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Survival, body weights, feed efficiency, and carcass traits of 7/8 White Composite and 1/8 Duroc, 1/8 Meishan, 1/8 Fengjing, or 1/8 Minzhu pigs

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Survival, Body Weights, Feed Efficiency, and Carcass Traits of $\frac{7}{8}$ White Composite and $\frac{1}{8}$ Duroc, $\frac{1}{8}$ Meishan, $\frac{1}{8}$ Fengjing, or $\frac{1}{8}$ Minzhu Pigs^{1,2}

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ABSTRACT: Pigs were the progeny of White Composite boars mated to gilts that were either $\frac{1}{4}$ Duroc, $\frac{1}{4}$ Meishan, $\frac{1}{4}$ Fengjing, or $\frac{1}{4}$ Minzhu and the remainder $\frac{3}{4}$ White Composite. One-eighth Meishan and $\frac{1}{8}$ Fengjing pigs averaged approximately .5 more nipples than $\frac{1}{8}$ Duroc pigs and .2 more nipples than $\frac{1}{8}$ Minzhu pigs ($P < .05$), respectively. Duroc, Meishan, and Minzhu crosses did not differ ($P > .05$) for survival at birth or at 14 and 28 d. Fengjing crosses had a lower survival rate ($P < .05$) at all three ages than Duroc and Meishan crosses. Duroc crosses were heavier ($P < .05$) than Chinese crosses at birth. At 56 d, Duroc and Meishan crosses did not differ ($P > .05$) for BW, but both were heavier ($P < .05$) than Minzhu crosses. Body weight at 70 d did not differ significantly ($P > .05$) among breed types. Duroc crosses were heavier ($P < .05$) than any of the Chinese crosses at 98, 126, and 154 d of age. At 154 d, Fengjing crosses were lighter ($P < .05$) than Meishan or Minzhu crosses. The effect of breed type was not detected for

average probe backfat thickness of gilts at 99.7 kg. Duroc crosses consumed the most feed, and Fengjing crosses consumed the least during each interval and during the total period ($P < .05$). Feed consumption of Meishan and Minzhu crosses was intermediate to and significantly ($P < .05$) different from that of Duroc and Fengjing crosses. At 184 d of age, breed types did not differ ($P > .16$) for measures of carcass fat thickness, marbling score, color score, and firmness score. At 184 d of age, weights of all carcass cuts were heavier ($P < .05$) for Duroc than for Chinese crosses with the exception of untrimmed loin weight of Minzhu crosses. There were few significant differences among breed types when carcass traits were compared at a constant carcass weight, although Duroc crosses generally were superior. Relative to similar Duroc crosses, these results suggest that $\frac{1}{8}$ Chinese pigs would grow less rapidly ($P < .05$) and produce less weight of trimmed lean cuts at a constant carcass weight.

Key Words: Breeds, Growth, Carcasses, Pigs

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Introduction

Research in Europe has documented the greater reproductive rate, less-rapid growth rate, and smaller lean yield of crosses involving Meishan relative to domestic European crosses (Legault and Caritez, 1983; Legault et al., 1985; Bidanel et al., 1989, 1990, 1993; Haley and Lee, 1990; Haley et al., 1990, 1992). Meishan, Fengjing, and Minzhu were imported into

the United States in 1989 (Rothschild et al., 1990). The future impact of these Chinese breeds on the swine industry will depend on the economic contributions of productive traits relative to reproductive traits as these breeds are used in crossbreeding systems. Thus, evaluation of growth and carcass traits of pigs produced by females containing various levels of Chinese germplasm is required.

Previous reports from this location have presented data on carcass traits (Young, 1992a), growth (Young, 1992b), and reproduction (Young, 1995a) of first-cross Duroc, Meishan, Fengjing, and Minzhu. Young (1995b) presented growth and carcass data, and Young (1998) presented reproductive data on animals that were $\frac{1}{4}$ Duroc, $\frac{1}{4}$ Meishan, $\frac{1}{4}$ Fengjing, or $\frac{1}{4}$ Minzhu. The objectives of the research reported here were to evaluate the preweaning and postweaning performance and carcass traits of $\frac{1}{8}$ Duroc, $\frac{1}{8}$ Meishan, $\frac{1}{8}$ Fengjing, or $\frac{1}{8}$ Minzhu pigs.

¹Sadly, Dr. Young passed away after this paper had been submitted to JAS. Sincere appreciation is extended to Kreg Leymaster for completing the revision of this paper. Appreciation is expressed to Brad Freking for data collection and data analysis.

²Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.

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Experimental Procedures

Pigs were either $\frac{1}{8}$ Duroc, $\frac{1}{8}$ Meishan, $\frac{1}{8}$ Fengjing, or $\frac{1}{8}$ Minzhu and the remainder $\frac{7}{8}$ White Composite. All pigs were born during two farrowing seasons (beginning approximately mid-January and mid-July of 1992) and were the progeny of 53 White Composite boars mated to gilts that were either $\frac{1}{4}$ Duroc, $\frac{1}{4}$ Meishan, $\frac{1}{4}$ Fengjing, or $\frac{1}{4}$ Minzhu and the remainder $\frac{3}{4}$ White Composite (Young, 1998). White Composite boars were nested within farrowing season. White Composite boars were from advanced generations of an *inter se*-mated, composite population with equal contribution from Chester White, Landrace, Large White, and Yorkshire.

