Feed Intake Patterns and Growth Performance of Purebred and Crossbred Meishan and Yorkshire Pigs

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ABSTRACT : Two experiments were conducted to compare the feed intake patterns and growth performance of Meishan and Yorkshire growing pigs. Experiment 1 was carried out over a 6-wk period and used 48 barrows with equal numbers of purebred Meishan (M) and Yorkshire (Y). Pigs were allocated to four groups of 12 pigs consisting of equal numbers of M and Y. Initial BW were 36.4±0.32 kg and 42.1±1.41 kg for M and Y, respectively. Experiment 2 was carried out over a 5-week period and used 48 pigs consisting of equal numbers of both barrows and gilts and of crossbred Meishan× Yorkshire (MY) and purebred Yorkshire (Y) animals. Pigs were allotted to 6 pens of 8 pigs, with 4 single- and 2 mixed-genotype groups (initial BW=28.5±0.99 kg). In both experiments, pigs were given ad libitum access to a grower diet (17% crude protein, 0.9% lysine, 3365 kcal/kg ME) via feed intake recording equipment (F.I.R.E.). Pigs carried an ear-tag transponder with an unique identification which allowed the time, duration, and size of individual meals to be recorded. In Exp. 1, Y had higher ADG (721 vs 353 g, $p<0.01$), daily feed intake (DFI; 2.338 vs 1.363 kg, $p<0.01$), made more frequent visits to the feeder per day (NFV; 18.5 vs 7.7, $p<0.01$), had a shorter feeder occupation time per visit (FOV; 7.4 vs 12.9 min, $p<0.01$), and ate less feed per visit (FIV; 130 vs 177 g, $p<0.01$) than M pigs. Feed consumption rates (CR) were greater for Y compared to M (19.3 vs 14.8 g/min, $p<0.01$). Feeder occupation time per day (FOD) was longer for Y than M (114.3 vs 82.8 min/pig, $p<0.01$). Yorkshire pigs visited the feeder more frequently between 0800 and 1100 h. Meishan pigs showed more frequent feeder visits between 0600 and 0800 h, and between 1600 and 2100 h when feeding competition with Y was reduced. In Exp. 2, there was no effect of genotype or group composition on DFI, ADG or gain:feed ratio. Crossbred pigs (MY) made fewer feeder visits (12.6 vs 17.7, $p<0.01$), and had greater FIV (124 vs 98 g/visit, $p<0.01$), and longer FOV (8.11 vs 7.24 min/visit, $p<0.01$) and FOD (112 vs 100 min, $p<0.05$) than Y pigs. Results of this study suggest substantial genetic variation in feeding patterns as well as in growth performance. (*Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 6 : 837-843*)

Key Words : Swine, Growth, Feed Intake Pattern, Meishan, Yorkshire

INTRODUCTION

An understanding of feed intake behavior in pigs and of the genetic and environmental factors that influence this behavior may help explain the considerable individual animal variability in performance that is observed in commercial practice and could lead to management methods for reducing such variability. There is, however, limited information on feeding patterns and growth performance of various breeds and their crosses. Cöp and Buiting (1977) reported that differences in daily feed intake between six European lines of pigs increased from 150 g at 25 kg to more than 500 g at 95 kg body weight. De Haer and De Vries (1993a) observed that there were differences in growth performance and protein deposition between breeds and sexes that were related to variation in feed intake pattern.

Chinese breeds of pigs, and particularly the Meishan, have received considerable interest in Europe and the United States of America. This interest has focussed largely on the prolificacy of this breed compared to conventional Western breeds. However, the Meishan also differs markedly from conventional breeds for all production traits, including feed intake and growth rate. In addition, there is evidence that the Meishan has different behavior patterns than other breeds of pigs. For example, Mormede et al. (1984) found that Meishan pigs when exposed to a new environment had lower locomotor activity and lower feed intake latency after 24 h of feed deprivation than other Chinese breeds.

The objectives of the current research were to evaluate differences in growth performance, level of feed intake, and feeding patterns between Meishan and Yorkshire pigs, and Yorkshire and Meishan Yorkshire pigs using electronic feed intake recording equipment.

