EFFECTS OF TIME-RESTRICTED VS AD-LIBITUM FEEDING ON PERFORMANCE, CARCASS TRAITS AND BEHAVIOR OF FINISHING PIGS

by

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INTRODUCTION

Feeding patterns i.e., the relationship of diet ingestion to time, have received attention because of their marked effects upon overall body metabolism and body composition in several species (Leveille, 1970). The frequency with which feed is supplied to individuals can be divided into two categories:

Ad-libitum or "nibbler" in which animals have twenty-four hour availability of food. With constant access, animals are likely to have frequent feeding bouts with relatively small intake per bout.

Meal or timed-fed in which feed is available only during certain periods of time. With time-restricted feeding, animals are likely to consume large amounts in relatively short periods.

The concept of meal feeding usually includes the assumption that no feed restriction is imposed; animals allowed to eat during certain periods should receive the quantity and quality of nutrients in their ration to provide a rapid and healthy growth pattern.

Metabolic effects, carcass characteristics and performance of meal fed animals.

The effects of feeding frequency on metabolism of nutrients have been evaluated in laboratory animals. These effects are manifested by increased body fat of rats consuming fully spaced meals compared to those receiving frequent small feedings (Cohn and Joseph, 1965; Tepperman and Tepperman, 1958). Rats ingesting a single daily meal, demonstrate an enhanced rate of glucose absorption and an increased lipogenic activity (Leveille and Hanson, 1966). It has been suggested that

specific rate-limiting enzymatic reactions may not be capable of handling an enormous supply of substrate, leading to alternate metabolic pathways and subsequent changes in total body composition (Cohn and Joseph, 1960 a; Cohn et al., 1963; Veum et al., 1970). The lipogenic changes induced by meal feeding rats seems to occur predominantly in the adipose tissue and to a lesser extent in the liver, suggesting that the initial hyperlipogenesis observed in the meal-fed rats are due to changes in substrate uptake by adipose tissue rather than changes in the quantity of enzyme present in the tissue (Leveille and Hanson, 1966; Chakrabarty and Leveille, 1968; Armstrong et al., 1976).

Chickens also appear to respond to meal feeding with an increased rate of lipid synthesis (Leveille and Hanson, 1965 b). In this species the liver seems to be the major organ of lipid synthesis (O'Hea and Leveille, 1968 a).

In man, the effect of feeding frequency on metabolism has been summarized by Cohn et al., (1962). They reported increased body fat, increased urinary nitrogen excretion, decreased thyroid activity secondary to decreased TSH formation or release, and an increased severety of diabetis mellitus with meal eating.

Feeding patterns have been shown to influence the growth of certain organs in rats. Meal-fed rats appear to have an intestinal hypertrophy compared with nibblers (Leveille, 1970; Veum et al., 1970). Meal feeding in the morning increased the weights of liver, small intestine and tibia when compared with [illegible] (Pond et al., 1978).

Meal feeding has resulted in [illegible] (nibblers) fed rats. Attempts have been made to determine if that difference was due to decreased energy expenditure of the meal fed

animals. The effect of activity on energy utilization in meal and nibbler-fed rats has been examined by different researchers with inconsistent results (Leveille and O'Hea, 1967; Romsos and Leveille, 1977). Spangler and Johnson (1981) reported that ad-libitum nibblers were about 23 % more active during the average twenty-four hour period than meal eaters although this difference was not statiscally significant. When they expressed the energy used for activity as a fraction of maintenance requirements, the values were 48 % for meal eaters and 59 % for nibblers.

Swine seem to differ in their response to feeding frequency in comparison with other species. Pigs allowed to eat the same amount of diet once or five times daily did not show any significant changes in performance or metabolism patterns (Braude et al., 1963; Friend and Cunningham, 1964, 1967). Comparing pigs fed ad-libitum (nibblers) with pigs allowed to eat during a period of two hours daily (meal eaters) O'Hea and Leveille (1969 b), reported that meal-fed pigs consumed less feed and had a superior feed efficiency. The nibbler pigs had significantly more kidney fat and tended to be fatter than their meal-fed littermates. However, Sharma et al (1973), working with young weanling pigs being fed twice or five times daily under a positive energy balance, found no differences in the percent of fat, water, protein and gross energy of the empty body weight nor in body composition.

When adipose tissue metabolism was studied in relation to periodicity of feeding , no adaptive changes in the lipogenic mechanism were found (O'Hea and Leveille, 1969 b). It was postulated that the slow rate of food passage through the digestive tract of the pig (Castle and Castle, 1956, 1957) did not allow the animal's body to reach a post-absorptive state and consequently no hyperlipogenic activity was produced. Allee et al (1972), working with pigs being fed two hours during each forty-eight-hour period, observed hyperlipogenic activity in the adipose tissue, consequently changes in the lipogenic mechanism had to have occurred.

Adipose tissue plays a major role in overall lipogenesis in pigs presumably because of its high synthetic capacity in vitro and its much greater overall mass relative to the liver (O'Hea and Leveille, 1968 a).

In swine, meal frequency appears to have influenced growth of the digestive tract. Meal eating pigs had significantly heavier empty stomachs than nibblers. The empty weight of the small intestine followed a similar nonsignificant trend (O'Hea and Leveille, 1969 b; Veum et al., 1970; Allee et al., 1972).

Effect of time-restricted feeding on feeding and social behavior of finishing pigs

Since the behavioral capabilities of pigs have been recognized, it is possible to incorporate features into the system that will take advantage of these capabilities (Hartsock, 1982). A practical and convenient method of feeding pigs that is used for almost all commercial animals is ad-libitum feeding. Programmed timed feed systems are now available and offer an alternative to the traditional method. Whenever new alternatives are considered it is important to establish the significance of new rearing conditions on the biology of the animals, to identify factors that could affect their behavioral patterns, to integrate the physical and biological principles, and to construct a program of economic advantages (Jensen, 1971).

When meal-time feeding is used, changes in the way that individuals satisfy their appetite and changes in the expression of social interactions are expected to occur. Changes have been reported for pigs and several other species when different environmental conditions were related to feeding and social patterns. Research with chickens has shown that when feed was readily available, birds ate

small, frequent meals, but they shifted to a pattern of infrequent, large meals as a result of an increasing energy expenditure in procuring their food, when restricted time to feeding was imposed (Kaufman and Collier, 1983). It has been suggested that both meal size and meal frequency would be expected to vary with different feeding stimuli (Barbato et al., 1980).

Several factors have been shown to influence feeding patterns in the pig: nutrition, genetics and managment. A tryptophan deficient diet reduced the rate of eating in growing pigs (Montgomery et al., 1978). Strains of pigs differ in their feeding patterns. Obese pigs spend more time at the feeder and have slower rate of eating compared to lean pigs (Wangsness et al., 1980). Pigs kept at a high stocking rate spent more time eating and less time drinking than pigs kept at low or medium stocking rates (Bryant and Ewbank, 1972). Nevertheless, few observations have been made regarding the relationship between feeding behavior and timed feeding methods.

McBride (1969) stressed the importance of social behavior on productivity and its repercussions on experimental designs. Later, he concluded that social position has an important effect on growth of pigs (McBride et al., 1964). He found that 13 % of the variance in growth rate was due to social order. Dominance hierarchies in pigs fed ad-libitum from one or several self-feeders were described by Hansen et al (1982), who also discussed possible relationship between sex, rank, level of aggression, and performance of growing pigs. Meese and Ewbank (1972), found no correlation between social rank and sex or weight, and suggested that rank is a result of the interaction of a number of factors. Beilharz and Cox (1967) reported on social dominance hierarchies in pigs raised together as complete litters from birth. They found that males were usually dominant to females. Bryant and Ewbank (1974) suggested that measurements of agonistic interactions may provide some

indications of "social stress" within the group. These findings suggest that social patterns, frequency of social interaction and social rank can be related with important productive parameters in a complex way.

One significant step in behavioral analysis is the characterization of individual responses to any particular environment. Feeding patterns need to be interpreted in terms of responses of individuals mainly in satisfying their physiological needs and in adjusting to the environmental conditions. Social interactions and relations between individuals are usually interpreted as responses associated with psychological and environmental status. If behavioral parameters are measured for any particular feeding system and are related to productivity, a wider perspective of their impact upon the biology of the individual and better understanding of the entire system can be achieved.

This study was designed (1) to evaluate the expression of feeding activities and quality and quantity of agonistic interactions, (2) to establish the social order and (3) to investigate the relationship between these behavioral parameters and productivity. Insight into the implications of using time-restricted systems of feeding were also sought.

EXPERIMENTAL PROCEDURE

Three experiments were conducted to evaluate the performance and carcass characteristics of time-restricted and ad-libitum fed pigs. In addition, two types of feeders were compared for the ad-libitum fed pigs.

Finishing pigs from the KSU Swine Herd were alloted by sex, weight, and litter to the treatments. The treatments, number of replicates per treatment and type of diet were the same for the three trials. The ration consisted of a milo-soybean meal fortified diet that had a calculated analysis of 15.5 % crude protein, 0.80 % calcium and 0.70 % phosphorous (table 1). Treatments were as follows:

Treatment 1. Time-restricted fed pigs: Pigs were fed to appetite during two three-hour periods daily from 0800 to 1100 h and from 1700 to 2000 h. Water was available during the feeding periods and also during two extra periods of three hours each from 0400 to 0600 h and from 1400 to 1600 h.

A programmed, timed-feeding system (Chore Time Equipment Inc.) was used. Details of the feeder can be seen in figure 1.

Four pens containing twenty pigs were used.

Treatment 2. Pigs fed ad-libitum feed and water.

Two rectangular self feeders (Pride of the Farm Co.) with two holes each were used in each pen. Details of the feeder can be seen in figure 3.

Two pens containing twenty pigs were used.

