Feed Intake Pattern of Group-Housed Growing-Finishing Pigs Monitored Using a Computerized Feed Intake Recording System

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ABSTRACT: The feed intake pattern and growth performance of boars, barrows, and gilts fed diets differing in lysine and protein content were measured on 120 crossbred pigs from 27 (SD 3.7) to 81.5 (SD 9.2) kg live weight. The pigs were housed in eight mixed-sex groups with five pigs of each sex in each group. They were fed from an electronic feed station that recorded individual meal sizes and the time and duration of visits to the feeder for each animal in the group. Four dietary treatments were compared. During the grower period (27 to 55 kg), diets ranged in lysine content from .98 to 1.31%; for the remainder of the study, lysine content was .88 to 1.18%. Barrows had a greater ($P < .01$) number of meals per day than the other two sexes (7.4 vs 7.0 vs 7.0 ± .10, respectively), but there were no significant differences among sexes for daily feed intake or other feed intake traits. Daily feed intake increased with dietary lysine content, largely because of increased meal sizes resulting from longer feeder occupation times at each visit. Visits to the feeder were greatest between 0900 and 1100 and lowest between 2000 and 0400. Correlations between feeding pattern and growth traits were relatively low. Repeatabilities of feeding pattern traits were generally higher when measured over shorter time periods. These results suggest a change in feeding behavior with increasing dietary lysine levels and a relatively small effect of sex on feeding pattern for mixed-sex groups of 15 pigs fed from a single electronic feed station.

Key Words: Pigs, Feed Intake, Growth, Feeding Behavior

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Introduction

There are practical difficulties associated with measuring feed intake, particularly for groups of pigs. Each group of pigs produces a single estimate of feed intake, and, large numbers of groups and animals are needed to obtain accurate feed intake data. Alternatively, individual penning of pigs has been used experimentally and commercially to obtain individual animal feed intakes. However, this approach is expensive and may result in different feed intakes (De Haer and Merks, 1992) and feeding behavior (De Haer and De Vries, 1993b) compared with group situations.

Recently, equipment was developed to allow the measurement of feed intake of individual pigs housed in groups (Brown and Henderson, 1989; De Haer et al., 1992a,b). In addition to data on individual feed intake, such equipment also records feeding patterns and provides a method to obtain detailed individual animal feed intake behavior data as well as absolute intake in group situations. However, there are limited published data on feed intake behavior of growing-finishing pigs housed in groups. The study reported in this article used electronic feed intake recording equipment to investigate feed intake and feeding patterns of boars, barrows, and gilts fed diets with various lysine and protein levels.

Materials and Methods

Treatments and Experimental Design. The study was a completely randomized design in a 3 × 4 factorial arrangement, with the treatments being three sexes (boar, barrow, and gilt) and four diets that differed in protein content (Table 1). Eight pens of pigs were randomly allocated to dietary treatment to provide two pens for each diet. The test started when mean pen live weight was 27 (SD 3.7) kg and ended after a 10-wk period at a mean pig weight of 81.5 (SD 9.2) kg. The study period was split into two phases; the first phase was from start of test to a mean pen live weight of 55 kg, and the second phase was from 55 kg

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Table 1. Diet formulations and percentage composition

	Phase 1 (27 to 55 kg)				Phase 2 (55 to 80 kg)			
Ingredient, %	Diet 1	Diet 2	Diet 3	Diet 4	Diet 1	Diet 2	Diet 3	Diet 4
Corn	78.96	75.11	71.14	67.17	86.08	82.73	79.39	75.98
Soybean meal (48%)	14.68	18.54	22.55	26.56	10.69	14.06	17.43	20.80
Soybean oil	3.14	3.15	3.15	3.15	—	—	.005	.026
Lysine-HCL	.421	.419	.412	.405	.430	.434	.438	.441
DL-Methionine	.016	.037	.057	.076	—	.010	.026	.052
L-Threonine	.076	.086	.094	.102	.056	.074	.082	.090
L-Tryptophan	.027	.024	.020	.016	.029	.028	.028	.028
Dicalcium phosphate	1.00	.92	.84	.76	1.03	.96	.89	.83
Limestone	.84	.86	.88	.90	.84	.86	.88	.89
Trace-mineral mixture[a]	.35	.35	.35	.35	.35	.35	.35	.35
Vitamin mixture[b]	.2	.2	.2	.2	.2	.2	.2	.2
Copper sulfate	.1	.1	.1	.1	.1	.1	.1	.1
Tylan (2%)	.2	.2	.2	.2	.2	.2	.2	.2
Composition, % of fresh matter								
Dry matter[c]	89.02	89.09	89.17	89.24	88.56	88.63	88.69	88.76
Crude protein[c]	14.3	15.8	17.4	19.0	12.9	14.3	15.6	17.0
ME, kcal/kg[d]	3,436	3,436	3,436	3,436	3,315	3,315	3,315	3,315
Total lysine[d]	.98	1.09	1.20	1.31	.88	.98	1.08	1.18

[a]Trace-mineral mixture provided the following (per kilogram of diet): Se, .30 mg; I, .35 mg; Cu, 8 mg; Mn, 20 mg; Fe, 90 mg; Zn, 100 mg; NaCl, 2.73 g.