MATERIALS AND METHODS

Two experiments were conducted at the Swine Research Center of the University of Illinois to evaluate the effect of genotype on growth performance and feeding patterns in growing pigs. The experimental protocols used in these studies were approved by the University of Illinois Laboratory Animal Care Advisory Committee.

Experimental designs

Experiment 1 : The study, which was carried out

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over a 6-wk period, compared two breeds of pigs with two treatments and four replicates. An equal number of Meishan (n=24) and Yorkshire (n=24) barrows were selected from a group of pigs that showed no visible signs of any health problems at approximately 32 kg live weight and were moved to their test pens 1-wk prior to the start of the test period. All pigs were fitted with an electronic ear tag transponder with an unique identification. Animals were allocated to one of four pens from outcome groups of four pigs, formed on the basis of breed and weight. Each pen contained 12 pigs with an equal number of pigs from each breed. Each pen was equipped with electronic feed intake recording equipment (F.I.R.E., Osborn Industries, Osborn, KS). The experiment started at an average BW of 36.4±0.32 kg for M and 42.1±1.41 kg BW for Y.

Experiment 2 : The study was carried out as a 2 ×2×2 factorial with three treatments: two genotypes (Yorkshire [Y] vs Meishan×Yorkshire [MY]), two group compositions (single-genotype vs mixed-genotype), and two sexes (barrows vs gilts). Single-genotype groups were defined as pens containing either only Yorkshire or only Meishan-cross pigs. Mixed-genotype groups were defined as pens containing equal numbers of both Yorkshire and Meishan-cross pigs. The pigs used in this study were produced from sows that had been inseminated with a mixture of Meishan and Yorkshire semen and, therefore, both genotypes had common dams. A total of 24 Y and 24 MY animals, consisting of equal numbers of barrows and gilts, were selected from a group of healthy pigs at about 23 kg body weight. Animals were allocated to six pens of eight pigs per pen on the basis of genotype, sex, litter of origin, and body weight. Pigs were moved to the test pens 10 days prior to the start of the experiment. Each pen was equipped with a F.I.R.E. system feeder and all the pigs were fitted with an electronic ear tag transponder with an unique identification. The trial started at an average pen live weight of 28.5±0.99 kg and ended after a 5-wk period.

Diet and housing

A single corn and soybean meal based diet formulated to meet or exceed NRC (1998) requirements for growing pigs was fed in both studies. The diet composition and calculated analysis are given in table 1. Pigs were given *ad libitum* access to feed via F.I.R.E. feeders. Pigs were housed in a mechanically-ventilated grower house which had half-slatted, half-solid concrete floors and provided 0.8 and 0.9 m^2/pig floor space in Exp. 1 and 2, respectively. The accommodation had 24-h lighting and water was continuously available via a nipple drinker in each pen. The temperature within the building was maintained at 21-22 ℃ throughout both experiments using a thermostat and fan ventilation. Temperature and humidity levels in the building were recorded daily.

Recording of feed intake and feeding pattern

Feed intake was recorded using the F.I.R.E. system. Each pen was equipped with a feed station which consisted of a feed trough connected to a load cell and receiving equipment to pick up radio signals from the ear tag transponder carried by the pigs. Pigs had 24-h access to the feed station which was equipped with a protective crate in front of the feed trough that allowed only one pig to access the feeder at any time. All feed stations were connected to control equipment which continuously logged all visits to the feeder, the duration of each visit, and the amount of feed consumed per visit as well as cumulative feed consumption over a 24-h period. Data were downloaded daily from the control equipment memory and stored on diskettes until required for analysis. All feed stations were calibrated at the start of the study and once per week thereafter, using a 1 kg test weight.

Data on daily feed intake traits for individual animals were used to estimate mean values for daily feed intake (DFI, kg), number of feeder visits per day (NFV), feed intake per visit (FIV, g), feeder occupation time per visit (FOV, min), total feeder occupation time per day (FOD, min), and feed consumption rate (CR, g/min), estimated as feed intake per visit divided by feeder occupation time per visit.