Treatment 3. Pigs fed ad-libitum feed and water.

One round feeder per pen (Osborne Co.) was used in this treatment.

Details of the feeder can be seen in figure 2.

Two pens containing twenty pigs were used.

Experiment 1

A total of 160 crossbred pigs from the KSU Swine Herd were used. The mean initial weight of pigs was 53±2 kg. They were reared in pens (3 x 4m) with 100 % concrete slatted floors and two nipple waterers for ad-libitum pigs. Trial 1 was terminated at an average final weight of 106 ±3 kg.

Pigs were weighed every fourteen days and at the end of the experimental period. Performance was evaluated by average daily gain, average daily feed intake and feed to gain ratio. Water consumption was recorded in each pen of the timed-fed pigs. Special care was taken in the adjustment of the ad-libitum feeders to minimize feed wastage.

The 52-day trial was conducted during the spring months of April, May and June.

Experiment 2

One hundred and sixty crossbred pigs were assigned to the different treatments in groups of twenty pigs per pen. The trial began when pigs were at an initial weight of 52±2 kg and terminated at a final weight of 99±2 kg. Each pen had the same dimensions and characteristics as in trial 1.

Performance was evaluated by average daily gain, daily feed intake and feed to gain ratio. Water consumption was recorded in one pen of the timed-fed pigs and in one pen of the ad-libitum fed pigs.

To compare carcass characteristics of pigs eighteen barrows were randomly selected from groups of ad-libitum and time-restricted fed pigs. Pigs were slaughtered at the slaughtering facilities in the Department of Animal Sciences and Industry, KSU.

Backfat thickness was determined from the average of three

meassurements at the first rib, last rib and last lumbar vertebra. The area of the longissimus dorsi muscle was traced after it was exposed by cutting between the tenth and eleventh ribs. Area was then determined with a compensating polar planimeter. Hot carcass weight was recorded for each pig. After chilling for 24 h at 1 °C the lean cuts ie., trimmed ham, loin, boston butt and picnic shoulder were weighed and their combined weight was expressed as percentage of chilled carcass weight using the equation:

Weight of lean cuts = weight of ham + weight of loin + weight of shoulder (boston butt + picnic shoulder).

Percentage of lean cuts = weight of lean cuts : cold carcass weight.

The percentage of muscle was calculated following the method described in the USDA Program Aid 1157 (1981). The equation is as follows:

Weight of muscle = 2.1 + 0.45 x hot carcass weight (lb) + 5.0 x loin eye area (in^2) - 11.0 x fat depth over loin eye (in.).

Percentage of muscle = weight of muscle : hot carcass weight.

The 62-day trial was conducted during the summer months of June, July and August.

Experiment 3.

One hundred and sixty crossbred pigs were assigned to this trial following the same criteria as in earlier trials. Pigs had an initial weight of 52 $\pm$2 kg and reached an average final weight of 92 $\pm$2 kg. In this trial pens had been remodeled so that the floor was 50 % concrete slats and 50 % solid concrete.

Performance was evaluated by the same criteria as in the earlier two trials. The feeders in the pens with timed-feeding pigs were programmed to release feed and water from 1100 to 1400 h and from 2300 to 0200 h. Water was available at the same time as feed and also during two other three-hour periods from 0500 to

0800 h and from 1700 to 2000 h.

This 58-day trial was conducted during the spring month of April, May and June.

Experiment 4.

The objectives of this experiment were to evaluate the growth and carcass characteristics of pigs fed with varying time lengths of feed availability.

Pigs were alloted to the following treatments:

1.- Feed available during one period of two hours daily (time-restricted fed, 2h/24h).

2.- Feed available during one period of four hours daily (time-restricted fed, 4h/24h).

3.- Feed available during one period of six hours daily (time-restricted fed, 6h/24h).

4.- Feed available ad-libitum, 24 hours daily ("nibblers").

Each treatment had three replicates with two pigs per pen.

Twenty-four crossbred barrows weighing 41.9 $\pm$2.8 kg were housed in open front pens at the KSU Swine Test Station. Each 4.75 x 1.25 m pen contained one automatic waterer, a two hole self feeder and had a 100 % solid concrete floor. Pigs were slaughtered at the slaughtering facilities in the Department of Animal Sciences as they reached an average weight of 104 $\pm$2.8 kg.

Pigs were weighed every fourteen days and feed consumption determined. Performance was evaluated as average daily gain, average feed intake, feed to gain ratio, and experimental days to reach market weight. Carcass characteristics were evaluated using the same criteria and parameters as in previous trials. Weight of empty and full stomachs were determined for each group of pigs.

This 84-day experiment was conducted during the fall months of August,

September and October.

Experiment 5.

This experiment was designed to study the behavioral response of finishing pigs during restricted-time feeding in terms of their feeding patterns and agonistic interactions. Secondly, a methodology for such studies was investigated and correlations between behavioral responses and performance were calculated.

One pen containing ten crossbred barrows and ten crossbred gilts was assigned to this experiment. The 3 x 4 m pen had 50 % slatted floor and 50 % solid concrete floor. A programmed, restricted-feeding system (Chore Time Equipment Inc.), was used to realese feed and water from 1100 to 1400 h and from 2300 to 0200 h and there were two extra watering periods from 0500 to 0800 h and from 1700 to 2000 h. Artificial lights were on 24 h.

All pigs were identified with a number painted on their rump and shoulder. The paint was a combination of Japanese paint dryer and oil paint in a proportion of 1:8, respectively.

In order to record the behavior of pigs from a convenient point, a step ladder was set outside the pen in the feeding alley, four meters from the feeder. To have a better view of the activities in the pen, the observational point was about three meters above the floor .

Observations were carried out during both feeding periods and each lasted three and a half hours. Observations started as feed and water were released from the feeder and ended half an hour after the system shut off.

One observer was responsible for recording all observations in order to maintain consistent criteria to characterize the behavioral activities. The observer was equipped with a timer and an appropriate record sheet. Several minutes before the observational period began, the observer noted the general activities and

environment in the pen i.e., presence of other people, noises, activity of pigs, etc.

A scanning technique was used to record feeding activities in the pen. This technique was performed after each elapsed time of three minutes during the entire observational period. The three-minute time period was established after a preliminary test. Bryant and Ewbank (1972) indicated that no statistical differences were established when observations at six minute intervals were compared with those taken at 0.25 minute intervals, in pens containing eight pigs.

The scanning technique started when the feeding period began. The observer would then turn on a digital timer and record which individuals were displaying feeding activities. After recording those pigs feeding and waiting to feed, which typically required 20 to 30 seconds, the observer attemped to record all agonistic activities during the rest of the three-minute period. When three minutes had elapsed both light and sound were emitted from the timer. At that moment, the observer would reset the automatic timer and begin to record the activities of the next period. The experiment had a total of 18 observational periods: 13 during the daytime and five during the night.

Feeding activities were characterized as:

At the feeder. Actual presence of pig's head in the bowl of the feeder.

Waiting. Pigs trying to reach the bowl of the feeder, with their heads directed to the feeder but obstructed by other pigs.

Characterization of feeding activities can be seen in drawing 1.

Agonistic activities were characterized as follows:

Bite. Pigs throwing the head with bites directed toward the head, ears or flank of the others. Performer's mouth is open.

Head Thrust. A rapid thrust upwards or sideways with the head or snout against neck, head or ears of the others. The performer's mouth is shut.

Threat. Aggressive movement, but not involving physical contact.

Fights. Two pigs biting, pushing, head thrusting, one to the other. Several of these agonistic activities may be performed at the same time, during the same bout of activity.

Displacement. The physical replacement of one pig by another.

Characterization of agonistic activities can be seen in drawing 2. Agonistic activities as described were modified from Meese and Ewbank (1972), and Jensen (1980).

Each identified pig was weighed at the beginning and the end of the experimental period. Performance was evaluated as the average daily gain of each individual.

For each three-minute observational period the number of pigs at the feeder, number of pigs waiting and types and frequencies of aggressive acts were determined.

A feeding bout for an individual pig was defined as a period of feeding uninterrupted by any other behavior (Meunier-Salaun and Faure, 1983). Another variable was defined as "at the feeder bout" which includes waiting activities and a feeding bout. This kind of bout consisted of the period of time during which the pig was feeding and waiting continously. In this way, every time a pig was feeding or feeding and waiting was considered as an "at the feeder" bout. A waiting activity by itself was not considered as a bout.

In order to express the social status of each pig in relation to its penmates a social rank index was used (Lee et al 1982). The social rank index $X = 1/2 (D - S + N + 1)$, where D = number dominated, S = number dominating, and N = group size.

Average length of time prior to first feeding was recorded for each pig

for each three and a half hour period.

Observations were performed any day from May 12 to June 7, 1983. Pigs were assigned to this experiment 30 days before observations began in order to allow them to become accustomed to the experimental conditions and establish their dominance hierarchy before feeding activities and social interactions were recorded.

ANALYSIS OF DATA

Analysis of variance was utilized to compare the effects of ad-libitum vs time-restricted feeding on performance and carcass measurements of finishing pigs in experiments one, two, three and four, according to the G-L-M procedure (General Linear Models) in the Statistical Analysis System (1979).

In experiment five, the analysis of variance was used to compare the effects of sex and time of feeding (daytime or nighttime) on the following variables:

Frequency of feeding.

Frequency of waiting.

Time to first feeding. Mean time in minutes required for pigs to go to the feeder for the first time during the observational periods.

Aggressive acts.

Average daily gain over the 84-day test.

Social rank index.

Frequency of "at the feeder bouts".

Length of "at the feeder bouts".

Correlation coefficients were calculated for all pairs of variables in experiment five.

RESULTS

Experiments 1, 2 and 3.