[b]Vitamin mixture provided the following (per kilogram of diet): retinal acetate, 3,300 IU; cholecalciferol, 330 IU; all-*rac*-α-tocopherol acetate, 44 IU; menadione sodium bisulfite, 2.2 mg; vitamin B_{12}, .02 mg; riboflavin, 4.4 mg; D-pantothenic acid, 12.1 mg; niacin, 16.5 mg; choline chloride, 165 mg.

[c]Values from proximate analysis.

[d]Calculated values based on published estimates for ingredients (NRC, 1988).

to the end of the study. Different diet specifications and formulations were used for each phase of the study (Table 1). Diets were based on corn, soybean meal, and synthetic amino acids and were formulated using the ideal protein ratio for essential amino acids suggested by Baker and Chung (1992) to provide the required levels of lysine, methionine, threonine, tryptophan, and isoleucine. Other essential amino acids were present in excess of requirements. All diets were fed as a ground meal and contained Tylan 10 (40 ppm, Elanco Animal Health, Indianapolis, IN) and copper sulfate (to provide 250 ppm added copper). Samples of each diet were analyzed for moisture and crude protein using AOAC (1990) methods; results are shown in Table 1.

Animals and Housing. The pigs used in this study were the progeny of PIC Line 26 males mated to Camborough females. Animals (n = 120, with equal numbers of boars, barrows, and gilts) were selected at 23 (SD 1.9) kg live weight from 22 litters that had been produced by two sires. Animals were formed into outcome groups of four pigs on the basis of sire, sex, and weight. Pigs were randomly allocated from within outcome group to one of four pens to produce test groups of 15 pigs per pen and equal numbers of each sex within each group. Groups were randomly allocated to one of the dietary treatments. This allocation procedure was repeated to form a total of eight pens of pigs. The study was conducted in an environmentally regulated building located on the Swine Research Center at the University of Illinois. The temperature within the building was controlled by mechanical ventilation linked to a thermostat set at 24°C during the early stages of the study and reduced to 21°C after the pigs had reached an average of 40 kg live weight. The pens had partially slatted floors, and the space allowance was constant throughout the study at .8 m^2/pig. The accommodation had continuous lighting for 24 h each day, and water was available at all times via two nipple drinkers in each pen. After pigs were transferred to the test pens, a transponder ear tag with a unique identification signal was attached to each animal. Pigs were allowed a 7-d period to adjust to the test environment and feeding equipment, and then the test was started. Pigs were weighed weekly to estimate growth rate.

Feed Intake Recording. Feed intake was recorded using Feed Intake Recording Equipment (F.I.R.E., Hunday Electronics, Newcastle-upon-Tyne, England). Each of the eight pens was equipped with a feed station that consisted of a feed trough connected to a load cell and equipment to receive radio signals from the ear tag transponder carried by the animals. Pigs had 24-h access to the feed station, which was equipped with a full-length protective crate in front of the feed trough to prevent access to the trough by more than one pig at any time. All feed stations were connected to control equipment that continuously logged the time and duration of each feeder visit, and the weight of feed consumed per visit as well as the cumulative feed consumed for an individual pig over a 24-h period. Data were downloaded daily from the

Table 2. Least squares means for sex and diet effects on growth, feed efficiency, and feed intake

	Sex				Diet				
Trait	Barrow	Boar	Gilt	Avg. SE	Diet 1	Diet 2	Diet 3	Diet 4	Avg. SE
Initial weight, kg	27.3	26.9	27.0	.64	26.8	27.3	26.7	27.4	.74
Final weight, kg	82.9	82.5	79.0	1.36	76.2[a]	81.2[ab]	84.4[b]	84.1[b]	1.58
ADG, g	795[a]	795[a]	743[b]	14.6	706[a]	770[b]	824[c]	810[bc]	17.9
Gain:Feed, kg/kg	.45[ab]	.47[a]	.44[b]	.008	.43	.45	.46	.46	.009
ADFI, kg[d]	1.79	1.70	1.69	.033	1.64[a]	1.70[b]	1.79[c]	1.78[c]	.038

[a,b,c]Means within a row, within treatment, with differing superscripts differ, $P < .05$.
[d]Transformed to a logarithmic scale.

control equipment memory and stored on diskette 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.