Pigs were born and raised in a totally enclosed production system. For details on facilities and diet composition, see Young (1992b). Pigs identified as dead at birth were found dead behind the sow and were partially or fully enclosed in amniotic membranes. Number of nipples was recorded at birth on fully formed pigs without any evaluation of their potential to become functional. All fully formed pigs were weighed within 12 h after birth. At 14 d, pigs were individually weighed, given access to creep feed, and males were castrated. Pigs were weighed and weaned at 28 d and moved by litter to a nursery facility. Pen feed consumption was recorded in the nursery during the interval from 28 to 56 d of age. Pigs were weighed at 56 d of age. Number of pens in the nursery was less than the number of litters; thus, some litters were combined. Records on mixed litters were excluded from analyses of traits relating to feed consumption during the nursery period.

Approximately 60 gilts and 48 barrows of each breed type were sampled each season to provide data on growth rate and feed efficiency during the finishing period from 70 to 154 d of age. All pigs with a 56-d weight ≤ 6.8 kg were not used for subsequent data collection. As a result, two (.5%) $\frac{1}{8}$ Meishan, five (1.4%) $\frac{1}{8}$ Fengjing, eight (2.3%) $\frac{1}{8}$ Minzhu, and one (.3%) $\frac{1}{8}$ Duroc pigs were discarded. Remaining pigs within a litter were chosen by ranking on 56-d weight; pigs were eliminated by alternating between the lightest and heaviest pigs, starting with the lightest pig, until the desired number from that litter was obtained. Pigs were chosen as equally as possible from all litters within a breed type to balance numbers across sires. There were six to eight barrows per pen (12 pens per breed type) and 18 to 22 gilts per pen (six pens per breed type). Pigs were assigned to pens to minimize variation in age within a pen. Pigs were moved weekly during a 3-wk interval to finishing pens at approximately 63 d of age. Body weight and feed consumption data were recorded for 28-d intervals from approximately 70 d of age until approximately 154 d of age. Ultrasonic backfat measurements (Renco Lean Meter, Minneapolis, MN) were recorded

on gilts when the individuals in the pen averaged approximately 100 kg.

At 7-d intervals from 168 to 203 d of age, all barrows from one of the six pens of each breed type were slaughtered each season. Range of age within a pen was generally less than 3 d. Final live weight was recorded on the day of slaughter. Pigs were slaughtered at our abattoir in accordance with USDA guidelines. All carcasses were scalded, and the skin was left on the carcass. After a 24-h chill, carcasses were weighed, and the left side of the carcass was evaluated. Weight of leaf fat was recorded. Carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone. Backfat was measured on the midline at the first and last thoracic vertebrae and last lumbar vertebra. The side was then cut into the major wholesale cuts: ham, loin, picnic, Boston butt, and belly. Weight of each untrimmed cut was recorded.

The loin was cut between the 10th and 11th thoracic vertebrae. Guidelines of the NPPC (1991) were used to assign color and marbling scores each on a scale of 1 to 5. A score of 1 was pale to pinkish gray in color with devoid or practically devoid marbling. A score of 5 was dark purplish red in color with moderately abundant or greater marbling. Firmness was scored as 1 = soft and watery, 2 = intermediate, and 3 = firm. Fat thickness at the 10th rib was measured perpendicular to the skin, three-fourths of the distance from the medial side of the longissimus muscle. The longissimus muscle was traced on acetate paper, and the area was measured using computerized morphometric planimetry (Bioquant IV System, R & M Biometrics, Nashville, TN).

Hams, loins, picnics, and Boston butts were closely trimmed so that no more than 6 mm of fat was left on the surface. The weight of each trimmed cut was recorded.

Data were analyzed using least squares mixed-model procedures (Harvey, 1985). The most basic statistical model was used to analyze traits for which litter was the experimental unit, for example, feed consumption during the nursery period. This basic model included effects of farrowing season, sire within farrowing season, breed type, breed type \times farrowing season, and sire within farrowing season \times breed type. Sire within farrowing season and sire within farrowing season \times breed type were assumed to be random, and all other effects were assumed to be fixed. The effect of farrowing season was tested against sire within farrowing season. Breed type and breed type \times farrowing season were tested against sire within farrowing season \times breed type. All other effects were tested against the residual mean square.

The fixed effect of sex and its interactions with breed type and farrowing season were added to the basic model when analyzing number of nipples, preweaning survival, ADG, and BW at 0, 14, 28, and 56 d of age measured on individual pigs.