Statistical analysis

For all variables, the individual animal was considered as the experimental unit. All data were analyzed using the PROC GLM procedure of SAS (SAS Inst. Inc., Cary, NC). In Experiment 1, the statistical model used in the analysis included the effect of genotype, with initial body weight being fitted as a covariable. In Experiment 2, the statistical model included the effects of genotype, sex, dam, and group composition (single or mixed genotype).

Diurnal patterns for feed intake traits were estimated by totaling the number of feeder visits, total feeder occupation time, mean feeder occupation time per visit, and feed consumption rate for each pig over every 24-h period. Comparison of the hourly means of feeding pattern traits between the two genotypes was carried out using the PROC GLM procedure of SAS.

RESULTS AND DISCUSSION

Experiment 1

Growth performance and feeding patterns : Least-squares means for the effect of genotype on growth

performance and feed intake traits are presented in table 2. Yorkshire pigs had higher average daily gain (ADG; 721 vs 353 g/day, respectively, p<0.01) and daily feed intake (DFI; 2.338 vs 1.363 kg/day, respectively, p<0.01) than Meishan pigs; however, there was no difference between the breeds for gain:feed ratio (table 2). Haley et al. (1992) suggested that published estimates of the growth rates of purebred Meishans were in the range of 50 to 65 % of those for conventional breeds and the results of the present study are consistent with this.

Yorkshire compared to Meishan pigs made more frequent visits to the feeder (18.5 vs 7.7, respectively, P<0.01), had a shorter feeder occupation time per visit (7.4 vs 12.9 min., respectively, p<0.01), and consumed less feed per visit (130 vs 177 g, respectively, p<0.01). There was considerable variation between individual animals in the frequency of feeder visits, which ranged from 8 to 23 per day across both breeds over the study period. Previous studies that have evaluated feeding behavior in conventional breeds have generally found frequencies of feeder visits within the upper half of the range found in this study (i.e., 14 to 22/pig/day) (De Haer and Merks, 1992; De Haer and De Vries, 1993a, b). Young and Lawrence (1994), who used similar equipment to that used in the present study, reported an average of 12 feeder visits per day, but a much greater range of visits for individual animals from 3 to 69 per day. Quiniou et al. (1999) reported that the daily number of meals per day was higher in Pietrain boars (14.4), Large White boars and Large White barrows (12.2 on average) than in Meishan barrows (7.3). Means for feed intake per visit in the current experiment were similar to values reported by De Haer and Merks (1992) and De Haer and De Vries (1993a, b), but these authors reported significantly shorter feeder occupation times for each visit and each day.

Feeder occupation time per day (114.3 vs 82.8 min, respectively, P<0.01) and consumption rates (19.3 vs 14.8 g/min, respectively, p<0.01) were greater for Yorkshire compared to Meishan pigs (table 2). Consumption rates in the current study, relative to those found in other studies that have used pigs within a similar body weight range, were lower than those reported by De Haer and Merks (1992) and De Haer and De Vries (1993a, b), but higher than those found by Feddes et al. (1989). Differences between studies for absolute values for feed intake levels and patterns are likely to reflect differences in genotypes, sexes, body-weight ranges, pen designs, floor-space

Table 1. Composition of the experimental diet (Experiments 1 and 2)

Item	Inclusion rate (%)
Ingredient	
Corn	73.70
Dehulled soybean meal	23.00
Dicalcium phosphate	1.50
Limestone	1.30
Trace-mineral mixture1[1]	0.30
Vitamin mixture[2]	0.20
Chemical composition[3]	
Crude protein	16.90
Lysine	0.90
Calcium	0.88
Phosphorus	0.63
Energy content (ME Kcal/kg)	3,365

[1] Trace mineral mixture provided the following (per kg diet): Se, 0.30 mg; I, 0.35 mg; Cu, 8 mg; Mn, 20 mg; Fe, 90 mg; Zn, 100 mg; NaCl, 2.73 g.

[2] Vitamin mixture provided the following (per kg diet): retinal acetate, 3,300 IU; cholecalciferol, 330 IU; Dl-α-tocopheryl acetate, 44 IU; menadione sodium bisulfite, 2.2 mg; vitamin B12, 0.02 mg; riboflavin, 4.4 mg; D-pantothenic acid, 12.1 mg; niacin, 16.5 mg; choline chloride, 165 mg.