When finishing pigs were allowed to eat for six hours daily during two, three-hour periods, their average daily gain, daily feed consumption and feed to gain ratio did not differ from pigs fed ad-libitum, when data were pooled over the three trials (table 2). However, in experiment 1, restricted-time fed pigs ate slightly more feed per day than did ad-libitum fed pigs, resulting in 4 % less efficient gain (P=.02). Pigs using round or rectangular feeders did not differ in performance.

When carcass measurements were analyzed, restricted-time fed pigs yielded carcasses similar to ad-libitum fed pigs (table 3). The only significant difference was that meal-fed pigs had less backfat thickness than ad-libitum fed pigs.

Table 4 presents the water consumption data of timed-fed pigs. Table 5 compares the water consumption of timed-fed and ad-libitum fed pigs. Those pigs having access to water ad-libitum used 7.60 liters of water per day or a water to feed ratio of 3.11 kg of water per kg of feed. Timed-fed pigs consumed only 4.23 liters of water daily and had a water to feed ratio of 1.76. This difference in water consumption did not affect growth rate or feed efficiency.

Experiment 4.

Performance was calculated until day 75 of this experiment when the first pigs reached 105 kg. Pig performance was similar for all the treatments (table

6), except that pigs fed ad-libitum consumed nonsignificantly more total feed than pigs fed for restricted feeding periods.

Pigs fed only two hour per day required an average of six more experimental days to reach market weight than pigs fed ad-libitum ($P<.09$).

Table 7 presents the effect of feeding duration on carcass measurements. Timed-fed pigs had a slight tendency to be leaner than ad-libitum fed pigs. However, no significant differences were noted among carcass meassurements due to treatments.

The empty weight of stomachs was significantly heavier in pigs fed two and six hours daily compared with pigs fed ad-libitum, when expressed as percentage of total body weight (table 8). There was a tendency for the empty weight of stomachs from pigs fed two hours daily to be heavier than ad-libitum fed pigs.

Experiment 5.

Tables 9 and 10 show total and mean frequencies of three-minute scanning observations during which each pig was seen feeding and waiting during daytime and nighttime observational periods, respectively.

During the day, pigs were seen at the feeder or waiting more frequently and remained longer ($P<.05$) than during the night (table 11). Pigs spent 51 minutes feeding during the daytime as compared with 23 minutes during the night, assuming that each animal was performing such activity during the entire three minutes intervening between each scanning period.

About 72 % of all feeding bouts lasted nine minutes or less, whether occurring during the day or the night (table 12 and graph 1).

In using "at the feeder bouts" (table 13 and table 14), it shows that

individual pigs had more uniform frequencies as contrasted with feeding bouts only, as shown in table 12. When sex was considered, barrows tended to have more frequent bouts at night than did gilts (2.80 vs 1.80, respectively; $P<.05$).

Table 15 presents total and mean frequencies of aggressive acts recorded for each pig during the daytime and nighttime observation periods. On the average each pig performed 6.5 aggressive acts against other pigs during the daytime feeding period and only 2.3 during the nighttime period.

Table 16 shows the total frequencies and percentages of the different types of aggressive acitivity performed during all 18 observational periods. Displacements (39 %), head thrusts (32 %) and bites (27 %) were the most frequent aggressive acts observed.

Aggression was more frequent during the daytime than during the nighttime feeding period as shown in table 17. When sexes were compared in terms of their aggressiveness, gilts were more aggressive than barrows and had higher social rank indexes (table 18).

Each pig's average daily gain, social rank index, time to first feeding, initial weight and sex is summarized in table 19.

Table 20 summarizes the correlation coefficients between agonistic, feeding and performance parameters. Frequency of aggressive acts had significant correlation coefficients with average daily gain, time to first feeding and frequency of feeding activities. Frequency of aggression was highly correlated with social rank index. Social rank index had nonsignificant correlation coefficients of the same sign but of less magnitude with the same variables. Average daily gain was positively associated with frequency of "at the feeder" bouts. Time to first feeding was negatively correlated with frequency of aggression, frequency of waiting, and frequency of "at the feeder" bouts.

DISCUSSION

Performance and carcass measurements

Performance of timed-fed and ad-libitum fed pigs were not significantly different. Rate of gain, feed intake and feed efficiency were similar in both groups, indicating that frequency and availability of feed as imposed by these treatments had neither benefical nor detrimental effects on productivity. The pigs received a daily allowance of nutrients adequate to meet their requirements. However, in experiment 4, pigs with only two hours of daily food availability, required six more experimental days to reach market weight than their counterparts (P=.09). This result suggests that further restriction in feed availability could lead to an inadequate level of nutrient intake. In this experiment, open-fronted pens were used and only two pigs were reared in each pen. It was observed that even though the feeder had two holes, several times one of the pigs did not allow his penmate to reach the feeder until he had finished eating.

Frequency of feeding did have an effect on carcass backfat in that timed-fed pigs were leaner than ad-libitum fed pigs. However, carcass length, loin eye area, percentage of lean cuts, and percentage of muscle were not different. Relative weights of stomachs differed significantly between timed-fed and ad-libitum fed animals, indicating that this portion of the digestive tract had a differential pattern of growth, perhaps in response to greater feed intake per unit of time in meal-time fed pigs.

Water consumption

In experiment 1, timed-fed pigs had a water to feed ratio of 1.61 : 1. In experiment 2, the ratios were 1.76 : 1 for timed-fed pigs and 3.11 : 1 for ad-libitum fed pigs. In both experiments the performance of the pigs was similar, suggesting that pigs under the schedule of daily water intake imposed for the time-restricted feeding treatments consumed enough water to meet their requirements. This result is in agreement with the findings of Castle and Castle (1957) which concluded that variation in water to feed ratio from 1.5 : 1 to 3.75 : 1 had little effect on overall performance of pigs.

Higher water to feed ratios obtained in timed-fed pigs in experiment 2 can be attributable to the higher environmental temperatures of summer when experiment 2 was conducted, in constrast with the milder temperatures during the fall in experiment 1. In this regard, Yang et al (1981) pointed out that for growing pigs to compensate for their daily loss of water, al least 50 ml/kg/24 h of water was required when the environmental temperature was 22 °C and more water would be needed if the environmental temperature was higher.

In measuring the water utilization of timed and ad-libitum fed pigs, the amount of water released in the waterer was considered as being ingested, which might not be the case. This might be especially important when temperatures were above normal.

Feeding patterns of timed-fed pigs

Ten minutes before feed became available in the time-programmed feeding system, pigs were lying down in 70 % of the observational periods. The

general activity of the pen was calm with few animals around the feeder. When the system began to operate, those pigs at the bowl of the feeder or at the waterer would start feeding or drinking. This activity effectively stimulated the other penmates to rapidly congregate around the feeder. Around 55 % of the pigs came together around the feeder during the first fifteen minutes and few required as long as sixty minutes to get to the feeder for first time (graph 2).

In those pigs fed three hours during the day and three hours at night, relatively few animals displayed feeding activities during the nighttime, although there was a strong tendency to be active and display feeding activity during the daytime. This pattern of diurnal activity has been reported by several workers (Ingram et al., 1980; Dantzer, 1973; Dantzer and Mailhe, 1972; Wangsness et al., 1980). They found that domesticated pigs display greater feeding and general activity predominantly during the day in comparison with the night. Auffray and Marcilloux (1980, 1983) characterized the feeding behaviour of ad-libitum fed pigs as involving uninterrupted meals and a circadian distribution of food intake. They pointed that whatever the breed, animals prefer to eat during the daytime. Wild pigs, in contrast, are reported to be most active nocturnally (Conley et al., 1972). However, when feral pigs were captured and kept in a zoo, their behavior was predominantly diurnal (Briedermann, 1971). Graves (1984) has postulated that weather is the most important factor in determining the diurnal activities in wild swine. He observed that during cloudy and temperate days pigs displayed during the daytime more frequent feeding and general activity.

Earlier reports indicated that patterns of feeding could be altered by changes in the environmental temperatures; e.g., when temperatures where increased to 35 °C during 12 hours of light and decreased to 25 °C during 12 hours of darkness, grouped pigs were most active at night (Ingram et al., 1980). In addition,

diurnal patterns of feeding are influenced by the age of pigs, being more pronounced in older pigs (Auffray and Marcilloux, 1983; Montgomery et al., 1978; Hsia and Wood-Gush, 1983). In experiment 5, pigs consistently displayed reduced feeding activities during the nighttime despite the fact that they were deprived of food for almost nine hours since their last meal.

Social interactions

As soon as feed became available with time-restricted feeding, pigs congregated around the feeder. Presumably about 90 % of the total number of daily aggressive acts were observed when pigs were feeding in ad-libitum feeding system (Meese and Ewbank, 1972). From the recorded total number of aggressive acts, 97 % were displacements, bites and head thrusts. Displacements were most frequent (38 %), pigs were frequently changing their position at the feeder. Consequently, continuous feeding for long periods was uncommon.

The act of displacement was typically accompanied or preceded by other aggressive acts either from or towards the pig which successfully displaced another. It was observed that displacements were usually associated with an offensive action i.e., pigs attempting to reach the feeder forcefully displaced those eating. On the other hand, thrusts (32 %) and bites (27 %) were often displayed as defensive actions, i.e., by pigs mantaining a position at the feeder.

Social dominance in swine has been evaluated primarily by two methods. One uses ordinal ranks obtained on the basis of aggressive acts delivered and received between animals (Meese and Ewbank, 1972; McBride et al., 1964). The second determines dominance value either using a quantitative score or looking at a least square solution for paired values (Beilharz and Cox, 1967). The latter method

was developed to determine a pig's dominance status relative to its littermates. A social rank index was used in this experiment. This index takes into account the dominance-submissiveness relationships of each pig with its penmates and the size of the group in which the animal is evaluated. The social rank index has been used with chickens to associate social status with productivity traits. The social rank index tends to be normally distributed (Lee et al., 1982).

