Anim. Prod. 1988, **47**: 139-148

0003-3561/88/71200139$02.00

SOCIAL HIERARCHY AND FEEDER ACCESS IN A GROUP OF 20 SOWS USING A COMPUTER-CONTROLLED FEEDER

E. J. Hunter[1], D. M. Broom[1]†, S. A. Edwards[2]‡ and R. M. Sibly[1]

[1]*Department of Pure and Applied Zoology, University of Reading, Whiteknights, Reading RG6 2AJ*

[2]*MAFF Terrington Experimental Husbandry Farm, Terrington St Clement, Kings Lynn, Norfolk PE34 4PW*

ABSTRACT

Twenty pregnant sows sharing a double-entry back-out Pig Code feeder with a similar group of 20 were observed over six 24-h feed cycles by a combination of direct observation and video recording. The group had access to an area of 47 m^2. Sows were fed once a day on a pelleted diet and water was continually available. Feeding order was relatively constant from day to day, and was positively correlated with parity. A social hierarchy based on displacements and attacks within pairs of sows was found to be basically linear, with the exception of six reversals of dominance. Social hierarchy was positively correlated with feeding order overall, but this was not the case for the latter half of the feeding order. This was partly due to disruption of feeder use by non-feeding visits made by early-feeding dominant sows. Overall the results showed that older sows with more experience of the feeder in two or three previous parities were higher in the feeding order and social hierarchy than younger sows, and may exclude them from the feeder by repeated non-feeding visits.

INTRODUCTION

Interest in group-housing systems for sows, as an alternative to stalls and tethers, has led to a number of studies on the use of computerized feeding systems which can provide individual rations for group-housed sows (Edwards and Riley, 1986). The effects of group size (Edwards, 1985; Beckett, Edwards, Simmins and Walker, 1986), 'dynamic' grouping (Lambert, Ellis and Rowlinson, 1986) and feeding frequency (Edwards, Armsby and Large, 1984; Lambert, Ellis and Rowlinson, 1985) have all been investigated in computerized systems. Although some information has been collected on levels of aggression and docility (Edwards *et al.*, 1984; Lambert *et al.*, 1986) there is little information on the behaviour of individual sows, and the relationship between social hierarchy and use of the feeder. The way in which newly introduced sows adapt to a group is of particular interest as levels of aggression may be high shortly after their introduction (Lambert *et al.*, 1986).

The aim of this study was to assess the relationship between social hierarchy and feeder access within a group of sows. The group contained newly introduced animals so that the factors affecting their success within the group could be investigated. Information on general patterns of group activity and behaviour should be of use not only in relation to computerized feeding systems, but also to other types of group housing for sows.

MATERIAL AND METHODS

Animals

The study group, at Terrington Experimental Husbandry Farm, consisted of 20 Large White × Landrace pregnant sows, sharing a double-entry back-out Pig Code feeder with 20 sows in a neighbouring pen.

For details of feeder design and operation

Present addresses:

† Department of Clinical Veterinary Medicine, Madingley Road, Cambridge CB3 0ES.

‡ North of Scotland College of Agriculture, 581 King Street, Aberdeen AB9 1P.

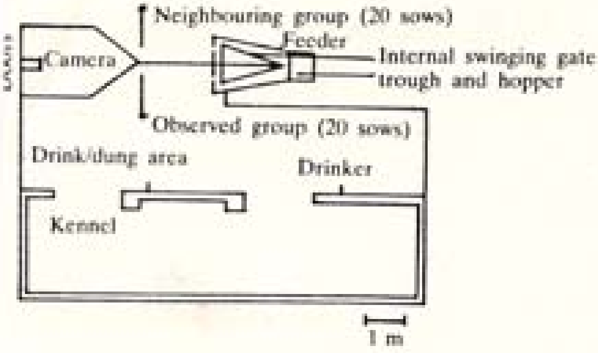

FIG. 1. Area available to the observed group.

see Edwards (1985). All 40 animals using the feeder were trained and had been using the feeder for about 1 week before the start of observations. The study group contained no gilts and the parities of the sows ranged from two to nine. Five sows from the study group were replaced by five sows from the neighbouring group on the day before observations began. Each sow was clearly spray-marked with a number (1 to 20) across her back.