Fixed effects of sex and age (70, 98, 126, and 154 d) and their respective two-way interactions with other fixed effects were added to the basic model for body weight. Fixed effects of sex and interval (70 to 98, 98 to 126, and 126 to 154 d) and their respective two-way interactions with other fixed effects were added to the basic model for ADG, daily feed consumption, and feed efficiency. Because of limits on number of pens and number of pigs required per pen, it was necessary to mix litters from different sires during the finishing period. Because feed consumption data were collected by pen, sire within farrowing season was not included in the model for daily feed consumption and feed efficiency.

Live weight at measurement of probe backfat was fit as a covariate and its interaction with breed type was added to the basic model for analyses of age and backfat thickness at 99.7 kg for gilts.

The linear effect of slaughter age in days and its interaction with breed type were added to the basic model for analyses of carcass traits.

Six pairwise linear contrasts were made among the breed type means if the F-test for breed type was significant ($P < .05$); contrasts were among breed types within subclass for significant interactions. For discussion of Type I error rates under these conditions, see Young (1995a). Depending on the number of true breed type means that are identical and the size of the difference between the true means, the Type I error rates of the combined F-test and t -test range from .05 to .13.

Regression of carcass traits on slaughter age provides a method of adjusting the age-constant breed type means to different end points. In this article, the regression coefficients were used to adjust each trait to the age when the breed type would produce an average cold carcass weight of 78 kg. Young (1992a) provides a discussion of the methods for estimating the adjusted means and their associated standard errors. Tests of significance among adjusted least squares means were made by t -test using the adjusted sampling errors.

Results and Discussion

General. Because the objective was to compare the four breed types, least squares means and SE are presented for the main effect of breed type for all traits and for interaction subclasses when the interactions involving breed type were significant at $P < .05$ or to provide comparison with previous reports from this experiment.

Traits Measured from Birth to 56 Days of Age. Pigs that were $\frac{1}{8}$ Meishan and $\frac{1}{8}$ Fengjing averaged approximately .5 more nipples than $\frac{1}{8}$ Duroc pigs and .2 more nipples than $\frac{1}{8}$ Minzhu pigs. These differences are approximately one-half and one-quarter of the differences among pigs containing $\frac{1}{4}$ or $\frac{1}{2}$ of these

breed types (Young, 1992b, 1995b). The larger number of nipples for Meishan and Fengjing relative to Minzhu is also consistent with data from the People's Republic of China (Cheng, 1983; Zhang et al., 1986).

Breed type was significant ($P < .05$) for survival at birth (percentage born alive) and for survival of pigs born alive to 14 or 28 d of age. Duroc, Meishan, and Minzhu crosses did not differ significantly for survival at any of the three stages. Fengjing crosses had a significantly lower survival rate at all three stages than Duroc and Meishan crosses, but differed significantly from Minzhu crosses only for survival at birth. Young (1995b) reported that differences among $\frac{1}{4}$ Duroc, $\frac{1}{4}$ Meishan, $\frac{1}{4}$ Fengjing, and $\frac{1}{4}$ Minzhu were significant for survival at birth (percentage born alive), but he did not detect differences for survival of pigs born alive to 14 or 28 d of age. Survival at birth was highest for $\frac{1}{4}$ Meishan crosses (98.1%), followed in order by $\frac{1}{4}$ Minzhu (97.1%), $\frac{1}{4}$ Fengjing (92.8%), and $\frac{1}{4}$ Duroc (92.1%) crosses. Young (1992b) reported no significant breed of sire effects on survival at birth of pigs produced by mating Duroc, Meishan, Fengjing, and Minzhu boars to White Composite females. Minzhu-sired pigs had a lower ($P < .05$) survival rate to 14 and 28 d of age than those sired by Meishan, Fengjing, or Duroc (Young, 1992b).

Effect of breed type was significant for BW at 0 and 56 d of age, but not for BW at 14 and 28 d of age. Duroc crosses were heavier ($P < .05$) than the Chinese crosses at birth. At 56 d, Duroc and Meishan crosses did not differ ($P > .05$) for BW, but both were heavier ($P < .05$) than Minzhu crosses. Fengjing crosses were intermediate ($P > .05$) for BW at 56 d of age. Average daily gain from 28 to 56 d of age was greater ($P < .05$) for Duroc and Meishan crosses than for Minzhu crosses, but no other differences among breed groups were detected for ADG from 0 to 14, 14 to 28, or 28 to 56 d of age. Young (1995b) reported that differences among $\frac{1}{4}$ Meishan, $\frac{1}{4}$ Fengjing, and $\frac{1}{4}$ Minzhu crosses were not detected for BW at 56 d or earlier. However, $\frac{1}{4}$ Duroc crosses were heavier than the $\frac{1}{4}$ Chinese crosses at 0, 28, and 56 d of age with all differences significant except for the difference in 28-d BW relative to Meishan crosses (Young, 1995b). The only significant difference among $\frac{1}{4}$ breed types for ADG before 56 d of age was the more rapid ADG for Duroc than for Chinese crosses from 14 to 28 d of age (Young, 1995b). In contrast to these results, Young (1992b) reported that ADG and BW from 0 to 56 d of age were generally greater for pigs sired by Meishan and Fengjing than for Duroc- and Minzhu-sired pigs.

