Section II

EXPERIMENTAL WORK

(The experimental work has been divided into 3 parts each of which is described separately in terms of the materials and methods employed and the results obtained. A discussion of the results from experiments 1 and 2 is included at this stage as these were introductory studies and the results obtained led to the setting up of the major trial in experiment 3).

Chapter 12

EXPERIMENT 1

OBSERVATIONS OF THE FARROWING PERFORMANCE OF SOWS IN 2 COMMERCIAL BREEDING HERDS

12.1 Aim

The aim of this work (which was carried out between April 1980 and September 1981) was to compare the farrowing performance of sows kept under 2 contrasting management systems which allowed differing amounts of exercise.

12.2 Materials and methods

i. Animals and management

A total of 71 sows was used from 2 commercial herds. One herd was located at Harper Adams Agricultural College and these sows were housed in strawed cubicles (figs. 14.4, 14.8) throughout pregnancy before farrowing in conventional crates (figs. 14.11 and 14.14). Throughout gestation the sows were fed a daily ration of 2.5kg sow meal (the composition of which is shown in appendix tables A.5 and A.6) to which approximately 0.25kg bran and 2l of water were added once the sows were transferred into the farrowing house at day 112 of gestation and this ration was continued until farrowing.

The 52 sows involved in this herd were selected at random and included animals from the 1st to the 12th parity, the majority of which were crossbred (Landrace x Large White) as shown in appendix table A.2. As it was management policy to induce farrowing by injecting 1cm^3 of prostaglandin $F_2\alpha$ analogue ('Planate', I.C.I. Ltd.) on day 113, some of the observed sows had been induced, whereas others farrowed before induction took place (table A.2).

The other commercial herd was owned by A. Parry (Farmers) Ltd. and was managed extensively under the Roadnight system. Pregnant sows

Fig 12.1 Housing of the Free Range Sows

were kept in batches of 30–40 animals at a similar stage of gestation on grass leys at a stocking rate of approximately 10 sows/ha. Feeding was on a group rather than an individual basis and varied throughout the season, the level being approximately 2.5kg/sow daily in April but falling to nearer 1.5kg/sow in June and July. The ration was supplied in the form of a commercial sow cob and in addition, sows had constant access to grass.

Housing of the sows involved the use of simple, semi-circular shelters made of corrugated sheets (fig. 12.1). These were placed throughout the field when the sows were turned in at the start of gestation, so that one hut was available for each sow. Approximately half a bale of straw was placed in each hut a few days before the expected farrowing date and this was often augmented by bedding material carried by the sow herself. The 19 sows involved were again selected at random and included animals from the 2nd to the 7th parity and were all crossbred animals (Landrace x British Saddleback) as shown in appendix table A.3. Induction of farrowing was never practised in this herd.

ii. <u>Observations of farrowing</u>

As described above, observations were carried out on farrowing sows selected at random. The imminence of farrowing was assessed by frequent observation of sow behaviour and the state of the mammary secretions. The term "colostrum" was used to designate the straw coloured serous fluid which was usually the first indication of mammary secretions, while "milk" referred to a white secretion. A 4 point code was used to indicate the amount of secretion present (table 12.1).

Table 12.1 Key for recording mammary secretions

C/M -	colostrum/milk	absent
C/M +	" "	present as minute drops
C/M ++	" "	present as large drops
C/M +++	" "	readily expressed from teat

The presence of colostrum or milk in the udder which could be freely expressed by manual massage, together with a general state of restlessness followed by recumbency and tail twitching, was taken to indicate imminent parturition and continuous observation commenced. Throughout the observation period, the observer remained as quiet and unobtrusive as possible; this was quite easy in the case of sows farrowing in crates as the observer could remain seated at the rear of the sow, but it was more difficult in the case of free-range sows as they were able to turn freely.

The time of delivery of each piglet was recorded, along with details of its presentation, the amount of meconium present, the state of the umbilical cord, the time taken to break an intact cord in addition to the times taken to achieve regular breathing and the first successful suckle. Observations regarding sow behaviour were also recorded on a pro-forma sheet (appendix table A.1). Identification of individual piglets was facilitated by the use of spray markers and the complete expulsion of the placenta was taken to indicate the end of farrowing.

12.3 Results

Sow farrowing performance is shown in appendix tables A.2 and A.3

Table 12.2 Summary of sow reproductive performance - experiment 1

(results shown as means ± S.E.)

Herd	Mean number of livebirths	Mean number of stillbirths	Mean duration of farrowing (minutes)	Mean birth interval (minutes)	Mean time taken for cord to break (minutes)	Mean time taken to first successful suckle (minutes)	% born head first	% born with intact cords
Harper Adams Agricultural College. n=52	11.3 ± 0.37	0.6 ± 0.12	153 ± 9.47	14.7 ± 1.06	5.7 ± 0.57	20.5 ± 1.44	65.7 ± 2.97	75.8 ± 3.08
A. Parry (farms) Ltd. n=19	12.6 ± 0.60	0.4 ± 0.21	155 ± 15.52	13.9 ± 1.74	4.8 ± 0.93	12.4 ± 2.22	56.5 ± 4.86	88.1 ± 5.04
Significance (p)	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	< 0.01**	> 0.05	< 0.05*

and a summary is included in table 12.2. The results were subjected to an Analysis of Variance which indicated that there were no significant differences between the herds for most of the reproductive characteristics studied. However, a significantly ($P < 0.05$) higher proportion of the piglets born to the free range sows had intact umbilical cords at birth and they were also quicker to suckle successfully ($P < 0.01$). A discussion of these results is given at the end of experiment 2.

Chapter 13

EXPERIMENT 2

PILOT TRIAL TO INVESTIGATE THE EFFECTS OF RESTRICTED EXERCISE DURING PREGNANCY ON SOW REPRODUCTIVE PERFORMANCE

13.1 Aim

The results from experiment 1 had indicated some differences in farrowing characteristics between sows which had very different opportunities for exercise and so it was decided to investigate this further, in a more controlled trial rather than by using occasional observations. The sows involved in this experiment were all from the Harper Adams herd and the aim of this trial was to examine the feasibility of keeping pregnant sows tethered in a converted cubicle house throughout their gestation, so that all factors other than the amount of exercise available to the sows could be more closely controlled than had been possible in experiment 1. In addition to determining the feasibility of housing sows in a converted building, this experiment was designed to investigate whether such restriction of exercise led to prolonged farrowings and a high stillbirth rate.

13.2 Materials and methods

i. Animals and management

The trial involved a total of 17 sows and took place between September 1980 and June 1981. Sows were selected in pairs at weaning on the basis of matching breed and parity; wherever possible sibs were used. At weaning, sows were placed in a service house and were fed a commercial sow meal (composition shown in tables A.5 and A.6) on a feeding scale of 2.5 kg daily for body condition score of 3 and above, but 3.0 - 3.5 kg daily for sows with condition scores of 2.5 and 2.0 respectively. This feeding regime was continued until service when all sows received 2.5 kg daily until farrowing; as described in experiment 1.

On day 24 following successful service, the sows were transferred to the dry sow house shown in figs 14.4 and 14.5. One member of each pair was tethered by the neck (figs. 14.6 and 14.7), while the other was allowed unrestricted movement around the cubicle and dunging area (fig. 14.8). In practice, sows were moved into the dry sow accommodation in batches of 4 (i.e. 2 pairs), in order to minimise mixing stress between the 2 unrestricted sows in the cubicles.

Conversion of the dry sow house from cubicles only to a combination of cubicles and tether places involved the construction of a sloping floor (to facilitate drainage), the incorporation of a 30cm glazed channel at the front of the tether place (to act as a food and water trough) and the installation of barred gates behind the tethered sows to prevent bullying by the sows in cubicles (fig 14.6). Towards the end of the trial, individual drinkers were fixed just above the trough. Both cubicle and tether places had solid floors to which a thick layer of straw was added daily.

At day 110 of gestation, the sows were transferred to farrowing crates (figs. 14.11, 14.14) where their management was identical to that described for the Harper Adams sows in experiment 1.

ii. <u>Observations of farrowing</u>

Assessment of the imminence of farrowing and observations of the farrowing process were similar to those described in experiment 1.

Table 13.1 Summary of Farrowing Data From Experiment 2

Sow	Parity	Breed	Pregnancy treatment	Farrowing treatment	Induced	Litter size born alive	Litter size born dead	comments	Duration of farrowing (minutes)	mean birth interval (minutes)	mean time to cord breakage (minutes)	mean time to 1st suckle (minutes)	Born head first (%)	Born with cord intact (%)	Placenta expelled (minutes after birth of last pig)
183	7	LW x L/LW	tether	crate	X	12	0	3 crushed by 48 hr post partum	FARROWING UNATTENDED – NO DATA OBTAINED						
3	5	LW	tether	crate	X	18	0	Manual assistance after pig 1	165	9.7±14.3	3.1± 1.56	19.6±15.7	76.5	88.9	with last pig
144	5	L x LW	tether	crate	X	11	0		FARROWING UNATTENDED – NO DATA OBTAINED						
296	3	LW x L/LW	tether	crate	X	17	0	1 piglet soon died	FARROWING UNATTENDED – NO DATA OBTAINED						
221	7	LW x L/LW	tether	crate	/	11	2	pigs 7 & 10 still born	293	24.4±29.9	5.2± 2.2	12.1± 6.7	53.9	100	with last pig
251	7	L x LW	tether	crate	X	9	8	pig 10 mummified 11-17 stillborn	1685	FIRST 9 PIGS BORN AT NIGHT – NO DATA OBTAINED					
39	2	L x LW	tether	crate	X	11	0		73	7.3± 6.7	19.8±16.4	22.1±13.8	90.9	100	?
346	2	L x LW	tether	crate	X	12	1	pig 1 stillborn	115	9.5± 8.1	4.9± 4.12	9.2± 6.1	61.5	66.7	40
15	5	LW	tether	crate	X	12	0		160	14.6±17.4	3.8± 2.5	16.5± 6.3	41.6	100	87
184	7	LW x L/LW	cubicle	crate	/	14	0		FARROWING UNATTENDED – NO DATA OBTAINED						
8	5	LW	cubicle	crate	/	14	1	pig 15 stillborn	144	10.3±15.4	1.6± 0.7	?	64.3	86.7	with last pig
249	3	L x LW	cubicle	crate	X	6	0		213	42.6±47.1	4.5± 1.9	10.7± 3.1	83.3	100	53
233	3	L x LW	cubicle	crate	/	9	1	pig 3 mummified	150	16.7± 9.5	4.3± 1.3	8.4± 3.4	80.0	80.0	with last pig
253	3	L x LW	cubicle	crate	/	9	2	pigs 2 & 7 stillborn	141	14.1±14.4	7.8± 2.9	17.0± 8.9	63.6	90.0	10
379	2	L x LW	cubicle	crate	X	14	0		85	6.5± 7.1	3.7± 1.2	11.5± 6.7	63.6	76.9	80
138	5	L x LW	cubicle	crate	X	10	3	pigs 3,6 & 11 stillborn	193	16.1±10.3	4.5± 4.0	15.3± 7.9	72.7	100	?
128	5	L x LW	cubicle	crate	X	14	0		246	18.9±29.6	11.3± 6.5	28.2±16.0	64.3	85.7	20