Statistical Analysis. The study was analyzed as a completely randomized design in a 3 × 4 factorial arrangement (three sexes and four diets). For all variables, the individual animal was considered the experimental unit. Data on daily feed intake traits for individual animals were accumulated over the 10-wk study period. These data were used to estimate mean values for individual animals for daily feed intake, gain:feed ratio, number of feeder visits per day, feed intake per visit, feeder occupation time per visit, feeder occupation time per day and feed consumption rate, which was defined as feed intake per visit divided by feeder occupation time per visit.

For grouping visits into meals, an intrameal interval was determined using the approach described by Petrie and Gonyou (1988). The frequency distribution of the intervals between the time of the end of a visit and the time of the start of the next visit by the same animal was plotted as a histogram. When a behavior occurs in bouts, such as visits to a feeder, the histogram can be divided into two sections. The first part of the distribution consists of a high frequency of short intervals (intrameal intervals), and the remainder of the distribution comprises longer, between-meal intervals (Clifton, 1987). A two-slope, broken-line model (Robbins et al., 1979) was fitted to the distribution using the NLIN procedure of SAS (1990), with the break point of the two slopes defining the intrameal interval. Using this approach, an intrameal interval of 28.3 min was determined and used to estimate the number of meals per day. The weight of feed consumed and the occupation time of all visits starting within a 28.3-min interval were combined into a single meal, and meal data were used to compute feed intake and feeder occupation time per meal for the study period.

Weekly means for individual animals for feed intake traits were analyzed using PROC UNIVARIATE procedures of SAS (1990) to check for normality; consequently, the data for daily feed intake, feed intake per visit and per meal, number of feeder visits per day, number of meals per day, and feeder occupation time per visit, per meal, and per day were transformed to a logarithmic scale, and that for feed consumption rate was transformed using a (square root + 1) scale to meet normality.

Individual animal live weight gain, transformed feed intake traits, and gain:feed ratio measured over the 10-wk period were analyzed using the PROC GLM procedure of SAS (1990), with the model used including the effects of sex, diet, pen within diet, and sex × diet interaction. The relationships of feed intake traits, growth rate, and feed efficiency were determined using the PROC CORR procedure of SAS (1990). Diurnal patterns for feed intake traits were estimated by counting the number of visits, feeder occupation times, and feed intake per visit for every hour of 24 h for the 10-wk study period for all animals. Weekly means for feed intake traits and live weights were used in regression analyses to establish the changes in feeder activity and consumption patterns over the study period.

Repeatability, defined as the ratio of the within-animal variance to the total phenotypic variance (Falconer, 1972), was estimated for the daily feed intake traits as

$$\text{Repeatability} = \sigma^2_A/(\sigma^2_E + \sigma^2_A)$$

where σ^2_A = between animal variance and σ^2_E = environmental variance.

Variance components were estimated within each 2-wk and 5-wk period of the study and for the entire study period using a model that included animal, sex, diet, pen within diet, sex × diet, and week of the study.

Results and Discussion

Sex and Diet Effects. Least-squares means for sex and diet effects on growth performance and feed intake are presented in Table 2. There were no sex × diet interactions for any of the traits. Average daily gain was higher for boars and barrows than for gilts, and gain:feed ratio was higher for boars than for gilts, with barrows being intermediate but not different from the other two sexes. Other studies have shown similar effects of sex on growth rate and feed efficiency

Table 3. Least squares means for sex and diet effects on feed intake patterns

	Sex				Diet				
Trait	Barrow	Boar	Gilt	Avg. SE	Diet 1	Diet 2	Diet 3	Diet 4	Avg. SE
Number of feeder visits	12.6	11.6	11.9	.49	12.8	12.7	11.4	11.2	.57
Number of meals per day	7.4[a]	7.0[b]	7.0[b]	.10	7.5[a]	7.4[a]	6.8[b]	6.8[b]	.12
Feed intake per visit, g[d]	150	155	152	6.9	134[a]	141[a]	168[b]	169[b]	8.9
Feed intake per meal, g[d]	261	264	261	4.8	230[a]	245[b]	290[c]	283[c]	5.6
Feeder occupation time per visit, min[d]	6.5	6.6	6.6	.27	6.2[a]	6.0[a]	7.1[b]	7.1[b]	.31
Feeder occupation time per meal, min[d]	10.8	11.0	11.1	.23	10.0[a]	10.1[a]	12.0[b]	11.8[b]	.27
Total feeder occupancy time per day, min[d]	78.1	73.4	75.8	2.61	75.6	73.7	76.9	76.9	3.01
Feed consumption rate, g/min[e]	23.6	24.1	23.4	.85	22.5	24.2	23.6	24.3	.98

[a,b,c]Within a row and within treatment, means with differing superscripts differ ($P < .05$).
[d]Transformed to a logarithmic scale.
[e]Transformed to a (square root + 1) scale.