Table 2 presents the results of analyses of ADG, daily feed consumption, and feed efficiency measured on litters from 28 to 56 d of age. The ADG means reported in Table 2 differ slightly from those in Table 1 because these means do not include data on pigs from litters that were mixed or received cross-fostered pigs. Also, the standard errors for average daily gain

Table 1. Least squares means, standard errors, and levels of significance for effect of breed type on number of nipples, survival to weaning, and average daily gain and body weight to 56 d of age

Item	Least squares means				Largest SE	P-value for breed type
	¼ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu		
No. of observations						
0 d ^a	359	434	478	425	—	—
56 d	311	371	353	349	—	—
No. of nipples	13.78 ^h	14.24 ^g	14.36 ^g	13.99 ^h	.11	<.01
Survival, %						
at Birth ^b	96.1 ^g	95.9 ^g	88.4 ^h	97.2 ^g	2.4	.02
to 14 d ^c	92.7 ^g	94.8 ^g	84.4 ^h	91.3 ^{gh}	2.7	.03
to 28 d ^c	90.7 ^g	94.6 ^g	83.6 ^h	89.3 ^{gh}	2.8	.03
BW, kg						
0 d	1.41 ^g	1.29 ^h	1.23 ^h	1.30 ^h	.04	.01
14 d ^d	3.9	3.68	3.62	3.67	.12	.18
28 d ^e	6.89	6.5	6.49	6.44	.19	.17
56 d ^f	14.84 ^g	14.54 ^g	14.18 ^{gh}	13.77 ^h	.35	.03
Daily gain, g/d						
0 to 14 d	176	169	165	167	6	.47
14 to 28 d	213	201	204	197	8	.42
28 to 56 d	283 ^g	287 ^g	271 ^{gh}	260 ^h	8	.01

^aNumber of observations recorded on fully formed pigs.

^bPercentage of pigs born alive.

^cPercentage of pigs born alive that survived to 14 or 28 d.

^dCreep feed provided starting at 14 d of age.

^ePigs weaned at 28 d of age.

^fEnd of nursery period.

^{g,h}Means within a row lacking a common superscript differ ($P < .05$).

in Table 2 are larger than those in Table 1 because litters were the experimental units rather than individual pigs. Breed type was not significant for ADG or feed efficiency but was significant for daily feed consumption. Duroc crosses consumed more ($P < .05$) feed per day than Fengjing or Minzhu crosses. The daily feed consumption of Fengjing crosses was intermediate and did not differ ($P > .05$) from that of the other breeds. Young (1995b) reported that differences among ¼ crosses were not detected for ADG or feed efficiency but approached significance ($P = .06$) for daily feed consumption. Young (1992b)

reported that breed of sire did not affect daily feed consumption but significantly affected ADG and feed efficiency from 28 to 56 d of age for pigs sired by Duroc, Meishan, Fengjing, and Minzhu. Meishan-sired pigs were more efficient ($P < .05$) than Duroc-sired pigs, but neither differed significantly from Fengjing- or Minzhu-sired pigs (Young, 1992b).

Traits Measured During the Finishing Period. Results of the analyses of BW and ADG measured for 28-d intervals from 70 to 154 d of age are reported in Table 3. Interaction of breed type with age was significant for BW but the interaction of breed type

Table 2. Least squares means, standard errors, and levels of significance for effect of breed type on daily gain, daily feed consumption, and feed efficiency from 28 to 56 d of age for litters

Item	Least squares means				Largest SE	P-value for breed type
	¼ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu		
No. of litters ^a	37	38	38	41	—	—
Daily gain, kg	.3	.283	.271	.284	.014	.37
Daily feed consumption, kg	.645 ^b	.594 ^{bc}	.563 ^c	.559 ^c	.023	.01
Gain:feed	.469	.486	.482	.513	.022	.11

^aEquivalent to number of pens.

^{b,c}Means within a row lacking a common superscript letter differ ($P < .05$).

Table 3. Least squares means, standard errors, and levels of significance for effect of breed type on body weight and daily gain of barrows and gilts from 70 to 154 d of age and backfat thickness and age at 99.7 kg for gilts

Item	Least squares means				Largest SE	P-value for breed type ^a
	¼ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu		
No. of observations						
Gilts	456	464	432	472		
Barrows	384	384	376	368		
BW, kg						<.01
70 d	22.0 ^c	21.5 ^c	20.9 ^c	21.1 ^c	.5	
98 d	41.2 ^c	39.7 ^d	38.8 ^d	39.6 ^d	.5	
126 d	63.9 ^c	61.2 ^d	59.6 ^d	60.9 ^d	.5	
154 d	86.3 ^c	82.8 ^d	80.1 ^e	82.5 ^d	.5	
Gilt	51	49.2	47.4	48.9	.5	
Barrow	55.7	53.4	52.2	53.1	.5	
Daily gain, g						<.01
70 to 98 d	697	666	660	679	10	
98 to 126 d	815	775	756	764	10	
126 to 154 d	798	767	733	773	10	
Gilt	719	690	665	696	9	
Barrow	821	782	767	781	9	
Backfat thickness at 99.7 kg, mm ^b	22.9	23	23.3	23.6	.6	.67
Age at 99.7 kg, d ^b	185.0 ^c	189.4 ^d	193.5	186.8 ^c	1.2	<.01

^aLevels of significance (*P*-value) for breed type effects are approximate. *P* = .55 and < .01 for breed type × sex and breed type × age effects, respectively, on BW. *P* = .49 and .11 for breed type × sex and breed type × interval effects respectively, on daily gain.