13.3 Results

A summary of the farrowing data is shown in tables 13.1 and 13.2

Table 13.2 Mean values for reproductive parameters studied in experiment 2

	Type of sow housing during pregnancy	
	Tether	Cubicle
No. pigs born alive	12.6 ± 3.0	11.3 ± 3.2
No. pigs born dead	1.2 ± 2.6	0.9 ± 1.1
Duration of farrowing (min)	415 ± 627	167 ± 54
Mean birth interval (min)	13.1 ± 6.9	15.7 ± 13.2
Time to cord breakage (min)	7.4 ± 7.0	5.4 ± 3.2
Time to first suckling (min)	15.9 ± 5.3	15.2 ± 7.1
% born with intact cords	91.1 ± 14.5	88.5 ± 9.0

When the results were subjected to an Analysis of Variance, there were no significant differences between the 2 treatments in terms of any of the parameters studied. This was not all together surprising as only a small number of sows was involved in this pilot trial and in addition, there were problems due to a lack of personnel to carry out the observations which meant that much valuable data were lost as farrowings were unattended. Despite the paucity of the data however, the pilot trial was a useful exercise in that it proved the feasibility of tethering sows in a converted cubicle house, a technique which was used as one of the treatments in the subsequent major trial (experiment 3). In terms of the results, although there were no significant differences in stillbirth rate between the sows having differing opportunities for exercise during pregnancy, it is interesting that the sole case of a very prolonged farrowing was in fact a tethered sow and that the entire second half of the litter was born dead. However, any confounding effects of parity were ignored in this experiment.

13.4 General discussion on experiments 1 and 2

The results of experiment 1 showed that piglets born to free-range sows suckled significantly sooner after birth than did piglets born to mothers who had been more closely confined and when this is considered in conjunction with the fact that more of the former were born with intact umbilical cords, it may be taken to indicate that these piglets may have been less subject to anoxia or hypoxia during farrowing and so were able to show a greater level of activity at birth. Although no records of preweaning mortality were kept in this study, it is obviously advantageous for piglets to suckle as soon after birth as possible and thus the free-range piglets would appear to have had a better start in life than those piglets which were born into more confined conditions, although any confounding factors such as diet and environmental temperature were ignored. The relatively small numbers of sows involved in these observations and the existence of many variable factors between the 2 herds (breed, diet etc) means that only tentative conclusions can be drawn from these observations. Nevertheless, although there was no difference in duration of farrowing or stillbirth rate between the 2 groups of sows, those which had more opportunity for exercise did actually produce piglets which showed a greater degree of viability at birth (as evidenced by the greater activity levels and more rapid suckling) which might agree with the general hypothesis that exercise produces a more physically fit animal having better muscle tone which farrows more quickly and thus incurs less danger of anoxia or hypoxia in the piglets.

With reference to sow behaviour, although no objective recordings of

Figs 13.1 - 13.3

<u>Nest Building in Free Range Sows</u>

this were taken, observation of pre-farrowing sows suggested that the free-range sows walked considerable distances (in the order of 1-2 miles) gathering bedding in the final hours _prepartum_ but, when nest building was completed, they tended to lie down and show much less restlessness during the farrowing process than did the sows in crates. It was considered that this high level of activity before farrowing was part of the sow's instinctive behaviour and that if prevented (by placing the sow within the confines of a crate), this might account for the restlessness shown by the sows in crates during farrowing which in turn could possibly affect piglet mortality due to crushing. Observations of nestbuilding behaviour in the free-range sows also suggested that this was the result of a very strong instinct (the sows did not _have_ to build nests but they all did, frequently spending several hours in the creation of an elaborate construction as in figs 13.1-13.3) and even the sows in crates which only had access to a limited amount of bedding, showed attempts at nest building.

In experiment 1, it is difficult to know whether the significant differences obtained were due to the housing system or whether they were a reflection of the differences in parity, genotype and diet between the 2 herds. In experiment 2, an attempt was made to control some of these variable factors such as breed and diet, while the amount of exercise available only differed during gestation. The results showed no significant differences although there was some indication of a slight advantage of loose housing, although this could reflect the younger ages of animals on this treatment. Also, although the statistical analysis of experiment 2 did not reveal any significant differences between the 2 treatments in terms of sow reproductive performance, this may well have been due to the small number of animals involved and to the imposition of the treatments for a relatively short time (i.e. 88 days) whereas, if commercial tether systems are employed, these may extend over 112 days (i.e. the entire pregnancy) and the restriction of exercise for a longer period may have aggravated any effects of the confinement.

In conclusion, as was stated at the outset, experiments 1 and 2 were purely introductory studies and were designed as such, but they did raise some interesting points which were investigated in more detail in experiment 3.

Chapter 14

EXPERIMENT 3

THE EFFECT OF RESTRICTION OF EXERCISE ON SOW BEHAVIOUR, REPRODUCTIVE PERFORMANCE AND PIGLET VIABILITY

14.1 Introduction

The pilot trial in experiment 2 had indicated that it was feasible to keep tethered sows in a converted cubicle house and so it was decided that in experiment 3, the trial should be enlarged and extended and should also include 2 exercise treatments at farrowing and during lactation. In addition, although no objective observations had been made of the behaviour of the tethered sows compared to those in cubicles, it was felt that there were considerable behavioural differences between them and so experiment 3 should include objective observations of sow behaviour during gestation and at farrowing, in addition to recording sow reproductive performance and piglet viability.

14.2 Aim

The aim of experiment 3 was to test the hypothesis that sows given greater opportunity for exercise will farrow more efficiently and produce more viable piglets. This hypothesis was based largely on evidence in the scientific literature concerning non-porcine species as well as some tentative indications from the results of the preliminary trials described in experiments 1 and 2. The trial involved 2 treatments which allowed differing amounts of exercise; free (F) and restricted (R) imposed at 2 stages of the production cycle, namely gestation and farrowing/lactation, thus giving 4 treatments (table 14.1).

Table 14.1 Design of experiment 3

Treatment	Gestation	Farrowing/Lactation
RR	Restricted day 24-109	Restricted day 110-weaning
RF	Restricted day 24-109	Free day 110-weaning
FR	Free day 24-109	Restricted day 110-weaning
FF	Free day 24-109	Free day 110-weaning

The experimental design was that of a randomised block involving 4 treatments with 5 replicates (table 14.2). The trial was carried out between June 1981 when the first gilts were selected and August 1983 when the last sow was weaned, so that each animal was on the trial for 4 successive parities.

Table 14.2 Randomised block design
(letters refer to sow identification)

		Treatment			
		RR	RF	FR	FF
Block	1	A	B	C	D
	2	H	F	E	K
	3	N	I	L	J
	4	P	Q	S	R
	5	V	W	U	T

14.3 Materials and methods

i. Animals

a) Selection of the gilts

As an important part of the trial involved monitoring farrowings, it was necessary that these were distributed evenly throughout the year in order to facilitate observations, thus the plan was to have 1 batch of 4 animals (1 on each treatment) farrowing each month.

To this end, gilts were selected in 5 batches over a period of 5 months from June to October 1981. An initial selection was made on the basis of genotype, growth rate and teat number when the gilts were approximately 140 days of age. Initially, it was hoped that full sibs could be used to make up each batch of gilts but this proved difficult to achieve and usually only half sibs were available. Whenever possible, 6 gilts were selected initially so as to provide a reserve from which to select the final 4.

After selection at 140 days of age, the gilts were removed from the bacon house and placed in a deep straw pen with both water and food (a standard finisher diet) available ad libitum. The pen was located at some distance from the boar accommodation, the aim being to isolate the gilts from any boar stimuli in the period leading up to puberty, even though they had been reared in mixed groups with entire males until 140 days. The gilts were inspected visually for signs of oestrus but none had shown any by 165 days of age.

