

TO MY PARENTS - MR AND MRS TSE-CHUNG HSIA

獻給敬愛的父母親

夏子中先生暨夫人



DECLARATION

I declare that the composition of this thesis and the investigations described herein are my own work, except where reference has been made to published literature.

Liang Chou Hsia

## ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Professor D G M Wood-Gush for many helpful suggestions in the preparation of this thesis. I also thank Mr R Morlèy Jones, Head of the Statistics Department, ARC Poultry Research Centre, Roslin, for his suggestions for the various statistical analyses.

Many thanks to the staff of the Pig Unit and the Library of the School of Agriculture, University of Edinburgh, for their kind help. Many thanks also to the staff of the Edinburgh Regional Computing Centre for their assistance in the use of the computer.

I would like to thank the National Science Council, Pig Research Institute, Taiwan, Republic of China, for their partial financial support.

Finally I wish to express my special gratitude to my parents, my wife and children for their patience and encouragement.

## SUMMARY

The relationship between social facilitation and feeding behaviour was studied, using growing and finishing pigs. The results showed that the pigs' feeding activity was influenced by their social environment.

Both positive and negative social facilitation was found in the feeding behaviour of pigs kept in groups. The factors which caused these different types of social facilitation were studied. Moderate competition in an 8-hour feeding régime may produce positive social facilitation of feeding behaviour while serious competition, eg in a newly founded group, can cause negative social facilitation of feeding behaviour.

Pigs with different social ranks show different reactions to the stimulation from their social environment, which produces different results with regard to social facilitation. The dominant pigs reacted more strongly to the social environment than the inferior pig in the present results.

The group size of the pigs may also cause differences in social facilitation, but results are not clear on this point. The feeding speed of a companion pig seems to be unimportant in causing differences in social facilitation of the feeding behaviour of the subject pigs.

The physical character of feeds may play an important rôle in influencing social facilitation in some circumstances. The present results demonstrated that, if the feeding drive is the dominant drive, it can be positively facilitated by social environment, but when the feeding drive is a subordinate drive, then social

facilitation can be decreased by the social environment.

The pigs showed strong allelomimetic behaviour in feeding activity. The food intake and eating speed of the pigs increased with increase in body weight but the total feeding time decreased, or kept constant, when the body weight increased. The eating speed may vary according to the following factors: the individual pig, the pig's body weight, competition, the length of the period of food availability and physical characteristics of the feeds. The pattern of feeding behaviour changes with increasing body weight. The present thesis also strongly indicates that the food in the form of meal is not as easily ingested by pigs as pelleted food.

Activity	22
Feet	23
Various experiments	23
Learning	26
Causes of social facilitation	30
Definition of social facilitation	32
COMPETITION IN PIGS	36
Responsibility for resources	37
Screened competition	38
Unscreened competition	38
Intensity	39
The effect of competition on the performance of piglets before weaning	39
The relationship between the birth order and the social order of weaning pigs with respect to competition	40
Social dominance	41
The effect of social order on performance	43
Fighting and submission	44

CONTENTS

	Page
<u>INTRODUCTION</u>	1
<u>CHAPTER 1 LITERATURE AND REVIEW</u>	3
GENERAL REVIEW OF SOCIAL FACILITATION	3
Negative social facilitation	6
The factors which affect social facilitation	10
Competition	10
Dominance and social organisation	16
Deprivation	19
Strange environment	21
Activity	22
Fear	23
Previous experience	23
Learning	26
Causation of social facilitation	30
Definition of social facilitation	35
COMPETITION IN PIGS	36
Competition for resources	36
Scramble competition	36
Contest competition	36
Territory	37
The effect of competition on the performance of piglets before weaning	39
The relationship between the teat order and the social order of weaning pigs with respect to competition	40
Social dominance	41
The effect of social order on performance	43
Fighting and cannibalism	44

	Page
Aggressive behaviour patterns	46
Encounters between adult pigs	46
Encounters between suckling piglets	46
Encounters in growing and finishing pigs	47
FEEDING ACTIVITY OF PIGS	50
Introduction	50
The development of feeding activity in pigs	50
The suckling period	52
The growing and finishing period	52
Mature pigs	53
Conclusions	53
The relationship between feeding behaviour and competition	54
Social facilitation in pigs	56
<u>CHAPTER 2   GENERAL MATERIAL AND METHODS</u>	58
Animals	58
Housing	58
<u>CHAPTER 3   THE DEVELOPMENT OF FEEDING BEHAVIOUR AND ALLELOMIMETIC BEHAVIOUR</u>	62
INTRODUCTION	62
MATERIALS AND METHODS	62
Animals	62
Treatments	62
Housing and facilities	63
Husbandry and Procedure	65
Behavioural measurements	65
RESULTS	66
Definition of a 'meal'	66

	Page
Total food consumption	67
Feeding time	68
Feeding time in a period as a percentage of total feeding time	71
Number of meals	73
DISCUSSION	76
<u>CHAPTER 4 THE RELATIONSHIP BETWEEN SOCIAL FACILITATION AND FEEDING BEHAVIOUR</u>	109
INTRODUCTION	109
METHODS AND MATERIALS	109
Animals	109
Husbandry	111
Procedure	111
Feeding behaviour	112
Aggressive behaviour	112
Other relevant behaviour	113
RESULTS	117
1 Aggressive behaviour	117
(a) Social hierarchy	117
(b) Aggressive behaviour	118
2 Feeding behaviour	121
(a) General observations	121
(b) Food consumption	123
(c) Total feeding time	126
Total feeding time during first meal	127
(d) Eating speed	128
(e) Feeding bouts	129
3 'Other relevant' behaviour	131

	Page
(a) Drinking behaviour	131
(i) Drinking after waking from sleep and before feeding	131
(ii) Drinking within one minute after the start of feeding	131
(iii) Drinking during the meal period excluding the first minute of the meal	132
(iv) Drinking after the meal	132
(v) Drinking during the sleeping period	132
(vi) Drinking during rooting period	132
(vii) Total number of drinking bouts	133
(b) Urination	133
(i) Urination between two feeding bouts, in that pigs stopped eating and went to urinate then returned to eat again	133
(ii) Urination between two sleeping bouts	133
(iii) Urination after sleep but before feeding	134
(iv) Urination during rooting periods	134
(v) Total number of urinations	134
(c) Defecation behaviour	135
(i) Defecation between two consecutive feeding bouts within one meal	135
(ii) Defecation after feeding	135
(iii) Defecation after sleeping but before feeding	135
(iv) Defecation during rooting	135
(v) Number of double defecations within a ten minute period	136
(vi) Total number of defecations	136
DISCUSSION	137

	Page
<u>CHAPTER 5 THE EFFECT OF REUNION AND SEPARATION IN THE MORNING ON THE FOOD INTAKE OF PIGS</u>	173
INTRODUCTION	173
MATERIALS AND METHODS	173
Animals	173
Treatment	173
Procedure and Husbandry	174
RESULTS	175
DISCUSSION	175
<u>CHAPTER 6 THE EFFECT OF THE DISTANCE BETWEEN TWO PIGS ON THEIR FOOD INTAKE</u>	179
INTRODUCTION	179
MATERIALS AND METHODS	179
Animals	179
Treatment	179
Part 2	180
Husbandry	180
Procedure	180
RESULTS	181
Part 1	181
Part 2	181
DISCUSSION	182
Part 1	182
Part 2	182
<u>CHAPTER 7 THE EFFECT OF MIXING PIGS WITH STRANGE PIGS ON THE FEEDING BEHAVIOUR OF THE PIGS</u>	186
INTRODUCTION	186
MATERIALS AND METHODS	186

	Page
Animals	186
Treatment and Procedure	186
Behavioural observations	187
Housing and Management	188
RESULTS	188
DISCUSSION	189
<u>CHAPTER 8 THE EFFECT OF SOCIAL ORDER ON THE FEEDING BEHAVIOUR OF PIGS</u>	199
INTRODUCTION	199
MATERIALS AND METHODS	199
Part 1	199
Animals	199
Treatment	199
Procedure	200
Part 2	201
Animals	201
Treatment	201
Procedure	201
Part 3	201
Animals	201
Procedure	202
Treatment	202
RESULTS	203
Part 1 and Part 2	203
Part 3	204
DISCUSSION	204
Part 1 and Part 2	204
Part 3	205

	Page
<u>CHAPTER 9    OBSERVATIONS ON THE EFFECT OF SENSE ORGANS ON THE                   FOOD INTAKE OF PIGS</u>	214
INTRODUCTION	214
MATERIALS AND METHODS	214
Animals	214
Treatments	214
Procedure	215
RESULTS	215
DISCUSSION	215
<u>CHAPTER 10    THE EFFECT OF THE PHYSICAL CHARACTERISTICS OF THE                   FOOD AND THE GROUP SIZE OF THE PIGS ON THE                   FEEDING BEHAVIOUR OF THE PIGS</u>	219
INTRODUCTION	219
MATERIALS AND METHODS	219
Animals	219
Treatments	219
Husbandry	221
Procedure	222
RESULTS	224
Total feeding time	224
The total feeding time of the first meal	225
Total number of feeding bouts	225
Total number of feeding bouts in the first meal	226
Food intake	226
Eating speed	227
Social Hierarchy	227
Aggression	228
DISCUSSION	228

	Page
<u>CHAPTER 11 THE EFFECT OF LENGTH OF FOOD DEPRIVATION OF THE COMPANION PIGS ON THE FEEDING ACTIVITY OF THE SUBJECT PIGS</u>	237
INTRODUCTION	237
MATERIALS AND METHODS	237
Part 1	237
Animals	237
Treatments	237
Part 2	238
Animals	238
Treatments	238
Procedure and Husbandry	239
Procedure	240
RESULTS	241
Part 1	241
Part 2	242
DISCUSSION	243
Part 1	243
Part 2	246
<u>CHAPTER 12 THE EFFECT OF LENGTH OF FOOD DEPRIVATION ON THE RUNNING SPEED AND FEEDING ACTIVITY IN SOLITARY AND SOCIAL CONDITIONS</u>	258
INTRODUCTION	258
MATERIALS AND METHODS	258
Part 1	258
Animals	258
Treatment	258
Procedure and Husbandry	259

LIST OF TABLES

	Page
Part 2	260
Table 1. Animals	260
Treatment	260
Part 3	262
Table 2. Treatments	262
Table 3. Procedure	263
<b>RESULTS</b>	265
Part 1	265
Part 2	267
Part 3	270
<b>DISCUSSION</b>	272
Part 1	272
Part 2	273
Part 3	274
<b><u>GENERAL DISCUSSION</u></b>	291
Allelomimetic behaviour	292
Competition	293
The social hierarchy	293
The physical characteristics of the food	294
Group size	294
The eating speed of the other pig	294
Other activities	295
The causation of social facilitation	295
<b>REFERENCES</b>	297

LIST OF TABLES

		Page
Table 1.1	The conflicting reports on social facilitation in which learning is involved	29
Table 2.1	The composition and ingredients of feed	60
Table 3.1	The minimum meal interval of each pig in the two treatments and in each body weight stage	83
Table 3.2	The effect of light treatments and body weight on food intake, eating speed and the percentage of total time devoted to feeding of pigs in 23.5 hours	84
Table 3.3	The effect of light treatment and body weight on the total feeding time for the three time periods and combinations of these periods	85
Table 3.4	The effect of light treatments and body weight on percentage of total feeding time for the three time periods and combinations of the time periods	86
Table 3.5	The effect of light treatments and body weight on the total number of meals for the three time periods and combination of the time periods	87
Table 3.6	The results of how many meals which any two pigs of four pigs in both Treatment 1 and Treatment 2 ate at the same time under different body weights	88
Table 4.1	The initial body weights (IWT) and final body weights (FWT) and position in the social hierarchy of the pigs in the experiment	146
Table 4.2	The total number of skirmishes which occurred between the pigs of different ranks in both competitive treatments	147
Table 4.3	The number of 'win-lose' and undecided skirmishes together with the total number of skirmishes for the four social ranks in two competitive treatments	148
Table 4.4	The effect of group, closed stall and isolated feeding on the feeding behaviour of pigs	149

	Page	
Table 4.5	The effect of group, closed stall and isolated feeding on the food consumption of the four pigs in each replicate	150
Table 4.6	The effect of group, closed stall and isolated feeding on the feeding behaviour of the pigs in replicate 2	151
Table 4.6a	The effect of social order and treatment on total feeding time of pigs in replicate 2	152
Table 4.7	The effect of social order on food intake and eating speed of pigs in single pig with sheep treatment and closed stall treatment	153
Table 4.8	The effect of treatment and rank on total feeding time (TFT) of the pigs	154
Table 4.9	The effect of treatment and rank on number of feeding bouts of the pigs	155
Table 4.10	The effect of treatment and social rank on drinking behaviour of the pigs	156
Table 4.11	The effect of treatment and social rank on number of urinations	157
Table 4.12	The effect of treatment and social rank on the number of defecations in the pigs	158
Table 5.1	The effect of reunion and separation in the morning on the food intake of pigs	177
Table 6.1	The effect of distance between two pigs on the food intake of the pigs	183
Table 7.1	The relationship between food intake and the pigs in temporary groups of the different ranks during three occasions of mixing in the treatment	192
Table 8.1	The effect of the treatments on food intake and feeding time of the pigs	206
Table 8.2	The effect of the treatments on the feeding times of the remaining pigs within ten minutes after introducing a hungry pig in part 3	207
Table 9.1	The effect of treatment on food intake of pigs	217

LIST OF FIGURES

		Page
Table 10.1	The effect of the physical characteristics of the food and group size of the pigs on feeding activities of the pigs	230
Figure 2-1		33
Table 11.1	The relationship between the length of food deprivation and feeding activities	249
Figure 1-4		31
Table 11.2	The effect of length of food deprivation of the companion pig on the feeding activities of the subject pig	250
Figure 2-1		31
Table 12.1	The effect of length of food deprivation time on feeding activities and running speed of pigs	277
Figure 2-2		36
Table 12.2	The effect of treatment on feeding activities and running speed of pigs	278
Table 12.3	The effect of feeding in pairs and alone on feeding activities of pigs	279
Table 12.4	The effect of social facilitation and frustration on running speed of pigs	280
Figure 3-3a	Survivorship curves for feeding interval of pigs when they weighed around 30 kg	34
Figure 3-4	The relationship between food intake and body weight of pigs in Chapter 3	35
Figure 3-5	The relationship between eating speed and body weight of pigs in Chapter 3	36
Figure 3-6	The relationship between eating speed per unit of body weight and body weight	37
Figure 3-7a	The distribution charts of total feeding time of each pig (P) in each treatment (T) during the last day when the pigs weighed around 30 kg	39
Figure 3-7b	The distribution charts of total feeding time of each pig (P) in each treatment (T) during the last day when the pigs weighed around 40 kg	39
Figure 3-7c	The distribution charts of total feeding time of each pig (P) in each treatment (T) during the last day when the pigs weighed around 50 kg	100
Figure 3-7d	The distribution charts of total feeding time of each pig (P) in each treatment (T) during the last day when the pigs weighed around 60 kg	101

LIST OF FIGURES

	Page
Figure 1-1	38
Figure 1-2	51
Figure 2-1	61
Figure 3-1	89
Figure 3-2	90
Figure 3-3a	91
Figure 3-3b	92
Figure 3-3c	93
Figure 3-3d	94
Figure 3-4	95
Figure 3-5	96
Figure 3-6	97
Figure 3-7a	98
Figure 3-7b	99
Figure 3-7c	100
Figure 3-7d	101

		Page
Figure 3-8	The relationship between total feeding time and body weight of pigs in Chapter 3	102
Figure 3-9	The relationship between feeding time over the first and second 8 hours and last 7.5 hours and body weight of pigs	103
Figure 3-10	The relationship between the percentage of total feeding time over the first and second 8 hour and last 7.5 hours and body weight of pigs	104
Figure 3-11a	The minimum similarity on feeding at same time between four pigs in which No 1 and No 2 were in the same room and No 3 and No 4 were in the same room. This was recorded when pigs weighed around 20 kg	105
Figure 3-11b	The minimum similarity on feeding at the same time between four pigs in which No 1 and No 2 were in the same room and No 3 and No 4 were in the same room. This was recorded when the pigs weighed around 40 kg	106
Figure 3-11c	The minimum similarity on feeding at the same time between four pigs in which No 1 and No 2 were in the same room and No 3 and No 4 were in the same room. This was recorded when the pigs weighed around 60 kg	107
Figure 3-11d	The minimum similarity on feeding at the same time between four pigs in which No 1 and No 2 were in the same room and No 3 and No 4 were in the same room. This was recorded when the pigs weighed around 80 kg	108
Figure 4-1	Plan of room arrangement in single pig with sheep treatment	159
Figure 4-2	Plan of room arrangement in closed stall treatment	160
Figure 4-3	Plan of room arrangement in long trough treatment	161
Figure 4-4	Plan of room arrangement in single trough treatment	162

		Page
Figure 4-5a	The figures denote the social order of the pigs and the order of observations in the closed stall treatment. In the SP treatment only one pig was observed each day and the order of observation is given by the column which forms part of the Latin square	163
Figure 4-5b	For explanation see Figure 4-5a	164
Figure 4-5c	For explanation see Figure 4-5a	165
Figure 4-5d	For explanation see Figure 4-5a	166
Figure 4-6	The encounters which happened in second replicate. The arrow shows which pig beat which pig in win-loss encounters. In draw encounters it represents which started fighting. The number on the arrow represents the number of encounters	167
Figure 4-7	The relationship between food intake and body weight of pigs in different treatments	168
Figure 4-8	The relationship between food intake per unit of body weight and body weight of pigs in different treatments	169
Figure 4-9	The relationship between total feeding time and body weight of pigs	170
Figure 4-10	The relationship between eating speed and body weight of pigs in different treatments	171
Figure 4-11	The relationship between eating speed per unit of body weight and body weight of pigs in different treatments	172
Figure 5-1	The 4 x 4 Latin square design of experiment in Chapter 7. The figures represent the treatment	178
Figures 6-1, 6-2 and 6-3	Plan of room arrangement of the 3 treatments in Chapter 6	184
Figure 6-4	The 3 x 3 Latin square design of the experiment in Chapter 6. The figures represent the treatment	185
Figure 7-1	A schedule of observations for Treatment 1 and Treatment 2 in Chapter 7	193
Figure 7-2	Plan of room arrangement in Chapter 7	194

	Page	
Figure 7-3a	The average daily food intake of pigs in Treatment 1 after the start of the experiment	195
Figure 7-3b	The average daily food intake of pigs in Treatment 2 after the start of the experiment	196
Figures 7-4a and 7-4b	The skirmishes which occurred in both group 7-4a and 7-4b in Treatment 1 after mixing of the pigs	197
Figures 7-5 and 7-6	The skirmishes which occurred in the temporary mixed group of dominant pigs on the 12th, 22nd and 32nd day	198
Figure 8-1	The 6 x 6 Latin square design in part 1 of Chapter 8	208
Figure 8-2	Plan of room arrangement in part 1 of Chapter 8	209
Figure 8-3	Plan of room arrangement in part 2 of Chapter 8	210
Figure 8-4	The 6 x 6 Latin square design in part 2 of Chapter 8	211
Figure 8-5	The 3 x 3 Latin square design in part 3 of Chapter 8	212
Figure 8-6	Plan of room arrangement in part 3 of Chapter 8	213
Figure 9-1	Plan of room arrangement in Chapter 9	218
Figure 10-1	Plan of room arrangement in Treatment 1 and Treatment 4 of Chapter 10	231
Figure 10-2	Plan of room arrangement in Treatment 2 and Treatment 5 in Chapter 10	232
Figure 10-3	Plan of room arrangement in Treatment 3 of Chapter 10	233
Figure 10-4	The 6 x 6 Latin square design in Chapter 10	234
Figure 10-5	The relationship between eating speed per unit of body weight and body weight of pigs in different treatments of Chapter 10	235

	Page	
Figure 10-6	The relationship between eating speed and body weight in different treatments of Chapter 10	236
Figure 11-1	Plan of room arrangement in Chapter 11	251
Figure 11-2	The 5 x 5 Latin square design in part 1 of Chapter 11	252
Figure 11-3	The 6 x 6 Latin square design in part 2 of Chapter 11	253
Figure 11-4	The effect of the length of food deprivation on food intake of light-weight pigs	254
Figure 11-5	The effect of the length of food deprivation on food intake of heavy-weight pigs	255
Figure 11-6	The effect of the length of food deprivation on food intake on total feeding time of light-weight pigs	256
Figure 11-7	The effect of the length of food deprivation on total feeding time of heavy-weight pigs	257
Figure 12-1	Plan of development house for running experiment in Chapter 12	281
Figure 12-2	The 5 x 5 Latin square design in part 1 of Chapter 12	282
Figure 12-3	The 5 x 5 Latin square design in part 2 of Chapter 12	283
Figure 12-4	The effect of the length of food deprivation on food intake of pigs in Chapter 12	284
Figure 12-5	The effect of the length of food deprivation on the total feeding time of pigs	285
Figure 12-6	The effect of the length of food deprivation on the wandering time of pigs	286
Figure 12-7	The effect of the length of food deprivation on running speed of pigs on the first section of the course	287
Figure 12-8	The effect of the length of food deprivation on running speed of pigs on the second section of the course	288

Figure 12-9 The effect of the length of food deprivation on running speed of pigs on the whole course 289

Figure 12-10 The effect of treatment on the running speed of pigs on the first section of the course 290

and more in the growing stage.

There were a lot of studies on the effect of external and internal factors on the food intake of pigs. However, the first aspect of feeding behavior in pigs which has not attracted attention in the past is the effect of social factors. Some work has been done on social facilitation of feeding in other animals, for example, the monkey (Singer, 1948; Selman, 1954, 1957; Sleytr, 1956, 1971; De Goo, 1958, 1959; Sneyd and Jevons, 1961; and monkey (Singer and Selman, 1951) and the dog (Clem and Bray, 1949).

To investigate whether social environment may change a pig's eating behavior, it was one of the objects of this study. In particular the thesis is concerned with the studies of whether social facilitation occurs in the feeding behavior of pigs at work. It also investigated the problem of whether both positive and negative social facilitation occurs in the pig. If both positive and negative social facilitation are found in pigs, then it is interesting with finding which factors cause such differences. Finally, it was concerned with the occurrence of social facilitation.

To answer the above questions, the following experiments were designed. The normal feeding pattern of pigs and also abnormal behavior were studied in Chapter 3. Whether hunger or satiety of pigs in the growing stage influence the food intake of pigs was studied in Chapter 5.

## INTRODUCTION

To increase the food intake of growing pigs is a critical problem for the farmer, because pigs grow more efficiently if they eat more in the growing stage.

There were a lot of studies on the effect of external and internal factors on the food intake of pigs. However, one important aspect of feeding behaviour in pigs which has not received much attention in the past is the effect of social factors. Some work has been done on social facilitation of feeding in other species, for example, the poultry (Bayer, 1929; Tolman, 1964, 1967; Clayton, 1976, 1977), the rat (Harlow, 1932; Hoyenga and Aeschleman, 1969), the monkey (Harlow and Yudin, 1933) and the dog (Ross and Ross, 1949).

To investigate whether social environment may cause a pig to eat more, or less, is one of the objects of this thesis. In particular the thesis is concerned with the problem of whether social facilitation occurs in the feeding behaviour of pigs or not. It also investigated the problem of whether both positive and negative social facilitation occurs in the pig. If both positive and negative social facilitation are found in pigs, then it is concerned with finding which factors cause such differences. Finally, it was concerned with the causation of social facilitation.

To answer the above questions, the following experiments were designed. The normal feeding pattern of pigs and allelomimetic behaviour were studied in Chapter 3. Whether reunion or separation of pigs in the morning would influence the food intake of pigs was studied in Chapter 5.

The following factors which may affect the result of social facilitation were studied. (1) Competition (Chapter 4 and Chapter 10). (2) Reunion (Chapter 5). (3) The distance between two pigs (Chapter 6). (4) The effect of severe competition of feeding (Chapter 7). (5) Social order (Chapter 8). (6) The physical characteristics of food and group size (Chapter 10). (7) The eating speed of the companion pig (Chapter 11). The sensory modalities involved in the social facilitation of feeding was studied in Chapter 9. The causation of social facilitation was studied in the final experiment (Chapter 12). Discussion follows the results in each chapter and a general discussion, which puts all the important points together, is given in the final part of the thesis.

CHAPTER 1 LITERATURE AND REVIEW

## GENERAL REVIEW OF SOCIAL FACILITATION

The pioneer researcher on social facilitation, Triplett (1897), investigated the racing times of cyclists and found that the best times were always during simultaneous competition, while somewhat poorer but still very good times were obtained for paced races against time. Distinctly inferior performances were always made by cyclists racing alone against time. Using the results of this bicycle racing experiment, Triplett examined seven theories and recommended one of them - 'the theory of dynamogenesis'. His theory assumed that the bodily presence of another rider is a stimulus to the racer in arousing the competitive instinct; that another can thus be the means of releasing, or freeing, nervous energy for him that he cannot release by himself; and further that the sight of movement in the other perhaps suggests a higher rate of speed, and is also an inspiration to greater effort. Allport (1924) modified the dynamogenetic theory and suggested that the activity of an individual in groups is enhanced by two factors. The first is social facilitation, which consists of an increase of response merely from the sight or sound of another making the same movements. The second is rivalry or emotional reinforcement of movement accompanied by the conscious desire to win. Its precise meaning and its relationship to other terms, such as imitation, social stimulation, social inhibition, allelomimetic behaviour etc, has not been clear since the social facilitation was first introduced by Allport (1924).

Some people have tried to define social facilitation. For

example, Crawford (1939) suggested that the general term 'social facilitation' may refer to any increment of individual activity which results from the presence of another individual, and can be regarded as one of the most basic forms of social interaction. In the literature on animal behaviour its meaning has been restricted to the increment in the frequency and intensity of responses by an individual, shown in the presence of other individuals usually engaged in the same behaviour. In this definition he excluded any decrement which may be caused by the presence of other individuals. Allee *et al* (1949) recommended that social facilitation should refer to any increment or decrement in an individual's behaviour resulting from the presence of another conspecific. His definition did not avoid confusion, eg whether the behaviour is learned or unlearned and whether both actor and reactor engaged in the same behaviour or not.

Some other people try to define social facilitation by including causal implications. For example, Armstrong (1951) felt that the term social facilitation had been used in so many varying and imprecise ways as to be virtually useless. As a substitute he suggested the term 'mimesis' and gave it the following definition - 'mimesis occurs when, and implies that, the species is so constituted that the perception of certain innate behaviour-patterns performed by another animal is the releaser of the same, or closely similar, innate behaviour-patterns by the observing individual' - or more briefly - 'mimesis consists of the reproduction by one animal of the instinctive behaviour-patterns of another'. In this definition some ambiguities were pointed out by Hinde (1953). One of them is the causal implication of the words '... is the

releaser'. Hinde considered this rather improbable: When a bird is feeding in a flock its behaviour is released by the food as well as by the behaviour of its neighbour. Such causal implications may cause ambiguity when included in the definition of social facilitation. This is because, as Clayton (1978) has stated, the causation may vary between species, or may even vary for the same species, in different situations.

Recently, Clayton (1978) modified Crawford's definition and suggested that socially facilitated behaviour can be defined as an increase in the frequency or intensity of responses or initiation of particular responses already in an animal's repertoire, when shown in the presence of others engaged in the same behaviour at the same time. He stressed that the term should be used descriptively without any causal implications. He also made the following five points to clarify his definition.

- 1 The initiation of behaviour in one animal, subsequent to its performance by another individual, can be considered as being social facilitation.
- 2 In as much as the definition specifically refers to increments in behaviour, the description of decrements in behaviour as social facilitation is misleading.
- 3 The definition also precludes behaviour that is in the course of acquisition.
- 4 The animals should be engaged in the same activity.
- 5 The effect should be transitory and confined to the period of co-action.

Confusion arises from the following points.

- A Allelomimetic behaviour also means the initiation of particular

- responses already in an animal's repertoire. Furthermore, it is advisable to separate the initiation of a particular response from the increment of the response. Allelomimetic behaviour will be used to cover initiation, and social facilitation will cover changes in increment and decrement.
- B If animals are kept in the same conditions, both negative or positive social facilitation may be produced by different levels of motivation, and the description of decrements in behaviour as social facilitation is correct.
- C If the conditions only allow one of a group of animals to do a thing one at a time, then social facilitation in which both actor and reactor engage in the same behaviour at the same time cannot occur.

#### Negative social facilitation

It is interesting to speculate whether negative social facilitation could result from the different levels of stimulation by the same factors that cause positive social facilitation. Shelley (1965) reported that group-reared rats ate less than rats reared singly under an *ad lib* feeding schedule. He came to the conclusion that the social facilitation effect might be the product of 'Once a day feeding as contrasted with *ad lib* feeding schedule'. This explanation was thought to be due to the higher levels of drive under a deprivation schedule, eg feeding once per day, which could preclude the effect of other drives such as curiosity, and to reduce the effectiveness of stimuli eliciting such behaviour as all animals are eating vigorously and making fewer irrelevant responses.

It was also suggested that the once a day schedule elicited

direct competition over the food (Shelley, 1965). That the socially isolated rats eat more, because there is little else to do, was suggested by Premack and Premack (1963). On the other hand, Hoyenga and Aeschleman (1969) have shown that 'social facilitation' did occur under *ad lib* as well as periodic feeding, but the work indicated rats on a periodic feeding schedule are more sensitive to social living conditions than rats on an *ad lib* feeding schedule. Hoyenga and Aeschleman (1969) used 4 rats for their social rearing group in the experiment, instead of 6 to 8 rats, as used in Shelley's experiment. They also suggested that Shelley's results might possibly be due to crowding in the cages, which caused the food to become contaminated with faeces and urine, thus becoming unpalatable to the social rats. The other explanation might be the size of group of the rats. The group size of rats in Shelley's trial was twice that of Hoyenga's.

Group size could induce two possibilities. First, when total eating time is limited and resting frequency does not change, then the total eating time of a low ranked animal may be limited, thus reducing the total food consumption. Secondly, aggression may increase with the increase of group size and it is possible that anxiety is higher among rats under a greater frequency of aggression. This may reduce total food intake too. According to some evidence (Le Magnen and Devos, 1970) the rat has an average of 7.9 discrete meals in a 24 hour period on an *ad lib* feeding schedule, and the interval between two meals has a strong correlation with previous meal size.

Another report (Syme *et al* 1974) pointed out that rats can take turns in feeding. For example, one rat can take his food ration

while the other chews, so that if the group size is small, then each rat may not only have sufficient time to eat but also the total food consumption may be increased by social stimulation. However, when the group size becomes big, although each animal may still have a chance to eat, the socially inferior animals may be disturbed by higher ranking animals. In this situation, if the animals still keep resting time constant, or reduce it only a little, then a decrement in food consumption of this group of animals is to be expected.

Another possibility which was demonstrated by Strongman (1975) is that the intake of popular food showed eating to be increased above control level by a low level of anxiety\*, and slightly decreased by medium and high levels of anxiety. On the other hand, a direct relationship was observed between level of anxiety and suppression of the intake of food, with food which had been adulterated with quinine. This report may suggest that small groups of animals eat more (eg Hoyenga and Aeschleman's findings) because of low levels of aggression which produce only slight anxiety. Conversely, large groups of animals eat less (eg Shelley's rats) because of more aggression which produces medium or high anxiety.

In running tests with dogs, Scott and McCray (1967) suggested that excessive competition has a disruptive effect, causing dogs to avoid each other, but that mild competition has no negative effect. Some other reports have also shown that either positive or negative social facilitation can happen in a group of animals.

\*Anxiety. A chronic complex emotional state with apprehension or dread as its most prominent component (Penguin Dictionary of Psychology).

Klopfer (1957) studied the feeding behaviour of wild adult male Green Finches (*Chloris Chloris*) and pointed out that, in the presence of untrained partners, learning speed was considerably reduced, while the presence of trained partners had a positive effect. This finding might be explained by the suggestion of Klopfer's (1959) in another report which pointed out that the learning ability of wild birds can be severely impaired when the training occurs under unnatural conditions and the presence of untrained birds might make the conditions unnatural. However, this suggestion cannot explain the result reported by Deni and Jorgensen (1976). They assessed the bar-pressing behaviour in experimentally naive undeprived rats during exposure to three conditions: (1) a trained companion, (2) an untrained companion, and (3) no companion. Non-nutritive sucaryl solution was used as the reinforcement for bar-pressing. Though overall levels of bar-pressing were low, the response during exposure to either trained or untrained companions was significantly lower compared to the no companion treatment. These differences between Klopfer's positive results and Deni and Jorgensen's negative results may be due to the use of different species, the difficulty of the learning task, the particular experimental conditions and so on.

Chen (1937) pointed out in his results that the amount of work accomplished by ants is more when they work in association than when they work in isolation, but he also pointed out that the slow co-worker has a retarding effect upon the work of an individual. This is further evidence to suggest that social facilitation may have either positive or negative results depending on the particular experimental conditions.

### The factors which affect social facilitation

The previous discussion has shown that the phenomenon of social facilitation can induce positive or negative results in a given behaviour pattern. It is of interest to know which factors can cause this variation and in which circumstances it can be found. The main factors to be considered here are competition, social order, deprivation, rate of response, fear, previous experience and environmental differences. The way these factors influence social facilitation will be discussed in detail one by one.

#### Competition

With regard to reward, there are two types of competition. Type 1: In which the winner, but also the other animals involved in a competition, are rewarded. Type 2: Where only the winner is rewarded. Although there are some differences between these two types of competition, animals may become anxious when they try to get their basic requirements, or to obtain a common goal, in either type of competition. The relationship between each type of competition and social facilitation will be discussed separately below. Type 1 competition: All animals in a group can be rewarded during competition.

Before investigating the relationship between this type of competition and social facilitation, first it is important to know whether group feeding can cause competition; secondly, the effect of serious or moderate competition on social facilitation will be discussed. Finally, some other factors which cause variation in competition and which induce different levels of social facilitation will be discussed.

With regard to group feeding and competition, an experiment by Harlow (1932) may be cited. Using rats, he took measurements during two 1 hour feeding periods per day, the rats fed individually during the first five days and fed in a group of four during the sixth day. Comparison was made between the fifth day (last day of individual feeding) and sixth day (first day group feeding). The results demonstrated that rats which fed in groups not only ate more but also caused three times more spillage of food when compared with the rats fed individually.

Later Harlow and Yudin (1933) studied the feeding behaviour of monkeys under the following four treatments. The first was called direct competitive facilitation. On the control days, a single animal was placed in a cage with food and the number of pieces of food eaten in 15 minutes was recorded. On the experimental days, two monkeys were introduced into the cage and the same measurement was taken. A second treatment was called non-competitive facilitation. In this non-competitive situation the animals were placed in separated living cages a foot apart, with food in the middle of each cage. On the control days, one of the cages was empty and only one monkey was scored. On the experimental or competitive days a single animal was placed in each cage and the amount of food eaten in 15 minutes was scored. The third treatment was called combined competitive and non-competitive facilitation. This situation was the same as the second, but while each cage had its own food, there was some additional food between the two cages, thus the monkeys could get food not only from their own cages but also from between the two cages. On the control day, there was again only one monkey in one of the cages. In the fourth treatment, the

robber situation, the two cages were placed side by side and the food was placed in the inside back corner of each cage, so that the two food stocks were side by side. On the competitive days, the monkey might eat from his own cage or else steal from his neighbour's cage by putting his fingers through the bars. The average result showed that monkeys ate more when paired than when single in all of the four treatments. Each treatment was run 5 times, and, looking at the four treatments in more detail, we find that in the direct competitive treatment (bread as food), the paired animals ate more in three out of five trials and in four out of five trials in the non-competitive treatment (orange as food). Furthermore, in both the robber treatment and the third treatment, the paired animals ate more in all trials. These results seem to suggest that monkeys in competition may show more positive facilitation than in non-competitive situations but, when the competition becomes more serious, positive facilitation may be damaged in some cases.

Other experimental results seem to support the view that serious competition will impair social facilitation. For example, in one of Welty's (1934) experiments in which mudminnow fishes (*Umbra limi*) were used, fishes were conditioned to jump out of the water for food held on the end of a feeding needle when a red light appeared 75 mm overhead. The average number of jumps, when the fish were fed in isolation, in pairs, groups of four and groups of ten, were recorded. The results showed that the isolated and paired fishes average about 20 jumps per fish per minute under the red light, while the groups of four averaged 10.3, and the groups of ten averaged 5.9 over 48 days. Welty explained these results by

pointing out that a part of the slowing down of the groups was undoubtedly due to the lessened opportunity of jumping in a given time. Furthermore, observations showed that definite antagonism between members of a group prevented many otherwise possible jumps. As one fish would assume the characteristic jumping position, another fish would often attack it with a vigorous jab in the belly. Welty's results not only demonstrated that competition can cause negative social facilitation but also showed that serious competition could damage social facilitation. For example, when the number of fish is increased, the amount of competition is increased, and the number of jumps is decreased. On the other hand, he found that the fish fed in groups ate more than isolated fish. These results were different from other experimental results mentioned by Welty (1934). Differences might firstly be due to the various species of fish being used. The fishes used in the former one were mudminnows (*Umbra limi*) and in the others were goldfish, paradise fish and zebra fish. Secondly, the differences might be due to the divergent feeding methods adopted. In the feeding method used in the former experiment, the fish had to jump out of the water, simultaneously, to get the food. The fishes in the other experiments, however, could get food from the tank easily. This seems to suggest that the serious competition which happened in the first experiment caused the negative social facilitation but the light competition which occurred in the later experiments caused positive social facilitation.

Tolman and Wilson (1965) used newly-hatched chicks as their experimental subjects and demonstrated that chicks ate even more in a group of sixteen than when alone, when the feed was spread on the

floor of the cage. This result might be due to light competition, because firstly newly-hatched chicks possibly do not show aggression. Secondly, the spreading of food on the floor would also decrease the level of competition. From the above discussion we may conclude that social facilitation can be influenced by the level of competition.

Individual variation between animals may be the other factor which causes variation in competition and social facilitation. For example, Vogel, Scott and Marston (1949) compared the running speed of a dog running alone with its speed when running with another dog. They found that, although the overall average was faster when running in pairs than when running alone, in some cases a dog ran faster singly than when in pairs. Similarly, Winslow (1944) reported that paired cats, on average, learned to solve a problem box faster than when tested alone, but still a small proportion responded more slowly in pairs than when alone. It clearly shows that individual variation can influence the results of social facilitation. From this discussion of Type 1 competition, it may be suggested here that social grouping may have two kinds of effect: One result of social grouping is to reduce the fear of an animal compared with its fear when the animal is alone. In this way social grouping may induce positive social facilitation. On the other hand competition can induce anxiety. Light competition may cause a light level of anxiety, and serious competition may cause a high level. As mentioned previously, Strongman (1965) has demonstrated that light anxiety can cause an increase of food intake and serious anxiety can cause a decrease in food intake - so that competition may induce either negative or positive social facilitation

according to the different levels of competition. The effect of group size on competition, and consequently on social facilitation, is still not very clear and needs further investigation.

Type 2 competition: Only the winner in a group of animals gets rewarded.

This type of competition can be produced in two ways. Firstly when rewards are provided only for the winner. Secondly, a limited reward is taken by the winner during competition. The relation between social facilitation and either of these types of competition will be discussed in the following two examples.

In the first examples reward was provided only for the winner. Scott and McCray (1967) studied the running speed of dogs. In their experiment they gave dogs 3 days of preliminary individual training. Each dog was given one single and one paired trial, each day, alternating the order on successive days. In some cases only the winner could get the reward in paired running; in other cases both dogs could get rewards after running. They found during repeated running that the dogs ran faster when paired than when alone, even when only the winning dog was rewarded. They also found that excessive competition (serious fighting) had a disruptive effect, causing dogs to avoid each other, but that mild competition had no such effect.

In the second example of the reward taken by the winner, Winslow (1944) studied the running speed of cats and reported that the cats were inhibited in their speed of running by the presence of competitors. An increase in the number of competitors did not seem to have made a big difference on running speed when compared with only one competitor. Aggression occurred more frequently and more

intensively when there were three competitors than when there were two. It was usually directed by one loser against the other loser, as a form of displaced aggression. According to those reports on Type 2 competition, the following four interesting suggestions can be made. First, the unrewarded dogs did not decrease their speeds and some dogs ran the course and entered the goal box but would not touch the food in it (Vogel, Scott and Marston, 1949). This suggests that, apart from competition, there are still some other factors which cause social facilitation. For example, allelomimetic behaviour in which the dogs win at the same time but are not rewarded. Secondly, the running speed of the cats was decreased during paired running (Winslow, 1944) but not in all of the dogs (Vogel *et al* 1949). This suggests that the effect of competition on social facilitation varies between species. Thirdly, the evidence again shows that excessive competition has a disruptive effect on the running speed of dogs, but mild competition does not. Why excessive competition should happen in some pairs of dogs, but not on others, may really depend on individual animals. If this is true, then the fourth suggestion here is that the social facilitation may vary even within species.

#### Dominance and social organisation

An individual animal usually has its given social order in a social group. The effect of the social group on the social facilitation shown by an individual animal may vary depending on the animal's position in the social order. This kind of effect may be due to different levels of competition and fear according to the social rank of a given animal.

Bayer (1929) reported an experiment in which a hungry S-chick\* was placed before a large heap of wheat and allowed to eat until satiated and a hungry R-chick\* was then introduced. As soon as the R-chick was placed in front of the food it began to eat with great zeal. If the S-chick was the dominant animal, it began to attack the R-chick immediately. As soon as the S-chick noticed, however, that attack was having little success and that the R-chick continued to eat, the S-chick began once more to eat the food, intermittently striking at the R-chick. Even if the S-chick was the subordinate animal, it would begin to eat again, in spite of the fact that the dominant R-chick would strike at it from time to time. Bayer (1929) suggested that the sight of the dominant animal eating was apparently a strong stimulus to inhibit the fear which a subordinate animal normally felt. We may also explain these results in which the introduction of a hungry animal into a pen causes the satiated animal to eat again, by suggesting that the satiated animal becomes anxious because of competition and feeds, or that some other factor, such as allelomimetry, causes it to feed.

Harlow and Yudin (1933) demonstrated that when two Java monkeys were fed together, the inferior one did not eat during the first 5 minutes and watched the dominant one eating. Afterwards, the inferior monkey might eat but it never fed at the same time as the dominant animal. However, during the 15 minute observation every day the social pair did not eat more than a solitary animal would on its own. It seems not only that the inferior animal, but also the dominant one, ate less when they were feeding as a pair during the 15 minutes, but over the whole period monkeys ate more in social pairs than alone. It seems that a dominance-submission

\* S-chick = subject chick; \* R-chick = reactor chick

relationship may sometimes influence social facilitation during short testing periods. This kind of influence may vary according to the individuals. If some dominant animals are more aggressive than others, their influence will be different.

James (1961) used four puppies as experimental subjects. The four puppies were separated after weaning and kept in isolation until 90 days of age. After this time they were placed on a programme of individual versus social eating for 40 days, 20 days under each condition, on alternate days. The puppies were fed only once daily. In the 20 comparisons, the dominant animal ate more in 15 of the daily social tests than in the preceding individual tests, while the animal second in the social order ate more in 13 of the 20. The other two animals, the third and fourth in social order, had a higher food intake only in 5 and 7 social tests respectively. According to this result, James (1961) suggested that dominance is an important factor in social eating. Stamm (1961) demonstrated that although paired monkeys in adjacent pens ate more than when they were alone, the dominant monkey did not necessarily always eat more than the submissive one. Under solitary conditions the dominant monkey pressed the reward box significantly less than did the submissive partners.

The summary of reports in this section seems to suggest first, that the effect of the social order on social facilitation is not only through competition but is also through the attitude of animals of different rank. Second, in short testing periods, the social order may sometimes have an affect on social facilitation. However the long term effect is still not very clear. Third, the effect of the social order on social facilitation is not always the same.

For example, James and Cannon (1955) found that of five puppies which showed the greatest amount of positive social facilitation, two were the dominant animals and three were at the bottom of the hierarchy.

### Deprivation

The effect of food or water deprivation, or the interaction between deprivation and other factors on social facilitation of drinking and eating, will be discussed in this section. As I mentioned previously, Hoyenga and Aeschleman (1969) demonstrated that rats are more sensitive to social living conditions under periodic feeding than on *ad lib* feeding schedules. The rats showed stronger positive social facilitation under periodic feeding than under the *ad lib* feeding schedule. This result may indicate that deprivation time is an important factor for strong positive social facilitation.

Tolman and Wilson (1965) used chicks as their subjects. The chicks were tested for the amount of food consumed under a variety of social conditions which involved varying lengths of food deprivation. The results showed that positive social facilitation is optimal in the region of 6 hours of food deprivation and only minimal, if existent, at 0, 12 and 24 hours of food deprivation. Tolman and Wilson suggested that at 0 hour deprivation the rate of eating by chicks is low enough to be increased but too low to be stimulating to a companion. At around 6 hours deprivation the rate of eating is low enough to be increased to high enough to be stimulating. At 12 and 24 hours the rate is high enough to be stimulating but too high to show any increase. This seems to

suggest that positive social facilitation can be produced by a certain deprivation period in a group of animals. Whether a satiated animal still can be facilitated positively by a social group is uncertain. Some reports are negative. For example, Beck (1931) found that three hens once satiated could not be induced to further feeding by the addition of a fourth hungry hen. Harlow (1932) allowed rats an hour to feed to satiation. At the end of this 1 hour period a hungry rat (24 hour feed deprivation) was introduced and allowed to feed for an hour. The results showed that the satiated animals ate no more in the second hour in the presence of the hungry rat than when alone. These last two reports showed no positive social facilitation in satiated animals. However Ross and Ross (1945) allowed dogs deprived of food for 6 hours to feed until they stopped eating. Fifteen minutes later a hungry dog was introduced into the room and the satiated dogs started eating again. Thus the answer as to whether a satiated animal can be facilitated positively by social factors is uncertain.

These conflicting reports might be because either different species of animal show different responses, or different periods of food deprivation give different results. Clayton (1977) used 120 three to four day old Khaki Campbell ducklings as subjects to study drinking behaviour. In this experiment the number of ducklings deprived of water in a flock of four birds was varied from one to three. The test conditions were three deprived/one non-deprived (3D/1C); two deprived/two non-deprived (2D/2C); one deprived/three non-deprived (1D/3C). Non-deprived birds had access to both food and water and deprived birds only to food. The results showed that positive social facilitation of drinking among the deprived

ducklings was confined to the initial three minutes of the test during which time the birds from the 3D group drank more than those from the 2D or 1D groups. After the first three minutes there were no significant differences between any of the groups. This phenomenon indicates that after three minutes drinking motivation is decreasing. Clayton (1976) reported that the presence of deprived ducklings was not effective in eliciting drinking in non-deprived ducklings but was able to facilitate their sieving behaviour. Sieving is one possible method of drinking water by ducklings but in this method there is no need for a duckling to raise its head so that it costs less energy than the normal drinking method. Summarizing the previous discussion in this section it may be concluded that social facilitation in a group of animals during eating or drinking varies according to the level of deprivation.

#### Strange environment

The effect of deprivation on social facilitation in group feeding animals could also be influenced by some other factors. Wiepkema (1971) investigated the feeding behaviour of mice, either in their home cage or in a strange cage, after 0 hour, 24 hours and 48 hours of food deprivation and found that in the home cage, as measured by feeding bout length, there were striking increases for all three types of food deprivation during the first 5 minutes. In the strange environment, however, the tendency to feed only increased in the most deprived animals. Although the measurements were recorded using isolated mice, it does indicate that emotional factors can influence feeding motivation. Animals fed in groups may also possibly be influenced by strange environments.

### Activity

In Tolman's suggestion, which we mentioned previously, the food deprived companion's feeding behaviour is only partly responsible for the facilitative effect upon the subject. This section will discuss this relationship in detail. Vogel, Scott and Marston (1950) reported work already described in which pure-bred dogs, representing five breeds, were tested singly and in pairs for running through an alley for a reward of food and petting. In their results there was no indication that the faster animals were slowed down by their partner during paired running and paired running was faster than single running. These workers concluded that social facilitation is much more important in the slower animal. Similarly Chen (1937) demonstrated that, in the case of ants, a rapid co-worker (ant) has an accelerating effect and a slow co-worker has a retarding effect upon the work of an individual. The accelerating effects of association is greater for the slow workers than for the rapid workers.

Collias (1952) reported that chicks could be induced to eat an unfamiliar food by tapping it with a finger and Tolman (1964) also reported that chicks could be induced to feed by the tapping of a pencil. Furthermore, Tolman (1967) found that by increasing the pecking rate of a model chick from 60 to 120 or 240 pecks per minute, the pecking rate of an experimental chick could be increased. In these reports the influence of a companion's activity on the activity of the subject animal was clearly demonstrated. However as to whether a slow animal will be influenced by a fast animal, or vice versa, may vary between species and circumstances.

Fear

Davitz and Mason (1955) demonstrated that the presence of a non-fearful rat reduced the strength of a fear response exhibited by a fearful rat. However the presence of a fearful animal also reduced the strength of a fear response exhibited by a fearful subject. Furthermore, the presence of a fearful rat does not seem to have any influence on the non-fearful rat, which behaves in the same way as two non-fearful rats put together. Masserman (1943) suggested that a cat's fear of eating was reduced by observing a non-fearful cat eating. Liddell (1950) demonstrated that the presence of a mother goat increased the tolerance of kids to environmental stress. The level of emotion in two animals may affect each other so that variation in emotion in different situations may cause different results in social facilitation.

Previous experience

Whether social facilitation can be affected by previous experience will be discussed here. Frank and Meyer (1974) trained three day-old White Leghorn cockerel chicks for 1 day in a modified Hess pecking preference box to peck at a green stimulus in preference to a blue stimulus, when either in social contact or in isolation. During extinction, the chicks were within either the same or opposite condition (social or alone) to their training condition. The results demonstrated that both learning and performance were facilitated by social interaction. For example, during the extinction trials the results showed that a single chick, which had social experience on the previous day, had higher frequencies of response, while a social chick which had had isolation experience on

the previous day, had lower frequencies of response.

Brown and Kieley (1974) used newly-hatched chicks, which were reared either communally or in isolation for 36 hours, 4 days, or 8 days, and then tested for rate of pecking in the presence of an artificial model or without the model. The results showed that the chicks reared in isolation tended to increase pecking overall during testing. Rearing also influenced pecking through its interaction with the testing conditions, with pecking increasing under conditions which were similar to those of rearing. These authors suggest that an animal reared in isolation is likely to find isolation less strange than a socially reared one and that time is needed for an isolated animal to develop social facilitation. James and Gilbert (1955) also pointed out the significance of previous experience for the development of social facilitation. In their experiment, one group of three dogs was fed separately for 90 days following weaning. From day 91 they were fed together on alternate days for nearly six weeks. Positive social facilitation was not present during the first 14 days but it gradually appeared after that. A similar control group, fed together for the first 90 days, showed positive social facilitation from the beginning of the tests. Clayton (1976) placed isolated ducklings together in an arena for 5 minutes and 30 minutes prior to the commencement of a test which compared the sieving and drinking behaviour of ducklings deprived of water for 3 hours and of non-deprived ducklings either in isolation or under social conditions. The test lasted 12 minutes and analyses were performed on the total scores, 1 minute or 3 minutes after the commencement of the test. The sieving movements of non-deprived birds were of longer duration than

those of the deprived but no differences were found in drinking behaviour. Pre-test isolation of flock members was also shown to increase the duration of sieving movements. Reintroducing the isolated ducklings to each other for the last 5 minutes of deprivation failed to eliminate the difference in either the drinking or the sieving behaviour between the isolated and non-isolated birds. The difference in drinking behaviour, but not sieving, could be eliminated by reuniting the birds for the last 30 minutes of deprivation.

Tolman and Wellman (1968) investigated the possibility that pre-exposure to the test environment would decrease the apparent facilitative effect of the companion. In their experiment sixty 4-5 day old White Leghorn cockerels were used. On the first day two groups of 20 chickens were put into the test apparatus for 7 minute exposure sessions. In one group, pairs of chickens were placed into each of the compartments of the observation box. In the other group, single chicks were placed into each of the compartments of the observation box. A third group of 20 chickens was not given exposure sessions in the test apparatus. Food was present in the observation box. On the second day, each of the three groups was divided into two subgroups of 10 birds, one being tested in pairs and the other singly. The test sessions were 7 minutes long. The response recorded for each bird was the total number of food directed pecks emitted by a chick during the test session. The results showed that prior exposure to the test situation clearly increased feeding. It did so independently of the socially facilitated increase in feeding. However there is no suggestion in the results that the social effect was decreased by

the chickens being given experience of the test box in pairs.

Tolman (1964) also used chickens in an earlier experiment. He found that the method of rearing new hatched chickens either in isolation or in groups for 4 days had no effect on the amount of feeding in a later test. The tests were of 4 types: completely social, partially social (wire screen between the chickens), visual contact (periglass between the chickens), and isolation. In this experiment the food intake was measured over 12 hours per day. The reason why the previous experience of these chicks did not influence the results of the test may be because first, the chickens used were young, second, the rearing period was only 4 days, and third, 12 hours feeding time during the test may not have been long enough for them to become familiar with a new environment.

### Learning

There are conflicting reports (see Table 1.1) on social facilitation in which learning is involved. If learning is necessary to accomplish a task, then either positive or negative results may be obtained whether the animals are tested under social conditions compared with solitary conditions. Bar-pressing behaviour, studied by Deni and Jorgensen (1976a), was assessed in experimentally naive, non-deprived rats, during exposure to three conditions: a trained companion, an untrained companion, and no companion. Non-nutritive sucaryl solution was presented as the reinforcement for bar-pressing. Though overall levels of bar-pressing were low, the number of responses during exposure to either a trained or an untrained companion was significantly lower than in the no-companion

condition. (A > ON). Five subjects were used in the last three

Zentall and Levine (1972) reported on naive rats, which had to learn to get water by bar-pressing during a 30 minute learning and testing period. These observer rats were divided into 4 groups, each with a different sort of companion in the next cage.

- (1) Rats that made both bar-pressing and drinking responses (OB).
- (2) Companion rats that could drink without bar-pressing (OD).
- (3) Companions that made neither bar-presses nor drinking responses (ON).
- (4) An empty adjacent cage (OE).

All cages were separated by a transparent division. The companion rat also could only get water by bar-pressing. The results showed that the observer rats in group OE and OD learned to get water significantly slower than the observers in group OB. The observers in group ON learned significantly slower than any other group. The differences between groups OD and OE was not significant.

Bankart, Bankart and Burkett (1974) also used naive rats as subjects for a bar-pressing test. There were three treatments in their experiments.

- (1) An observer rat with a trained rat (O/T).
- (2) An observer rat alone (O/A).
- (3) An observer rat with a naive rat (O/N).

During the course of the experiment, all animals were deprived of water for 48 hours. Trained animals were regulated to a criterion of bar-pressing of 8 responses per minute. Each observer (naive rat) animal was placed with his conspecific (a trained, a naive rat, or with no companion) for two consecutive half hour sessions, with an average of 7 hours between sessions. The results showed that there was no significant difference between O/T treatment and O/A treatment but that there were significant differences between O/T treatment and O/N ( $O/T > O/N$ ) and between O/A treatment

and O/N ( $O/A > O/N$ ). Naive subjects were used in the last three bar-pressing experiments and all the results showed negative social facilitation when a naive subject observed a naive companion compared with the naive subject observing an empty box. There were conflicting results when the naive subject observed a trained companion compared with the subject observing an empty box. For example, the results shown by Deni and Jorgensen indicated negative social facilitation. Their results might be due to the artificial noise (80 dB) which prevented them hearing the sound of the others feeding and the fact that the rats could only see each other.

The results of Zentall and Levine (1972) may have shown positive social facilitation because a subject observed a well trained companion compared with the subject observing an empty cage. However there were no differences between a subject which observed a half trained companion (ie a rat which only learned the drinking method but no bar-pressing) and a rat with no companion. There were no significant differences found in the experiment done by Bankart, Bankart and Burkett (1974) in which they compared a well trained companion and another rat observing from an empty cage.

The subjects used in the next two experiments were trained. Levine and Zentall (1974) reported on the bar-pressing by trained rats, deprived of water for 4 hours or 23 hours, in the presence of a naive rat, or alone. Performance was significantly higher when the conspecific was present rather than absent and when the responder was deprived of water for 23 hours rather than for 4 hours.

Deni and Jorgensen (1976b) reported on rats trained to bar-press for food, where rats were given 12 daily, 15 minute test

TABLE 1.1 The conflicting reports on social facilitation in which learning is involved

Authors	Condition of subject	Condition of companion	Result of subject rat	Reward
Deni and Jorgensen (1976a)	Not trained (naive)	1 Trained companion (T) 2 Not trained companion (N) (naive) 3 No companion (A)	$A > T \cong N$	Subject - sucaryl solution & water Companion - water
Zentall and Levine (1972)	Not trained (naive)	1 Well trained companion (OB) 2 Drinking trained only (OD) 3 No companion (OE) 4 Naive (ON)	$OB > OD \cong OE > ON$	Water
Bankart, Bankart and Burkett (1974)	Not trained (naive)	1 Trained companion (O/S) 2 No companion (O/A) 3 Naive (O/N)	$O/S \cong O/A > O/N$	Water
Levine and Zentall (1974)	Trained	1 Not trained (naive) (N) 2 No companion (A)	$N > A$	Water
Deni and Jorgensen (1976b)	Trained	1 Trained companion (T) 2 Not trained companion (naive) (N) 3 No companion (A)	$A \cong N > T$	Feed
				48 hrs water deprivation Animal - male rats (Holtzman rats)
				4 hrs or 23 hrs water deprivation Animal - male rats (Long Evans rats)
				Animal - male rats (Long Evans strain)

sessions, with different types of conditions. Each subject was tested a total of four times under each type of condition.

(1) A trained companion present in an adjacent cage. (2) An untrained companion in the adjacent cage. (3) No companion. All the companion rats had to press a bar for their food. The specific order of presentation of these conditions was random. During testing the levers and food cups were located on opposite walls within two adjacent cages. The results showed the bar-pressing was significantly lower in the condition with a trained companion than with no companion. However the fact that lever and food cups were located on opposite walls within each two adjacent cages led to frequent crossing back and forth by both trained companion and subject and this may have affected the results.

#### Causation of social facilitation

The term 'social facilitation' has been used in various behavioural studies (eg in connection with feeding, drinking, running speed, etc). Due to the wide use of this term, the causation of social facilitation thus becomes very difficult to explain through a unitary concept. Two theories have been used to try to provide an explanation (Zajonc 1965, 1969; Tolman 1968).

Zajonc (1965) hypothesized that the presence of conspecific organisms, as either co-actors or passive audience, produces an increment in general arousal, which in turn serves as a drive that energizes dominant responses at the expense of subordinate ones in accordance with the Hull-Spence equation:  $E = D \times H^*$ . Zajonc (1969) quotes Hull and Spence as postulating that one property of

\* E - reaction potential; D - drive; H - habit strength

drive, (D), is that it affects behaviour by combining additively with underlying habits. Thus, reaction potential ( ${}^s E_r$ ) is said to be a function of both the underlying habit strength ( ${}^s H_r$ ) and generalized drive state present at the moment; specifically,  ${}^s E_r = f(D \times {}^s H_r)$ . According to the classical formulation, when more than one response may occur, the one that will occur depends on the extent to which its underlying reaction potential, ( ${}^s E_r$ ), exceeds all others. Given two responses,  $R_1$  and  $R_2$  and  ${}^s H_{r1} > {}^s H_{r2}$ . We have

$${}^s E_{r1} - {}^s E_{r2} = f \sqrt{(D \times {}^s H_{r1}) - (D \times {}^s H_{r2})} = f \sqrt{D({}^s H_{r1} - {}^s H_{r2})}$$

An increase in drive must result in an increased difference between  ${}^s E_{r1}$  and  ${}^s E_{r2}$  and, therefore, in an increased likelihood of the emission of the dominant response. In those cases in which emission of dominant responses would be 'incorrect' the reverse of social facilitation should occur. One important point of Zajonc's (1965) use of drive theory, to analyse social facilitation, is its distinction between the effects of learning and performance. From several experimental results, Zajonc (1965) suggested that the emission of well-learned responses is facilitated by the presence of spectators, while the acquisition of new responses is impaired. To put the statement in conventional psychological language, performance is facilitated and learning is impaired by the presence of spectators.

If we use the drive theory to explain this phenomenon, we can say that a well-learned response will be performed at a higher rate in the presence of others because of energization of the response due to the presence of others, but learning itself will be impeded

in a social situation because the dominant responses energized are at the outset 'incorrect'. For example, the experimental results of Zajonc, Heingartner and Herman (1969) show that the paired cockroaches run more quickly than when they run alone, in a straight alley, but paired cockroaches run slower in a cross maze when compared with individual cockroaches. This is because the straight alley does not involve difficult learning.

In another case, Broen and Storms (1961) suggested that, among experienced performers, the appropriate responses in the complex tasks are relatively well learned but not thoroughly mastered, so that competing responses are still possible. Increased drive therefore energizes competing responses more than dominant ones, assuming that the ceiling strength for the latter has been attained.

Zajonc (1965) provided some physiological evidence to prove the presence of others as a source of arousal. He believes that one of the more reliable indicators of arousal and drive is the activity of the endocrine systems in general, and of the adrenal cortex in particular. Zajonc (1965) quoted two experiments done by Mason and Brady (1956) and Thiessen (1964) as evidence to support his 'Drive Theory'. Mason and Brady (1956) reported that monkeys caged together had considerably higher plasma levels of hydrocortisone than monkeys housed in individual cages. Thiessen (1964) found that adrenal weight increases in mice housed in groups of ten and twenty compared with mice housed alone. Mason and Brady (1956) have shown that even the mere presence of other animals in the same room, but in separate cages, was also found to produce elevated levels of hydrocortisone. Latane and Cappell (1972) reported cardiac acceleration as a correlate of social arousal in rats.

Quoting from the detailed reviews by Hinde (1970) and Andrew (1975), Clayton (1978) pointed out that the theory of general arousal is questionable on several grounds. He suggested that the data usually cited as supporting this hypothesis are equivocal and inconclusive. The term 'drive' is a confused term but as Zajonc (1965, 1969) is specific in his definition of drive, then we should follow his definition for discussion here. The questions about it which were raised by Clayton (1978) will be discussed.

(1) Klopfer (1961) and Turner (1964) showed that passerine birds select the same type of food as that eaten by a conspecific bird. Clayton mentions that 'this fits arousal concept less readily because arousal should lead to indiscriminate pecking of food items'. But as discussed before, doing the same thing at the same time is not social facilitation.

(2) 'It does not explain all situations in which increments in learning occur'. The question here is whether the learning is easy or not, because if the dominant responses are largely inappropriate, performance in the presence of others will probably be impaired, but if the dominant responses are not largely inappropriate, then in the presence of others they will probably be facilitated.

(3) 'It does not explain these cases in which both increments and decrements are observed in the same behaviour, such as when animals increase their running speed when running with faster individuals but decrease it when running with slower ones'. It could be argued that either the level of arousal was different in these two different cases, or, when a fast running animal runs slowly with a slow running animal, this may be because the increased drive energizes competing responses (eg resting drive) more than the

dominant running response when an animal is running with slower ones.

(4) 'Arousal theory also does not satisfactorily explain the initiation of particular behaviour patterns by social facilitation.' Zajonc (1969) separated the motivational effects of social settings from the non-motivational ones. Social facilitation describes socially produced changes in level of performance but does not involve the initiation and direction of the behaviour.

Another theory, suggested by Tolman (1968), to explain the causation of social facilitation, used the following four alternative categories.

(1) The reflexive mechanism. The behaviour of one animal elicits an immediate and identical reaction from another.

(2) The motivation mechanism. The performance of an activity by a companion in response to a particular stimulus increases the response of the subject to the same stimulus.

(3) The perceptual mechanism. The reaction of one individual to a particular stimulus results in another individual attending to and subsequently reacting to the same stimulus.