[3] Calculated values

Table 2. Least-squares means for the effect of genotype on growth performance and feeding patterns of growing pigs (Experiment 1)

Items	Meishan	Yorkshire	Avg. SEM	Significance[1]
No. of pigs	24	24		
Initial body weight (kg)	36.4	42.1	1.19	**
Final body weight (kg)	51.2	72.3	1.52	**
Average daily gain (g)	353.3	720.6	24.04	**
Daily feed intake (kg)	1.363	2.338	0.0672	**
Gain: Feed	0.27	0.31	0.015	NS
Number of feeder visits per day	7.7	18.5	0.23	**
Feed intake per visit (g)	176.7	129.6	2.62	**
Feeder occupation time per visit (min)	12.9	7.4	0.23	**
Feeder occupation time per day (min)	82.8	114.3	1.67	**
Feed consumption rate (g/min)	14.8	19.3	0.17	**

[1] NS, *, ** not significant, p<0.05, p<0.01.

allowances, group sizes, other environmental conditions, and diet composition, particularly with respect to the energy content of the diet.

Diurnal feeding patterns : A different diurnal pattern in feeding behavior was observed for the two breeds as illustrated in figure 1. Feeder visits for Yorkshire pigs (figure 1a) were lowest during the early morning and the evening periods (i.e., between 0300 and 0600 h, and 1600 and 1800 h, respectively), showed a rapid increase from 0700 to 0800 h, and peaked at 0800 to 1100 h. Feeding activity of M pigs was higher ($p<0.05$) than Y in the morning and evening, i.e., between 0600 and 0800 and between 1600 and 2100 h, respectively, when feeding competition with Yorkshire pigs would be less. The diurnal distribution for feed intake per hour for the two genotypes generally showed similar trends to the distribution for feeder visits (figure 1b). The diurnal distribution for feeder occupation time per visit for the two breeds (figure 1c) generally showed the opposite pattern to that for the number of feeder visits ($p<0.05$). Feed consumption rate was relatively constant over the 24-h period for both genotypes (figure 1d) and tended to be higher for the Yorkshire pigs, however, the differences between breeds were not statistically significant ($p>0.05$). Most other studies have shown a similar diurnal pattern of feeding behavior to that observed in this trial (Young and Lawrence, 1994; De Haer and Merks, 1992).

Experiment 2

Growth performance and feeding patterns : There were no significant ($p>0.05$) treatment interactions for the growth performance traits. Yorkshire pigs had numerically higher feed intakes (10%) and growth rates (9%) than the Meishan-crosses, however, these differences were not statistically significant, and gain:feed ratio was similar for the two genotypes (table 3). Generally, crosses of Meishan and conventional breeds have been shown to have lower daily gain than crosses of conventional breeds; however, growth rates of crosses between Meishan and western breeds have generally been more similar to those of the western breeds than to the purebred Meishan (Haley et al., 1992; Bidanel et al., 1993). There was no effect of group composition on growth performance (table 3). Barrows had numerically higher feed intake and daily gain than gilts, however, these