(Campbell and Taverner, 1988; Labroue et al., 1994; Hahn and Baker, 1995). There was no difference among the sexes for daily feed intake (Table 2). The majority of studies that have compared the three sexes have shown that barrows have a higher feed intake than boars or gilts (Campbell and Taverner, 1988; Fuller et al., 1995). The lack of difference in feed intake among the sexes in the present study may result from the feeder design and the size and sex composition of groups used, which may have restricted access to the feeder and could have reduced the feed intake of barrows relative to the other two sexes.

Barrows ate more meals per day than boars and gilts ($P < .01$); however, the sex differences were small, and there was little influence of sex on the other feed intake traits (Table 3). This is in contrast to the findings of De Haer and De Vries (1993a), who compared Yorkshire boars and gilts in single-sex groups of eight pigs per group over the weight range 30 to 100 kg and showed that boars ate less frequently than gilts but spent more time in the feeder at each visit and consumed bigger meals, resulting in similar average daily feed intakes for the two sexes. However, they found no differences in feeding behavior for Dutch Landrace boars and gilts, a similar finding to that of the present study. Young and Lawrence (1994) showed no difference between boars and gilts for feeding behavior but suggested that there was a strong trend for boars to have shorter visits to the feeder and to consume less feed at each visit. The influence of sex on meal size and duration is therefore uncertain and may vary between genotypes but seems to be relatively small.

Growth rates increased over Diets 1, 2, and 3, but the daily gains for pigs fed Diet 4 were not different from those fed Diets 2 or 3 (Table 2). These results suggest a growth rate response to increasing lysine and protein up to approximately the levels in Diet 3, namely 1.2 and 1.1% lysine and 17.4 and 15.6% crude protein for the two phases of the study, respectively. However, the variation among diet groups in growth rates was largely a reflection of feed intake differences; there was little dietary effect on gain:feed ratios (Table 2). The higher feed intake of pigs fed Diets 3 and 4 was the consequence of greater meal sizes resulting from increased feeder occupation times at each meal, rather than from an increase in feeding frequency (Table 3). There is evidence of an effect of amino acid deficiency on feed intake and feeding patterns. Montgomery et al. (1978) reported a reduction in total feed intake and average meal sizes for tryptophan-deficient diets. However, these authors found relatively small effects on the number of meals per day or average meal duration, suggesting that the main influence of tryptophan deficiency was to reduce the rate of feeding.

Feed Intake Behavior. The data presented in Table 3 suggest that pigs visited the feeder on average 12 times per day, and approximately half of these visits were classified as meals on the basis of an intrameal interval of 28.3 min. There was considerable variation among individual animals in the frequency of feeder visits, with the range over the study period being from 8 to 23 per day. Studies performed in Holland (De Haer and Merks, 1992; De Haer and De Vries, 1993a,b) have reported a greater frequency of daily feeder visits, ranging between 14 and 22 per pig. However, Young and Lawrence (1994), in an experiment using the same type of equipment as in the present study, reported a similar frequency of feeder visits of approximately 12 visits per day, but a much greater range of 3 to 69 visits per day for individual animals. These authors suggested that variation in the frequency of visits is related to the size of animal, with (in their study) the greatest frequency of feeder visits being made by the heaviest pigs and the lowest frequency by the lightest animals. In the current study, the correlations between live weight and number of visits to the feeder estimated within each week of the study were low (i.e., less than .10; data not shown) as was the correlation between individual pig live weight relative to the group mean and the number of feeder visits (data not shown), suggesting little association between feeding frequency and absolute or relative weights.