(4) The disinhibition mechanism. A behaviour pattern exhibited by one individual seems to remove constraints on that behaviour in another.

Clayton (1978) pointed out that in this theory it is difficult to distinguish between the first three mechanisms, which seem to explain the causation of allelomimetic behaviour. However none of the four mechanisms explains the causation of negative social facilitation which happens in groups of animals.

### Definition of social facilitation

Social facilitation can be defined as a positive or negative increase in the frequency or intensity of responses, already in an animal's repertoire, shown in the presence of others.

The following points about this definition need to be clarified.

(1) The initiation of behaviour by one animal after another animal has started it is not considered to be social facilitation as suggested by Clayton (1978) and is considered to be allelomimetic behaviour.

(2) Both positive or negative increases in the frequency or intensity of responses will be considered as social facilitation.

(3) The result of social facilitation is different from the result of release from inhibition due to isolation. The mere presence of an animal should be considered not only as a stopper of inhibition, due to isolation, but also as a possible cause of social facilitation.

(4) For social facilitation to occur it is not necessary for the animals to be engaged in the same behaviour at the same time. This not only makes it easy to distinguish social facilitation from other terms, but also suggests that if a situation only allows one of a group of animals to do something at any one time, then social facilitation can still exist.

## COMPETITION IN PIGS

### Competition for resources

Competition is defined as the active demand by two or more organisms for a common resource (Wilson, 1975). It can be divided into two categories (according to their purpose) - sexual and resource competition. Here only the latter will be considered. Graves and Graves (1975) reported that during winter food such as acorns or paemetto berries occurred in 'nodes' about certain trees, and that dominant animals often defended such areas from intruders and had a distinctive advantage over less dominant animals. Some other instances of competition for resources were reported and suggested in relation to food (Braude, 1948; Fradrich, 1974; Graves, Graves and Sherritt, 1978), bedding area (Braude, 1948), teat position (Fraser, 1975; Hartsock and Graves, 1976; Schell, Graves and Sherritt, 1977).

### Scramble competition

If we divide competition according to whether it involves aggression or not, then it is possible to classify competition into two broad types - scramble and contest (Nicholson, 1954). Wilson (1975) suggested that scramble competition is exploitative. The winner is the one who uses up the resource in a range first, without specific behaviour responses to other competitors. No work has been done on scramble competition either in grazing or confined pigs.

### Contest competition

Contest competition can be subdivided into three sub-classes:

(1) Territorial competition. (2) Dominance order. (3) Fighting.

### Territory

Noble (1939) defined territory as 'any defended area' while Willis and Oniki (1978) considered the territory as a dominance space. Emlen (1957), on the other hand, defines a territory as a space within which an animal is aggressive towards, and usually dominant over, certain categories of intruders. Hediger (1949) suggested that the territorial animal feels stronger the nearer it is to its home.

The teat order of piglets may be considered as a special case of territorial behaviour. Hartsock and Graves (1976) found that piglets fighting at their home teats won 80.8% of fights on the average but only won 38.7% of the fights taking place at teats other than the home teat. The means were significantly different, indicating that piglets have a 'home court advantage' when fighting at their home teat, a phenomenon characteristic of territorial behaviour in many species.

Figure 1.1 shows the relationship between teat order and competition, their related factors and the consequence of teat order and competition. Competition between suckling piglets is not only observed through their aggressive activity but also found in the following well designed experiment.

Lodge and Pratt (1963) investigated the influence of within-litter competition on growth rate. Sixteen litters of Large White sows which farrowed in pairs, were redistributed as soon as possible after birth so that one sow of a pair received the heavier and the



other the lighter half of the combined litters. The results showed that correlations between birth weight and 3, 5 and 8 weeks weight were 0.59, 0.52 and 0.45 respectively in all the groups. Partial removal of within-litter variation in birth weight appeared to have had little effect on the overall correlations between birth and subsequent weight. However, when comparison was made between the four lightest pigs from each 'heavy' litter, and the four heaviest pigs from each 'light' litter, the highly significant difference ( $P < 0.01$ ) in mean birth weight between these two groups were no longer apparent at 3, 5 or 8 weeks, indicating that an effect due to competition did, in fact, exist.

#### The effect of competition on the performance of piglets before weaning

Hartsock, Graves and Baumgardt (1977) reported that the more successful fighters among piglets of a litter were heavier at birth, gained more weight and consistently suckled a specific teat. The relationship between competition and survival rate was reported by Hartsock and Graves (1976). They found that individuals surviving past 21 days of age won an average of 52% of their fights and suckled on an average during 79% of all possible nursing periods. Piglets that died during the first 21 days won only 30% of their fights and suckled during only 53% of possible nursings; differences between both pairs of means were statistically significant.

Larger litter size results in the birth of smaller piglets and an increase in competition at the udder. This lower birth weight and higher competition would tend to increase mortality (Hartsock and Graves, 1976; Hartsock, Graves and Baumgardt, 1977). The

relationship between teat order and competition is quite complex. There are still a few unsolved questions left. For example: whether teat order is formed due to pure resource competition or teat preference. Further study is needed.

The relationship between the teat order and the social order of weaning pigs with respect to competition

Although fighting has been noted in piglets during the first day after birth and severe fighting, lasting more than three minutes, has been seen in three day old piglets away from the udder, no work has been done to try to find out the relationship between the teat order and any social relationship which may exist away from the udder. The relationship between the teat order and later social rank, built up after weaning, was studied by McBride, James and Wyeth (1965). They found that teat order position accounted for 40% of body weight at three weeks of age (weaning) and that body weight at weaning was significantly correlated (0.53) with later social dominance rank. Perhaps these findings merely indicate that piglets which are large at weaning tend to succeed in competition.

McBride, James and Hodgens (1964) reported that there is a fairly strong and highly significant overall tendency for the heavier pigs at weaning to have a higher social rank as growing pigs. Scheel, Graves and Sherritt (1977) found that dominance rank during suckling was highly correlated with rank after weaning. Dominance rank of a newly formed group was negatively correlated with mixing weight, indicating that the pigs that were heavier at mixing obtained a high rank. McBride, James and Wyeth (1965)

suggested that social order within the litter was not laid down until after three weeks of age, although social fighting occurred.

### Social dominance

Social dominance usually establishes priority of access to resources and is usually attained by those individuals who fight most successfully, chase, or otherwise supplant, the other members of their group (Morse, 1974). Dominance is distinguished from territorial behaviour (which may also be considered a form of dominance) by the absence of a clear reference point in space.

As in most social species, groups of pigs form a dominance hierarchy. The most dominant animal has priority to resources and is the victor in an agonistic encounter, but the social order is not always linear. Ewbank (1969) describes three kinds of social order of pigs: Straight linear, linear but with two pigs equally placed, and linear but with a dominance 'circle'. Different types of social order must have different degrees of social competition, but there is a lack of this kind of information at present.

After a series of fights, a new order develops within a day or two when pigs from different litters or groups are intermingled (Meese and Ewbank, 1973; McBride, James and Hudgens, 1964). Fighting at this time is for social rank. As suggested by Guhl (1962), fighting among species members has traditionally been viewed as occurring only when dominance relationships are being established or when a competitive situation requires the reinforcement of relationships among group members. Meese and Ewbank (1972) observed groups of pigs for over 80 days and found persistent fluctuations in fighting behaviour. However 90% of the fighting

occurred during feeding time (resource competition). This is quite different from the fighting in a newly formed group of pigs.

The social order may be influenced by sex (Beilharz and Cox, 1967) but Meese and Ewbank reported that although males tended to be more aggressive, they were not necessarily the most dominant.

Dantzer (1971) found that rank in the hierarchy depended mainly on initial weight at mixing and sex. On the other hand, Meese and Ewbank (1973) found that weight has little or no effect on rank with pigs from separate litters. Likewise Fraser (1974) reported that weight is not the only factor which determines dominance. Meese and Ewbank (1972) reported on the difficulty of altering social ranks artificially. Top animals, after being placed within a strange group of much larger pigs, and subjected to the experience of being bottom pigs, seem completely unaffected when returned to their own groups. Similarly, allowing a bottom pig the experience of being a dominant animal (ie placing in a group of small pigs) has no carry-over effect when it is subsequently returned to its original group. As no fighting occurred when pigs were put into these temporary groups, the question in these experiments is whether a dominant animal, after being defeated in another group, could still be a dominant animal in its original group.

Whether pigs can recognise each other during competition is another interesting subject. Ewbank and Meese (1971) studied several groups of eight fattening pigs, with well-formed social orders. Individual pigs were removed one at a time, from different places in the social order, isolated for varying periods of time, and then replaced in their groups. It was found that the removal of a pig from any rank in the dominance order altered

neither the basic social hierarchy nor the amount of aggression within the remainder of the group. Top ranking animals could be safely returned, even after 25 days' isolation, but low ranking animals were severely attacked after only 3 days' absence. This seems to suggest that the pigs can recognise the social rank of others.

#### The effect of social order on performance

James (1967) indicated that, in pigs, social status significantly affected growth rate during the suckling and post-weaning periods and appeared to play a major rôle in determining growth rate. He suggested that, during any given period the growth of pigs is determined by an inherent capacity, indicated by its body weight at the start of that period, and by its ability to realise that potential in competition, indicated by its social status. Since a heavy pig (one with high growth capacity) tends to be dominant, it has a better chance of realising its potential and a continual reinforcement of difference in body weight will take place. He also suggested that body weight at a given time represents a summation of previous growth effects. James (1967) found that differences in social status had their greatest effect at the lower end of the social hierarchy. That is the gap or social distance between the bottom pig and its immediate superior is greater than the gap between any two other animals.

McBride, James and Wyeth (1965) reported that only 3-week weight and social rank appeared important in affecting 8-week weight. The regression on rank indicated that, after allowing for the effects of weight at 3 weeks, pigs at the top half of the social

order were on average about 5 lb heavier at 8 weeks than pigs in the lower half of the order.

Dantzer (1971) reported that there was some indication that pigs higher in the hierarchy gained weight faster and that this was partially related to initial weight.

McBride, James and Hodgins (1964) found that there is clear evidence that initial weight affected growth rate independently of rank. Similarly there was a marked effect of rank independent of initial weight. They suggested that low birth weight leads in turn to a series of social effects which may contribute to an already low growth rate potential in young pigs. Hassen (1977) has shown that in a group of eight pigs, with access to a self-feeder, the dominant animal had a daily weight gain of 100 grams higher than the average of the rest of the group. Dantzer (1970) deliberately disturbed groups of pigs by introducing strangers into their midst and by changing their quarters and showed that these treatments lead to an increase in aggression and a decrease in weight gain.

### Fighting

The largest part of aggression among members of the same species can be viewed as a set of behaviours that serve as competitive techniques (Wilson, 1975). Competitive techniques can be influenced in several ways. For example, in the case of the young piglet, Fraser (1974), pointed out that aggressive behaviour (frequency of biting at pen mates) was worst on the first day after weaning. The severity of the hyperactivity and aggressiveness varies from one pig to another and from one litter to another, apparently depending on the general condition of the animals. It

would be interesting to know whether this difference is simply due to variation in aggressiveness between litters or because some litters form their social order before weaning so they have less fighting.

In growing pigs the effect of feeding method on competition during mixing of pigs was investigated by Graves, Graves and Sherritt (1978). They studied the behaviour and average daily weight gain, after mixing pigs amongst litters or maintaining them in their original litters after weaning. Two feeding treatments were used: full feeding (*ad lib* supply of food) and limited feeding, thus giving four treatments, ie - full feed with littermates (FL), full feed with mixed litter (FM), limited feed with littermates (LL), limited feed with mixed litter (LM). The ranking of the treatments according to the total number of fights over the first seven days was as follows:  $LM > FM > FL > LL$ . The results demonstrated that the effect of fighting on mixing pigs amongst litters was much greater than was the effect of providing *ad lib* or limited feed. Of special interest was the indication that limited feeding with littermates resulted in a greater reduction in fighting in pigs than did the other treatments. On the other hand, the group - limited feed with littermate - was observed standing more frequently than were the pigs in the other groups. In both treatment groups undergoing limited feeding the pigs exhibited restlessness and spent a great deal of time investigating the pen, as reflected by the high mean number observed standing, especially during days 1 to 7. In the limited feed, mixed litter group, the restlessness associated with initially limiting feed led to a greater number of agonistic encounters as one restless irritable pig encountered another

unfamiliar individual. Such encounters among littermate pigs did not lead to fighting. This seems to suggest that limited feeding of itself may not be a direct cause of the increased fighting during the mixing of pigs, so the movement by the pigs themselves might lead to more fights.

### Aggressive behaviour patterns

#### Encounters between adult pigs

Beuerle (1975) reported the aggressive behaviour of wild boar. Observations were limited to boars, aged over 3 years, and to sows, aged over 1½ years. The aggressive behaviour patterns of the wild pig include biting, shaking head, shoving from below, various pushes with snout, shoving the opponent away with the body, avoidance and carrying away food. Sometimes the loser reacts with a specific defence posture (not a submissive posture). Some encounters are decided merely by nose-to-nose contact.

#### Encounters between suckling piglets

Hartsock and Graves (1976) described the fighting techniques of new born piglets. These techniques, in the form of biting or pushing with the nose or shoulder, are shown by intruders towards piglets which are suckling from teats, while suckling piglets respond to interference by positioning the body so as to make the teat position inaccessible to the challenger. Fraser (1975) noted that fighting piglets generally give loud vocalizations. Facial wounding is largely confined to litters with unclipped teeth. McBride *et al* (1964) suggested that the squeal of the young pig could serve as a submission signal.

Encounters in growing and finishing pigs

Ewbank and Meese (1973) found that the squealing occurred in most cases when an animal was attacked on being returned from isolation to its own group but the main response seemed to be simply to run around the pen to avoid the aggressors or to attempt to reduce the attack by turning the body and facing into a corner.

Fraser (1974) found nosing a recumbent partner was common only in one experiment, in which pigs were mixed with a familiar partner in a familiar enclosure: it was virtually never seen in another two experiments in which the pigs were generally less familiar both with the enclosure and with the partner. Similarly, Ewbank and Meese (1973) reported high frequencies of this behaviour when a pig was returned to its former pen after a period of separation.

Ewbank and Meese (1973) also described the fighting seen during the mixing of strange pigs. The fighting was very characteristic, both pigs usually attempting to bite the opponent about the head and ears. Frequently the head to head position altered so that each pig stood with its head alongside the flank of the other. In this position they would lean on each other and bite the opponent's flanks and back legs. On a number of occasions this resulted in one pig falling over and this enabled its antagonist to resume the attack to the head. The pigs often took up this head to flank position and continued pushing and circling until apparently exhausted. McBride and James (1964) reported that the hair on the back of a pig's neck was raised during fighting.

Ewbank and Meese (1973) reported that it is worth noting, during mixing of pigs, that submission is difficult to define in the pig. There appears to be no clear submission posture in the

sense of a signal inhibiting all further aggression, but animals can be seen to show subordinate behaviour, eg turning or running away from threats and attacks or standing with the tail and ears lowered and the back arched.

McBride, James and Hodgens (1964) reported the signal of submission was generally avoidance during the fighting of a newly assembled pen of pigs, but in extreme cases it could be a high pitched squeal. Such a squeal is seldom heard in a well established pen but sometimes occurs when a pig receives an unexpected attack.

For the purpose of this study, aggression or fighting technique of pigs has been subdivided into several categories by behaviourists in recent years. Ewbank and Meese (1973) divided the aggression into attack, threats and replacement. Although these categories are quite simple, they clearly divide aggressive motivation into three levels. However it is difficult to say whether threats should have no physical contact and because of this ambiguity it is difficult to assess aggressive motivation. Some other workers have divided fighting technique into several categories, eg (1) butting, chasing, running, scampering, rubbing on walls, vigorous biting, mounting and mutual pushing (Fraser 1975), (2) parallel pressing, parallel pressing cum-bite, inverse parallel pressing head-to-head knock, head-to-head knock-cum-bite, head-to-body knock, head-to-body knock-cum-bite, levering, nose-to-nose, nose-to-body, anal-genital nosing, head tilt and withdrawing (Jensen, 1980), (3) head thrust, bite, chasing, replacements, threats, avoidance and fights (Shell, Graves and Sherritt, 1977). These kinds of classification of aggression are quite detailed but

sometimes are too detailed (eg Jensen's classification) to classify aggression. The best classification should consider both the classification of aggressive motivation and detailed fighting technique.

In the study of feeding behaviour, (1) What causes an animal to initiate feeding? (2) What determines how much an animal will eat once feeding has begun? Figure 1.2 is based on the work of (1952) theory to explain the mechanism of food intake. In the past, workers who studied food intake over emphasized a single factor such as a placenteric, homeostatic, lipostatic or anorectic mechanism, but they must accept Edward Sclafani's notion that food intake is under the control of multiple factors. The control of food intake by metabolic signals and related neural-humoral factors in pigs has been postulated in a recent review by Bost, Bost and Bond (1979). The food preference of pigs has also been reviewed by Bost and Bond (1978), Bond (1980), or (1981) and Amstutz (1983). The effect of obesity on feeding and food intake has also been discussed by Bost, Bost and Bond (1979). Furthermore, the effect of water intake on food intake was reported by Friend and Cuthbert (1964), Bond (1971), and Bond and Bond (1971). However, there is a lack of information on the effect of social factors on the food intake of pigs. The general feeding activity of pigs and the relationship between feeding behaviour and motivation will be discussed below.

#### The development of feeding activity in pigs

The feeding activity over the whole life of the pig may be divided into three stages: the suckling period, the growing or finishing period and the mature stage.

## FEEDING ACTIVITY OF PIGS

### Introduction

Food intake is a complex mechanism. Two questions are usually asked in the study of feeding behaviour. (1) What causes an animal to initiate feeding? (2) What determines how much an animal will eat once feeding has begun? Figure 1.2 is based on the Jacob *et al* (1962) theory to explain the mechanism of food intake. In the past, workers who studied food intake over emphasized a single factor such as a glucostatic, thermostatic, lipostatic or aminostatic mechanism, but today most people accept Edward Adolph's dictum that food intake is under the control of multiple factors. The control of food intake by metabolic signals and related neural-humoral factors in pigs has been postulated in a recent review by Houpt, Houpt and Pond (1979). The food preferences of pigs has also been reviewed by Houpt and Houpt (1976), Baldwin (1980), Orr (1980) and Aumaitre (1980). The effect of obesity and breeding on food intake has also been discussed by Houpt, Houpt and Pond (1979). Furthermore, the effect of water intake on food intake was reported by Friend and Cunningham (1966), Close and Mount (1975), and Bowland and Standish (1966). However there is a lack of information on the effect of social factors on the food intake of pigs. The general feeding activity of pigs and the relationship between feeding behaviour and competition will be discussed below.

### The development of feeding activity in pigs

The feeding activity over the whole life of the pig may be divided into three stages: the suckling period, the growing to finishing period and the mature stage.

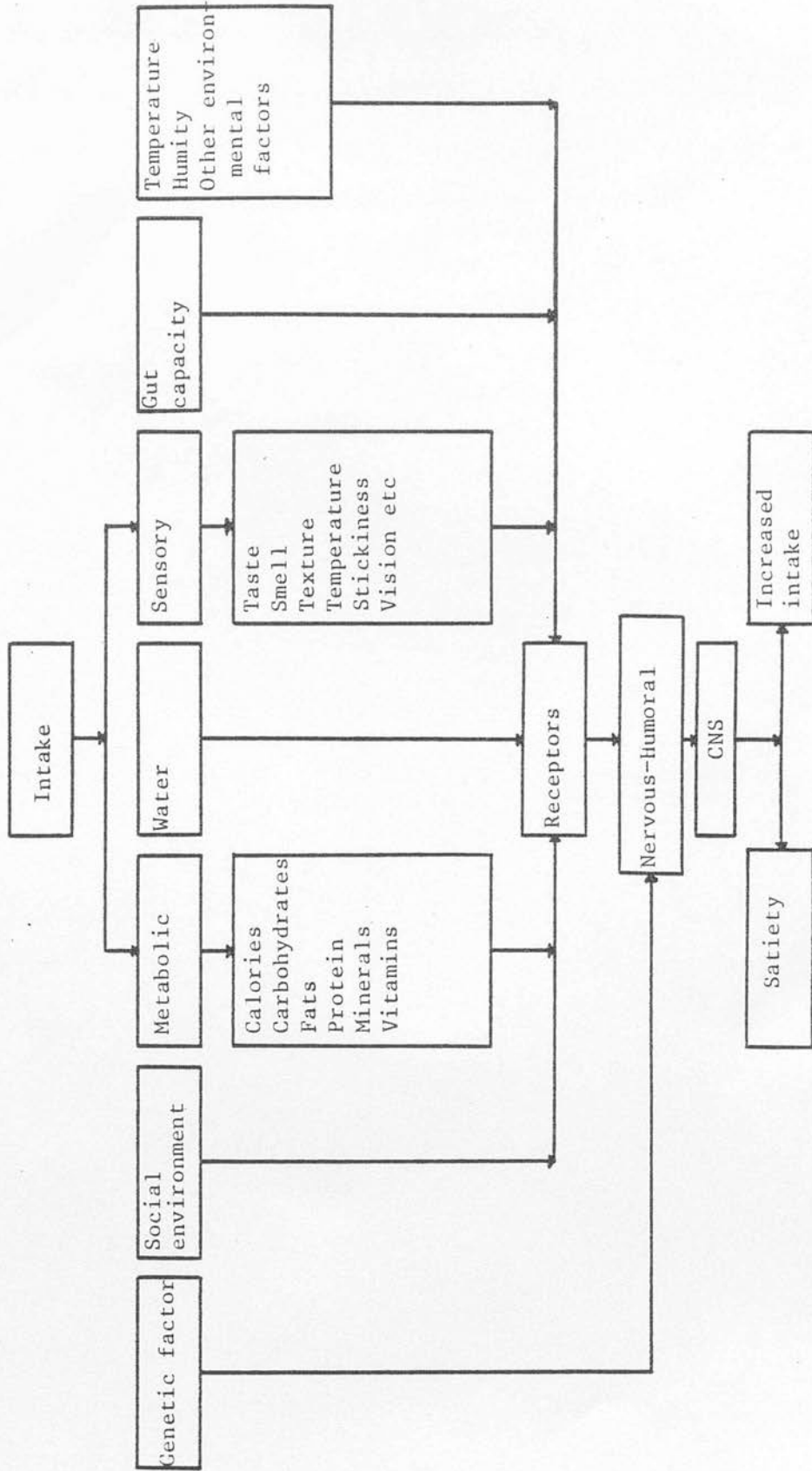


FIGURE 1-2

The mechanism of food intake



### The suckling period

The average natural suckling interval was reviewed by Barber, Braude and Mitchell (1955). From that review we can understand that the average interval between successive sucklings is approximately 1 hour during early and mid-lactation and  $1\frac{1}{2}$  hours during late lactation. That means the suckling frequency is around 24 times and 16 times per day for early, mid-lactation and late lactation respectively. The average interval between suckling seems longer in the evening (8.00 pm to 8.00 am) than in the day time (8.00 am to 8.00 pm). Hartman, Ludwick and Wilson (1962) found no significant differences between day and night nursing intervals but a significant difference between sows in the length of nursing intervals. The average nursing interval for both day and night was 43.5 minutes during the first week and gradually extended to 58.2 minutes by the sixth week.

### The growing and finishing period

Fraser (1974) observed the feeding behaviour of piglets before and after weaning at three weeks. Before weaning, these animals spent less than 1 per cent of their time at the trough and, on the first day after weaning, this had increased to over 15 per cent and this rate was maintained over the next two weeks. However, not all animals are so quick to regulate their food intake. A few do not eat at all during the first day, while, very occasionally, a healthy three-week old piglet will over eat during the first day after the sow is removed and will scour badly for two or three days afterwards. Fraser (1978) reported that the percentage of feeding activity of piglets increased with age from birth to six weeks old for piglets

weaned at both 3 and 6 weeks, but an especially large increase between 3 to 6 weeks for piglets weaned at 3 weeks. However Wood-Gush and Csermely (1981) reported that feeding activity does not differ between groups of early weaned piglets of 3 weeks and 6 weeks of age.

Halasz and Zambo (1970) studied 10 herds of pigs, weighing 40 to 50 kg. During the day there were 2 peaks of eating activity, in the morning and the afternoon, though throughout the day there were always some pigs at the feeder. Heitman, Hahn, Kelley and Bond (1961) reported that growing-finishing pigs spend around 13% to 15% of their time eating.

#### Mature pigs

Friend (1971, 1973) found that the dry matter intake of gilts decreased in the weeks in which oestrus occurred when compared with the average weekly intake between successive oestrus periods, thus indicating a temporary change in appetite due to oestrus in swine.

Finally, Olsson and Claesson (1978) reported very large variations in speed of eating between pigs and that the eating speed increased with body weight.

#### Conclusions

The following points of interest arise from the review of the above reports on the development of feeding activity in pigs. Although the total amount of milk production of the sow increases over the 4 weeks after farrowing, the suckling frequency of piglets decreases with increasing age. This decrease in suckling frequency of the piglets must be accompanied by an increase in the speed of

suckling, the length of suckling periods, or both. No detailed study has been reported on this point. It has been reported that the feeding activity of weaned piglets increases from week 3 to week 6. Whether this kind of increase in feeding activity continues in the growing and finishing stages of pigs is not known. Total food consumption is increased with the increasing body weight of pigs and the eating speed of pigs, under restricted feeding régimes, also increases. However the relationship between total eating time and body weight is not clear and it is not known whether the eating speed of pigs increases with the increase in body weight under *ad lib* feeding régimes. Other questions arise: Does eating frequency decrease with age? Is eating activity influenced by the lighting régime? Do pigs eat in the night? Does the physical composition of diet affect eating activity? What is the relationship between the social environment and eating activity of a pig? Some of these questions will be investigated in this thesis.

#### The relationship between feeding behaviour and competition

Fradrich (1974) reported on competition during the feeding of wild pigs in which there is often a hasty collection of a large amount of food which is carried to a safe place. As soon as the food is deposited it is quickly swallowed and, while eating, the animal turns its rear towards its competitors. If one of them approaches, short warning grunts are given and these are sometimes sufficient to keep him away. If a rival is not respected, the defending animal may threaten the other by a short and sudden upward movement of the head, without touching him. If this is in vain, the rival is pushed with the shoulder region, or, more or less,

vigorously with the snout. In this last case, he can be slightly lifted, or even thrown, or knocked over. An animal repulsed in this way usually lowers its head and walks backwards which often occurs in defence of the food.

McBride, James and Hodgens (1964) reported that when self-feeders provided enough space for only two pigs to feed side by side, it was extremely rare to find two pigs feeding together, and that this never lasted for more than a few minutes. Hansen and Hayels (1978) suggested that feed intake may be increased by competition. Heitman (1961) reported that 3 pigs sharing one feeding space eat more than 6 animals sharing two feeding spaces or 12 animals sharing three feeding spaces. At the same time, behavioural studies of the animals' daily activity showed that in pens with 12 pigs, less time was spent walking and standing than in pens with 3 or 6 pigs. According to this result Hansen and Hagelso (1978) suggested that competition was less in pens with twelve pigs, as less time was spent waiting around the feeding places for a chance to eat.

As mentioned before, some reports suggested that the dominant animals may benefit from competition in eating. Ewbank and Bryant (1972) studied groups of eight pigs that were housed at  $0.56 \text{ m}^2$ ,  $0.77 \text{ m}^2$  and  $1.19 \text{ m}^2$  per pig. Feeding, drinking and dunging facilities were equal for all treatments. Results were obtained from 8 hour observation periods and all agonistic encounters observed in the lying area of the pens were recorded. The results showed that the decrease in area available, per pig, appeared to cause a quantitative increase in agonistic interactions in all competitive situations. With regard to feeding, the decreasing area

allowed per pig was associated with - (1) a decrease in the mean percentage of decided encounters, (2) an increase in the likelihood of retaliation, (3) an increase in the occurrence of encounters contrary to the dominance order, and (4) an increase in aggression.

### Social facilitation in pigs

There have been few experiments designed for this study of social facilitation in pigs but some experiments designed for other purposes have shown some evidence of social facilitation in pigs. Wiechert and Barr (1966) found a significant negative linear relationship between time spent in the maze and number of pigs in the litter. Jonsson (1959) found that castrated boars, fed in groups, grow faster than those fed in individual pens, but group fed gilts grow slower than individually fed gilts. The most striking difference between the two treatments (group v individual feeding) was that the variation in daily weight gain was much larger in the group fed animals - which could be due to competition in group feeding treatments.

Csermely and Wood-Gush (1981) reported that when comparing the sound of cows with the sound of piglets suckling and of the sows' nursing grunts, the last sound had a significant effect on stimulating the release of both suckling and feeding behaviour. The result seems strong support for the existence of allelomimetic feeding behaviour.

Although these experimental results showed some indication of social facilitation we still lack information to understand social facilitation in pigs. For example, what is the relationship between competition and social facilitation? How is social

facilitation influenced by the social order? Is it influenced by group size? What is the importance of different kinds of stimulation in social facilitation? What is the relationship between eating motivation and social facilitation and what is the causation of social facilitation? This thesis tries to investigate these problems in more detail.

### Facilities

The majority of the experiments were conducted in the Development House (Figure 2-1) which is located in the Pig Unit of The School of Agriculture, University of Edinburgh. The house has five totally separate rooms with walls of asbestos and laminated wood and the ceilings are well insulated with expanded polystyrene sheets. Each room has two doors on opposite walls but the only light source in any room comes from an electric light bulb (100W/230V). About one third of the floor is solid concrete and movable steel bar divisions can be fixed inside the room to make stalls.

Several types of divisions were used for the rooms and these will be mentioned in the appropriate chapters.

The diameter of each steel bar was 2.5 cm and the division was 17.5 cm high with a 100 mm gap between each vertical bar.

The five rooms had a passage along two sides, with windows. There were two gates at the north end of the building and another two at the south end. The temperature of the five rooms could be controlled by a fan heater, thermotatically controlled, in each room.

The body weight of the pigs was measured on a machine accurate to 0.1 kg while the food was measured on a scale accurate to 1 mg.

Unless otherwise stated, the form of the food used in the study

### Animals

All the pigs used in this study were two-way cross bred, the two breeds being Large White and Landrace.

### Housing

The majority of the experiments were conducted in the Development House (Figure 2-1) which is located in the Pig Unit of The School of Agriculture, University of Edinburgh. The house has five totally separate rooms with walls of asbestos and laminated wood and the ceilings are well insulated with expanded polystyrene sheets. Each room has two doors on opposite walls but the only light source in any room comes from an electric light bulb (100W/220V). About one third of the floor is solid concrete and movable steel bar divisions can be fixed inside the room to make stalls.

Several types of divisions were used for the rooms and these will be mentioned in the appropriate chapters.

The diameter of each steel bar was 2.7 cm and the division was 12.5 cm high with a 105 cm gap between each vertical bar.

The five rooms had a passage along two sides, with windows. There were two gates at the north end of the building and another two at the south end. The temperature of the five rooms could be controlled by a fan heater, thermostatically controlled, in each room.

The body weight of the pigs was measured on a machine accurate to 0.1 kg while the food was measured on a scale accurate to 1 mg.

Unless otherwise stated, the form of the food used in the study

was pellets of 1.2 cm diameter and less than 2.5 cm in length.

The ingredients and the major nutrient contents of the pellets are shown in Table 2.1.

Ingredients	Quantity	Units
Barley	200.0	g/kg
Soya bean	117.0	
Flake maize	100.0	
Fish meal	50.0	
Sulphur	50.0	
Wheat feed	30.0	
Fat	27.0	
Dicalcium phosphate	5.0	
Limestone	4.0	
Salt	3.0	
Vitamins	2.5	
Composition		
Digest energy	2315	kJ/kg
Gross protein	175.0	g/kg
Fibre	40.0	
Lysine	10.5	
Methionine	6.0	
Calcium	3.0	
Phosphorus	3.0	
Fat	31.0	

TABLE 2.1 The composition and ingredients of feed

Ingredients	Barley	503.5 g/kg
	Soya bean	232.0
	Flake maize	100.0
	Fish meal	50.0
	Molasses	50.0
	Wheat feed	20.0
	Fat	27.0
	Dicalcium phosphate	8.0
	Limestone	4.0
	Salt	3.0
	Vit/mins	2.5
Composition	Digest energy	13.5 MJ/kg
	Crude protein	173.0 g/kg
	Fibre	40.0
	Lysine	10.9
	Methionine	6.0
	Calcium	8.0
	Phosphorus	7.0
	Fat	31.0

BEHAVIOUR

INTRODUCTION

The development of spatial behavior and alternative behavior is a complex process. It involves the interaction of various factors, including the physical environment, social structure, and individual characteristics. The study of these behaviors is essential for understanding human settlement patterns and the development of urban areas.

MATERIALS AND METHODS

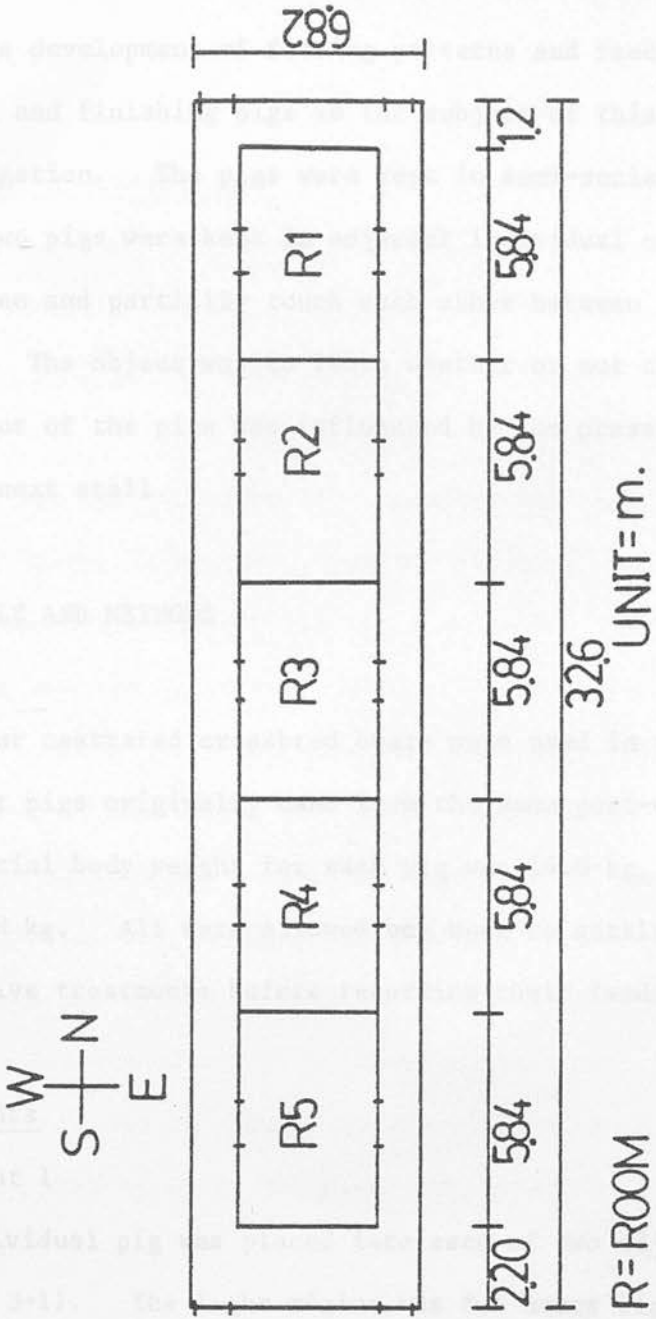
Methods

The study was conducted using a combination of field observations and interviews. Data was collected from various sources, including maps, aerial photographs, and local residents. The analysis of this data revealed several key findings regarding the development of spatial behavior and alternative behavior.

RESULTS AND DISCUSSION

The results of the study indicate that the development of spatial behavior and alternative behavior is a dynamic process. It is influenced by a variety of factors, including the physical environment, social structure, and individual characteristics. The discussion of these results highlights the importance of understanding the complex interactions between these factors in order to effectively plan and manage urban development.

FIGURE 2-1



Plan of development house

Figure 2-1

CHAPTER 3 THE DEVELOPMENT OF FEEDING BEHAVIOUR AND ALLELOMIMETICBEHAVIOUR

## INTRODUCTION

The development of feeding patterns and feeding behaviour of growing and finishing pigs is the subject of this part of the investigation. The pigs were kept in semi-social conditions in which two pigs were kept in adjacent individual stalls. The pigs could see and partially touch each other between the steel bar divisions. The object was to learn whether or not the feeding behaviour of the pigs was influenced by the presence of a neighbour in the next stall.

## MATERIALS AND METHODS

Animals

Four castrated crossbred boars were used in this experiment. All four pigs originally came from the same post-weaning group. The initial body weight for each pig was 14.0 kg, 13.8 kg, 14.2 kg and 14.8 kg. All were allowed one week to settle into their respective treatments before recording their feeding behaviour.

Treatments

## Treatment 1

One individual pig was placed into each of two adjacent stalls (Figure 3-1). The light régime was 8.5 hours light and 15.5 hours of darkness. The time spent feeding was recorded for 23.5 hours when the pigs weighed around 20 kg, 40 kg, 60 kg and 80 kg.

## Treatment 2

One pig was placed in each of two adjacent stalls which had the same arrangement as Treatment 1, but a twenty-four hour light régime was adopted. The times spent feeding were measured on the same day as Treatment 1.

## Housing and facilities

Rooms 2 and 3 of the development house (Figure 2-1) were used for Treatment 1 and 2 respectively and the two pigs were kept in the southern part of the room in adjacent stalls (Figure 3-1) in both treatments.

An automatic feeding time recorder was used. The essence of this equipment is a micro-light switch and a small lamp fixed on either side of a self-feeder (Figure 3-2). The micro-light switch, the lamp and the wires were fully protected by a steel pipe to avoid damage by the pigs. The equipment depended on the movement of a pig's head to switch off the electric circuit so that when the pig put its head into the feeder the light was blocked and thus cut the electrical circuit, turning off the micro-light switcher. When the pig's head was withdrawn from the feeder the electrical circuit was complete and turned on the micro-light switcher. A Rustrak Events recorder was used to record the on-off readings of the electrical circuit. The speed of the recorder was set at 0.25 inches/10 seconds.

## Statistical Model

$$\text{Model 3-1a: } Y_{ijk} = \mu + \theta_i + \tau_j + \beta_k + \psi_{jk} + e_{ijk}$$

$$\text{Model 3-1b: } Y_{ijk} = \mu + \theta_i + \tau_j + \beta_k + \psi_{jk} + rx_{ijk} + e_{ijk}$$

In which Y = independent variable

$\mu$  = grand mean

$\theta$  = replicate

$\tau$  = treatment

$\beta$  = different body weight stage

r = regression coefficient

x = body weight

$\psi$  = treatment x different body weight stage

e = error

### Husbandry and Procedure

The pelleted food was weighed every morning between 8.30 am and 9.00 am for each pig and put into an individual basket with more food than a pig could consume in a day being provided. The light was switched on at 9.00 am and off at 5.30 pm for Treatment 1 (room 2) and left on for 24 hours for Treatment 2 (room 3). At 9.00 am the self-feeders were moved out of the pen and the residual food of each pig was collected, weighed and recorded. The old roll of recording sheet was replaced by a new one and each pig weighed.

Fresh water was always available throughout the day and night in a water trough. All the faeces on the solid floor were removed. The recorder was switched on at 9.29 am and food provided at 9.30 am. As soon as food was provided the doors of the room and the house were closed. The recorder roll was renewed at 5.30 pm and 1.30 am.

Room temperature was set at 26°C, 24°C, 22°C, 20°C and 18°C to correspond with the following body weights - 14 kg to 25 kg, 25 kg to 30 kg, 30 kg to 35 kg, 35 kg to 60 kg and 60 kg to 84 kg respectively.

### Behavioural measurements

Two categories of behaviour were recorded, feeding and non-feeding. The feeding unit was defined at two levels: 'bouts' and 'meals'. All the time spent in other behaviour was classified as non-feeding. A feeding bout was defined here as the time from when a pig put its head into a trough to start feeding until the head was withdrawn for longer than 10 seconds. The end of a feeding bout was considered the second in which the head left the trough. A

cluster of feeding bouts between two long non-feeding intervals was considered to be a meal. The criterion for deciding what constituted a long non-feeding period will be discussed in the results.

## RESULTS

### Definition of a 'meal'

Two basic working hypotheses were used for the analysis of the criteria of a meal. (1) When an animal does not eat, sooner or later it's responsiveness to the food stimuli will increase. (2) When the animal eats, sooner or later this responsiveness to food stimuli will decrease (Metz, 1975). Figures 3-3,a,b,c and d show the log survivorship curves for the interval between two eating bouts as shown on the recorder charts. Each individual figure in Figures 3-3,a,b,c and d represents the log survivorship curve for the data from an individual pig in the first 8 hours of the testing day for a particular weight stage. For each animal, the curve started as a straight line which indicated more short intervals and fewer intervals of medium and long periods. This result agrees with Wiepkema's (1968) suggestion in which he described the existence of two types of non-feeding interval. Type 1 is a short interval with a high probability of starting to eat. Type 2 is a long interval with a low probability of starting to eat. The log survivorship curves plotted showed a fairly clear division between the two types of feeding interval in the present results. The minimum meal interval is shown on Table 3.1 for each pig at the different body weight stages.

### Total food consumption

The food intake was analysed by the regression based on daily records of food intake on the body weight of the pigs. The results showed no significant differences in total food intake between pigs which lived on a 24 hour light cycle and those on an 8.5 hour light cycle. The regression equations show the relationship between food intake and body weight (Equation 3-1) and between food intake and metabolic body weight (Equation 3-2).

$$Y = 820 + 34.8 \times WT \quad \text{Equation 3-1}$$

$$Y = 324 + 121.1 \times MWT \quad \text{Equation 3-2}$$

In which Y = food intake

WT = body weight

MWT = metabolic body weight

Figure 3-4 shows the relationship between body weight and food intake.

When the pigs weighed between 20 kg and 70 kg there was a simple linear relationship between food intake and body weight. However for pigs weighing more than 70 kg, the relationship was not so straightforward. The slope of the graph comparing body weight and food intake was steeper for pigs weighing 15 kg to 20 kg.

The total food intake was also analysed by Model 3-1a based on the results of each testing day, when the body weight was around 20 kg, 40 kg, 60 kg and 80 kg. The results show no significant differences ( $p > 0.05$ ) in food intake between treatments. The food intake was significantly different ( $p < 0.01$ ) between body weights. There were no significant interactions ( $p > 0.05$ ) between body weight and food intake (Table 3.2).

The eating speeds were calculated by dividing the total food

consumption on that particular day by the total feeding time of the same day. The eating speed of pigs of around 20 kg, 40 kg, 60 kg and 80 kg body weight was analysed by Model 3-1 and no significant differences ( $p > 0.05$ ) in eating speed of pigs in the two treatments were found (Table 3.2). However pigs of different body weights did show significant differences in eating speeds ( $p < 0.005$ ). The eating speed increased with increased body weight (Figure 3-5). When the eating speed was adjusted for body weight (Model 3-1a and b), the differences disappeared (Figure 3-6) and the interaction between treatment and body weight produced no significant results ( $p > 0.05$ ).

#### Feeding time

The percentage of total time devoted to feeding was calculated by dividing the total feeding time of a particular test day by the 23.5 hours (84600 seconds) and multiplying by 100. The results (Table 3.2) show that there were no significant differences between treatments ( $p > 0.05$ ). However, there were significant differences ( $p < 0.05$ ) between pigs with different body weights. Furthermore there were no significant interactions between treatments and body weights ( $p > 0.05$ ).

The distribution charts of total feeding times of each pig in each test day are shown in Figures 3-7,a,b,c and d. The basic unit of these charts is 300 seconds (5 minutes) and each chart shows the numbers of seconds spent eating in every 300 second period, with 12 units being one hour. For further analysis the day was divided into two 8 hour and one 7.5 hour period.

Models 3-1a and b were used to analyse the total feeding time

for the three time periods and combinations of the time periods in this part of the study.

(1) A comparison of the treatments: total feeding time over 23.5 hours (Table 3.3, Figure 3-8).

The total feeding times over 23.5 hours did not reach a significant level ( $p > 0.05$ ) between treatments, although the average total feeding time was higher in the short day than in the long day treatment. Furthermore, the total feeding time tended to decrease with an increase of body weight, although the differences also did not reach a significant level.

(2) Total feeding time over the first 8 hour period (Table 3.3, Figure 3-9).

The results showed significant differences ( $p > 0.05$ ) between the two light régimes but there were no significant differences in this measurement ( $p > 0.05$ ) between pigs of different body weights. However the lightest pigs had the highest average total feeding time during the first 8 hours of the test day.

(3) Total feeding time over the second 8 hour period (Table 3.3, Figure 3-9).

There were no significant differences ( $p > 0.05$ ) between treatments or between pigs of different body weights, although the total feeding time of pigs in this period showed a decrease with increasing body weight. There were no significant interactions ( $p > 0.05$ ) between treatments and body weight.

(4) Total feeding time over the third (7.5 hour) period. (Table 3.3, Figure 3-9).

There were no significant differences in this period ( $p > 0.05$ ) between treatments or between different body weight classes.

Although the total feeding time of pigs in this period tended to decrease with increasing body weight, no significant interactions ( $p > 0.05$ ) between treatments and body weight were found.

(5) Total feeding time 0 - 16 hours (Table 3.3)

There were no significant differences ( $p > 0.05$ ) between treatments or between pigs of different body weights, although the pigs in the short day treatment had a higher average total feeding time for this period than the pigs in the long day treatment. The average total feeding time of pigs in this period decreased with increasing body weight. Again there were no significant interactions between treatments and different body weights ( $p > 0.05$ ).

(6) Total feeding time 8 - 23.5 hours (Table 3.3)

There were no significant differences ( $p > 0.05$ ) between treatments or between pigs of different body weights. The interaction between treatment and different body weight was also not significant ( $p > 0.05$ ).

(7) Total feeding time. A comparison between 0 - 8 hours and 8 - 23.5 hours (Table 3.3).

The results showed significant differences in total feeding time between treatments ( $p < 0.005$ ) and also between pigs of different body weights ( $p < 0.01$ ). The longest total feeding time for this period occurred when the pigs weighed around 80 kg. Also there were no significant interactions between treatments and different body weights.

(8) Total feeding time. Comparisons between 0 - 8 hours and 8 - 16 hours (Table 3.3) and between 8 - 16 hours and 16 - 23.5 hours (Table 3.3).

The results showed no significant differences between

treatments or between pigs of different body weight. Also the interactions between treatments and different body weights for each of the three periods did not reach a significant level ( $p > 0.05$ ).

#### Feeding time in a period as a percentage of total feeding time

It was difficult to assess the true differences between treatments because of the variation in the eating speed of individual pigs. Consequently the percentage total feeding time was analysed in order to gain a better understanding of the effect of the treatments. The percentage total feeding time was calculated by dividing the feeding time in a particular period during the day by the total feeding time for the whole of that day and multiplying by 100. Model 3-1a,b was used to analyse this measurement (which is called percentage total feeding time) for all the time periods and combination of time periods in this part of the study.

(1) Percentage total feeding times, 0 - 8 hours (Table 3.4)  
Figure 3-10.

The results showed no statistically significant differences between treatments ( $p > 0.05$ ), but body weight did have a significant effect on percentage total feeding time. When the pigs reached 80 kg they showed a significantly higher percentage total feeding time in this period than those pigs weighing less than 80 kg ( $p < 0.01$ ). Pigs lighter than 60 kg showed a significantly lower percentage of total feeding time in this period than pigs weighing around 60 kg ( $p < 0.01$ ). There were no significant differences in these measurements when the pig's body weight was around 20 kg and 40 kg ( $p > 0.05$ ).

(2) Percentage total feeding times, 8 - 16 hours (Table 3.4)

Figure 3-10.

Neither treatment nor body weight had any significant effect on the results for the period 8 - 16 hours ( $p > 0.05$ ).

(3) Percentage total feeding times, 16 - 23.5 hours (Table 3.4)

Figure 3-10.

As in the second period, the period of observation 16 - 23.5 hours, produced no significant results from the treatments of body weight ( $p > 0.05$ ).

(4) Percentage total feeding times, 8 - 23.5 hours (Table 3.4).

When the results from (2) and (3) above were combined there were also no significant differences between treatments. However pigs of 80 kg had a significantly lower percentage total feeding time than those of 60 kg and less ( $p < 0.01$ ). Likewise the pigs of around 60 kg had a significantly lower percentage total feeding time than those of 40 kg and 20 kg for the 8 - 23.5 hour period. There was no significant ( $p > 0.05$ ) interaction between treatment and body weight for this period.

(5) Comparison percentage total feeding time between

0 - 8 hours and 8 - 23.5 hours (Table 3.4).

There were no significant differences between treatments ( $p > 0.05$ ). However body weight did have a significant effect on the results ( $p < 0.01$ ). The pigs of 80 kg had significantly higher scores in this measurement than pigs weighing around 60 kg, 40 kg, and 20 kg. Also the pigs weighing around 60 kg had significantly higher scores than the pigs weighing around 40 kg and 20 kg. The interaction between treatment and different body weights was not significant ( $p > 0.05$ ).

(6) A comparison percentage total feeding time between 0 - 8 hours and 8 - 16 hours (Table 3.4).

In the results shown there were no significant differences between day light treatment ( $p > 0.05$ ) while the differences between the various body weights were significant ( $p < 0.05$ ). However there were no significant interactions ( $p > 0.05$ ) between treatments and different body weights.

(7) Comparison percentage total feeding time between 8 - 16 hours and 16 - 23.5 hours (Table 3.4).

There were no significant differences ( $p > 0.05$ ) between treatments and between different body weights nor did the interaction between treatment and body weight reach a significant level ( $p > 0.05$ ).

#### Number of meals

The number of meals in the first eight hours was determined by the method which was mentioned in the beginning of the Results section.

The number of meals in the last 15.5 hours of each test day was determined in the following way: the minimum length of the interval between meals measured in the first 8 hour period for each pig on a particular day was used as the minimum interval length between meals for the last 15.5 hours of the test day for that pig. This figure was then used to determine the number of meals.

Model 3-1a and b was used to analyse the number of meals for all the time periods and the combinations of any time periods in this part of the study.

(1) The number of meals taken within 23.5 hours (0 - 23.5 hours) (Table 3.5).

The results showed significant differences in the total number of meals eaten by the pigs on the two light treatments ( $p < 0.005$ ). Pigs of different body weights also showed significant differences in the total number of meals eaten. There were no significant interactions ( $p > 0.05$ ) between treatments and the different body weight stages.

(2) The number of meals taken within the first eight hours (0 - 8 hours) (Table 3.5).

The results from this period were the same as for the last one.

(3) The number of meals taken within the second eight hour period (8 - 16 hours) (Table 3.5).

There were no significant differences ( $p > 0.05$ ) between treatments or between the different body weight stages, nor were there any significant interactions found between treatments and the different body weight stages.

(4) The number of meals taken during the last 7.5 hours (16 - 23.5 hours) (Table 3.5).

During the last 7.5 hours the pigs ate significantly more meals in the second treatment than in the first ( $p < 0.005$ ). There were also significant differences in the total number of meals between pigs of different body weights ( $p < 0.005$ ).

(5) A comparison of the total number of meals between 0 - 8 hours and 8 - 23.5 hours (Table 3.5).

There were no significant differences in the total number of meals eaten between treatments ( $p > 0.05$ ). Body weights did have a significant influence on the total number of meals eaten in the

period. The pigs weighing around 80 kg had a significant higher number of meals in this comparison ( $p < 0.05$ ) than the pigs in the other body weight stages but there were no significant differences when the pigs' body weights were 20 kg, 40 kg and 60 kg. Also there were no significant interactions between body weight stages and treatments ( $p > 0.05$ ).

(6) A comparison of the total number of meals between 0 - 8 hours and 8 - 16 hours (Table 3.5).

There were no significant differences ( $p > 0.05$ ) between treatments in the total number of meals in this comparison. Also no significant differences were found between different body weight stages ( $p > 0.05$ ). There was no significant interaction between treatments and body weight stages ( $p > 0.05$ ).

The following two comparisons also yielded non-significant results.

(7) A comparison between the total number of meals eaten between 8 - 16 hours and 16 - 23.5 hours (Table 3.5).

(8) A comparison of the total number of meals between 0 - 16 hours and 16 - 23.5 hours period (Table 3.5).

In order to discover whether or not pigs in the same room ate at the same time, the feeding sequences of each pair of pigs was compared. The pigs were recorded as having eaten at the same time if they fed from their troughs at the same time simultaneously, irrespective of how long they ate together in the meal. Table 3.6 shows the results of how many meals which any two pigs of four pigs in both Treatment 1 and 2 ate at the same time.

Figures 3-11a,b,c and d show the results of the Minimum Similarity Analysis of the data from the four pigs at each body

weight. The pigs in the same room had a high similarity during most periods, the only exception being during the last 7.5 hour period.

#### DISCUSSION

Although there were some reports on the allelomimetic behaviour in domestic sheen (Arnold, 1962) and the dog (Scott and Marston, 1950) there are no <sup>formal</sup> reports on this type of behaviour in pigs. The results of the analysis by Minimum Similarity Analysis of feeding strongly supports the view that the allelomimetic behaviour occurs in the feeding behaviour of pigs - that is the pigs tend to go to eat at the same time. The results in part 3 of Chapter 12 also show the occurrence of allelomimetic behaviour of pigs. Whether allelomimetic behaviour causes an increase or decrease in food intake in pigs is not quite certain. If this behaviour can induce pigs to eat more then it will benefit the growth of pigs. However, this behaviour may induce all pigs in a group to go to the trough at the same time and thus cause competition which may result in some inferior animals having less chance to eat. Whether group feeding benefits the pigs' food intake will be closely studied in Chapter 4.

The present results demonstrate that allelomimetic behaviour does not decrease with increasing body weight of the pigs, at least in the following range of body weight - 20 kg to 80 kg. On the other hand, the results seem to suggest that allelomimetic behaviour may sometimes be decreased by high motivation to sleep. For example, the present results show that the Similarity Rate of feeding in the pigs in the same room was not consistent in the last 7.5 hours test period. However this may not be due to the

motivation to sleep, but due to a low motivation to feed in the evening so that the pig which initiates the feeding may not eat long enough to stimulate the non-feeding pigs to eat and it itself may also have a low level of motivation to feed, so that it, too, needs social stimulation. This suggestion is supported by the results of part 3 of Chapter 12.

Summarizing the present results, it appears that when food is available all the time pigs kept in individual pens under one of the present two light régimes, may change their feeding behaviour but the total food intake is not changed. In this experiment the most significant difference is in the total number of meals. The pigs kept under 24 hour light régime had more meals than the pigs in 8 hour - 15.5 hour light-dark régime. This difference may either be caused by (1) The pigs on the short day realizing that the period of light is limited while the others may know that they have a long period for feeding. (2) The 24 hours light régime may cause some psychological change in the pigs so that they cannot concentrate on feeding, or they become over-active. The pigs under the 24 hour light régime appeared to be over-active, compared with the pigs under the 8 - 16 hour light-dark régime. This was very noticeable during the half hour routine work every morning. (3) A combination of the above two factors. The relationship between 24 hour light régime and the hyperactivity of pigs needs further study.

Another interesting result of this experiment is the development of feeding behaviour in pigs from around 15 kg to 80 kg body weight. The Figure 3-4 shows that the trends in food intake within this body weight range can be divided into three stages. In the first stage, in which the pigs weigh between 15 kg and 20 kg, the

rate of food intake of the pigs increases more sharply than in other stages. In the second stage, in which the pigs weigh between 20 kg and 70 kg, the increase in the rate of food intake is between first and third stages. In the third stage, in which the pigs weigh between 70 kg and 80 kg, there is a big variation in food intake and the rate of increase is the lowest of the three stages.

These findings may explain some of the complexity of feeding behaviour in pigs. For example, all the studies in this thesis show that the total feeding time of pigs either keeps constant or decreases a little with increased body weight for pigs heavier than 25 kg. The same finding was reported by Wood-Gush and Csermely (1981) for 3 to 6 week old piglets. However Fraser (1978) reported that the total feeding time increased with an increase in body weight for 3 to 6 week old piglets. This ambiguity is not impossible, because if the increase of eating speed of some piglets cannot cope with the increased rate of food intake, as shown in Figure 3-4, then the total feeding time naturally will increase with the increase of body weight or age. The present results show that the increase in food intake is very fast in piglets weighing up to 20 kg. The time spent feeding will depend on eating speed, so that if eating speed cannot cope with the increase in rate of food intake over this period of growth, then there will be an increase in feeding time.

The big variation in food intake in heavier pigs may have been because their food intake rhythm is longer than 24 hours, ie their food intake in a certain day may be more than their requirements for 24 hours so that food intake is decreased on the next day. This kind of survival technique may be found in some wild animals which

eat a big meal which can last for a fairly long period. It is an interesting phenomenon and needs further study in the future.

There is a big variation in eating speed between individuals and it increases with increasing body weight, even in the *ad lib* feeding conditions of the present experiment. Olsson and Claesson (1979) also reported that the eating speed of pigs increases with increases in body weight under restricted feeding conditions. However, when the results from the eating speed data were divided by body weight and plotted against body weight then the eating speed per unit of body weight remains fairly constant. These results suggest that the increase of eating speed with increase in body weight may simply be due to the increase of the size of mouth, tongue, teeth, etc, and not due to feeding motivation, ie feeding motivation is fairly constant and is not influenced by the age or weight of the pig.

The total feeding time of pigs also kept constant and even increased with increasing body weight. As explained previously, the decrease in total feeding time with the increase of body weight is due to the increase in eating speed when pigs become bigger and heavier.

The total feeding time of the pigs during the first 8 hour period either kept very constant or even decreased as their body weights increased. When the percentage during the first 8 hours of total feeding time is compared for different body weights, the results show that the pigs spent a relative low percentage of the total feeding time in the first 8 hours when their weights were around 20 kg and 40 kg. However the percentage of total feeding time in this period increased with increases in body weight. On

the other hand, the percentage of total feeding time decreased with the increasing body weight in the last 15.5 hours (8 - 23.5 hours), but this kind of tendency was not clear in the second 8 hours (8 - 16 hours) and last 7.5 hours. It might be suggested that these last 15.5 hours have to be considered as a whole.

The total number of meals decreased with the increasing body weight from 20 kg to 40 kg. The same happened in the first 8 hours. The changes in total feeding time and total number of meals clearly indicated that day-time feeding behaviour developed more strongly with increases in age or body weight, ie the pigs decrease their feeding activity at night time with the increase in age and body weight.

Briedermann (1971) reported that the wild pig readily changed from nocturnal to diurnal activity. Steinbach (1978) found that pigs have more day time feeding in tropical environments.

Ingram, Walters and Legge (1980) found that 6 - 12 week old pigs had their most food in the day time under a 12 - 12 light-dark light régime, when the piglets are in groups and have environmental temperature around 25°C. However this was less marked in pigs kept alone, although the piglets still tended to be more active in the light. They also found that the feeding activity of piglets tended not to follow the above rhythms when the piglets were put into continuous light.

According to common knowledge 6 - 12 week old pigs may weigh around 14 kg - 30 kg. In this range of weights the piglets would still have a high percentage of feeding in the evening so that the pigs in this range of weight may not be ideal animals to ascertain whether the pigs are diurnal or nocturnal animals in any husbandry

system. during the day, otherwise they will eat at night. If this

On the other hand, the present results may not be totally satisfactory to answer this question because they were interrupted every day at a fixed time, which could have acted as a starting point for their activity rhythms. However, if we compare suckling frequency of piglets with the present pigs' feeding frequency (meals), some interesting similarities are seen. Piglets decrease their suckling frequency as their body weights or age increase (Niwa, Yokoyama and Otsuka, 1951), but their total milk intake increases with increasing age until 3 weeks old (Onderscheka, 1970). The present results indicate that the frequency of meals also decreases with increased body weight, especially when body weight increases from 20 kg to 40 kg, while the total food intake increased with increases in body weight.

The points raised here are: First, the food intake mechanism may develop with the increase in body weight or age. Second, newly-weaned piglets may be accustomed to suckling at certain times and their feeding pattern may follow that pattern after weaning. The pigs may feed as frequently as before weaning, no matter whether the light period is 24 hours or whether there is a light-dark cycle.

Another point, which was mentioned previously, is that the mature pigs may eat a quantity of food which exceeds their needs over 24 hours so that they do not have to eat so much on the next day. Thus the feeding behaviour of piglets may be influenced not only by their environment but by habits which build up in the suckling stage. When they are mature, they are more influenced by their environment. If the mature pigs can find food in day time,

they eat during the day, otherwise they will eat at night. If this is the case then pigs generally should not be considered to be either diurnal or nocturnal animals with regard to their feeding behaviour.