Housing and feeding

The 20 sows observed had access to a kennelled area (10·21 × 2·44 m) containing straw and a straw-bedded area outside the kennel for dunging, drinking and lying of 2·13 × 10·21 m (Figure 1). The feed station was on a concrete strip 2·00 m across, with half in each neighbouring pen. This was raised to a height of about 10 cm above the straw-bedded area. Water was continuously available from two nipple drinkers, and a 100-W bulb suspended above the feed station was continuously illuminated. The feed station was programmed to provide the daily ration for each sow in one feeding visit. Depending on condition score, rations for individual sows were either 2·1 or 2·4 kg of a commercial pelleted diet containing 160 g crude protein and 13 MJ digestible energy per kg diet as fed. Each 24-h feed cycle was programmed to start at 04.00 h.

Observation routine and data collection

Each of six observation days consisted of two, 3-h periods of continuous observation (07.00 to 10.00 h, and 12.00 to 15.00 h). The first 3 observation days (session 1) were from 3 to 5 October 1986 and the next 3 days (session 2) from 17 to 19 October 1986. The observer entered the sow house about 20 min before the start of each observation period, and observed the sows from the roof of the kennel. The sow house was not entered during observation time. The following data were collected during each 3-h observation period using an Epson HX20 lap computer: entry and exit time of each feeder visit and identity of visiting sow; identity of each sow queuing whenever the feeder was vacated; the identities of the two sows involved in each social interaction; the location and type of each social interaction.

Locations of social interactions were described as: inside the feeder; in the feeder queue, defined as standing within about 2 m of the feeder entrance, facing the feeder entrance; in the straw bedded area outside the kennel; at one of the drinkers.

The categories of social interaction recorded in all locations were as follows: displacement with strong resistance shown before displacement — the sow displaced showing resistance in the form of head swing with open mouth and/or loud vocalization before being displaced; displacement with moderate resistance shown — the sow displaced showing resistance in the form of head swing with closed mouth towards the approaching sow and/or vocalization in the form of quiet grunting; displacement of one sow by another with no resistance shown — the displaced sow often retreating with head and eyes lowered; failure to displace by the approaching sow — the approaching sow signalling her intention to displace by attempts at parallel pressing (Jensen, 1980) or, more commonly, by head swings towards the sow she intends to displace; the sow approached maintaining her position; failure to displace by the approaching sow, followed by retaliation by the sow approached, in the form of head swinging, with or without open mouth and/or vocalization towards the approaching sow; attack, consisting of an approach of one sow to another with an attempt to butt or bite, often followed by a pursuit of 1 m or more.

Activity scans were carried out every 10 min during direct observation by counting the number of sows lying, sitting and standing in each location. These scans were used to calculate the pattern of general activity within the group. In addition to direct observation, a 72-h video-recording was made to cover each 3-day period during which direct observation was made. Recordings were made using a National Panasonic reel-to-reel time-lapse video recorder and a camera with a wide-angle lens positioned above the double doors behind the feeder (Figure 1). After the second 3-day visit, the video-recording was continued for 24 h to provide further information on feeding order.

Statistical analysis

Paired-sample *t* tests were used to compare general activity, social behaviour and feeder use at different times of day. Because of the infrequency of lying in the feeder queue during morning observations, a non-parametric test (Wilcoxon paired-sample test) was used to compare the number of sows lying in the feeder queue at different times of day. The stability of the feeding order was estimated using Kendall's coefficient of concordance, *W* (Daniel, 1978). Sows 1, 4 and 9 were excluded because of their failure to feed on one occasion. A value of 1 for *W* indicates that all feeding orders were identical, and a value of 0 indicates that feeding order was random.

Calculation of the social hierarchy was carried out by the method described by Reinhardt and Reinhardt (1975). The criteria were that at least two active competitive encounters with the same outcome were present within a pair in order to assess dominance, and that where reversals were present, a ratio of at least 4 : 1 was required in order to assume dominance of one sow in the pair. Landau's index of linearity (Martin and Bateson, 1986) was calculated to provide a measure of the linearity of the dominance hierarchy. Spearman's rank order correlation coefficient (Spearman's rho) was used to calculate correlations between variables, using the correction for ties where appropriate.