At approximately 165 days of age, the gilts were transferred to a service pen in close proximity to a mature stock boar so that they were able to receive olfactory, visual, auditory and limited tactile stimuli (figs. 14.2 and 14.3). This was an attempt to s imulate the "boar effect" described by Brooks, Pattinson and Cole (1970) so as to synchronise the onset of puberty in the gilts. After transferring to the service pen, the gilts were observed daily for signs of oestrus and when these appeared, the final selection of 4 gilts took place based on the synchrony of puberty and the degree of genetic relationship between the animals. The ancestry of the selected gilts is shown in appendix table A.4. Any gilts which were not selected were returned to the commercial College herd while the selected animals were ear-tagged using letters as identification and were randomly allocated to 1 of the 4 treatments. In batch 4, one of the selected gilts (O) on treatment FF had to be destroyed due to a uterine infection and was replaced by one of the reserve gilts (R).

b) Boars

Over the course of the trial, several boars were used all of which were purebred Large White or Landrace. Ideally, all the gilts and sows should have been served by the same boars, but this was not possible owing to injury and illness of the boars. Whenever possible, gilts and sows were served by the same 2 boars one for the first service and the other for the second.

ii. Feeding

The feeding of the gilts up to the time of selection has been outlined above. Once selected, they were then fed 2.3kg daily of a commercial sow ration (composition shown in tables A.5 and A.6 until day 110 of gestation when they were transferred to the farrowing house and approximately 0.25kg bran and 2l water were added to the daily ration. After farrowing, the gilts were fed the standard sow ration on a scale of 2kg/gilt plus 0.5kg/piglet daily, increasing from 3.5kg the day following parturition in 0.5kg daily increments up to the maximum amount. The ration was offered as a wet meal with approximately 5l of water. On the day of weaning, the ration was fed as normal but on the following days until service, gilts were fed according to body condition as was described in experiment 2. At service, feeding reverted to 2.3kg of the dry meal daily, the aim being to achieve a 15kg weight gain from one weaning to the next.

The feeding of the sows (i.e. animals from parities 2-4) was identical to that described above. The only alterations in feeding occurred in the period December 1981-January 1982 when the weather turned exceptionally cold (see later) and the pregnant animals were fed approximately 4.5kg/day as well as in February 1983 when they were fed approximately 3.5kg/day.

With reference to feeding the piglets, creep feed (the composition of which is shown in table A.7) was introduced at 7 days <u>post partum</u> and was changed to a grower ration (table A.8) at 28 days. Both feeds were offered <u>ad libitum</u> and water was also available <u>ad libitum</u> to all groups of stock continuously.

iii. <u>Housing</u>

a) <u>Service pen</u>

The layout of this area can be seen in figs. 14.1, 14.2 and 14.3. It consisted of a straw kennel sleeping area and a solid floor dunging area along the front of which ran 30cm glazed food/water troughs. The presence of a barred gate between this pen and the adjacent boar pen allowed considerable sexual stimulation (by visual, tactile, olfactory and auditory means) of the pubertal gilts and newly weaned sows. When the pen was used for service, the dunging area was covered in deep straw to provide a firm footing and the non-oestrous animals were shut away in the kennel. In September 1982 six individual feeders were added to replace the troughs.

b) <u>Dry sow accommodation</u>

This had to provide for the 2 treatments imposed (i.e. tether places and cubicles) as has been described in chapter 13 and the layout can be seen in figs. 14.4, 14.5, 14.6, 14.7 and 14.8. The house was not heated artificially and so straw bales were always stacked above the tether places and cubicles except in mid-summer. Ventilation and house temperature were controlled by opening or closing the 2 end doors. This arrangement was generally satisfactory apart

Fig. 14.1 **Plan of Service Pen**

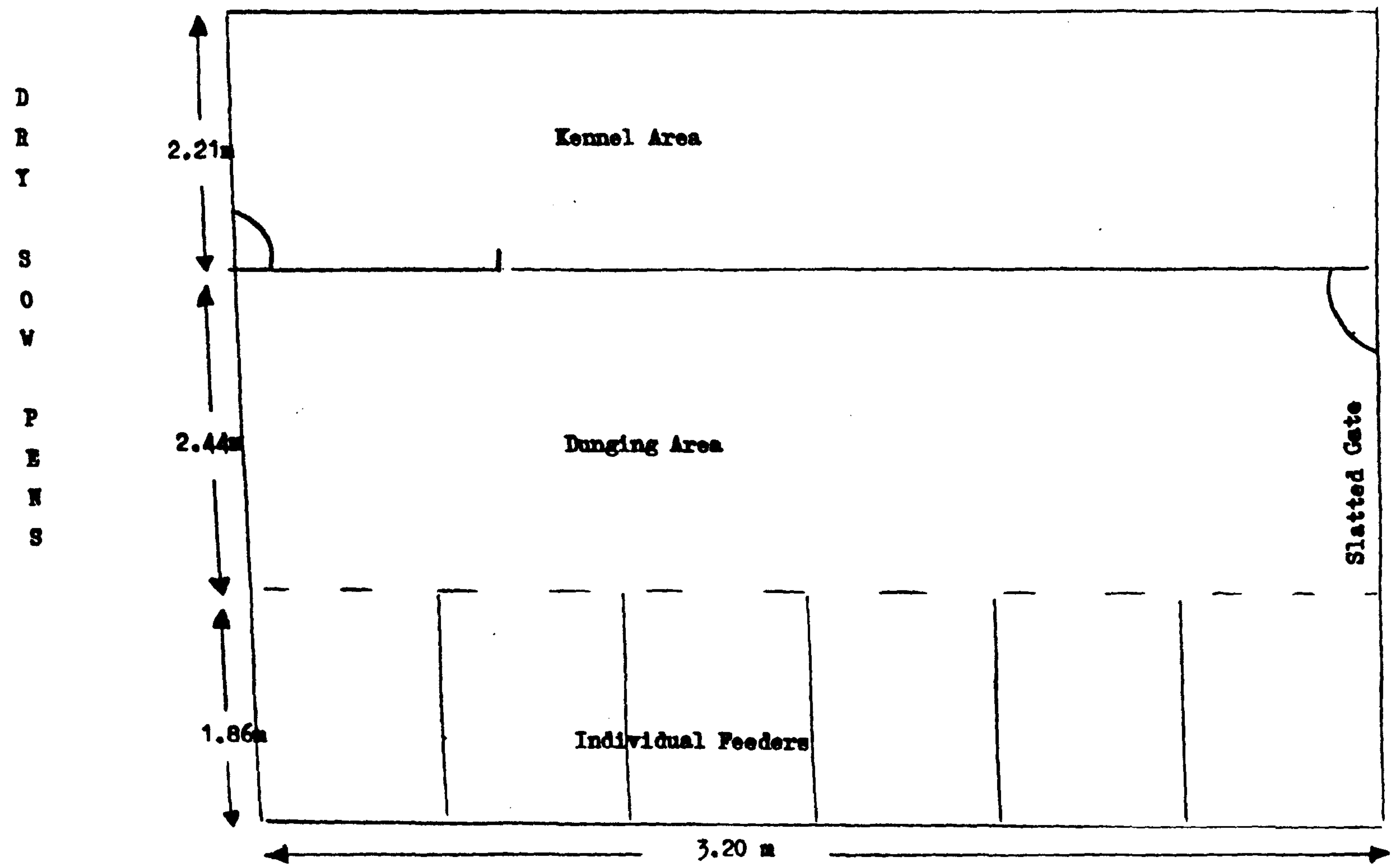
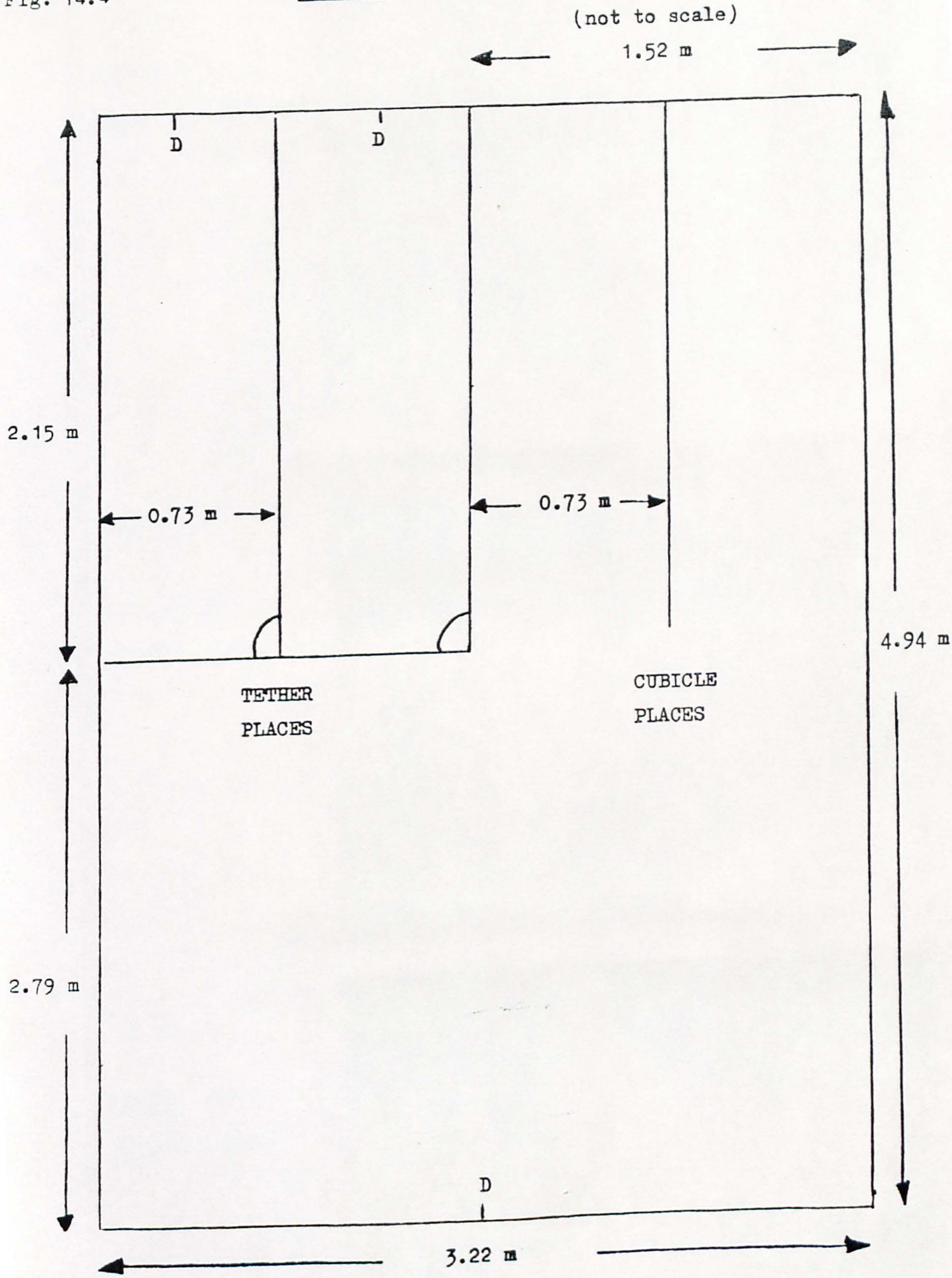


Fig 14.2 View of Service Pen before installation of Individual Feeders

Fig 14.3 View of Service Pen and Boar Pen

Fig. 14.4

Plan of Cubicle House



N.B. 5 identical pens in cubicle house to accommodate 20 sows.