Feeding rate and feed intake at each body weight stage

Body weight stage	20 kg	40 kg	60 kg	80 kg
Treatment	Pig No.			
1	1	1387	1461	1518
1	2	1619	1643	1709
2	3	873	1175	969
2	4	496	1623	832

Units - seconds

TABLE 3.1 The minimum meal interval of each pig in the two treatments and in each body weight stage

Body weight stage	20 kg	20 kg	40 kg	60 kg	80 kg
Treatment	Pig No	Food Intake (kg)			
1	1	1127	1461	1018	1630
1	2	1814	1243	1209	1461
2	3	879	1190	949	2810
2	4	496	1683	852	973

Treatment	(II) Eating speed (g/second)				
1	0.173	0.287	0.283	0.303	0.395
2	0.279	0.627	0.667	1.203	0.744
Average	0.225	0.457	0.475	1.031	

Treatment	(III) The percentage of total time devoted to feeding (X) in 21.5 hours				
1	8.3	8.4	9.0	4.8	9.1
2	4.1	5.0	1.4	2.0	3.8
Average	7.1	3.7	4.8	3.7	

TABLE 3.1 The effect of light treatment and body weight on the (total) feeding time for the United time periods and combinations of these periods

TABLE 3.2 The effect of light treatments and body weight on food intake, eating speed and the percentage of total time devoted to feeding of pigs in 23.5 hours

Body weight stages	20 kg	40 kg	60 kg	80 kg	Average
Treatment	(i) Food intake (kg)				
1	1.150	2.674	3.200	3.406	2.608
2	1.314	2.384	3.298	3.195	2.548
Average	1.232	2.529	3.249	3.300	
Treatment	(ii) Eating speed (g/second)				
1	0.171	0.583	0.765	0.863	0.595
2	0.279	0.627	0.867	1.203	0.744
Average	0.225	0.605	0.816	1.033	
Treatment	(iii) The percentage of total time devoted to feeding (%) in 23.5 hours				
1	8.3	6.4	5.0	4.8	6.1
2	6.1	5.0	4.6	2.6	4.6
Average	7.2	5.7	4.8	3.7	
Treatment	(iv) Comparison between 0 - 5 hours and 5 - 23.5 hours				
1	731	1413	1306	1761	1303
2	1057	548	1039	825	882
Average	894	981	1173	1293	
Treatment	(v) Comparison between 0 - 15 hours and 15 - 23.5 hours				
1	1128	284	354	488	392
2	553	336	338	297	381
Average	841	310	346	393	

TABLE 3.3 The effect of light treatment and body weight on the total feeding time for the three time periods and combinations of these periods

Body weight stage	20 kg	40 kg	60 kg	80 kg	Average
Treatment	(i) 0 - 23.5 hours				
1	6997	5408	4205	4059	5167
2	5132	4180	3845	3182	4085
Average	6065	4794	4025	3621	
Treatment	(ii) 0 - 8 hours				
1	3193	2821	2390	2682	2772
2	2598	1871	2070	1843	2096
Average	2896	2346	2230	2263	
Treatment	(iii) 8 - 16 hours				
1	2462	1407	1084	921	1469
2	1543	1323	1048	1018	1233
Average	2003	1365	1066	970	
Treatment	(iv) 16 - 23.5 hours				
1	1342	1179	730	456	927
2	990	986	710	321	752
Average	1166	1083	720	389	
Treatment	(v) 0 - 16 hours				
1	5655	4228	3475	3603	4240
2	4142	3194	3136	2861	3333
Average	4899	3711	3305	3232	
Treatment	(vi) 8 - 23.5 hours				
1	3804	2587	1814	1377	2396
2	2534	2309	1758	1339	1985
Average	3169	2448	1786	1358	
Treatment	(vii) Comparison between 0 - 8 hours and 8 - 23.5 hours				
1	738	234	576	1857	851
2	64	-438	329	504	115
Average	401	-102	453	1181	
Treatment	(viii) Comparison between 0 - 8 hours and 8 - 16 hours				
1	731	1413	1306	1761	1303
2	1055	548	1039	825	867
Average	893	981	1173	1293	
Treatment	(ix) Comparison between 8 - 16 hours and 16 - 23.5 hours				
1	1120	228	354	464	542
2	553	336	338	697	481
Average	836	282	346	581	

Unit - seconds

TABLE 3.4 The effect of light treatments and body weight on percentage of total feeding time for the three time periods and combinations of the time periods

Body weight stage	20 kg	40 kg	60 kg	80 kg	Average
Treatment	(i) 0 - 8 hours				
1	46.7	52.3	57.2	65.9	55.5
2	50.7	44.8	54.5	62.7	53.2
Average	48.7	48.5	55.9	64.3	
Treatment	(ii) 8 - 16 hours				
1	34.5	25.9	25.4	24.0	27.5
2	29.2	31.5	27.7	22.7	27.8
Average	31.9	28.7	26.6	23.4	
Treatment	(iii) 16 - 23.5 hours				
1	18.8	21.7	17.3	10.0	17.0
2	20.0	23.6	17.8	14.5	19.0
Average	19.4	22.7	17.5	12.3	
Treatment	(iv) 8 - 23.5 hours				
1	53.3	47.7	42.7	34.1	44.5
2	49.3	55.2	45.5	37.3	46.8
Average	51.3	51.4	44.1	35.7	
Treatment	(v) Comparison between 0 - 8 hours and 8 - 23.5 hours				
1	-6.6	4.6	14.5	31.8	11.1
2	1.4	-10.4	9.0	25.4	6.4
Average	-2.6	-2.9	11.7	28.6	
Treatment	(vi) Comparison between 0 - 8 hours and 8 - 16 hours				
1	12.2	26.3	31.8	41.8	28.0
2	21.4	13.2	26.8	39.9	25.4
Average	16.8	19.8	29.3	40.9	
Treatment	(vii) Comparison between 8 - 16 hours and 16 - 23.5 hours				
1	15.7	4.2	7.7	14.0	10.4
2	9.2	7.9	9.9	8.2	8.8
Average	12.4	6.1	8.8	11.1	

TABLE 3.5 The effect of light treatments and body weight on the total number of meals for the three time periods and combination of the time periods

Body weight stage	20 kg	40 kg	60 kg	80 kg	Average
Treatment	(i) 0 - 24 hours				
1	15.5	13.0	11.5	8.5	12.1
2	23.0	14.0	19.5	16.0	18.1
Average	19.25	13.5	15.5	12.3	
Treatment	(ii) 0 - 8 hours				
1	8.0	5.5	5.5	5.0	6.0
2	10.0	6.5	8.5	9.0	8.5
Average	9.0	6.0	7.0	7.0	
Treatment	(iii) 8 - 16 hours				
1	4.0	5.0	3.5	2.5	3.8
2	7.0	3.5	6.0	5.0	5.4
Average	5.5	4.3	4.8	3.8	
Treatment	(iv) 16 - 23.5 hours				
1	3.5	2.5	2.5	1.0	2.4
2	6.0	4.0	5.0	2.0	4.3
Average	4.8	3.3	3.8	1.5	
Treatment	(v) Comparison between 0 - 8 hours and 8 - 23.5 hours				
1	0.5	-2.0	-0.5	1.5	-0.1
2	-3.0	-1.0	-2.5	2.0	-1.1
Average	-1.3	-1.5	-1.5	1.8	
Treatment	(vi) Comparison between 0 - 8 hours and 8 - 16 hours				
1	4.0	0.5	2.0	2.5	2.3
2	3.0	3.0	2.5	4.0	3.1
Average	3.5	1.8	2.3	3.3	
Treatment	(vii) Comparison between 8 - 16 hours and 16 - 24 hours				
1	0.5	2.5	1.0	1.5	1.4
2	1.0	-0.5	1.0	3.0	1.1
Average	0.8	1.0	1.0	2.3	

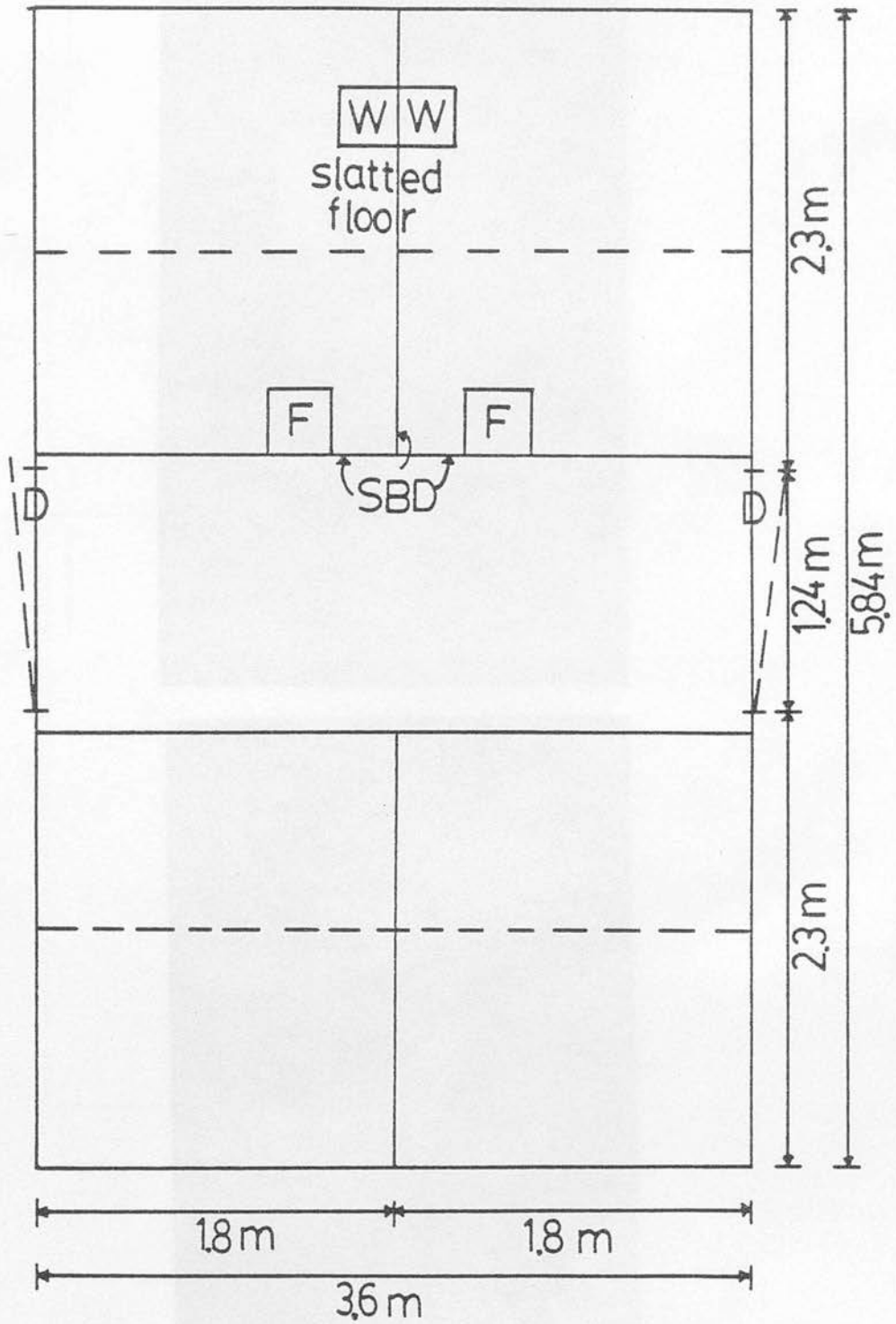
TABLE 3-6 The results of how many meals which any two pigs of four pigs in both Treatment 1 and Treatment 2 ate at the same time under different body weights

Body weight	No 1 and No 2	No 1 and No 3	No 1 and No 4	No 2 and No 3	No 2 and No 4	No 3 and No 4
~20 kg	13	6	6	7	5	18
~40 kg	7	2	2	4	4	11
~60 kg	10	4	4	5	4	18
~80 kg	5	2	4	0	2	9

Pig No 1 and No 2 were in the same room

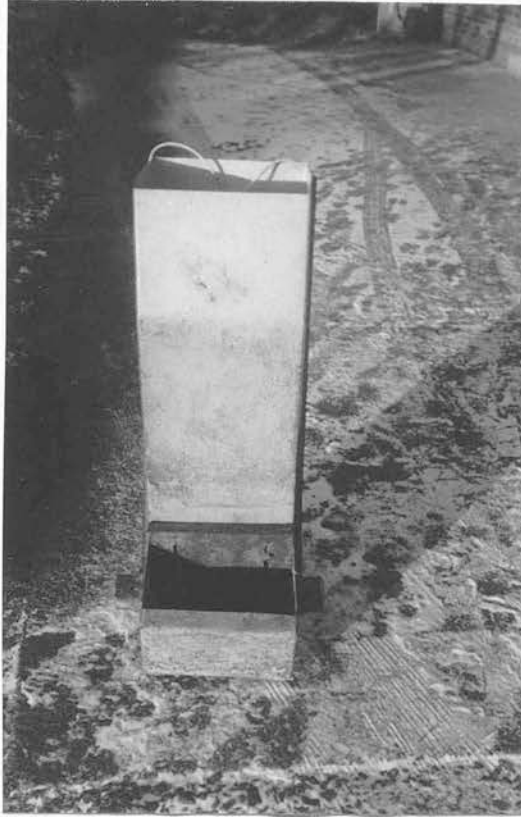
Pig No 3 and No 4 were in the same room

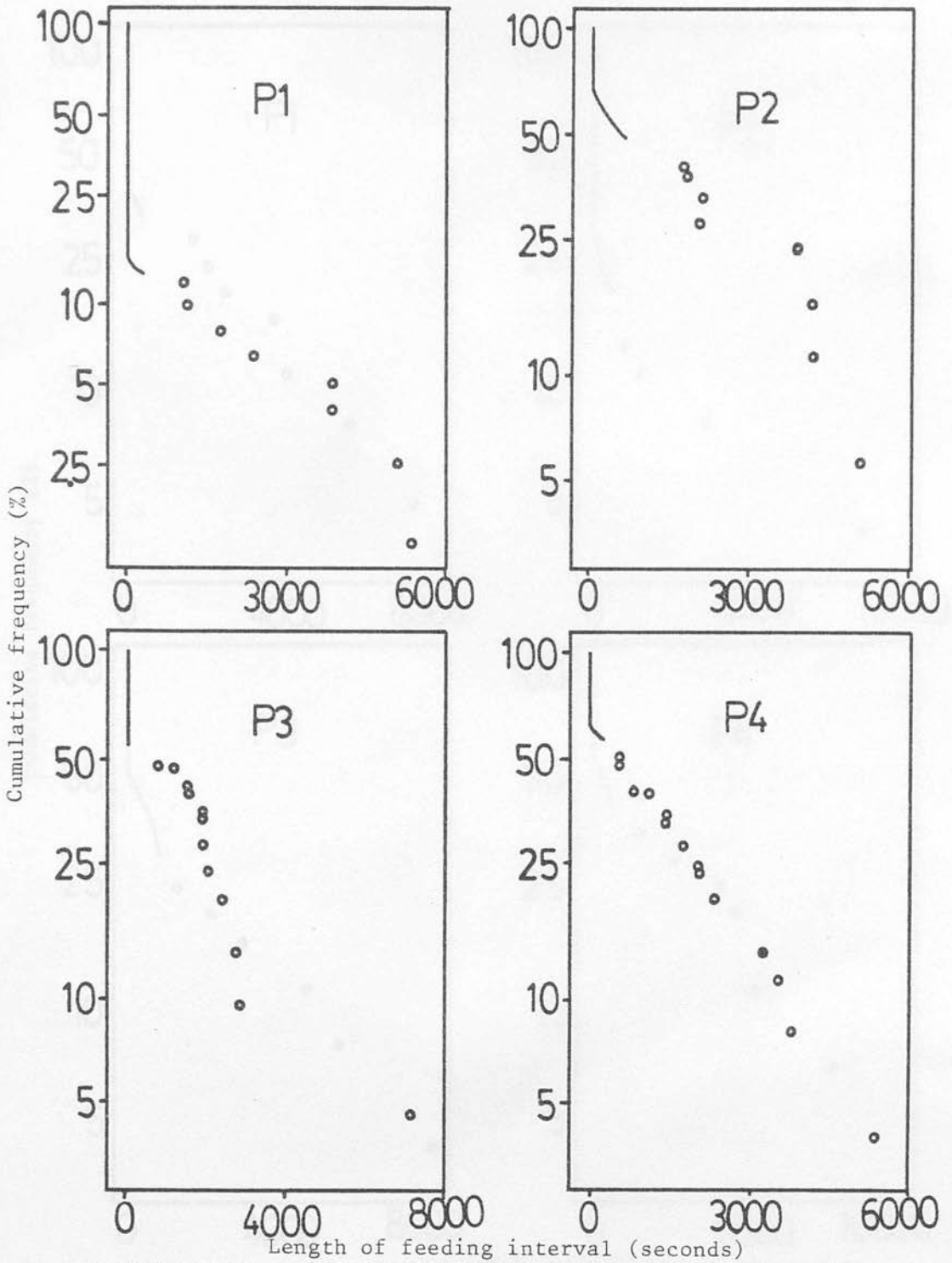
FIGURE 3-1



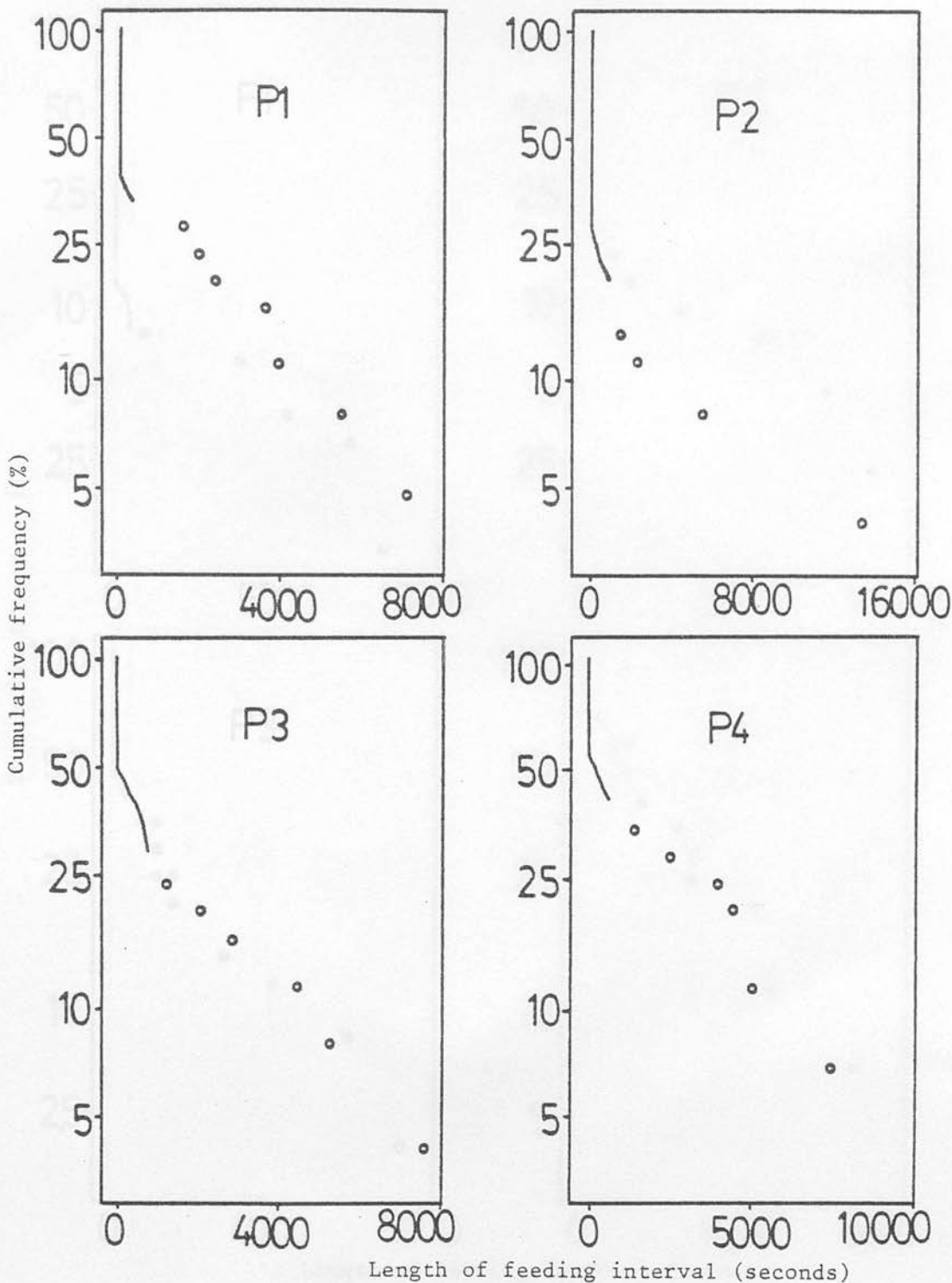
Plan of room arrangement of treatment in Chapter 3  
 D - door; F - food trough; SBD - steel bar division;  
 W - water trough

FIGURE 3-2 The self feeder used in the present experiment



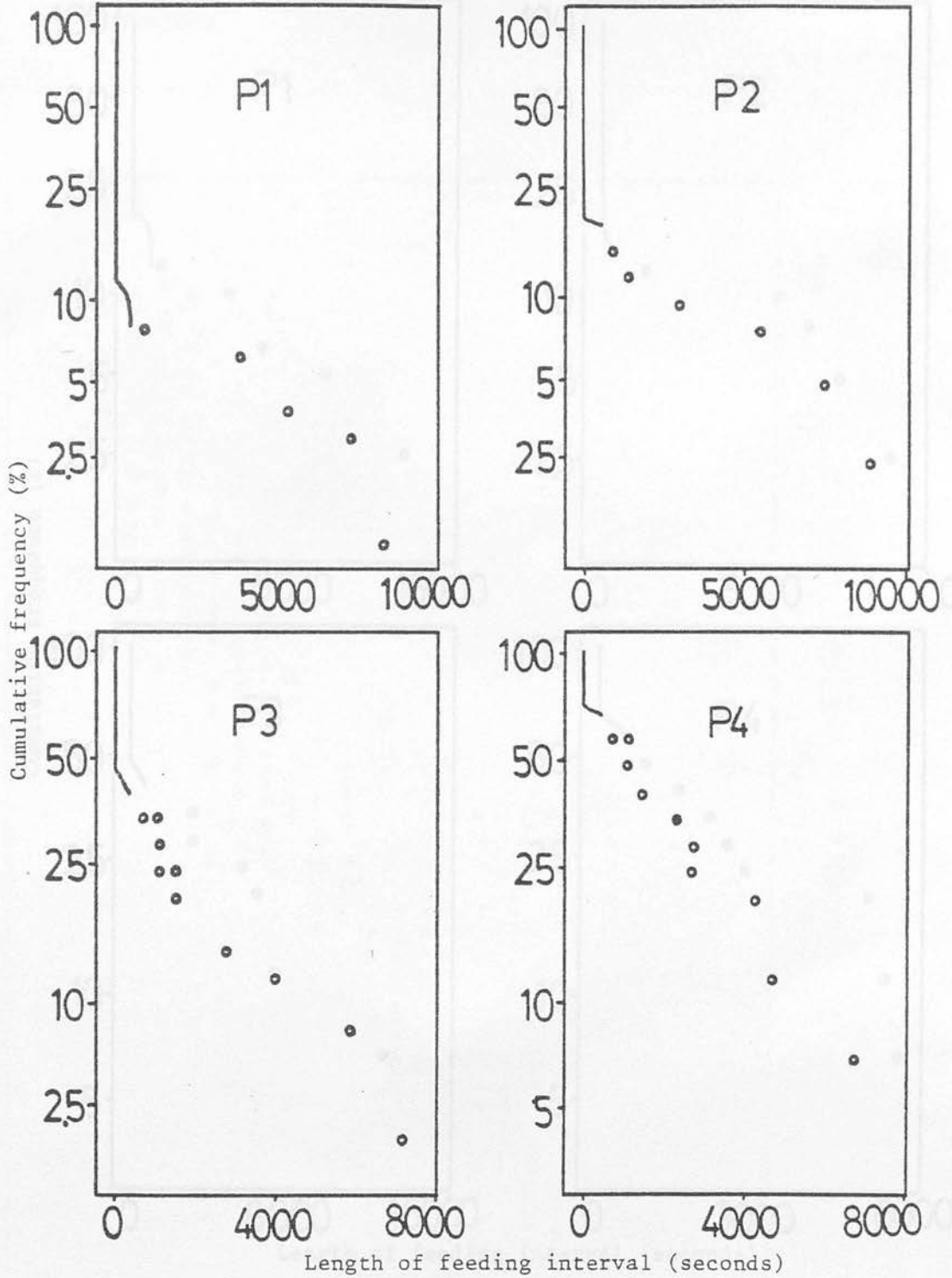


Survivorship curves for feeding interval of pigs when they weighed around 20 kg  
P - pig



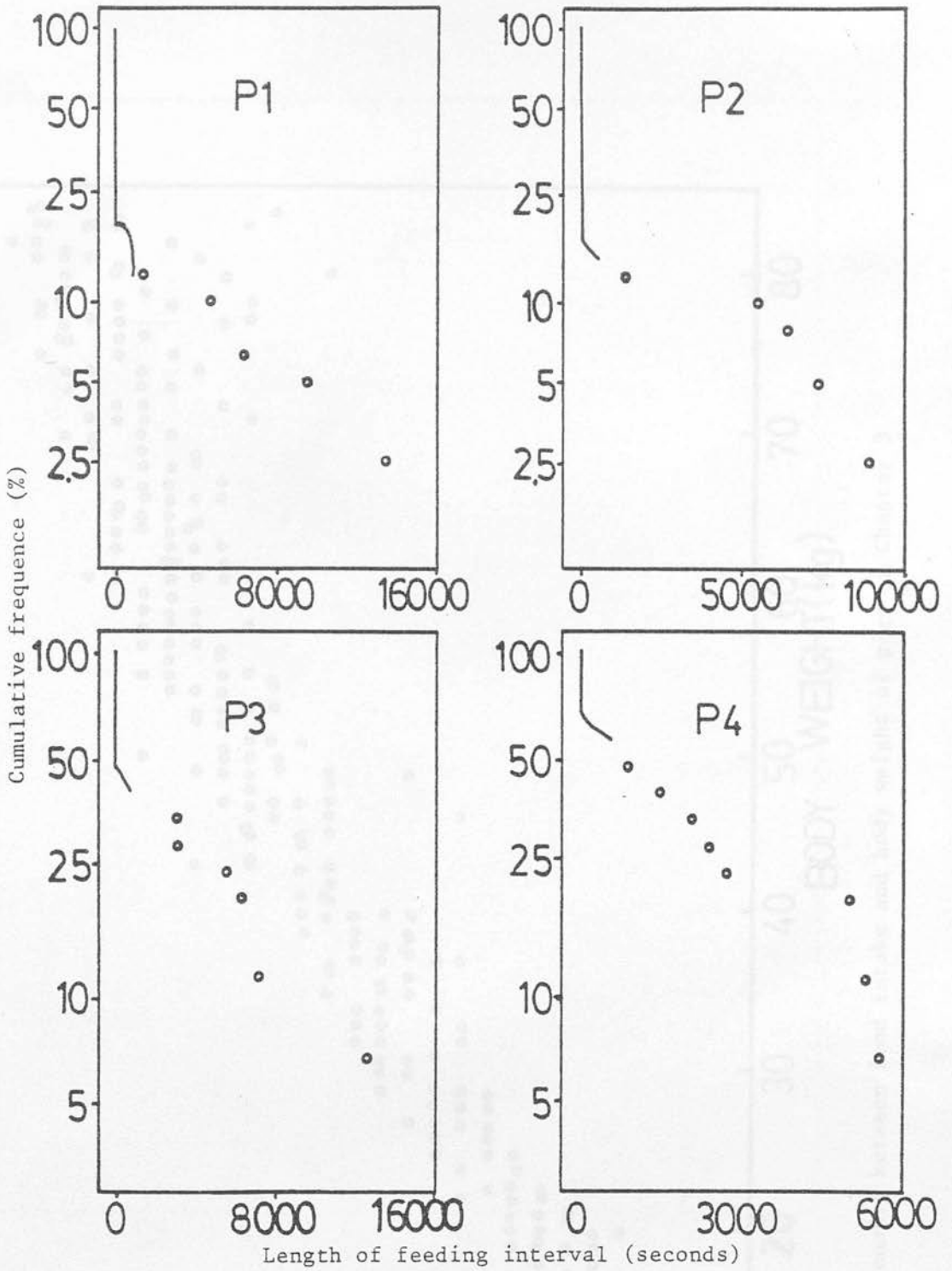
Survivorship curves for feeding interval of pigs when they weighed around 40 kg  
 P - pig

FIGURE 3-3c



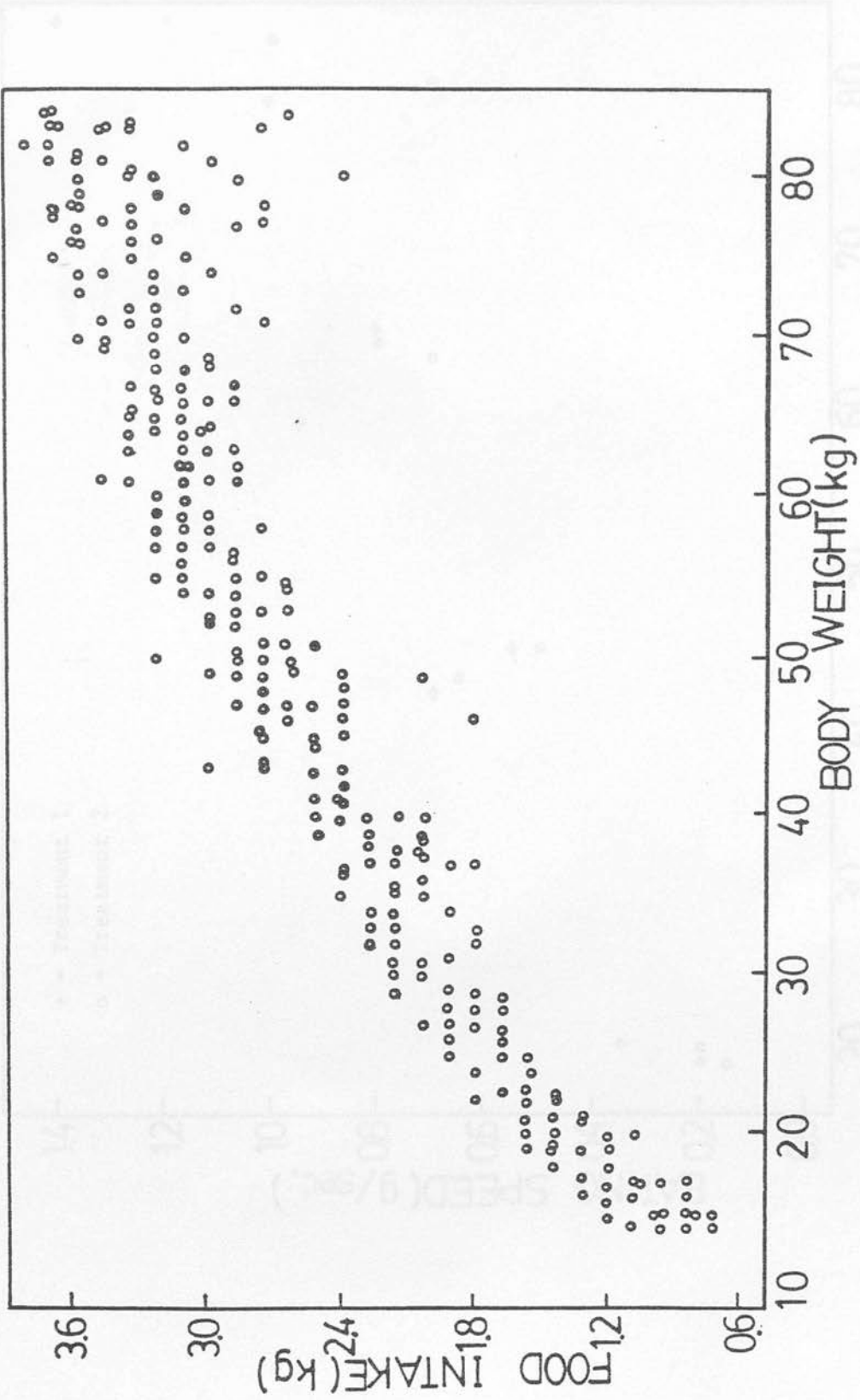
Survivalship curves for feeding interval of pigs when they weighed around 60 kg  
 P - pig

FIGURE 3-3d

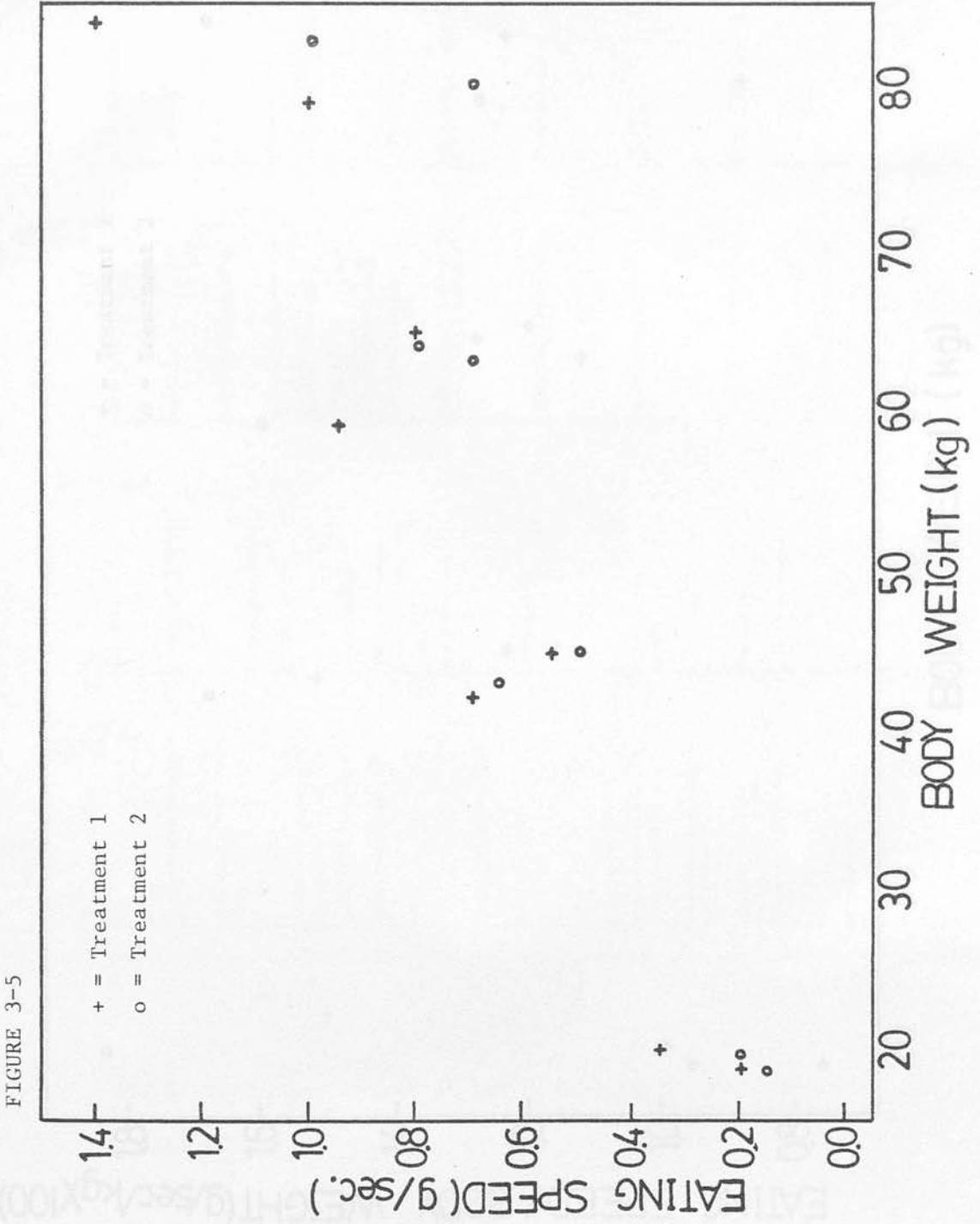


Survivorship curves for feeding interval of pigs when they weighed around 80 kg  
 P- pig

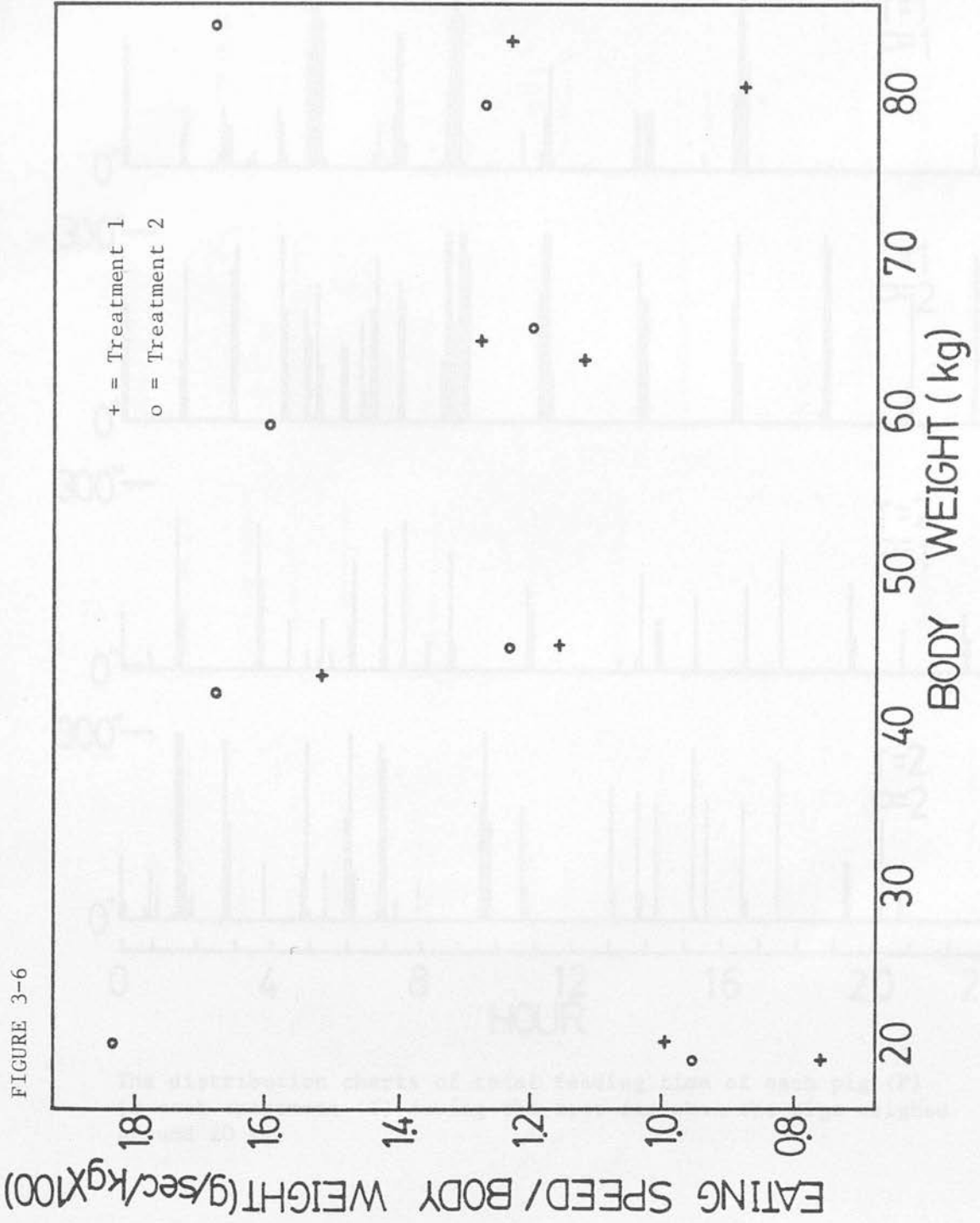
FIGURE 3-4



The relationship between food intake and body weight of pigs in Chapter 3

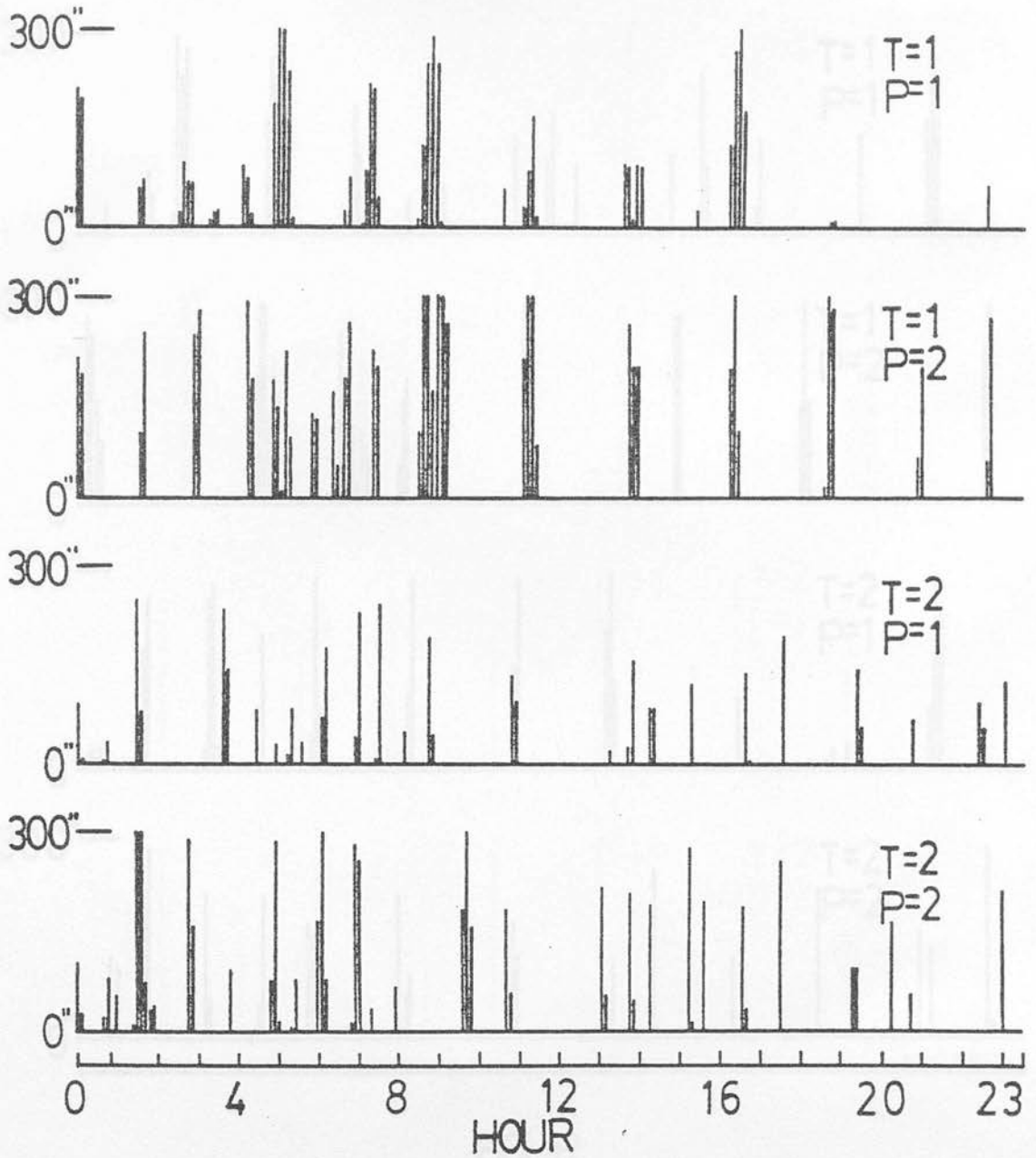


The relationship between eating speed and body weight of pigs in Chapter 3



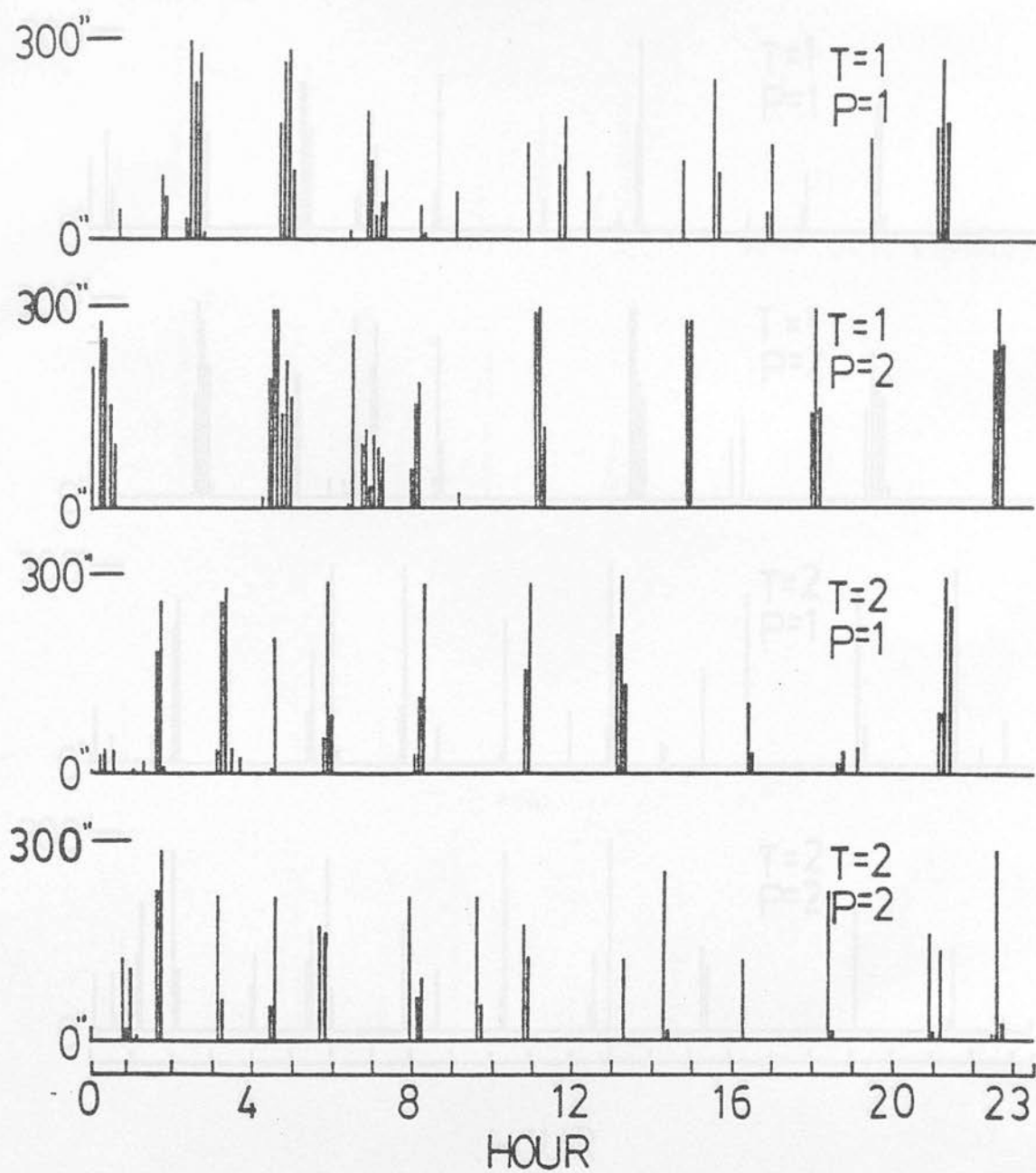
The relationship between eating speed per unit of body weight and body weight

FIGURE 3-7a



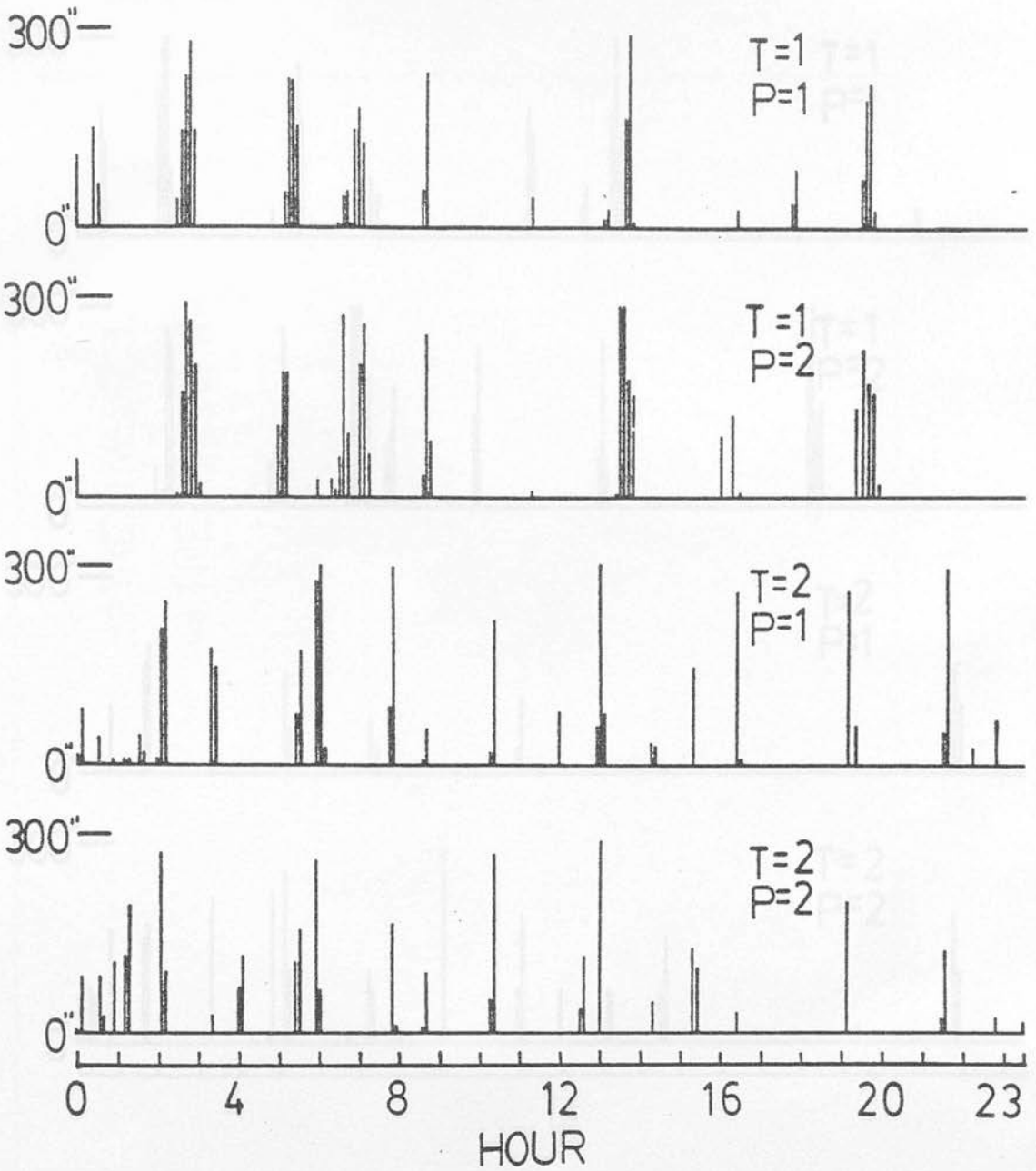
The distribution charts of total feeding time of each pig (P) in each treatment (T) during the test day when the pigs weighed around 20 kg

FIGURE 3-7b



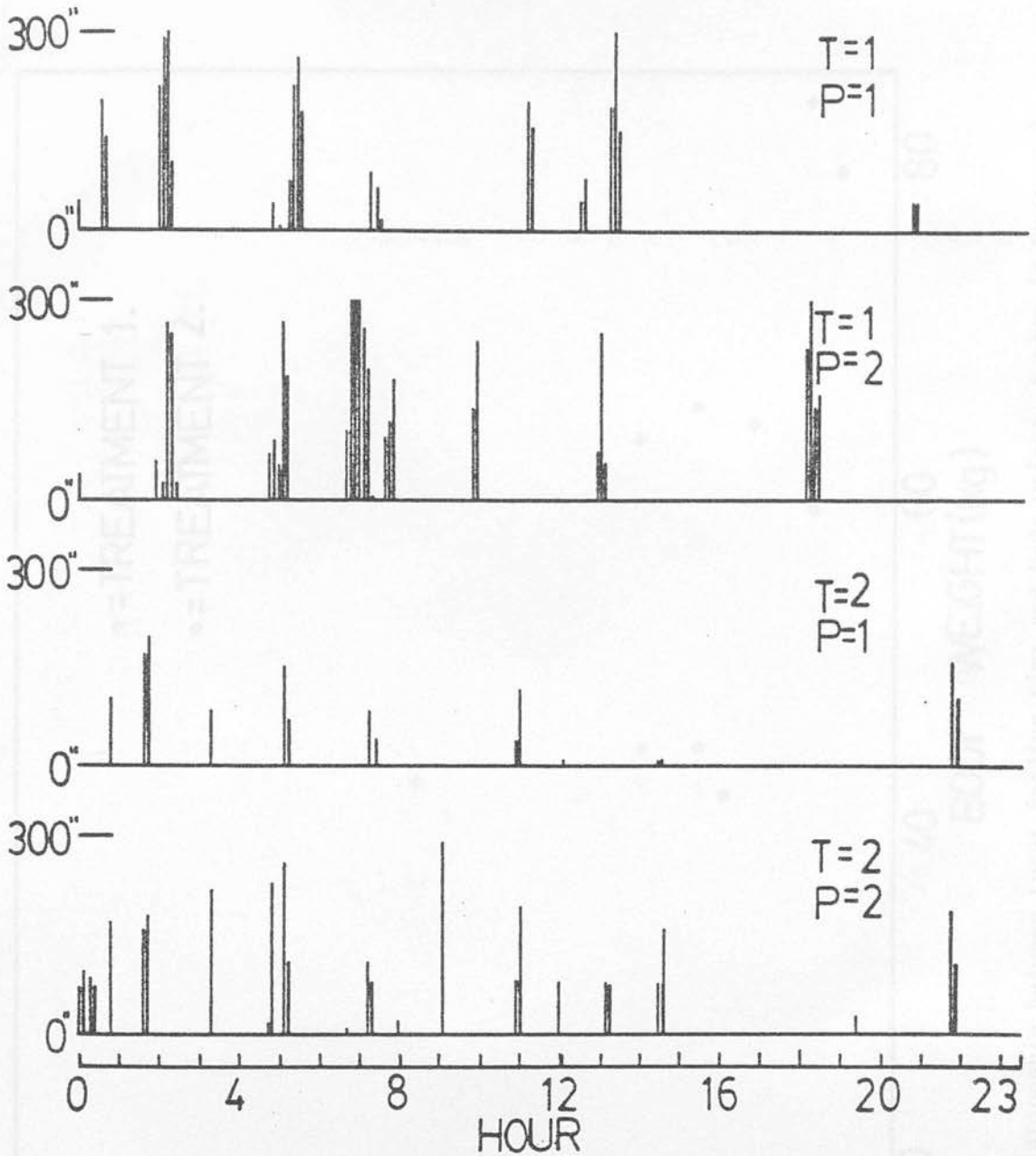
The distribution charts of total feeding time of each pig (P) in each treatment (T) during the test day when the pigs weighed around 40 kg

FIGURE 3-7c



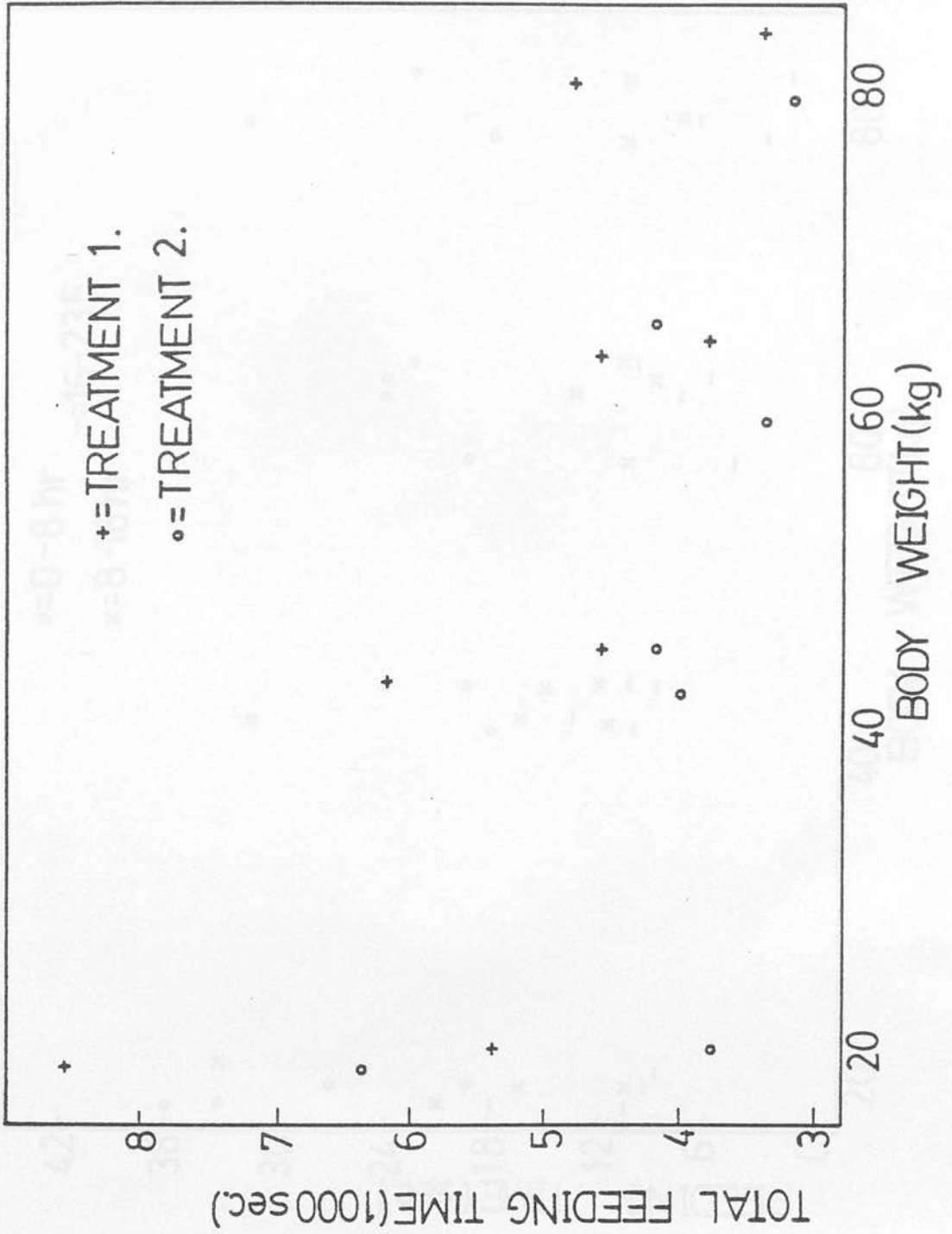
The distribution charts of total feeding time of each pig (P) in each treatment (T) during the test day when the pigs weighed around 60 kg

FIGURE 3-7d



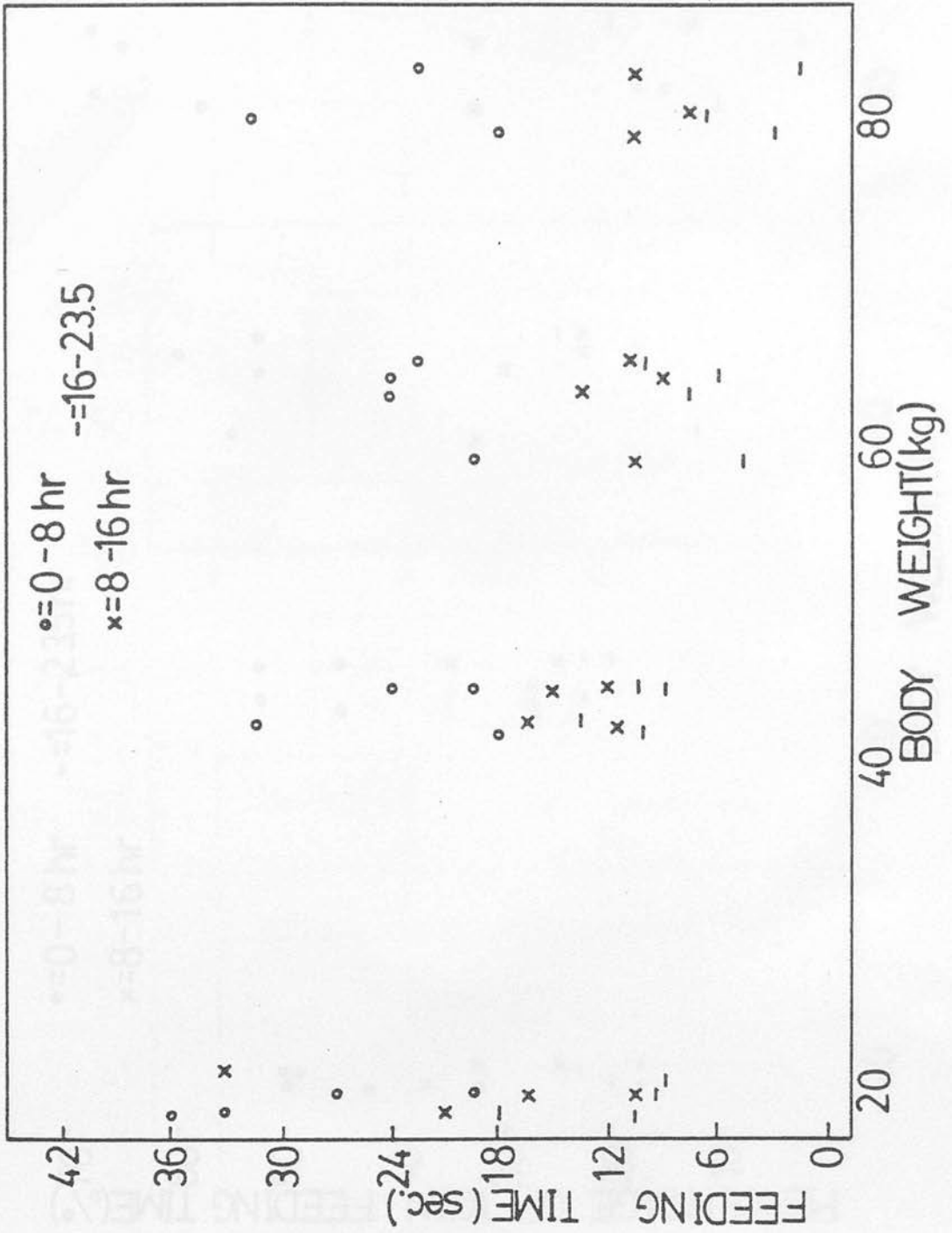
The distribution charts of total feeding time of each pig (P) in each treatment (T) during the test day when the pigs weighed around 80 kg

FIGURE 3-8



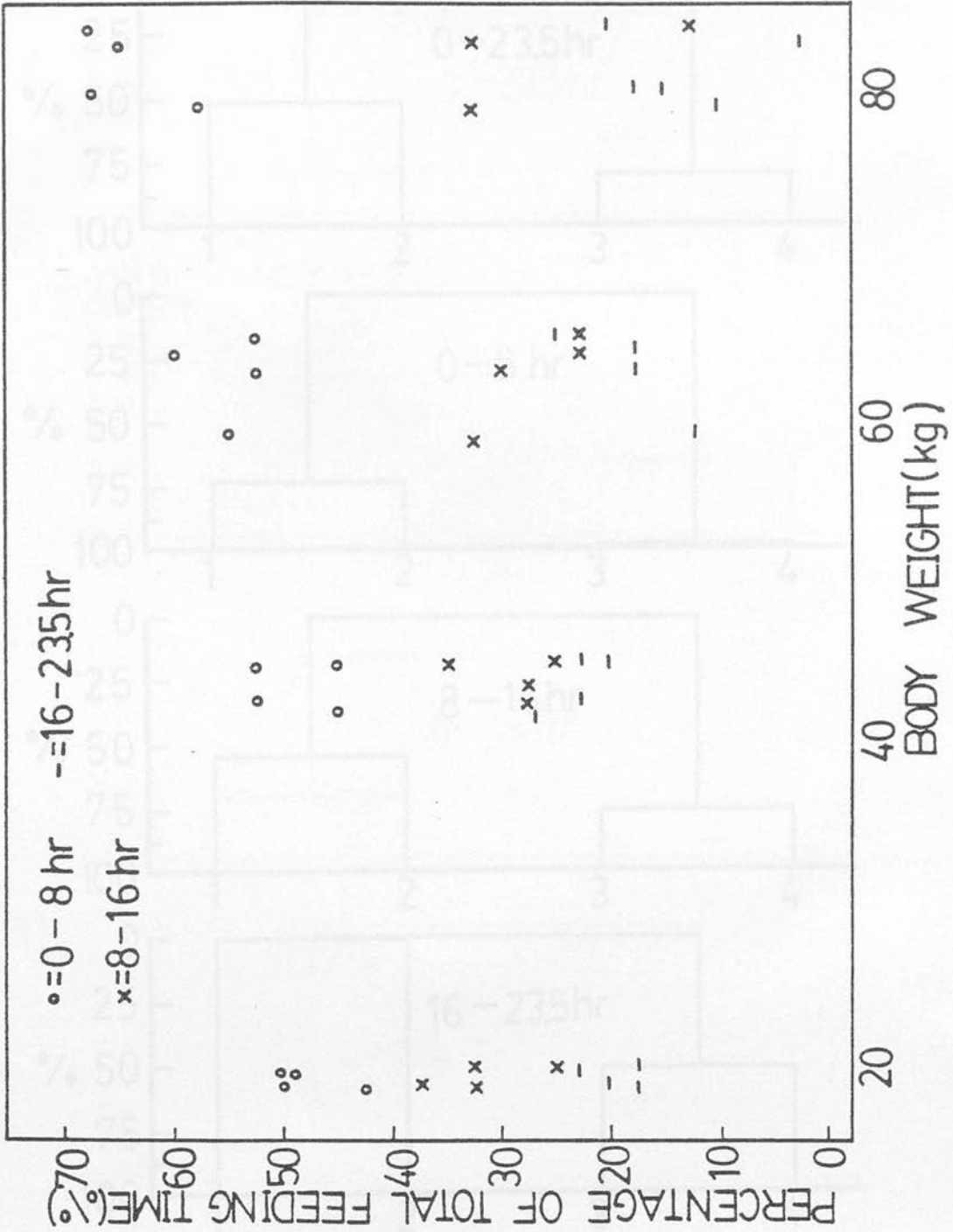
The relationship between total feeding time and body weight of pigs in Chapter 3