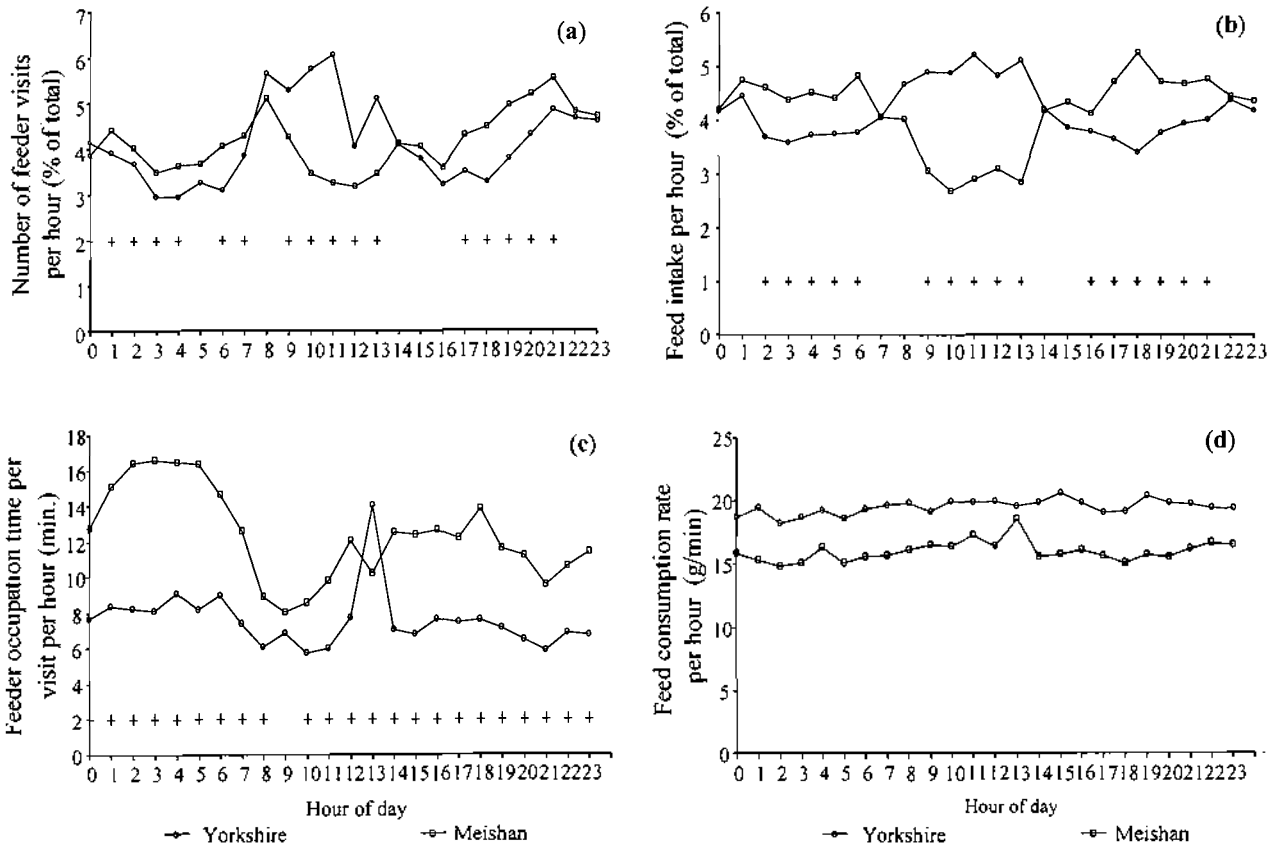

Figure 1. Diurnal distribution of feeding pattern traits for Yorkshire and Meishan growing pigs - Experiment 1: (a) number of feeder visits (percentage of total visits); (b) feed intake (percentage of total feed intake); (c) feeder occupation time per visit; (d) feed consumption rate (g/min). + Genotype means differ ($p<0.05$)

differences were not statistically significant. Most studies have shown that barrows have a higher feed intake and growth rate compared to gilts (Labroue et al., 1994; Hahn and Baker, 1995).

There was a significant ($p<0.05$) interaction between genotype and group composition for number of feeder visits per day (table 3). Yorkshire pigs had a greater number of feeder visits than Meishan-crosses in single- and mixed-genotype groups ($p<0.05$). However, Yorkshire pigs had a lower number of feeder visits when penned in mixed-compared to single-genotype groups. In contrast, there was no effect of group composition on the number of feeder visits per day for Meishan-cross pigs ($p>0.05$) (table 3).

There were differences between the genotypes for feeding pattern that were independent of group composition. Yorkshire pigs had lower feeder occupation time and feed intake per visit but higher feeder occupation time per day compared to the crossbred animals ($p<0.01$) (table 3). However, feed consumption rates were similar for the two genotypes.

The effect of sex on feeding patterns is summarized in table 3. Differences between barrows and gilts for feed intake patterns were modest, which is in general agreement with previous research conducted at this center by Hyun et al. (1997).

There was a significant ($p<0.05$) interaction between group composition and sex for feeder occupation time per visit and feed consumption rate (table 3). Group composition did not influence the feeding pattern of barrows, however, gilts in the mixed-genotype groups had increased feeder occupation time per visit and decreased feed consumption rate compared to the single-genotype groups.