^bProbe backfat thickness and age at 99.7 kg were measured on gilts only. Probe backfat thickness represents the average of three measurements taken off the midline at 1st rib, last rib, and last lumbar vertebra; probe site × breed type was not significant.

^{c,d,e}Means within a row lacking a common superscript letter differ (*P* < .05).

and interval was not detected (*P* ≈ .11) for ADG. To be consistent for the two traits and to allow comparisons with previous generations (Young, 1992b, 1995b), means are presented for these subclasses. Even though the interaction of breed type with sex was not detected for BW or ADG, the interaction means are presented to allow comparison to results reported on the previous generations (Young, 1992b, 1995b). Body weight at 70 d was similar (*P* > .05) among breed types. Duroc crosses were heavier (*P* < .05) than any of the Chinese crosses at 98, 126, and 154 d of age. Among Chinese crosses, the only significant difference was for BW at 154 d when Fengjing crosses were lighter (*P* < .05) than Meishan or Minzhu crosses. Duroc crosses grew faster (*P* < .05) than Chinese crosses during each 28-d interval. Young (1995b) reported ¼ Duroc crosses were heavier than ¼ Fengjing or ¼ Minzhu crosses at all ages and heavier than ¼ Meishan crosses at 98, 126, and 154 d of age. Also, ¼ Meishan crosses were heavier than ¼ Fengjing and ¼ Minzhu crosses at 126 and 154 d of age (Young, 1995b). Young (1992b) reported Duroc-sired pigs were lighter than Meishan-sired pigs at 70, 98, and 126 d of age but were heavier at 154 d of age. Meishan-sired pigs were heavier than Fengjing- or Minzhu-sired pigs at 98, 126, and 154 d of age.

The effect of breed type was not detected (*P* ≈ .67)

for average probe backfat thickness of gilts at 99.7 kg (Table 3). Duroc and Minzhu crosses were younger at 99.7 kg (*P* < .05) than Meishan and Fengjing crosses. Meishan crosses were also younger (*P* < .05) than Fengjing crosses at 99.7 kg. Breed types were similar for average backfat thickness of ¼ gilts of these breeds at 99.7 kg (Young, 1995b). Chinese-sired gilts were fatter (*P* < .05) than Duroc-sired gilts, and Meishan-sired gilts were fatter than Fengjing- or Minzhu-sired gilts at 99.7 kg (Young, 1992b). With the exception of the switch in rank of the ¼ Meishan and ¼ Minzhu, differences among these ¼ breed types for age at 99.7 kg agree with the differences for gilts sired by Duroc, Meishan, Fengjing, and Minzhu (Young, 1992b) and differences among ¼ crosses of these breeds (Young, 1995b).

Interactions of breed type with interval or sex were not detected (*P* > .50) for daily feed intake or gain: feed ratio (Table 4). Breed type was significant for daily feed intake but did not affect (*P* ≈ .15) gain:feed ratio. Duroc crosses consumed the most, and Fengjing crosses consumed the least feed per day over each interval and over the total period (*P* < .05). Daily feed consumption by Meishan and that by Minzhu crosses did not differ (*P* > .05) from each other and was intermediate to, and significantly different from, that of Duroc and Fengjing crosses. Significant interactions

Table 4. Least squares means, standard errors, and levels of significance for breed type effect on pen feed consumption and feed efficiency measured at 28-d intervals from 70 to 154 d of age^a

Item	Least squares means				SE
	½ Duroc	½ Meishan	½ Fengjing	½ Minzhu	
No. of pens	18	18	18	18	
Daily feed intake, kg					
Overall	2.350 ^b	2.255 ^c	2.122 ^d	2.244 ^c	.023
70 to 98 d	1.782	1.706	1.624	1.738	.039
98 to 126 d	2.446	2.368	2.209	2.343	.039
126 to 154 d	2.821	2.693	2.533	2.650	.039
Gilt	2.139	2.011	1.915	2.023	.038
Barrow	2.560	2.499	2.328	2.465	.027
Gain:feed					
Overall	.3369	.3366	.3453	.3385	.0031
70 to 98 d	.3897	.3918	.4037	.3963	.0051
98 to 126 d	.3359	.3294	.3420	.3269	.0051
126 to 154 d	.2851	.2885	.2903	.2924	.0051
Gilt	.3443	.3502	.3537	.3497	.0050
Barrow	.3296	.3229	.3370	.3274	.0036

^a $P < .01$ and $P = .15$ for breed type effects on overall daily feed intake and overall gain:feed, respectively. Breed type \times interval and breed type \times sex were not significant ($P > .50$) for daily feed intake or gain:feed.