FIGURE 3-9



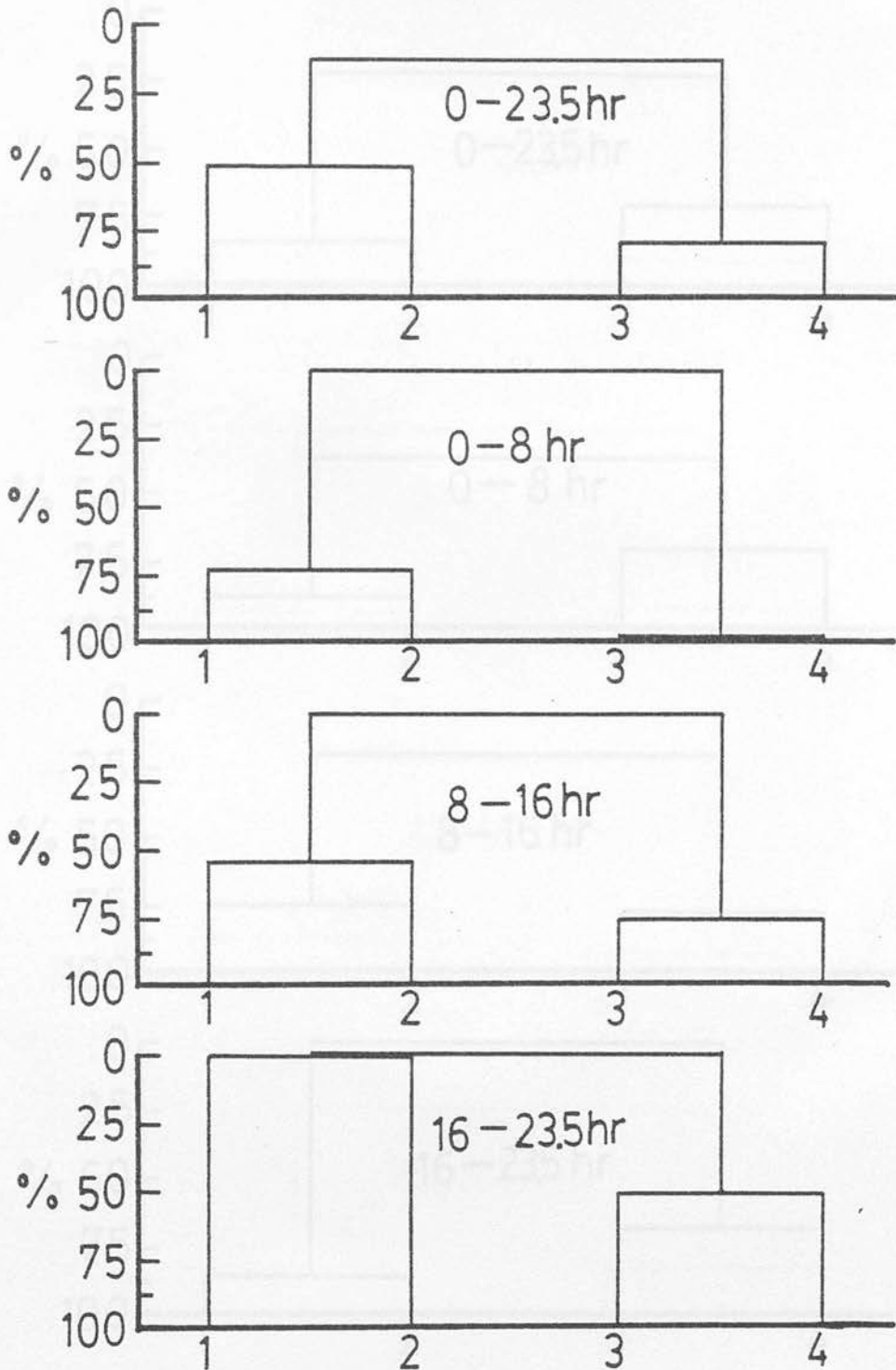
The relationship between feeding time over the first and second 8 hours and last 7.5 hours and body weight of pigs

FIGURE 3-10



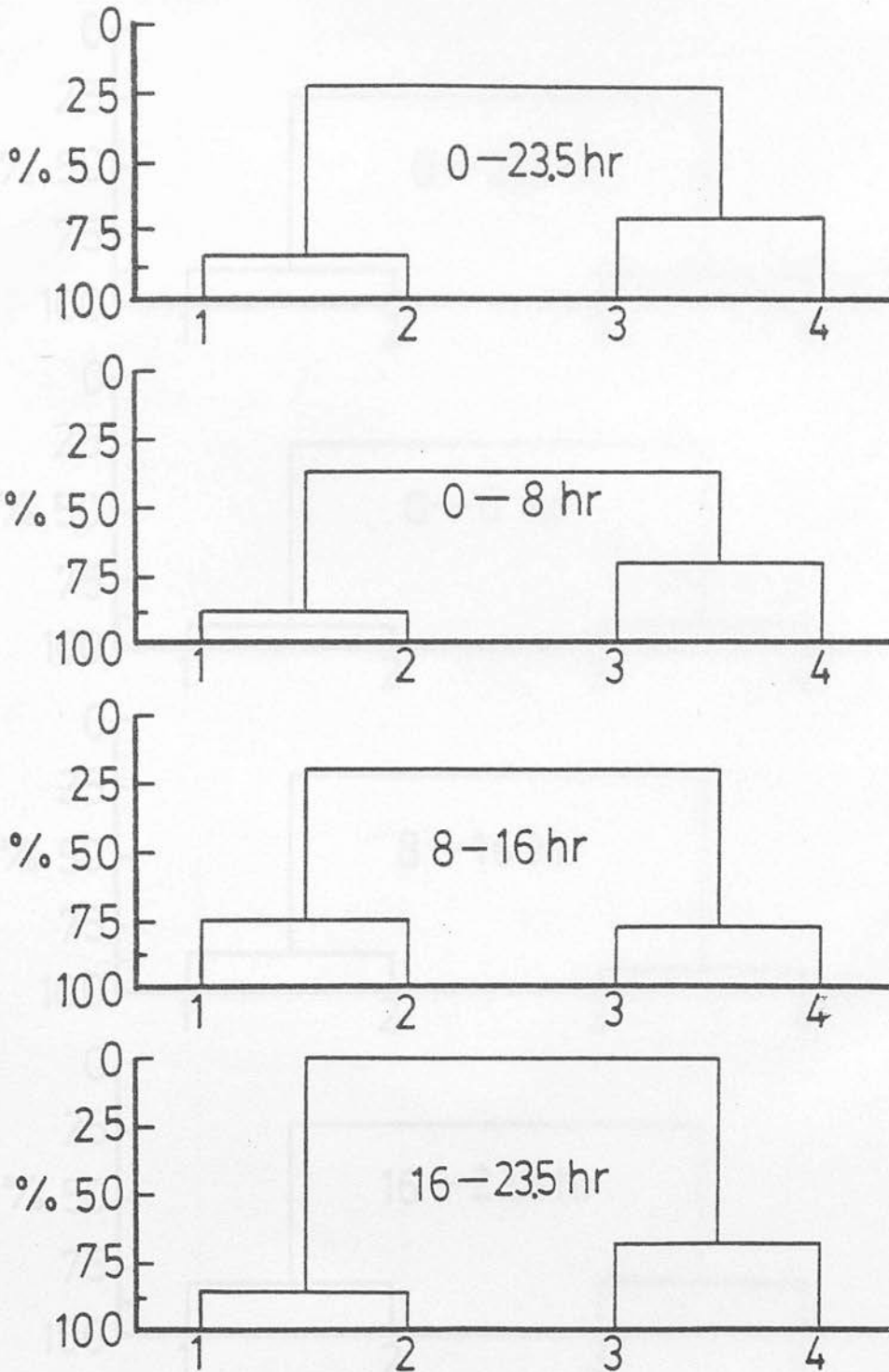
The relationship between the percentage of total feeding time over the first and second 8 hour and last 7.5 hours and body weight of pigs

FIGURE 3-11a



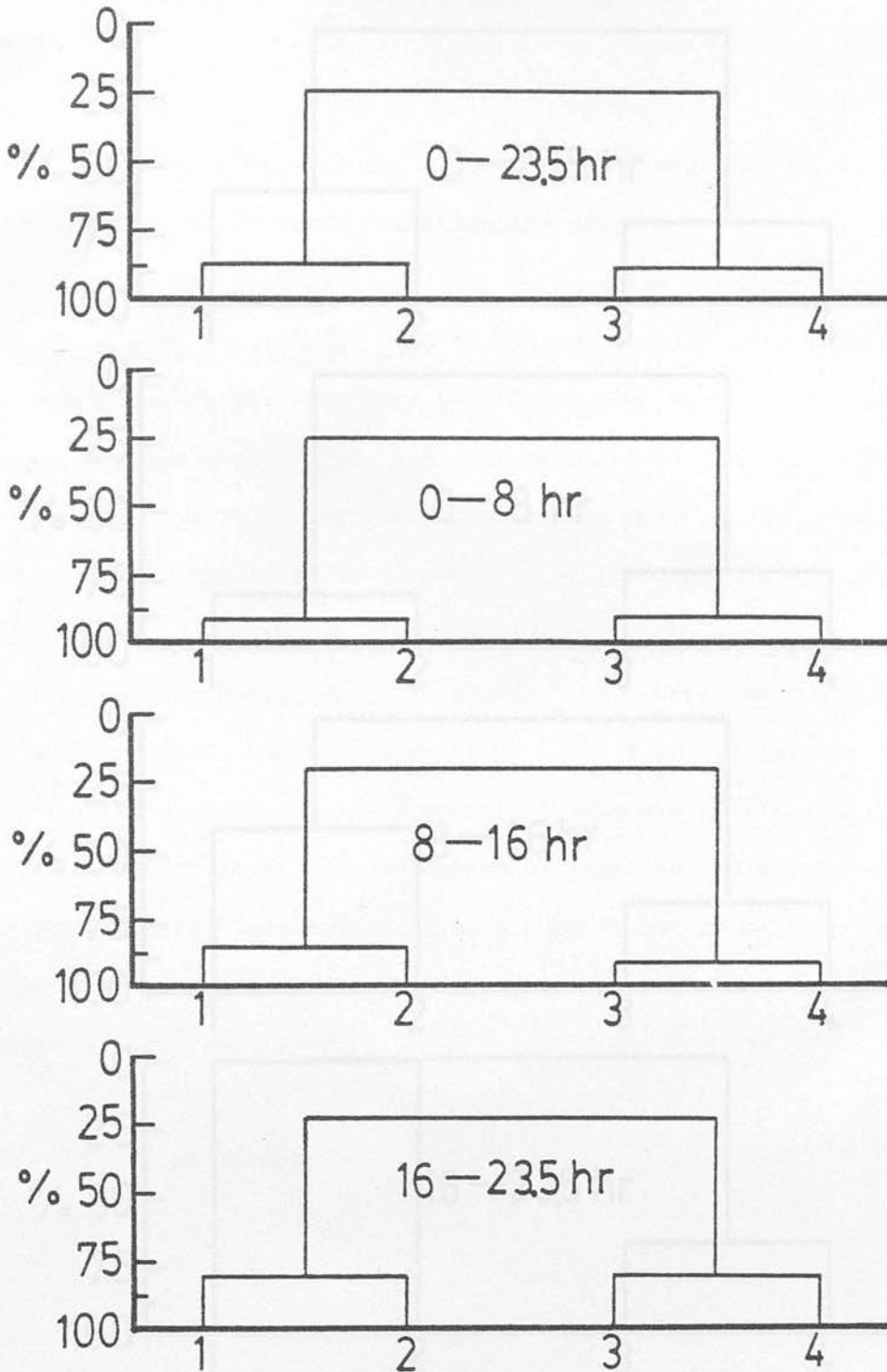
The minimum similarity on feeding at same time between four pigs in which No1 and No2 were in the same room and No3 and No4 were in the same room. This was recorded when pigs weighed around 20 kg.

FIGURE 3-11b



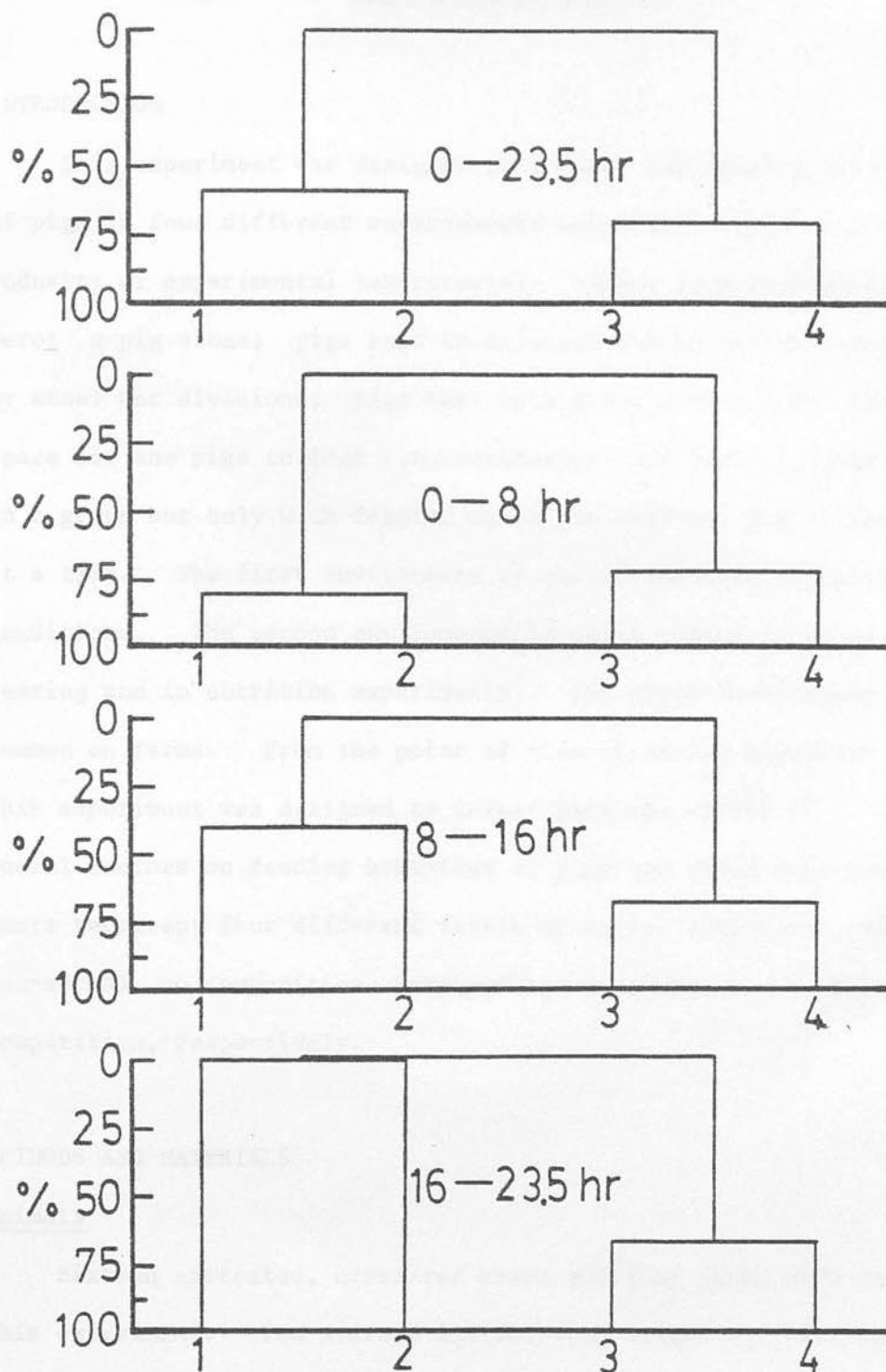
The minimum similarity on feeding at the same time between four pigs in which No1 and No2 were in the same room and No3 and No4 were in the same room. This was recorded when the pigs weighed around 40 kg.

FIGURE 3-11c



The minimum similarity on feeding at the same time between four pigs in which No1 and No2 were in the same room and No3 and No4 were in the same room. This was recorded when the pigs weighed around 60 kg.

FIGURE 3-11d



The minimum similarity on feeding at the same time between four pigs in which No1 and No2 were in the same room and No3 and No4 were in the same room. This was recorded when the pigs weighed around 80 kg.

CHAPTER 4 THE RELATIONSHIP BETWEEN SOCIAL FACILITATIONAND FEEDING BEHAVIOUR

## INTRODUCTION

This experiment was designed to compare the feeding behaviour of pigs in four different environments which are common to the pig industry or experimental laboratories. These four environments were: a pig alone; pigs kept in adjacent stalls and separated by steel bar divisions; pigs kept in a group with enough feeding space for the pigs to feed simultaneously; and finally, pigs kept in a group but only with feeding space for only one pig to feed at a time. The first environment is quite common in laboratory conditions. The second environment is quite common in progeny testing and in nutrition experiments. The third environment is common on farms. From the point of view of social behaviour this experiment was designed to investigate the effect of social factors on feeding behaviour of pigs and these four environments represent four different levels of social conditions, viz - non-social, no competition, intermediate competition and vigorous competition, respectively.

## METHODS AND MATERIALS

Animals

Sixteen castrated, crossbred boars and four sheep were used in this experiment. The average initial body weight was 34.1 kg.

## Treatments

The four treatments were as follows.

#### Treatment 1

A single pig with a sheep (Figure 4.1): The four pigs were housed in separate rooms, without visual contact, and with a minimum of auditory contact. Each pig was fed in a stall separated from the sheep in the room, the stall having an area of  $5.256 \text{ m}^2$  and containing feeding and water troughs, both 30 cm in length.

#### Treatment 2

Closed stall treatment (Figure 4.2): The four pigs were housed in a room, in four stalls of equal size, each being the same as in treatment 1. Similarly, feeding and water troughs of the same size as in treatment 1 were available in each stall. The stalls were separated by moveable steel bar divisions and were described in detail in the general method and material section.

#### Treatment 3

Long trough treatment (Figure 4.3): A 1.2 m long trough was provided for the four pigs. The trough was placed against a steel bar division so that feeding was confined to one side. The stocking rate was one pig per  $5.256 \text{ m}^2$  and two water troughs were provided; water was available all the time.

#### Treatment 4

One feeding space treatment (Figure 4.4): The housing was arranged in the same way as in treatment 3 except that the feeding trough was only 30 cm long.

### Husbandry

Light was provided for 8.5 hours per day from 4.30 am to 1.00 pm and eight hours observation were made each day from 5.00 am to 1.00 pm. Pelleted food was provided once, at 5.00 am in all treatments, and additionally three times in treatment 4, to ensure that food was always available for animals during the observations in all treatments. Observations were limited to 8 hours because of having only a single observer. In treatment 4 the food was supplied with the minimum of noise while the pigs were sleeping so as not to stimulate them. In all treatments food spilt was collected and weighed with the residual food at the end of the eight hours observation period. No food was provided for the remaining sixteen hours, but water was freely available for the whole 24 hours per day. Room temperatures were always kept around  $21 \pm 1^{\circ}\text{C}$ .

### Procedure

For all these treatments direct observations were carried out with the observer in the room. There were four replicates in this experiment. The individual pigs were identified by numbers clearly painted on the back. One week was allowed for the animals to settle down and to go through each treatment once. One day each for treatment 2, 3 and 4 successive days for treatment 1 so that each pig could be observed for one day. The pigs were weighed between 4.30 am and 5.00 am each day and then returned to individual rooms with the sheep at the end of each daily observation. After the settling in period, the animals in each replicate were put through the treatment according to a  $4 \times 4$  Latin square design so that each replicate lasted 28 days as shown in Figures 4-5a,b,c,d. In treatment 1, the four pigs were each observed on a different day

of four successive days and food intake was measured once in each room for each of four successive days. In treatment 2, the stalls of the individual pigs were allocated according to the randomization for the Latin square. Three categories of behaviour were noted. All behaviour was recorded by the same observer who measured the duration of each behaviour pattern, using a stop watch.

### Feeding behaviour

Feeding bouts (F): The start of a bout in this experiment was defined as the change from another behaviour to the pig putting his head into a food trough and commencing a sequence of feeding elements, food selection (eg rooting and sniffing the food) and ingestion. The end of a bout was noted when a pig lifted his head from the feeding trough and changed to another behaviour pattern for more than 10 seconds. The first second of the head being lifted was taken as the end of a bout.

### Aggressive behaviour

Each skirmish was classified according to the following fighting techniques.

Thrusting: The shoulder, head or flank of a pig pressed firmly against the shoulder, head or flank of another.

Knocking: One pig used the side of the head to knock another pig, or two pigs knocking the sides of their heads together.

Intention knocking: When one pig, already feeding, shook his head at a pig approaching the trough, without physical contact.

Jostling: When a third pig tried to jostle between two pigs, or a single pig which tried to push into a place at the food trough

already occupied by another pig.

**Butting:** This was scored when one pig pushed or rammed another with the front of the head without biting.

**Biting:** One pig bit another, usually on the head or flank, if the pigs were standing. When both pigs were lying down, other parts of the body were bitten. Biting was recorded when the teeth were used in aggression.

Butting and biting usually take a few seconds longer than the other behaviour patterns listed and were classified as severe aggression. The other encounters were considered as moderate aggression. If there was withdrawal after an encounter it was considered as win-loss encounter. If both sides stayed, or left the place where the encounter happened, then the encounter was considered as a draw.

#### Other relevant behaviour

##### 1 Drinking behaviour.

The following drinking activities were recorded.

- (a) Drinking after waking from sleep and before eating.
- (b) Drinking within one minute after the start of eating.
- (c) Drinking during the meal period, excluding the first minute of the meal.
- (d) Drinking within two minutes after the meal.
- (e) Drinking between two sleeping bouts, eg the pig wakes up, drinks, and then returns to sleep again.
- (f) Drinking during a rooting period. This was the period from two minutes before or after eating time and after or before sleeping.

(g) Total number of drinking bouts.

## 2 Urination

The following urination activities were recorded.

(a) Urination between two eating bouts, in which pigs stopped eating and went to urinate, then returned to eat again.

(b) Urination between two sleeping bouts.

(c) Urination after sleep but before eating.

(d) Urination during rooting period, which was defined the same as in drinking behaviour.

(e) Total number of urination bouts.

## 3 Defecation

The following defecation activities were recorded.

(a) Defecation between two consecutive eating bouts within one meal.

(b) Defecation after eating a meal.

(c) Defecation between two sleeping bouts and after sleep before eating.

(d) Defecation during a rooting period which was defined the same as in drinking behaviour.

(e) Number of double defecations within a ten minute period.

(f) Total number of defecations.

## Statistical Model

$$\text{Model 4-1: } Y_{ijk} = \mu + \theta_k + P_i + P_j + e_{ijk}$$

$$i, j = 1 \dots 4 \ (i \neq j), \ k = 1, 2.$$

Where  $P_1 \dots P_4$  represent different degrees of fighting motivation among the four ranks of pigs.  $\theta_1$  and  $\theta_2$  represent two competitive treatments.

$$\text{Model 4-2a: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

$$\text{Model 4-2b: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + rx_{ijkl} + e_{ijkl}$$

$$\text{Model 4-3a: } Y_{ijklm} = (\mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}) + \phi_m + \psi_{lm} \\ + z_{ijklm}$$

$$\text{Model 4-3b: } Y_{ijklm} = (\mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}) \phi_m + \psi_{lm} \\ + rx_{ijklm} + z_{ijklm}$$

$$\text{Model 4-4a: } Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + e_{ijk}$$

$$\text{Model 4-4b: } Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + rx_{ijk} + e_{ijk}$$

$$\text{Model 4-5a: } Y_{ijkl} = (\mu + \alpha_i + \beta_j + \tau_k + e_{ijkl}) + \phi_l + \psi_{kl} + z_{ijkl}$$

$$\text{Model 4-5b: } Y_{ijkl} = (\mu + \alpha_i + \beta_j + \tau_k + e_{ijkl}) + \phi_l + \psi_{kl} + rx_{ijkl} \\ + z_{ijkl}$$

In which  $\mu$  = grand mean of the measurement

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

$r$  = regression coefficient used for the adjustment of result by body weight

$x$  = body weight

$\phi$  = social order

$\psi$  = social order x treatment interaction

$e$  and  $z$  are error terms

The Model 4-2a was used to analyse both the average food intake and average eating speed for the four pigs in the different treatments. The Model 4-2b was used to conduct the same analysis as Model 4-2a but with adjustment made for body weight. The observation Y in both Model 4-2a and Model 4-2b represents the average food intake or average eating speed of a set of four pigs.

Model 4-3a and Model 4-3b were used to analyse each of the following measurements: total feeding time, total feeding time in the first meal, total number of feeding bouts, total feeding bouts in first meal, number of defecations, number of urinations and number of drinking bouts for each of the four pigs in different treatments. The only difference between Model 4-3a and Model 4-3b is that the latter uses adjustment of body weight. The Y in both Model 4-3a and Model 4-3b represents the same measurements as above, for each individual pig.

Model 4-4a and Model 4-4b were used to analyse the food intake and eating speed in replicate 2. The only difference between Model 4-4a and Model 4-4b is that the latter uses adjustment of body weight. The Y in both Model 4-4a and Model 4-4b represents the average food intake and eating speed of a set of four pigs. Model 4.4a and Model 4-4b were also used to analyse the food intake and eating speed in closed stall treatment, but  $\tau$  in both models represents social rank instead of treatment.

Model 4-5a and Model 4-5b were used to analyse the total feeding time in replicate 2. The only difference between Model 4-5a and Model 4-5b is that the latter uses adjustment of body weight. The Y in both Model 4-5a and Model 4-5b represents the total feeding time of each individual pig.

## RESULTS

The results of this experiment will be described in three parts which are as follows.

- 1 Aggressive behaviour
- 2 Feeding behaviour
- 3 'Other relevant' behaviour

- 1 Aggressive behaviour

The aggressive behaviour scored in this experiment was divided into fighting concerned with the social hierarchy and total aggression which included the former.

- (a) Social hierarchy

Skirmishes were recorded during all the eight hour observation periods. The dominant pig was decided by observing which pig won the majority of skirmishes with the other three pigs. The second placed pig in the hierarchy won all the skirmishes apart from those with the dominant animal. The same method was used to decide the third and fourth placed animal in the hierarchy. Linear hierarchies occurred in replicates 1, 3 and 4. In replicate 2, excluding the inferior pig, the remaining three pigs developed a triangular loop (Figure 4-b). In replicate 2, after a seven day settling down period, with two repeats on the competitive treatment, pig No 3(c) broke the linear hierarchy with severe fights with the No 1(a) pig and won the skirmishes at feeding time. After these fights the loop was established and the No 1(a) pig avoided the original No 3(c) pig at all times.

Table 4.1 summarizes the initial and final body weight of

the pigs in different positions in the hierarchy. The results show that the dominant pig did not always have the highest initial body weight. Also the pig lowest in the hierarchy was not always the lightest. However the heaviest pigs at the onset of the experiment were never the lowest in the hierarchy.

(b) Aggressive behaviour

The total number of skirmishes which occurred between any two pigs of different rank in both competitive treatments are summarized in Table 4.3. The Table was produced in the following way: the numbers of skirmishes that occurred in four 8-hour observation periods were added together to give the total for each replicate of the treatment. The totals for each replicate were then added together to give the grand total for each treatment. The total number of skirmishes in which each pig of different rank was involved, in both the long trough and single trough treatments, are summarized in Table 4.2, which is produced by the same method as Table 4.3.

The fighting activities or skirmishes were all analysed by multiple regression with least square statistical analysis. Model 4-1 was used in these analyses.

All the original data are weighted by their square roots unless there is a further description. The hypothesis to be tested is that there is no difference between replicate, treatments, individual pigs and individual pigs not fighting towards a pig of particular rank.

The total number of skirmishes, which included those won or lost, and undecided encounters (see Methods and Materials), were analysed by the above Model. The results showed that in

the long trough treatment there were less skirmishes than in the single trough treatment at the probability level of 0.1%. The total number of skirmishes in which individual pigs were involved is significant ( $p < 0.05$ ) among four different ranks of the social hierarchy. The dominant animal was involved in more fighting than pigs of other ranks. The lowest, or fourth placed pig, was involved in less fighting than any of the other pigs of higher rank.

There were no significant differences ( $p > 0.5$ ) due to interaction between all four ranks of pigs, ie no particular rank of pig fought more with any other particular rank of pig. There was also no significant difference in the interactions ( $p > 0.5$ ) between trough treatments and social ranks, ie the different trough treatments did not influence the degree of fighting activity of individual pigs with pigs of any particular rank. Only when the won and lost skirmishes are considered did the single trough treatment reveal significantly ( $p < 0.01$ ) more skirmishes than long trough.

There were also significant differences ( $p < 0.05$ ) in fighting activity amongst the different ranking animals. Dominant pigs were involved in more skirmishes than others and the fourth placed pigs were involved in the lowest number of encounters. There were no significant ( $p > 0.5$ ) differences in the interaction of fighting amongst the four social ranks. The interaction between trough treatments and social ranks was not significant ( $p > 0.5$ ).

Only when undecided skirmishes are considered did the long trough treatment have a significantly greater number of

skirmishes ( $p < 0.05$ ) than the single trough treatment. There were no significant differences ( $p > 0.05$ ) among pigs of the four ranks and there were no interactions between pigs of the four different ranks and between trough treatments and social rank. Those differences between trough treatments were due to the inferior pigs starting more undecided skirmishes in the long trough treatment. Furthermore these undecided skirmishes were started by pigs of any inferior rank ( $p > 0.05$ ). The interactions between the four ranks and between trough treatments and social ranks were also not significant ( $p > 0.05$ ).

The results of different fighting techniques are reported as follows.

There were no significant differences ( $p > 0.05$ ) in the occurrence of thrusting and butting in the long trough or the single trough treatment. However the pigs in the long trough treatment used more knocking than the single trough pigs ( $p < 0.05$ ), while pigs in single trough treatment used more jostling ( $p < 0.005$ ), intension knocking ( $p < 0.05$ ) and biting ( $p < 0.01$ ) in fighting. When analysed by the Model 2-1, no significant differences in moderate fighting between treatments were found ( $p > 0.05$ ), but there was significantly more ( $p < 0.05$ ) serious fighting in the single trough treatment. The exact opposite results are found if the data were analysed by using the test on the sum of the two trough treatments in each replicate. In that case there was a significant difference between the two trough treatments in moderate fighting and a non-significant difference in serious fighting.

There were significant differences among pigs of different ranks in the use of thrusting ( $p < 0.05$ ), jostling ( $p < 0.01$ ), butting ( $p < 0.01$ ) and biting ( $p < 0.01$ ) as a fighting technique (Table 4.4).

On the other hand there were no significant differences among pigs of different ranks in the use of intension knocking ( $p > 0.5$ ) and knocking ( $p > 0.1$ ) as fighting techniques.

Dominant animals used less thrusting than pigs of other ranks, while the fourth placed animal used less jostling than the higher ranking animals. Furthermore, the dominant animals used more butting and biting than pigs of other ranks and the fourth placed animal used more of the moderate fighting techniques than the others. The first placed animal used more serious fighting techniques.

## 2 Feeding behaviour

### (a) General observations

The results of feeding behaviour will be recorded in the following sequence: general description of feeding behaviour, food consumption, total feeding time, eating speed and number of feeding bouts.

Very loud noises were made by pigs a few seconds before food was presented but once the food was provided the pigs concentrated on eating in the closed stall and single trough treatment. After a period of feeding, the pigs often stopped eating and had a drink. If they went to drink not long after the presentation of food then the speed of running between the food trough and water trough was very fast, but this speed

decreased after a long period of eating.

Regardless of what occurred immediately after the first meal, the pigs always had a long sleep. In the closed stall treatment, if one pig awoke and commenced eating, other pigs would also awake and begin to eat. In the long trough treatment, pigs concentrated on eating for a very short period after presentation of food, and, after a short period of eating, fighting with a near neighbour often occurred. At other times changes of place along the trough took place. After the meal the pigs slept in the same way as those in the closed stall treatment. The awakening of one pig to eat after a long sleep also caused some of the others to wake up and eat. However the pigs in the single trough treatment started fighting for food immediately after the presentation of food. The dominant pig frequently occupied the feed trough at once, or a few seconds after food presentation, and the remaining pigs often reacted by making a kind of 'eager' noise. Some would go near the trough, taking a chance to eat, but the dominant animal would try very hard to chase the pigs near the trough away. If the dominant pig left the trough to drink, the pig second in the hierarchy would occupy the trough until the dominant animal returned. The dominant animal would then chase the eating animal away. This kind of encounter happened many times. Eventually the other pigs would lie down or root near the trough.

Once the dominant animal had finished eating, the second ranking pig would start the dominant fighting and feeding cycle. Sometimes the third and fourth placed pigs would just

lie by the side of the dominant pig. Once the second placed animal had stopped eating, it lay down by the side of the group, then the third and fourth placed animals would go to eat. Whilst the third placed pig ate, the fourth placed animal would lie near the trough or go back to the other lying pigs. Finally the fourth pig would eat. The problem was that as the fourth pig was eating, the first or second would return to resume eating. It was interesting to note that pigs lying down would occasionally distinguish the pig returning to the group by raising their heads and sniffing without opening their eyes. In these cases the pig only got up if the returning pig was ranked immediately above it.

(b) Food consumption

The effects of the four treatments on the total food intake of the four pigs and the effect of the hierarchy on food intake of the pigs, in the closed stall, and the single pig with sheep treatments, are analysed by Model 4-2a and Model 4-2b.

As only one pig at a time could be observed in the single pig with sheep treatment, the total food consumption of the four pigs in that treatment was calculated in the following way.

The food consumption of each individual pig was obtained by taking its average intake on the four successive days, then the average weight of food consumed by each of the four individual pigs was added together, to become the total food consumption of four pigs in that treatment. The total food consumption of four pigs in the other treatments was simply produced by weighing the food consumed by four pigs in one

observation day.

Total food intake in the replicates 1, 3 and 4 was significantly different between treatments ( $p < 0.01$ ) (Table 4.4). There was no significant difference ( $p > 0.05$ ) in food consumption between the long trough treatment and the single trough treatment, although the average food intake of replicate 1, 3 and 4 was higher in the long trough treatment than in the single trough treatment. There were significant differences in food consumption between the long trough treatment and the single pig with sheep treatment ( $p < 0.01$ ) and between long trough treatment and close stall treatment ( $p < 0.05$ ). There were also significant differences in consumption between the single trough treatment and the single pig with sheep treatment ( $p < 0.01$ ). No significant difference was found in food consumption between the single trough treatment and the closed stall treatment ( $p > 0.05$ ). The results of comparing food intake with treatment were not always as consistent as shown above. For example, the food consumption of the long trough treatment was lower than that of the closed stall treatment in the first row of first replicate (Table 4.5).

The food intake of the second replicate was analysed by the Model 4-4a and Model 4-4b.

There were no significant differences ( $p > 0.005$ ) in treatments on food intake when the results were analysed by Model 4-4. The differences only became significant ( $p < 0.05$ ) when analysed by Model 4-4b, when food intake was adjusted for body weight. The pigs in the long trough treatment and the single trough treatment ate significantly more

( $p < 0.05$ ) food than the single pig with sheep treatment. However, there were no significant differences between the single pig with sheep treatment and the closed stall treatment. Between the closed stall treatment and either the long or single trough treatment there was no significant difference. The long trough treatment and single trough treatment also showed no significant differences in food intake (Table 4.6).

The food intake of any particular ranking pig in the single pig with sheep treatment, which was in the form of a twelve 4 x 4 Latin square in three replicates (1, 3 and 4), was analysed by Model 4-2a and Model 4-2b,  $\tau$  now representing pigs of different ranks. When the result was analysed by Model 4-2, there were significant differences ( $p < 0.01$ ) between ranks. The differences between the dominant and the third or fourth placed pig and between the second placed and the fourth placed pig were significant. The differences between pigs of the different ranks were still significant ( $p < 0.01$ ), when the results were analysed by Model 4-2b. However the differences between any particular rank were changed, significant differences only existed between the second and fourth placed pigs ( $p < 0.01$ ) (Table 4.8). There were no significant differences in food intake ( $p > 0.05$ ) amongst pigs with different ranks in the closed stall treatment (Table 4.7).

The results were analysed by both Model 4-4a and Model 4-4b. The total food intake of pigs increased with the increase in body weight and metabolic body weight. The differences between the four treatments can be seen in Figure 4-7.

A slight negative relationship was shown between food consumption per unit of body weight and body weight (Figure 4-8) but a slight positive relationship still existed between food consumption per unit body weight and metabolic body weight.

(c) Total feeding time

The total feeding time of the pigs in the four treatments in each three replicates was analysed by Model 4-3a and Model 4-3b in which Y is total feeding time (Table 4.4). The total feeding time of each pig in the closed stall treatment, long trough treatment and single trough treatment was observed directly by observation. However, as each pig in the pig with sheep treatment could be observed on one day only, total feeding time was calculated in the following way.

The pig's eating speed on the day of observation was multiplied by its average food intake over the four days. On the other hand, the eating speed of pigs in that treatment was obtained by dividing food consumption by the total eating time, both of which were recorded on the day of observation. The total feeding times were significantly different ( $p < 0.01$ ) between treatments, except for the relationship between the single pig with sheep treatment and the closed stall treatment ( $p > 0.05$ ).

There was an interesting result in that the total eating time of pigs with different social ranks varied significantly ( $p < 0.01$ ). When total eating time was considered between individual ranks, the only significant difference ( $p < 0.01$ ) occurred between the second placed pig and all the other ranks of pigs. There were no statistical differences ( $p > 0.05$ )

amongst the first, third and fourth placed pigs. The second placed pig always ate for the longest time when compared with the other three ranking pigs in all four social treatments (Table 4.8). The lowest total eating time was recorded for the pigs which were in the fourth place in the single trough treatment.

All the above phenomena in total feeding time were still true after adjustments for body weight or for metabolic body weight. The total feeding time slightly decreased with the increase in body weight (Figure 4-9). There was a negative relationship between total feeding time per unit body weight and body weight or metabolic body weight. Total eating time of replicate 2 is analysed by the Model 4-5a and Model 4-5b.

There were significant differences ( $p < 0.01$ ) among treatments but no significant differences between the trough treatments (Table 4.7). Furthermore, between the long trough treatment and the single pig with sheep treatment, there were no significant differences. The other comparisons were, however, all significant. There were also significant differences between the four pigs, the inferior pig had a significantly shorter total feeding time than the rest of the three pigs (Table 4.6a). These results were also still true after the total feeding time was adjusted by body weight.

Total feeding time during first meal (Table 4.8)

The first meal was taken as the period from the presentation of food in the morning until the start of the first 30 minute period with no feeding action. The

reason for choosing the 30 minute interval as the end of the first meal was because the pigs took a long rest after the first meal and the duration of this first rest was generally more than 30 minutes. The total eating time during the first meal differed significantly between treatments ( $p < 0.01$ ). There was no significant difference between the two competitive treatments and between the two non-competitive treatments.

The difference is significant ( $p < 0.01$ ) between the competitive and non-competitive treatments. The second placed animals ate for longer ( $p < 0.01$ ) than the other ranking animals during the first meal but there were no significant differences ( $p > 0.05$ ) between the remaining three ranks of pigs. If we look more closely then it can be found that the dominant animal had a significantly ( $p < 0.05$ ) longer total eating time in the single pig with sheep treatment than the dominant animal in the closed stall treatment. Furthermore, in the single trough treatment, the fourth placed animal had a significantly shorter feeding time ( $p < 0.05$ ) than the dominant animal.

(d) Eating speed

The average eating speed amongst the four treatments was analysed by the Model 4-2 and Model 4-2b, in which  $Y$  = average eating speed in each treatment on each day. The average eating speed was produced by dividing the total food consumption of four pigs by the total eating time during the day of observation, in all treatments. There were significant differences ( $p < 0.01$ ) in average eating speed between

treatments. When considering the individual comparison between any two treatments, it was discovered that there was no significant ( $p > 0.05$ ) difference between the single pig with sheep treatment and the closed stall treatment. There were, however, significant differences ( $p < 0.01$ ) compared with the other treatments. The pigs ate fastest in the single trough treatment, followed by the pigs in the long trough treatment, then by the pigs in closed stall treatment or single pig with sheep treatment. The results were still true after adjustment for body weight. There were no significant differences ( $p > 0.05$ ) in eating speed amongst the four different ranks of pigs in both the single pig with sheep treatment and closed stall treatment (Table 4.7). The eating speed increased with the increased body weight in all the treatments (Figure 4-10).

The relationship between eating speed per unit of body weight and body weight was kept at quite a constant level (Figure 4-11). The variation in eating speed between individual pigs was very large. Some pigs ate slowly and did so throughout the test period. The fast eaters also always ate consistently. The result of replicate 2 was analysed by Model 4-4a and Model 4-4b. The result (Table 4.6) was similar to the result of the other replicates. The only difference was that the results of the long trough treatment and the single trough treatment were not significantly different ( $p > 0.05$ ).

(e) Feeding bouts

The total number of feeding bouts during each eight hour observation period and during the first meal are reported here.

(Table 4.9).

There were no significant differences ( $p > 0.01$ ) between the four treatments in total numbers of feeding bouts during the eight hours of observation. The dominant pigs had more ( $p < 0.01$ ) feeding bouts than the other ranks in all treatments. The second placed pig had significantly ( $p < 0.01$ ) more eating bouts than the third and fourth placed pigs. There were no significant ( $p > 0.05$ ) difference between the third placed and fourth placed animals, but the fourth placed pig in the single trough treatment had the lowest number of feeding bouts when compared with all the others.

When considering the number of feeding bouts during the first meal, there were significant differences between treatments and between pigs of different ranks ( $p < 0.01$ ) (Table 4.9). When considering individual treatments, the results showed that the single pig with sheep treatment had significantly lower numbers of feeding bouts than the pigs in the other treatments. There were no significant ( $p > 0.05$ ) differences in eating bouts amongst the closed stall, long trough and single trough treatments. The first ranking pigs had more feeding bouts than the third and fourth placed pigs ( $p < 0.05$ ) (Table 4.9). The second placed pig had significantly more feeding bouts than the fourth placed animal. If this is examined closely (Table 4.9) then it can be found that the ranks only truly differed in the following situations. The dominant pig and the second placed pig had significantly ( $p < 0.01$ ) more feeding bouts in the first meal than the fourth placed pig in the single trough treatment, but not in the other

three treatments.

### 3 'Other relevant' behaviour

This category of behaviour included drinking behaviour, urination and defecation.

#### (a) Drinking behaviour

Drinking behaviour will be discussed here in relation to the situation in which drinking activity occurred.

##### (i) Drinking after waking from sleep and before feeding (Table 4.10)

There were no significant differences between treatments ( $p > 0.05$ ). Although the pigs in the single trough treatment had the lowest average occurrence, there were significant differences ( $p < 0.01$ ) between different ranks of pigs in drinking. The third placed pigs drank more frequently after sleep and before feeding than the other ranks.

##### (ii) Drinking within one minute after the start of feeding (Table 4.10)

There were no significant differences between the treatments ( $p > 0.05$ ), but the occurrence almost reached the 0.05 difference level, between treatments. The two non-competitive treatments had a higher number of occurrences than the competitive treatments. Furthermore there were no significant differences between the four social ranks.

(iii) Drinking during the meal period excluding the first minute of the meal (Table 4.10)

There were significant differences between treatments ( $p < 0.01$ ). However, when individual treatments were considered, there were no significant differences between the single pig with sheep treatment and the closed stall treatment. However the differences between the competitive treatments and the non-competitive treatments and the differences between the long trough treatment and single trough treatment were significant ( $p < 0.01$ ). There were no significant differences between the four different ranks of pigs.

(iv) Drinking after the meal (Table 4.10)

There were significant differences between treatments. Drinking activity after the meal occurred more frequently ( $p < 0.05$ ) in the single trough treatment than in the long trough treatment and the single pig with sheep treatment. The third placed animals showed drinking activity more frequently than the pigs of other ranks.

(v) Drinking during the sleeping period (Table 4.10)

There were no significant differences ( $p < 0.05$ ) between treatments. The third placed pig had significantly higher occurrences of drinking activity than the pigs in the other ranks.

(vi) Drinking during rooting period (Table 4.10)

There were no significant differences ( $p > 0.05$ ) between treatments. The third and fourth placed pigs showed significantly more of this drinking activity than

the first and second placed pigs.

(vii) Total number of drinking bouts (Table 4.10)

There were significant differences ( $p < 0.01$ ) between the four treatments. The pigs in the two competitive treatments had a significantly lower ( $p < 0.01$ ) number of bouts than the pigs in the two non-competitive treatments. There were no significant differences ( $p > 0.05$ ) between the two competitive treatments on the one hand nor between the two non-competitive treatments on the other. The third placed pig showed significantly more drinking activity than the pigs of other ranks.

(b) Urination

(i) Urination between two feeding bouts, in that pigs stopped eating and went to urinate then returned to eat again (Table 4.11)

There were significant differences ( $p < 0.01$ ) between the four treatments. The pigs in the single trough treatment showed significantly lower numbers of this activity than pigs in the other treatments. The differences amongst the other three treatments were not significant. There were no significant differences between pigs of the four ranks.

(ii) Urination between two sleeping bouts (Table 4.11)

There were significant differences between the four treatments. The pigs in the single trough treatment and the closed stall treatment had significantly higher numbers of this activity than the pigs in the long trough

treatment and the single pig with sheep treatment. The frequency of this activity was also significantly different between the four different ranks. The dominant pigs had significantly lower ( $p < 0.01$ ) scores for this activity than the pigs of other ranks. The third placed pigs showed significantly higher ( $p < 0.01$ ) numbers of this activity than the pigs of the other ranks.

(iii) Urination after sleep but before feeding (Table 4.11)

There were no significant differences ( $p > 0.05$ ) between treatments. However the fourth ranking pigs showed significantly more of this activity than the dominant and second placed animals.

(iv) Urination during rooting periods (Table 4.11)

There were significant differences between treatments ( $p < 0.05$ ). The pigs in the single trough treatment showed significantly more of this activity than the pigs in the single pig with sheep treatment and those in the long trough treatment. No significant level ( $p > 0.05$ ) was reached between the pigs of the four different ranks.

(v) Total number of urinations (Table 4.11)

There were significant differences between treatments ( $p < 0.05$ ). The pigs in the closed stall treatment showed significantly higher numbers ( $p < 0.05$ ) of urinations than those in both the long trough and the single trough treatment.

(c) Defecation behaviour(i) Defecation between two consecutive feeding bouts within one meal (Table 4.12)

There were significant differences ( $p < 0.01$ ) between treatments. The pigs in the single trough treatment showed significantly ( $p < 0.01$ ) less of this activity than those on the other three treatments. Significant ( $p < 0.05$ ) differences also existed between the pigs of the four ranks - the dominant animals showing more of this activity than the third and the fourth placed pigs ( $p < 0.05$ ).

(ii) Defecation after feeding (Table 4.12)

There were significant differences ( $p < 0.05$ ) between treatments and between the four different ranks.

(iii) Defecation after sleeping but before feeding (Table 4.12)

There were no significant differences between treatments. The differences between different ranking pigs were significant ( $p < 0.05$ ). The dominant pigs showed this activity less than the third and fourth placed pigs ( $p > 0.05$ ).

(iv) Defecation during rooting (Table 4.12)

There were no significant differences ( $p > 0.05$ ) between treatments, but the fourth placed animals showed significantly more ( $p < 0.05$ ) of this activity than the pigs of other ranks.

(v) Number of double defecations within a ten minute period (Table 4.12)

There were no significant differences between treatments ( $p > 0.05$ ), but the fourth placed animals showed significantly ( $p < 0.01$ ) more of this activity than the pigs of other ranks.

(vi) Total number of defecations (Table 4.12)

There were significant differences ( $p < 0.05$ ) between the four treatments but these differences only existed between the single pig with sheep treatment and the single trough treatment. There were no significant differences ( $p > 0.05$ ) between the pigs of different rank.

## DISCUSSION

From a theoretical point of view, it is very difficult to measure the food intake of an animal because food intake can be influenced by isolation or by social conditions. The reason a sheep was used to accompany a single pig was to try to minimize the effect of isolation and to avoid introducing a strong social stimulation in the form of another pig. These results might have been different if the pig had been entirely alone.

The results of these experiments on the relationship of body weight to social hierarchy agree with the results of Meese and Ewbank (1973), in that the heaviest pigs may not necessarily be the dominant animal and vice versa.

Fraser (1974) suggested that body weight was not the only determinant of social order. This suggestion is a little imprecise, because if the differences in body size are large, then the smaller animal could normally submit to the very much larger animal. How great a difference in body weight is required to cause naturally submissive behaviour by the smaller pig is still not known.

If the results of the total number of skirmishes between any two pigs are considered alone, for the first replicate, then there were more skirmishes between the dominant and fourth ranking pigs than between any other ranks. When the results of all three replicates are considered together and analysed by the Model 4-1 then between any two particular ranks of pigs there were no significant differences between the following scores: number of skirmishes, win-lose skirmishes, undecided skirmishes and in the use of different fighting techniques. The results also showed that a pig with a particular rank did not always fight the pigs with the

nearest rank or that the dominant animal always attacked the most inferior pig. Frequently two pigs would fight more than other pigs in a particular group but this was not related to rank. This result did not agree with the results reported by Meese (1973), in which he suggested that the highest levels of individual aggression were directed to the animal immediately inferior in the social order. This difference might be due to the variation in group size in the two studies. However the present results partly agree with the suggestion of Ewbank and Meese (1971), in which they suggested that aggression from the top pig tended to be directed towards a particular individual and not towards an animal occupying a certain rank. The observations here did not agree with that statement, it was not the dominant pigs which tended to attack a particular pig, but that particular pigs tended to return to the trough after being attacked by the dominant pig.

Although the dominant pig did not attack any pig with a particular rank in the group, it was involved in a greater number of skirmishes than the other three ranks of pigs. The most inferior pig was involved in the least number of skirmishes, probably because it always lost the fights or avoided fighting by going to eat when the other more dominant pigs were already satiated.

More skirmishes occurred in the single trough treatment than in the long trough treatment, especially when considering the won-lost skirmishes scores only. On the other hand, undecided fighting occurred significantly more in the long trough treatment than in the single trough treatment. This result could be explained by the fact that the pigs in the single trough treatment had to have a definite outcome in order to obtain a place at the trough. The

pigs in the long trough treatment did not have to expend so much energy establishing access to the trough so it was less important to win all the skirmishes.

The present results also clearly demonstrated the fact that pigs use one particular fighting technique in a particular environment, eg the pigs used more knocking in the long trough treatment but more jostling in the single trough treatment. Therefore it is important that a fighting technique is not used as the only measure to compare aggressive motivation in pigs in different environments. The question then is - how should fighting technique be used in scoring aggression? Here it was considered that thrusting, intention knocking, knocking and jostling were all indicators of moderate levels of aggression, while butting and biting were taken as serious aggression. Serious fighting techniques always involve movement when attacking. The moderate fighting techniques contain either movement or attack elements but not the combination as found in serious fighting. The conclusion here is: it is useful to separate the individual fighting technique as done by Fraser (1975), Jensen (1980), Schell, Graves and Sherritt (1977), but it may not be good to use them to measure aggressive motivation. Although the division of the six fighting techniques into two levels of aggressive motivation, serious and moderate fighting, may not be ideal, it seemed very useful to use them to describe the different levels of aggressive motivation and fighting techniques between long trough and single trough treatments.

The results differed when the moderate fighting was compared with the serious fighting in the two competitive treatments using the Model 2-1 and a 't' test. The reason for this finding is that

the number of skirmishes used in Model 4-1 was based on the number of skirmishes between two individual ranks in each replicate. This number might have been higher between two particular ranks in the single trough treatment and lower between two other ranks in the single trough treatment. This variation may have caused the different results in Model 4-1 and 't' test results. The number of skirmishes used in the 't' test was based on the total skirmishes which occurred in either the single trough treatment or the long trough treatment during a particular eight hour observation period. The Model 4-1 test, as mentioned above, tested inter-rank skirmishes and, as mentioned before, showed that the fighting between pigs of any two ranks was by chance. These ranks can be neglected when comparing aggression between treatments and a 't' test was then used to examine the differences between the two competitive treatments in moderate and serious fighting. The results showed that the pigs did more serious fighting in single trough treatment than in the long trough treatment but the difference did not reach a significant level ( $p > 0.05$ ). On the other hand, the pigs did show significantly more moderate fighting in the single trough treatment than in the long trough treatment. Therefore it can be concluded that the significantly larger number of skirmishes in the single trough treatment was due mainly to moderate fighting.

In the present experiment, it was shown that competition resulted in a higher food intake than in the non-competitive treatment. However the differences between the closed stall treatment and the competitive treatment were not always consistent and this may have been because aggressive behaviour might have diminished

the motivation to eat in some cases. However aggressive behaviour and other social factors may be important in stimulating the motivation to eat. As suggested by Tindsley (1979) the dominant pigs eat more than the other pigs in group feeding. If the dominant pig eats more than it used to eat in the non-competitive situation, and if the food intake of the other pigs does not drop, then the total food consumption of this group will be higher in a competitive situation than in a non-competitive situation. On the other hand, if the dominant pig does not eat more than it would under competition, and at the same time the food consumption of inferior pigs is diminished by being defeated in skirmishes, then the total food intake will be higher in non-competitive than in competitive treatments. In the present experiment, in which food was available for 8 hours, the inferior pigs may have been stimulated to eat more in the period after the first meal. This might be another reason why the total food consumption was higher in the competitive treatment than in the non-competitive treatment.

Adams (1975) reported that pigs ate less in competitive than in non-competitive situations under a 24-hour feeding régime. Such results may have been due to permanently lower eating motivation when food is always available. In the present experiment the pigs had a high level of motivation to feed after 16 hours deprivation. According to Zajonc's 'drive theory' (1965, 1969) on social facilitation, a lower motivated behaviour may be impaired by another more highly motivation behaviour or sometimes increased by it. Whether this theory is suitable for pigs will be examined more closely in Chapter 12.

The total eating times were significantly longer in the

non-competitive treatment but the eating speeds were higher in the pigs on the competitive treatment. Combining all the evidence on food consumption, total feeding time, and eating speed data, it may be suggested that the pigs may eat in a more relaxed way in the non-competitive situation, while in a competitive situation the pigs eat much more hurriedly. Although this might be common sense, it has not been reported before. It is not easy to draw conclusions as to why pigs ate more in the closed stall treatment than in the single pig with sheep treatment. It may be due to stimulation by social factors in the closed stall treatment, as has been suggested by some authors studying other species (Tolman, 1967; Harlow, 1932). Conversely, the decreased food intake by the pig with the sheep may have been caused by inhibition due to isolation from other pigs as has been suggested by some authors (Hinde, 1970; Stamm, 1961). A combination of both social stimulation and inhibition due to isolation have influenced the results.

After adjustment for body weight, the food intake of the second placed pig was significantly higher than the pigs of other ranks in the single pig with sheep treatment. However rank did not affect total food consumption in the closed stall treatment. Whether this phenomenon was general for all second placed pigs is not quite clear. The second placed animal also had the longest total feeding time in the overall average, but the longest total feeding time of a second placed pig occurred in the last replicate. This was simply due to the pig having the slowest eating speed. In fact sometimes its eating speed was less than half the eating speed of the other pigs in the last replicate. As the total feeding time of the second placed pigs was not always the longest in the other replicates the

results may well have been influenced by the extremely slow eating time of these pigs. It was difficult to assess the reason for the slow eating speed of these individuals and it may have influenced the total feeding time scores for second rank pigs during the first meal in the data from all replicates.

The fourth placed pigs spent significantly less time feeding in the single trough treatment than the other pigs throughout all the 8 hour observation periods and also during the first meal. These pigs also spent less time feeding in the long trough treatment during the first meal, although the results are not statistically significant. Furthermore, the results demonstrated that a single trough would seriously reduce the total feeding time of the inferior pigs. The long trough treatment only slightly reduced the total feeding time of inferior pigs during the first meal but not over the whole 8 hour observation period. Direct observations indeed showed that the inferior pigs had more opportunity to return to feed after the first meal in the long trough treatment.

The reason why the dominant pigs had significantly less total feeding time in the closed stall treatment than in the single pig with sheep treatment is unknown. It is interesting to speculate on whether or not different ranks react differently to different social conditions. Chapter 8 will attempt to explain this problem in more detail.

The variable eating speed may well just reflect individual ability and preference rather than the effect of social order. It would be interesting to investigate the effect of oral anatomy on eating speed.

Hansen (1977) suggested that the dominant animal had the

highest daily gain and some other reports found that the daily weight gain was positively correlated with dominance rank (Beilharz and Cox, 1967; Scheel, Graves and Sherritt, 1977). Dantzer (1970) has suggested that this relationship is due to dominant animals having more access to the trough. However the present experimental results suggest that the total eating time may not be a good index of total food intake among pigs with different ranks even for the first meal. This is because of the large variation in eating speed among pigs.

Furthermore, Tindsley (1979) has shown that pigs with the greatest intake do not necessarily have the best feed conversion ratio or highest liveweight gain. It is now very clear that there is no perfectly clear-cut relationship between social rank and the following phenomenon such as total feeding time, eating speed, total food intake, feed conversion and liveweight gain.

The numbers of feeding bouts in the two competitive treatments for the first meal were significantly higher than in the other two treatments. However this difference vanished over the total eight hours of observation. This could be due to one of three alternative explanations. (1) Isolation may have caused the pigs to have few feeding bouts in the first meal, but have more in their later meals. (2) Social factors may have caused more feeding bouts in the first meal; the presence of one animal feeding would induce another non-eating animal to start feeding within a short period of time. (3) One pig eating might prevent another animal from eating. Such a stimulus might have been stronger in the first meal due to higher feeding motivation caused by sixteen hours' deprivation and weakness later.

The results on drinking, urination and defecation also give some evidence of competition in the competitive treatment, when compared with the non-competitive treatments. For example - (1) The pigs in the competitive treatment had significantly fewer drinks during the meal period, and during one minute after feeding, suggesting that the pigs did not want to interrupt their feeding to drink in the competitive treatments. (2) The pigs in the single trough treatment had significantly more drinks after the meal - when they were free from the compulsion to eat. (3) The pigs in the single trough treatment concentrated on eating and did not waste valuable eating time on urination and defecation during meals. (4) The pigs urinated more during the rooting period in the single trough treatment - which may indicate that some urination is caused by frustration or too much competition.