RESULTS

Activity in the straw-bedded area

Patterns of general activity were estimated using the data obtained from the activity scans carried out every 10 min during direct observation. The mean number of sows lying and sitting in the straw-bedded area outside the kennel rose from 2·9 (s.d. = 2·3) during morning observations to 4·0 (s.d. = 2·0) during afternoon observations (paired-sample *t* test, $P < 0.001$). This may have been due to sows being less active after mid day (the majority of sows had eaten by 12.00 h), and a tendency to lie outside the kennel during the warmest part of the day. The mean number of sows standing in this area was not significantly different between morning (mean = 2·2, s.d. = 1·7) and afternoon (mean = 2·6, s.d. = 4·2) observation periods. It was not possible to observe social activity inside the kennelled area, but the level of noise indicated that sows inside were very inactive. At any one time during direct observation, there were between 5 and 12 sows inside the kennel. This provided a generous space allowance for each sow, and as there was no competition for resources (e.g. food, water and space) in the kennel, sows used this area for lying and sleeping.

Activity in the feeder queue

There was no significant difference between the mean number of sows in the feeder queue during morning (mean = 2·0, s.d. = 1·5), and afternoon (mean = 2·3, s.d. = 1·5) periods. There was, however, a significantly higher number of sows lying in the feeder queue during afternoon observation periods (median = 3) than during morning observations (median = 0, $P < 0.001$, Wilcoxon test). In order to estimate each sow's attempts to enter the feeder, the number and identities of sows waiting to enter each time the feeder was vacated was also noted. There were no overall differences between morning and afternoon observations or between sessions one and two in this respect. However, the pattern of queuing appeared to change from sessions one to two.

More sows queued in the morning period in session one, perhaps because both feeding

TABLE 1
Mean number of sows queuing when the feeder was vacated

	a.m. (07.00 to 10.00)		p.m. (12.00 to 15.00)	
	Mean	s.e.	Mean	s.e.
Session 1 (3 to 5 October)	3·0	0·20	1·8***	0·12
Session 2 (17 to 19 October)	2·1	0·11	2·7***	0·14

order and social hierarchy were being established following the introduction of five new sows on the day before observations began. Two weeks later, with feeding order well established, fewer sows were queuing to use the feeder in the morning and numbers queuing in the afternoon had increased slightly.

Feeder use throughout the feed cycle

The differences between morning and afternoon observations are summarized in Table 2. There was a tendency for the number of feeder visits to be higher in the afternoon. Morning visits were longer and included a higher proportion of feeding visits.

Video recording showed that at least half of the sows always fed between 04.00 h and 10.30 h. The significantly longer visits in the morning are largely a reflexion of the greater proportion of feeding visits occurring during the early part of the feed cycle, each feeding visit lasting about 14 to 15 min. Given that there were 40 sows using the feeder (Figure 1), all sows should have fed by 14.00 h. However, because of non-feeding visits, the time of the last feeding visit ranged from 16.39 to 17.31 h within the seven recorded feed cycles. Some sows made repeated attempts to enter the feeder before gaining access to food (Table 5), while others made repeated non-feeding visits after feeding early in the day (Figure 4). Overnight (19.00 to 04.00 h) sows were generally inactive, with only two or three sleeping outside the kennel, or leaving it to visit the feeder (mean of 1·5 visits per h).

TABLE 2
Mean number and duration of feeder visits during sessions 1 and 2

	a.m. (07.00 to 10.00)		p.m. (12.00 to 15.00)	
	Mean	s.e.	Mean	s.e.
Mean no. of feeder visits	7·3	0·56	10·3	1·4
Mean proportion which were feeding visits	0·84	0·02	0·46***	0·06
Mean duration of feeder visits (min)	14·9	0·82	10·7***	1·58

Consistency of feeding order

A combination of video-recording and direct observation provided the sequence of feeder visits for seven, 24-h feeding periods. The sows were relatively constant in their order of feeding. The extent to which each sow deviated from her mean position in the feeding order is shown in Figure 2 by plotting the standard deviation from the mean position for each sow. Three sows (numbers 1, 4 and 9) missed one feed during session one. Reasons for sows failure to feed are not clear. In the case of two of the non-feeders, 4 and 9, they always ate late in the day, and 9 was receiving treatment for lameness during session one. The other non-feeder, sow 1, generally fed early in the feed cycle, before 07.00 h.