D = Drinker.

Fig 14.5

General View of

Dry Sow House

Fig 14.6

Rear View of

Tethered Sows

Fig 14.7

Front View of

Tethered Sows

Fig 14.8 View of Cubicle Places

Fig 14.9 Use of Polythene Sheeting over Fronts of Tether and Cubicle Places to Conserve Heat during Winter of 1981-82.

from 2 notable exceptions. The first was the period December 1981–January 1982 when Shropshire became the centre of the extremely cold weather afflicting Britain. (In fact, it was the official meteorological station only 30m from the dry sow house which registered a minimum temperature of $-26.1^{o}C$ on 10 January 1982; a new record for England!) Due to such abnormal weather and despite the copious use of straw as bedding for both the tethered animals and those in cubicles, the house temperature fell to $-5^{o}C$ and could not be raised artificially. In an attempt to minimise heat loss, all windows were boarded and heavy polythene sheeting was hung over the front and rear of the tether places and cubicles (fig. 14.9), but the temperature still remained below freezing for nearly 5 weeks.

The other cold spell was in February 1983 when building work necessitated the removal of one of the end doors and the house temperature fell to $4^{o}C$. The aim was to keep the temperature around $17^{o}C$ (the lower critical temperature).

c) Farrowing accommodation

The layout of this is shown in figs. 14.10–14.15. The building was formerly a pig finishing house, designed to take pigs up to bacon weight and it was converted to provide 2 alternative types of farrowing accommodation within the one building. The walls and roof were lined with insulating material (Scyro-foam, Farm Feed Formulators Ltd.) and this was also used in the lids of the pen creeps. Fan heaters were mounted at either end of the house and the aim was to maintain an overall house temperature of between 18–$23^{o}C$, while the creeps were kept around $29^{o}C$. During the summer months, the fans were used to provide ventilation.

Fig. 14.10 **Overall Plan of Farrowing House**

(not to scale)

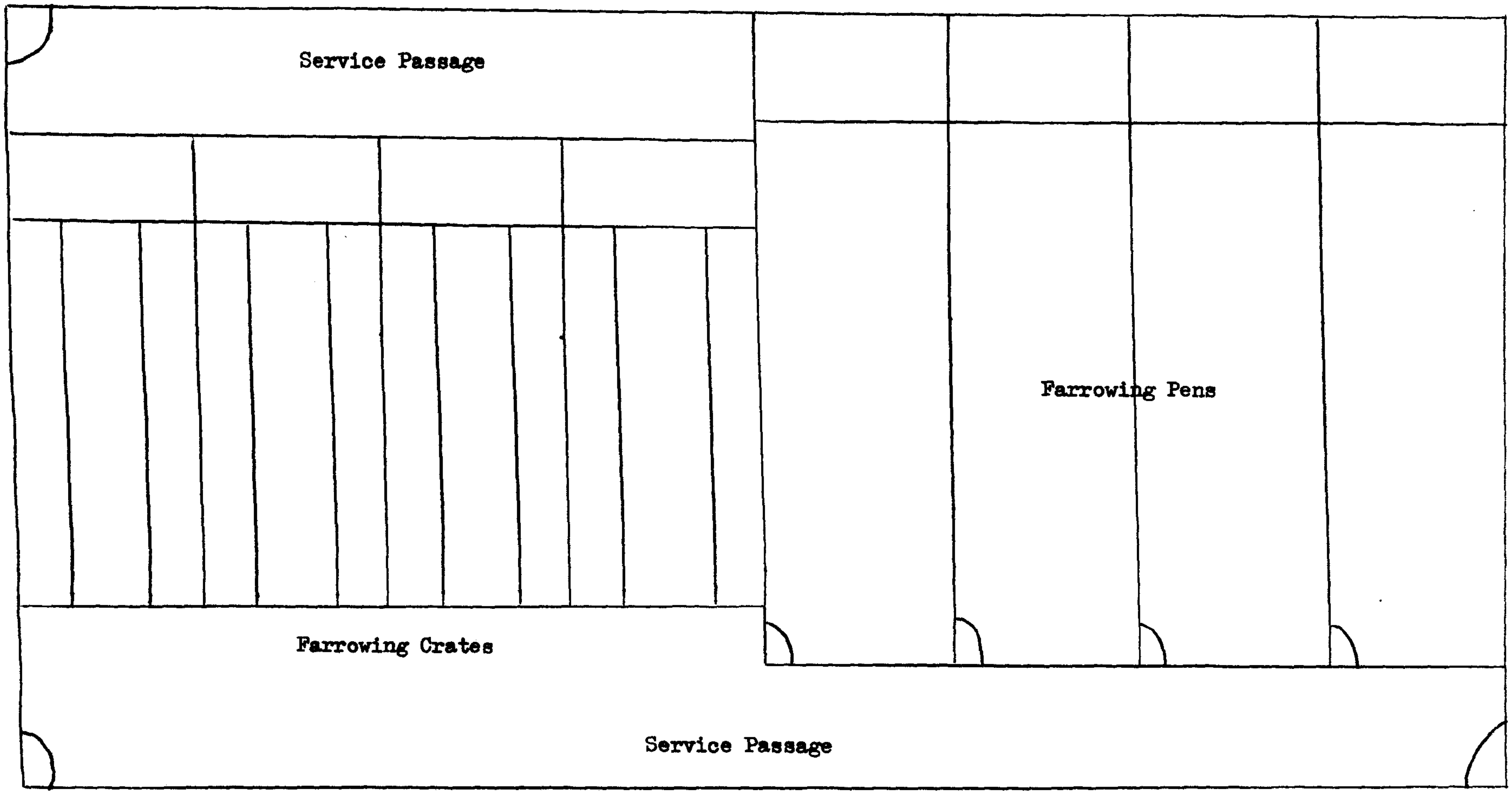
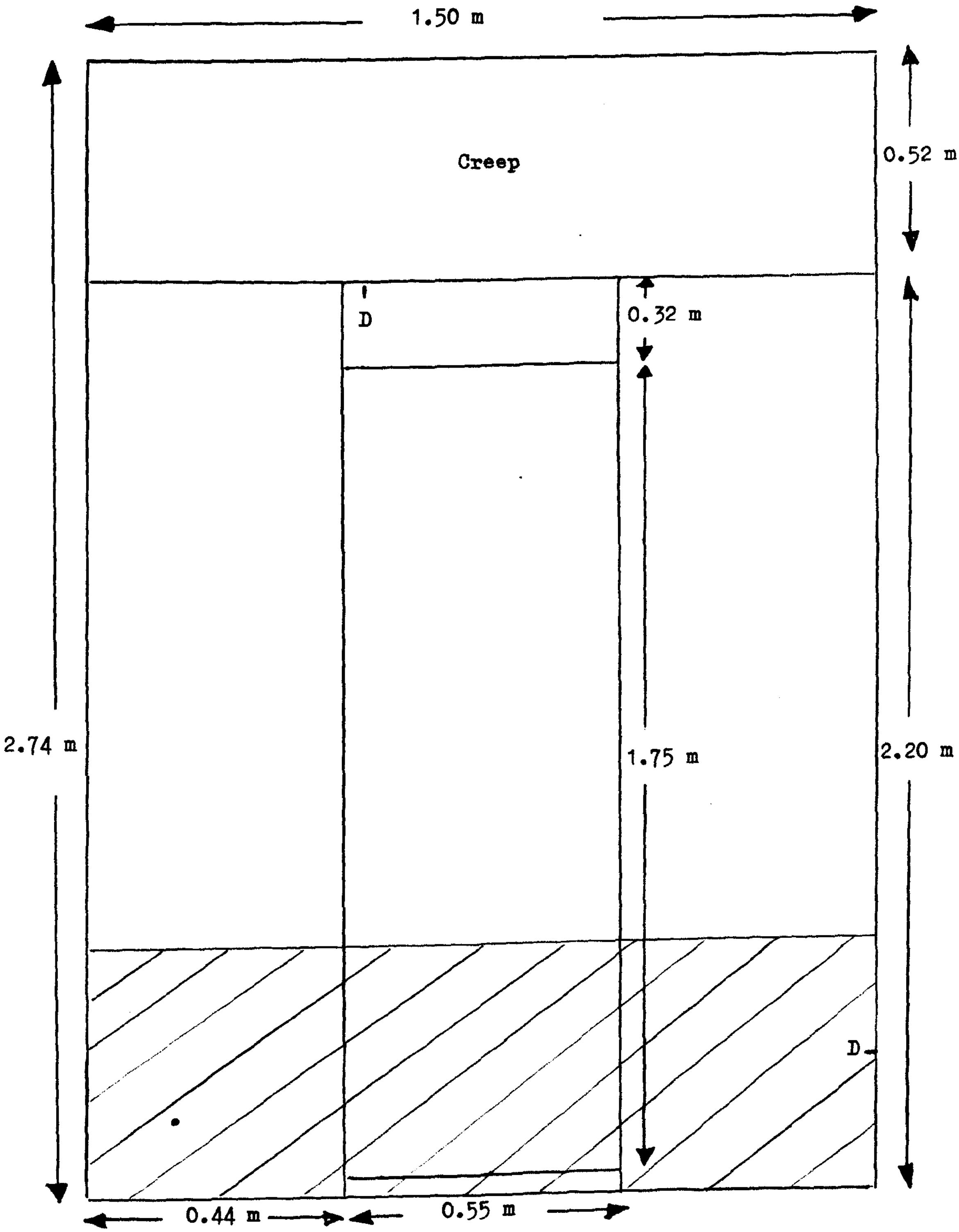


Fig. 14.11 Plan of Farrowing Crate

(not to scale)



= Slatted area.