TABLE 4.1 The initial body weights (IWT) and final body weights (FWT) and position in the social hierarchy of the pigs in the experiment

Rank	Replicate 1		Replicate 3		Replicate 4		Replicate 2	
	IWT	FWT	IWT	FWT	IWT	FWT	IWT	FWT
1	33.8	61.8	35.5	62.3	30.5	57.7	34.9	59.6
2	36.0	63.1	35.3	61.2	25.5	51.0	31.4	55.4
3	36.1	62.0	34.0	60.8	28.5	55.0	37.6	61.8
4	34.2	56.0	34.5	61.7	28.5	54.0	32.0	51.8

Unit = kg

TABLE 4.2 The total number of skirmishes which occurred between the pigs of different ranks in both competitive treatments

Rank of two encounter pigs	Thrusting T		Jostling J		Intension knocking I		Knocking K		Butting BU		Biting BI		T + J + I + K		BU + BI		Total	
	LT	ST	LT	ST	LT	ST	LT	ST	LT	ST	LT	ST	LT	ST	LT	ST	LT	ST
1-2	12	1	24	131	9	25	131	78	12	21	11	30	176	235	23	51	199	286
1-3	5	6	18	69	21	31	97	73	27	33	21	52	141	179	48	85	189	264
1-4	1	2	7	32	23	38	101	49	34	11	24	45	132	131	58	56	190	187
2-3	14	6	21	94	9	13	137	55	14	5	4	23	181	169	18	28	199	197
2-4	19	10	17	33	13	45	64	78	4	7	3	7	113	166	7	14	120	180
3-4	19	24	7	50	4	13	49	39	8	4	2	12	79	137	10	16	89	153
Total	70	49	94	409	79	165	579	372	99	81	63	169	822	1017	164	250	986	1267

(Results of replicates 1, 3 and 4 only)

TABLE 4.3 The number of 'win-lose' and undecided skirmishes together with the total number of skirmishes for the four social ranks in two competitive treatments

Social rank	Win-lose skirmishes				Sub-total
	1	2	3	4	
Long trough treatment	490	379	382	323	1574
Single trough treatment	721	644	586	489	2440
Sub-total	1211	1023	968	812	4014
	Undecided skirmishes				
Long trough treatment	88	139	94	75	396
Single trough treatment	17	20	28	31	96
Sub-total	105	159	122	106	492
	Overall totals				
Long trough treatment	578	518	476	398	1970
Single trough treatment	738	664	614	520	2536
Total	1316	1182	1090	918	

(Results of replicates 1, 3 and 4 only)

Each figure represents the sum of 12 days' observations,  
four days in each replicate

TABLE 4.4 The effect of group, closed stall and isolated feeding on the feeding behaviour of pigs

	Treatment SP	CS	LT	ST	se of difference	Level of significance
Total food consumption (kg) per four pigs	9.440 (2.360)	10.350 (2.360)	10.884 (2.721)	10.647 (2.662)	0.18	***
Total feeding time (seconds)	6268	6334	5659	4959	221	***
Total feeding time during first meal (seconds)	2025	2019	1676	1539	102	***
Eating speed (g/sec)	0.409	0.433	0.518	0.567	0.013	***
Total feeding bouts	38.5	39.3	39.1	37.9	3.1	NS
Total feeding bouts during first meal	7.6	12.9	12.4	15.1	2.2	*

SP - single pig with sheep treatment, CS - closed stall treatment,

LT - long trough treatment, ST - single trough treatment

Figures in brackets represent the average food intake for the four pigs  
(Results of replicates 1, 3 and 4 only)

\* -  $p < 0.05$ , \*\* -  $p < 0.01$ , \*\*\* -  $p < 0.005$

TABLE 4.5 The effect of group, closed stall and isolated feeding on the total food consumption of the four pigs in each replicate

## Replicate 1

8.825 (LT)	9.037 (CS)	10.225 (ST)	8.693 (SP)
11.431 (CS)	9.775 (ST)	10.168 (SP)	12.549 (LT)
12.775 (ST)	11.336 (SP)	13.212 (LT)	11.746 (CS)
11.295 (SP)	13.899 (LT)	13.638 (CS)	13.421 (ST)

## Replicate 2

6.942 (SP)	9.029 (LT)	7.501 (CS)	8.841 (ST)
9.820 (CS)	8.511 (SP)	10.680 (ST)	9.770 (LT)
10.601 (LT)	10.570 (ST)	8.324 (SP)	10.921 (CS)
11.105 (ST)	10.755 (CS)	10.981 (LT)	10.785 (SP)

## Replicate 3

7.570 (SP)	8.990 (LT)	8.789 (ST)	9.093 (CS)
8.993 (CS)	9.383 (ST)	10.180 (LT)	9.091 (SP)
11.053 (ST)	10.482 (SP)	11.135 (CS)	12.497 (LT)
12.887 (LT)	12.689 (CS)	11.882 (SP)	14.350 (ST)

## Replicate 4

6.520 (SP)	7.600 (ST)	8.362 (LT)	7.842 (CS)
8.865 (ST)	8.163 (SP)	9.283 (CS)	10.190 (LT)
10.305 (LT)	10.383 (CS)	10.220 (ST)	10.059 (SP)
11.968 (CS)	11.860 (LT)	11.218 (SP)	12.700 (ST)

SP - single pig with sheep treatment

CS - closed stall treatment

LT - long trough treatment

ST - single trough treatment

Unit - kg

TABLE 4.6 The effect of group, closed stall and isolated feeding on the feeding behaviour of the pigs in replicate 2

	Treatment			se of difference	Level of significance
	SP	CS	LT		
Total food consumption (kg/four pigs)	8.64	9.60	10.10	0.89	**
Total feeding time (seconds)	4714	5163	4446	208	***
Eating speed (g/second)	0.460	0.460	0.571	0.628	**

SP - single pig with sheep treatment, CS - closed stall treatment, LT - long trough treatment, ST - single trough treatment

\* -  $p < 0.05$ , \*\* -  $p < 0.01$ , \*\*\* -  $p < 0.005$

TABLE 4.6a The effect of social order and treatment on total feeding time of pigs in replicate 2

Social order	Treatment				Average
	SP	CS	LT	ST	
1	4487	5121	4389	4144	4535
2	6350	6727	5831	5331	6060
3	5008	4733	4176	4140	4514
4	3014	4070	3387	2825	3324
Average	4714	5163	4446	4110	

SP - single pig with sheep treatment, CS - closed stall treatment,

LT - long trough treatment, ST - single trough treatment

unit - seconds

TABLE 4.7 The effect of social order on food intake and eating speed of pigs in single pig with sheep treatment and closed stall treatment

	Social order 1	2	3	4	se of difference	Level of significance
	Single pig with sheep treatment					
Total food consumption (kg/pig)	2.607	2.493	2.404	2.286	0.077	***
Total food consumption (kg/pig) (adjusted for covariates of weight)	2.475	2.564	2.363	2.388	0.059	***
Eating speed (g/second)	0.439	0.406	0.397	0.389	0.037	NS
Eating speed (g/second) (adjusted for covariates of weight)	0.409	0.420	0.388	0.415	0.029	NS
	Closed stall treatment					
Total food consumption (kg/pig)	2.779	2.618	2.686	2.519	0.102	NS
Total food consumption (kg/pig) (adjusted for covariates of weight)	2.732	2.647	2.668	2.556	0.100	NS
Eating speed (g/second)	0.474	0.426	0.424	0.409	0.034	NS
Eating speed (g/second) (adjusted for covariates of weight)	0.443	0.445	0.412	0.433	0.023	NS

\* -  $p < 0.05$ , \*\* -  $p < 0.01$ , \*\*\* -  $p < 0.005$

TABLE 4.8 The effect of treatment and rank on total feeding time (TFT) of the pigs

Social rank Treatment	TFT during eight hours' observation				Average
	1	2	3	4	
SP	5975	7034	6178	5885	6268
CS	5939	6762	6374	6259	6334
LT	4746	6829	5394	5665	5659
ST	4483	6258	4202	4894	4959
Average	5286	6721	5537	5676	
	TFT during first meal				
SP	2122	2050	2048	1881	2025
CS	1643	2269	2104	2059	2019
LT	1629	1848	1853	1375	1676
ST	1594	1804	1651	1105	1539
Average	1747	1993	1914	1605	

SP - single pig with sheep treatment, CS - closed stall treatment,

LT - long trough treatment, ST - single trough treatment

Unit - second

TABLE 4.9 The effect of treatment and rank on number of feeding bouts of the pigs

Social rank Treatment	Average number of feeding bouts during eight hours' observation				Average NS
	1	2	3	4	
SP	44.6	38.83	32.08	38.58	38.54
CS	46.42	39.67	33.50	37.50	39.27
LT	46.33	43.25	36.08	30.58	39.06
ST	49.50	40.33	35.17	26.50	37.88
Average (***)	46.73	40.52	34.21	33.29	
	Average number of feeding bouts during first meal				Average *
SP	8.75	7.33	6.58	7.58	7.56
CS	13.67	14.67	10.92	12.50	12.94
LT	13.83	13.67	12.08	10.17	12.44
ST	18.67	16.92	14.83	10.00	15.10
Average (**)	13.73	13.15	11.10	10.06	

SP - single pig with sheep treatment, CS - closed stall treatment,

LT - long trough treatment, ST - single trough treatment

\* -  $p < 0.05$ , \*\* -  $p < 0.01$ , \*\*\* -  $p < 0.005$

TABLE 4.10 The effect of treatment and social rank on drinking behaviour of the pigs  
(numbers denote average number of drinking bouts)

Social rank	1	2	3	4	Average
Treatment	(i) After waking from sleep and before eating				
SP	2.08	3.00	4.50	2.75	3.08
CS	3.08	3.75	5.75	2.33	3.73
LT	3.67	2.67	4.00	2.42	3.19
ST	2.42	2.25	3.33	2.67	2.67
Average	2.81	2.92	4.40	2.54	
	(ii) Within 1 minute after start of feeding				
SP	1.25	0.33	0.67	0.25	0.63
CS	0.83	0.75	0.42	0.83	0.71
LT	0.08	0.42	0.08	0.25	0.21
ST	0.50	0.17	0.25	0.25	0.29
Average	0.67	0.42	0.35	0.40	
	(iii) During the meal period but excluding the first minute of the meal				
SP	8.42	8.25	7.92	7.67	8.06
CS	7.33	7.50	7.08	6.75	7.17
LT	4.50	4.00	3.50	2.42	3.60
ST	2.92	1.83	1.08	1.75	1.90
Average	5.79	5.40	4.90	4.65	
	(iv) After the meal				
SP	2.33	2.92	2.75	2.17	2.54
CS	3.25	3.00	4.50	1.75	3.12
LT	2.25	2.00	4.33	2.50	3.67
ST	3.17	3.17	5.17	3.67	3.79
Average	2.75	2.77	4.19	2.52	
	(v) During sleeping periods				
SP	0.83	0.92	2.08	1.00	1.21
CS	1.00	0.67	2.25	1.25	1.29
LT	1.33	1.00	2.08	1.67	1.52
ST	1.17	0.83	2.33	1.33	1.42
Average	1.08	0.85	2.19	1.31	
	(vi) During rooting periods				
SP	0.17	0.25	0.25	0.42	0.27
CS	0.17	0.50	0.58	1.00	0.56
LT	0.00	0.00	0.67	0.58	0.31
ST	0.33	0.42	0.75	1.08	0.65
Average	0.17	0.29	0.56	0.77	
	(vii) Total number of drinking bouts				
SP	15.08	15.67	18.17	14.33	15.81
CS	15.67	16.17	20.58	14.00	16.60
LT	11.83	10.25	14.67	9.75	11.63
ST	10.50	8.50	13.00	10.75	10.69
Average	13.27	12.65	16.60	12.21	

SP - single pig with sheep treatment, CS - closed stall treatment  
LT - long trough treatment, ST - single trough treatment

TABLE 4.11 The effect of treatment and social rank on number of urinations

Social rank	Average number of urinations				Average
	1	2	3	4	
Treatment	(i) Between two feeding bouts				
SP	5.17	5.00	4.25	4.50	4.73
CS	4.58	5.08	4.17	4.92	4.69
LT	4.17	5.42	3.92	3.33	4.21
ST	3.67	3.50	2.83	3.08	3.27
Average	4.40	4.75	3.79	3.96	
	(ii) Between two sleeping bouts				
SP	0.08	0.33	0.50	0.33	0.31
CS	0.58	0.33	1.08	0.58	0.65
LT	0.08	0.50	0.75	0.50	0.46
ST	0.17	1.00	0.92	0.58	0.67
Average	0.23	0.54	0.81	0.50	
	(iii) After sleep but before feeding				
SP	0.67	1.33	1.58	2.33	1.48
CS	1.42	1.33	1.75	1.33	1.46
LT	1.00	0.75	1.33	1.50	1.15
ST	0.83	1.42	1.08	1.92	1.31
Average	0.98	1.21	1.44	1.77	
	(iv) During rooting periods				
SP	0.33	0.17	0.00	0.08	0.15
CS	0.08	0.17	0.42	0.42	0.27
LT	0.00	0.17	0.17	0.42	0.27
ST	0.25	0.50	0.42	0.67	0.46
Average	0.17	0.25	0.25	0.40	
	(v) Total number of urinations				
SP	6.33	6.83	6.25	7.08	6.63
CS	6.67	6.83	7.42	7.25	7.04
LT	5.25	6.83	6.08	5.58	5.94
ST	4.92	6.42	5.08	6.17	5.65
Average	5.79	6.73	6.21	6.52	

SP - single pig with sheep treatment

CS - closed stall treatment

LT - long trough treatment

ST - single trough treatment

TABLE 4.12 The effect of treatment and social rank on the number of defecations in the pigs

Social rank	1	2	3	4	Average
Treatment	(i) Between two consecutive feeding bouts within one meal				
SP	3.50	2.50	2.08	2.33	2.60
CS	2.50	1.83	2.08	1.67	2.02
LT	2.50	1.50	1.00	1.33	1.58
ST	0.50	0.92	0.67	0.25	0.58
Average	2.25	1.69	1.46	1.40	
	(ii) After feeding				
SP	0.83	1.25	0.92	2.08	1.27
CS	0.83	1.00	1.75	1.00	1.15
LT	0.83	1.58	2.17	1.25	1.46
ST	1.67	1.50	1.08	1.67	1.48
Average	1.04	1.33	1.48	1.50	
	(iii) After sleeping but before feeding				
SP	1.00	1.08	2.08	1.42	1.40
CS	0.33	1.17	1.92	1.67	1.27
LT	1.17	1.08	1.50	1.50	1.31
ST	1.33	1.83	1.83	1.58	1.65
Average	0.96	1.29	1.83	1.54	
	(iv) During rooting periods				
SP	0.08	0.08	0.00	0.42	0.15
CS	0.08	0.17	0.17	0.75	0.29
LT	0.00	0.25	0.17	0.50	0.23
ST	0.00	0.25	0.33	0.42	0.25
Average	0.04	0.19	0.17	0.52	
	(v) Average number of double defecations within a ten minute period				
SP	0.50	0.25	0.33	1.25	0.58
CS	0.00	0.17	0.50	0.67	0.33
LT	0.25	0.42	0.33	0.50	0.38
ST	0.17	0.17	0.17	0.25	0.19
Average	0.23	0.25	0.33	0.67	

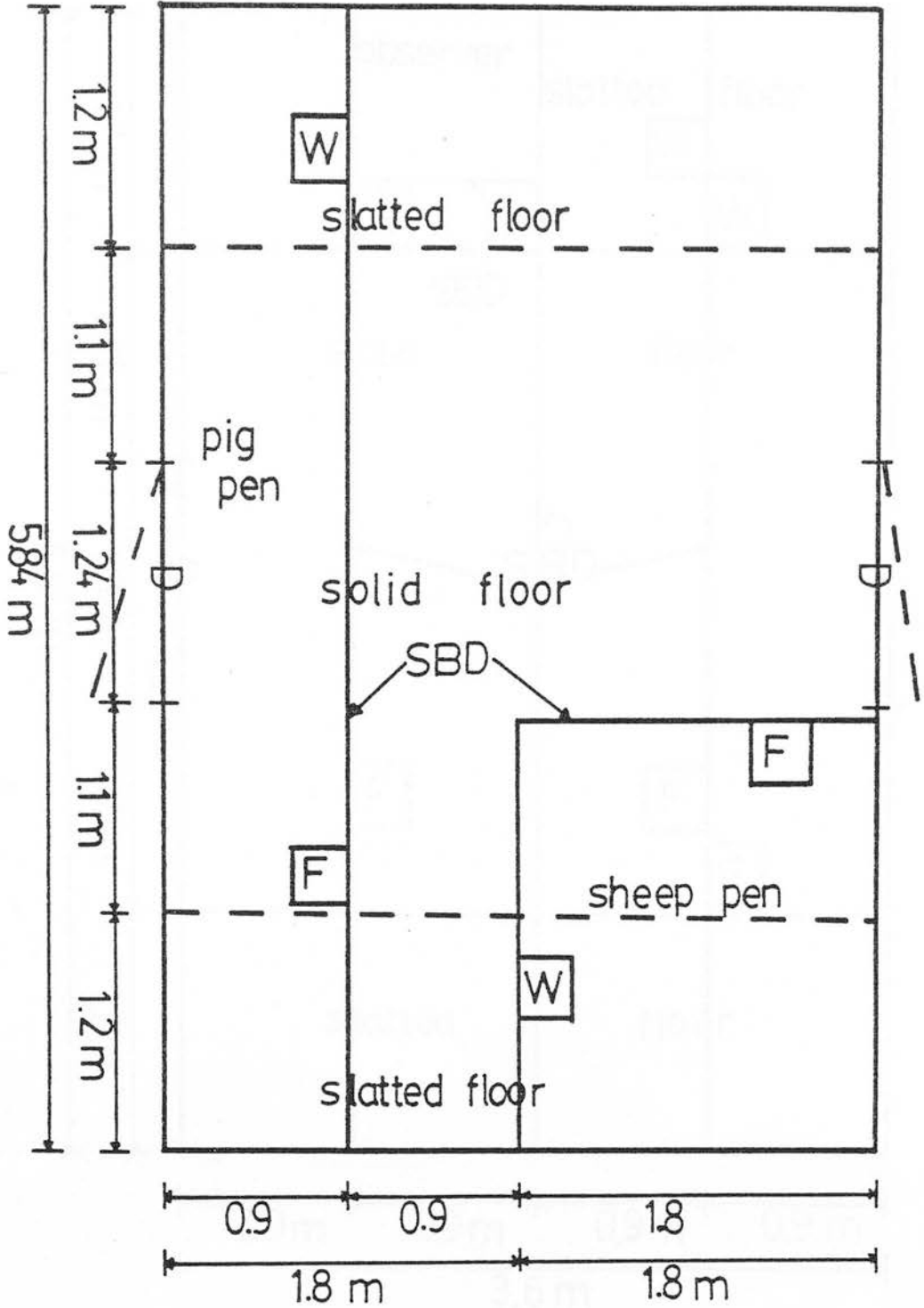
SP - single pig with sheep treatment

CS - closed stall treatment

LT - long trough treatment

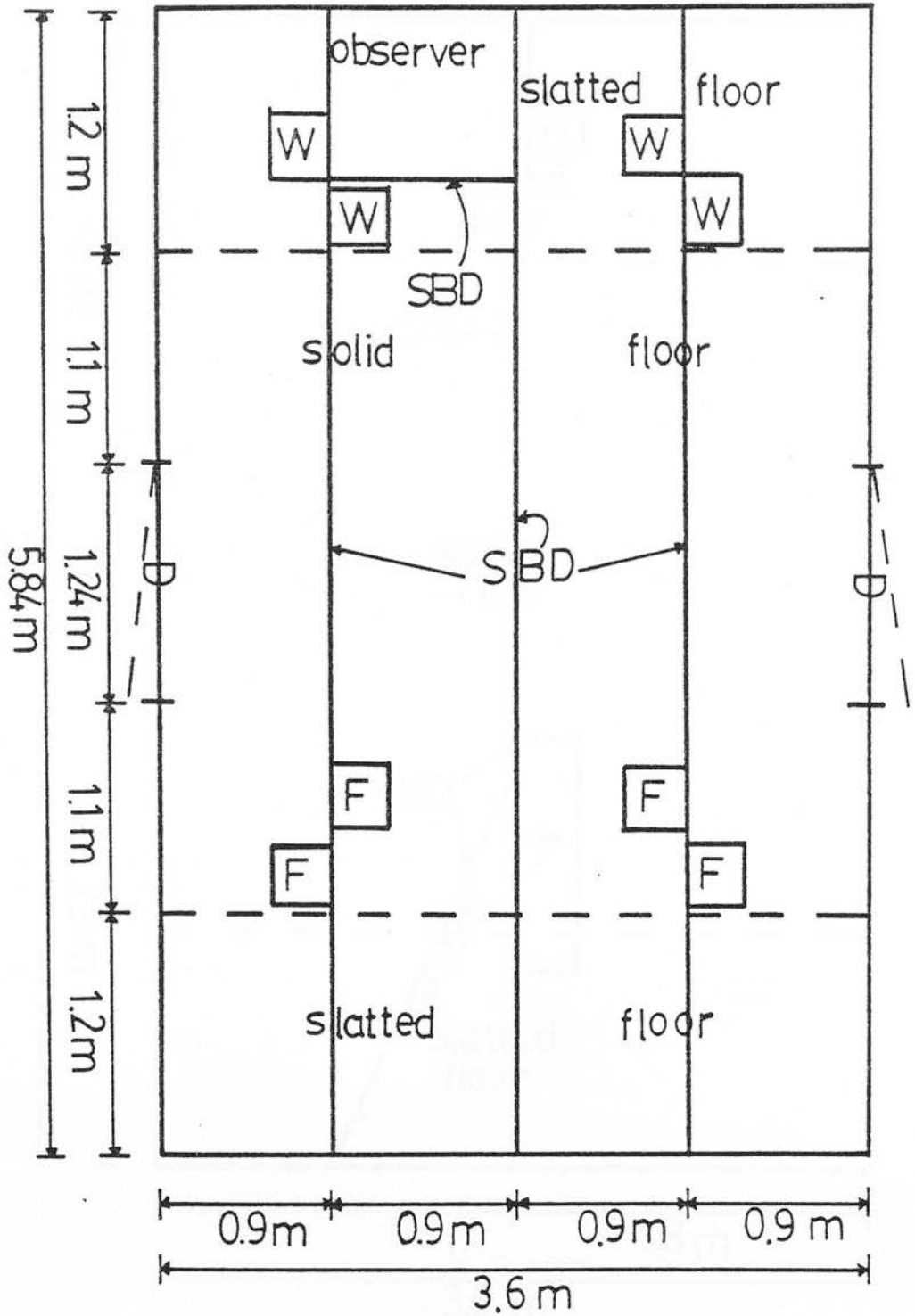
ST - single trough treatment

FIGURE 4-1



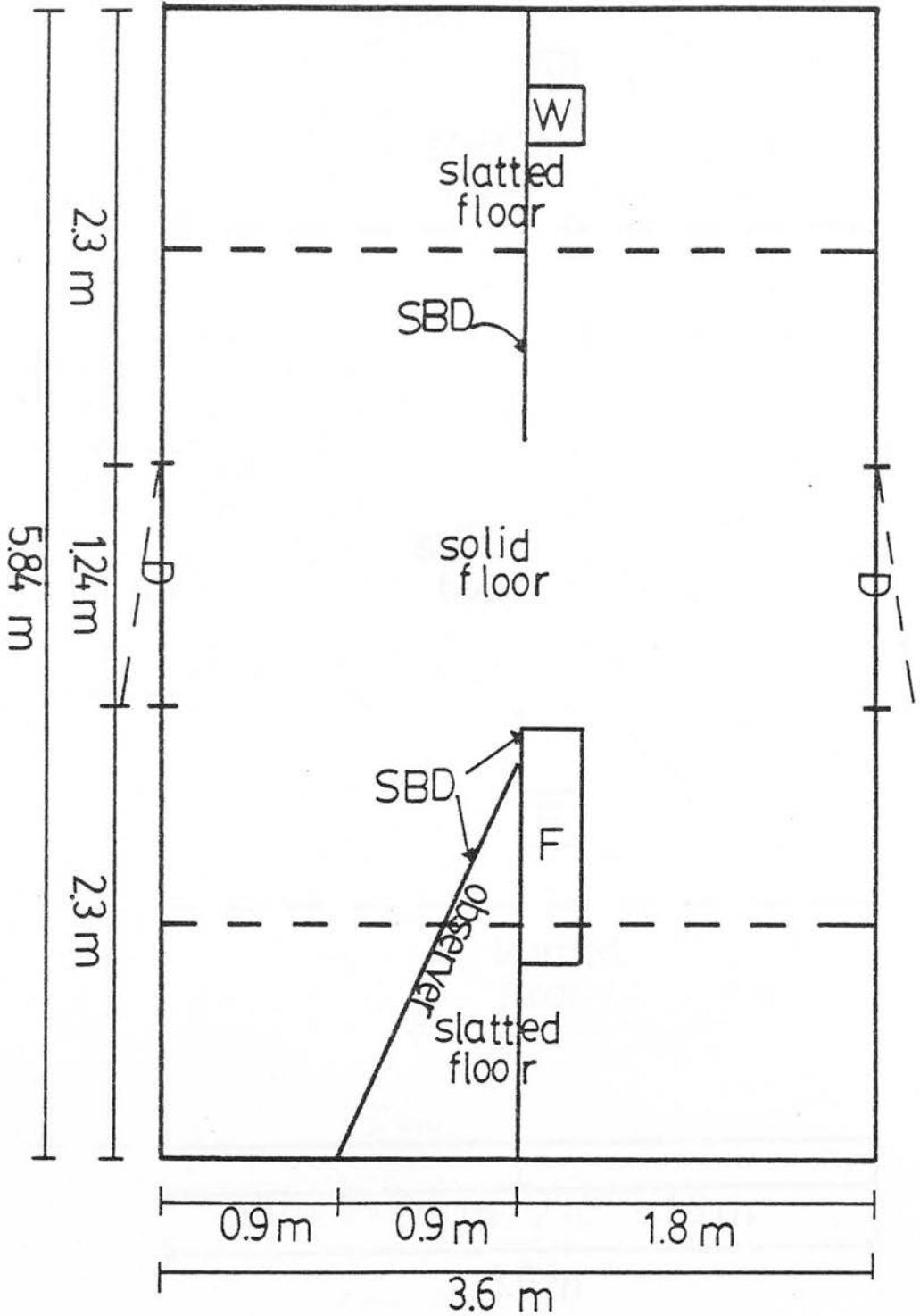
Plan of room arrangement in single pig with sheep treatment  
 F - feed trough; D - door; SBD - steel bar division;  
 W - water trough

FIGURE 4-2



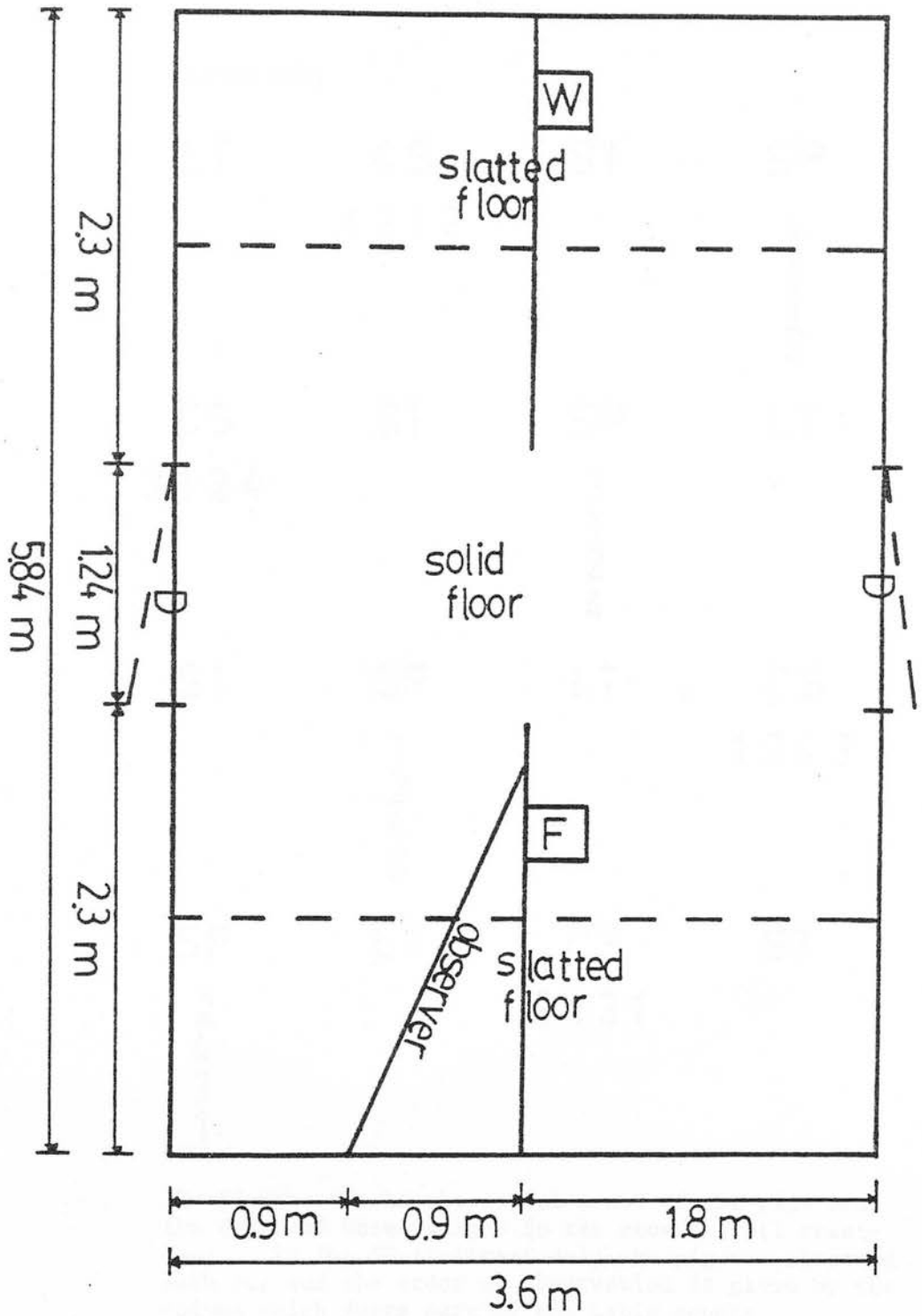
Plan of room arrangement in closed stall treatment  
 D - door; F - food trough; SBD - steel bar division;  
 W - water trough

FIGURE 4-3



Plan of room arrangement in long trough treatment  
 D - door; F - food trough; SBD - steel bar division;  
 W - water trough

FIGURE 4-4



Plan of room arrangement in single trough treatment  
 D - door; F - food trough; W - water trough

FIGURE 4-5a

LT	CS	ST	SP
	4 3 1 2		4 3 1 2
CS	ST	SP	LT
3 1 2 4		3 1 2 4	
ST	SP	LT	CS
	1 2 4 3		1 2 4 3
SP	LT	CS	ST
2 4 3 1		2 4 3 1	

The figures denote the social order of the pigs and the order of observations in the closed stall treatment. In the SP treatment only one pig was observed each day and the order of observation is given by the column which forms part of the Latin square.

LT - long trough treatment; CS - closed stall treatment; ST - single trough treatment; SP - single pig with sheep treatment.

FIGURE 4-5b

SP	LT	CS	ST
2		2 1 3 4	
1			
3			
4			
CS	SP	ST	LT
3 2 4 1	3		
	2		
	4		
	1		
LT	ST	SP	CS
		1	1 4 2 3
		4	
		2	
		3	
ST	CS	LT	SP
	4 3 1 2		4
			3
			1
			2

For explanation see Figure 4-5a

FIGURE 4-5c

SP	LT	ST	CS
4			2413
1			
2			
3			
CS	ST	LT	SP
3142			3
			4
			1
			2
ST	SP	CS	LT
	2	1234	
	3		
	4		
	1		
LT	CS	SP	ST
	4321	1	
		2	
		3	
		4	

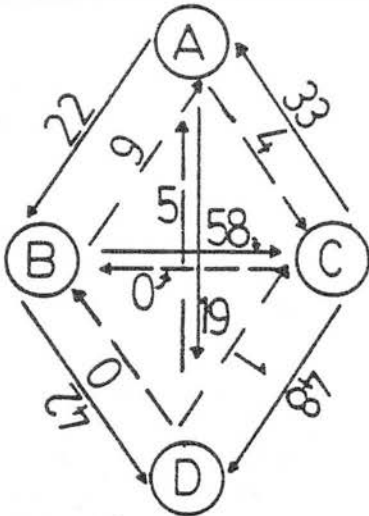
For explanation see Figure 4-5a

FIGURE 4-5d

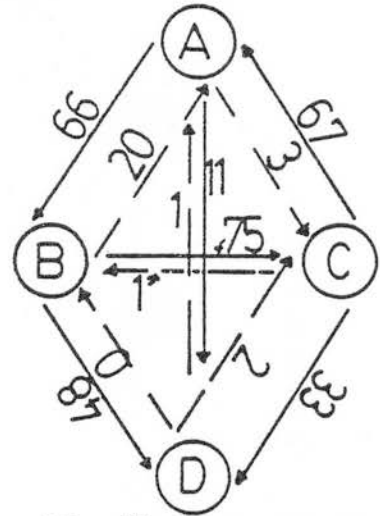
SP	ST	LT	CS
1			3 1 2 4
2			
3			
4			
ST	SP	CS	LT
	4	4 2 1 3	
	1		
	2		
	3		
LT	CS	ST	SP
	2 3 4 1		3
			4
			1
			2
CS	LT	SP	ST
1 4 3 2		2	
		3	
		4	
		1	

For explanation see Figure 4-5a

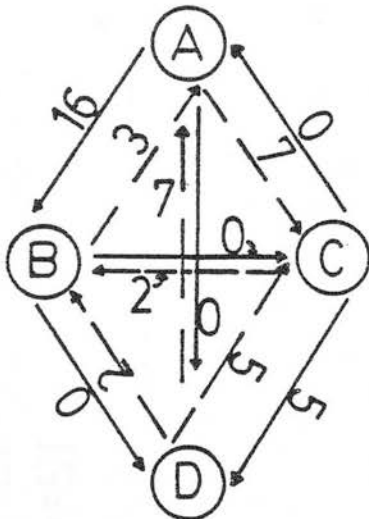
FIGURE 4-6



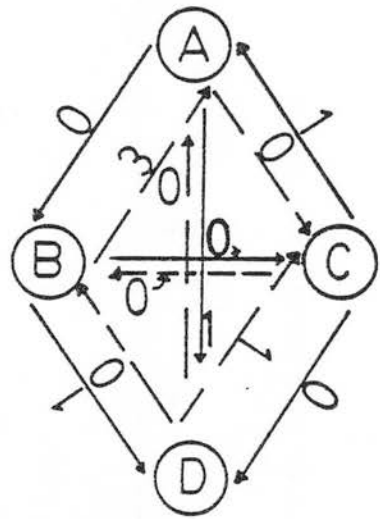
LT: Win-loss encounter



ST: Win-loss encounter



LT: Draw encounter

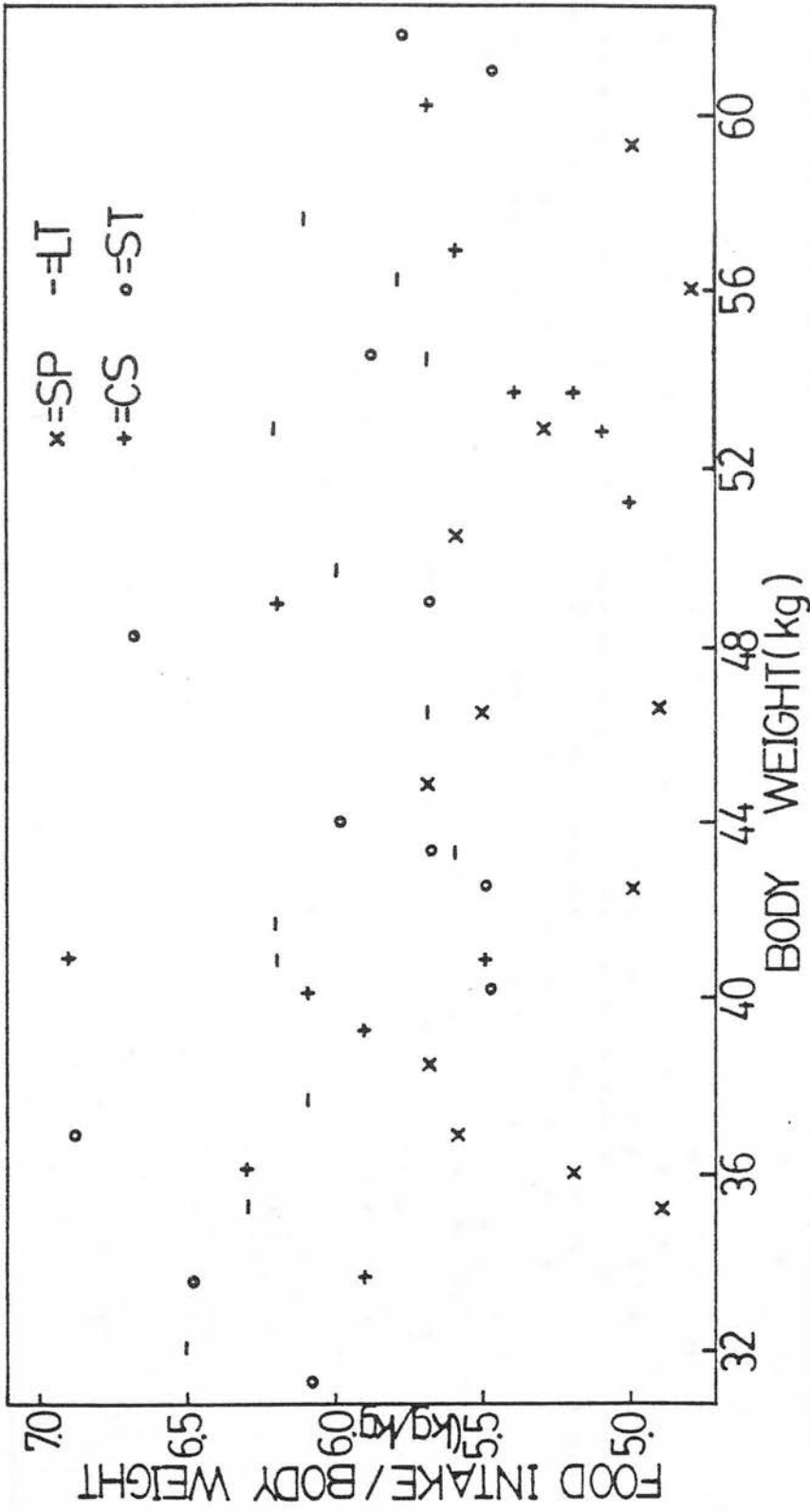


ST: Draw encounter

The encounters which happened in second replicate. The arrow shows which pig beat which pig in win-loss encounters. In draw encounters it represents which started fighting. The number on the arrow represents the number of encounters.

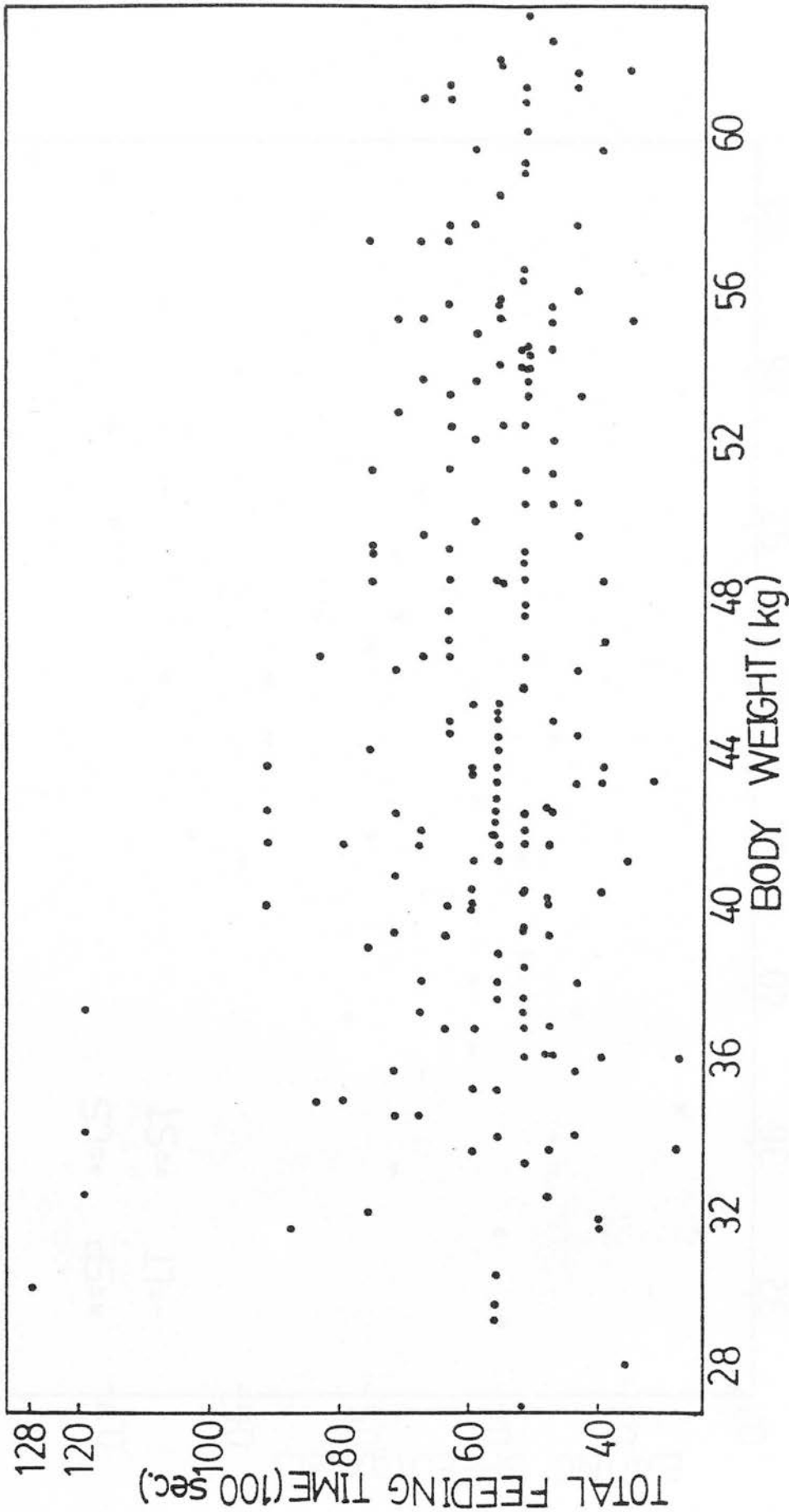


FIGURE 4-8



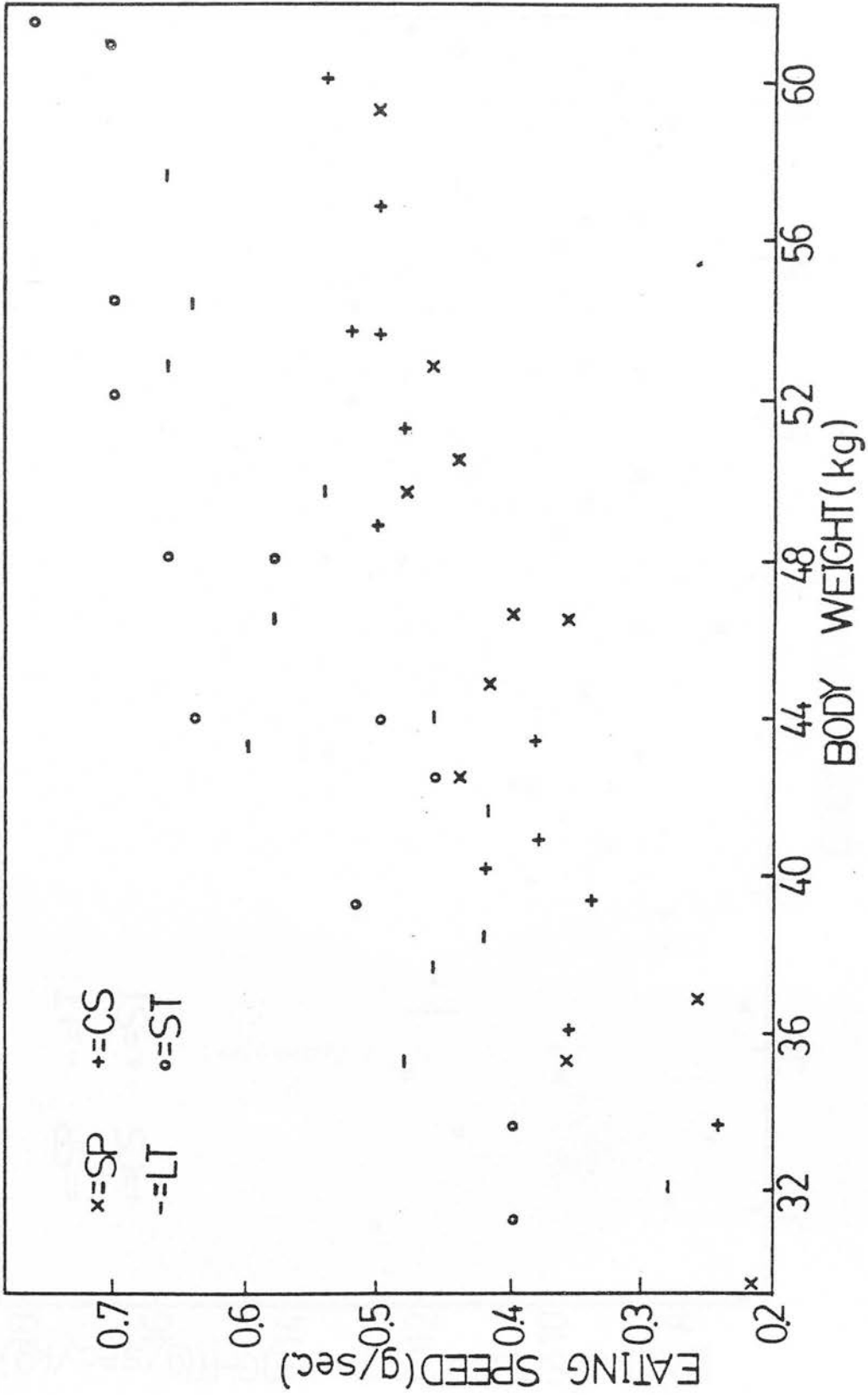
The relationship between food intake per unit of body weight and body weight of pigs in different treatments

FIGURE 4-9



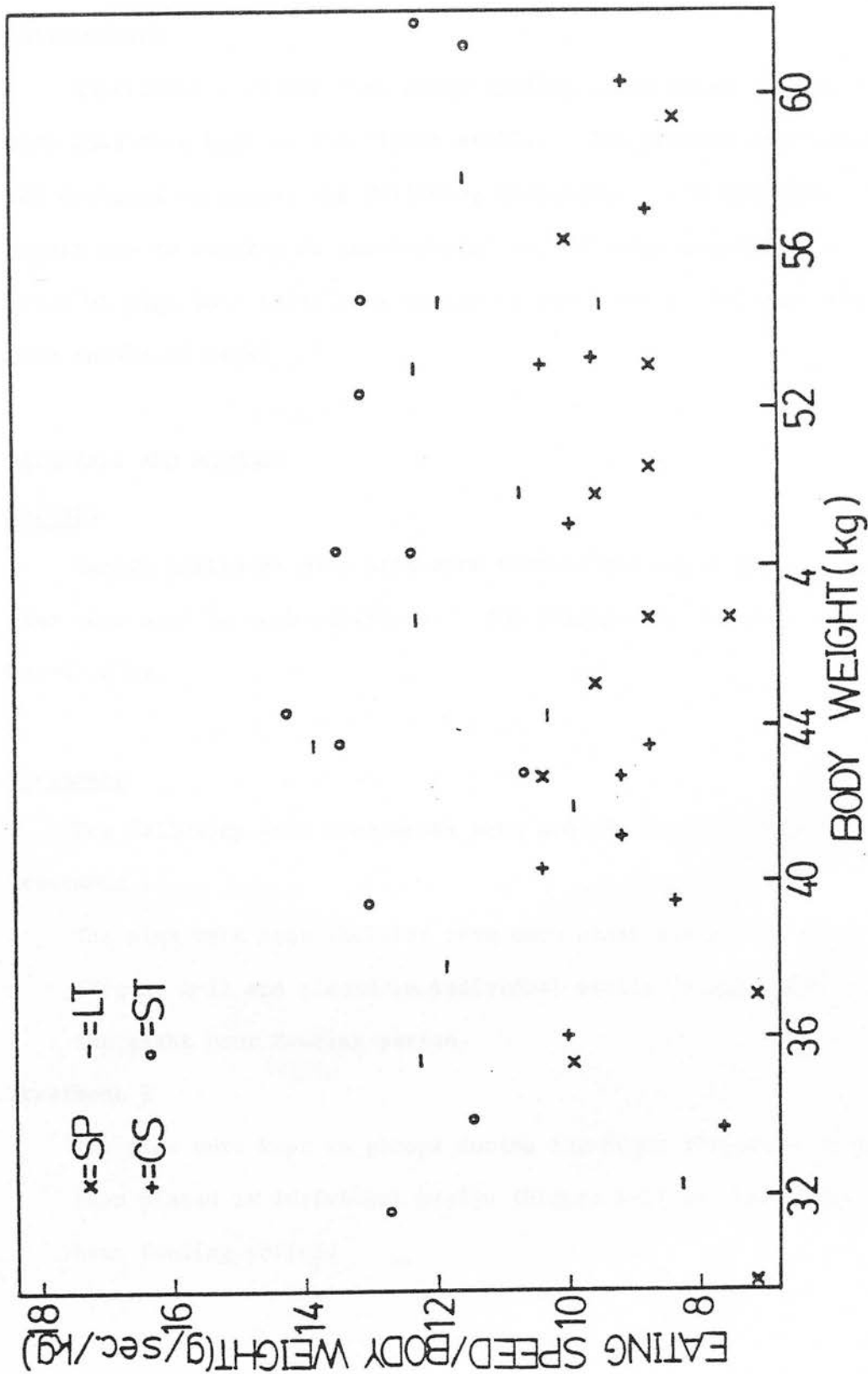
The relationship between total feeding time and body weight of pigs

FIGURE 4-10



The relationship between eating speed and body weight of pigs in different treatments

FIGURE 4-11



The relationship between eating speed per unit of body weight and body weight of pigs in different treatments

CHAPTER 5 THE EFFECT OF REUNION AND SEPARATION IN THE MORNING ON  
THE FOOD INTAKE OF PIGS

INTRODUCTION

Experiment 2 showed that group feeding could cause pigs to eat more than when kept in individual stalls. The present experiment was designed to answer the following questions. (1) Was this result due to reunion in the morning? or, (2) Does separating a group of pigs into individual stalls in the morning influence the food intake of pigs?

MATERIALS AND METHODS

Animals

Twelve castrated male pigs were used in the experiment. Four pigs were used in each replicate. The average initial body weight was 27.8 kg.

Treatment

The following four treatments were used in three replicates.

Treatment 1

The pigs were kept isolated from each other during the night (Figure 4-1) and placed in individual stalls (Figure 4-2) for the eight hour feeding period.

Treatment 2

The pigs were kept in groups during the night (Figure 4-3) and then placed in individual stalls (Figure 4-2) for the eight hour feeding period.

### Treatment 3

The pigs were kept in isolation during the night (Figure 4-1) and put together in the morning (Figure 4-3) immediately before the eight hour feeding period.

### Treatment 4

The pigs were kept in groups (Figure 4-3) overnight and then remained in the same groups for feeding during the eight hour feeding period.

The four stalls were in the same room. When the pigs were isolated during the night, a sheep was placed in the adjacent stall to provide company.

### Procedure and Husbandry

One week was allowed for settling in and the four pigs in each replicate went through a 4 x 4 Latin square. The three Latin squares are shown in Figure 5-1. According to the requirements of the treatment, the pigs were kept in groups or put into adjacent stalls in the morning, between 8.00 am and 8.30 am, and were weighed during the same period. Weighed food was provided at 8.30 am and the food troughs were removed at 4.30 pm, the residues were then weighed and recorded. No observations were made during this experiment, only food intake was recorded.

## Statistical Model

$$\text{Model 5-1: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

In which  $Y$  = independent variable

$\mu$  = grand mean

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

$e$  = error

## RESULTS

The results show that there were significant differences ( $p < 0.05$ ) in food intake between treatments (Table 5.1). The difference between Treatment 1 and Treatment 2 and between Treatment 2 and Treatment 3 did not reach significant levels ( $p > 0.05$ ). The pigs in the group feeding treatment (Treatments 3 and 4) had significantly higher ( $p < 0.05$ ) food intake than the pigs kept in individual stalls, although the group fed pigs may not have always consistently eaten more.

## DISCUSSION

These results suggest that the reunion of the pigs in the morning and the separation of the pigs in the morning did not affect the food intake over the next eight hours, although Clayton (1976) reported that reunion can cause thirsty ducks to drink more. However, as his results concerned periods of only 8 minutes, so the

effect of reunion reported by him might only have had a short-term effect rather than a long-term effect.

The present results once again showed that the food intake of pigs is higher in group than in individual stalls. However this result was not consistent. The factors causing this variation will be studied in the following chapters.

TABLE 5.1 The effect of reunion and separation in the morning on the food intake of pigs

Treatment <sup>φ</sup>	1	2	3	4	se of difference	level of significance
Food intake (kg/4 pigs)	6.961	6.930	7.438	7.305	0.171	**

<sup>φ</sup> - see text for details

\*\* -  $p < 0.01$

FIGURE 5-1

4	2	3	1
1	3	2	4
3	4	1	2
2	1	4	3

REPLICATE 1.

4	1	3	2
3	4	2	1
1	2	4	3
2	3	1	4

REPLICATE 2.

1	3	2	4
4	2	3	1
3	4	1	2
2	1	4	3

REPLICATE 3.

The 4 x 4 Latin square design of experiment in Chapter 5. The figures represent the treatment.

CHAPTER 6 THE EFFECT OF THE DISTANCE BETWEEN TWO PIGS ON THEIR  
FOOD INTAKE

INTRODUCTION

The purpose of this experiment was to investigate (1) Whether the distance between two pigs in adjacent pens will influence their food intake. (2) Whether a strange pig in the adjacent stall will influence the food intake of the pig.

MATERIALS AND METHODS

Animals

Thirty castrated males were used in this experiment, half each in parts 1 and 2. The initial average body weight was 25.9 kg and the range of weight was 22.0 kg to 27.0 kg.

Treatment

The three treatments were as follows.

Treatment 1

Five pigs were housed in five adjoining stalls which were separated by steel bar divisions (Figure 6-1).

Treatment 2

One pen interval (Figure 6-2). Five pigs were housed in alternate stalls, so that there was an empty pen between two adjacent pigs.

Treatment 3

Two pen intervals (Figure 6-3). Five pigs were housed with two pens intervening between two adjacent pigs.

All the five pigs in each replicate originated from the same group.

## Part 2

All the three treatments in part 2 were the same as the treatments in part 1. The only difference was that the five animals in part 2 originated from two different sources. Three animals from one group and the other two from another group.

## Husbandry

Light was provided for 8.5 hours per day, from 7.30 am to 4.00 pm, and the food intake for eight hours per day was measured from 8.00 am to 4.00 pm.

The food used was the same as in Chapter 3, *ad libitum* for eight hours. All food spilt was collected and weighed with the residual food at the end of each measurement period. No food was provided for the remaining sixteen hours but water was available all the time.

## Procedure

The measurements for these treatments were carried out in the same room as the observations. There were three replicates in both part 1 and part 2. A three day settling in period was allowed and each treatment was carried out once before measurements were recorded.

The pigs were weighed between 7.30 am and 8.00 am each day. After the settling in period the animals in each replicate were put through the treatment according to a 3 x 3 Latin square. Consequently each replicate lasted for nine days (Figure 6-4). The data on the food intake results of the three pigs in the three middle pens were analysed by Model 6-1.

## Statistical Model

$$\text{Model 6-1: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

In which  $Y$  = independent variable

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

$e$  = error

## RESULTS

Part 1

The pigs in this part all came from the same original group. The results showed significant differences in food intake between treatments ( $p < 0.05$ ).

There were no significant differences between Treatment 1, in which the pigs were in adjacent stalls, and Treatment 2, in which the pigs were separated by an empty pen. However the difference between Treatment 3, in which the pigs were separated by two empty pens, and other two treatments, reached a significant level ( $p < 0.05$ ; Table 6.1).

Part 2

The pigs in the adjacent pens in this part came from the different original groups and there were no significant differences between treatments ( $p > 0.05$ ; Table 6.1).

## DISCUSSION

Part 1

The results suggest that the food intake of the pigs was influenced by the distance between any two pigs in adjacent pens. Whether this finding was caused by reduced social stimulation between pigs due to distance, or by solitary inhibition, is not certain.

Part 2

The lack of significant differences between treatments in the food intake of these pigs may be due to (1) These unacquainted pigs disturbed each other, rather than stimulating each other to eat more, in the first few days, but later any positive effect may have been disturbed by the following factor. (2) When the distance between any two pigs was increased, then the feeding behaviour may have been influenced by both less social stimulation and by solitary inhibition. The factors causing this lack of significance in the differences between treatments are probably very complex.

TABLE 6.1 The effect of distance between two pigs on the food intake of the pigs

Treatment <sup>φ</sup>	1	2	3	se of difference	level of significance
Part 1					
Food intake (kg/pig)	1.852	1.874	1.693	0.048	***
Part 2					
Food intake (kg/pig)	1.843	1.878	1.890	0.067	NS

\*\*\* -  $p < 0.01$

<sup>φ</sup> - see text for details

FIGURE 6-1

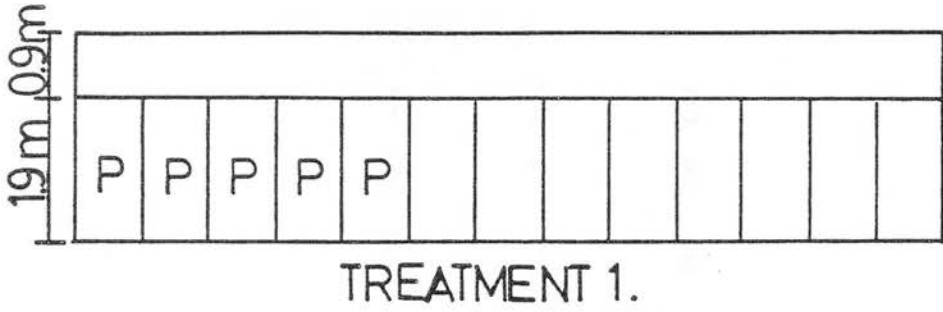


FIGURE 6-2

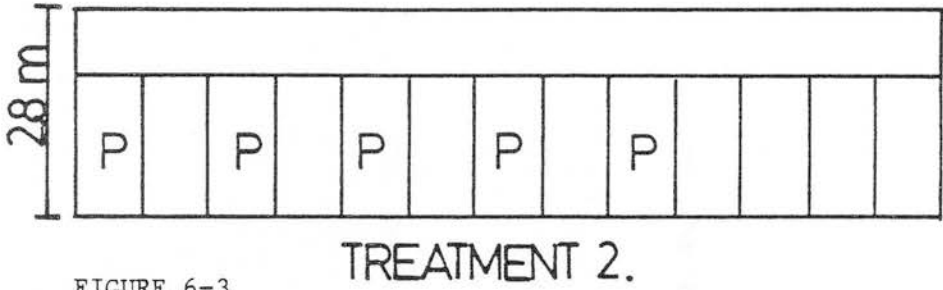
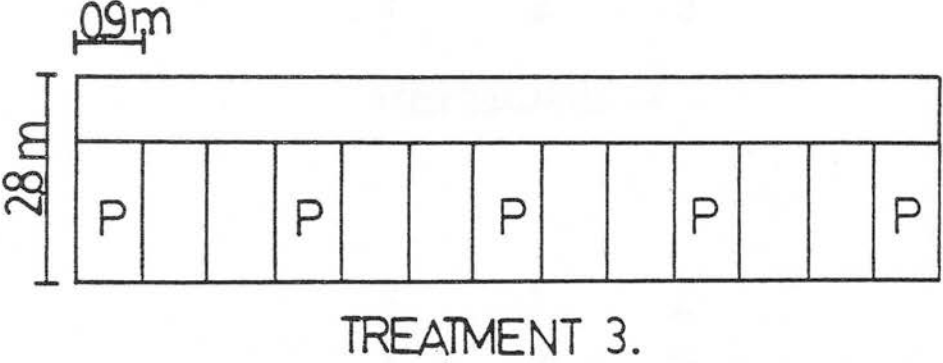


FIGURE 6-3



P=PIG

Plan of room arrangement of the 3 treatments  
in Chapter 6

FIGURE 6-4

1	2	3
2	3	1
3	1	2

REPLICATE 1

2	3	1
3	1	2
1	2	3

REPLICATE 2

3	1	2
1	2	3
2	3	1

REPLICATE 3

The 3 x 3 Latin square design of the experiment in Chapter 6. The figures represent the treatment.

CHAPTER 7 THE EFFECT OF MIXING PIGS WITH STRANGE PIGS ON THE  
FEEDING BEHAVIOUR OF THE PIGS

INTRODUCTION

The interaction between fighting and feeding of a newly-formed group of pigs was studied. As reported in Chapter 3, competition seems to play some rôle in positive social facilitation of feeding behaviour of pigs. This experiment was designed to investigate whether serious fighting would result in negative social facilitation of feeding behaviour.

MATERIALS AND METHODS

Animals

A total of fifteen castrated males were used in this experiment. All of the three pairs of pigs in Treatment 1 came from different groups. In Treatment 2 there were three pigs in each group, also from different origins.

Treatment and Procedure

Treatment 1

Three pairs of pigs were kept in different rooms for the first fifteen days. The first five days allowed the pigs to settle in. From the sixth day (first day for records) onward food intake and body weights were recorded. The dominant pig from each pair was placed in one room to form a new group on the sixteenth day and the inferior pigs, from each pair, were mixed together in another room to form a new group on the thirteenth day. Observations were carried out on alternate days for

each new group. The observations commenced on the thirteenth day for the dominant group and on the fourteenth day for the group of inferior pigs.

#### Treatment 2

After five days settling in, the food intake and body weights were recorded. The three temporary groups were formed of (1) all dominant pigs, (2) second ranking pigs, and (3) third ranking pigs from the original three groups. The pigs were returned to their original groups at the end day 12, day 22 and day 32 (Figure 7-1). The aggressive behaviour was observed in group 1 one day before the temporary group formed and also in the dominant pig group on the day the temporary group was formed. An eight hour feeding régime was used in all treatments and in the settling in periods. The food was provided at 7.00 am and withdrawn at 3.00 pm. The light régime was fifteen hours dark and nine hours of light, starting at 6.00 am and ending at 3.00 pm. Food was provided *ad libitum* during the observation period. The pigs were weighed every morning between 6.00 am and 7.00 am and regrouped at 7.00 am. Fresh water was available at all times. The rooms were cleaned by shovel between 6.00 am and 7.00 am.

#### Behavioural observations

The observations were itemized in the same way as in Chapter 4 for feeding and aggressive behaviour.

### Housing and Management

The pigs occupied half the room (Figure 7-2). Long troughs were used in this experiment so that either two or three feeding spaces were provided depending on whether the group contained two or three pigs. Each feeding space was 30 cm, which was long enough for pigs to use freely. Room temperature was kept between 19°C - 21°C.

### RESULTS

The results in Figure 7-3a and b are the average food intake in Treatments 1 and 2 respectively. The results demonstrate that the food intake was seriously decreased during the day when a group of three unfamiliar pigs were mixed together.

The interesting thing in Treatment 1 was that the food intake increased to a quite high level during the second or third day after the mixing of the pigs, and then dropped down on the fourth day, returning to a normal level thereafter.

The food intake of the pigs dropped sharply during the day of mixing on the first and second occasions but not on the third occasion in Treatment 2. The pigs were returned to their original groups after mixing with the strange pigs for eight hours. However it seems that the food intake did not return to the normal level during the first two days after the first occasion of mixing, but returned to the normal level during the first day after the second and third occasions of mixing in Treatment 2.

Table 7.1 shows the food intake and body weights of the pigs in the groups of the different ranks during the three occasions of mixing. The results indicate that the food intake of the top rank

group was higher than that of the second ranked group and that the second ranked group also had a higher food intake than the third ranked group.

Figures 7-4a and b show the result of serious fighting (butting and biting) and moderate fighting (thrusting, knocking, intention knocking and jostling) respectively, in the two newly formed groups in Treatment 1 after mixing. These results indicate that the fighting which happened on the first day was serious. Later it decreased and moderate fighting increased for a short period, then decreased.

Figure 7-5 shows the aggression in the well-formed group in Treatment 2 during the test period. The figure demonstrates that aggression was fairly constant during all the three measurements.

Figure 7-6 shows the aggression in the group of dominant pigs during the three days of mixing. The results show that although the serious fighting decreased, moderate fighting did not increase.

In the well-formed group, serious fighting usually only lasted for a few seconds and rarely for more than ten seconds. However, in a newly formed group, serious fighting in most cases lasted quite long, one pair even fought for three minutes.

## DISCUSSION

This experiment really needs more than one observer, or a video recorder, to observe the pigs in the different groups at the same time. The present results were obtained by only one person so that the results only can provide a general picture without great detail.

The results show that the aggression of the pigs during the first day of mixing with strange pigs did have a very big influence

on the food intake of pigs under the eight hour feeding régime.

Fraser (1979) suggested that when a group of pigs unknown to each other are mixed, aggression initially is the dominant behaviour, but aggression soon becomes increasingly inhibited and, as it does, so social order results. As aggression is waning, feeding is waxing.

Although the basic principle of his suggestion is quite right, the present results also suggest that when food intake was cut down too much by the aggression during the first day, then the feeding drive may reach a very high level and become the dominant drive. In this situation the pigs may try to feed more than usual. This kind of overfeeding then caused the pigs to eat less on the next day.

These results suggest that while the aggression may wane gradually, feeding is not waxing gradually after the formation of a new group of pigs, ie when the drives reach a certain level it may overcome the pig's fear, although aggression has not waned entirely.

The first interesting point which arises from Treatment 2 is why the food intake did not return to the normal level after one day in the mixed condition after the first episode of mixing. This finding did not happen in the second occasion of mixing.

It is not clear whether this kind of mixing had some detrimental influence on the food intake of the pigs on the next day, through a psychological effect, and further study on this finding is needed.

The second interesting point which arose from Treatment 2 is that the social order cannot reach stable form in a period of eight hours even with only three pigs. However it seems that the pigs

did not forget the experience, because they fought less on the second occasion of mixing than on the first occasion. On the third occasion, when they were mixed, although the number of serious fights decreased further and their food intake did not show a serious drop, the relationship between the three pigs was still not stable.

The third interesting point is that the dominant pigs as a group in Treatment 2 always had a higher food intake than the group of second ranked pigs which, in turn, had a higher food intake than the group of third ranked pigs in all three episodes of mixing. It seems to be not simply due to body weight differences because the difference in body weight was not big between the three temporary groups of different ranking pigs. Whether these results are simply due to chance or due to the method used to determine the social order in the present experiment is not clear. The social order described here was based on which pig was first dominant at the trough and this method may result in the dominant pig having the high feeding motivation. If this is the case, then the above result, in which the group of dominant pigs ate more than the others, was simply because all the three dominant pigs had a higher feeding motivation than the other two groups.