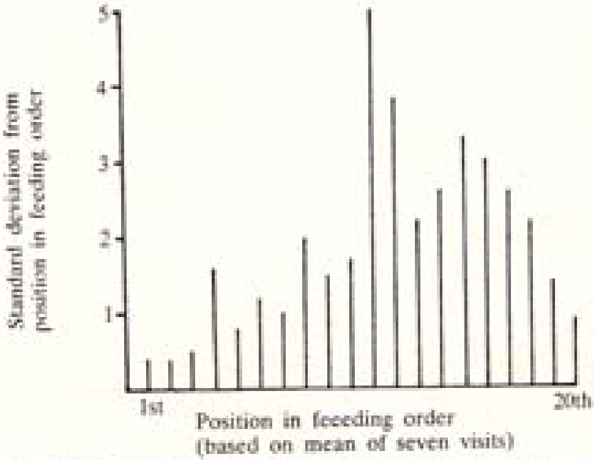

FIG. 2. Standard deviation from feeding order position.

Calculation of Kendall's coefficient of concordance (W) indicated that the feeding order was stable over the seven feeding periods recorded ($W = 0{\cdot}856$, $P < 0{\cdot}001$) and hence each sow could be characterized by her mean position in the feed order. Feeding order was stable both overall and within each 3-day period. W was 0·966 ($P < 0{\cdot}001$) for the first 3 days recorded, although the introduction of five new sows to the group occurred less than 24 h before recordings began. For the second 4 days recorded (2 weeks later) W was 0·910 ($P < 0{\cdot}001$). These results indicate that sows quickly established and maintained a relatively stable feeding order.

Within the feeding order, the standard deviations for later feeders (Figure 2) were larger (mean deviation of 2·94 positions) than those for sows in the earlier half of the feeding order (mean deviation of 1·05 positions, $P < 0{\cdot}01$, t test).

Distribution of social activity

There were no significant differences between sessions one and two, or between a.m. and p.m. observations with respect to total number or distribution of social interactions, so results from both sessions were pooled and are presented in Table 3.

There were 839 interactions observed during session 1 (3 October to 5 October 1986) and 819 during session 2 (17 October to 19 October 1986). There were more displacements and more failures to displace in the feeder queue than in the straw (both $P < 0{\cdot}001$, paired t test), but there was no consistent difference in the number of attacks in these two areas. Interactions at the drinkers were infrequent (18 in total) and all were displacements with no resistance.

The most common social interaction was displacement from the feeder queue with no resistance shown, accounting for 0·46 of all social interactions observed. Attacks accounted for 0·13 of all social interactions. No serious or prolonged attacks were observed in the feeder queue or the straw-bedded area. Of the 19 attacks occurring inside the feeder, three resulted in bites on the rump or vulva, leaving traces of blood. The majority of attacks in the feeder consisted of the attacking sow butting or attempting to lift up the occupying sow, by placing her snout beneath the rump of the occupying sow and pushing upwards. The 'poaching' of food, which can occur if a sow is chased out after her first portion of food is delivered (Beckett *et al.*, 1986), was not seen in this group. In summary, the level of aggression in the group was generally low. The commonest interaction was displacement with little resistance shown by the sow approached.

TABLE 3
Distribution of social activity
(proportions of all 1658 interactions)

	Feeder queue	Straw-bedded drink/dung area
Displacements	0·54	0·18***
Failures to displace	0·12	0·004***
Attacks	0·06	0·06

Calculation of social hierarchy

Displacements and attacks in the feeder queue, straw-bedded area and at the drinkers were used as the basis for calculating a dominance hierarchy in the group. The few social interactions occurring in the kennel could not be seen, but it is very unlikely that their inclusion would have altered the overall pattern of dominance. Attacks in the feeder were not included in calculating the social hierarchy because sows did not have the opportunity to retaliate or escape while in the feed station. A total of 1462 displacements and attacks were recorded during 36 h of direct observation, distributed amongst a total of 190 possible pair combinations of sows. The proportion of pairs within which there were no interactions was 0·06, and the proportion of pairs within which no reversals occurred was 0·63. This value rose from 0·52 during visit one to 0·64 during visit two.