McBride et al (1964) have suggested a sex difference between ranked pigs. Beilharz and Cox (1967) found that on the average males were dominant to females. However, Meese and Ewbank (1972) found a slight excess of females ranking on the top of the social order. In the present work when social rank indexes were compared between sexes, gilts ranked higher ($P<.07$) and also were more aggressive ($P<.05$) than castrated males (table 18).

Associations between parameters

Frequency of aggresion was shown to be significantly correlated with average daily gain ($r=.56$; $P<.05$), table 20; to have a negative correlation with time to first feeding ($r=-.50$; $P<.02$); and positive correlations with daily frequency of feeding and "at the feeder" bouts ($r=.48$ and $.69$, respectively; $P<.05$). More aggressive pigs went first to the feeder, spent more time in the area surrounding the feeder and gained faster.

Social rank index was significantly correlated with frequency of aggression ($r=.77$; $P<.01$), table 20. Although none of the correlation coefficients obtained between social rank index and other traits were significant, there was a tendency to obtain similar but smaller correlation coefficients as compared to those involving frequency of aggression.

It appears that the dominance hierarchy of finishing pigs is not absolutely stable, i.e. subordinate animals may retaliate (Meese and Ewbank, 1972; Beilharz and Cox, 1967). In experiment 5, competition for food appears to be the major cause of agonistic behavior. Competition would be related to the number of spaces available at the bowl of the feeder and to the level of hunger. Dominance orders become less stable and dominance order violations more frequent under conditions of competition as demostrated by King (1965) in chickens and by Hansen et al (1982) in growing pigs. Under these circumstances, aggression becomes the relevant interaction a means of succeeding in competition.

Some of the factors that influence social rank are known, e.g. size in cattle. McBride (1964) found a high correlation between initial weight and subsequent social rank in pigs raised together from birth to market. Beilharz and Cox (1967), working with complete litters, found a good rank-weight correlation after weaning. On the other hand, Rasmussen et al (1962) and Meese and Ewbank (1972) working with groups of pigs randomly selected, did not find such a correlation. In the present work initial weight of pigs was not significantly correlated with any of the other parameters considered. It its possible that the relatively uniform weight with which pigs were grouped served to dilute the influence of initial body weight.

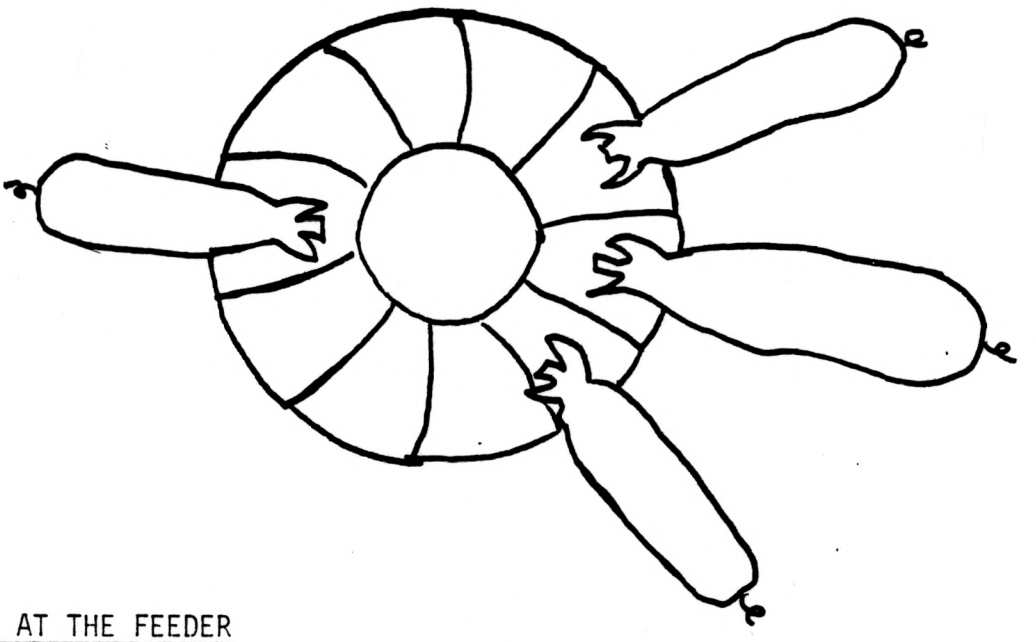
Time to first feeding is considered to be an expression of both level of hunger drive and relative dominance or aggresiveness. This parameter was negatively correlated with frequency of feeding ($r=-.56$; $P<.01$), frequency of waiting ($r=-.43$; $P<.06$); frequency of "at the feeder" bouts ($r=-.62$; $P<.04$) and with correlated with social rank index or with average daily gain. Pigs wich took less time to get the feeder were more aggressive and were more frequent to the feeder.

The frequency of "at the feeder" bouts was positively correlated with

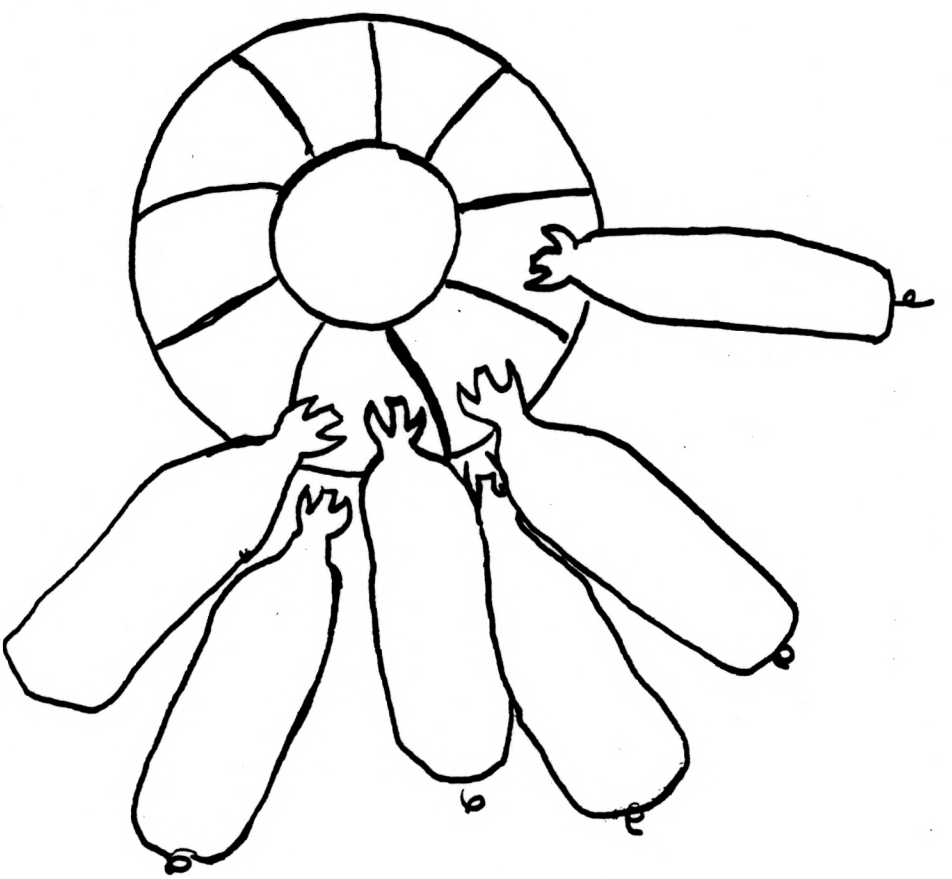
frequency of aggression (r=.69; P<.05), average daily gain (r=.60; P<.05), frequency of feeding (r=.57; P<.10) and negatively correlated with time to first feeding (r=-.62; P<.05) and length of feeding (r=-.45; P<.10). These correlations suggest that pigs which changed their position at the feeder freequently were more aggressive animals. They tended to be the first to go to the feeder, fed more often, but with shorter duration and gained more.

The findings of this study suggest that time-restricted fed pigs were competing for food and for available space at the begining of the feeding period. Hungrier pigs were aggressively trying to reach a position or to mantain a position at the feeder. At that time dominance order played the important role in the social relationships within the group. Athough social status had the same tendency, it was less sensitive to behavioral patterns, perhaps because of the rank violations postulated in a competitive situation. Feeding activities were very dynamic in that pigs spent only a few minutes eating on a great number of occasions. Nevertheless, the fact that time-restricted fed pigs performed similar to ad-libitum fed pigs suggests that no feed restriction was imposed on the pigs.

Drawing 1. Characterization of Feeding Activities.