TABLE 7.1 The relationship between food intake and the pigs in temporary groups of the different ranks during three occasions of mixing in the treatment

Social rank of the group	Dominant		Second		Third	
	Twt	FI	Twt	FI	Twt	FI
First occasion of mixing*	120.4	6.200	121.5	5.715	120.9	5.055
Second occasion of mixing*	151.2	7.461	150.0	6.400	146.0	6.285
Third occasion of mixing*	183.1	8.810	177.5	8.709	174.9	8.440

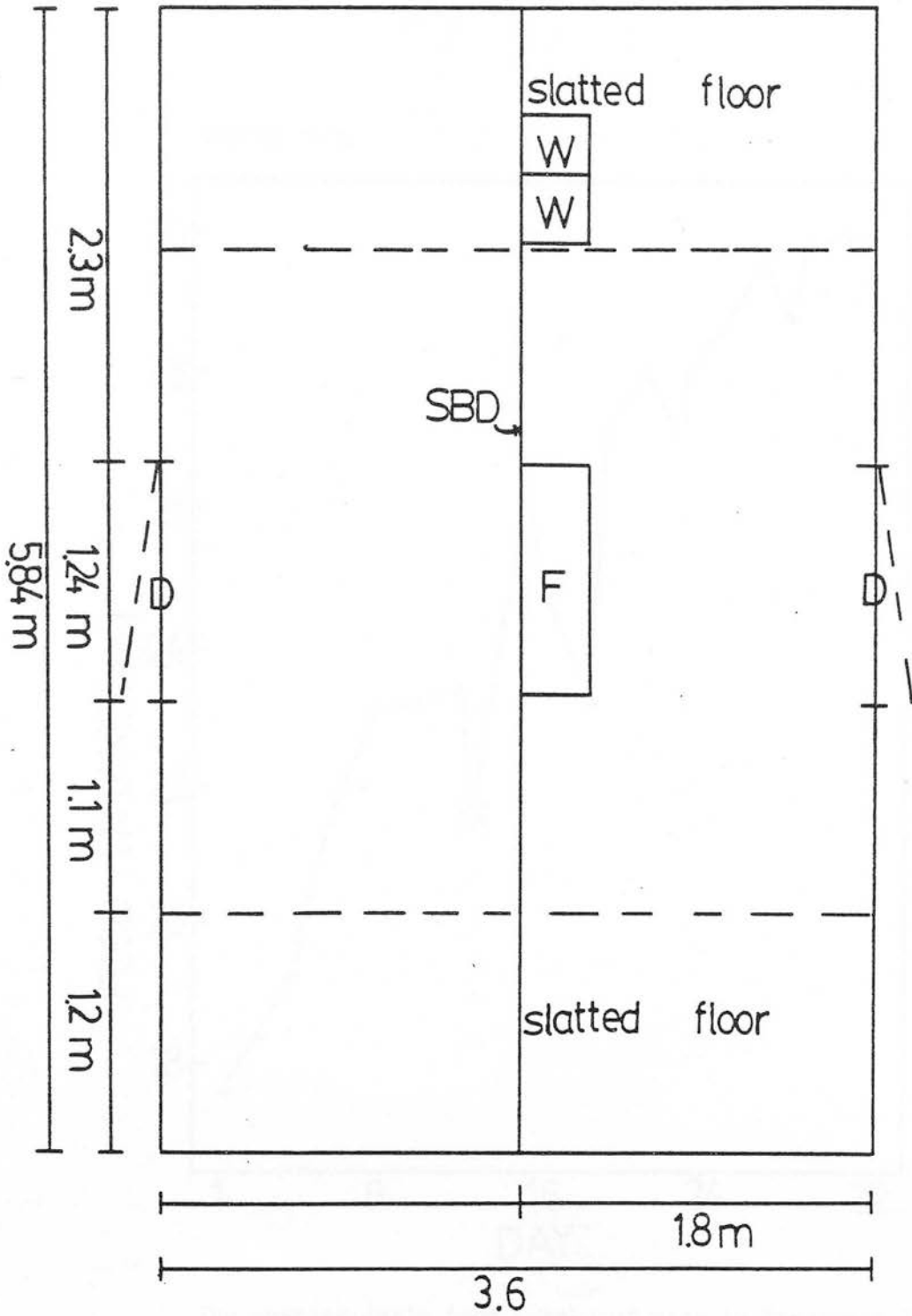
Twt - total body weight of three pigs (kg)

FI - food intake of three pigs (kg)

\* - see text for details



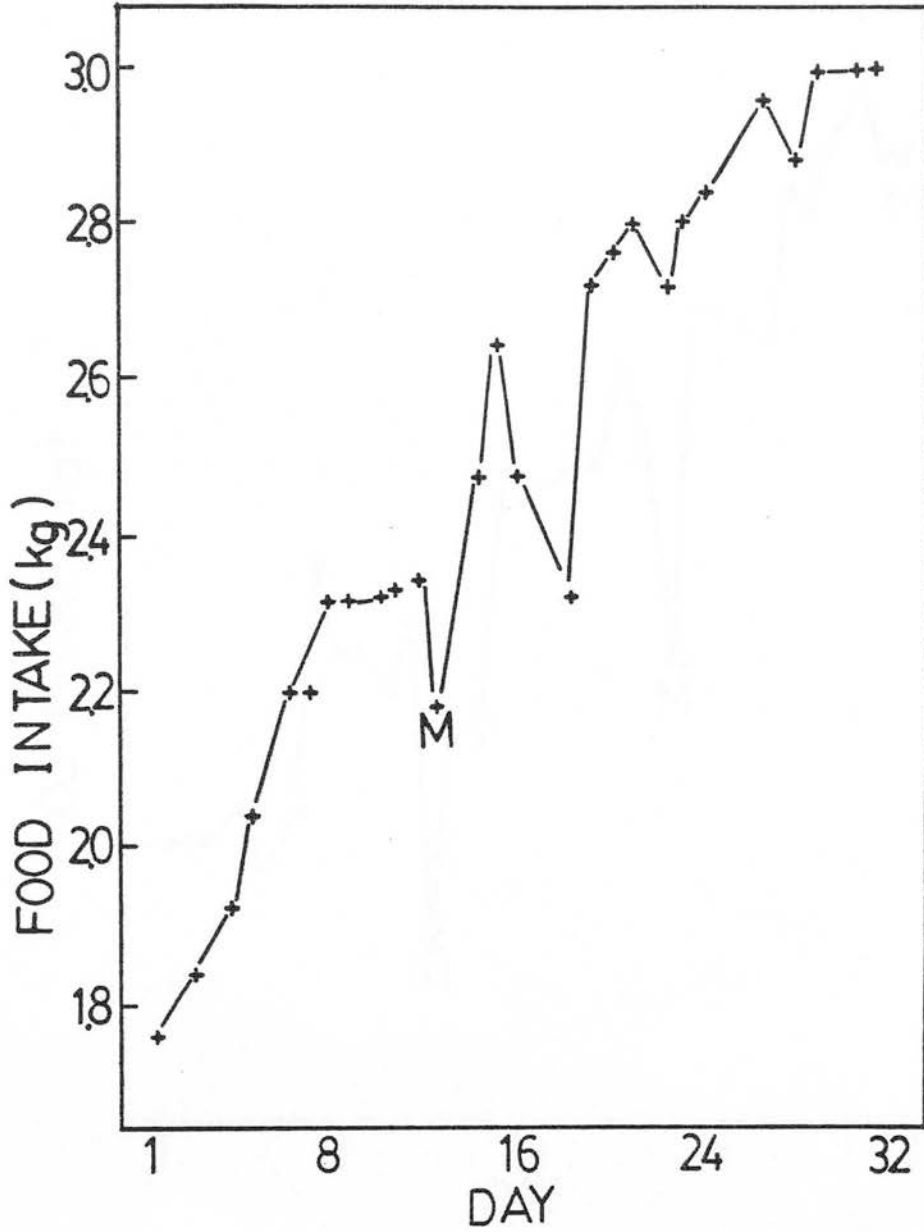
FIGURE 7-2



Plan of room arrangement in Chapter 7

D - door; F - food trough;  
 SBD - steel bar division; W - water trough

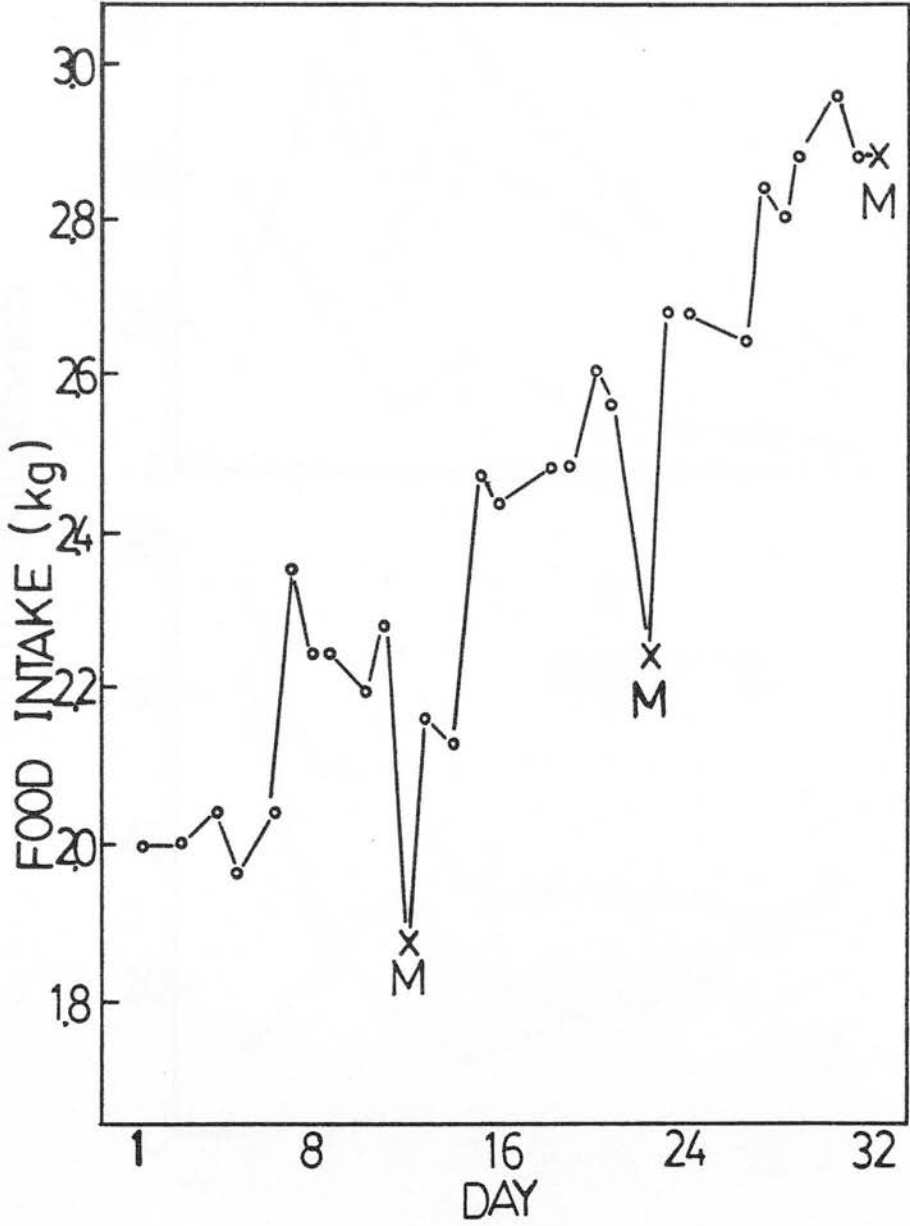
FIGURE 7-3a



The average daily food intake of pigs in Treatment 1 after the start of the experiment

M - The day after the mixing of the pigs

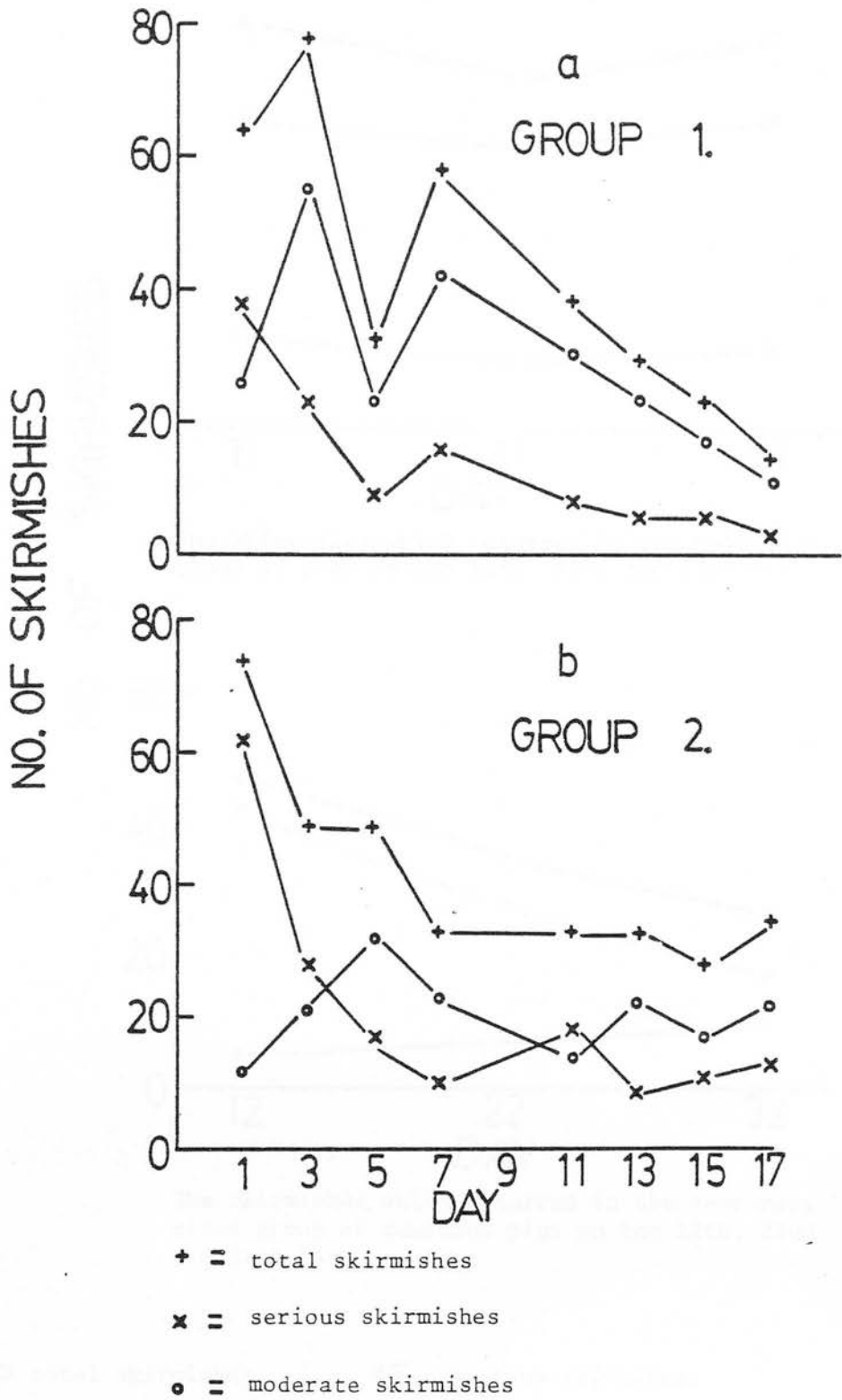
FIGURE 7-3b



The average daily food intake of pigs in Treatment 2 after the start of the experiment

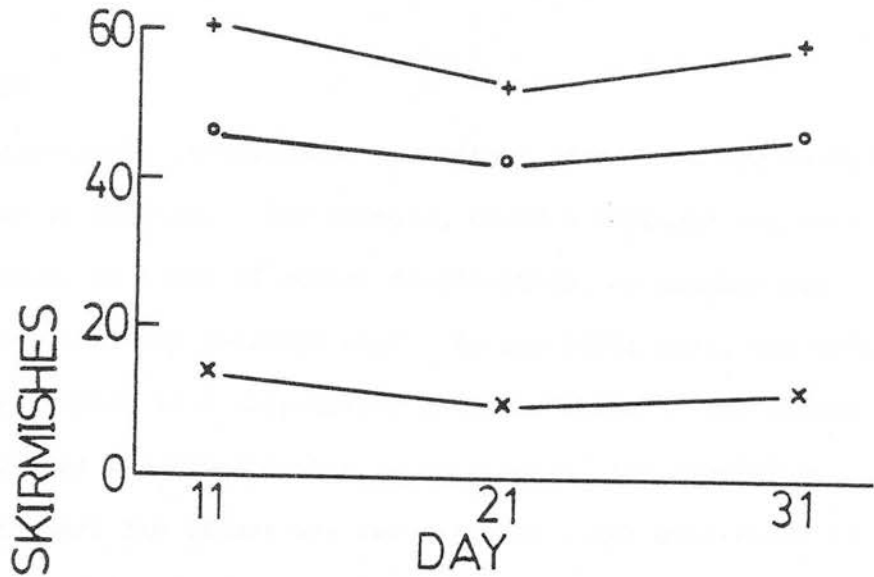
M - The day after the mixing of the pigs

FIGURES 7-4a and 7-4b

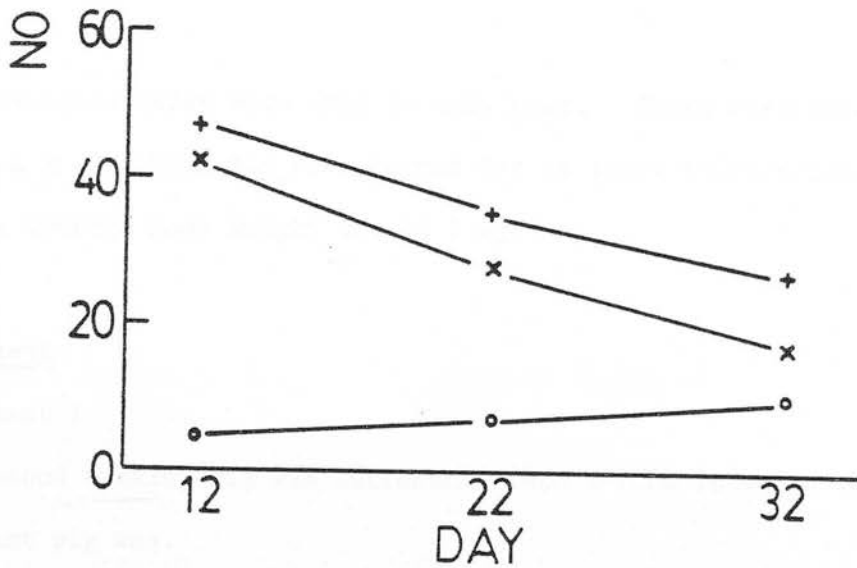


The skirmishes which occurred in both group 7-4a and group 7-4b in Treatment 1 after mixing of the pigs

FIGURES 7-5 and 7-6



The skirmishes which occurred in the well-formed group of pigs on the 11th, 21st and 31st day



The skirmishes which occurred in the temporary mixed group of dominant pigs on the 12th, 22nd and 32nd day

+ = total skirmishes                      x = serious skirmishes

o = moderate skirmishes

CHAPTER 8 THE EFFECT OF SOCIAL ORDER ON THE FEEDING BEHAVIOUR  
OF PIGS

INTRODUCTION

This experiment investigates the effect of rank on the social facilitation of feeding. For example, would a dominant pig have a greater effect, in terms of social facilitation, on another pig compared to a socially inferior pig? In the first part, the effect of rank was studied in a competitive context, while in the second part this effect was investigated in non-competitive conditions. In the third part the effect was investigated under conditions in which any effect due to previous isolation was excluded.

MATERIALS AND METHODS

Part 1

Animals

Six castrated males were used in this part. There were three pigs in each group which had been formed for at least thirty-five days. The average body weight was 62.3 kg.

Treatment

Treatment 1

The second ranking pig was introduced into a room in which the dominant pig was.

Treatment 2

The third ranking pig was introduced into a room in which the dominant pig was.

Treatment 3

The dominant pig was introduced into a room in which the second

ranking pig was.

Treatment 4

The third ranking pig was introduced into a room in which the second ranking pig was.

Treatment 5

The dominant pig was introduced into a room in which the third ranking pig was.

Treatment 6

The second ranking pig was introduced into a room in which the third ranking pig was.

The social order was decided in the following way. The pigs were deprived of food for twelve hours and food was then provided in a feeding trough with one space. The pig which dominated the trough was recorded as the dominant pig and was then removed; the next animal which dominated the trough was then recorded as the second ranking pig and so on.

Procedure

The test progressed according to the 6 x 6 Latin square design. Each group of pigs went through on this Latin square design in eighteen days (Figure 8-1).

There was a twelve hour period between the end of one test and the start of the next test. When a test started one of the test pigs stayed in its original pen (Figure 8-2) and the other two pigs were moved to a resting room. The food was provided for the remaining pig *ad libitum*. After ten minutes the remaining pig usually stopped eating and the hungry pig was then introduced into

the same pen. The food consumed by the remaining pig was then measured. Plenty of food was put into the trough before the arrival of the second pig. The total feeding times of both the remaining and the introduced pig were recorded during the first ten minutes after the arrival of the introduced pig.

## Part 2

### Animals

Six castrated males were used in the trial. The average initial body weight was 62.3 kg.

### Treatment

All six treatments in part 2 were the same as in part 1. The only difference was in the use of stalls to prevent competition (Figure 8-3). The introduced pig was placed in the adjacent stall instead of in the same pen. Each group of pigs went through the 6 x 6 Latin square design shown in Figure 8-4.

### Procedure

The procedure, which differed from part 1, was to record the total food consumption by individual pigs during the first ten minutes after the introduction of the second pig. The total food consumption was also recorded for both the remaining and the introduced pigs from the time of the introduction of the second pig until it stopped feeding.

## Part 3

### Animals

All the animals from part 1, and one group from part 2 were

used, giving a total of nine castrated males for this trial.

### Procedure

The procedure and measurements were the same as in part 2. The differences between part 2 and part 3 were as follows.

(1) Two pigs remained in part 3. (2) Each group of three pigs went through a row of a 3 x 3 Latin square (Figure 8-5), in which three treatments were involved.

As in the previous treatment, the pigs were put into individual stalls which were placed as shown in Figure 8-6. The introduced pig was always put into the apical stall.

### Treatment

#### Treatment 1

The second (No 2) and third (No 3) placed pigs in the hierarchy remained in two stalls and the hungry dominant animal (No 1) was introduced into the third (apical) stall once pigs No 2 and No 3 were satiated.

#### Treatment 2

The dominant and third placed animals remained and the hungry second ranking pig was introduced once No 1 and No 3 were satiated.

#### Treatment 3

The dominant and second ranking pigs remained while the hungry, third ranking pig, was introduced when No 1 and No 2 were satiated.

## Statistical Model

$$\text{Model 8-1: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

$$\text{Model 8-2: } Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + e_{ijk}$$

In which  $Y$  = independent variable

$\mu$  = grand mean

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

$e$  = error

## RESULTS

Part 1 and Part 2

The results of part 1 and part 2 were analysed by Model 8-1. There were significant differences ( $p < 0.05$ ) between treatments in the food intake of the pigs that remained, although they had consumed a lot before the hungry pig was introduced into the pen. The dominant pigs ate significantly more than the inferior pigs (Table 8.1). However the differences in food intake between the dominant and the second ranked pigs were not significant ( $p > 0.05$ ).

When the dominant pig was the satiated remaining pig it had a significantly greater ( $p < 0.001$ ) total feeding time within ten minutes of the introduction of a hungry second or third ranked pig in both part 1 and part 2 of the experiment (Table 8.1). However

the total food consumption of the introduced pigs during the first ten minutes of feeding did not differ significantly between treatments (Table 8.1).

In part 1 of the experiment the total food consumption of the remaining dominant pigs, during the period from the arrival of the hungry pigs until both pigs stopped feeding, was significantly higher ( $p < 0.05$ ) than those cases in which the remaining pig was the second or third ranked pig (Table 8.1).

### Part 3

The results of part 3 were analysed by Model 8-2. There were no significant differences between treatments, but all the two remaining pigs both started to eat when the hungry pig was introduced into the room (Table 8.2).

## DISCUSSION

### Part 1 and Part 2

The present results show that both in a competitive (part 1) and a non-competitive situation (part 2), the remaining animal, if dominant, reacted more strongly than the remaining second or third ranked pigs when the hungry pig was introduced into the room, even if it had previously appeared to be satiated.

These results cannot be explained by their eating less when they were alone in the room, for the dominant pigs, on average, ate more than the third placed pigs in the similar situation. It seems therefore that pigs may react to their social environment differently according to their social rank.

On the other hand, as the social order was decided by

competition over one feeding space, the dominant pigs here may also have been those which had higher feeding tendencies than the other two pigs. When the apparently satiated dominant pig remained, it reacted strongly when a hungry pig was introduced into the pen (part 1), or into the adjacent pen (part 2), and this may also have been due to the high feeding motivation of the dominant pig.

### Part 3

The original design of this part of the experiment was to try to understand whether the remaining satiated pigs would still react to the introduction of a hungry pig if they had eaten in a social environment of two remaining pigs before the cessation of feeding.

The present results demonstrate that the remaining, apparently satiated pigs, react to hungry pigs, not purely because of the cessation of solitary inhibition caused by the return of another pig.

The results therefore strongly suggest that the reaction of these pigs to the return of a hungry pig is caused by social stimulation.

The effects of rank on social facilitation are not easy to interpret in the last part of this experiment, because although the remaining satiated pigs may have been stimulated by the return of the hungry pig, they may also have stimulated one another.

TABLE 8.1 The effect of the treatments on food intake and feeding time of the pigs

Treatment $\phi$	1	2	3	4	5	6	se of difference	Level of significance
(1) The food intake (kg) of remaining pig before the hungry pig was introduced into the pen (result of part 1 + part 2) $\phi$	1.279	1.238	1.151	1.207	0.990	1.005	0.110	*
(2) Total feeding time (seconds) of remaining pig within ten minutes after introducing a hungry pig	143.4	119.5	2.0	34.8	4.4	1.3	23.1	***
Part 1 $\phi$	350	365	148	115	240	242	47.5	***
Part 2 $\phi$	655	620	627	579	622	645	33.6	NS
(3) Total food consumption (kg) of introduced pigs within first ten minutes	0.864	0.946	0.546	0.553	0.968	0.635	0.129	**
(4) Total food consumption (kg) of remaining pig during the period from the arrival of the hungry pig until both pigs stopped feeding								

\*\*\* -  $p < 0.005$ , \*\* -  $p < 0.01$ , \* -  $p < 0.05$

$\phi$  - see text for details

TABLE 8.2 The effect of the treatments on the feeding times of the remaining pigs within ten minutes after introducing a hungry pig in part 3

Treatment <sup>φ</sup>	1	2	3	se of difference	Level of significance
	211	234	249	19.3	NS

<sup>φ</sup> - see text for details

Unit - seconds

FIGURE 8-1

B	A	D	F	F	C
F	C	E	B	D	A
C	D	B	A	F	E
D	F	A	E	C	B
A	E	F	C	B	D
E	B	C	D	A	F

REPLICATE 1.

D	C	F	B	A	E
B	E	A	D	F	C
E	F	D	C	B	A
F	B	C	A	E	D
C	A	B	E	D	F
A	D	E	F	C	B

REPLICATE 2.

	A=T1	B=T2	C=T3	D=T4	E=T5	F=T6			
social order →	1	2	1	3	2	1	2	3	3
	1	2	1	3	2	1	2	3	3
	S	H	S	H	S	H	S	H	S

T=TREATMENT    S= Satiated pig or remaining pig  
H= Hungry pig or introduced pig

The 6 x 6 Latin square design  
in part 1 of Chapter 8

FIGURE 8-2

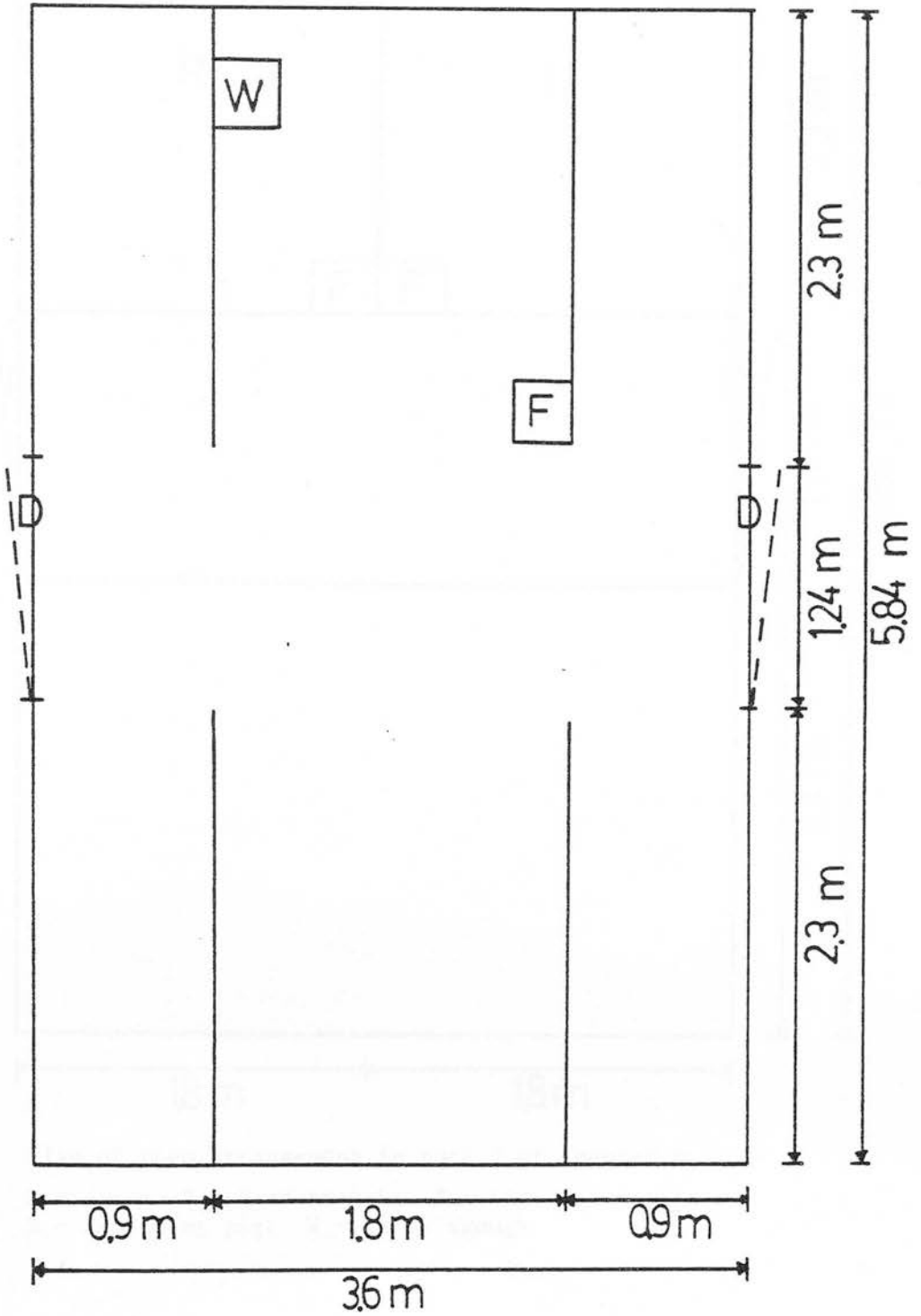
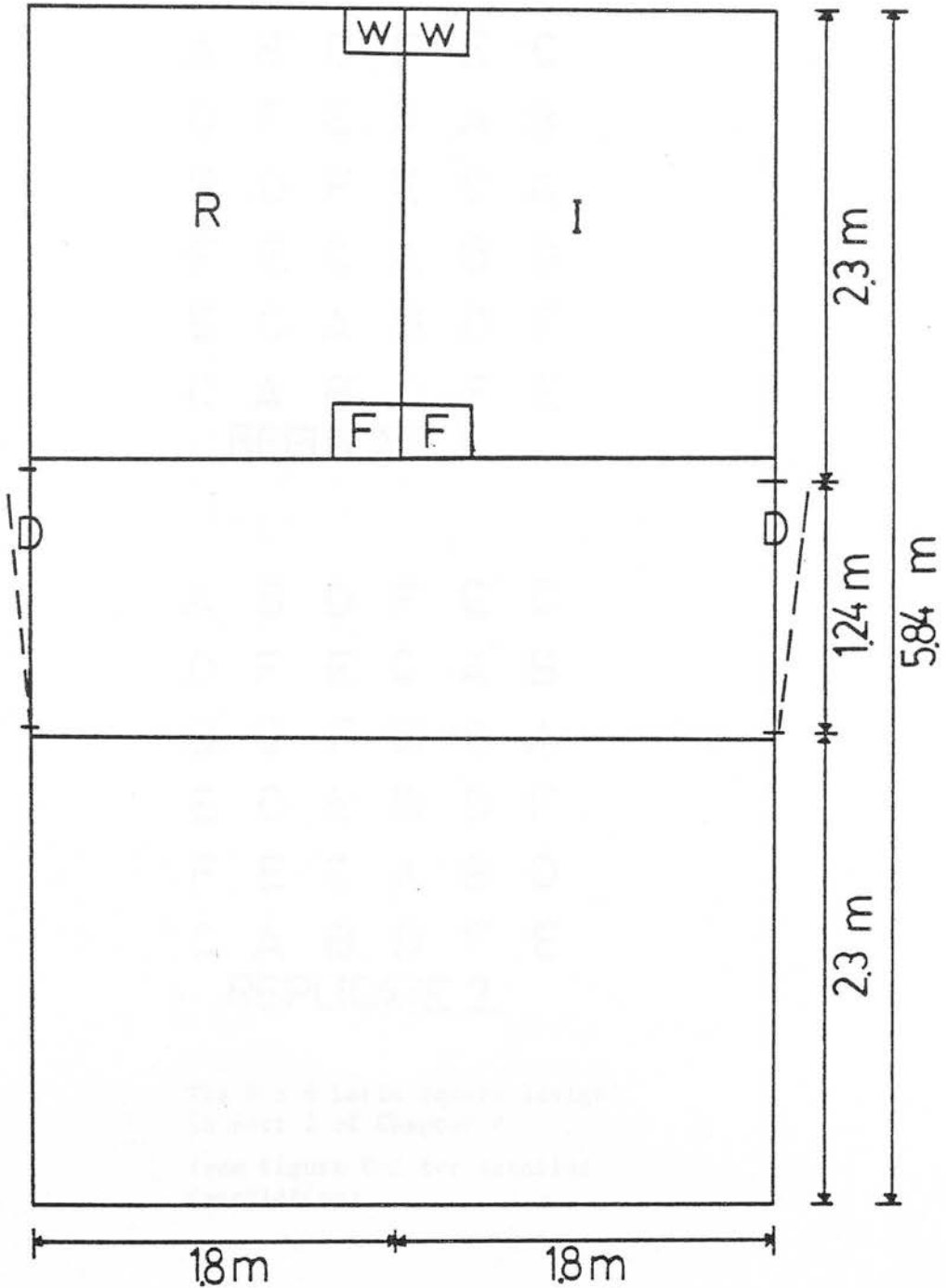


FIGURE 8-3



Plan of room arrangement in part 2 of Chapter 8

D - door; F - feed trough; I - introduced pig;  
R - remaining pig; W - water trough

FIGURE 8-4

A	B	D	F	E	C
D	F	E	C	A	B
B	D	F	E	C	A
F	E	C	A	B	D
E	C	A	B	D	F
C	A	B	D	F	E

REPLICATE 1.

A	B	D	F	E	C
D	F	E	C	A	B
B	D	F	E	C	A
E	C	A	B	D	F
F	E	C	A	B	D
C	A	B	D	F	E

REPLICATE 2.

The 6 x 6 Latin square design  
in part 2 of Chapter 8

(see Figure 8-1 for detailed  
description)

FIGURE 8-5

GROUP 1.	1S	2S	2S	3S	1S	3S
		3H		1H		2H

GROUP 2.	2S	3S	1S	3S	2S	1S
		1H		2H		3H

GROUP 3.	1S	3S	1S	2S	2S	3S
		2H		3H		1H

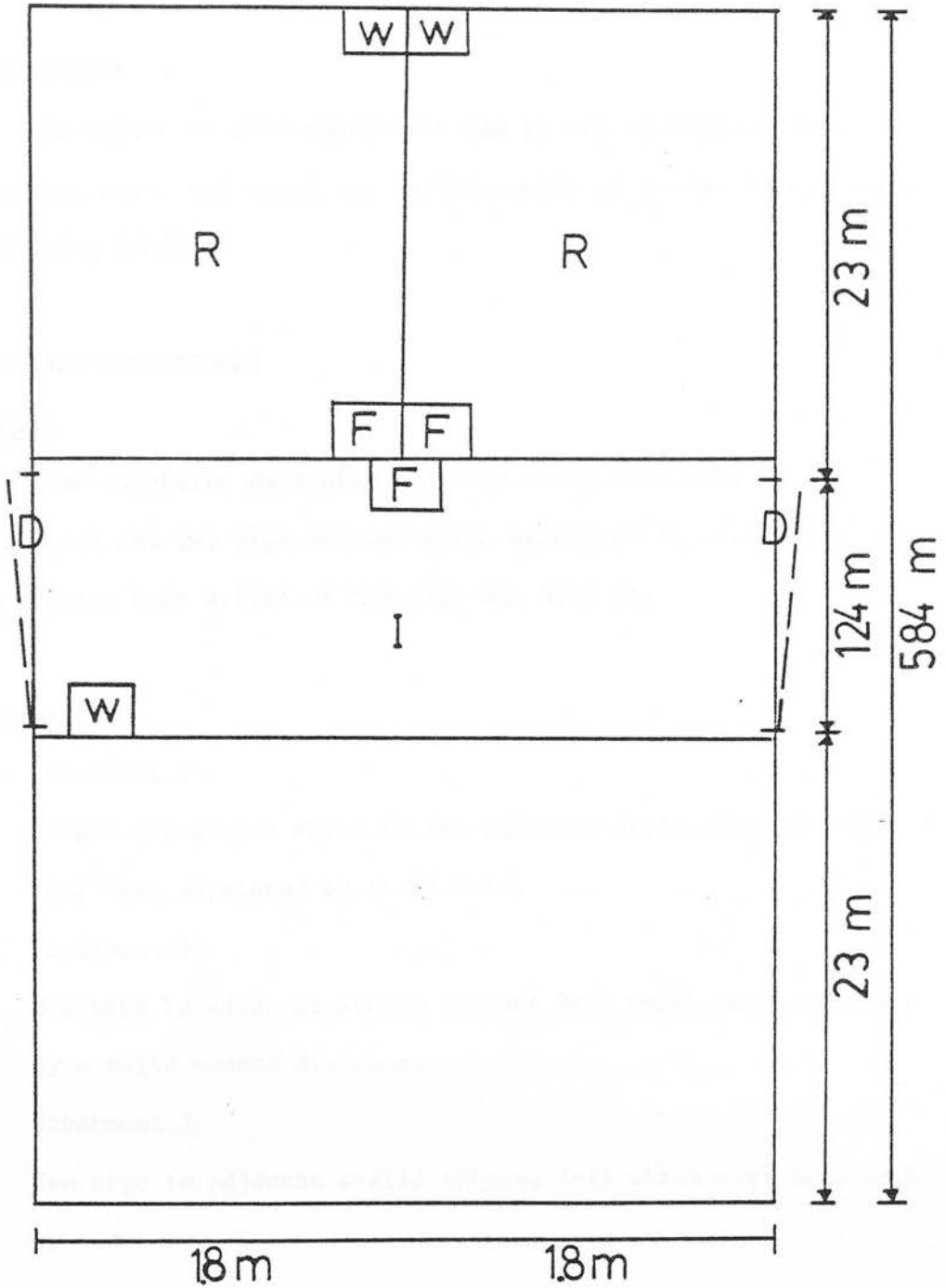
SOCIAL ORDER= 1, 2, 3.

S= remaining pig

H= introduced pig

The 3 x 3 Latin square design in part 3  
of Chapter 8

FIGURE 8-6



Plan of room arrangement in part 3 of Chapter 8

D - door; F - food trough; I - introduced pig;  
R - remaining pig; W - water trough

CHAPTER 9 OBSERVATIONS ON THE EFFECT OF SENSE ORGANS ON THE FOOD  
INTAKE OF PIGS

INTRODUCTION

The object of this experiment was to try to find out how important sight and sound are in the course of social facilitation of feeding in pigs.

MATERIALS AND METHODS

Animals

Four castrated male pigs and four sheep were used in the experiment and two pigs and two sheep were used in each replicate. The average body weight of the pigs was 59.8 kg.

Treatments

Treatment 1

Single pig with a sheep in the adjacent stall (Figure 9-1).

They were separated by steel bars.

Treatment 2

Two pigs in adjacent stalls (Figure 9-1) which were separated by a solid wooden division.

Treatment 3

Two pigs in adjacent stalls (Figure 9-1) which were separated by steel bars.

Treatment 4

Two pigs in adjacent stalls (Figure 9-1) which were separated by steel bars. However both ears of the pigs were filled with cotton wool and the ears were wrapped with sellotape.

### Procedure

Two pigs in each replicate were put through a 4 x 4 Latin square design (Figure 9-2) in which the four treatments were involved in each row. The pigs were weighed between 7.30 am and 8.00 am and, after weighing, the pigs were put into the stalls according to the treatment on that particular day.

Weighed food was provided at 8.00 am and withdrawn at 4.00 pm when the residual food was weighed. No food was provided during the other sixteen hours of the day but water was available at all times.

The pigs were allowed to go through all four treatments twice before the experiment was started. The cotton wool was placed in the ears of the pigs, in Treatment 4, sixteen hours before the test started.

### RESULTS

There were significant differences between treatments ( $p < 0.01$ ). The pigs in Treatment 4 had significantly lower food intakes than the other treatments ( $p < 0.05$ ).

The pigs in Treatment 1 had significantly lower food intakes ( $p < 0.05$ ) than the pigs in Treatment 3, but there were no significant differences ( $p > 0.05$ ) between Treatments 1 and 2 and between Treatments 2 and 3, although the average food intake in Treatment 2 was lower than Treatment 3 (Table 9.1).

### DISCUSSION

Whether the lowest food intake in Treatment 4 was due to the discomfort from the cotton wool in the ears, or due to the

treatment, is very difficult to assess.

The pigs in single pig with sheep treatment ate less than the pigs ate with another pig in the adjacent stall. This result agrees with the results in Chapter 4. Although the solid division between two pigs may have had some effect, it did not seem to be big. Pigs use several senses in their social behaviour.

Meese, Connor and Baldwin (1975) reported that olfaction is important for pigs to identify each other.

Pond and Houpt (1978) suggest that auditory signals appear to be one of the most important factors in communication between pigs.

Ewbank, Meese and Cox (1974) suggested that sight alone is not necessary for hierarchy maintenance.

However which sense organs play the most important rôle in social facilitation is still not clear from the present results. It needs further study in the future.

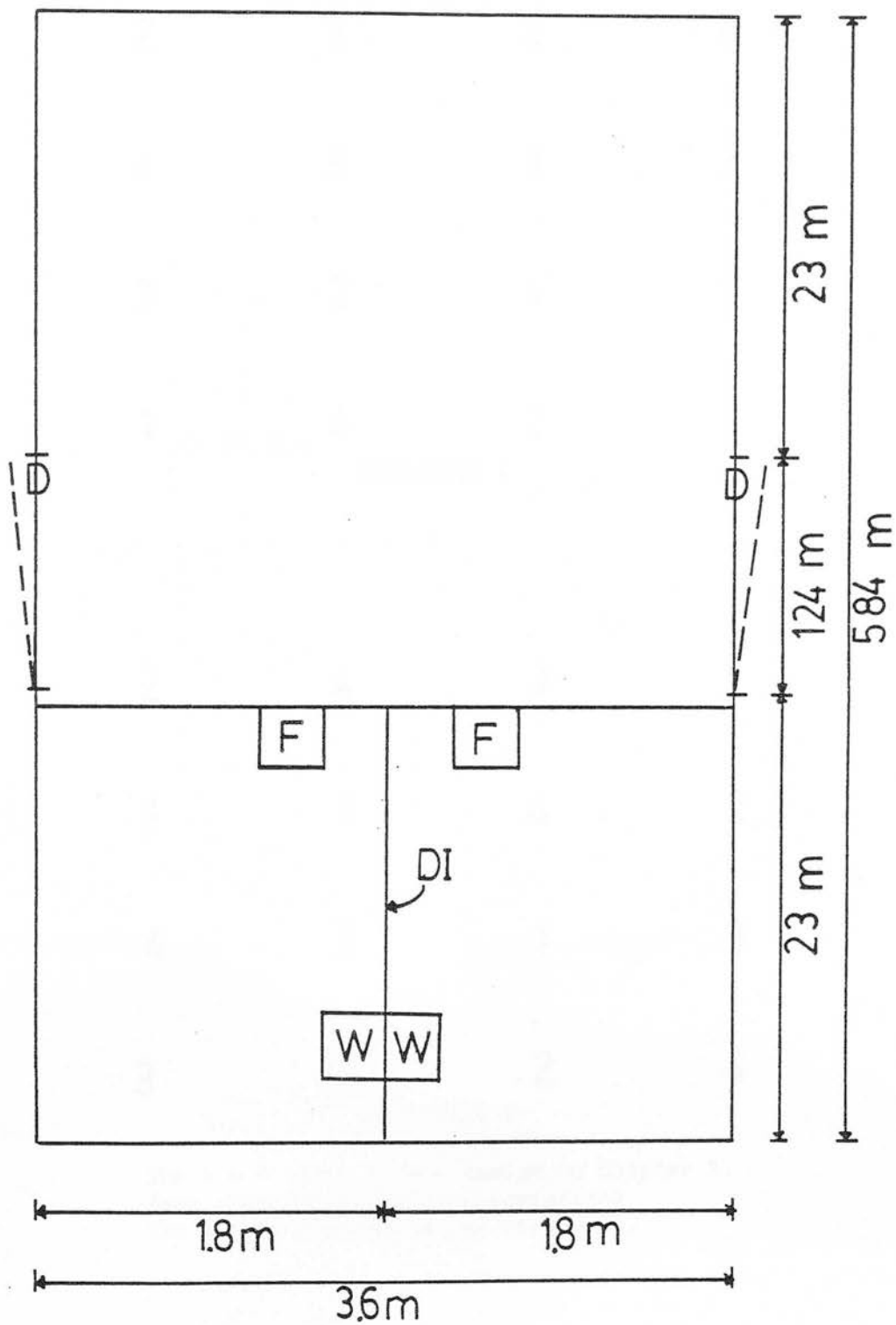
TABLE 9.1 The effect of treatment on food intake of pigs

Treatment <sup>φ</sup>	1	2	3	4	se of dif- ference	Level of signifi- cance
Food intake (kg/pig)	2.945	3.004	3.168	2.715	0.109	**

<sup>φ</sup> See text for details

\*\* -  $p < 0.01$

FIGURE 9-1



Plan of room arrangement in Chapter 9

DI - divisions; D - door; F - feed trough;  
W - water trough

FIGURE 9-2

2	1	3	4
4	3	1	2
3	2	4	1
1	4	2	3

REPLICATE 1

2	4	3	1
1	3	4	2
4	2	1	3
3	1	2	4

REPLICATE 2

The 4 x 4 Latin square design in Chapter 9.  
 (see text for detailed description)  
 The figure represents the treatment.

CHAPTER 10 THE EFFECT OF THE PHYSICAL CHARACTERISTICS OF THE FOOD  
AND THE GROUP SIZE OF THE PIGS ON THE FEEDING  
BEHAVIOUR OF THE PIGS

### INTRODUCTION

The purpose of this chapter was to compare the feeding behaviour of pigs in groups of medium and small sizes and in individual stalls. This would allow one to measure the influence of increased group size on feeding behaviour.

Another object of this chapter was to investigate whether the physical characteristic of food would cause any change in the feeding behaviour of the pigs in any of the environments mentioned above.

### MATERIALS AND METHODS

#### Animals

A total of eight pigs were used in this part, of which four were castrated males and four were females. The average initial body weight was 27.9 kg.

#### Treatments

Six treatments were involved.

## Treatment 1

Pelleted food for a group of eight pigs (P8) (Figure 10-1). The eight pigs were fed together in one room. Two 1.2 m long troughs were provided, each being divided into four eating places by steel bars. The troughs were placed in one line against the wall so that feeding was confined to one side of the trough. The stocking rate was one pig per  $2.628 \text{ m}^2$ . Four water troughs were provided and water was available at all times.

## Treatment 2

Pelleted food for two groups of four pigs (P4) (Figure 10-2). The room was divided into two equal parts by steel bars to house the two groups. Four pigs, two castrated males and two females, were kept on each side. One 1.2 m long trough was provided for each side of the pen. The two troughs were placed against the middle division facing each other, so that feeding on each side was confined to one side of the trough. The stocking rate was one pig per  $2.628 \text{ m}^2$  and two water troughs were provided on each side and water was available at all times.

## Treatment 3

Pelleted food for eight pigs in individual stalls within one room (P1) (Figure 10-3). The eight pigs were fed in eight individual stalls in one room. Each stall had its own feeding and water trough. The stalls were separated by steel bar divisions and water was available at all times.

## Treatment 4

Meal for a group of eight pigs (M8) (Figure 10-1). The

arrangement was the same as Treatment 1. The only difference was that meal was provided instead of pellets.

#### Treatment 5

Meal for two groups of four pigs within one room (M4) (Figure 10-2). The arrangement was the same as in Treatment 2. The only difference was that meal was provided.

#### Treatment 6

Meal was provided for eight pigs in individual stalls within one room (M1) (Figure 10-3). The arrangement was the same as in Treatment 3.

The pelleted food was described in the General Material and Methods. The composition of meal used in Treatments 4, 5 and 6 was the same as the pelleted food, except that no binding agent was added to the meal.

#### Husbandry

Light was provided for 8.5 hours per day from 5.30 am to 2.00 pm and eight hour periods of observation were made each day from 6.00 am to 2.00 pm.

The food was provided once at 6.00 am in all treatments. In all treatments spilt food was collected and weighed along with the residual food at the end of the eight hour observation period. No food was provided for the remaining sixteen hours, but water was constantly available. Room temperature was always kept around 19°C - 21°C. The faeces were shovelled out every morning.

Procedure

The observations on the six treatments were carried out in the same room. During the six day settling in period, the pigs were put through the six treatments once. Then the eight pigs were put through a 6 x 6 Latin square design (Figure 10-4). Individual pigs were identified by numbers clearly painted on their backs. They were weighed between 5.30 am and 6.00 am every day on each of the 36 days of the experiment.

At the end of the eight hour observation, all the pigs remained in the same room as a group. Feeding behaviour and aggressive behaviour were noted. The details of measurements of these two types of behaviour were described in Chapter 4.

All the behaviour was recorded by the same observer who sat in the corner of the room. The duration of each behaviour pattern was measured with a stop watch.

## Statistical Model

$$\text{Model 10-1a: } Y_{ijkl} = \mu + \alpha_i + \beta_j + \tau_k + \phi_l + \psi_{kl} + e_{ijkl}$$

$$\text{Model 10-1b: } Y_{ijkl} = \mu + \alpha_i + \beta_j + \tau_k + \phi_l + \psi_{kl} + rx_{ijkl} + e_{ijkl}$$

$$\text{Model 10-2a: } Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + e_{ijk}$$

$$\text{Model 10-2b: } Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + rx_{ijk} + e_{ijk}$$

In which

- Y = independent variable
- $\mu$  = grand mean
- $\alpha$  = row
- $\beta$  = column
- $\tau$  = treatment
- $\phi$  = individual pig
- $\psi$  = treatment x individual pig
- r = regression coefficient
- x = body weight
- e = error

## RESULTS

Model 10-1a and Model 10-1b were used to analyse the total feeding time, the length of the first meal, the total number of bouts and total number of bouts in the first meal.

The only difference between Model 10-1a and Model 10-1b is that the results were adjusted for body weight by the regression method in Model 10-1b. Y in both 10-1a and 10-1b represents the total feeding time or total feeding time of first meal or total numbers of feeding bouts or total numbers of feeding bouts in the first meal of each pig in each observation.

Model 10-2a and Model 10-2b were used to analyse the average food intake and average eating speed of four pigs in each observation.

The only difference between Model 10-2a and 10-2b is that the results were adjusted for body weight by the regression method in Model 10-2b. Y in both 10-2a and 10-2b represents the average food intake and average eating speed for the pigs in each treatment.

Total feeding time (Table 10.1)

The results show there were significant differences between treatments ( $p < 0.001$ ). All the pigs in the meal treatments (M8, M4 and M1) had significantly longer ( $p < 0.001$ ) total feeding times than the pigs in the pellet treatments (P8, P4 and P1). There were no significant differences ( $p > 0.05$ ) within either the meal treatments or within the pellet treatments. However, in the pellet treatments, the pigs in the individual stalls (P1) tended to have longer total feeding times than the pigs feeding in groups (P8 and P4).

On the other hand, there is a tendency for the pigs in the meal treatment to feed for longer when in groups than when in individual stalls. The individual variation in total feeding time also reached a very high level of significant difference ( $p < 0.005$ ).

The total feeding time of the first meal (Table 10.1)

The first meal in the present experiment was decided in the following way. It started from the presentation of food in the morning and ended at the start of the first ten minutes interruption of feeding.

The results show that there were significant differences ( $p < 0.01$ ) between treatments. All the pigs in the meal treatment (M8, M4 and M1) had significantly longer total feeding times than the pigs in the pellet treatments (P8, P4 and P1).

There were no significant differences between Treatments P8, P4 and P1, although the pigs tended to eat, on the average, longer in the individually stalled treatment (P1) than in group feeding treatments (P8 and P4). The pigs in the M1 Treatment had significantly shorter ( $p < 0.05$ ) first meals than the pigs in the M4 Treatment.

There were no significant differences between M1 and M8, but the average figure shows that the pigs in the M8 Treatment had longer first meals than pigs in the M1 Treatment. The individual variation between pigs also reached a high level of significance ( $p < 0.01$ ).

Total number of feeding bouts (Table 10.1)

The definition of a bout was as in Chapter 4. There were

significant differences between treatments.

The pigs in the meal treatments (M8, M4 and M1) had a significantly higher total number of feeding bouts than the pigs in the pellet treatment (P8, P4 and P1).

There were no significant differences between Treatments P8, P4 and P1. The number of feeding bouts of the pigs were significantly higher ( $p < 0.05$ ) in M1 and M4 Treatment than in the M8 Treatment. There were no significant differences ( $p > 0.05$ ) between M1 and M4. The individual variations between pigs were also very high ( $p < 0.01$ ).

#### Total number of feeding bouts in the first meal (Table 10.1)

The results showed that there were significant differences between treatments ( $p < 0.01$ ). The pigs in meal treatments (M8, M4 and M1) had a significantly ( $p < 0.01$ ) higher number of feeding bouts in the first meal than did pigs in pellet treatments (P8, P4 and P1).

There were no significant differences between the meal treatments (M8, M4 and M1) or between pellet treatments (P8, P4 and P1) in the number of feeding bouts in the first meal. Individual variation was again significant ( $p < 0.01$ ).

#### Food intake (Table 10.1)

There were no significant differences ( $p > 0.05$ ) between treatments in food intake when analysed by Model 10-2a.

However the differences between treatments become significant ( $p < 0.05$ ) when results were analysed by Model 10-2b which adjusts the data for body weight differences.

The pigs in M8 Treatment had significantly higher food intake than the pigs in Treatment M1, P4 and P1. Also the pigs in M4 Treatment had significantly higher food intakes than the pigs in the pellet treatments.

#### Eating speed (Table 10.1; Figure 10-5)

There were significant differences in the eating speed of pigs in the different treatments ( $p < 0.005$ ). The pigs in meal treatments (M8, M4 and M1) ate significantly more slowly ( $p < 0.005$ ) than the pigs in the pellet treatments (P8, P4 and P1).

In P1 Treatment the pigs ate significantly more slowly ( $p < 0.05$ ) than in P8 Treatment.

The differences in the eating speed of pigs in P1 and P4 did not reach a significant level ( $p < 0.05$ ), although the average eating speed of the pigs was faster in P4 than in P1. Figure 10-6 again shows that eating speed increases with increases in body weight, but when plotted as eating speed per unit of body weight against body weight, then the eating speed per unit of body weight keeps quite constant over the different body weights in all the experiments.

#### Social hierarchy

The social hierarchy of the eight pigs was very difficult to assess on the basis of the method used in Chapter 4. Although the pig No A was clearly dominant over the remaining pigs, these remaining pigs however showed a non-linear, but non-circular rank order.

### Aggression

The pigs in meal food treatment (M8 and M4) had a significantly higher number of skirmishes than in the pellet food treatments (P8 and P4) ( $p < 0.05$ ). However the difference between different group size on skirmishes is not significant ( $p > 0.05$ ).

### DISCUSSION

The most interesting result from this study was that the pigs spent almost twice as much time eating the meal than on eating the same amount of pelleted food.

This result raises three points. First, in the pigs kept in groups there were more skirmishes between the pigs with the meal than between the pigs with pelleted food. This increase in aggression may simply be due to the physical character of the food or due to the fact that the pigs spent more time in eating the meal than the pelleted food. On the other hand, the slow rate of eating the meal might have caused frustration in those pigs and the increase in skirmishes may have been a kind of redirected behaviour.

The second point is whether the pigs have a preference for the meal as they spent such a long time feeding on it. Hunger may have been one of the reasons for this, but not necessarily so, because some reports show pigs can decrease their food intake when they do not like one kind of food (Orr, 1980).

The third point is that meal is difficult for pigs to pick up and thus might cause them to spend most of their time feeding. This might happen anywhere when food is difficult to pick up or to get. All these points need further study.

The present results showed that the differences in food intake

between the competitive treatments and the treatments with pigs in individual stalls were non-significant. This could have been because the pigs received more stimulation from each other in individual stalls with eight pigs present compared with the pigs in Chapter 4 which only numbered four.

The number of skirmishes between the pigs with eight in a group, and the pigs with four to a group, did not differ significantly so that the lack of significant differences in food intake between the pigs in competitive treatments and the pigs in individual stall treatments were not mainly due to an increase or decrease in competition.

Estimated from the purely mathematical point of view, the pigs in P8 and M8 groups should have had more chances to fight than the pigs in P4 and M4 groups respectively. However, as the pigs in the groups of both sizes had the same amount of fights, then from the theoretical point of view it seems that the pigs in P4 and M4 treatments had more fights than the pigs in the large groups.

The results on eating speed agree well with the results in Chapter 4. They are (1) The eating speed is faster in pigs in competitive treatments than in pigs kept in individual stalls. (2) Eating speed increases with increasing body weight. With respect to eating speed, it may suggest that it is more difficult for pigs to pick up a given amount of meal than the same amount of pelleted food by mouth.