Interactions from both visits were pooled, because there were no instances of dominance reversals between the two visits. Similarly, when a separate dominance hierarchy was calculated solely for displacements and attacks in the feeder queue, which constituted 0·57 of all interactions, the direction of dominance was the same as the hierarchy calculated for all interactions. Three dominance reversals were seen however, when interactions in the straw-bedded area were compared with those in the feeder queue only. The social hierarchy calculated in this way is contained in Table 4.

Calculation of Landau's index of linearity gives a value of 0·6, indicating that the hierarchy is not strongly linear, due mainly to the six reversals of dominance.

Social hierarchy and feeder access

Table 4 lists the position in the feeding order and social hierarchy for 17 of the 20 sows in the group. Sows 1, 4 and 9 are excluded from the feeding order because of failure to feed on one occasion. Dominance hierarchy was positively correlated with feeding order overall (Spearman's rho = 0·718, $P < 0·001$) as illustrated in Figure 3.

Position in the overall feeding order was also positively correlated with parity (Spearman's rho = 0·540, $P < 0·05$), and

TABLE 4
Dominance hierarchy based on displacements and attacks

Sow no.	Total no. of displacements or attacks involving sow	Position in feeding order	Parity‡
2† (top)	108	2	5 (1)
14	128	3	4 (2)
17	42	1	9 (3)
13	124	4	3 (2)
5†	163	6	9 (2)
18†	91	10	5 (1)
19	201	13	2 (0)
3†	92	5	4 (3)
12	243	9	2 (1)
8	206	16	2 (0)
4	142		2 (0)
20	74	17	3 (0)
15	287	8	2 (1)
7	207	11	2 (0)
1†	50		8 (3)
16	167	7	5 (3)
11	130	14	2 (1)
10	271	12	6 (3)
9	46		2 (0)
6 (bottom)	137	15	3 (0)

† Indicates 'newcomers' to the group.
‡ Indicates the number of previous parities in which the sow used the feeder.

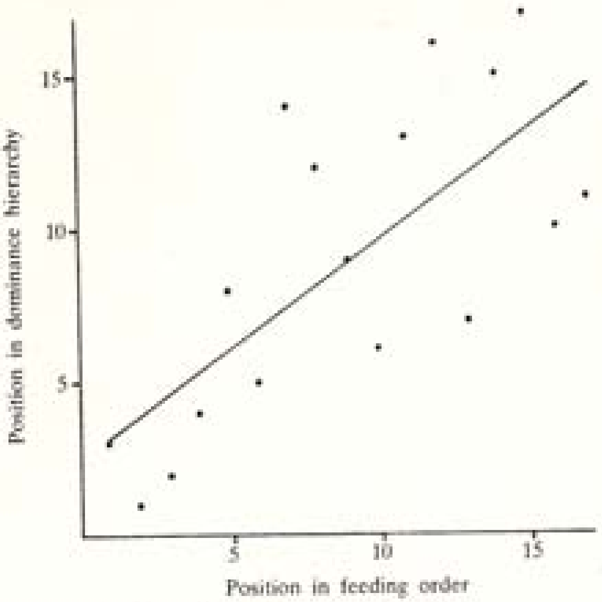

FIG. 3. Dominance hierarchy *v.* feeding order.

with previous use of the feeder (Spearman's rho = 0·753, $P < 0·001$). There was however no correlation between the later half of the feeding order and the social hierarchy (Spearman's rho = 0·214). There was a positive correlation between the top half of the dominance hierarchy and parity (Spearman's rho = 0·632, $P < 0·05$), although surprisingly neither parity nor previous use of the feeder were correlated with position in the dominance hierarchy overall (Spearman's rho = 0·301 and 0·217 respectively).

In addition to feeding visits, non-feeding occupation of the feeder is of interest, particularly since feeding order is correlated with dominance. Figure 4 illustrates the total number of non-feeding visits over all seven feed cycles of which video-recordings were made. Visits made after all sows had fed are not included in the Figure, so that sows who have not fed are being excluded from the feeder by the visits shown.