In the current study, feed intake per visit and per meal, feeder occupation time per visit and per meal, and total feeder occupation time per day averaged approximately 150 and 260 g, 6.6 and 11.0 min, and 76 min, respectively (Table 3). The feed intake per visit is 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 per visit and per day. Values for number of meals, feed intake per meal, and feeder occupation time per meal are within the range reported by Labroue et al. (1994), De Haer and De Vries (1993b), and De Haer and Merks (1992). Feed consumption rate was approximately 24 g/min, which is lower than that reported by De Haer and Merks (1992) and De Haer and De Vries (1993a,b) but is within the range reported by Nielsen and Lawrence (1993) of between 23.8 and 31.6 g/min, and the rate is higher than that found by Feddes et al. (1989) of 15 g/min for pigs of approximately 36 kg live weight. Differences among studies for absolute values for feed intake traits are likely to reflect differences in the conditions used in terms of genotypes, sexes, live weight ranges, pen designs, stocking densities, group sizes, feed form, and environmental conditions. In addition, a major factor determining feed intake behavior is likely to be the design of the feed station. Nielsen et al. (1995) compared feeder entrance designs that afforded low, medium, or high protection against disturbance of the feeding pig. The medium protection treatment was a full-length race similar to the design used in the present study. Pigs with high protection had longer feeder visits and higher feed intake per visit than pigs receiving the other two treatments. The number and duration of visits and feed consumed per visit were similar for medium and low protection; however, pigs receiving the low protection treatment had higher feed consumption rates than the other two treatment groups.

Diurnal Feeding Patterns. A strong diurnal pattern in feed intake behavior was observed, as illustrated in Figure 1, where data are presented for the number of events per hour averaged over the 10-wk period of the study for the three sexes separately. The number of visits to the feeder (Figure 1a) were lowest during the night time (i.e., between 2000 and 0400), showed a rapid increase from 0600 to 0900, peaked at approximately 0900 h, and declined from 1000 to 2000. Feed consumed (Figure 1b), feeder occupation time (Figure 1c), and feed consumption rate (Figure 1f) showed similar trends. However, feed intake per visit (Figure 1d) and feeder occupation time per visit (Figure 1e) showed an inverse pattern to the number of feeder visits. Thus, the length of visits decreased and consumption rates increased at times of the day when competition for the feeder was greatest, which is in agreement with other studies (Young and Lawrence, 1994). Increasing feed consumption rate seems to be a mechanism for maintaining feed intake level in group situations when competition for feeder access is high.

The single peak in feeder activity observed in the present study is similar to the findings of Young and Lawrence (1994). However, a number of studies have reported two peaks of feeding activity, one in the morning and one in the afternoon (Montgomery et al., 1978; De Haer and Merks, 1992). These later studies employed a discontinuous lighting regimen over the 24-h period; the lights were turned off during the nighttime. Feddes et al. (1989) suggested that the two peaks in feeder usage are primarily a response to light:dark pattern and the timing of the turning on and off of the lights.

The feeding patterns in boars, barrows, and gilts were generally similar (Figure 1). Boars consumed a

Table 4. Correlations between growth performance and feed intake traits

Trait	BW	ADG	DFI	G:F	NFV	NM	FIV	FIM	FOV	FOM	FOD	CR
Body weight (BW)	—											
Average daily gain (ADG)	.70	—										
Daily feed intake (DFI)	.58	.59	—									
Gain:Feed (G:F)	.19	.53	–.34	—								
No. of feeder visits per day (NFV)	–.02[a]	—	–.28	.14[a]	—							
No. of meals per day (NM)	.06[a]	–.08[a]	–.24	.16[a]	.92	—						
Feed intake per visit (FIV)	.29	.38	.70	–.29	–.84	–.80	—					
Feed intake per meal (FIM)	.30	.39	.73	–.28	–.73	–.79	.95	—				
Feeder occupation time per visit (FOV)	–.01[a]	.11[a]	.42	–.31	–.61	–.59	.68	.63	—			
Feeder occupation time per meal (FOM)	–.01[a]	.11[a]	.42	–.31	–.50	–.65	.62	.66	.96	—		
Feeder occupation time per day (FOD)	–.01[a]	.02[a]	.25	–.24	.17[a]	.16[a]	.01[a]	.04[a]	.64	.68	—	
Feed consumption rate (CR)	.35	.32	.31	.06[a]	–.26	–.22	.34	.32	–.43	–.46	–.79	—

[a]Not significant ($P > .05$).