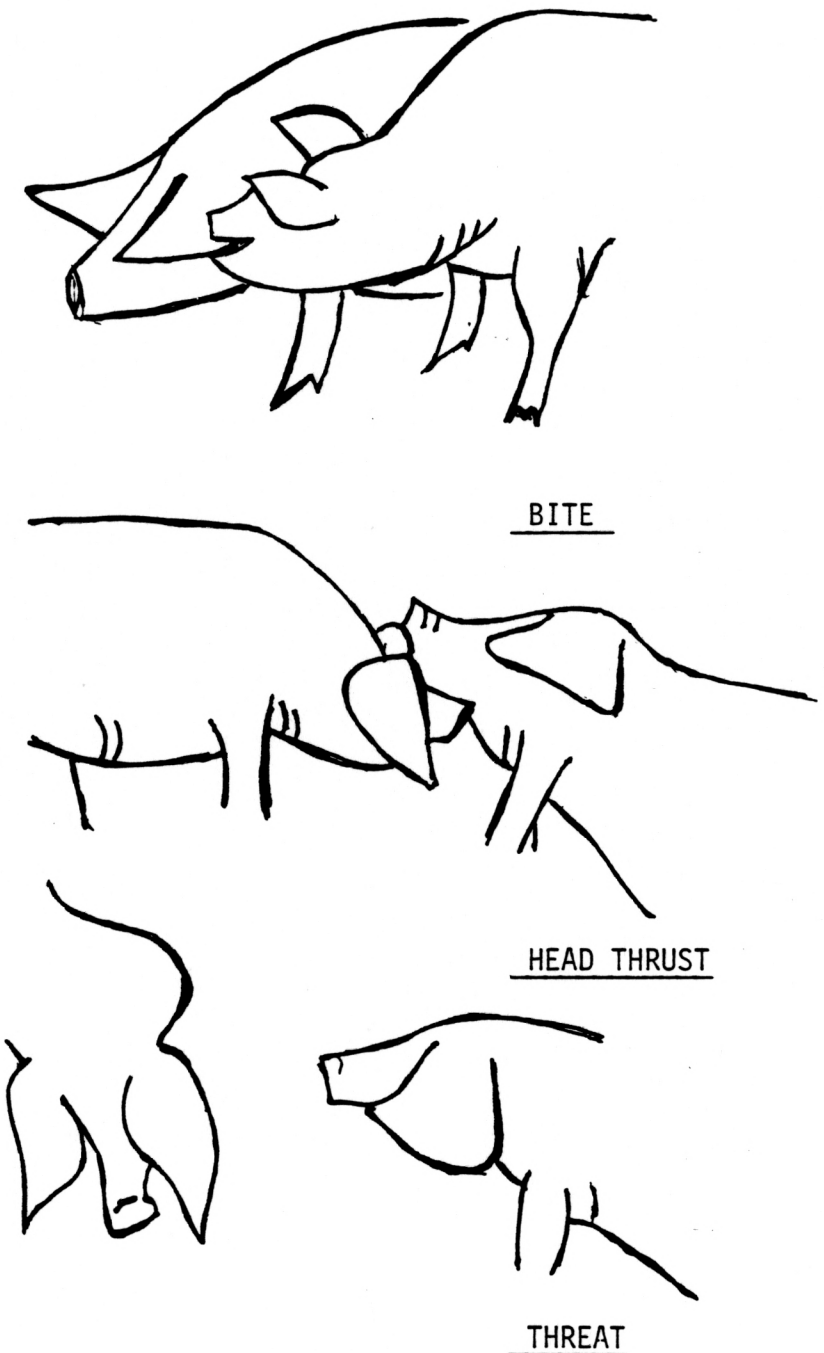


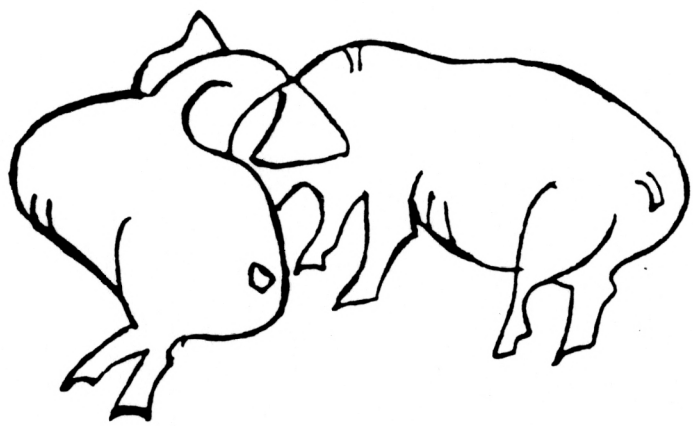
AT THE FEEDER



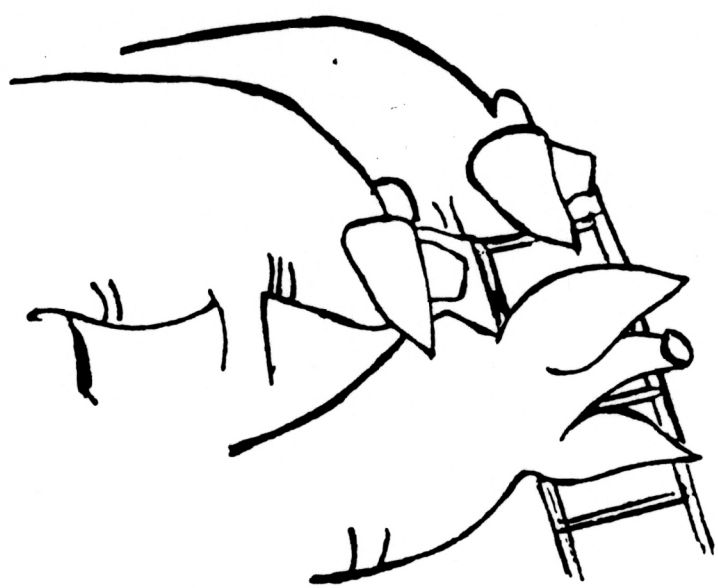
WAITING

Drawing 2.- Characterization of Agonistic Activities.