High social rank and total time of non-feeding occupation of the feeder were positively correlated (Spearman's rho = 0·664, $P < 0·01$), as were position in the feeding order and non-feeding occupation (Spearman's rho = 0·725, $P < 0·01$). This relationship is due mainly to the activity of the two most

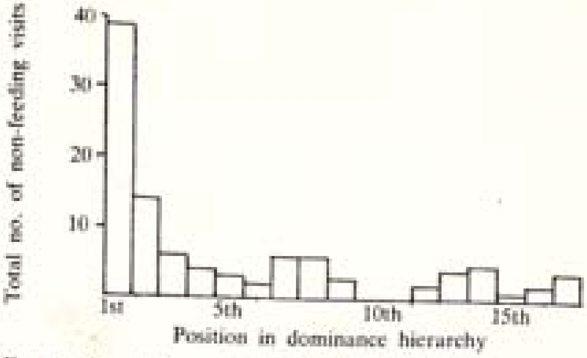

FIG. 4. Non-feeding visits before all sows have fed *v.* position in dominance hierarchy.

dominant sows, whose non-feeding visits accounted for 0·52 of all non-feeding visits.

The results show that older sows with experience of the feeder during previous parities, tended to be high in the feeding order and dominance hierarchy, and could exclude younger sows from the feeder by repeated non-feeding visits.

Social behaviour of late feeders

The pre-feeding behaviour of late feeders was very variable both in the total number of each sow's interactions, and the type of interactions in which sows are involved (Table 5). As before, sows 1, 4 and 9 have been excluded, due to failure to feed on one occasion.

TABLE 5
Social interactions of late feeders before feeding (sum of all observation periods)

Sow no.	Total interactions before feeding	Proportion of all interactions which are: Attacks/ displaces in queue	Is attacked/ is displaced in queue	Total unsuccessful attempts to enter feeder
18 (10th in order)	76	0·49	0·20	6
7	162	0·15	0·43	12
10	267	0·07	0·52	33
19	203	0·46	0·23	23
11	127	0·20	0·39	18
6	157	0·05	0·53	17
8	182	0·35	0·26	23
20 (17th in order)	79	0·33	0·25	4

Within Table 5, there is no significant difference between the categories, 'displaces or attacks' and 'is displaced or attacked', outside the feeder, indicating that late feeding sows are as likely to displace and attack, as be displaced or attacked themselves. Unsuccessful attempts to enter the feeder were estimated during direct observation by counting the number of times a sow was in the feeder queue when the feeder was vacated without subsequently gaining access to the feeder. There was no significant correlation between position in the lower half of the feed order and total number of unsuccessful attempts to enter the feeder.

This lack of consistency in the behaviour of late feeders may be explained in part by the fact that the later half of the feed order is significantly less stable than the earlier half (Figure 2) and the correlation between feed order and dominance hierarchy is not significant for the lower half of the feed order, as reported in the previous section. Certain sows in the upper half of the social hierarchy ate relatively late, for example sow 19 (Table 4) and this accounted for the success of some late feeders in displacements and attacks outside the feeder. There was no significant relationship (median test) between position in the feeding order or dominance hierarchy, and tendency to attack or be attacked inside the feeder, although it is worth noting that two sows in the lower half of the social hierarchy and feeding order (sows 7 and 11) were responsible for proportionately 0·58 of all attacks in the feeder, and 0·65 of sows never attacked others in the feeder.

DISCUSSION

Social hierarchy

Dominance hierarchies, based mainly on avoidance behaviour of subordinate animals, have been found previously in group-housed (Jensen, 1982) and free-ranging sows (Jensen and Wood-Gush, 1984) and the results of this study would seem to support the idea of an 'avoidance order' as being a better description of the social organization of sows than a dominance hierarchy based on aggressive encounters. One of the behavioural categories (displacement with no resistance) is very similar to that described for a group of pigs by Schnebel and Griswold (1983). These authors suggested that the lowering of the head and eyes of the retreating sow may have the effect of inhibiting aggression in the dominant animal, and this may explain why attack was much less frequent than non-aggressive displacement in the feeder queue. Ranking in a linear order may not be the best way to represent the dominance hierarchy, as assumptions have to be made about unclear relationships within pairs of sows. However, with the exception of six reversals of dominance (Table 4), the hierarchy does seem to be reasonably linear. Instability within the middle and lower part of the hierarchy has also been found by Meese and Ewbank (1972), observing groups of growing pigs.