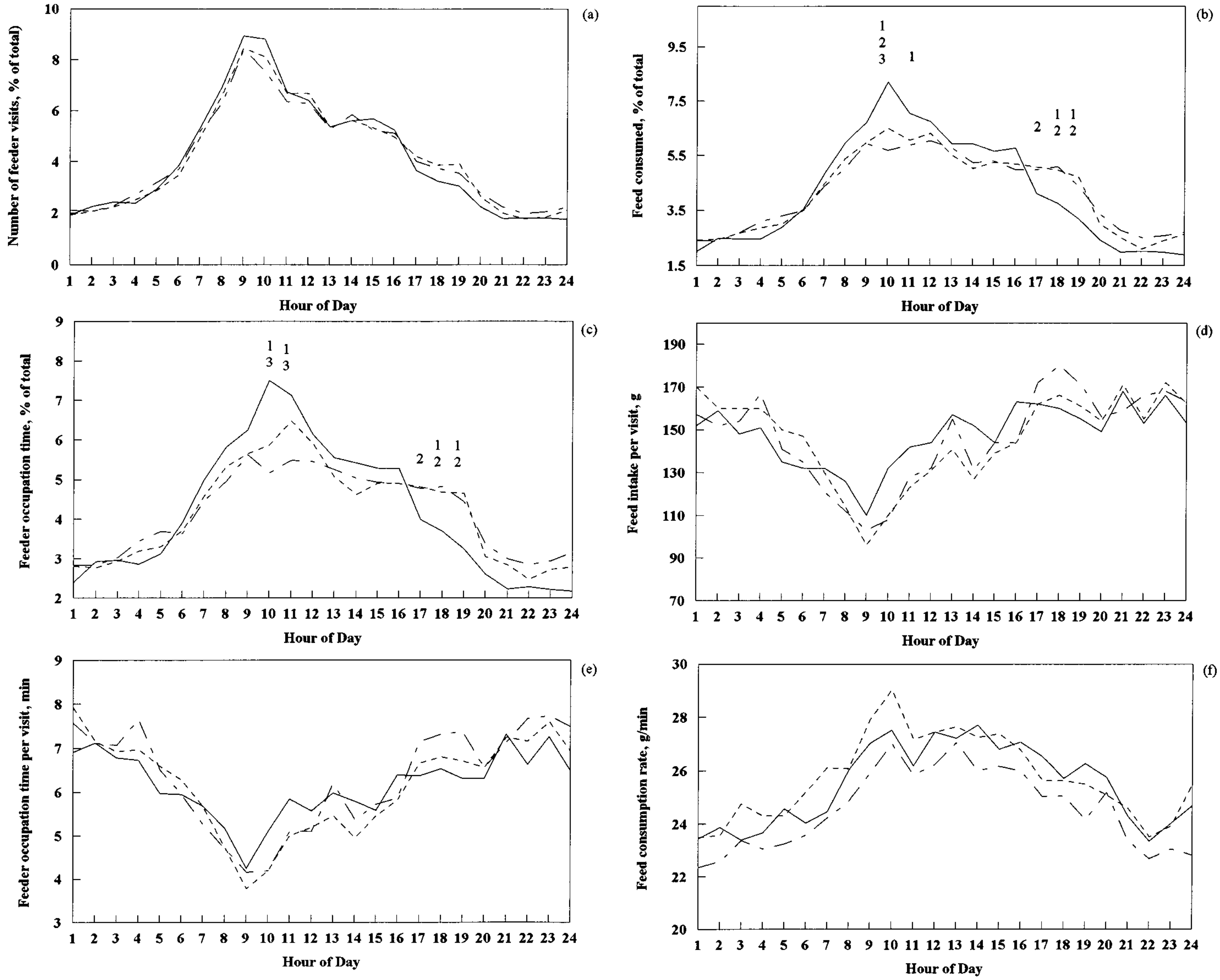

Figure 1. Diurnal distribution of feed intake traits of boars (-), barrows (· · ·), and gilts (- · -) by hour of day: (a) number of feeder visits, (b) feed consumed, (c) feeder occupation time, (d) feed intake per visit, (e) feeder occupation time per visit, (f) feed consumption rate. 1 = boars and gilts differ ($P < .05$); 2 = boars and barrows differ ($P < .05$); 3 = barrows and gilts differ ($P < .05$).

greater proportion of their total daily feed during the period of peak feeder activity (Figure 1b), and this was mainly associated with longer feeder occupation times compared with barrows and gilts (Figure 1c). These data therefore suggest that boars were more successful at achieving feeder access when competition was greatest. However, the use of single-sex groups is common practice on commercial units, and, under such conditions, the feeding pattern of the sexes may be different compared with those observed in mixed-sex groups in the present study.

Correlations Between Growth Performance and Feed Intake Traits. Correlations between growth performance and feed intake traits are summarized in Table 4. Correlations between average daily gain or gain: feed ratio with the number of feeder visits, feeder occupation time, and feed consumption rate were generally low (Table 4). Correlations of daily feed intake with number of meals per day ($r = -.24$), feeder occupation time per day ($r = .25$), and feed consumption rate ($r = .31$) were relatively low. Daily feed intake was positively correlated with feed intake per meal ($r = .73$) and feeder occupation time per meal ($r = .42$). This suggests that increases in feed intake were associated with greater meal sizes resulting from longer feeder occupation time rather than an increase in feeding frequency.