Animals in mixed-genotype groups had a longer daily feeder occupation time ($p<0.01$) than single-genotype groups, but feed intake per visit was not different between the two group compositions ($p>0.05$) (table 3). These results indicate that some factor was altering feeding behavior when the two genotypes were penned together compared to when they were in single-genotype groups. Previous research has indicated that the Meishan is less active in feeding behavior at the feeder than other Chinese breeds (Mormede et al., 1984). Surprisingly, in the current experiment, the Meishan-cross appeared to alter the feeding behavior of the Yorkshire when the two genotypes were penned together.

The results of the present study suggest that there is a genetic difference in feeding pattern between the Meishan-cross and Yorkshire pigs which is independent of the genetic composition of the group. These two

Table 3. Least squares means for the effect of genotype, group composition, and sex on growth performance and feeding patterns of growing pigs (Experiment 2)

	Genotype				Group Composition				Sex			
Item	York shire	Meishan x Yorkshire	Avg. SE	Sig[1]	Single	Mixed	Avg. SE	Sig[1]	Barrows	Gilts	Avg. SE	Sig[1]
No. of pigs	24	24			24	24			24	24		
Intial body weigt (kg)	28.5	28.6	0.72	NS	28.6	28.5	0.71	NS	28.1	29.0	0.70	NS
Final body weight (kg)	53.0	51.1	1.11	NS	52.3	51.8	1.10	NS	51.7	52.5	1.08	NS
Average daily gain(g)	700	644	20.2	NS	677	667	19.9	NS	674	670	19.7	NS
Daily feed intake (kg)	1.62	1.50	0.074	NS	1.54	1.58	0.073	NS	1.56	1.56	0.072	NS
Gain: Feed	0.44	0.44	0.016	NS	0.45	0.43	0.015	NS	0.43	0.45	0.015	NS
Number of feeder visits per day[2]	-	-	-	-	-	-	-	-	15.8	14.5	0.44	*
Single	19.2[a]	12.7[c]	0.61	*	-	-	-	-	-	-	-	-
Mixed	16.2[b]	12.4[c]	0.61	*	-	-	-	-	-	-	-	-
Feed intake per visit (g)	98	124	3.6	**	108	114	3.6	NS	106	116	3.6	NS
Feeder occupation time per visit (min)[3]	7.0	8.4	0.25	**	-	-	-	-	-	-	-	-
Single	-	-	-	-	-	-	-	-	7.3[ab]	7.2[a]	0.34	*
Mixed	-	-	-	-	-	-	-	-	7.3[ab]	8.9[b]	0.34	*
Feeder occupation time per day (min)[3]	112	100	2.8	**	100	113	2.8	**	106	107	2.8	NS
Feed consumption rate (g/min)[3]	15.1	14.7	0.44	NS	-	-	-	-	-	-	-	-
Single	-	-	-	-	-	-	-	-	14.7[ab]	15.9[a]	0.62	*
Mixed	-	-	-	-	-	-	-	-	15.5[ab]	13.6[b]	0.62	*

[a,b] Means within the same row within treatment with different superscripts differ ($p<0.05$).

[1] NS, *, **=not significant, $p<0.05$, $p<0.01$.

[2] Interaction effect between genotype and group composition ($p<0.05$).

[3] Interaction effect between group composition and sex ($p<0.05$).

breeds are examples of extremes in terms of biological and production characteristics and exhibit differences in most traits. However, there is evidence of differences in feeding patterns among conventional breeds and lines (De Haer and Merks, 1992; De Haer and De Vries, 1993a).