Fig. 14.12 **Plan of Farrowing Pen**

(not to scale)

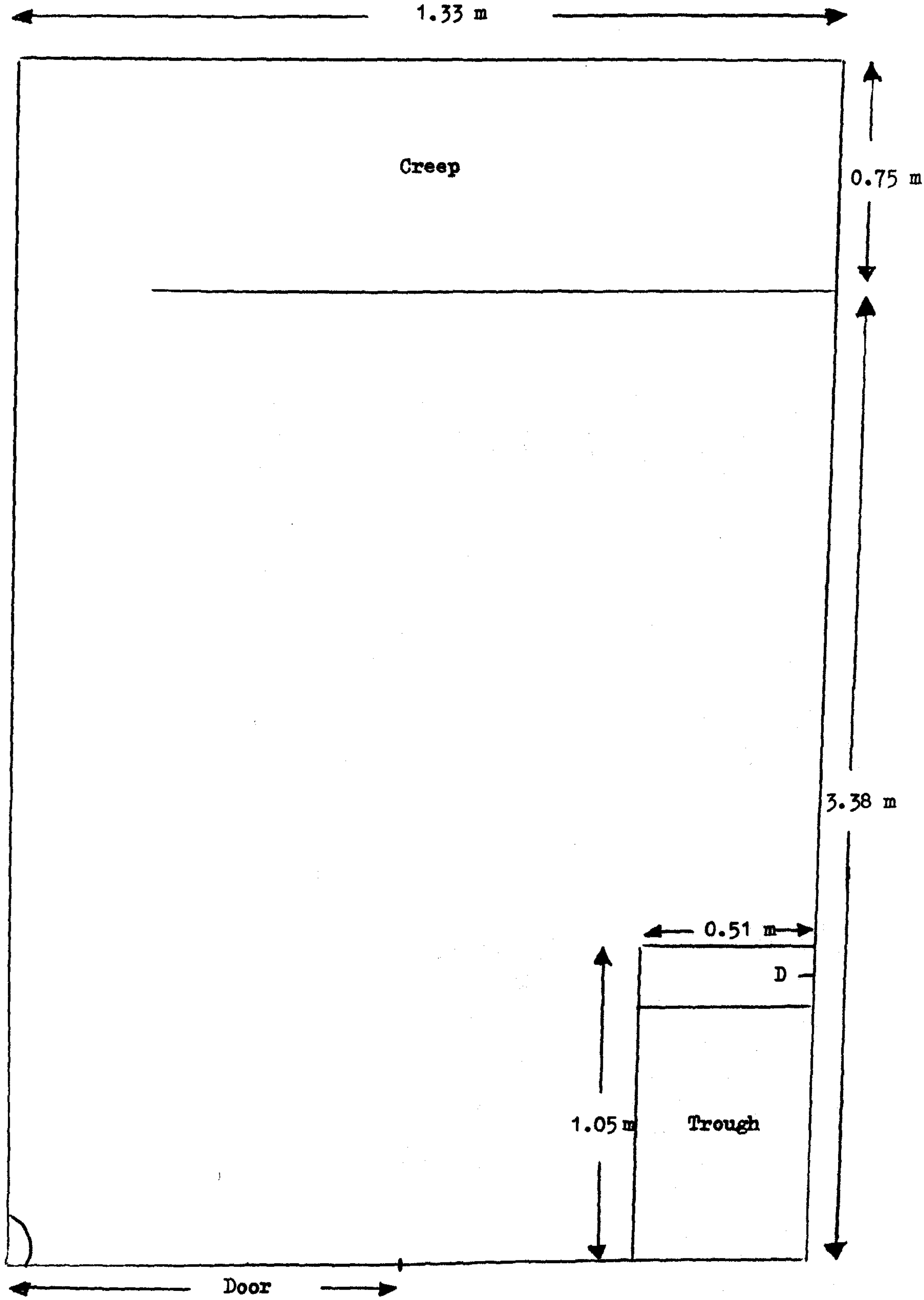


Fig 14.13

General View of Farrowing House (Pens are in the background)

Fig 14.14

Farrowing Crate

Fig 14.15

Farrowing Pen

The farrowing crates were of a conventional design (Beacon Ltd., Penrith, Cumbria) and were used in conjunction with a fairly deep layer of straw bedding. The farrowing pens were constructed using concrete blocks and again, the creep areas and that part of the pen adjacent to these had a deep layer of straw added daily.

iv. General management routine

This is outlined in table 14.3 and was the same throughout the 4 parities with the exception of Intagen (Unilever, Ltd.) injections which were introduced for parities 3 and 4 following bad mastitis/ piglet scour problems in the 1st 2 parities.

Table 14.3 General Management Routine of Sows in Experiment 3

Gestation day no.	Management
0	Served twice (with different boars if possible).
20-22	Observed for returns to heat.
24	Allocated to pregnancy treatment. Weighed. Condition scored.
30	Preliminary ultrasonic pregnancy diagnosis.
40	Confirmation of pregnancy.
(93	Injected with 1cm^3 Intagen - Parities 3 and 4).
110	Treated with mange wash and pig oil . Weighed. Condition scored. Allocated to farrowing treatment.
111	Wormed.
Post partum day no.	
1 (Parity 4) 2 (Parities 1-3)	Piglets weighed, injected with iron (1cm^3 Gleptosil, Fisons), teeth clipped, ear notched, ear tagged.
7	Piglets weighed and creep feed introduced.
28	Grower ration introduced.
35 (approx.)	Piglets weaned. Piglets and sow weighed. Sow condition scored and injected with vitamins (3cm^3 Zylphon, Bayer) and against erysipelas (2cm^3 Erysorb, Hoechst).
Next few days	Observed for signs of heat and served.

v. <u>Recording of sow behaviour</u>

It was considered important to obtain recordings of sow behaviour at various stages throughout gestation and so pre-determined dates were chosen as shown in table 14.4. Based on the experience of recording behaviour in parity 1, it was decided to reduce the number of observation days during gestation in parities 2 and 3 but to include an observation carried out on day 5 *post partum*.

Table 14.4 Schedule of observation days

Parity	Day no. Gestation 24*	32	52	65	82	109	110†	Post partum 5
1	✓	✓	✓		✓	✓	✓	
2	✓			✓		✓	✓	✓
3	✓			✓		✓	✓	✓
4								✓

* entered pregnancy accommodation.

† entered farrowing accommodation.

All the gestation recordings were carried out using the pro-forma sheets shown in appendix table A.9, while observations on day 5 *p.p.* used the sheets shown in table A.10.

The recording technique was standardised throughout and involved recording the behaviour of each sow at 30 second intervals for a period of 12½ minutes, 4 times daily at approximately 10.30, 12.30, 14.30 and 16.30 hours. This system was chosen so that at the end of each day's observation there were 100 records of sow behaviour at intervals throughout the day and this facilitated analysis of the results. In all cases, the observer contrived to remain as unobtrusive as possible and after taking up position, there was always a period of several minutes before observation started in order to allow any initial disturbance (caused by the observer's presence) to die down.

By parity 4, it was felt that sufficient information had been collected regarding general sow behaviour, but that there were no data pertaining to the amount of movement undertaken by the pregnant sows. Consequently, a period of 6 hours continuous observation was carried out on a predetermined day between days 70 and 90 of gestation. An attempt involving the use of a pedometer strapped to the animal's hind leg did not prove satisfactory as it was considered to impede movement and was frequently dislodged by the other member of the pair when used with the unrestricted sows in cubicles. Thus, a more empirical method was employed in which changes of position were recorded using a tally counter and also movements of the right hind leg (appendix table A.11) which were categorised into "pace" (i.e. walking) and "other" (minor movements). For convenience, the recording was carried out in daylight hours between 10.00 and 16.00 hours and similar observations of 1 tethered and 1 unrestricted sow in a cubicle confirmed that there was in, fact, a minimal amount of movement between 22.00 and 04.00 hours (tables 14.17 and 14.18). Observations of behaviour during parities 1 to 3 had suggested that sow activity was related to time of feeding and so throughout the duration of parity 4, feeding of the animals in the dry sow house took place at 09.00 hours and recording of sow movement started approximately 1 hour after this.

On all occasions, the observer contrived to remain as unobtrusive as possible, taking up position at the rear of the tethered sows and sitting at a height of 2m above the sows in cubicles, as this was found to cause the least distraction.

For comparative purposes to see how much movement was undertaken by free-range sows, 2 of the animals described in chapter 12 were continuously recorded for a 6 hour period between 10.00 and 16.00 hours; unfortunately lack of time precluded observations of any more. As the recordings took place over a period of months, the ambient temperature varied considerably and was noted on each occasion in case it influenced the level of sow activity.