As anticipated, there were negative correlations between the number of meals and feed intake per meal ($r = -.79$) and feeder occupation time per meal

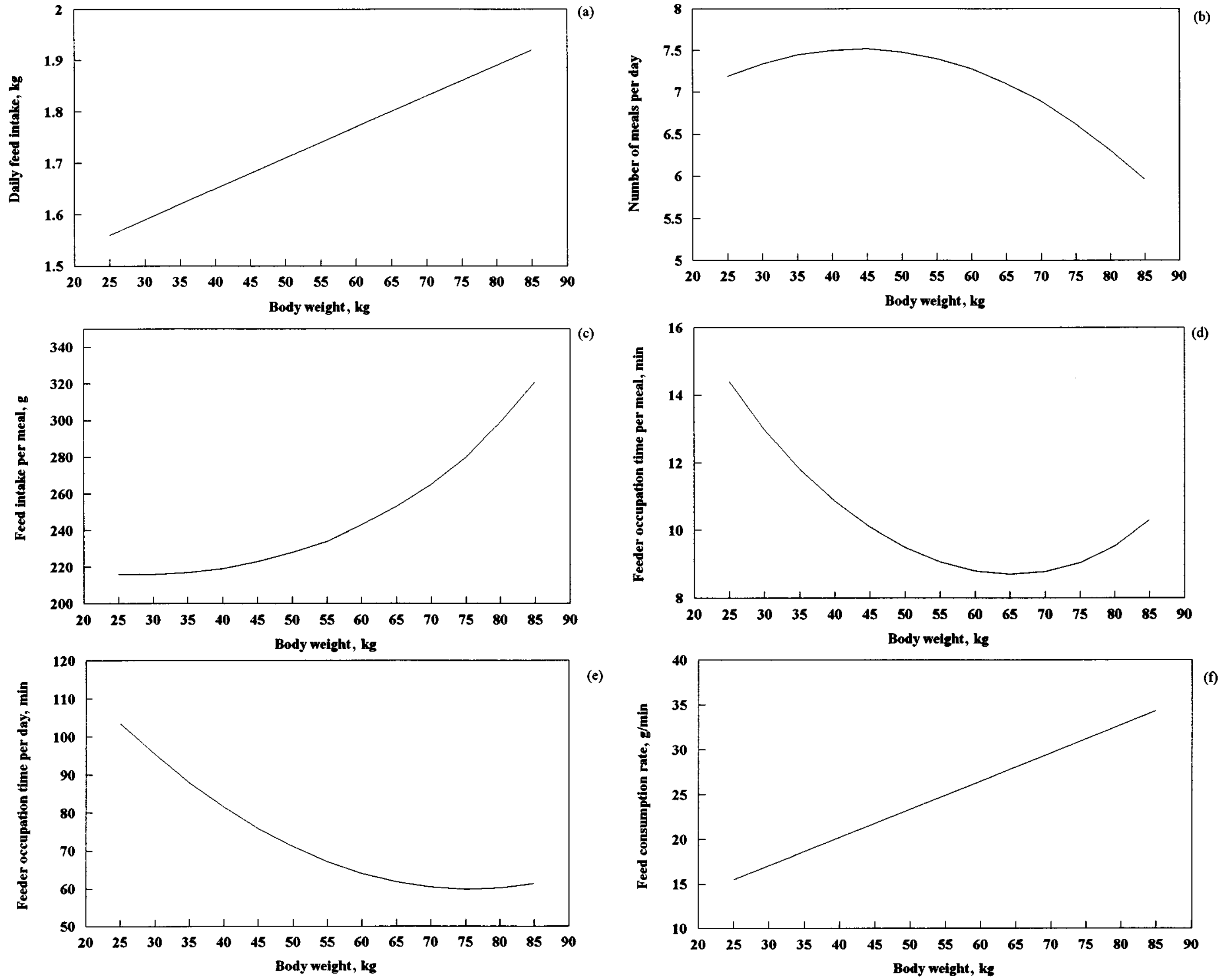

Figure 2. Regression of feed intake traits on body weight (BW); (a) daily feed intake = 1.42 (SE .34) + .006 (SE .0006)BW, R^2 = .15; (b) number of meals per day = 5.8 (SE .58) + .08 (SE .022)BW – .001 (SE .0002)BW^2, R^2 = .05; (c) feed intake per meal = 257.2 (SE 26.28) – 2.50 (SE 1.003)BW + .38 (SE .009)BW^2, R^2 = .14; (d) feeder occupation time per meal = 27.4 (SE 1.22) – .57 (SE .047)BW + .005 (SE .004)BW^2, R^2 = .17; (e) feeder occupation time per day = 136.9 (SE 6.71) – 1.66 (SE .256)BW + .009 (SE .0023)BW^2, R^2 = .24; (f) feed consumption rate = 8.32 (SE .616) + .378 (SE .011)BW, R^2 = .43.