There is some evidence that there may be differences in the dominance hierarchy in the straw-bedded area compared with that in the feeder queue, as three reversals of dominance were seen within pairs of sows when these two areas were compared. Evidence for this is limited because of the lower number of social interactions occurring in the straw, but it has been found previously that dominance hierarchies are not static, but change according to the type of resource (e.g. food or space) for which animals are competing (Gage, 1978).

Behaviour of introduced sows

Four of the five sows introduced to the group were in the top half of both the feeding order and social hierarchy (Table 4). The parities of these sows varied from four to nine, and all had experience of the feeder in at least one previous parity. As both of these variables were positively correlated with position in the feeding order this may explain in part the success of the newcomers within the group. The fact that the sows introduced were experienced older sows may have been a factor in quickly establishing a relatively stable feeding order and dominance hierarchy. Although direct comparison is difficult, the level of aggression seen in the observed group appeared to be more like that of the 'static' rather than 'dynamic' groups of 24 observed by Lambert *et al.* (1985 and 1986) despite the fact that five new sows were introduced less than 24 h before the start of observations.

Feeding order stability

Although feeding order was relatively stable and was positively correlated with dominance hierarchy (Figure 3) this relationship tended to break down in the later half of the feeding order. This is probably related to the competition between sows to make both feeding and non-feeding visits in the afternoon (Table 2). As may be expected, the most dominant sows chose to eat early in the feed cycle, and deviated little from their mean feeding positions (Figure 2). Older sows, with more experience of the feeder, ate earlier than younger, less experienced sows, a finding similar to that of Olsson, Andersson, Rantzer, Svendsen and Hellstrom (1986). During the later part of the day, sows lower in the dominance hierarchy were competing both with each other to make feeding visits, and with more dominant sows, such as 2 and 14, who made non-feeding visits later in the day. Hence the stability of the later half of the feed order is low. It is interesting that, although they had the opportunity to do so, none of the three non-feeders ate during the night. This suggests that the process of social faciliation which is known to affect groups of growing pigs (Hansen, Hagelso and Madsen, 1982) was affecting feeding behaviour in this group of sows. The continual presence of a queue outside the feeder provides further evidence for this, and raises questions about the welfare of sows who attempt to feed simultaneously but are unable to do so.

General discussion

Various strategies were adopted in using the feeder. Some sows fed early and were relatively inactive socially (Table 4) throughout the day. Number 17, for example, fed early and then spent most of the day inside the kennel. Others, such as number

20, lay in the kennel for most of the day, waiting till late in the afternoon to attempt to enter the feeder. Olsson *et al.* (1986) reported that many of the sows feeding late in the day were passive for most of the time. Some early feeders continued to revisit the feeder during the day, causing disruption of the later part of the feeding order, while some later feeders made repeated attempts to enter the feeder (Table 5). Sow number 2 for example, one of the introduced sows, was responsible for proportionately 0·45 of all non-feeding visits. Removal of this sow after feeding by means of a shedding facility (if available) may have reduced disruption at the later end of the feeding order, but it is also possible that the removal of the most dominant sow may have a destabilizing effect on the group and lead to other sows revisiting the feeder more often.

Apart from the problems caused by persistent revisiting of the feeder, the sows adapted well to the use of the system, mainly because of the quick establishment of a relatively stable dominance hierarchy based largely on avoidance by less dominant sows. This was reflected in a stable feeding order, and a low level of overt aggression within the group. Provided groups are carefully monitored when they are first formed, or when individuals are added, and such factors as siting of the feeder have been taken into account (Edwards and Riley, 1986), this study suggests that levels of aggression can be acceptably low in this type of housing system. However, extrapolation from the results of one study must be done with caution as the age and experience of animals being introduced to a group may be an important factor in determining how quickly social stability and low levels of aggression are achieved. Further studies on the introduction of sows of varying parities and experience of the feeder are required to evaluate how important these factors are. Information is also required on the social organization of larger groups of sows, using a number of different designs of feeder. Information on the behaviour of sows in groups is very limited and problem areas which may occur when sows are group-housed need to be identified.

ACKNOWLEDGEMENTS

The authors would like to thank the Director and staff of Terrington Experimental Husbandry Farm for their help during the study. E. Hunter is supported by a MAFF postgraduate studentship.

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(*Received* 21 *August* 1987—*Accepted* 13 *February* 1988)