FIGHT



DISPLACEMENT

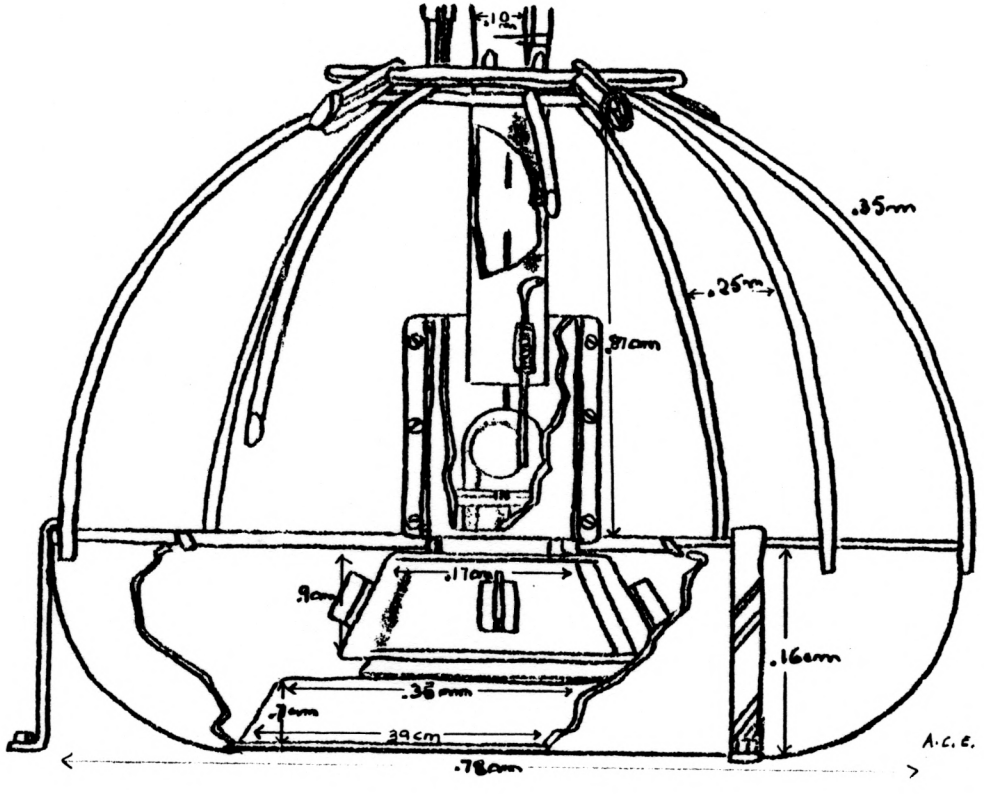


Figure 1. Diagram of Feeder Used to Feed Time-restricted Fed Pigs

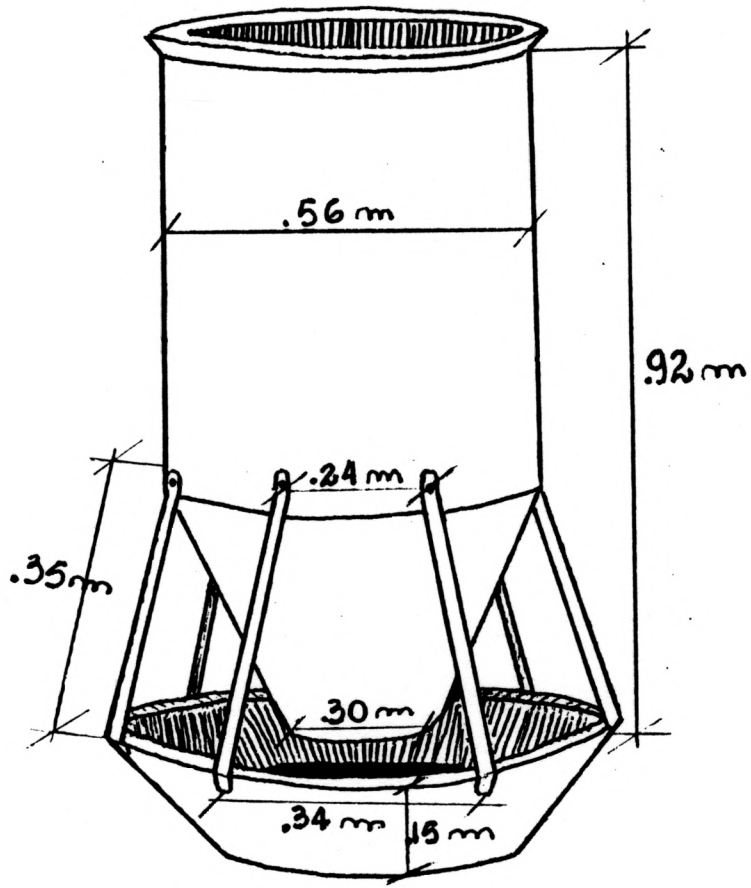


Figure 2. Diagram of round feeder

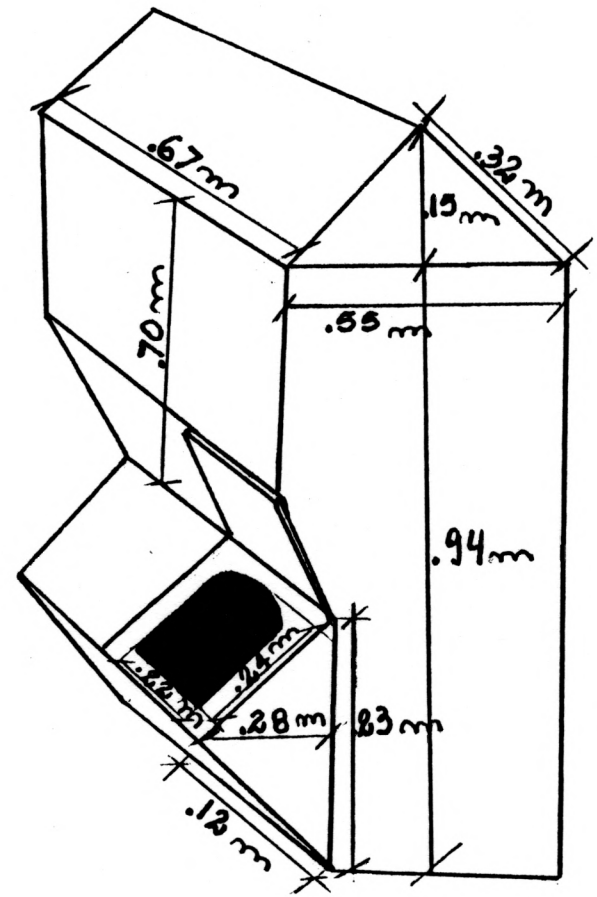
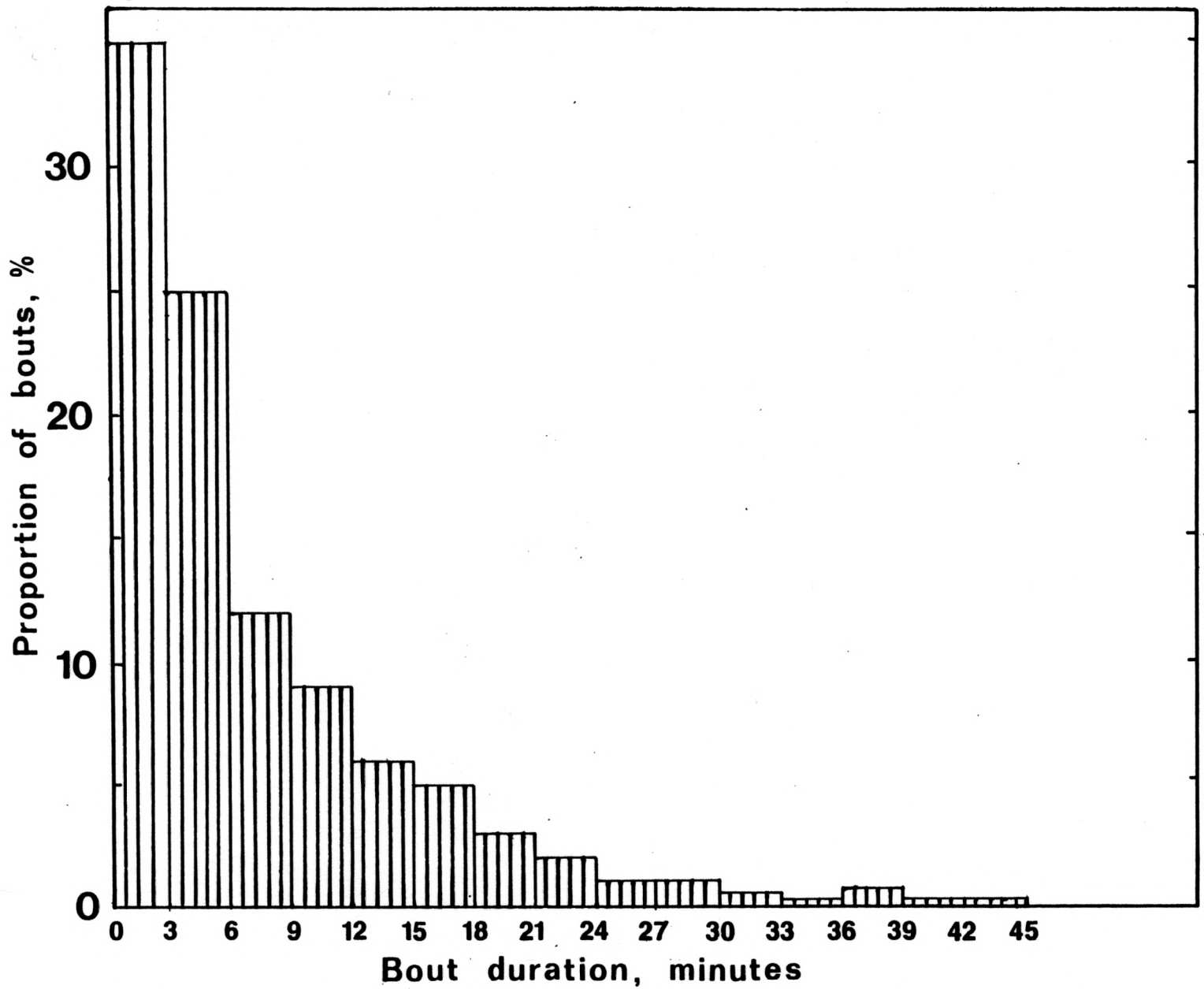
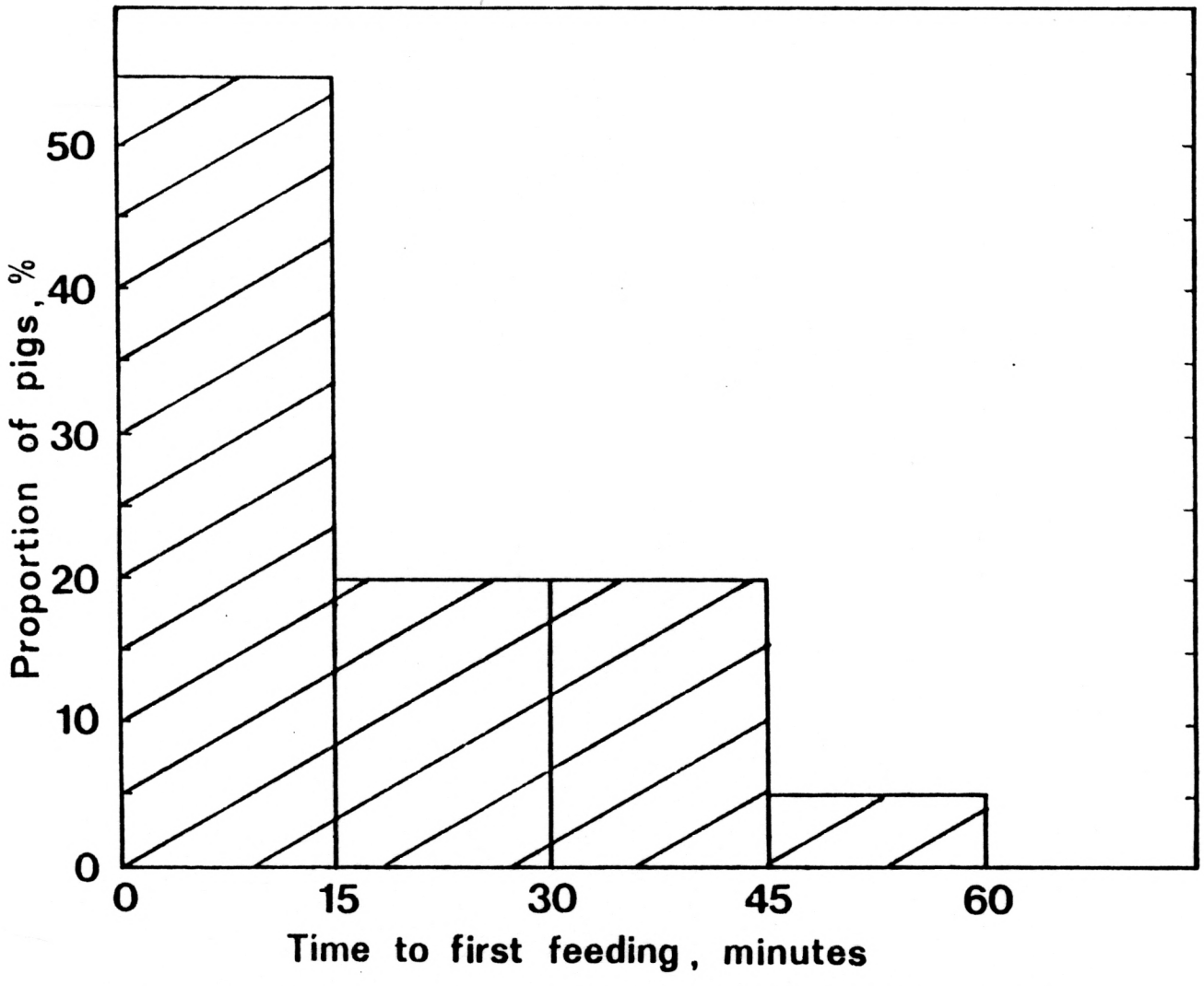


Figure 3. Diagram of rectangular feeder



Graph 1. Proportion and Length of Bouts Performed by Time-Restricted Fed Pigs.



Graph 2. Proportion of Pigs and Length of Time to First Feeding.

