5580x^2 - 0.0010x + 0.4469$	0.8804	57.34	60.20	2.87
Landrace	Gilts	Polynomial	$y = 19.7820x^2 - 0.0004x + 0.3037$	0.8678	57.06	59.58	2.52
Large White	Boars	Polynomial	$y = 17.9860x^2 - 0.0007x + 0.3696$	0.8529	56.67	59.77	3.10
Large White	Gilts	Polynomial	$y = 20.7740x^2 - 0.0004x + 0.2941$	0.8800	56.24	59.16	2.92
			Boar average	57.00	59.99	2.98	
			Gilt average	56.65	59.37	2.72	
			Overall average	56.83	59.68	2.85	

Table 5. Continuation...

Breed	Sex	Model type	Prediction equation	R2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Rump height, cm							
Landrace	Boars	Polynomial	$y = 24.3300x^2 - 0.0006x + 0.3637$	0.8853	64.46	68.19	3.74
Landrace	Gilts	Polynomial	$y = 33.1780x^2 + 0.0001x - 0.1887$	0.8447	64.13	67.22	3.09
Large White	Boars	Polynomial	$y = 23.8480x^2 - 0.0005x + 0.3615$	0.8551	65.51	69.60	4.17
Large White	Gilts	Polynomial	$y = 31.0780x^2 - 0.0001x + 0.2271$	0.8698	63.98	67.60	3.62
			Boar average	64.98	68.94	3.95	
			Gilt average	64.06	67.41	3.35	
			Overall average	64.52	68.17	3.65	

Table 4. Continuation...

Breed	Sex	Model type	Prediction equation	R2	Predicted Values Based on Market Weight		
					90 kg	110 kg	Difference
Average backfat thickness - AvBFT, mm							
Landrace	Boars	Polynomial	$y = 7.4485x^2 + 0.0003x - 0.0083$	0.5008	12.55	14.35	1.80
Landrace	Gilts	Polynomial	$y = 7.0068x^2 + 0.0002x + 0.0027$	0.3359	12.17	13.13	0.97
Large White	Boars	Polynomial	$y = 5.8365x^2 + 0.0002x + 0.0183$	0.4579	12.61	14.21	1.60
Large White	Gilts	Polynomial	$y = 0.9222x^2 - 0.0001x + 0.1040$	0.4601	14.42	15.69	1.27
			Boar average	12.58	14.28	1.70	
			Gilt average	13.29	14.41	1.12	
			Overall average	12.94	14.35	1.41	

mm), BL (+2.13 cm), SH (+0.43 cm), and lower RH (-1.47 cm) than Large White boars.

At 110 kg market weight, performance tested gilts were older (+16.0 days), had higher DFI (+0.30 kg/day) and ADG (+0.056 kg/day), poorer FE (+0.31 g/g), higher ABFT (+1.12 cm), BL (+6.19 cm), SH (+2.72 cm), and RH (+3.35 cm). Landrace gilts were younger (-1.3 days), lower DFI (-0.03 kg/day), lower ADG (-0.057 kg/day), better FE (-0.50 g/g), lower ABFT (-2.56 mm), higher BL (+0.31 cm) and SH (+0.42 cm), and lower RH (-0.42 cm) than Large White gilts.

In conclusion, high R^2 prediction models related to swine growth under local conditions have been developed for various performance test parameters. These models can be used to anticipate the proposed increase in market weight from 90 kg to 110 kg in local performance testing programs. In particular, the anticipated direct effects include prolonged length of test period, older animals that finish the test, higher daily feed intake, ADG and ABFT, and bigger body size, which in turn, implies greater farm expenses on feed and labor, and extra house repairs to allow bigger pigs be raised in groups based on the prescribed floor space requirements. Stock density, pen size for boar and/or gilt performance testing, and number of available pens will also change and may eventually downsize the farm's capacity to produce performance tested breeder pigs. As a consequence, the cost of performance testing per animal may substantially increase, thereby requiring an increase in the selling price of purebred boars and gilts. Alternatively, the 90 kg market weight may still be maintained but only if there existed a high positive correlation in selection index traits taken at 90 kg and 110 kg market weight.

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