(r = –.65) and a positive correlation between feed intake per meal and feeder occupation time per meal (r = .66). These correlations are generally in line with those found by De Haer and Merks (1992) and Young and Lawrence (1994). Correlations for feed consumption rate with average daily gain (r = .32), daily feed intake (r = .31), gain:feed ratio (r = .06, $P > .05$), and feeder occupation time per day (r = –.79) suggest that increases in consumption rates were associated with shorter feeder occupation time per day, higher feed intakes and growth rates, but little change in gain: feed. Pigs that eat faster may therefore have certain production advantages, and further study aimed at understanding the basis of variation in consumption rates would seem warranted.

Changes in Feed Intake Pattern with Body Weight. The regressions of daily feed intake and feed intake pattern on body weight are summarized in Figure 2. Daily feed intake increased linearly over the weight range studied (Figure 2a). There was a quadratic regression on body weight for number of meals (Figure 2b); however, the changes with weight were small, ranging from six to seven meals per day over the study period. As a consequence of these changes in feed intake and meal frequency, feed intake per meal (Figure 2c) changed little between 25 and 50 kg but increased thereafter. Feeder occupation time per meal

(Figure 2d) and per day (Figure 2e) declined with weight, whereas feed consumption rates (Figure 2f) increased linearly from less than 20 g/min at around 25 kg to in excess of 30 g/min at 80 kg.

Nienaber et al. (1990) and Bigelow and Houpt (1988) reported increases in meal size across a wider age and weight range than used in the present study. Meal duration changed little with age in the study of Bigelow and Houpt (1988) but generally increased in the report of Nienaber et al. (1990). The finding that feed consumption rate increases with weight is in line with the study of Bigelow and Houpt (1988) but in contrast to that of Nienaber et al. (1990), who reported no weight-dependent pattern when eating rate was expressed on a metabolic body weight basis (weight $^{.75}$). In addition, when Nienaber et al. (1990) adjusted the data of Bigelow and Houpt (1988) to a metabolic body weight basis they found that there was no weight-dependent pattern. When the data from the current study were adjusted on the same basis, consumption rates per minute ranged from 1.56 to 1.42 g/kg$^{.75}$ at weights of 30 and 80 kg, respectively, suggesting a small decline with increasing metabolic body weight.

Repeatabilities. Repeatabilities for feed intake traits are presented in Table 5. Values were estimated for the 10-wk study period and within 5-wk and 2-wk periods. The results presented for the 5-wk and 2-wk periods are the within-period values averaged across all periods. The repeatability of daily feed intake was low (.21 to .27) for all periods, and values for number of feeder visits and feed intake per visit were relatively high (.42 to .48 and .55 to .60, respectively) for all periods. Repeatabilities for feeder occupation time per visit and per day and for feed consumption rate were high for the shorter time periods but were lower when estimated across the whole study period (Table 5). De Haer and Merks (1992) also reported higher repeatabilities for feed intake traits when measured over shorter time periods, but these authors generally found substantially lower repeatabilities than in the present study. Two sires were represented in the current trial, and this may have reduced variation in the feed intake traits and may be responsible for the high repeatability estimates found. The results of the current trial suggest that measuring feeding frequency and feed intake per visit during shorter periods will give an accurate prediction of longer-term values. Repeatabilities also represent the upper limit for heritability, and these results also suggest significant additive genetic variation for a number of the feed intake traits, although further study involving a larger number of sires is required to address this issue.

Table 5. Repeatabilities of feed intake traits

Trait	10-wk period	5-wk period[a]	2-wk period[a]
Daily feed intake	.21	.27	.26
Number of feeder visits per day	.46	.48	.42
Feed intake per visit	.59	.60	.55
Feeder occupation time per visit	.23	.50	.50
Feeder occupation time per day	.24	.44	.42
Feed consumption rate	.36	.71	.61

[a]Averaged across periods.

Implications

This study indicates that with corn-soybean meal-based diets fortified with synthetic amino acids, increasing dietary lysine within the range likely to be encountered in practice resulted in a change in feeding behavior in growing-finishing pigs; meal frequency was reduced, and meal size and duration were increased. In addition, differences in feeding pattern among boars, barrows, and gilts in mixed-sex groups were relatively small. The relatively high repeatabilities for a number of the feed intake traits suggest that genetic selection for these traits may be feasible. Selection for feed consumption rate could have practical merit.

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