Table 1. Composition of the Diet.

Ingredients	Amount, kg	Percentage
Sorghum grain	687.1	76.3
Soybean meal (44 %)	180.0	20.0
Dicalcium phosphate	12.6	1.4
Ground limestone	9.0	1.0
Salt	0.9	0.5
Trace mineral[a]	0.9	0.1
KSU premix[b]	4.5	0.5
Antibiotic[c]	1.3	0.2

[a]Contain 0.1 % cobalt, 1.1 % cooper, 0.15 % iodine, 10 % iron 5.5 % manganese and 20 % zinc.

[b]Amount per kg: 880,000 USP units of vitamin A, 66,000 USP units of vitamin D_3, 990 mg of rivoflavin, 2,640 mg of d-pantothenic acid, 66,000 mg of choline, 5,500 mg of niacin, 4,400 I.U. vitamin E and 4.84 mg of vitamin B_{12}

[c]Aureomycin 200 g/ton.

Table 2. Effect of System of Feeding on Performance of Finishing Pigs. (Experiment 1, 2, 3).

Item	Average daily gain, kg	Average daily feed intake, kg	Feed to gain ratio
Trial 1			
Timed-fed[b]	0.84	2.73	3.22[d]
Ad-libitum, rec. feeders[b]	0.85	2.65	3.10[e]
Ad-libitum, round feeders[b]	0.83	2.60	3.10[e]
Trial 2			
Timed-fed[a]	0.69	2.39	3.43
Ad-libitum, rec. feeders[b]	0.70	2.44	3.48
Ad-libitum, round feeders[b]	0.69	2.39	3.44
Trial 3			
Timed-fed[a]	0.66	2.55	3.84
Ad-libitum, rec. feeders[b]	0.67	2.63	3.90
Ad-libitum, round feeders[b]	0.67	2.66	3.93
Summary - 3 trials			
Timed-fed[c]	0.73	2.58	3.50
Ad-libitum[c]	0.73	2.56	3.49

[a]Values are means of four observations.
[b]Values are means of two observations.
[c]Values are means of twelve observations.
[d e]Values with different superscripts differ significantly ($P<.01$).

Table 3. Effect of System of Feeding on Carcass Characteristics of Finishing Pigs (Experiment 2).

Carcass Measurements [a]	Feeding Method	
	Timed-fed	Ad-libitum
Backfat, cm	2.56[b]	3.12[c]
Tenth rib fat, cm	2.61	2.71
Loin eye, sq cm	27.42	28.38
Lean cut, %	59.60	58.20
Muscle, %	52.00	52.20
Dressing, %	72.28	72.50

[a]Values are means of 18 observations

[b c]Values with different superscripts differ significantly (P<.03).

Table 4. Water Intake of Timed-fed Pigs (Experiment 1).

Period	Water intake l/d	Feed intake kg/d	Water to feed ratio
01-14 d	3.54	2.29	1.53
15-28 d	4.34	2.75	1.56
29-42 d	4.49	2.91	1.68
42-62 d	4.80	2.89	1.65
Mean[a]	4.44	2.73	1.61

[a]Values are means of four pens with 20 pigs.

Table 5. Water Intake of Timed-fed Pigs and Ad-libitum Fed Pigs (Experiment 2).

Treatment[a]	Water intake l/d	Feed intake kg/d	Water to feed ratio
Timed-fed	4.23	2.39	1.76
Ad-libitum	7.60	2.44	3.11

[a]Each pen contained 20 pigs.

Table 6. Effect of Length of Feed Availability on Performance of Finishing Pigs (Experiment 4).

	Feeding Period			
Performance[a,b]	2h/24h	4h/24h	6h/24h	ad-lib.
Daily gain, kg	0.79	0.83	0.79	0.85
Daily feed intake, kg	2.64	2.90	2.65	2.86
Feed to gain ratio	3.43	3.50	3.36	3.46
Exp. da. to mkt. wt.	80.83[c]	78.50[c,d]	76.66[c,d]	74.83[d]

[a]Performance data collected until day 75 of experiment, with exception of days to market weigth.

[b]Values are the average of three pens with two pigs each.

[c,d]Values with different superscripts differ significantly (P=.09)

Table 7. Effect of Length of Feed Availability on Carcass Measurements of Finishing Pigs (Experiment 4).

	Feeding Period			
Carcass Measurements[a]	2h/24h	4h/24h	6h/24h	ad-lib.
Backfat thickness, cm	2.48	2.58	2.36	2.70
Loin eye area, sq. cm	31.47	33.31	36.46	32.19
Lean cuts, %	59.16	61.16	61.00	59.00
Muscle, %	54.10	55.60	55.60	53.30
Dressing, %	71.50	69.23	72.85	72.57

[a]Values are means of six observations per treatment.

Table 8. Effect of Length of Feed Availability on Weight of Stomachs of Finishing Pigs (Experiment 4).

	Feeding Period			
Weight of Stomach[a]	2h/24h	4h/24h	2h/24h	ad-lib.
Full, g	922.16	1161.00	887.16	720.50
Empty, g	502.66[b]	482.50[bc]	490.66[bc]	462.83[c]
Empty wt/body wt, %	4.96[d]	4.63[b]	4.70[b]	4.30[c]

[a]Values are means of six observations per treatment.

[b,c,d]Means with different superscripts differ (P=.08).

[d,c]Means with different superscripts differ significantly (P=.05).

Table 9. Daytime Frequency of Feeding and Waiting Activities (experiment 5).

Pig number	Frequency of feeding		Frequency of waiting		Frequency of feeding+waiting	
	Total number	Mean[a]	Total number	Mean[a]	Total number	Mean[a]
01	224	17.2	46	3.5	270	20.7
02	289	22.2	70	5.3	359	27.5
03	158	12.1	46	3.5	204	15.6
04	240	18.4	40	3.0	280	21.4
05	239	18.3	55	4.2	294	22.5
06	205	15.7	40	3.0	245	18.7
07	158	12.1	33	2.6	191	14.7
08	268	20.6	87	6.6	355	27.2
09	299	23.0	55	4.2	354	27.7
10	203	13.3	30	2.3	233	15.6
11	130	10.0	26	2.0	156	12.0
12	209	18.1	11	2.0	220	20.1
13	187	13.1	62	4.7	249	17.8
14	283	18.5	55	4.2	293	22.7
15	183	14.0	25	1.9	208	15.9
16	121	9.3	31	2.3	152	11.6
17	249	19.1	63	4.8	312	23.9
18	278	21.3	79	6.0	357	27.3
19	301	23.1	30	2.3	331	25.4
20	261	20.0	23	1.7	284	21.7

[a]Means of 13 observation periods from 1100 to 1430 h.

Table 10. Nighttime Frequency of Feeding and Waiting Activities. (Experiment 5).

Pig number	Frequency of feeding		Frequency of waiting		Frequency of feeding+waiting	
	Total number	Mean[a]	Total number	Mean[a]	Total number	Mean[a]
01	26	5.2	2	0.4	28	5.6
02	32	6.4	4	0.8	36	7.2
03	82	16.4	6	1.2	88	17.6
04	68	13.6	6	1.2	74	14.8
05	30	6.0	1	0.2	31	6.4
06	37	7.4	3	0.6	40	8.0
07	37	7.4	3	0.6	40	8.0
08	36	7.2	5	1.0	41	8.2
09	32	6.4	1	0.2	33	6.6
10	40	8.0	3	0.6	43	8.6
11	23	4.6	0	0.0	23	4.6
12	50	10.0	1	0.2	51	10.2
13	34	6.8	5	1.0	39	7.8
14	37	7.4	5	1.0	42	8.4
15	24	4.8	2	0.4	26	5.2
16	33	4.6	2	0.4	35	5.0
17	21	4.2	5	1.0	26	5.2
18	38	7.6	2	0.4	40	8.0
19	51	10.2	3	0.6	54	10.8
20	31	6.2	2	0.4	33	6.6

[a]Mean values of five observation periods from 2300 to 0230 h.

Table 11. Mean Frequencies of Feeding and Waiting Activities During Daytime and Nighttime of Timed-fed Pigs (Experiment 5).

	Daytime	Nighttime	Total
Freq. feeding	16.9[a]	7.5	24.4
Freq. waiting	3.5[a]	0.6	4.1
Feed.+waiting	20.5[a]	8.3	28.8

[a]Daytime and nighttime frequencies differ ($P<.05$).

Table 12. Frequency and Length of Feeding Bouts (Experiment 5).

Bout length, min	Daytime Number of bouts	%	Nighttime Number of bouts	%	Entire Period Number of bouts	%
03	557	36.0	77	31.0	634	35.0
06	387	25.0	67	27.0	454	25.0
09	188	12.0	32	13.0	220	12.0
12	137	9.0	24	10.0	161	9.0
15	92	6.0	15	6.0	107	6.0
18	74	5.0	7	3.0	81	5.0
21	43	3.0	11	4.0	54	3.0
24	34	2.0	7	3.0	41	2.0
27	17	1.0	2	1.0	19	1.0
30	16	1.0	3	1.0	19	1.0
33	9	0.5	1	0.4	10	0.5
36	2	0.2	1	0.4	3	0.1
39	6	0.3	1	0.4	7	0.4
42	3	0.2	0	0.0	3	0.1
45	3	0.2	0	0.0	3	0.1
Total	1569		248		1817	

Table 13. Frequency and Length of "At the Feeder" Bouts During the Daytime (experiment 5).