In addition to observation of sow behaviour during pregnancy and lactation, behaviour immediately pre- and intra partum was also recorded on pro-forma sheets (tables A.13 and A.14) with the key to behaviour being shown in table A.12.

vi. <u>Recordings of farrowing duration and stillbirth rate</u>

These were similar to those described in chapters 12 and 13 and utilised the recording sheets shown in tables A.13 and A.14. A still-born pig was defined as one showing no respiratory activity at birth while complete expulsion of the placenta was taken to indicate the completion of farrowing. There was no manual intervention in the farrowing process unless it was so protracted that veterinary assistance was considered necessary.

vii. Recordings of piglet viability

a) Appearance

The presentation of the piglet at birth (i.e. whether anterior or posterior) was noted together with the amount of meconium present which was recorded as follows: - none present, + 1-5 pellets, ++ 5-10 pellets, +++ more than 10 pellets/heavy staining. The state of the umbilical cord and time taken to break an intact cord were also recorded.

b) Piglet behavioural characteristics

The recordings made here included the times taken for each piglet to breathe regularly, to stand and to achieve its first successful suckle.

c) IgG uptake

One important measure of the viability of a piglet is its capacity to ingest and absorb antibodies from colostrum and so this was measured in piglets from parities 1 to 3. It is generally agreed (Porter, 1969; Martinsson, 1970; Bourne, 1971b) that IgG is the major immunoglobulin present in sow's colostrum and so this was the one monitored. It is also agreed (Asplund *et al.* 1962; Hardy, 1969a; Lecce 1972) that absorption of colostral antibodies ceases around 24 hours *post partum* while the half life of IgG is in the order of 9.5 days (Curtis and Bourne, 1973) to 14 days (Bourne, 1971a; Curtis and Bourne, 1971); thus it was decided to analyse blood samples for IgG levels at 36-40 hours *post partum* i.e. when absorption had been completed but before catabolic and dilution effects had been able to cause a noticeable reduction in immunoglobulin concentration.

Duplicate blood samples were obtained by tail docking and were collected in micro-haematocrit tubes containing an anticoagulant. After centrifuging, the plasma samples were deep frozen until it was convenient to analyse them for IgG levels. The method used was the single radial immunodiffusion technique described by Fahey and McKelvey (1965). The principle of the method is that an agar plate is produced incorporating the complementary antigen throughout the agar and the plasma sample is placed in a small well from which the antibody diffuses into the agar and forms a ring of antibody-antigen precipitate around the well. The diameter of this ring reflects the concentration of the antibody and can be determined graphically by comparison with known standards. The accuracy of the method is claimed to be ± 10% (Fahey and McKelvey, 1965).

d) <u>Haematocrit value</u>

Although this was not considered to be of profound importance as an indicator of piglet viability, after centrifugation to obtain the plasma samples as described above, the haematocrit values of each blood sample were recorded by comparing the height of the cell fraction in the microhaematocrit tube with a prepared scale.

e) <u>Piglet lactic acid levels at birth</u>

The observations of piglet behaviour described in section b) above, may be useful indicators of variations in viability at birth but another commonly used biochemical indicator of viability is the serum lactic acid level at birth (table 5.3). In parities 1 to 3, it was considered important that there should be no handling of the piglets at birth so that recordings of times taken to breathe regularly, to stand etc. could be made. In parity 4, however, blood samples were collected from the piglets immediately after delivery (i.e. within 2 minutes of birth) and were used to determine lactic acid levels. After consideration of the problems experienced by Randall (1968) in collecting blood from the umbilical cord in cases where the piglet had been born with a ruptured or "bloodless" cord, and also the statements by workers such as James (1960) that cord blood is unlikely to be representative of the intra-uterine environment, it was decided to use peripheral blood obtained by tail docking.

Immediately following delivery of a piglet, the tail was wiped to remove amniotic fluid, meconium etc. and approximately three quarters was removed. The blood was collected in micro-haematocrit tubes and was left to clot after which it was centrifuged and the serum samples deep frozen until analysis.

The method used was based on the determination of serum LDH by 1-lactate and NAD oxidoreductase (British Drug House Chemicals Ltd.). This method is based on the equation

$$\text{1-lactate} + NAD^{+} \rightleftharpoons \text{pyruvate} + NADH.$$

The pyruvate formed by the enzymatic oxidation of 1-lactate is measured as its 2, 4-dinitrophenylhydrazone. This produces a coloured complex in alkaline media, the intensity of which is compared with a calibration curve prepared from a standard which has been compensated for the colour contributed by the 2, 4 dinitrophenylhydrazone of NADH.

Practical difficulties in obtaining the blood samples were sometimes experienced if several piglets were born in rapid succession and also in the farrowing pens, where great care was needed to prevent the piglet from squealing and disturbing the sow. In addition, some piglets bled very poorly for some unknown reason. With this sampling technique, it was not possible to obtain blood samples from stillborn piglets as there was no circulation of blood in the tail.

f) Piglet growth rate

The stages at which piglets were weighed are shown in table 14.5. The differences in timing of the first weighing between parities 1 and 4 was related to management practice and was designed to minimise handling stress. During parities 1-3, weighing was carried out when blood samples were taken at 36-42 hours *post partum* but in parity 4, as blood samples were taken at birth, piglets were weighed at a convenient time in the first 24 hours *post partum*. In parity 1, there were no facilities for individual weighings and so litter weights were used, but in parities 2-4, ear tagging of piglets meant that individual weights could be recorded. As weaning only took place on a Thursday, piglets varied in age at weaning and so growth rate was calculated as daily liveweight gain from day 7 *post partum* to weaning.

Table 14.5 Schedule of piglet weighings

Parity	Time of weighing			
	In 1st 24hr. *p.p.*	36-42hr. *p.p.*	7 days *p.p.*	Weaning
1		✓	✓	✓
2		✓	✓	✓
3		✓	✓	✓
4	✓		✓	✓

g) Preweaning mortality

Any piglet deaths in the preweaning period were recorded and wherever possible the causes were noted.

h) Weight of placenta

In order to ascertain whether there was a relationship between placental weight and piglet viability, the placenta was collected after expulsion and was weighed.

viii. Sow condition

Condition scoring was carried out on all sows at days 24 and 110 of gestation and at weaning. The method involved the loin region only and was based on the 5 point scale used by A.D.A.S. (M. Yeo (1981) Personal Communication). Wherever possible, sows were condition scored by 2 people independently.

14.4 Results

For convenience, sow behaviour and reproductive performance will be discussed separately.

i. Sow behaviour

a) Behaviour during pregnancy

1. Behaviour in pregnancy housing treatment (day 24-day 109)

The 4 recording periods on each observation day provided a total of 100 individual records of sow behaviour in terms of the percentage of time spent in any particular activity. A summary of the results is shown in appendix tables A.15-A.17 and tables 14.6-14.7. Since the results were expressed as percentages, they were subjected to an arcsin transformation before being analysed by the analysis of variance technique for randomised blocks and randomised samples, while missing plots were calculated according to the method of Snedecor (1958). Any mean data are shown together with the standard error of the mean.

The significance of the results is summarised in table 14.8 which shows that the tethered sows spent significantly more time lying down, while the sows in cubicles spent significantly longer manipulating straw and this applied to all parities. With reference to parity 1 alone, there were significantly more aggressive interactions (i.e. those involving fighting) between sows in cubicles that between the tethered sows, although this was not true of the later parities. In parity 2, the sows in cubicles indulged in significantly more passive interactions (no fighting involved) than did the tethered sows.

Table 14.6 <u>Total activity shown by sows when observed between days 24-109 of gestation</u> (Figures refer to percentage of time which sows spent being "active" i.e. <u>other</u> than standing, sitting or lying)

Treatment	Sow	Parity		
		1	2	3
Tethers	A	25	51	36
	B	36	16	22
	F	53	65	49
	H	28	54	62
	I	44	27	39
	N	46	47	58
	P	60	42	38
	Q	18	42	55
	V	32	59	36
	W	36	46	54
		38±4.1	45±4.7	45±4.1
Cubicles	C	55	57	66
	D	52	26	57
	E	66	35	74
	J	74	64	62
	K	59	86	71
	L	64	63	62
	R	71	54	43
	S	49	59	89
	T	68	59	92
	U	81	73	85
		64±3.2	58±5.4	70±4.7

Table 14.7 Mean activity shown by sows at various stages of gestation. (Figures refer to percentage of time which sows spent being "active" i.e. other than standing, sitting or lying. Parities pooled).

Treatment	Sow	Stage of Pregnancy (day)		
		Early (22 - 25)	Mid (52 - 65)	Late (107 - 109)
Tethers	A	25	40	37
	B	23	27	17
	F	40	56	66
	H	41	68	39
	I	23	42	29
	N	43	69	42
	P	42	58	38
	Q	32	50	35
	V	36	42	59
	W	47	55	38
		35±2.8	51±4.1	40±5.1
Cubicles	C	69	56	55
	D	42	46	57
	E	66	64	51
	J	83	47	59
	K	73	75	66
	L	64	76	53
	R	47	60	59
	S	61	61	72
	T	58	65	90
	U	71	80	84
		63±3.8	63±3.8	65±4.1

TEXT
BOUND INTO THE
SPINE

Fig. 14.16 Differences in sow behaviour during gestation (parities 1-3) (ref table 14.8)