^{b,c,d}Means within a row lacking a common superscript letter differ ($P < .05$).

of breed type with interval were reported for these traits among pigs sired by Duroc, Meishan, Fengjing, and Minzhu (Young, 1992b) and among ¼ crosses of these breeds (Young, 1995b). In general, Young (1992b, 1995b) reported ½ and ¼ Duroc crosses consumed more feed and were more efficient than the corresponding Chinese crosses.

Carcass Traits of Barrows. Presented in Table 5 are the numbers of observations for each breed type; mean, range, and SD for age at slaughter; weight at slaughter; and cold carcass weight. Slaughtering these genotypes from 162 to 213 d of age (mean age = 187

d) caused slaughter weights to range from 70.3 to 146.6 kg and cold carcass weights to range from 46.0 to 108.4 kg. Overall mean slaughter weight and carcass weight were approximately 109 and 79 kg, respectively. These weights were very similar to the mean slaughter and carcass weights of 111 and 78 kg reported by Young (1992a) for pigs sired by Duroc, Meishan, Fengjing, and Minzhu and slaughtered from 158 to 211 d of age (mean age = 184 d). In contrast, ¼ Duroc, ¼ Meishan, ¼ Fengjing, and ¼ Minzhu averaged 92 and 73 kg live weight and carcass weight, respectively, when slaughtered at an average age of 186 d (Young, 1995b).

Table 5. Number of observations and descriptive statistics for slaughter age, slaughter weight, and cold carcass weight

Item	Breed type			
	½ Duroc	½ Meishan	½ Fengjing	½ Minzhu
No. of barrows	95	96	94	93
Age at slaughter, d				
Mean	186.6	186.8	187.1	186.7
Range	162–212	164–212	162–213	163–212
SD	14.87	15.26	15.65	15.55
Weight at slaughter, kg				
Mean	113.6	109.2	104.9	108.4
Range	70.3–146.6	82.9–140.2	71.0–137.1	75.2–140.6
SD	14.31	14.58	14.00	14.10
Cold carcass wt, kg				
Mean	82.3	78.2	75.9	78.6
Range	46.0–108.4	57.2–103.3	48.6–102.2	54.3–103.7
SD	12.12	11.48	11.05	11.14

Table 6. Least squares means, standard errors, and levels of significance for effect of breed type on carcass traits adjusted to 184 d of age^a

Trait	Least squares means				Range of SE	P-value for breed type ^b
	½ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu		
Live wt, kg	112.4 ^c	105.3 ^d	103.7 ^d	106.8 ^d	1.35–1.45	<.01
Cold wt, kg	81.3 ^c	75.2 ^d	74.8 ^d	77.2 ^d	1.02–1.09	<.01
Length, cm	78.9 ^c	77.4 ^d	77.0 ^d	77.5 ^d	.42–.45	<.01
Fat thickness, mm						
1st rib	54.6	52.4	54.0	55.0	1.05–1.11	.22
10th rib	39.7	37.0	37.6	39.7	1.19–1.36	.16
Last rib	31.1	29.0	30.2	30.0	.93–1.04	.40
Last lumbar	35.4	34.4	35.5	37.0	1.03–1.14	.23
Longissimus muscle area, cm ²	29.7 ^c	28.1 ^d	27.1 ^d	28.1 ^d	.56–.63	<.01
Untrimmed ham, kg	9.41 ^c	8.65 ^d	8.52 ^d	8.72 ^d	.119–.130	<.01
Trimmed ham, kg	6.73 ^c	6.17 ^d	6.00 ^d	6.14 ^d	.088–.098	<.01
Untrimmed loin, kg	10.19 ^c	9.54 ^d	9.46 ^d	9.90 ^{cd}	.171–.192	<.01
Trimmed loin, kg	6.49 ^c	6.11 ^d	5.93 ^d	6.09 ^d	.101–.112	<.01
Untrimmed butt, kg	4.51 ^c	4.02 ^e	4.10 ^{de}	4.21 ^d	.066–.070	<.01
Trimmed butt, kg	3.25 ^c	2.93 ^d	2.97 ^d	3.01 ^d	.045–.049	<.01
Untrimmed picnic, kg	4.22 ^c	3.82 ^d	3.80 ^d	3.83 ^d	.068–.072	<.01
Trimmed picnic, kg	3.24 ^c	2.91 ^d	2.90 ^d	2.92 ^d	.050–.053	<.01
Total untrimmed, kg	28.32 ^c	26.03 ^d	25.89 ^d	26.65 ^d	.350–.382	<.01
Total trimmed, kg	19.71 ^c	18.12 ^d	17.81 ^d	18.17 ^d	.237–.259	<.01
Belly, kg	9.27 ^c	8.61 ^d	8.53 ^d	8.85 ^d	.158–.176	<.01
Leaf fat, kg	1.27	1.24	1.28	1.29	.049–.057	.86
Marbling	2.28	2.04	2.10	2.15	.144–.160	.63
Color	3.00	3.24	3.06	3.17	.081–.090	.19
Firmness	2.05	2.17	2.09	2.16	.055–.063	.41

^aThe weights of all cuts are from the left side of the carcass.