Diurnal feeding patterns : There was a difference between the two genotypes for diurnal feeding patterns averaged over the 5-wk study period as illustrated in figure 2. There were two peaks in feeder visits (between 0700 and 0800, and between 1400 and 1500, respectively) for both Yorkshire and Meishan-cross pigs (figure 2a). Yorkshire pigs consistently made more frequent feeder visits than Meishan-cross pigs throughout the 24-h period ($p<0.05$) (figure 2a). Feed intake (figure 2b) and feeder occupation time per hour (figure 2c) showed similar daily patterns to those for feeder visits (figure 2a), and there were few significant differences between the genotypes for these traits. Yorkshire pigs did occupy the feeder longer than Meishan-cross pigs at 0800, 1100 and 1300 hours when the number of feeder visits was greatest ($P<0.05$) (figure 2c), however, the genotype differences were relatively small. Feed consumption rates were similar between the two genotypes over the 24 - h period. The diurnal pattern of feeding activity was observed in this study, and Experiment 1, is similar to the findings of Young and Lawrence (1994) and other studies at this center (Hyun et al., 1997).

The feeding behavior of the Yorkshire pigs in the two studies was relatively similar for number of feeder visits, and feeder occupation time per visit and per day (tables 2 and 3). However, feed intake per visit and feed consumption rate were lower for the Yorkshire pigs in Experiment 2 (table 3) compared to Experiment 1 (table 2). The most likely explanation for this difference is the lighter weights of the pigs used in Experiment 2; there is evidence that both feed intake per visit and feed consumption rate increase with live weight (Hyun et al., 1997). In study 2, the differences in most of the feeding pattern traits between the crossbred Meishans and the Yorkshires was still considerable despite the fact that the difference in feed intake and growth rate between these two genotypes was relatively small. This suggests that there may be a direct effect of the Meishan on feeding behavior that is independent of growth performance. Further research would be needed to address this issue.

IMPLICATION

The results of these studies confirm differences in feed intake and growth performance between the