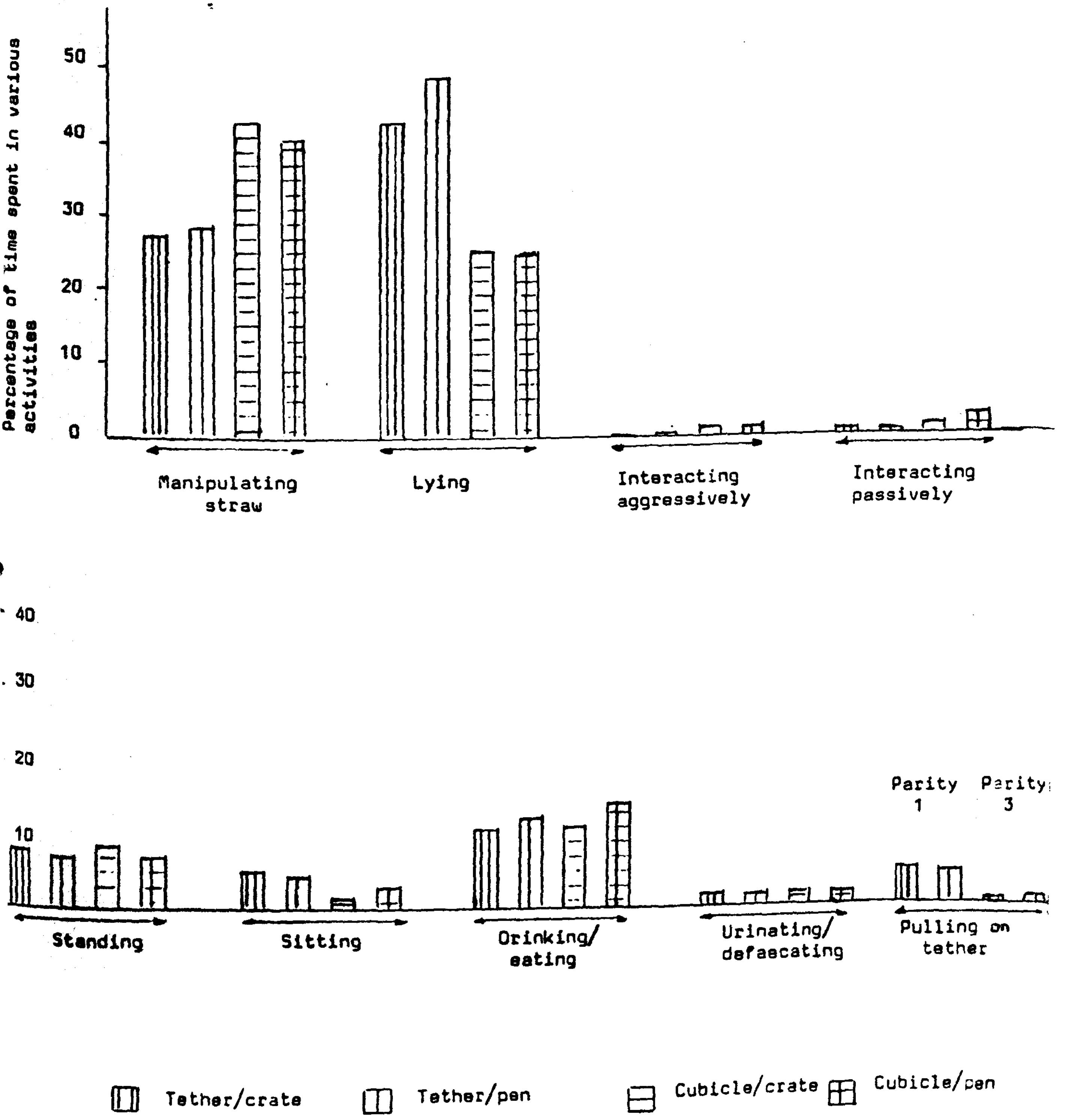


Table 14.8 Differences in sow behaviour throughout gestation over the course of parities 1-3 (Figures refer to mean percentage of time spent in that activity and parities are pooled unless otherwise stated. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly from each other)

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Tethers	Cubicles	
Manipulating straw	26.9_a (30.8^a	27.5_a 31.1^a (S.E.M. ±	43.1_b 40.9^b 1.9)	40.4_b 39.3^b)			***
					26.7_a (31.0^a (S.E.M. ±	41.9_b 40.1^b) 1.4)	***
Time spent lying	42.0_a (40.6^a	48.1_a 43.8^a (S.E.M. ±	25.0_b 29.0^b 2.0)	24.3_b 28.9^b)			***
					45.0_a (42.2^a (S.E.M. ±	24.7_b 30.0^b) 1.7)	***
Aggressive interactions	0_a2 (0^a	0.2_a 1.1^a (S.E.M. ±	1.2_b 8.4^b 0.8)	1.1_b 7.5^b)			***

Table 14.8 continued

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Tethers	Cubicles	
Passive interactions	0.5 (1.1^{a}	0.2 1.1^{a} (S.E.M. ± 1.0)	1.1 5.0^{b}	1.5 6.0^{b})			**
Pulling on tether	3.5 (9.4^{a}	3.1 8.4^{a} ± 2.7) Parity 1					
	0.4 (1.6^{b}	0.3 1.1^{b} ± 2.2) Parity 3					**
Standing	7.9 (15.5	6.7 13.8 (S.E.M. ± 1.4)	8.4 16.0	7.3 14.5)			n.s.
Sitting	4.9 (10.4	4.2 9.3 (S.E.M. ± 1.8)	1.3 3.6	2.6 6.6)			n.s.
Drinking/ eating	11.4 (19.7	12.2 19.8 (S.E.M. ± 1.2)	10.6 18.4	13.1 20.7)			n.s.
Urinating/ defaecating	0.7 (4.0	0.6 3.4 (S.E.M. ± 0.8)	0.8 4.0	0.9 4.9)			n.s.

When the amount of time the sows spent being "active" (i.e. indulging in activities other than purely standing, sitting or lying) was compared, the results showed that the sows in cubicles were significantly more active than the tethered sows. There were no significant differences between the activity levels of sows on the 2 treatments at various stages of gestation but, within the tethered treatment, the sows had a significantly higher activity level in mid-gestation than in the earlier stages. There was little evidence of any repeatability of behaviour i.e. the sow showing the highest (or lowest) activity levels in parity 1, did not necessarily do so in parities 2 and 3.

Finally, there was a significant reduction in the amount of time the tethered sows spent pulling on their tethers during parity 3 as compared to when they were first tethered in parity 1 but there were no significant differences between the sows on the various treatments with respect to the other behavioural characteristics studied.

2. <u>Locomotor activity in pregnancy (day 70-day 90)</u>

A summary of sow locomotor activity is shown in table 14.9 and further details are included in tables A.18 and A.19. The data for sow V are included in the results for the tethered sows but were not used in the statistical analysis as this sow was later found to be non pregnant. The remaining data were subjected to an analysis of variance and the significance of the results is shown in tables 14.10-14.11. The sows in cubicles made significantly more pace movements than did the tethered sows whereas the latter made more minor or "other" movements and particularly the most closely confined animals i.e. the tether/crate sows. There were no significant

Table 14.9.a SUMMARY OF CONTINUOUS OBSERVATION OF LOCOMOTOR ACTIVITY 0 - 6 hour (TETHERS)

SOW			A	B	F	H	I	P	Q	V	W	MEAN
PREGNANCY DAY			85	85	70	72	71	85	83	75	85	79±2.2
DATE			22.2.83	23.2.83	28.2.83	3.3.83	29.3.83	10.5.83	25.5.83	26.7.83	26.5.83	----
RECORDING PERIOD			10.32-16.32	10.25-16.25	10.22-16.22	10.00-16.00	10.00-16.00	10.30-16.30	10.05-16.05	10.00-16.00	10.00-16.00	10.13-16.13
CUBICLE HOUSE TEMPERATURE /°C			6	7	10	12	12	14	21	25	18	14±2.0
TIME SPENT STANDING/ MINUTE			273	136	235	203	151	83	111	127	161	164±19.4
RIGHT HIND LEG MOVEMENTS	CUBICLE DUNGING AREA	PACE	-	-	-	-	-	-	-	-	-	-
		OTHER	-	-	-	-	-	-	-	-	-	-
	CUBICLE /TETHER AREA	PACE	243	29	57	131	22	10	9	52	5	62±24.8
		OTHER	1579	727	754	2046	506	761	450	499	885	912±171.7
	SUBTOTAL		1822	756	811	2177	528	771	459	551	890	974±191.3
POSTURAL CHANGES	STANDING UP FROM DOG SITTING		1	1	2	3	2	2	2	4	1	2± 0.3
	STANDING UP FROM LYING		-	-	-	-	2	4	1	1	-	0.9± 0.7
	DOG SITTING FROM LYING		1	1	2	3	5	3	6	4	1	2.9± 0.6
	DOG SITTING MOVING		7	-	2	6	8	7	4	8	5	5.2 ± 0.9
	LYING MOVING		46	121	54	150	74	153	50	100	79	91.9±13.1
	ROLLING OVER		-	-	-	-	-	2	-	-	-	0.2±0.7
	DOG SITTING FROM STANDING		1	-	-	-	-	1	-	-	-	0.2±0.3
	LYING DOWN FROM STANDING		-	1	2	3	4	6	4	5	2	3 ±0.6
	LYING DOWN FROM DOG SITTING		1	-	-	-	3	2	4	-	-	1.1+0.8
	SUBTOTAL		57	124	62	165	98	180	71	122	88	107±13.9
	TOTAL		1879	880	873	2342	626	951	530	673	978	1081± 194

SUMMARY OF CONTINUOUS OBSERVATION OF LOCOMOTOR ACTIVITY 0-6 hr (CUBICLES)

SOW			C	D	E	J	L	R	S	T	U	MEAN
PREGNANCY DAY			69	86	77	84	85	79	83	81	83	81 ± 1.6
DATE			1.3.83	24.2.83	10.3.83	6.6.83	7.6.83	18.5.83	9.5.83	20.5.83	23.5.83	-
RECORDING PERIOD			10.00-16.00	10.20-16.20	10.00-16.00	11.20-17.20	9.30-15.30	10.00-16.00	10.30-16.30	10.00-16.00	10.15-16.15	10.20-16.2
CUBICLE HOUSE TEMPERATURE /°C			12	9	15	19	20	14	17	14	14	15 ± 1.0
TIME SPENT STANDING/ MINUTE			121	140	185	132	178	202	152	138	210	162 ± 10.4
RIGHT HIND LEG MOVEMENTS	DUNGING AREA	PACE	132	188	164	158	162	129	265	103	176	164 ± 14.6
		OTHER	221	185	210	664	470	408	393	221	282	339 ± 50.3
	CUBICLE /TETHER AREA	PACE	17	40	53	13	45	17	23	46	45	33 ± 5.1
		OTHER	97	155	126	174	282	204	221	432	157	205 ± 31.9
	SUBTOTAL		467	568	553	1009	959	758	902	802	660	742 ± 60.7
POSTURAL CHANGES	STANDING UP FROM DOG SITTING		1	1	2	1	3	4	4	1	-	1.9 ± 0.3
	STANDING UP FROM LYING		1	-	1	-	3	-	1	-	1	0.8 ± 0.5
	DOG SITTING FROM LYING		1	1	2	3	3	7	5	2	-	2.7 ± 0.7
	DOG SITTING MOVING		2	1	-	3	10	5	9	13	-	4.8 ± 1.7
	LYING MOVING		347	221	80	109	74	28	84	59	47	117 ± 32.
	ROLLING OVER		-	1	-	1	-	-	-	1	-	0.3 ± 0.3
	DOG SITTING FROM STANDING		-	-	-	-	-	-	-	-	-	0
	LYING DOWN FROM STANDING		3	2	3	1	7	4	6	2	2	3.3 ± 0.6
	LYING DOWN FROM DOG SITTING		-	-	-	2	-	3	1	1	-	0.8 ± 0.6
	SUBTOTAL		355	227	88	120	100	51	110	79	50	131 ± 31.3
	TOTAL		822	795	641	1129	1059	809	1012	881	710	873 ± 51.6

differences in the number of postural changes (i.e. standing up, lying or sitting down, rolling over etc.) made between the various groups and likewise no difference in the amount of time spent standing.