^bLevels of significance for effect of breed type are approximate.

^{c,d,e}Means within a row lacking a common superscript letter differ ($P < .05$).

Table 6 presents the results of the analyses of carcass traits from the model that included slaughter age and slaughter age \times breed type as covariates. The least squares means are adjusted to a mean value of 184 d to allow comparison with data from the previous generations of this experiment (Young, 1992a, 1995b). Breed types did not differ ($P > .16$) for fat thickness at the 1st rib, 10th rib, last rib, or last lumbar vertebra; weight of leaf fat; marbling score; color score; and firmness score. All weight measures were heavier ($P < .05$) for Duroc than for Chinese crosses except the lighter ($P > .05$) untrimmed loin weight from Minzhu crosses. The only significant difference among Chinese crosses was the lighter ($P < .05$) untrimmed butt weight of Meishan crosses compared to Minzhu crosses. These results are in general agreement with the differences reported by Young (1992a, 1995b) for pigs from previous generations of this experiment. Differences between breed types have generally been related linearly to breed composition for weight measurements but not for measures of fat thickness.

The estimates of the overall linear regression coefficient and the subclass regressions for each breed type are presented in Table 7. Also presented are levels of significance for the overall regression and

differences among breed type subclass regressions. These regression coefficients are reported so they can be used with the age-constant means to adjust the traits to other end points of interest. Differences among subclass regressions were significant only for weights of the untrimmed and trimmed picnic and approached significance only for fat thickness at the last rib. However, the significant effect of breed type for most carcass traits at a constant age indicates that the breed types have different growth rates for most carcass components. Therefore, the subclass regressions were used to adjust the breed type means to a 78-kg cold carcass weight. Although the mean carcass weight in this data set was about 79 kg, the traits were adjusted to 78 kg to allow comparison with the previous generations of this experiment (Young, 1992a, 1995b).

Least squares means and approximate standard errors for carcass traits adjusted to a cold carcass weight of 78 kg are presented in Table 8. There were few significant differences among breed types when carcass traits were compared at a constant carcass weight. Duroc crosses had heavier ($P < .05$) untrimmed and trimmed picnic than any of the Chinese crosses. Weight of leaf fat was less for Duroc crosses than for the Chinese crosses, but it differed signifi-

Table 7. Linear regression coefficients on age at slaughter (d), their standard errors, and levels of significance for overall and subclass regressions coefficients

Trait	Regression coefficient					SD ^a	P-value ^b	
	Overall	¼ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu		Overall	Subclass
Live wt, kg	.7047	.6121	.9486	.6229	.6351	9.25457	<.01	.17
Cold wt, kg	.5839	.5323	.7368	.5408	.5259	7.10269	<.01	.35
Length, cm	.1455	.1141	.2109	.1177	.1392	2.66272	<.01	.19
Fat thickness, mm								
1st rib	.0200	.0274	.0262	.0192	.0072	6.93017	<.01	.41
10th rib	.0211	.0160	.0389	.0161	.0136	6.46974	<.01	.14
Last rib	.0131	.0111	.0235	.0170	.0009	4.76596	<.01	.07
Last lumbar	.0121	.0085	.0168	.0211	.0021	5.87867	<.01	.24
Longissimus muscle area, cm ²	.0946	.0777	.0461	.1465	.1081	3.15674	<.01	.29
Untrimmed ham, kg	.0638	.0752	.0697	.0588	.0513	.82646	<.01	.44
Trimmed ham, kg	.0399	.0458	.0357	.0425	.0356	.57942	<.01	.74
Untrimmed loin, kg	.0706	.0584	.0924	.0730	.0587	1.05201	<.01	.31
Trimmed loin, kg	.0349	.0258	.0384	.0409	.0344	.58962	<.01	.54
Untrimmed butt, kg	.0351	.0327	.0399	.0321	.0359	.49356	<.01	.82
Trimmed butt, kg	.0219	.0183	.0217	.0225	.0251	.35245	<.01	.81
Untrimmed picnic, kg	.0194	-.001	.0361	.0227	.0202	.50617	<.01	<.01
Trimmed picnic, kg	.0141	-.0018	.0242	.0179	.0162	.36789	<.01	<.01
Total untrimmed, kg	.1890	.1651	.2382	.1865	.1661	2.40305	<.01	.37
Total trimmed, kg	.1108	.0881	.1200	.1239	.1113	1.58434	<.01	.64
Belly, kg	.0706	.0588	.0974	.0573	.0690	1.00595	<.01	.12
Leaf fat, kg	.0166	.0158	.0177	.0124	.0204	.25213	<.01	.27
Marbling	.0046	.0033	.0030	.0080	.0041	.85113	.41	.98
Color	.0067	.0200	-.0055	.0046	.0075	.52677	.06	.12
Firmness	-.0013	-.0013	-.0060	.0035	-.0014	.31194	.53	.36
Coefficient for SE	.007	.0147	.01393	.01031	.0131	—	—	—

^aStandard error of a regression coefficient can be obtained by multiplying the coefficient for SE at the bottom of the column times the standard deviation at the end of the row. The standard deviation is from the residual mean square.