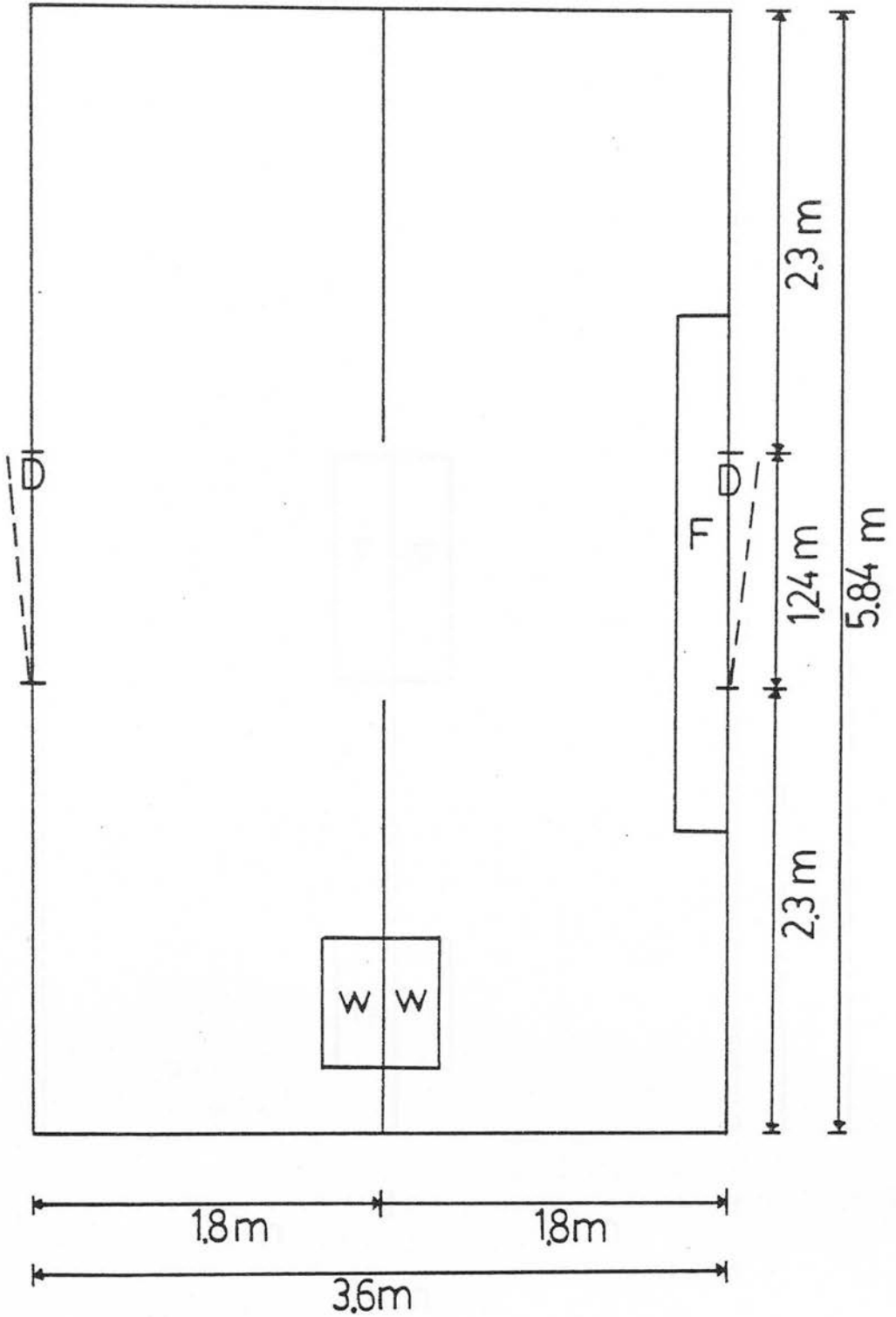
TABLE 10.1 The effect of the physical characteristics of the food and group size of the pigs on feeding activities of the pigs

Treatment <sup>φ</sup>	P8	P4	P1	M8	M4	M1	se of difference	Level of significance
Total feeding time (second/pig)	5928	6032	6339	11139	11606	10561	370	****
Total feeding time of first meal (second/pig)	1821	1936	2020	4039	4356	3675	247	***
Total number of feeding bouts	37.6	40.8	39.0	49.3	58.2	61.4	2.8	****
Total number of feeding bouts within first meal	8.9	8.5	7.4	17.5	19.8	17.9	1.8	****
Food intake (kg/8 pigs)	17.14	16.93	16.66	17.92	17.53	16.89	0.4	NS
Eating speed (g/second)	0.3626	0.3497	0.3262	0.2009	0.1913	0.2005	0.012	****

\*\*\*\* -  $p < 0.001$ , \*\*\* -  $p < 0.005$

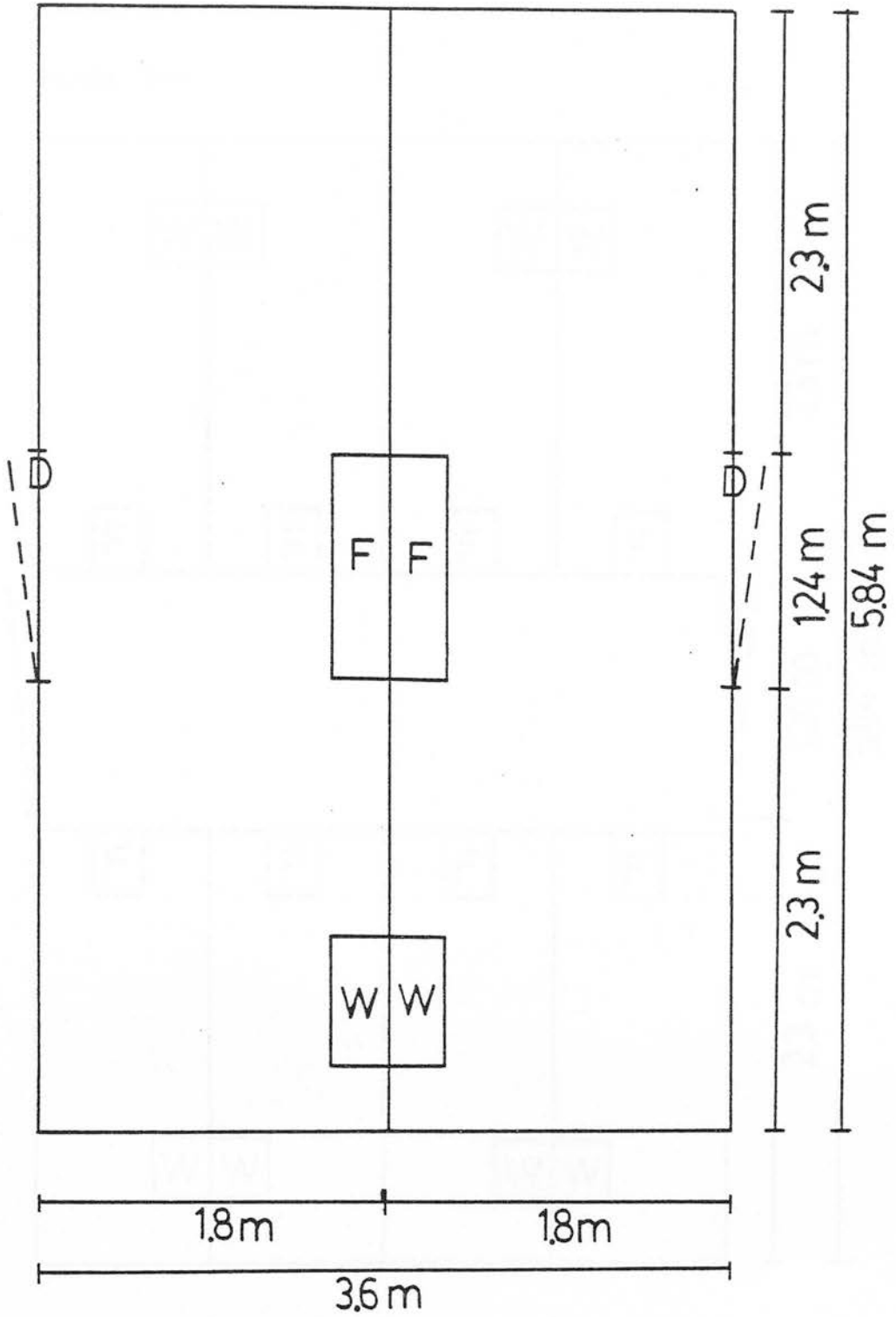
<sup>φ</sup> - see text for details

FIGURE 10-1



Plan of room arrangement in Treatment 1 and Treatment 4  
of Chapter 10  
D - door; F - feed trough; W - water trough

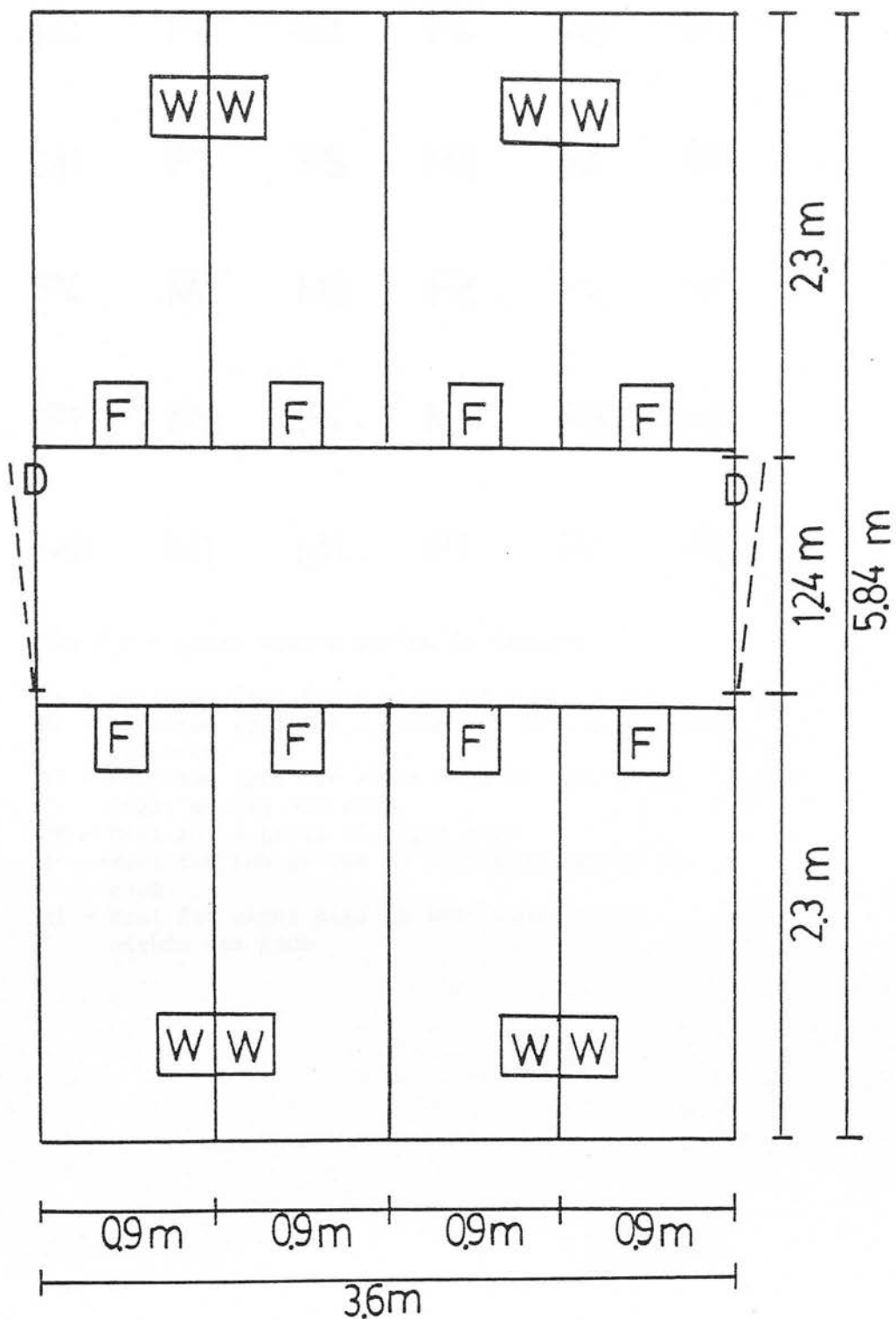
FIGURE 10-2



Plan of room arrangement in Treatment 2 and Treatment 5 of Chapter 10

D - door; F - food trough; W - water trough

FIGURE 10-3



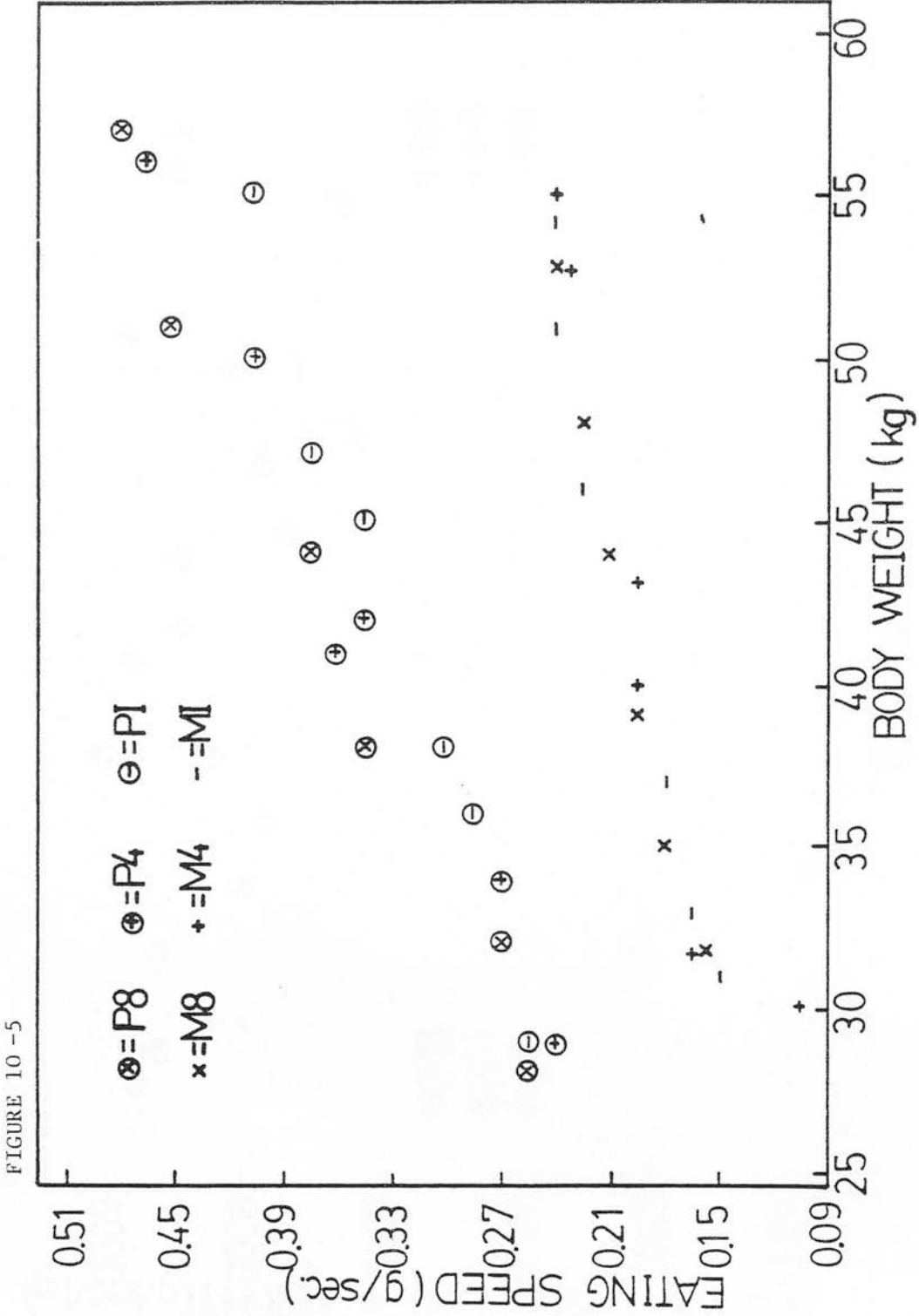
Plan of room arrangement in Treatment 3 of Chapter 10  
 D - door; F - food trough; W - water trough

FIGURE 10-4

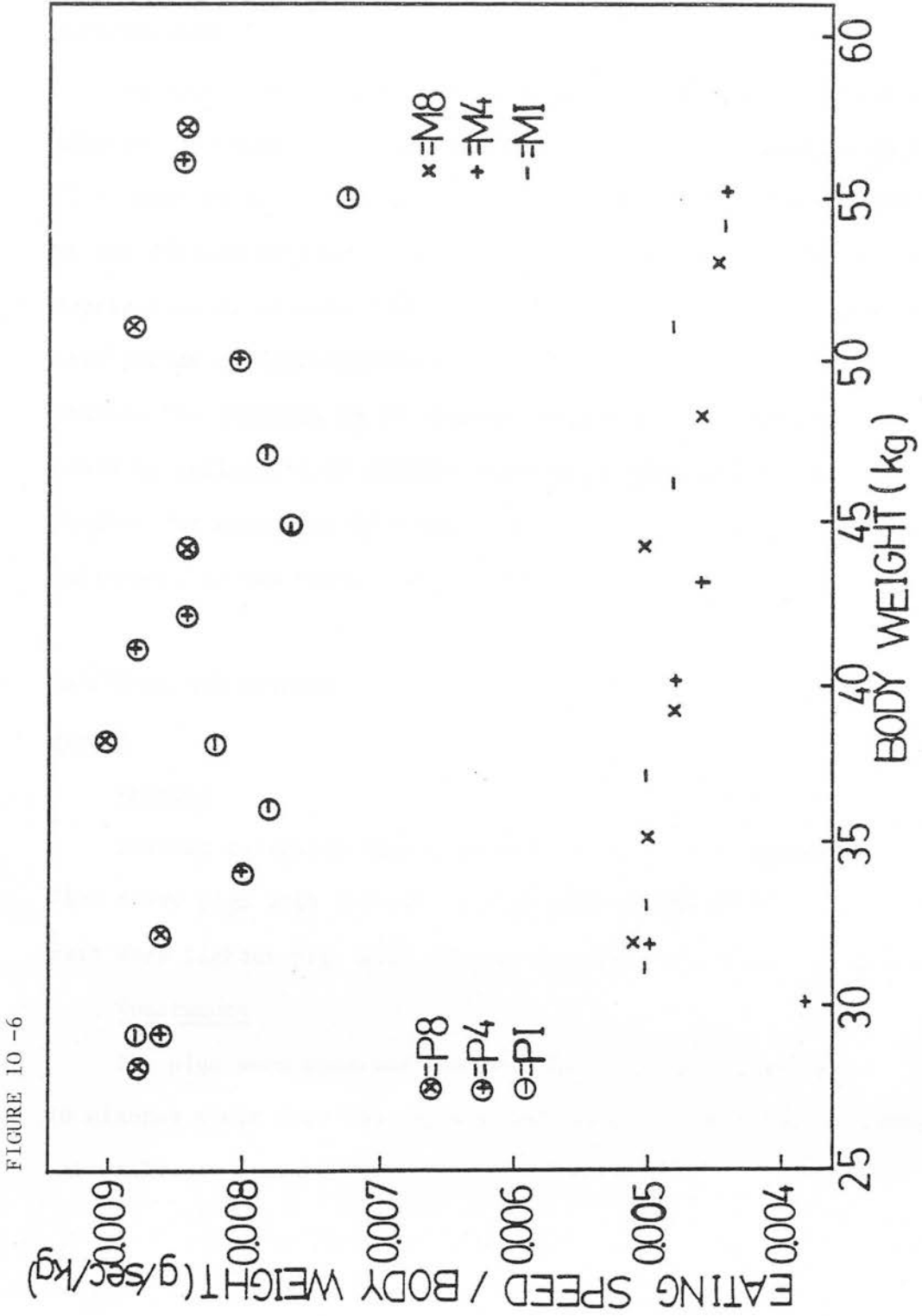
P8	P4	P1	M4	M1	M8
M4	P8	M1	P4	M8	P1
M1	P1	P8	M8	M4	P4
P4	M4	M8	P8	P1	M1
P1	M8	P4	M1	P8	M4
M8	M1	M4	P1	P4	P8

The 6 x 6 Latin square design in Chapter 10

- P8 - Pelleted food for a group of eight pigs
- P4 - Pelleted food for 2 groups of four pigs within one room
- P1 - Pelleted food for eight pigs in individual stall within one room
- M8 - Meal for a group of eight pigs
- M4 - Meal for two groups of four pigs within one room
- M1 - Meal for eight pigs in individual stall within one room



The relationship between eating speed and body weight in different treatments of Chapter 10



The relationship between eating speed per unit of body weight and body weight of pigs in different treatments of Chapter 10

CHAPTER 11    THE EFFECT OF LENGTH OF FOOD DEPRIVATION OF THE  
COMPANION PIGS ON THE FEEDING ACTIVITY OF THE  
SUBJECT PIGS

INTRODUCTION

An investigation into the relationship between the length of time of food deprivation and feeding motivation is reported in the first part of this chapter. One of the main questions was whether or not feeding motivation increases with increased periods of food deprivation or whether feeding motivation is constant after a certain period of food deprivation. The second part of this chapter studies the question as to whether the feeding motivation of a pig could be influenced by another pig highly motivated to feed and also whether the behaviour of a pig with a light body weight could be influenced by the behaviour of a heavier pig.

MATERIALS AND METHODS

Part 1

Animals

Fifteen castrated male pigs were used in this experiment. Five heavy pigs with average initial body weight of 92.1 kg. The rest were lighter pigs with average initial body weight of 40.2 kg.

Treatments

The pigs were observed and when they had not eaten for 10 minutes their food was removed and returned after the following intervals.

- Treatment 1 - one hour
- Treatment 2 - five hours
- Treatment 3 - ten hours
- Treatment 4 - fifteen hours
- Treatment 5 - twenty hours

#### Procedure and husbandry

Five groups of pigs were used, three pigs in each group, which included one heavy weight pig and two light weight pigs. They were kept in adjacent individual stalls (Figure 11-1) which were separated by bars. After seven days for settling in each group of pigs went through one row of a 5 x 5 Latin square (Figure 11-2). Five treatments were included in each row.

The last meal before deprivation was given in the morning at 9.00 am. Ten minutes after the last pig in a group stopped eating the troughs were removed. The time at which the last pig in a group stopped eating was considered as the first minute of the period of deprivation. Food was again introduced to the group after the particular length of deprivation, shown in the design in Figure 11-2. As soon as the food, which was more than the pigs could consume, was provided, the feeding time was recorded. Again the individual troughs were removed after the pigs stopped eating for ten minutes.

The definition of a feeding bout was the same as the definition in Chapter 4. The total food consumed was recorded for each pig and no food was provided during the rest of the time, except for the pre-deprivation meal and the test meal. Water was available at all times. Groups 1, 2 and 3 were run simultaneously then

groups 4 and 5 were run simultaneously. A 24-hour light régime was adopted in this experiment. Faeces were removed once per day before the pre-deprivation meal.

## Part 2

### Animals

Eighteen castrated male pigs were used in this part of the experiment. Six of them had an average initial body weight of 98.4 kg. The other pigs had an average initial body weight of 44.7 kg.

### Treatments

The subject pig in every group was a young, light-weight pig (A) which had been deprived of food for five hours at the start of each test. (B) represents the young, light-weight companion pig which was the same age and weight as pig (A). (C) represents the older, heavy-weight companion pig with twice the body weight of the subject pig (A).

Treatment	Period of food deprivation	
	Subject pig	Companion pig
1 (AB1)	Pig (A) - 5 hours	Pig (B) - 1 hour
2 (AB2)	Pig (A) - 5 hours	Pig (B) - 5 hours
3 (AB3)	Pig (A) - 5 hours	Pig (B) - 10 hours
4 (AC1)	Pig (A) - 5 hours	Pig (C) - 1 hour
5 (AC2)	Pig (A) - 5 hours	Pig (C) - 5 hours
6 (AC3)	Pig (A) - 5 hours	Pig (C) - 10 hours

### Procedure

After 7 days settling in, each group of pigs, one heavy pig and two light-weight pigs, were put through one row of a 6 x 6 Latin square (Figure 11-3). The first three groups, 1, 2 and 3 were run at the same period. The second three groups, 4, 5 and 6 were later run simultaneously. The husbandry and procedure were the same as for part 1, except that the pre-deprivation meal of the accompanying pig was decided according to the requirements of the treatment, ie when the companion pig was deprived for 1 hour, 5 hours, or 10 hours then it was fed on that particular day at 1.00 pm or 9.00 am or 4.00 am respectively. The subject pig was always fed at 9.00 am and the tests were always at 3.00 pm. During the test, only the subject and the companion pig were left in the room and the pig not required by the treatment on that particular day was moved to an empty room. The arrangements of the test room are shown in Figure 11-1.

### Statistical Model

$$\text{Model 11-1: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

$$\text{Model 11-2: } Y_{jkl} = \mu + \alpha_j + \beta_k + \tau_l + e_{jkl}$$

In which Y = independent variable

$\mu$  = grand mean

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

e = error

## RESULTS

Part 1

Food intake, total feeding time and eating speed were analysed by Model 11-1 and Model 11-2 for the results of light and heavy pigs respectively. There were significant differences ( $p < 0.001$ ) in food intake between treatments, for both light-weight (Table 11.1; Figure 11-4) and heavy-weight pigs (Table 11.1; Figure 11-5). The following results of food intake were the same for both light and heavy weight pigs. There were significant differences between Treatment 1 and the other treatments ( $p < 0.001$ ), between Treatment 2 and Treatments 3, 4 and 5 ( $p < 0.01$ ) and also between Treatment 3 and Treatments 4 and 5 ( $p < 0.05$ ). There were no significant differences between Treatments 4 and 5 ( $p > 0.05$ ).

The effect of body weight had no direct influence on the total feeding time of the pigs in the different treatments as both the light-weight and the heavy-weight pigs showed the same statistical results. The various treatments produced significantly different results ( $p < 0.001$ ) for both the light-weight (Table 11.1; Figure 11-6) and heavy-weight (Table 11.1; Figure 11-7) groups. There were significant differences between Treatment 1 and the other treatments ( $p < 0.001$ ). The results from Treatment 2 were significantly different to those of Treatments 3, 4 and 5 ( $p < 0.001$ ). Likewise Treatment 3 produced results significantly different from those of Treatments 4 and 5 ( $p < 0.05$ ). There were no significant differences between Treatments 4 and 5 ( $p > 0.05$ ).

The eating speed of both light (Table 11.1) and heavy-weight (Table 11.1) pigs was significantly different between treatments ( $p < 0.01$ ). Treatment 1 did make the pigs eat slower than any of

the other treatments ( $p < 0.05$ ). However there were no significant differences in eating speed between Treatments 2, 3, 4 and 5 ( $p > 0.05$ ).

## Part 2

Food intake, total feeding time and eating speed were analysed by Model 11-2.

The food intake and total feeding time of the subject pig showed no significant differences between the various treatments ( $p > 0.05$ ) (Table 11.2). However the eating speed of the subject pig did show significant differences between treatments ( $p < 0.01$ ; Table 11.2). The subject pig in AC1 Treatment ate slower than the subject pigs in the other treatments ( $p < 0.01$ ). There were no significant differences ( $p > 0.05$ ) in the eating speeds of the subject pigs between the following treatments - AB1, AB2, AB3, AC2 and AC3.

The companion pigs had a significantly lower food intake in Treatment AB1 than in Treatment AB2 ( $p < 0.05$ ). There was also a higher intake of food by the companion pigs in Treatment AB2 than in Treatment AB3 at a significant level ( $p < 0.05$ ). Food intake was higher in AC3 than in AC2 and also higher in Treatment AC2 than in Treatment AC3 (Table 11.2). The difference in food intake between AB1 and AC1, between AB2 and AC2 and between AB3 and AC3 did not reach a significant level. However from the average food intake of pigs in each treatment, it was found that the pigs in AB1 had a higher food intake than in Treatment AC1 while the pigs in AB2 and AB3 had a lower food intake than AC2 and AC3 respectively.

The total feeding time of the companion pigs showed

significant differences between treatments ( $p < 0.01$ ; Table 11.2). The pigs in AB1 and AC1 had a significantly lower total feeding time than in AB2 and AC2 respectively ( $p < 0.05$ ). Furthermore the pigs in AB2 and AC2 showed a significantly lower ( $p < 0.05$ ) total feeding time than in AB3 and AC3 respectively. The accompanying pigs in Treatments AB1, AB2 and AB3 had significantly higher total feeding times than the accompanying pigs in AC1, AC2 and AC3 respectively.

The eating speed of the companion pigs was significantly different between treatments ( $p < 0.01$ ; Table 11.2). The pigs in AB1, AB2 and AB3 Treatments had significantly slower eating speed than pigs in AC1, AC2 and AC3 respectively. The accompanying pigs in AC1 had significantly slower eating speeds than pigs in AC2 or AC3. There were no significant differences in eating speed between Treatments AB1, AB2 and AB3 ( $p > 0.05$ ). The eating speed of accompanying pigs did not reach a significant level ( $p > 0.05$ ) between Treatments AC2 and AC3.

## DISCUSSION

### Part 1

These results indicated very clearly that the food intake of pigs increased with increasing length of deprivation of food from one hour to fifteen hours.

There was no further increase in food intake when the deprivation time increased from fifteen hours to twenty hours. This suggests that there is an upper limit food intake beyond which the pigs would not consume any more food.

The same phenomenon was reported in the Japanese Quail by

Savory (1981). The food intake mechanism depends on many factors such as blood glucose levels, the presence of food in alimentary canal and the level of hormones connected with food intake. It was not possible in this study to determine which factor was the most important in control of food intake. Consequently the term 'level of food' will be used to cover all and any of the factors affecting food intake.

When pigs were deprived of food for more than fifteen hours, then the food reserves may already be very near to the lowest level because food deprivation for longer than fifteen hours did not induce the pigs to eat any more food. Whether fifteen hours of food deprivation produces the lowest level of food reserves in pigs is still not certain because - (1) The present experiment only deprived the pigs of food for twenty hours at the maximum. There is a possibility that the increase in the slope of food intake was decreased between fifteen and twenty hours food deprivation, so that a longer time interval may be needed to produce a difference in food intake for periods longer than fifteen hours of food deprivation. This needs to be studied further in the future. (2) Stephens (1975) studied the milk intake of piglets and suggested that gastric receptors exist and signal distension of the stomach. Kvasnitskii (1951) measured the capacity of the pig's stomach by filling it with water after slaughter and his results indicate that the amount of food eaten after fifteen hours of food deprivation in this experiment is unlikely to have filled the stomach although his experiment (Kvasnitskii, 1951) involves an artificial situation. However it is certain that the stomach distension is not the only controlling mechanism.

Another interesting result was that the heavy and light-weight pigs showed the same relationships between the length of the deprivation periods and the pattern of food intake. Both heavy and light-weight pigs reached their upper limit of food intake after fifteen hours of food deprivation. Both food intake and metabolic rate increase with increases in body weight. Thus, although the heavy pigs ate more than the lighter pigs, they spent energy more quickly and reached the same low level of food reserves in the same period as the light pigs.

At the lower level of food deprivation, if we compare the food intake of pigs deprived of food for one hour against those deprived of food for five hours, it was found that the proportion between food intake after one hour and food intake after five hours was lower for the heavy pigs than for the light-weight pigs. One reason for this could be that as the heavy pigs consumed more food than the light pigs they were still digesting food eaten before the food deprivation began.

The eating speeds of the pigs were not significantly different between treatments for the light pigs. The large pigs, which had been deprived of food for one hour, ate significantly slower than pigs which had been deprived of food for more than five hours. These results could be explained by the fact that eating speed was fast when the pigs started to eat but then decreased (Chapter 8).

The longer the pigs were deprived of food the longer the period of rapid eating may have lasted. After a certain level, when the pigs became more satiated, then the eating speed decreased. Consequently the average eating speed produced no significant differences between treatments.

The significantly slower eating speed of large pigs deprived of food for one hour was mainly due to the fact that they did not concentrate on eating as - (1) They often lifted their heads from the trough for a few seconds (less than 10 seconds) and then returned. (2) They played with the food trough rather than eating in it. The light pigs deprived of food for one hour also failed to concentrate on eating but direct observation showed that they played less than the heavy pigs. This indicated that the pigs were not very hungry after one hour of food deprivation although it suggests that the heavy pigs were even less hungry than the light pigs.

## Part 2

The results suggested the feeding activity of a subject pig in most situations was not influenced by the companion pigs which had been deprived of food either for a long or short time. As mentioned before, the companion pigs deprived of food for a long time would eat quickly in the first stage but then slow down so that any initial influence would be negated by their period of slow eating.

In the present experimental circumstances in which each pig ate in its own pen accompanied by another pig, the mere presence of another pig might have been enough to stimulate the pigs which have been deprived of food for five hours and which were moderately motivated to eat until they had reached their final upper food limit. It would be better, if this is the case, in future experiments to use pigs with one hour of food deprivation or even satiated pigs as subject pigs.

As mentioned in Chapters 3 and 4, the eating speed increased

with increasing body weight, and when the eating speed was divided by body weight the increase disappeared. This suggests that the feeding motivation did not increase with the increase of body weight. From the original design of the experiment it was expected that the period of rapid feeding in the companion pigs, deprived for a long time, could cause an increase in the eating speed of subject pigs. The subject pig did not show any influence of the companion pig regardless of whether it had been deprived of food for a long or short period.

This result differs from that found in the chicken. The pecking rate in the chicken has been shown to increase when the floor was tapped with a finger or even by a model chick (Collias, 1952; Tolman 1964, 1967). However, as mentioned before, the eating speed of the companion pigs deprived of food for a long time slowed down in the later stages of feeding so it is difficult to determine which factors are responsible for the lack of differences in the results. This aspect requires a more detailed study in the future.

The most interesting result from this experiment was the subject pig in Treatment AC1 which ate more slowly than the subject pigs in AC2 and AC3. At the same time the companion pig in AC1 ate more slowly than the companion pigs in Treatments AC2 and AC3. However, this feeding did not accord with AB1 Treatment. This might have been because the large pigs deprived of food for only one hour performed more activities unrelated to feeding. These activities might have disturbed or influenced the feeding activity of a small subject pig. The subject pig might have paid more attention to a large heavy companion than to a small lighter

companion. A similar result, in which one animal's activity was influenced by others, has been reported in the dog (Vogel, Scott and Marston, 1950) and the details were described in the literature review.

TABLE 11.1 The relationship between the length of food deprivation and feeding activities

Length of food deprivation (hours)	1	5	10	15	20	se of difference	Level of significance
Light weight pigs							
Food intake (kg)	0.242	0.668	1.005	1.203	1.215	0.085	****
Total feeding time (seconds)	712	1461	2345	2797	2947	172.3	****
Eating speed (g/second)	0.348	0.443	0.439	0.436	0.420	0.019	*
Heavy weight pigs							
Food intake (kg)	0.352	1.269	1.836	2.037	2.059	0.079	****
Total feeding time (seconds)	510	1483	2011	2332	2496	123.1	****
Eating speed (seconds)	0.643	0.891	0.968	0.908	0.850	0.096	*

\*\*\*\* -  $p < 0.001$ , \* -  $p < 0.05$

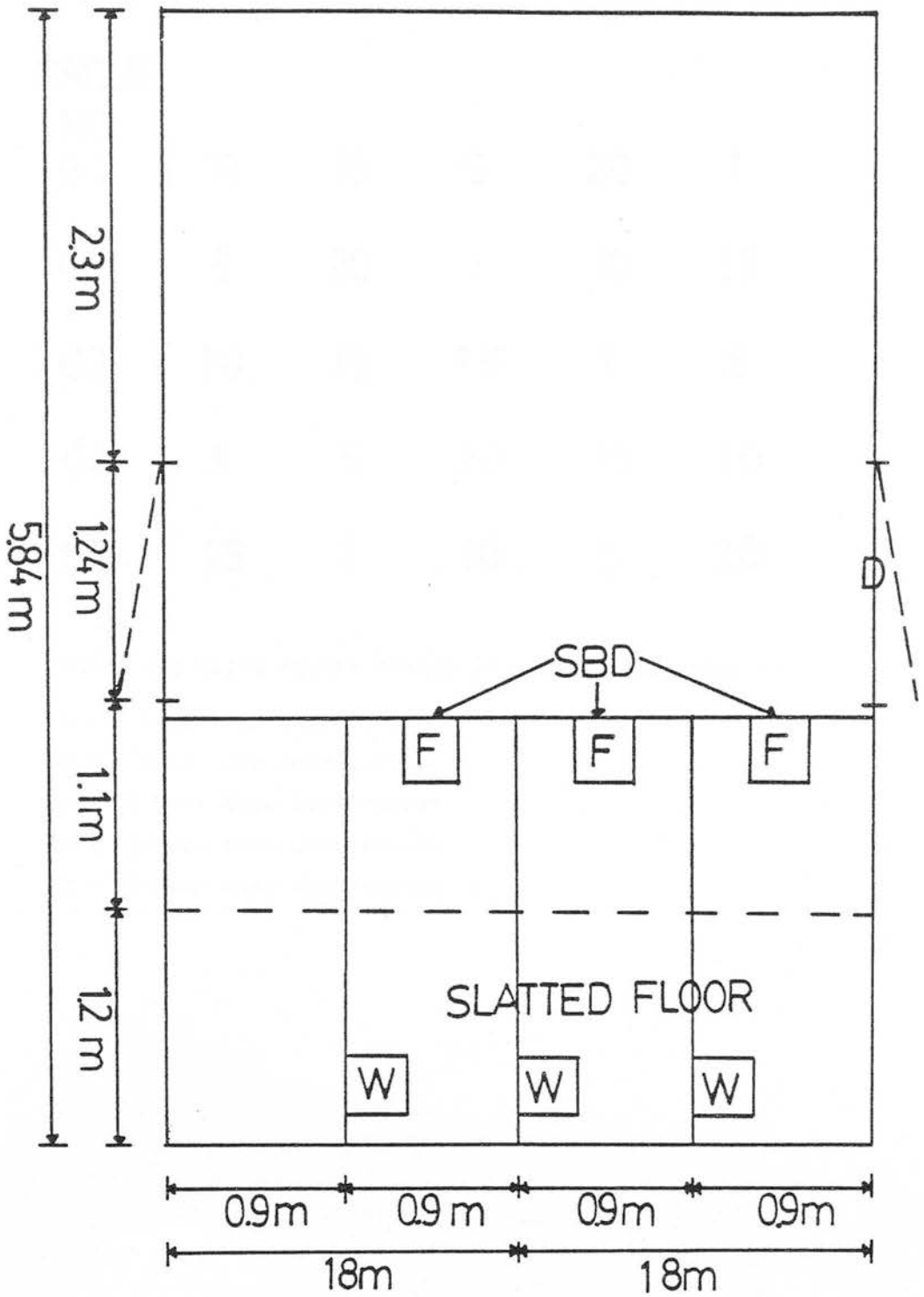
TABLE 11.2 The effect of length of food deprivation of the companion pig on the feeding activities of the subject pig

Treatment <sup>φ</sup>	AB1	AB2	AB3	AC1	AC2	AC3	se of difference	level of significance
	Subject pig							
Food intake (kg)	0.946	0.974	0.888	0.753	0.851	0.932	0.135	NS
Total feeding time (seconds)	1786	1740	1507	1568	1601	1713	260.3	NS
Eating speed (g/second)	0.534	0.557	0.566	0.457	0.537	0.543	0.021	**
	Companion pig							
Food intake (kg)	0.540	1.014	1.474	0.383	1.159	1.802	0.168	***
Total feeding time (seconds)	1314	1924	2641	547	1181	1759	229.5	**
Eating speed (g/second)	0.421	0.533	0.570	0.608	1.060	1.071	0.078	****

<sup>φ</sup> - for details see text

\*\*\*\* -  $p < 0.001$ , \*\*\* -  $p < 0.005$ , \*\* -  $p < 0.01$

FIGURE 11-1



Plan of room arrangement in Chapter 11

F - food trough; D - door; SBD - steel bar division;  
W - water trough

FIGURE 11-2

GROUP NO.					
G1	10	15	5	20	1
G2	5	20	1	10	15
G3	20	10	15	1	5
G4	1	5	20	15	10
G5	15	1	10	5	20

The 5 x 5 Latin square design in part 1 of Chapter 11

1 = 1 hour food deprivation

5 = 5 hour food deprivation

10 = 10 hour food deprivation

15 = 15 hour food deprivation

20 = 20 hour food deprivation

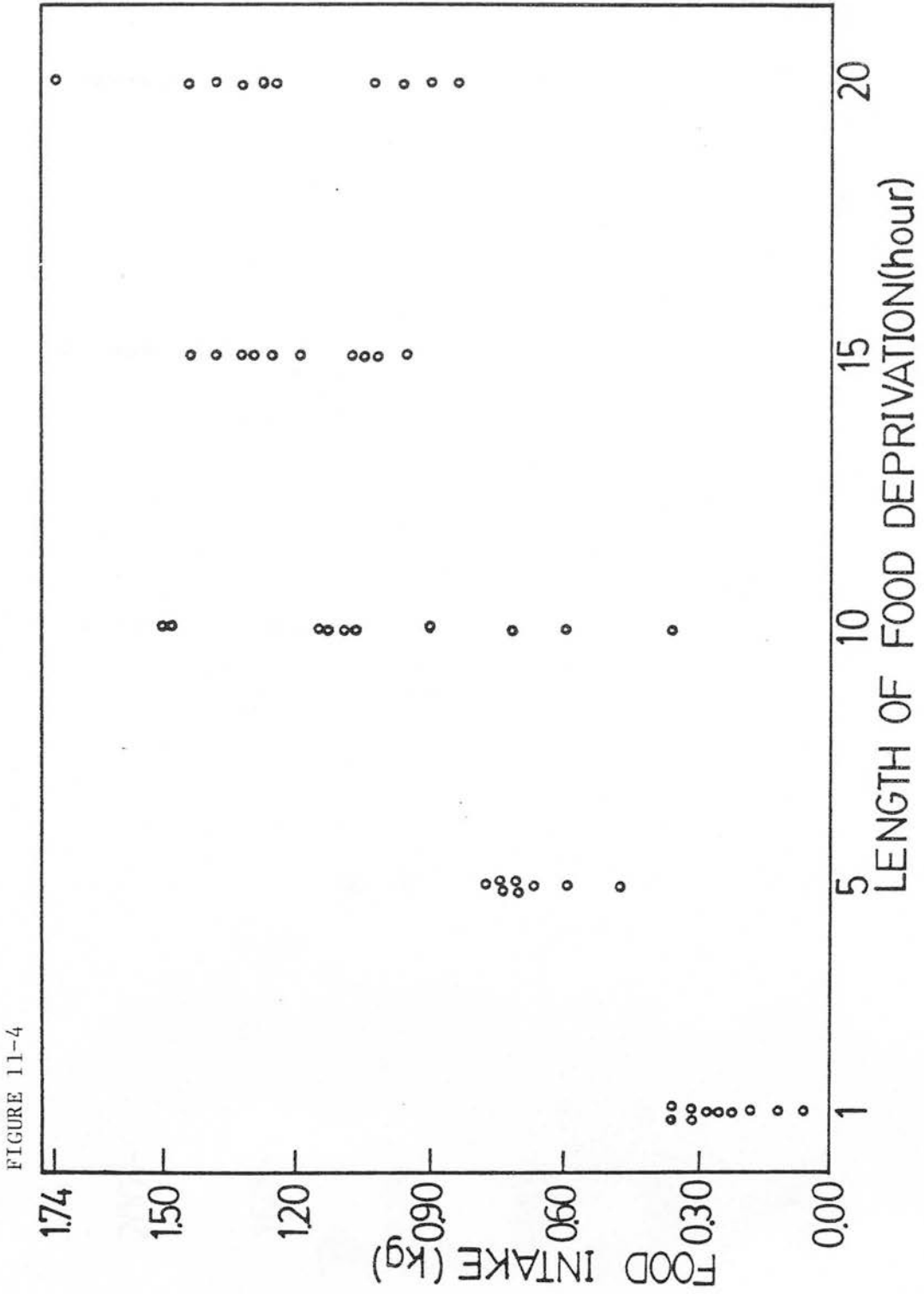
FIGURE 11-3

GROUP NO.	1	2	6	3	5	4
G1	1	2	6	3	5	4
G2	2	3	5	4	6	1
G3	6	5	4	2	1	3
G4	3	6	1	5	4	2
G5	4	1	3	6	2	5
G6	5	4	2	1	3	6

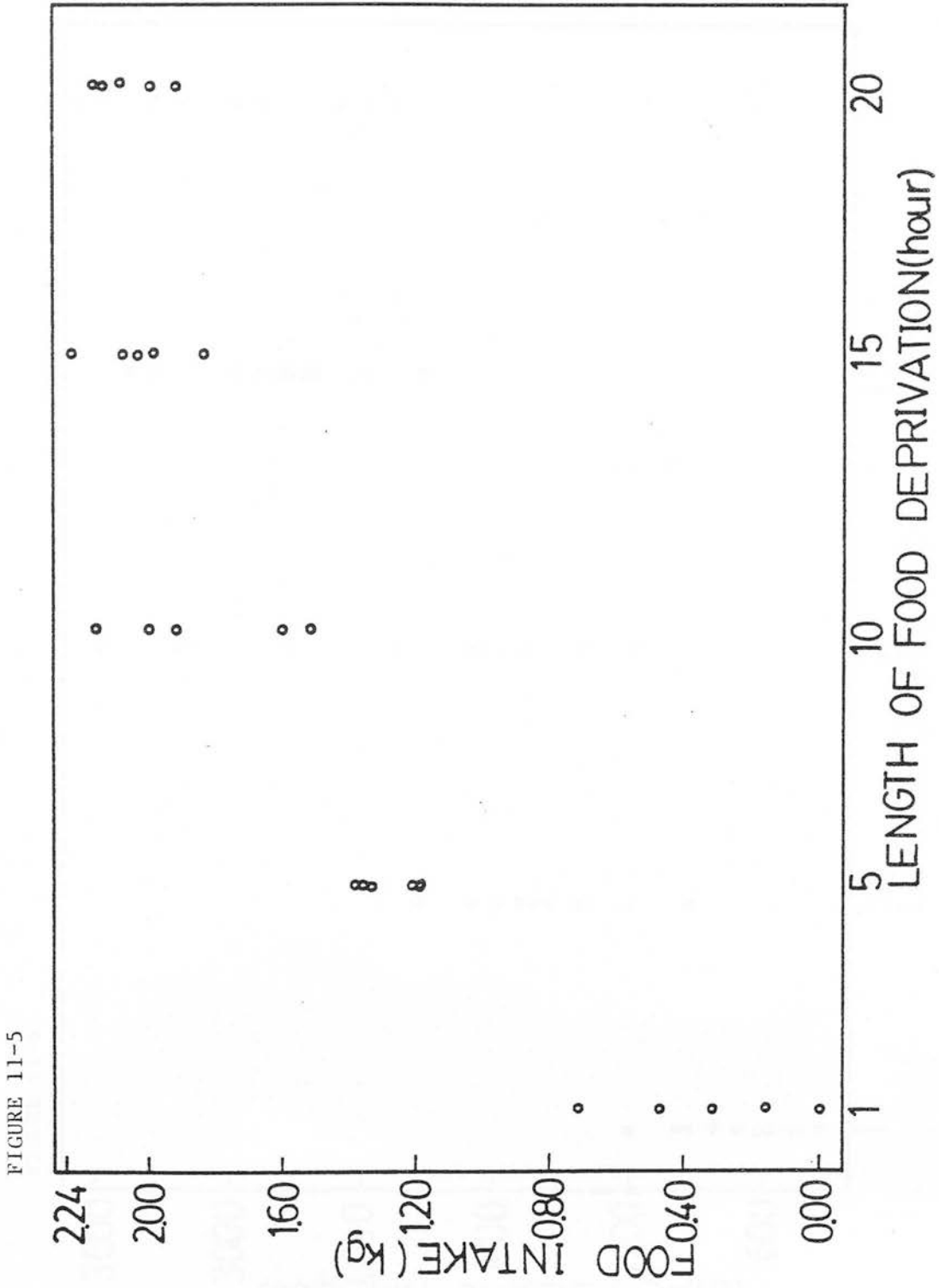
Period of food deprivation

	Subject pig	Companion pig
1 =	Pig A - 5 hours	Pig B - 1 hour
2 =	Pig A - 5 hours	Pig B - 5 hours
3 =	Pig A - 5 hours	Pig B - 10 hours
4 =	Pig A - 5 hours	Pig C - 1 hour
5 =	Pig A - 5 hours	Pig C - 5 hours
6 =	Pig A - 5 hours	Pig C 10 hours

The 6 x 6 Latin square design in part 2 of Chapter 11

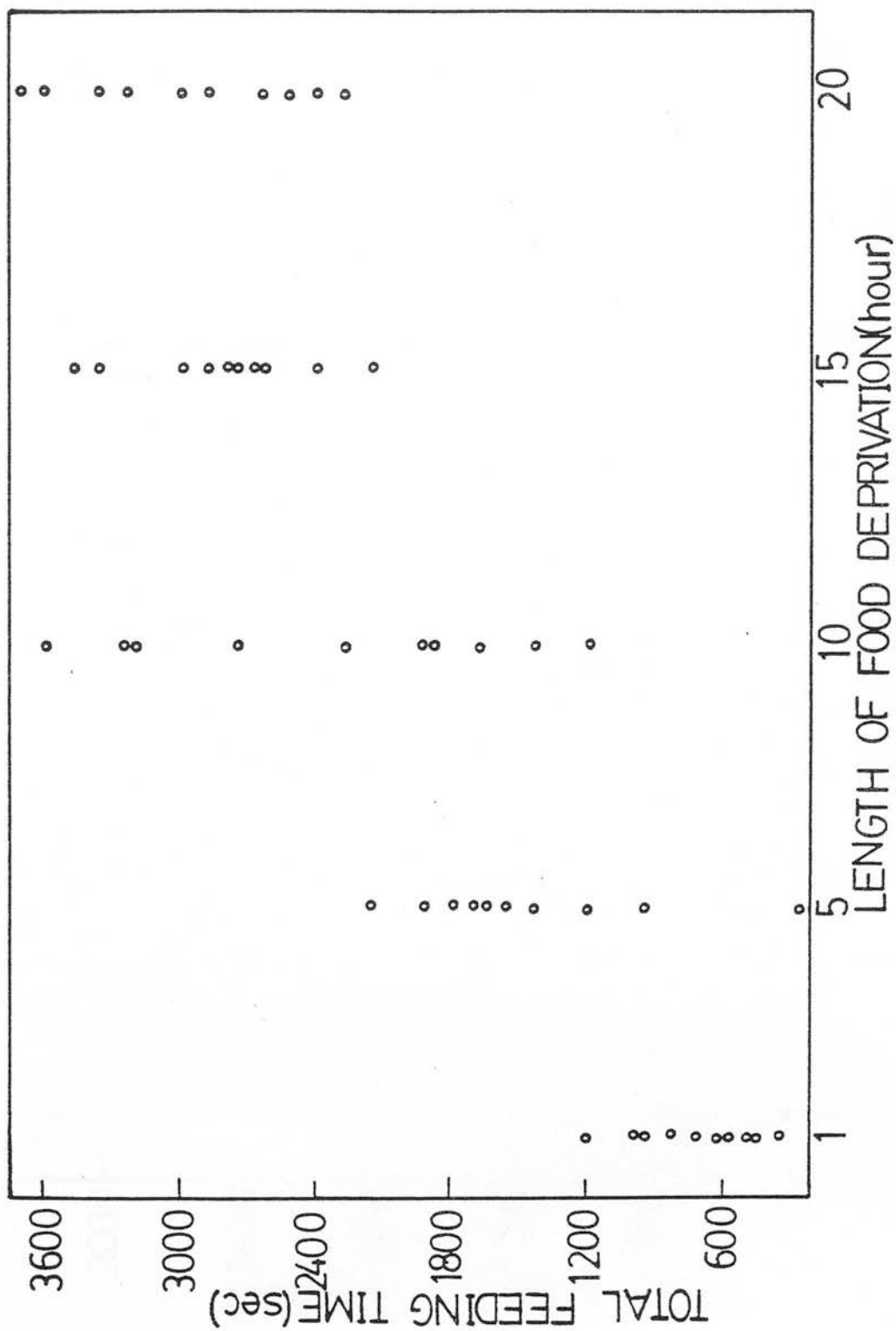


The effect of the length of food deprivation on food intake of light-weight pigs



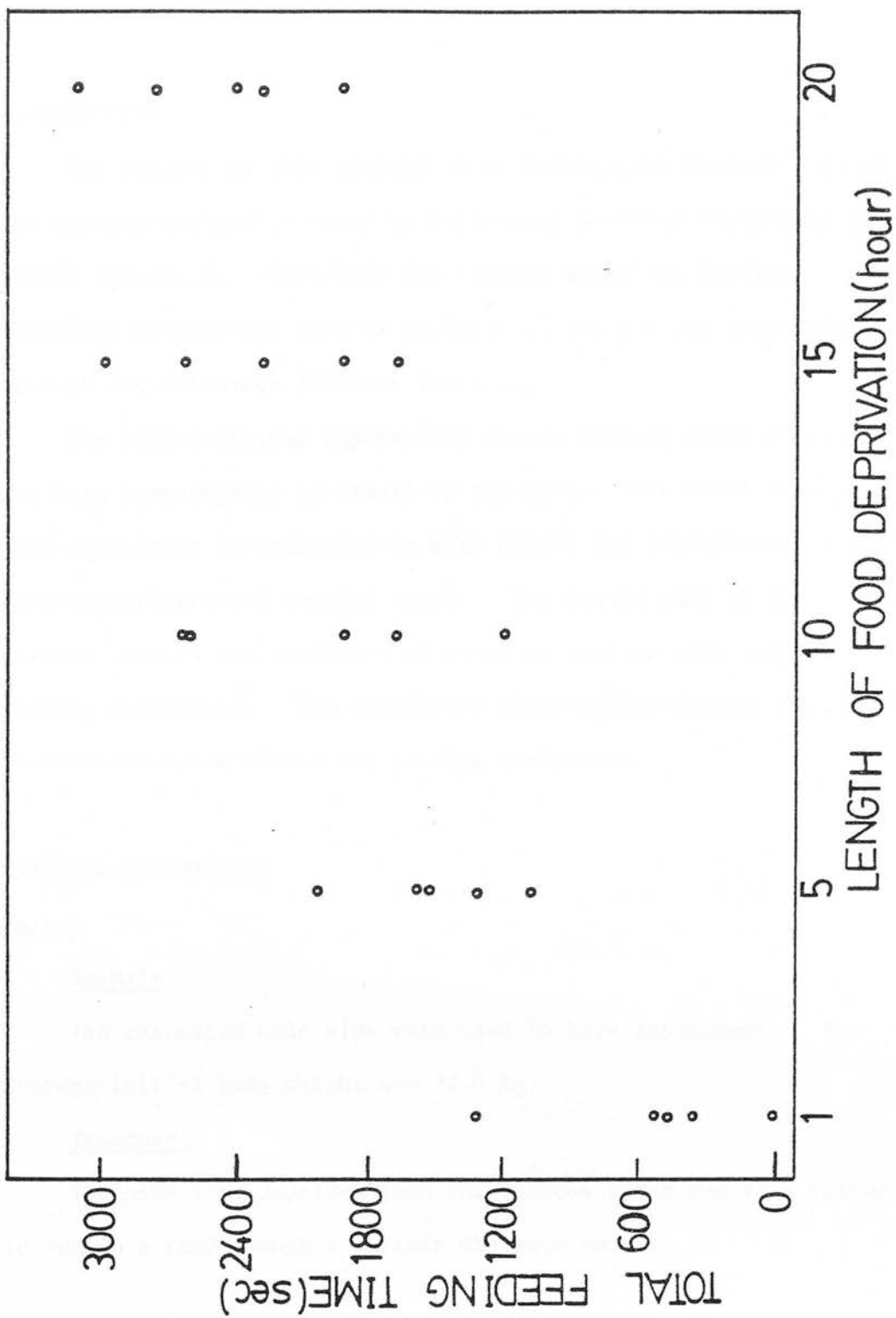
The effect of the length of food deprivation on food intake of heavy-weight pigs

FIGURE 11-6



The effect of the length of food deprivation of food intake on total feeding time of light-weight pigs

FIGURE 11-7



The effect of the length of food deprivation on total feeding time of heavy-weight pigs

CHAPTER 12 THE EFFECT OF LENGTH OF FOOD DEPRIVATION ON THE RUNNING  
SPEED AND FEEDING ACTIVITY IN SOLITARY AND SOCIAL  
CONDITIONS

INTRODUCTION

The purpose of this chapter is to investigate whether high and low feeding motivation could be influenced by other factors in a social situation. Here both the running speed and feeding behaviour of pigs was used as an index of the feeding motivation and also of the influence of other factors.

The effect of food deprivation on the running speed of pigs has not been investigated in detail in the past. The first part of this experiment investigates in more detail the relationship between food deprivation and running speed. The second part of the chapter studies the influence of other factors on high and low feeding motivation. The third part investigates whether or not frustration could affect the feeding motivation.

MATERIAL AND METHODS

Part 1

Animals

Ten castrated male pigs were used in this experiment. The average initial body weight was 33.0 kg.

Treatment

The pigs were deprived food for various times and then allowed to run to a food trough a certain distance away.

Treatment	Length of food deprivation	Length of run to food
1	1 hour	60.28 m
2	5 hours	60.28 m
3	10 hours	60.28 m
4	15 hours	60.28 m
5	20 hours	60.28 m

#### Procedure and Husbandry

The passage of the development house (Figure 12-1) was used as a running course.

The pigs were kept in room 1, the west side door of which was shut all the time. They were kept in pairs in the stalls of the room and five pigs were used in each of two replicates. Each of the five pigs was put through a row of a 5 x 5 Latin square (Figure 12-2) in each replicate in five days. Each row has five treatments.

The newly arrived pigs were kept in a group during the first three days and put into room 1 during the afternoon. The room had plenty of straw for bedding. On the first night only water was provided. The east side door of room 1 was opened for three days. The food was provided in two long troughs at the point (A) of the passage (Figure 12-1). For two days, the pigs were allowed to explore all the passages, except the area (L). From the fourth morning the pigs were confined in the stalls of room 1 whilst the straw was removed. The pigs were then only allowed to come out to eat at point (A) twice per day; once in the morning and once in the evening. They were trained to leave the room alone and to eat alone at point (A) for 6 days, twice daily.

The test started on the tenth morning after the pigs had arrived in room 1. Once the test started, the pigs were fed alone once in the morning (zero point run) at point (A) and once alone at point (A) according to the requirement of deprivation time of the 5 x 5 Latin square design (test run). The running speed and food consumption only was recorded during the test run. The following measurements were taken during the test run.

- 1 The total wandering time in room 1 after the stall gate was opened.
- 2 Running time between the door of room 1 and the first corner (26.28 m) (Figure 12-1).
- 3 The running time between the first corner and the trough at point (A) (34 m).
- 4 Total feeding time.
- 5 Total food consumption.
- 6 Eating speed.

Water was available *ad libitum* in each stall of room 1. The faeces were removed by shovel once per day before the zero point run. The area (L) was separated from the other passage by a 1 meter high wooden gate and a steel bar division.

## Part 2

### Animals

Ten castrated male pigs were used. The average initial body weight was 23.2 kg.

### Treatment

There were five treatments in this part of the experiment.

## Treatment 1

Two pigs ran together and ate together, both pigs had five hours of food deprivation before the run (D5).

## Treatment 2

Two pigs ran alone and ate alone but both pigs had five hours of food deprivation before the run (S5).

## Treatment 3

Two pigs ran together and ate together, both had one hour of food deprivation before the run (D1).

## Treatment 4

Two pigs ran alone and ate alone and both pigs had one hour of food deprivation before the run (S1).

## Treatment 5

Two pigs ran together, one pig had five hours of food deprivation and the other pig had one hour of food deprivation before the run (51).

Once the test started, the pigs were fed once in the morning (zero point run). Whether the pigs ran alone or in pairs in the zero point run depended on the particular test run. If the test run was in Treatments 1 and 3 then the pigs in zero point run were run in pairs. If, on the other hand, the test run was in Treatments 2, 4 and 5, the pigs in the zero point run were run individually.

Due to fire damage in room 1, the pigs were kept in room 5, and the feeding point was changed to point (B) (Figure 12-1), and the release point was changed to the east side of room 5.

Two pigs in each group were kept in the same stall. The

training procedure was the same as for the pigs in part 1. Each group of pigs was put through a row of a 5 x 5 Latin square (Figure 12-3) in five days. Five treatments were involved in a row. The feeding trough was 120 cm long, which was long enough for two pigs to eat at the same time.

The following measurements were taken during the test run.

- 1 The running time between the door of room 5 and the first corner (26.28 m) (Figure 12-1).
- 2 The running time between the first corner and the trough at point (B) (30.45 m).
- 3 Total feeding time.
- 4 Total food consumption.
- 5 Eating speed.

### Part 3

The same ten pigs used in part 2 were also used in this part of the experiment and the same ten pigs passed through all three stages in the treatments.

#### Treatments

Five groups of ten pigs were put through the following six treatments.

#### Treatment 1

The pigs ran and ate in pairs, both pigs had five hours of food deprivation during the first day and both could eat food at (B) point (D1).

#### Treatment 2

The pigs ran and ate alone but both pigs had five hours of food deprivation during the second day. Food was obtainable at (B) point (D2).

#### Treatments 3 - 6

Frustration treatments. The pigs ran in pairs and both pigs had five hours of food deprivation but only the dominant pig could get food at point (B). The inferior pig was chased back to room 5 and fed there. This stage was continued for four consecutive days. However each pair of pigs had eight experiences, four times on zero point running and four times on the test running (D3, D4, D5, D6).

The zero point run in all six treatments were exactly like the test run, ie if the pigs ran in pairs in the test run, then they were run in pairs in the zero point run (Treatment 1). Similarly, if they were run alone in the test run, then they were run alone in the zero point run (Treatment 2). If they were run in pairs, but only the dominant pig could get food in the test run, then they got the same treatment in zero point run too (Treatments 3 - 6).

#### Procedure

The food intake and total feeding time were only recorded during the first two treatments, but running speed was recorded at

all three stages. The same pigs were used in part two of the trial, so no training period was required.

The procedure and husbandary were as in part 2.

#### Statistical Model

$$\text{Model 12-1: } Y_{ijkl} = \mu + \theta_i + \alpha_j + \beta_k + \tau_l + e_{ijkl}$$

$$\text{Model 12-2: } Y_{jkl} = \mu + \alpha_j + \beta_k + \tau_l + e_{jkl}$$

$$\text{Model 12-3: } Y_{jklm} = \mu + \alpha_j + \beta_k + \tau_l + \phi_m + \psi_{lm} + e_{jklm}$$

$$\text{Model 12-4: } Y_{ilm} = \mu + \theta_i + \tau_l + \phi_m + \psi_{lm} + e_{ilm}$$

In which

Y = independent variable

$\mu$  = grand mean

$\theta$  = replicate

$\alpha$  = row

$\beta$  = column

$\tau$  = treatment

$\phi$  = social order

$\psi$  = treatment x social order

e = error

## RESULTS

The results for the three parts of this experiment will be described separately.

Part 1

The results of total feeding time and running speed were analysed by Model 12-1. The results for food intake and eating speed were analysed by Model 12-2.

Looking at the individual pigs deprived of food for either one hour or five hours, there were no significant differences in the amount of food eaten after food deprivation ( $p > 0.05$ ). When an average result was considered, the food intake after five hours' deprivation was greater than after one hour of food deprivation.

There were no significant differences in food intake of the pigs after deprivation for either ten hours, fifteen hours or twenty hours ( $p > 0.05$ ). However the average amount of food eaten did increase with increased length of deprivation.

A more interesting result showed that, pigs with a deprivation time of ten hours or longer, did consume significantly more food than the pigs deprived for only one hour or five hours ( $p < 0.005$ ) (Table 12.1; Figure 12-4).

Pigs deprived of food for either one hour or five hours showed no significant differences in total feeding time ( $p > 0.05$ ). Also there were no significant differences ( $p > 0.05$ ) in the total feeding time for the pigs deprived of food for ten hours, fifteen hours or twenty hours. The crucial period of time for deprivation was between five hours and ten hours because there were significant differences in total feeding times between the short deprivation

periods (one hour and five hours) and the long ones (ten hours, fifteen hours, twenty hours) ( $p < 0.005$ ; Table 12.1; Figure 12-5).

There were no significant differences ( $p > 0.05$ ) in eating speed between treatments (Table 12.1).

The wandering time was significantly different between treatments ( $p < 0.005$ ; Table 12.1; Figure 12-6). As was expected, the pigs deprived of food for one hour had the longest wandering time ( $p < 0.005$ ). This wandering time was significantly longer than that of the pigs deprived of food for five hours ( $p < 0.01$ ). The pigs with longer deprivation schedules (ten hours, fifteen hours and twenty hours) showed no significant difference in the length of wandering time between long deprivation treatments. However in all the long deprivation treatments the wandering time was much less than in the five hour treatment ( $p < 0.01$ ).

The running speed of the pigs was significantly different ( $p < 0.01$ ) between treatments in the first section of the course (Table 12.1; Figure 12-7). The pigs ran significantly slower ( $p < 0.01$ ) when they had been deprived of food for one hour than when they had been deprived of food for five hours or for more than five hours. The pigs ran significantly more slowly ( $p < 0.01$ ) when they had been deprived for five hours than when they had been deprived of food for ten hours, fifteen hours or twenty hours. There were no significant differences ( $p > 0.05$ ) in the running speeds of pigs deprived of food for ten hours, fifteen hours and twenty hours on the first section of the course.

The running speeds of the pigs were significantly different between treatments ( $p < 0.05$ ) on the second section of the course (Table 12.1; Figure 12-8). The running speed of the pigs which

had been deprived of food for one hour and five hours were significantly slower ( $p < 0.05$ ) than that of the pigs deprived of food for ten hours, fifteen hours and twenty hours. Furthermore, the running speeds were not significantly different ( $p > 0.05$ ) for pigs deprived of food for one hour or five hours. The differences in running speeds of pigs between Treatments 3, 4 and 5 also did not differ significantly ( $p > 0.05$ ) on section 2 of the course.

The running speeds of the pigs in the whole course were significantly different between treatments ( $p < 0.005$ ) (Table 12.1; Figure 12-9). The pigs which had been deprived of food for one hour ran significantly more slowly ( $p < 0.05$ ) than the pigs which had been deprived of food for five hours, ten hours and twenty hours. Also the pigs which had been deprived of food for five hours ran significantly more slowly ( $p < 0.05$ ) than the pigs which had been deprived of food for ten hours, fifteen hours and twenty hours. Once again the long deprivation treatments (ten hours, fifteen hours and twenty hours fast) showed no significant differences in running speeds.

The speed of the return was considered for section 1 and section 2 separately and also for the whole course (Table 12.1), ie section 1 plus section 2. These results showed no significant differences and the length of the deprivation period had no influence on the speed of return.

## Part 2

The results of food intake and eating speed were analysed by

Model 12-2. However the results of total feeding time and running speed were analysed by Model 12-3.

There were significant differences ( $p < 0.005$ ) in the food intake of pigs in different treatments (Table 12.2). The difference was not significant between Treatments D1 and S1 ( $p > 0.05$ ), but four of the five groups of pigs did eat more in the S1 Treatment than in the D1 Treatment and in only one group was there no difference in food intake between Treatments D1 and S1. There were no significant differences between Treatments D5, S5 and 51, but once again four of the five groups ate more in the D5 than in the S5 treatment, and only one group of pigs ate more in the S5 Treatment than in the D5 Treatment. The differences in food intake between Treatments D5, S5 or 51 and D1 or S1 were significant ( $p < 0.01$ ).

Between treatments the total feeding times showed significant differences ( $p < 0.01$ ; Table 12.2). These differences occurred between D1 and S1 and D5, S5 or 51 ( $p < 0.05$ ). There was no difference in the total eating time between Treatments D1 and S1 or between D5, S5 and 51.

The eating speeds of the pigs were significantly different between treatments ( $p < 0.05$ ) (Table 12.2). Treatments D5 and S5 had a faster eating speed than Treatments D1 and S1 ( $p < 0.05$ ). There were no significant differences in the eating speed of pigs in Treatments D5, S5 and 51 ( $p > 0.05$ ), or finally, between S1 and 51 ( $p > 0.05$ ).

Running speeds in section 1 of the course did show significant differences between treatments ( $p < 0.05$ ). There were no significant differences ( $p > 0.05$ ) in running speed between Treatments D5, S5 and 51, but nine pigs out of ten ran faster in the D5 treatment

than in the S5 Treatment.

There were also no significant differences in the running speed of the pigs between Treatments D1 and S1, but six pigs ran faster in Treatment D1 than in Treatment S1. This contrasted with the remaining four pigs which ran faster in S1 than in D1. In Treatment 51 the pigs which had been deprived of food for five hours did run faster than the pigs deprived of food for one hour in four of the five groups.

Section 2 of the course also produced significant differences in running speeds ( $p < 0.005$ ; Table 12.2). The pigs ran more slowly in Treatment D1 than in any other treatment ( $p < 0.01$ ) and faster in D5 than in Treatment S1 ( $p < 0.05$ ). There were no real differences in the running speeds of the pigs in Treatments D5, S5 and 51, even though nine of the ten pigs in D5 ran faster than those in S5. The differences in running speed between Treatments S1 and S5 or S1 and 51 were not significant ( $p > 0.05$ ).

When the running speed of the pigs on the whole course was considered, the results showed significant differences between treatments (Table 12.2). There were no significant differences between Treatments D5, S5 and 51, but nine out of ten pigs in Treatment D5 ran faster than those in S5. Also there were no significant differences between Treatments D1 and S1 on this score, but seven of the ten pigs in Treatment S1 ran faster than in D1 Treatment.

None of the treatments had any influence on the speed of the return from the feeding trough in any part of the course ( $p > 0.05$ ; Table 12.2).

Part 3

The food intake of the pigs in Treatments D1 and D2 was analysed by Model 12-4. The results showed that the differences in food intake of the pigs in the two treatments did not reach a significant level ( $p > 0.05$ ) (Table 12.3), but all the pigs in the five groups had higher food intakes in the paired Treatment D1 than in the individual Treatment D2.

The total feeding time of the pigs in Treatments D1 and D2 was analysed by Model 12-4. The results showed that the difference in total feeding time between the two treatments did not reach a significant level (Table 12.3), but nine of the ten pigs spent a longer time feeding in the paired Treatment D1 than in the individual Treatment D2. The dominant and inferior pigs showed no differences in feeding time ( $p > 0.05$ ).

The eating speed of the pigs in Treatments D1 and D2 was analysed by Model 12-4. The results showed no significant difference between the two treatments ( $p > 0.05$ ; Table 12.3).