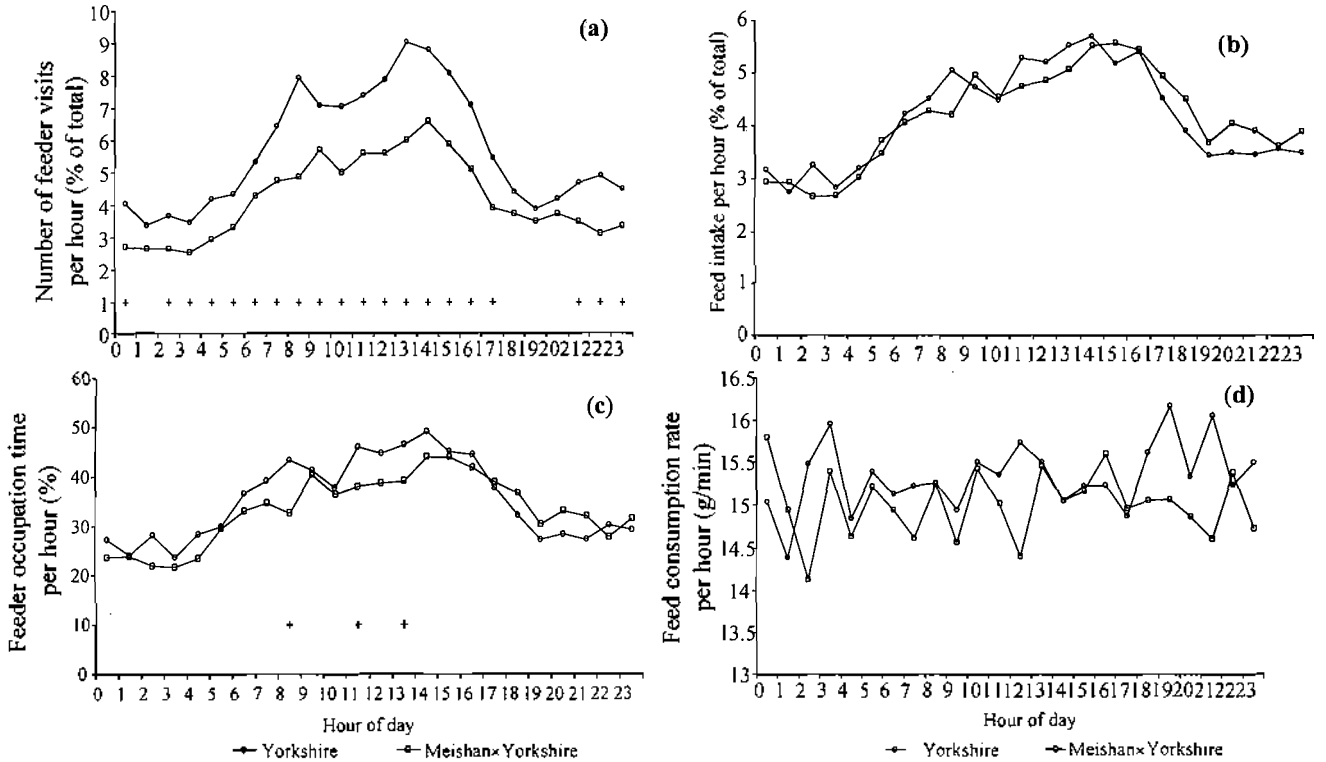

Figure 2. Diurnal pattern of feed intake traits for Yorkshire and Meishan × Yorkshire growing pigs - Experiment 2: (a) number of feeder visits (percentage of total visits); (b) feed intake (percentage of total feed intake); (c) percentage of time feeder occupied (% per hour); (d) feed consumption rate (g/min). + Genotype means differ ($p<0.05$)

Meishan and Yorkshire breeds and the F1 cross. The large differences in feeding behavior between these two extreme breeds highlight the substantial genetic component to these traits. The importance of this with regard to its possible implications for genetic selection and commercial production warrants further study.

REFERENCES

Bidanel, J. P., J. C. Caritez, J. Gruand, and C. Legault. 1993. Growth, carcass and meat quality performance of crossbred pigs with graded proportions of Meishan genes. Genet. Sel. Evol. 25:83-99.

Cöp, W. A. G. and G. A. J. Buiting. 1977. Feed intake in six lines of pigs and its influence on growth and carcass traits. Anim. Prod. 25:291-304.

De Haer, L. C. M. and A. G. de Vries. 1993a. Effects of genotype and sex on feed intake pattern of group housed growing pigs. Livest. Prod. Sci. 36:223-232.

De Haer, L. C. M. and A. G. de Vries. 1993b. Feed intake patterns of and feed digestibility in growing pigs housed individually or in groups. Livest. Prod. Sci. 33:277-292.

De Haer, L. C. M. and J. W. M. Merks. 1992. Patterns of daily food intake in growing pigs. Anim. Prod. 54: 95-104.

Feddes, J. J. B. A. Young and J. A. De Shazer. 1989. Influence of temperature and light on feeding behavior of pigs. Appl. Anim. Behav. Sci. 23:215-222.

Hahn, J., and D. H. Baker. 1995. Optimum ratio to lysine of threonine, tryptophan, and sulfur amino acids for finishing swine. J. Anim. Sci. 73:482-489.

Haley, C. S., E. d'Agaro, and M. Ellis. 1992. Genetic components of growth and ultrasonic fat depth traits in Meishan and Large White pigs and their reciprocal crosses. Anim. Prod. 54:105-115.

Hyun, Y., M. Ellis, F. K. McKeith, and E. R. Wilson. 1997. Feed intake pattern of group-housed growing-finishing pigs monitored using a computerized feed intake recording system. J. Anim. Sci. 75:1443-1451.

Labroue, F., R. Gueblez, P. Sellier, and M. C. Meunier-Salaun. 1994. Feeding behavior of group-housed Large White and Landrace pigs in French Central Test Stations. Livest. Prod. Sci. 40:303-312.

Mormede, P., R. Dantzer, R. M. Bluthe, and J. C. Caritez. 1984. Differences in adaptive abilities of three breeds of Chinese pigs. Behavioral and neuroendocrine studies. Genet. Sel. Evol. 16:85-102.

NRC. 1998. Nutrient Requirements of Swine (10th ed.). National Academy Press. Washington D.C.

Quiniou, N, S. Dubois, Y. Cozler, J. F. Bernier, and J. Noblet. 1999. Effect of growth potential (body weight and breed/castration combination) on the feeding behavior of individually kept growing pigs. Livest. Prod. Sci. 61:13-22.

Young, R. J. and A. B. Lawrence. 1994. Feeding behavior of pigs in groups monitored by a computerized feeding system. Anim. Prod. 58:145-152.