^bLevels of significance for overall regression and for differences among breed of sire regressions.

Table 8. Least squares means and approximate standard errors by breed type for carcass traits adjusted to a cold carcass weight of 78 kg^a

Item	¼ Duroc	¼ Meishan	¼ Fengjing	¼ Minzhu
Age, d	177.4	188.2	189.9	185.4
Live wt, kg	108.6 ± 1.85	108.8 ± 1.42	107.4 ± 1.43	107.7 ± 1.34
Length, cm	78.1 ± .56	78.2 ± .44	77.8 ± .45	77.7 ± .42
Fat thickness, mm				
First rib	52.8 ± 1.41	53.4 ± 1.09	55.1 ± 1.10	55.2 ± 1.04
10th rib	39.0 ± 1.48	38.2 ± 1.32	38.6 ± 1.34	39.9 ± 1.20
Last rib	30.4 ± 1.13	29.8 ± 1.02	31.1 ± 1.03	30.1 ± .93
Last lumbar	34.9 ± 1.30	35.1 ± 1.11	36.6 ± 1.13	37.0 ± 1.03
Longissimus muscle area, cm ²	29.3 ± .71	28.4 ± .62	27.9 ± .62	28.2 ± .56
Untrimmed ham, kg	8.89 ± .165	8.94 ± .128	8.88 ± .129	8.81 ± .119
Trimmed ham, kg	6.41 ± .119	6.34 ± .096	6.24 ± .097	6.21 ± .088
Untrimmed loin, kg	9.84 ± .224	9.89 ± .188	9.87 ± .191	10.00 ± .172
Trimmed loin, kg	6.33 ± .129	6.26 ± .110	6.15 ± .111	6.15 ± .101
Untrimmed butt, kg	4.30 ± .095	4.17 ± .069	4.29 ± .069	4.26 ± .065
Trimmed butt, kg	3.14 ± .067	3.02 ± .048	3.10 ± .048	3.04 ± .045
Untrimmed picnic, kg	4.26 ± .098 ^b	3.94 ± .071 ^c	3.93 ± .071 ^c	3.86 ± .068 ^c
Trimmed picnic, kg	3.29 ± .072 ^b	2.99 ± .052 ^c	2.99 ± .052 ^c	2.95 ± .050 ^c
Total untrimmed, kg	27.30 ± .481	26.94 ± .374	26.96 ± .377	26.93 ± .350
Total trimmed, kg	19.17 ± .322	18.60 ± .254	18.48 ± .256	18.34 ± .237
Belly, kg	8.92 ± .210	8.97 ± .172	8.88 ± .174	8.93 ± .158
Leaf fat, kg	1.18 ± .060 ^c	1.31 ± .055 ^{bc}	1.36 ± .056 ^b	1.30 ± .049 ^{bc}
Marbling	2.30 ± .185	2.05 ± .156	2.11 ± .158	2.14 ± .145
Color	2.86 ± .109 ^c	3.24 ± .008 ^b	3.08 ± .089 ^{bc}	3.16 ± .081 ^b
Firmness	2.06 ± .070	2.15 ± .062	2.11 ± .064	2.16 ± .056

^aThe weights of all cuts are from the left side of the carcass.

^{b,c}Means within a row lacking a common superscript letter differ ($P < .05$).

cantly only from that of Fengjing crosses. Color score was higher for all the Chinese crosses than for Duroc crosses, but the difference was not significant for Fengjing crosses. There were few significant differences among $\frac{1}{4}$ crosses of these breeds when carcass traits were compared at a constant carcass weight (Young, 1995b). Differences among $\frac{1}{4}$ breed types were significant for fat thickness at the 1st rib and 10th rib, longissimus muscle area, untrimmed ham, trimmed ham, untrimmed picnic, trimmed picnic, leaf fat, and color score (Young, 1995b). In most cases, the significant effects resulted from differences between only two breed types (Young, 1995b). Although the differences are smaller and often not significant, the differences among $\frac{1}{8}$ and $\frac{1}{4}$ crosses of these breeds are in general agreement with the differences reported by Young (1992a, 1995b) for pigs sired by Duroc, Meishan, Fengjing, and Minzhu boars.

Implications

There are no beneficial effects on growth and carcass traits of crossbred pigs containing $\frac{1}{8}$ Chinese (Meishan, Fengjing, and Minzhu) germplasm. Crossbred Chinese pigs will grow less rapidly and produce less weight of lean cuts. The use of Chinese breeds in commercial swine production is generally not recommended.

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