The running speed of the pigs on section 1 of the course was analysed by Model 12-4 and there were significant differences ( $p < 0.05$ ) between the six treatments (Table 12.4; Figure 12-10). The pigs were significantly faster ( $p < 0.05$ ) in D1 than in D2 or in D6. In some pigs the running speed dropped off on day 3 but in others it did not drop until day 6. They almost reached a significant level ( $p > 0.05$ ) between the dominant and inferior pigs. The dominant animal ran much more slowly ( $p < 0.05$ ) in D2 than did the inferior pig. From D3 (day 3) to D6 (day 6) the average running speed of the inferior pigs was slower than that of the dominant pigs.

The Model 12-4 was used to analyse the differences in the running speeds of pigs on section 2 of the course and the results showed no significant differences ( $p > 0.05$ ) between the six treatments (Table 12.4). Although it almost reached the 0.05 significant level. The pigs in D1 Treatment ran significantly faster ( $p < 0.05$ ) than the pigs in Treatment D2. There were significant differences ( $p < 0.05$ ) between pigs of the two different social orders but there were no significant interactions between treatments and social order ( $p > 0.05$ ).

The running speeds of pigs on the whole course for the six treatments were analysed by Model 12-3 and the results showed significant differences ( $p < 0.01$ ) between treatments (Table 12.4).

There were significant differences between D1 and D6 ( $p < 0.01$ ) and between D2 and D1, D3, D4 and D5. The social hierarchy had no significant ( $p > 0.05$ ) influence on the running speed for the whole course. The interaction between social order and treatments was significant. On day 2 (D2) the inferior pig ran faster but from day 3 (D3) to day 6 (D6) it was the dominant pig that showed the greatest speed in completing the whole course.

There were no significant differences ( $p > 0.05$ ) among treatments and social order or running speed of the pigs when returning either for the whole course or for sections 1 or 2.

## DISCUSSION

Part 1

The effect of food deprivation time on the food intake, total feeding time and eating speed had similar results as in Chapter 11. The interesting thing was the effect of food deprivation time on the running speed which gave a similar picture to total food intake in relation to the periods of food deprivation. This suggests that running speed also represents different levels of feeding motivation.

One interesting result, which was not analysed statistically, is that pigs deprived of food for one hour on average ran faster in the second course than in the first course, but pigs deprived of food for more than five hours ran on average faster in the first section of the course than in the second section.

One of the reasons which might have caused the pigs, deprived of food for longer, to run more slowly in the second section of the course is that they reduced speed when they actually reached the trough. The second reason might have been because they were tired, but it is not thought that this is the whole explanation and it needs more detailed study in the future.

The return running speed was not related at all to the length of the period of food deprivation before feeding. This suggests that once the pigs were satiated some other kind of motivation became dominant. They were motivated in the first short period of time either by exploration and/or feeding motivation. The occurrence of which kind of motivation appeared to depend on the individual.

Part 2

The selection of a five hour period of food deprivation was because in part 1, the results showed that ten hours of food deprivation caused the maximum running speed, so, in order to test for social facilitation, a period of food deprivation causing less than the maximum running speed was chosen.

The selection of one hour of food deprivation as the lower level for feeding motivation, instead of no food deprivation, was because the pigs may not even run without any food deprivation.

From the results of total food intake, total feeding time and running speed there was a clear indication that with high motivation the pigs ran faster when they were in pairs than when alone. This shows positive social facilitation. When pigs had a low feeding drive the results from running speed and total feeding time was reduced by the social conditions.

These results strongly support Zajonc's theory (1965, 1969) on the causes of social facilitation, which was discussed in detail in the literature review. The explanation of the present results by means of Zajonc's theory is as follows.

When the animal had a higher feeding drive the presence of a conspecific energizes the dominant responses (feeding) at the expense of the subordinate ones (the other behaviour). This effect in this situation caused the pigs to eat more, eat longer and run faster when paired than when they were alone. When the animal had a low feeding drive then the presence of a conspecific may have energized other behaviour, rather than eating, and in that case the pigs ate less in pairs than when alone.

Another interesting result is that the pigs deprived of food

for one hour in the 51 Treatment not only ran faster than they did in the D1 and S1 Treatments, but also the total feeding time of the pigs deprived for one hour was higher in the 51 Treatment than in the same pigs in D1 and S1 Treatments and about the same in D5 and S5 Treatments.

These results suggest that the pig with a low feeding drive could not reach its highest level of food intake or running speed when accompanied by another pig with a low feeding drive or when eating alone. However the performance of the pig was facilitated by the presence of a pig with a high feeding motivation.

### Part 3

The results of this part once again showed that the pigs ran faster in pairs than when alone, when they had been deprived of food for five hours.

The results of this part of the experiment showed that the incentive to feed could be reduced at the end of the course. Although the running speed of the pigs at the frustrating stage during the first three days (D3, D4, and D5) was faster than the pigs in D2 (individually run), the significance decreased between D6 and D2.

This raises two interesting points. (1) Why did the frustrated inferior pig still run - and run fairly quickly? The results from a study on dogs (Vogel, Scott and Marston, 1950) suggested that allelomimetic behaviour caused the frustrated dogs to run. On the other hand, the extinction rate was slower in pigs and dogs when they were in a social situation. In the present experiment the frustrated inferior pigs were only run eight times and

whether or not these pigs would continue to run with prolonged frustration is not certain.

However it also could be argued that the pigs show allelomimetic behaviour easily, so that the slow extinction rate was due to their allelomimetic behaviour. This idea is supported by some evidence, in that if the animals do not show allelomimetic behaviour, like the cat, then the lack of reward of food would result in no positive social facilitation for the winner and a definite social interference for the losers (Winslow, 1944). Whether the extinction rate is slowed down by allelomimetic behaviour is still not clear and further study on this subject is required.

In an experiment with dogs, Scott and McCray (1967) rewarded each dog when it ran singly on alternate days. On the other days two dogs were run together but the inferior dog was never rewarded at the end of the run. Under these conditions it may be difficult to produce frustration, as all the dogs were rewarded on alternate days when run singly. The present experiment frustrated the inferior pigs continuously from day 3 onwards in order to produce a clear result of frustration on running speed, and indeed the present results showed that some animals learned quickly for they reduced their running speed after only one experience of frustration while others were slower to learn. Kratzer (1971) suggested that the learning ability of pigs varied according to the individual.

Part 1 of the experiment showed that the running speed of pigs deprived of food for one hour could be facilitated by a pig deprived of food for five hours. This part of the experiment showed that the non-frustrated, dominant pigs, ran slower in

Treatments 3 to 6 than in Treatment 1 and this may be due simply to the influence of the decreased running speed of the frustrated inferior pig.

Vogel, Scott and Marston (1950) suggested that social facilitation is more important for slow animals than for the faster ones but the present result shows that both slow and fast pigs were facilitated by the social environment. The problem with the fast animal is that if the speed is already near the upper limit of its ability then it may not easily be facilitated by other factors.

TABLE 12.1 The effect of length of food deprivation time on feeding activities and running speed of pigs

	1	5	10	15	20	se of difference	level of difference
Length of food deprivation (hours)	0.267	0.469	1.093	1.176	1.228	0.111	****
Food intake (kg)	460	726	1659	1865	1996	174.7	****
Total feeding time (seconds)	0.581	0.614	0.669	0.649	0.630	0.035	NS
Eating speed (g/second)	32.3	22.3	13.9	13.7	13.4	3.6	****
Running speed (seconds for first section)	28.2	25.2	19.7	18.6	19.4	3.2	*
Running speed (seconds for second section)	60.5	47.5	33.6	32.3	32.8	5.8	****
Running speed (seconds for whole course)	494	195	3	2	2	57.8	****
Wandering (seconds)	23.0	30.7	21.5	26.9	30.5	7.0	NS
Return running speed (seconds for first section)	16.7	23.5	16.8	17.8	18.2	2.6	NS
Return running speed (seconds for second section)	39.7	54.2	38.3	44.7	48.7	7.6	NS
Return running speed (seconds for whole course)							

\*\*\*\* -  $p < 0.001$ , \* -  $p < 0.05$ , NS - no significant difference

TABLE 12.2 The effect of treatment on feeding activities and running speed of pigs

Treatment <sup>φ</sup>	D5	S5	D1	S1	S1	se of difference	level of significance
Food intake (kg)	1.122	0.983	0.334	0.402	1.045	0.089	****
Total feeding time (seconds)	1204	1076	472	508	1249	93.8	****
Eating speed (g/second)	0.472	0.463	0.349	0.391	0.422	0.032	*
Running speed (seconds for first section)	7	13	289	243	10	102.7	*
Running speed (seconds for second section)	11	14	28	18	13	3.1	****
Running speed (seconds for whole course)	18	27	317	261	23	104.6	*
Return running speed (seconds for first section)	13	16	27	19	15	7.7	NS
Return running speed (seconds for second section)	33	15	40	33	21	13.4	NS
Return running speed (seconds for whole course)	46	31	67	52	36	14.4	NS

<sup>φ</sup> - see text for details

\*\*\*\* -  $p < 0.001$ , \*\*\* -  $p < 0.005$ , \* -  $p < 0.05$ , NS - no significant difference

TABLE 12.3 The effect of feeding in pairs and alone on feeding activities of pigs

Treatment	Feeding in pairs	Feeding alone	se of difference	level of significance
Food intake (kg)	1.326	1.075	0.105	NS
Total feeding time (seconds)	1362	1115	114.9	NS
Eating speed (g/second)	0.495	0.491	0.025	NS

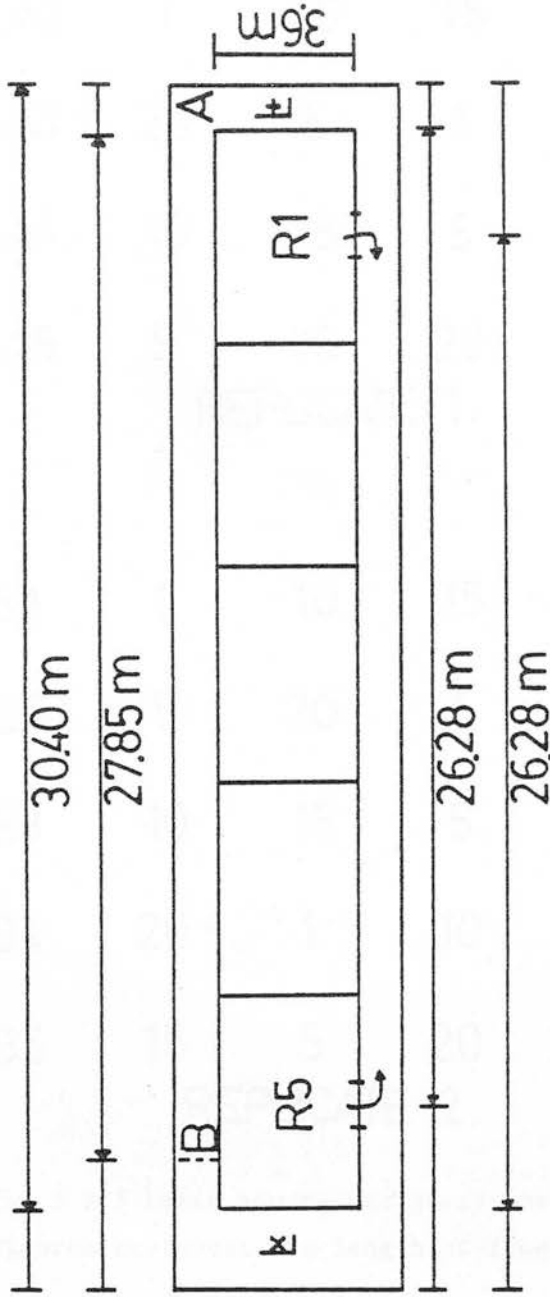
TABLE 12.4 The effect of social facilitation and frustration on running speed of pigs

Treatment $\phi$	1	2	3	4	5	6	se of difference	level of significance
Running speed (seconds for first section)	4.7	12.5	5.9	7.0	8.1	9.9	2.2	*
Running speed (seconds for second section)	12.9	14.9	13.5	12.9	12.6	13.9	0.7	NS
Running speed (seconds for whole course)	17.6	27.4	19.4	19.9	20.7	24.8	2.4	**

$\phi$  - see text for details

\*\* -  $p < 0.01$ , \* -  $p < 0.05$

FIGURE 12-1



R = ROOM. K = L area for part 1      B = 1 area for parts 2 and 3

Plan of development house for running experiment in Chapter 12

PIG NO. A1	15	1	10	5	20
A2	1	20	15	10	5
A3	20	5	1	15	10
A4	10	15	5	20	1
A5	5	10	20	1	15
REPLICATE 1.					
B1	1	10	15	20	5
B2	5	20	1	15	10
B3	10	15	5	1	20
B4	20	1	10	5	15
B5	15	5	20	10	1
REPLICATE 2.					

The 5 x 5 Latin square design in part 1 of Chapter 12.  
 Figures represent the length of food deprivation.

FIGURE 12-3

D5	S5	S1	D1	51
S5	D1	51	S1	D5
D1	S1	D5	51	S5
S1	51	S5	D5	D1
51	D5	D1	S5	S1

**D5** = Two pigs run together and ate together. Both pigs had 5 hour food deprivation before they ran.

**D1** = Two pigs ran alone and ate alone. Both pigs had 5 hour food deprivation before they ran.

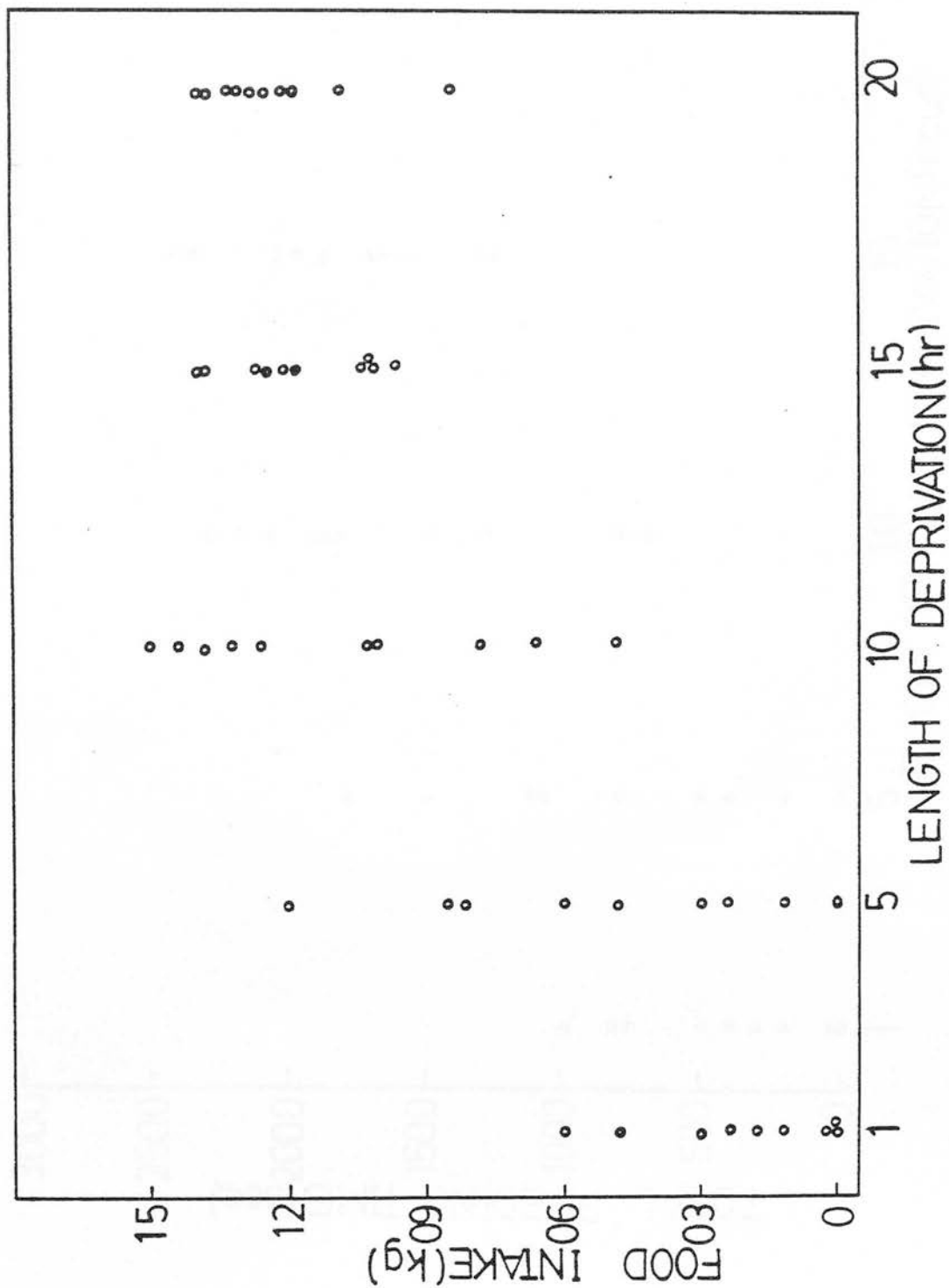
**S5** = Two pigs ran together and ate together. Both had 1 hour food deprivation before they ran.

**S1** = Two pigs ran alone and ate alone. Both had 1 hour food deprivation before they ran.

**51** = Two pigs ran together. One pig had 5 hour food deprivation and the other had 1 hour food deprivation.

The 5 x 5 Latin square design in part 2 of Chapter 12

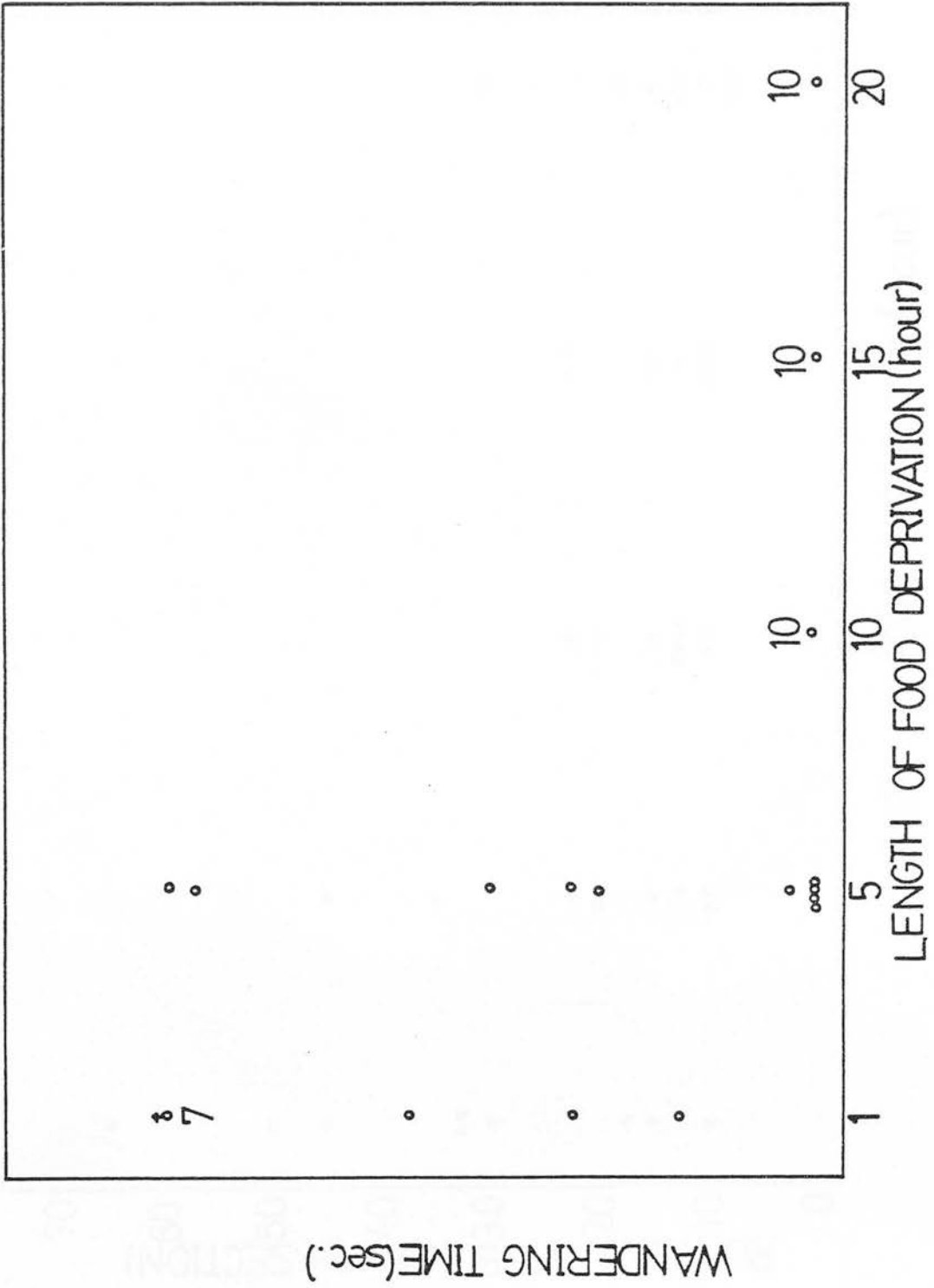
FIGURE 12-4



The effect of the length of food deprivation on food intake of pigs in Chapter 12

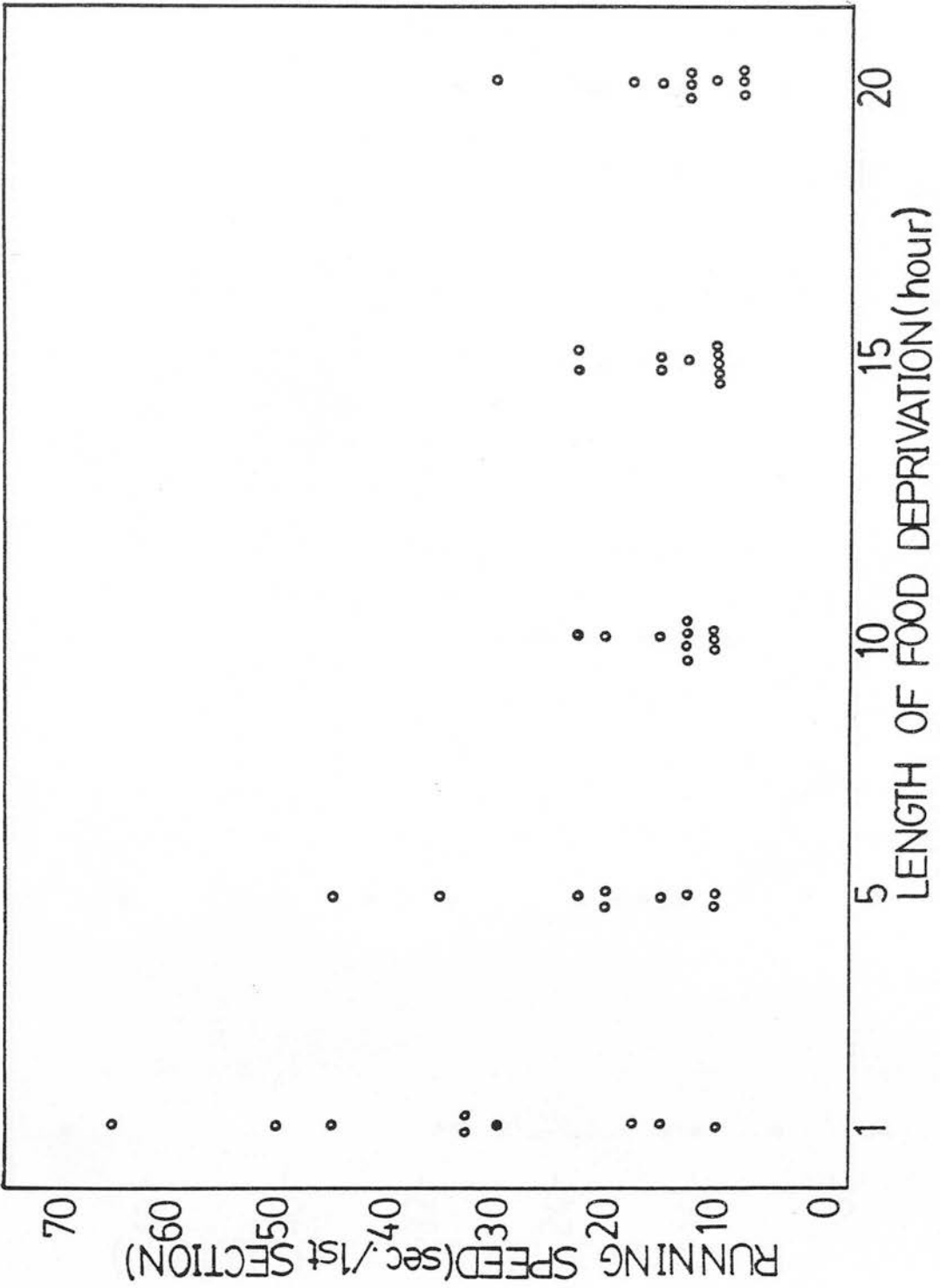


FIGURE 12-6



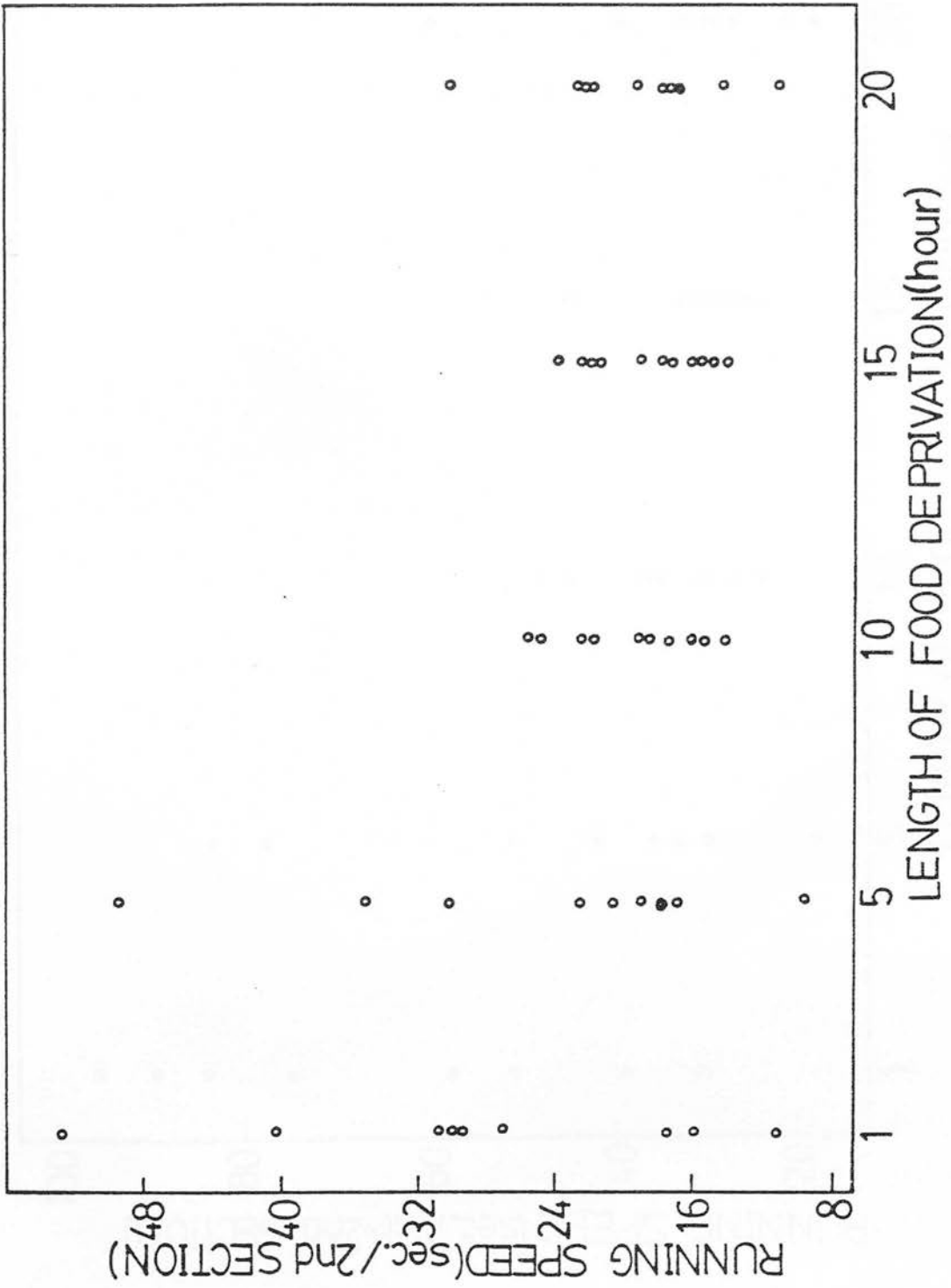
The effect of the length of food deprivation on the wandering time of pigs

FIGURE 12-7



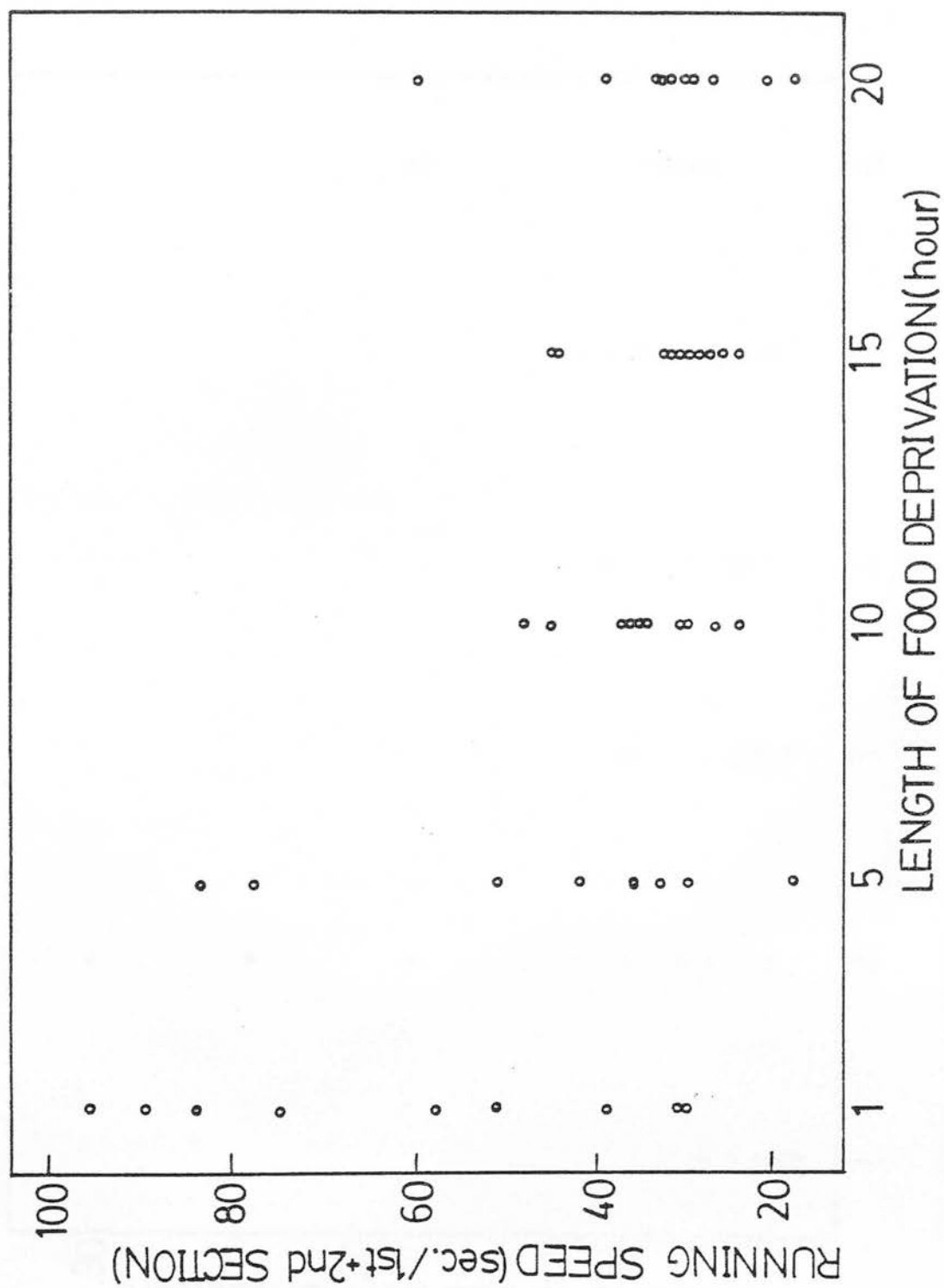
The effect of the length of food deprivation on running speed of pigs on the first section of the course

FIGURE 12-8



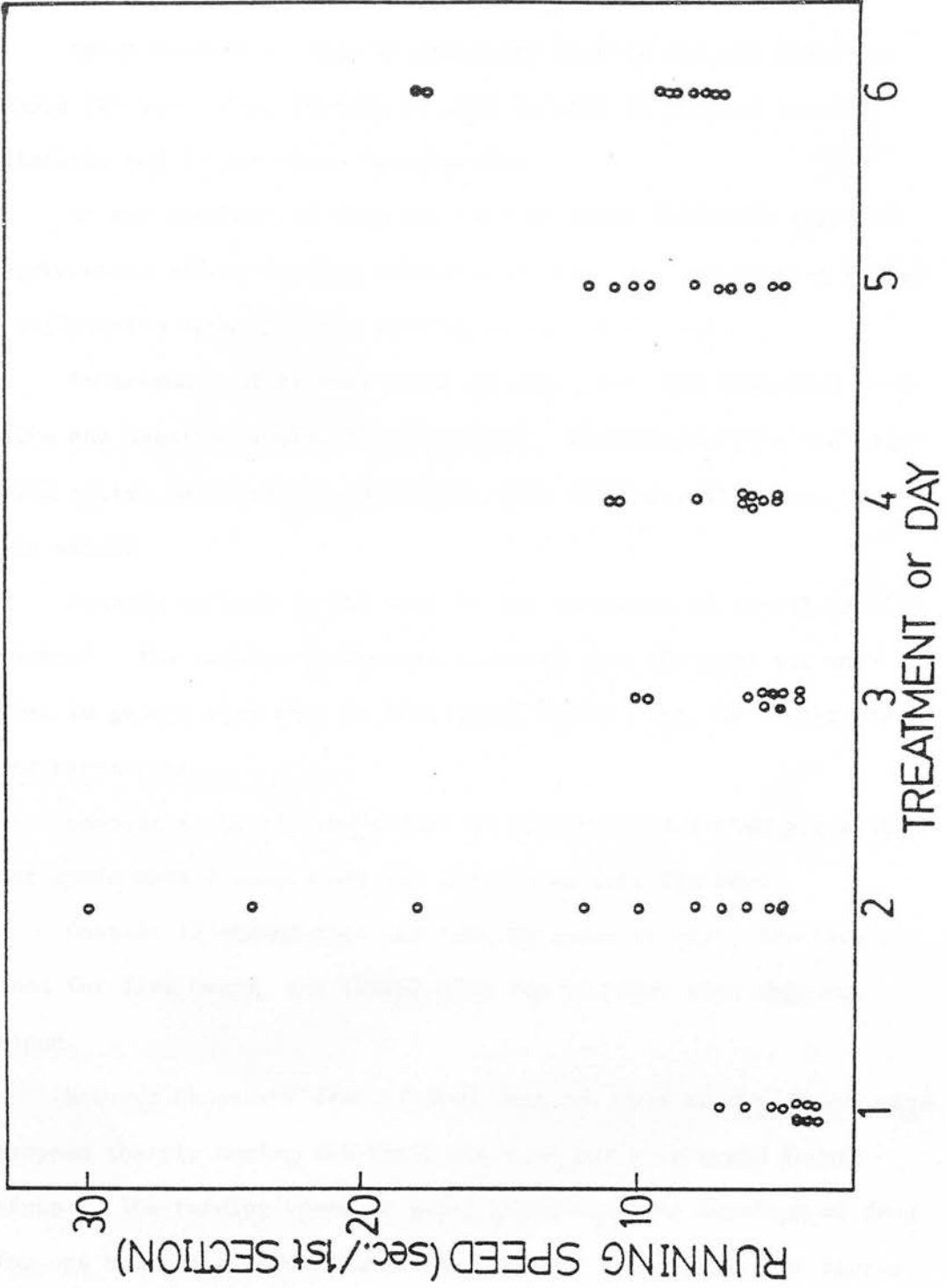
The effect of the length of food deprivation on running speed of pigs on the second section of the course

FIGURE 12-9



The effect of the length of food deprivation on running speed of pigs on the whole course

FIGURE 12-10



The effect of treatment (see text for details) on the running speed of pigs on the first section of the course

GENERAL DISCUSSION

The social facilitation of the feeding behaviour of pigs as reported in the results will be discussed.

Group feeding of pigs is generally used in the pig industry, while the individual feeding of pigs is used in progeny testing stations and in nutrition experiments.

It was intended to find out whether these different types of environment affect feeding behaviour differently and whether social facilitation occurs in the feeding behaviour of pigs.

Furthermore if it does occur in pigs, does one find both positive and negative social facilitation? If both positive and negative social facilitation can occur, then which factors cause one or the other?

Finally we have to ask what is the causation of social facilitation? The results in Chapter 4 showed that the pigs ate more when in groups than when in individual stalls, but the results were not consistent.

Chapter 8 clearly shows that an apparently satiated pig went to eat again when a hungry pig was introduced into the room.

Chapter 12 showed that the running speed of pigs, deprived of food for five hours, was faster when run in pairs than when run alone.

However Chapter 7 demonstrated that the food intake of the pigs dropped sharply during the first day when put in a newly formed group. The running speed of pigs, which had been deprived of food for one hour only, showed that they did not necessarily run faster in pairs than when they were alone.

All this evidence strongly supports the hypothesis that social facilitation occurs in the feeding behaviour of pigs. These results also demonstrated that not only positive social facilitation can happen in the feeding behaviour of pigs but also negative social facilitation.

The next question is - How do the social environments cause these different results? What are the causal factors?

#### Allelomimetic behaviour

The pigs demonstrated allelomimetic behaviour as shown in Chapter 3. In that chapter the pigs tended to eat at the same time, even when they were kept in adjacent stalls. As mentioned before, this behaviour may stimulate some pigs to eat more but it may also cause some pigs to eat less, due to more skirmishes.

Although the results show an increase in the food intake of pigs which were fed in groups, the results (Chapter 4) also show a decrease in total feeding time for the socially inferior pigs when only one feeding space was provided.

If we add all the feeding times of the pigs together in the single trough treatment (Chapter 4), then it is seen that there is a period of one to two hours without any pigs eating at all, ie they were all sleeping at the same time. It also indicates that they tended to eat at the same time. This finding shows that the socially inferior pigs had shorter total feeding times because of competition and that the competition is caused by the allelomimetic behaviour. If the inferior pigs had not done the same thing, at the same time as the others, then they could still have found time to eat alone.

### Competition

The results of Chapter 4 showed that moderate competition produced an increase in food intake in a group of four pigs.

Unfortunately the food intake of the individual pigs could not be ascertained so that one cannot be certain that all the pigs benefited from that social environment. It is possible that competition caused a dominant pig to eat more and the inferior pig to eat less.

Chapter 7 demonstrated that the serious competition in newly-formed groups did cause a sharp drop in food intake.

### The social hierarchy

The results in Chapter 8 clearly demonstrated that the pigs with different social ranks reacted differently to a particular social environment.

The apparently satiated dominant pigs reacted more strongly than the apparently satiated inferior pigs to the introduction of a hungry pig.

This may suggest that the dominant pig had a low threshold to the social environment, so that it was more easily stimulated by the social environment. Whether this suggestion is true or not needs further study.

On the other hand, the results in Chapter 7 showed that the temporary group of dominant pigs ate more than the temporary group of other pigs. Thus it may also suggest that the dominant pigs in that experiment had a higher feeding drive.

### The physical characteristics of the food

The results of Chapter 10 showed that the pigs spent nearly twice as much time in eating meal than in eating pelleted food. In that experiment the results also demonstrated that there was no reduction in food intake or feeding time in the group. If only one feeding space was provided or if food was provided for only four to six hours, then there would have been a reduction in food intake and feeding time. That is because most pigs under these conditions need at least around 1.5 hours feeding time, so that if feeding space is reduced or the time allowed for feeding is reduced, then the inferior pigs will be forced to decrease their feeding times, for there will not be enough time for them to take their turn properly.

### Group size

Chapter 10 showed that the food intake of eight pigs in individual stalls was not significantly less than their food intake when fed in groups.

This finding was different from the results of Chapter 4, in which the food intakes of four pigs in individual stalls were, on average, significantly less than their food intake when in groups.

It is possible that these results indicate that stimulation increases when the number of individually fed pigs in a room increases.

### The eating speed of the other pig

Due to difficulty of arranging a companion pig with a high eating speed, the results of Chapter 11 show that the food intake of a subject pig was not influenced by length of food deprivation of

the companion pig. It may also have shown that five hours food deprivation is enough and that it makes the subject pig eat at its maximum level.

#### Other activities

Other activities not related to feeding, by a companion pig, may have disturbed the feeding of the subject pigs but not their total food intake.

Chapter 11 shows that the one hour food deprived heavy pigs had a lot of activities unrelated to feeding which caused also the subject pigs to show low eating speeds as well.

#### The causation of social facilitation

Although the above factors could influence the results of social facilitation they do not explain its causation. The question is whether Zajonc's theory (1965) of social facilitation is suitable for pigs.

Chapter 12 demonstrates quite clearly that the balance between the drive to feed and other drives is very important.

When the feeding drive was high, then the social environment energized the dominant response - feeding. On the other hand, when the feeding drive was low, then the social facilitation of feeding behaviour may decrease in a social environment.

The conclusion here is that social facilitation can be influenced by many factors. However, whether one finds positive or negative social facilitation depends on the dominant drive, so that if the drive under investigation is the dominant one, positive social facilitation will occur; if it is not the dominant one,

then negative facilitation will occur.

The use of *ad lib* feeding in groups of pigs may not be the best way to induce pigs to eat more because the feeding drive may be low all the time and may not easily become the dominant drive. If a method of feeding is used in which the drive to feed can be high, then one might be able to induce positive social facilitation of feeding.

REFERENCES

- ADAMS, G. 1975. Some Effects of Social Environment on Voluntary Feed Intake in Pigs. MSc Thesis. Aberdeen University.
- ALLEE, W.C., PARK, O., EMERSON, A.E. and SCHMIDT, K.P. 1949. Principles of Animal Ecology. Saunders. Philadelphia.
- ALLPORT, F.H. 1924. Social Psychology. Houghton Mifflin. Boston.
- ANDREW, R.J. 1975. Arousal and the causation of behaviour. Behaviour 51, 135-165.
- ARMSTRONG, E.A. 1951. The nature and function of animal mimesis. The Bulletin of Animal Behaviour 1(9), 46-58.
- ARNOLD, G.W. 1962. The influence of several factors in determining the grazing behaviour of Border Leicester x Merino sheep. J. Br. Grassland Soc. 17, 41-51.
- AUMAÎTRE, A. 1980. Palatability of piglet feeds: trial methods and practical results. In 'Palatability and Flavor Use in Animal Feeds' (ed H. Bickel) Verlag Paul Parey. Hamburg and Berlin.
- BALDWIN, B.A. 1980. Operant studies and preference tests on the role of olfaction and taste in the ingestive behaviour of pigs and ruminants. In 'Palatability and Flavor Use in Animal Feeds' (ed H. Bickel) Verlag Paul Parey. Hamburg and Berlin.
- BANKART, C.P., BANKART, B.M., and BURKETT, M. 1974. Social factors in acquisition of bar pressing by rats. Psychol. Rep. 34, 1051-1054.
- BARBER, R.S., BRAUDE, R. and MITCHELL, K.G. 1955. Studies on milk production of large white pigs. J. Agric. Sci. Camb. 46, 97-118.

BAYER, E. 1929. Beitrage zur Zweikomponententheorie des Hungers.  
S. Tierpsychol. 112, 1-54.

BECK, G. 1931. Neue beitraege zur Zweikomponententheorie des Hungers. Z. Tierpsychol. 118, 283-349.

BEILHARZ, R.G. and COX, D.F. 1967. Social dominance in swine.  
Animal Behaviour 15, 117-122.

BEUERLE, W. 1975. Field observations on the aggressive and sexual behaviour of the European Wild Hog. Z. Tierpsychol. 39, 211-258.

\*

BRAUDE, R. 1948. Some observations on the behaviour of pigs in an experimental piggery. Bull. Animal Behaviour 1, 17-24.

BRIEDERMAN, L. 1971. Ermittlungen zur Aktivitätsperiodik des Mitteleuropäischen Wildschweines (*Sus Scrofa* L) Zool. Gart. Lpz. 40, 302-327.

BROEN, W.E. and STORMS, L.H. 1961. A reaction potential ceiling and response decrements in complex situations. Psychological Review 68, 405-415.

BROWN, C.P. and KIELY, P.C. 1974. The role of early experience and emotionality in social facilitation of pecking in chickens. Animal Behaviour 22, 100-109.

CHEN, S.C. 1937. Social facilitation of the activity of ants in nest building. Physiol. Zool. 10, 420-436.

CLAYTON, D.A. 1976. The effects of pre-test conditions on social facilitation of drinking in ducks. Anim. Behav. 24, 125-134.

\* Bowland, J.P. and Standish 1966. Influence of fasting, water deprivation and stress on carcass shrink of pigs and rats. J. Anim.Sci. 25, 377 - 380.

- CLAYTON, D.A. 1977. Social facilitation of drinking in flocks with both water deprived and non-deprived ducklings. *Biol. of Behaviour* 2, 171-179.
- CLAYTON, D.A. 1978. Socially facilitated behaviour. *The Q. Rev. of Biol.* 53, 373-390.
- CLOSE, W.H. and MOUNT, L.E. (1975). The rate of heat loss during fasting in the growing pig. *Br. J. Nutr.* 34, 279.
- COLLIAS, N.E. 1952. The development of social behaviour in birds. *Auk* 69, 127-159.
- CRAWFORD, M.P. 1939. The social psychology of the vertebrates. *Psychol. Bull.* 36, 407-446.
- CSERMELY, D. and WOOD-GUSH, D.G.M. 1981. Artificial stimulation of ingestive behaviour in early-weaned piglets. *Biol. of Behaviour* 6, 159-165.
- DANTZER, R. 1970. Retissement du comportement social sur le gain des poids chez des porcs en croissance. 11. Perturbation liées au melonge d'animaux et au changement de loge. *Annl. Rech. Vet.* 1, 117-127. (Cited by Signoret, Baldwin, Fraser and Hafez, 1975. *The Behaviour of Swine on the Behaviour of Domestic Animals* (3rd edition) (ed E.S.E. Hafez) Bailliere Tindall, London.
- DANTZER, R. 1971. Influence of social behaviour on weight gain of growing pigs. 1. Social behaviour, feeding time and weight gain. *Nutr. Abstr. and Rev.* 141, 297.
- DAVITZ, J.R. and MASON, D.J. 1955. Socially facilitated reduction of a fear response in rats. *J. Comp. Physiol. Psychol.* 48, 149-151.

- DENI, R. and JORGENSEN, B.W. 1976a. Inhibition of fixed interval bar-pressing in rats during exposure to a trained companion. *Psychol. Rep.* 39, 243-246.
- DENI, R. and JORGENSEN, B.W. 1976b. Social inhibition of bar-pressing in undeprived rats. *Bull. Psychon. Soc.* 7, 487-488.
- EMLLEN, J.T. 1957. Defended area? A critique of the territory concept and of conventional thinking. *Ibis* 99, 352.
- EWBANK, R. 1969. Social behaviour and intensive animal production. *The Vet. Rec.* 16, 183-186.
- EWBANK, R. and BRYANT, M.J. 1972. Aggressive behaviour amongst groups of domesticated pigs kept at various stocking rates. *Anim. Behav.* 20, 21-28.
- EWBANK, R. and MEESE, G.B. 1971. Aggressive behaviour in groups of domesticated pigs on removal and return of individuals. *Anim. Prod.* 13, 685-693.
- EWBANK, R., MEESE, G.B. and COX, J.E. 1974. Individual recognition and the dominance hierarchy in the domesticated pig. The role of sight. *Anim. Behav.* 22, 473-480.
- FRADRICH, H. 1974. A comparison of behaviour in the Suidae. In 'The Behaviour of Ungulates and its Relation to Management'. Vol. 1. (ed V. Geist and F. Walther) IUCN Publications. New Series No 24.
- FRANK, L.H., and MEYER, M.E. 1974. Social facilitation in the chick. Evidence for facilitation of learning. *Bull. Psychon. Soc.* 3, 196-198.
- FRASER, A.F. and HERCHEN, H. 1979. The behaviour of liberated livestock. *Appl. Anim. Ethol.* 5, 95-101.

- FRASER, D. 1974. The behaviour of growing pigs during experimental social encounters. *J. Agric. Sci. Camb.* 82, 147-163.
- FRASER, D. 1975. The 'teat order' of suckling pigs. II. Fighting during suckling and the effect of clipping the eye teeth. *J. Agric. Sci. Camb.* 85, 393-399.
- FRASER, D. 1978. Observations on the behavioural development of suckling and early-weaned piglets during the first six weeks after birth. *Anim. Behav.* 26, 22-30.
- FRIEND, D.W. 1971. Self-selection of feeds and water by swine during pregnancy and lactation. *J. Anim. Sci.* 32, 658.
- FRIEND, D.W. 1973. Self-selection of feeds and water by unbred gilts. *J. Anim. Sci.* 37, 1137-1141.
- FRIEND, D.W. and CUNNINGHAM, J.M. (1966). The effect of water consumption on the growth, feed intake and carcass composition of suckling piglets. *Canad. J. Anim. Sci.* 46, 203-209.
- GRAVES, H.B., and GRAVES, K.L. 1978. Some observations on biobehavioural adaptations of swine. In 'Research and Management of Wild Hog Populations' (ed G.W. Wood). Bell W Baruch Forest Science Institute of Clemson University, Georgetown, South Carolina.
- GRAVES, H.B., GRAVES, K.L. and SHERRITT, G.W. 1978. Social behaviour and growth of pigs following mixing during the growing-finishing period. *Appl. Anim. Ethol.* 4, 169-180.
- GUHL, A.M. 1962. The social environment and behaviour. In 'The Behaviour of Domestic Animals', pp 96-108. (ed E.S.E. Hafez) Williams and Wilkins, Baltimore.
- HALASZ, P. and ZAMBO, I. 1970. Behaviour of fattening pigs given dry meals from self feeders. *Nutr. Abstr. and Rev.* 40, 73.

- HANSEN, L.L. 1977. The stability of the dominance hierarchy in growing pigs in different environments. CIGR Section. II. The Agricultural University of Norway. A seminar on Agricultural Buildings. Behaviour Studies as a Means in Environmental Research. Farmsteads in the Countryside. Small Farms for Milk and Beef Production. Vol. 1, 179-187. ISSN 0105-6883.
- HANSEN, L.L. and HAGELSO, A.M. 1978. An *ad libitum* system as a means of avoiding the negative effects of social facilitation on feeding behaviour in pigs. First World Congress on Ethology Applied to Zootechnics 3, 73.
- HARLOW, H.F. 1932. Social facilitation of feeding in the albino rat. J. Genet. Psychol. 41, 211-221.
- HARLOW, H.F. and YUDIN, H.C. 1933. Social behaviour of primates. 1. Social facilitation of feeding in the monkey and its relation to attitudes of ascendance and submission. J. Comp. Psychol. 16, 171-185.
- HARTSOCK, T.G. and GRAVES, H.B. 1976. Piglet fighting behaviour, nursing order and growth. J. Anim. Sci. 43, 209.
- HARTSOCK, T.G., GRAVES, H.B. and BAUMGARDT, B.R. 1977. Agonistic behaviour and the nursing order in suckling piglets: Relationships with survival, growth and body composition. J. Anim. Sci. 44, 320-330.
- HARTMAN, D.A., LUDWICK, T.M. and WILSON, R.F. 1962. Certain aspects of lactation performance in sows. J. Anim. Sci. 21, 883-886.

- HEDIGER, H. 1949. Saugetier-Territorien und ihre Markierung. *Bijd. Dierk.* 28, 172-184. In 'Behaviour and Environment: The Use of Space by Animals and Men'. pp 26-27. (ed A.H. Esser) Plenum Press. New York - London, 1971.
- HEITMAN, H. Jr., HAHN, L., KELLY, C.F. and BOND, T.E. 1961. Space allotment and performance of growing finishing swine raised in confinement. *J. Anim. Sci.* 20, 543-546.
- HINDE, R.R. 1953. The term 'Mimesis'. *Br. J. Anim. Behav.* 1, 7-12.
- HINDE, R.A. 1970. *Animal Behaviour: A Synthesis of Ethology and Comparative Psychology.* (2nd edition). McGraw Hill, New York.
- HOUPT, K.A. and HOUPT, T.R. 1976. Comparative aspects of the ontogeny of taste. *Chem. Senses Flavor* 2, 219.
- HOUPT, K.A., HOUPT, T.R. and POOND, W.G. 1979. The pig as a model for the study of obesity and of control of food intake: A review. *The Yale J. Biol. Med.* 52, 307-329.
- HOYENGA, K.T. and AESCHILEMAN, S. 1969. Social facilitation of eating in the rat. *Psychon. Sci.* 14, 239-241.
- INGRAM, D.L., WALTERS, D.E. and LEGGE, K.F. 1980. Variations in moto activity and in food and water intake over 24 h periods in pigs. *J. Agric. Sci. Camb.* 95, 371-380.
- JACOBS, H.L. and SHARMA, K.N. 1962. Taste versus calories: sensory and metabolic signals in the control of food intake. *Annals New York Academy of Sciences.* Vol. 99, pp 1084-1125.
- JAMES, J.W. 1967. The value of social status to cattle and pigs. *Proceedings of the Ecological Society of Australia* 2, 171-181.

- JAMES, W.T. 1961. Relationship between dominance and food intake in individual and social eating in puppies. *Psychol. Rep.* 8, 478.
- JAMES, W.T. and CANNON, D.J. 1955. Variation in social facilitation for feeding behaviour in puppies. *J. Genet. Psychol.* 87, 225-228.
- JAMES, W.T. and GILBERT, T.F. 1955. The effect of social facilitation on food intake of puppies fed separately and together for the first 90 days of life. *Br. J. Anim. Behav.* 3, 131-133.
- JENSEN, P. 1980. An ethogram of social interaction patterns in group housed dry sows. *Appl. Anim. Ethol.* 6, 341-350.
- JONSSON, P. 1959. Investigations on group feeding versus individual feeding and on the interaction between genotype and environment in pigs. *ACTA Agric. Scand.* 9, 204-228.
- KLOPFER, P.H. 1957. Empathic learning in ducks. *Amer. Nat.* 91, 61-63.
- KLOPFER, P.H. 1959. Social interactions in discrimination learning with special reference to feeding behaviour in birds. *Behaviour* 14, 282-299.
- KLOPFER, P.H. 1961. Observational learning in birds: The establishment of behaviour modes. *Behaviour* 14, 282-299.
- KRATZER, D.D. 1971. Learning in farm animals. *J. Anim. Sci.* 32, 1268-1273.
- KVASNITSKII, A.V. 1951. Voprosy fiziologii pishchevareniyau svinei. *Sel'khozgiz, Moscow*. In 'Digestion in the Pig' (p 4) (ed D.E. Kidder and M.J. Manners). Scientifica, Bristol.
- LATANE, B. and CAPPELL, H. 1972. The effects of togetherness on heart rate in rats. *Psychon. Sci.* 29, 177-179.

- LE MAGNEN, J. and DEVOS, M. 1970. Metabolic correlates of the meal onset in the free food intake of rats. *Physiol. Behav.* 5, 805-814.
- LEVINE, J.M. and ZENTALL, T.H. 1974. Effect of a conspecific's presence on deprived rats' performance: Social facilitation v distraction/imitation. *Anim. Learn. Behav.* 2, 119-122.
- LIDDELL, H. 1950. Some specific factors that modify tolerance for environmental stress. *Res. Publ. Ass. Nerv. Ment. Dis.* 29, 155-171.
- LODGE, G.A. and PRATT, P.D. 1963. Birth weight and the subsequent growth of suckled pigs. *Anim. Prod.* 5, 225.
- MASON, J.W. and BRADY, J.V. 1956. Plasma 17-hydroxycorticosteroid changes related to reserpine effect on emotional behaviour. *Sci.* 124, 983.
- MASSERMAN, J.H. 1943. *Behaviour and Neurosis*. University of Chicago Press.
- McBRIDE, G., JAMES, J.W. and HODGENS, N. 1964. Social behaviour of domestic animals. IV. Growing pigs. *Anim. Prod.* 6, 129-139.
- McBRIDE, G., JAMES, J.W. and WYETH, G.S.F. 1965. Social behaviour of domestic animals. VII. Variation in weaning weight in pigs. *Anim. Prod.* 7, 67-74.
- MEESE, G.B. 1973. *Behavioural Studies in the Domesticated Pig with especial reference to the Social Hierarchy*. PhD Thesis, University of Liverpool.
- MEESE, G.B., CONNER, D.J. and BALDWIN, B.A. 1975. Ability of the pig to distinguish between conspecific urine samples using olfaction. *Physiol. Behav.* 15, 121.

- MEESE, G.B. and EWBANK, R. 1972. A note on instability of the dominance hierarchy and variations in level of aggression within groups of fattening pigs. *Anim. Prod.* 14, 359-362.
- MEESE, G.B. and EWBANK, R. 1973. The establishment and nature of the dominance hierarchy in the domesticated pig. *Anim. Behav.* 21, 326-334.
- METZ, J.H.M. 1975. 'Time Patterns of Feeding and Rumination in Domestic Cattle'. Department of Animal Husbandry, Agricultural University, Wageningen, The Netherlands.
- MORSE, D.H. 1974. Niche breadth as a function of social dominance. *Amer. Nat.* 108, 818-830.
- NICHOLSON, A.J. 1954. An outline of the dynamics of animal populations. *Aust. J. Zool.* 2, 9-65.
- NIWA, T.I., YOKOYAMA, S. and OTSUKA, M. 1951. Studies on milk secretion in the sow. 1. On nursing habits, milk yield, milk composition, etc. *Bull. Nat. Inst. Atri. Sci., Tokio.* 1, 135.
- NOBLE, G.K. 1939. The role of dominance on the social life of birds. *Auk* 56, 263-273.
- OLSSON, O. and CLAEISSON, O. 1978. Individual feeding of pigs in groups by biological fixation. *First World Congress on Ethology Applied to Zootechnics* 3, 79.
- ONDERSCHEKA, K. 1970. Quality and composition of sow's milk in relation to the growth of piglets. *Wien Tierarztl Monatsschr.* 56, suppl. 5-40.
- ORR, D.E. 1980. Determination of individual feed ingredient and total ration palatability. In 'Palatability and Flavor use in Animal Feeds' (ed. H. Bickel) Verlag Paul Parey. Hamburg and Berlin.

- PENGUIN DICTIONARY OF PSYCHOLOGY. 1964. (ed. J. Drever. Revised H. Wallerstein).
- POND, W.G. and HOUP, K.A. 1978. 'The Biology of the Pig'. Cornell University Press, Ithaca.
- PREMACK, D. and PREMACK, A.J. 1963. Increased eating in rats deprived of running. *Journal of The Experimental Analysis of Behaviour* 6, 209-212.
- SAVORY, C.J. 1981. Correlations between meals and inter-meal intervals in Japanese Quail and their significance in the control of feeding. *Behav. Processes* 6, 23-36.
- SCHEEL, D.E., GRAVES, H.B. and SHERRITT, G.W. 1977. Nursing order, social dominance and growth in swine. *J. Anim. Sci.* 45, 219-229.
- SCOTT, J.P. and McCRAY, C. 1967. Allelomimetic behaviour in dogs: negative effects of competition in social facilitation. *J. Comp. Physiol. Psychol.* 63, 313-319.
- SHELLEY, H.P. 1965. Eating behaviour: social facilitation or social inhibition? *Psychon. Sci.* 3, 521-522.
- STAMM, J.S. 1961. Social facilitation in monkeys. *Psychol. Rep.* 8, 479-484.
- STEINBACH, J. 1978. Diurnal behaviour patterns of pigs in a tropical environment. *First World Congress on Ethology Applied to Zootechnics* 3, 73.
- STEPHENS, D.B. 1975. Effects of gastric loading on the sucking response and voluntary milk intake in neonatal pigs. *J. Comp. Physiol. Psychol.* 88, 796-805.
- STRONGMAN, K.T. 1975. The effect of anxiety on food intake in the rat. *Q. J. Exp. Psychol.* 17, 255-260.

- SYME, G.J., POLLARD, J.S., SYME, L.A. and REID, R.M. 1974. An analysis of the limited access measure of social dominance in rats. *Anim. Behav.* 22, 486-500.
- THIESSEN, D.D. 1964. Population density and behaviour: A review of theoretical and physiological contributions. *Tex. Rep. Biol. Med.* 22, 266-314.
- TINDSLEY, W.E.C. 1979. Group Behaviour of Growing Pigs in Relation to Production. PhD thesis. University of London.
- TOLMAN, C.W. 1964. Social facilitation of feeding behaviour in the domestic chick. *Anim. Behav.* 12, 245-251.
- TOLMAN, C.W. 1967. The feeding behaviour of domestic chicks as a function of rate of pecking by a surrogate companion. *Behaviour* 29, 57-62.
- TOLMAN, C.W. 1968. The role of the companion in social facilitation of animal behaviour. In 'Social Facilitation and Imitative Behaviour', pp 33-54. (eds. E.C. Simmel, R.A. Hope and G.A. Milton). Allyn and Bacon, Boston.
- TOLMAN, C.W. and WELLMAN, A.W. 1968. Social feeding in domestic chicks: a test of the disinhibition hypothesis. *Psychon. Sci.* 11, 35-36.
- TOLMAN, C.W. and WILSON, G.F. 1965. Social feeding in the domestic chick. *Anim. Behav.* 13, 134-142.
- TRIPLETT, N. 1897-1898. The dynamogenic factors in pacemaking and competition. *Amer. J. Psychol.* 9, 507-533.
- TURNER, E.R.A. 1964. Social feeding in birds. *Behaviour* 24, 1-46.
- VOGEL, H.H., SCOTT, J.P. and MARSTON, M. 1950. Social facilitation and allelomimetic behaviour in dogs. *Behaviour* 2, 121-143.

- WELTY, J.C. 1934. Experiments in group behaviour of fishes. *Physiol. Zool.* 7, 85-128.
- WIEKERT, D.A. and BARR, G.R. 1966. Studies of learning ability in young pigs. *J. Anim. Sci.* 25, 1280.
- WIEPKEMA, P.R. 1968. Behaviour changes in CBA mice as a result of one gold thioglucose injection. *Behaviour* 32, 179-210.
- WIEPKEMA, P.R. 1971. Behavioural factors in the regulation of food intake. *Proceedings of the Nutrition Society* 30, 142-149.
- WILLIS, E.O. and ONIKI, Y. 1978. Birds and army ants. *Annual Review of Ecology and Systematics*, 9, 243-264.
- WILSON, E.O. 1975. 'Sociobiology: The New Synthesis'. The Belknap Press of Harvard University Press.
- WINSLOW, C.N. 1944. The social behaviour of cats. I. Competitive and aggressive behaviour in an experimental runway situation. *J. Comp. Psych.* 37, 279-313.
- WOOD-GUSH, D.G.M. and CSERMELY, D. 1981. A note on the diurnal activity of early-weaned piglets in flat-deck cages at 3 and 6 weeks of age. *Anim. Prod.* 33, 107-110.
- ZAJONC, R.B. 1965. Social facilitation. *Science* 149, 269-274.
- ZAJONC, R.B. 1969. 'Animal Social Psychology: A Reader of Experimental Studies'. John Wiley & Sons, New York.
- ZENTALL, T.R. and LEVINE, J.M. 1972. Observational learning and social facilitation in the rat. *Sci.* 179, 1220-1221.