Pig number	Frequency number	Mean[a]	Length minutes	Mean[a] minutes
01	83	6.3	124	9.5
02	86	6.6	162	12.4
03	66	5.0	139	10.6
04	85	6.5	125	9.6
05	65	5.0	189	14.5
06	50	3.8	201	15.4
07	64	4.9	104	8.0
08	82	6.3	152	11.6
09	60	4.6	251	19.3
10	52	4.0	173	13.3
11	52	4.0	114	8.7
12	86	6.6	103	7.9
13	75	5.7	133	10.2
14	86	6.6	134	10.3
15	55	4.2	151	11.6
16	49	3.7	126	9.6
17	63	4.8	189	14.5
18	73	5.6	184	14.1
19	83	6.3	177	13.6
20	78	6.0	157	12.0
Totals	1393		3088	

[a]Values are means of 13 observations from 1100 to 1430 h.

Table 14. Frequency and Length of "At the Feeder" Bouts During the Nighttime (Experiment 5).

Pig number	Frequency number	Mean[a]	Length minutes	Mean[a] minutes
01	12	2.4	34	6.8
02	10	2.0	38	7.6
03	18	3.6	43	8.6
04	20	4.0	51	10.2
05	9	1.8	45	9.0
06	6	1.2	84	16.8
07	20	4.0	28	5.6
08	16	3.2	36	7.2
09	7	1.4	45	9.0
10	14	2.8	55	11.0
11	9	1.8	14	2.8
12	18	3.6	37	7.4
13	12	2.4	40	8.0
14	14	2.8	40	8.0
15	5	1.0	59	11.8
16	7	1.4	33	6.6
17	6	1.2	45	9.0
18	5	1.0	92	18.4
19	14	2.8	59	11.8
20	9	1.8	56	11.2
Total	236		934	

[a]Means are values of five observations from 2300 to 0230 h.

Table 15. Frequency of Aggressive Acts Seen During Feeding Period Observations (Experiment 5).

Pig number	Daytime		Nighttime	
	Aggressive acts	Mean[a]	Aggressive acts	Mean[b]
01	116	8.9	10	2.0
02	81	6.2	4	0.8
03	48	3.6	5	1.0
04	134	10.3	19	3.8
05	72	5.5	2	0.4
06	40	3.0	2	0.4
07	12	9.0	3	0.6
08	31	2.3	3	0.6
09	30	2.3	4	0.8
10	41	3.1	13	2.6
11	87	6.6	3	0.6
12	113	8.6	20	4.0
13	88	6.7	12	2.4
14	44	3.3	5	1.0
15	58	4.4	2	0.4
16	15	1.1	2	0.4
17	101	7.7	5	1.0
18	117	9.0	6	1.2
19	74	5.6	3	0.6
20	145	11.1	8	1.6

[a]Values are means of 13 observational periods.

[b]Values are means of five observational periods.

Table 16. Number and Proportion of Different Kinds of Aggressive Acts (Experiment 5).

	Aggressive acts [a]	Percentage
Displacements	607	38
Head thrusts	519	32
Bites	434	27
Fights	29	2
Threats	19	1

[a]Values are total number of acts for 18 observational periods.

Table 17. Effect of Time of the Day on Mean Frequency of Aggressive Acts (Experiment 5).

	Feeding Period	
Aggressions	Daytime	Nighttime
Mean[a]	5.51[b]	1.59

[a]Values are means of 13 observations during the daytime and five during the nighttime.

[b]Values differ ($P<.05$).

Table 18. Effect of Sex on Social Rank Index and Mean Number of Aggressive Acts (Experiment 5).

	Sex	
	Barrows	Gilts
Social rank index[a]	8.40[b]	12.55
Mean number of aggression[a]	2.82[b]	4.28

[a]Values are means based on ten barrows and ten gilts.

[b]Values with superscript differs significantly ($P<.07$).

Table 19. Average Daily Gain, Social Rank Index, Time to First Feeding, Initial Weight and Sex of Individual Timed-fed Pigs (Experiment 5).

Pig number	Average daily gain,kg	Social rank index	Time to first feeding, min	Initial weight, kg	Sex (*)
01	0.70	16.5	16.4	55.7	G
02	0.72	9.5	12.9	53.0	B
03	0.63	10.0	25.8	52.1	B
04	0.71	17.0	5.2	54.8	G
05	0.62	9.0	6.5	53.5	G
06	0.55	10.0	49.7	50.8	G
07	0.67	2.5	31.0	52.1	B
08	0.61	4.0	5.0	49.8	B
09	0.66	7.5	22.8	58.9	G
10	0.72	10.5	42.4	57.1	B
11	0.60	12.5	40.8	51.7	G
12	0.69	13.0	11.2	54.8	B
13	0.67	12.0	5.6	58.5	G
14	0.68	5.0	10.2	64.4	B
15	0.56	12.5	24.4	56.2	G
16	0.59	9.0	33.0	61.6	B
17	0.60	11.5	3.6	48.5	G
18	0.67	9.5	16.6	59.8	G
19	0.61	11.0	4.8	50.8	B
20	0.60	17.0	2.8	53.5	G

(*)
G= Gilt
B= Barrow

Table 20. Correlation Coefficients for Social, Feeding and Performance Traits of Timed Fed Pigs.

	Social rank index	Frequency of aggression	Average daily gain	Initial weight	Time to first feeding	Frequency of feeding	Frequency of waiting	Frequency "at feeder" bouts
Frequency of aggression	0.77**							
Average daily gain	0.27	0.56**						
Initial weight	0.01	0.12	0.30					
Time to first feeding	-0.24	-0.50*	-0.29	0.02				
Frequency of feeding	0.21	0.48*	0.29	-0.19	-0.56**			
Frequency of waiting	-0.34	0.02	0.18	-0.03	-0.43*	0.34		
Frequency of "at the feeder" bouts	0.32	0.69**	0.60**	-0.10	-0.62**	0.57**	0.12	
Length of "at the feeder" bouts	-0.07	-0.13	-0.29	-0.02	-0.20	-0.38(*)	-0.17	-0.45 *

(*) P<.10
* P<.05
** P<.01

SUMMARY

Four hundred and eighty crossbred pigs were used in three experiments to compare effects of time-restricted feeding (two three-hour periods) and ad-libitum feeding on performance. Pigs had similar daily gain, daily feed intake and feed efficiency regardless of feeding system. Carcass traits of loin eye area, percentage of lean cuts, percentage of muscle and dressing percentage did not differ statistically between time-restricted and ad-libitum fed pigs. However, timed fed pigs were leaner. The performance of ad-libitum fed pigs being fed with round or rectangular feeders did not differ in these experiments.

In the fourth experiment, twenty four crossbred barrows were fed two, four, six hours daily or ad-libitum. Pigs did not differ significantly in their performance. Nevertheless, pigs fed two hours daily, required six more experimental days to reach market weight compared with those fed ad-libitum. Carcass measurements were not significantly different between treatments, even though restricted-fed pigs were slightly leaner than ad-libitum fed pigs. Empty stomachs were heavier in timed-fed pigs which suggest an apparent hypertrophy of the organ in response to the pattern of feeding imposed by the treatments.

In the fifth experiment, one pen containing ten barrows and ten gilts was used to study the behavior of pigs fed three hours during daytime and three hours at night. Feeding and agonistic activities were recorded at feeding time. A social rank index was used to establish social hierarchies in the group. Frequency of aggression was used to determine dominance order. Correlation coefficients were calculated for pairs of traits involving social and feeding patterns with rate of gain. The results of this study indicate that timed-fed pigs displayed predominantly daytime feeding activities. Differences in social rank indexes and frequency of

aggression were found between sexes in that gilts were more aggressive with higher social status than barrows. Dominance order was found to be closely correlated with most of the feeding parameters and with average daily gain suggesting that more aggressive pigs went first to the feeder, fed more frequently and gained faster. Social status follows the same but more modest trend. In this behavioral study competition for food and space at the feeder are postulated to be the major causes of aggression between pigs. The social hierarchy of the group is likely to be altered under these circumstances i.e., hungrier pigs with low social rank may retaliate against higher ranked pigs in their attempt to get feed.

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EFFECTS OF TIME-RESTRICTED VS AD-LIBITUM FEEDING ON PERFORMANCE, CARCASS TRAITS AND BEHAVIOR OF FINISHING PIGS

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ABSTRACT

Three experiments were conducted to compare effects of ad-libitum and of timed feeding (two three-hour periods daily) on the performance of finishing pigs. A total of four hundred and eighty crossbred pigs were used. When timed-fed pigs were compared with ad-libitum pigs, no statistical differences were found for average daily gain, average daily feed intake or feed to gain ratio. Timed-fed pigs did not differ from ad-libitum fed pigs in the carcass traits of loin eye area, percentage of lean cuts, percentage of muscle or carcass yield. No differences in performance of pigs were detected when rectangular or round feeders were used to feed ad-libitum pigs.

A fourth experiment was conducted to compare the performance of twenty four barrows being fed for periods of two, four or six hours daily with pigs fed ad-libitum. Length of feeding period did not significantly affect average daily gain, average daily feed intake or feed to gain ratio. However, pigs fed two hours required six more experimental days to reach market weight than ad-libitum fed pigs. Carcass yield, loin eye area, percentage of lean cuts and percentage of muscle were not statistically different among treatments.

The behavior of timed-fed pigs was studied during feeding periods in experiment 5. Frequency of aggression between pigs and feeding activities were recorded during eighteen observational periods: 13 during the daytime and five during the night. One pen containing ten barrows and ten gilts was used in this trial. Pigs were evaluated in terms of their social hierarchies, using a social rank index; dominance order, using frequency of aggression; feeding patterns, using frequency of feeding and feeding bouts, and average daily gain. Correlation coefficients were calculated for pairs of traits involving social order and feeding patterns with rate of gain. Results of this study indicate that timed-fed pigs

displayed predominantly daytime feeding activities. Gilts ranked higher socially and were more aggressive than castrated males. Social rank index was modestly correlated with feeding activities and rate of gain. Aggressive order was found to be more closely correlated with feeding activities and average daily gain.