At this stage, it might be of interest to mention the results obtained from observation of 2 free-range sows which are shown in tables 14.12 and A.20. Obviously, the limited sample size from which the data were obtained precluded any statistical analysis, but the differences between the free-range and confined sows are very marked (table 14.13) with an increasing degree of confinement leading to a reduction in the amount of walking but an increase in the number of minor movements and postural changes. Within the cubicles, the sows engaged in significantly more locomotor activity in the dunging area than in the lying area (table 14.14)

During the course of carrying out the observations over a 6 hour period, it became apparent that there was a well defined pattern of activity throughout the period and that this occurred irrespective of treatment (table 14.15).

Thus, the data show that the amount of locomotor activity decreases throughout the day, being maximal in the morning around the time of feeding and minimal in the afternoon. The observation periods ended at approximately 16.30 on each occasion, so it is not known if the activity levels increased after this but certainly locomotor activity was minimal at night (table 14.16). The limited amount of data obtained at night (tables 14.17 and 14.18) again prevented a statistical comparison with the daytime data, but the overall trend is very obvious.

Table 14.10 Significance of the differences in sow locomotor activity during parity 4 (Figures refer to the number of times the activity occurred during a 6 hour observation period and are the means for each treatment group. Values on the same horizontal line bearing different superscripts differ significantly from each other)

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Tethers	Cubicles	
Pace movements	128[b] ± 33	24[a] ± 25	216[b] ± 25	174[b] ± 28			***
					63[a] ± 24	197[b] ± 22	***
"Other" movements	1462[a] ± 179	664[b] ± 138	492[b] ± 138	611[b] ± 155			***
					964 ± 143	545 ± 135	approaching *
Postural changes	11 ± 4	9 ± 3	10 ± 3	10 ± 3			n.s.
					10 ± 2	10 ± 2	n.s.
Movements while lying or dog sitting	123 ± 48	79 ± 37	131 ± 37	110 ± 42			n.s.
					96 ± 28	121 ± 27	n.s.

Table 14.12 Summary of Locomotor Activity in Free-Range Sows (0-6 hr)

SOW		24				13				MEAN
PREGNANCY DAY		90				89				
DATE		23.8.83				23.8.83				
RECORDING PERIOD		10.00 - 16.00				10.00 - 16.00				
TEMPERATURE /°C		16 - 22				16 - 22				19
TIME SPENT STANDING/ MINUTE		227				237				232
RIGHT HIND LEG MOVEMENTS: PACE		1345				1184				1265
RIGHT HIND LEG MOVEMENTS: OTHER		18				8				13
SUBTOTAL		1363				1192				1278
POSTURAL CHANGES: STANDING UP FROM DOG SITTING										
POSTURAL CHANGES: STANDING UP FROM LYING		3				1				2
POSTURAL CHANGES: DOG SITTING FROM LYING										
POSTURAL CHANGES: DOG SITTING MOVING										
POSTURAL CHANGES: LYING MOVING		22				4				13
POSTURAL CHANGES: ROLLING OVER		2								1
POSTURAL CHANGES: DOG SITTING FROM STANDING										
POSTURAL CHANGES: LYING DOWN FROM STANDING		5				2				4
POSTURAL CHANGES: LYING DOWN FROM DOG SITTING										
SUBTOTAL		32				7				20
TOTAL		1395				1199				1297

Table 14.11 Amount of time spent standing by sows during gestation (Figures refer to mean number of minutes for which sows stood during a 6 hour observation period)

Treatment						Level of significance
Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Tethers	Cubicles	
186 ± 30	159 ± 23	169 ± 23	153 ± 26			n.s.
				169 ± 18	162 ± 17	n.s.

Table 14.13 Differences in locomotor activity over a 6 hour period between free-range and confined sows (Figures refer to mean values for that treatment group)

	Free-range	In Cubicles	Tethered
No. sows observed	2	9	8
Time spent standing (min.)	232	162	164
No. pace movements	1265	197	62
No. "other" leg movements	13	369	912
No. postural changes	20	131	107

Table 14.14 Comparison of sow locomotor activity within the dunging and lying areas of the cubicle (Figures refer to mean number of times the activity occurred during a 6 hour observation period and values on the same horizontal line bearing different superscripts differ significantly from each other)

Activity	Region of cubicle		Level of significance
	Dunging area	Lying area	
No. pace movements	$164^{a} \pm 11.4$	$33^{b} \pm 11.4$	***
No. "other" movements	$339^{a} \pm 44.4$	$205^{b} \pm 44.4$	*

Fig. 14.17

<u>Differences in sow locomotor activity during parity 4</u> (ref. table 14.10)

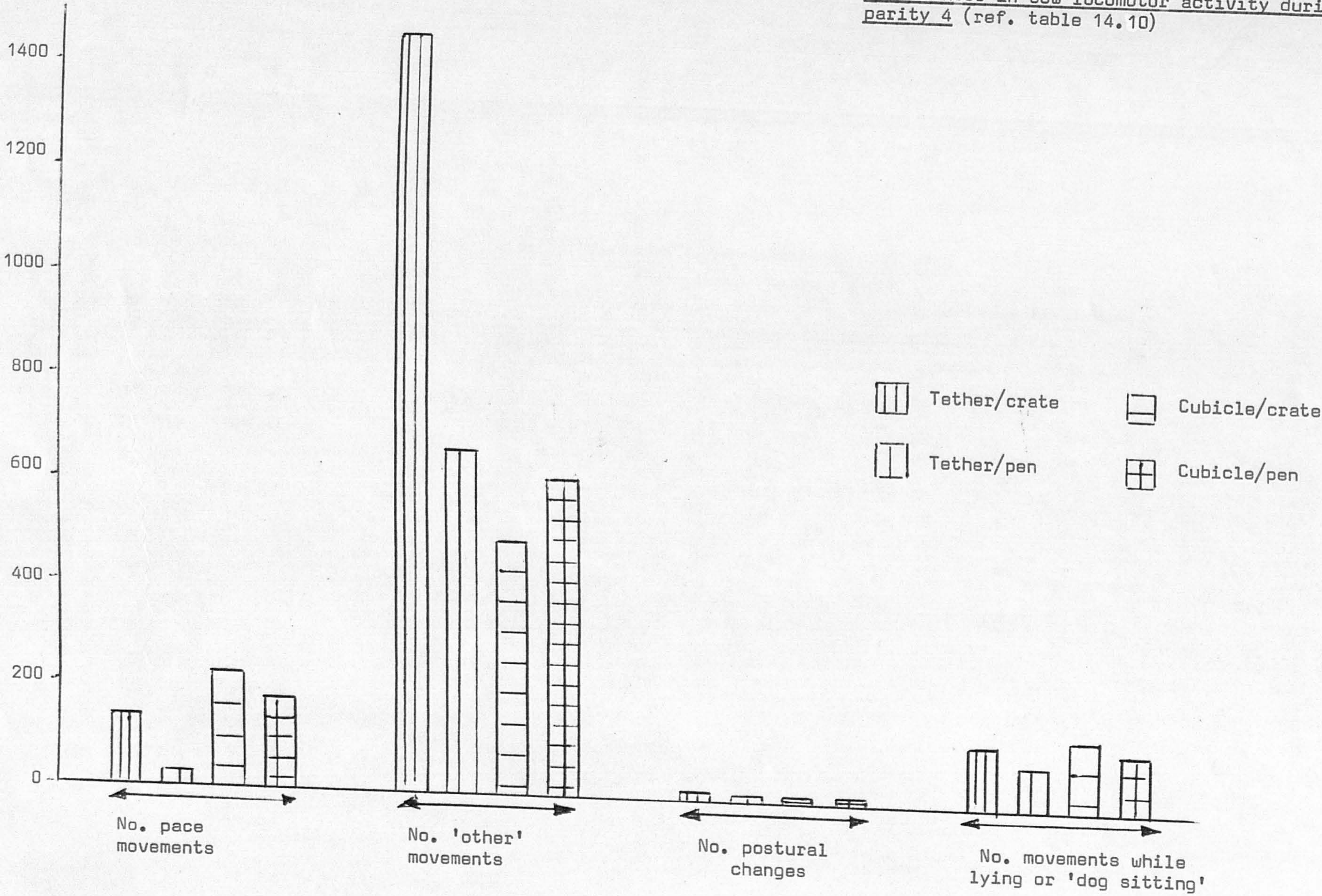


Fig. 14.18 Differences in sow locomotor activity between free range and confined sows (ref. table 14.13)

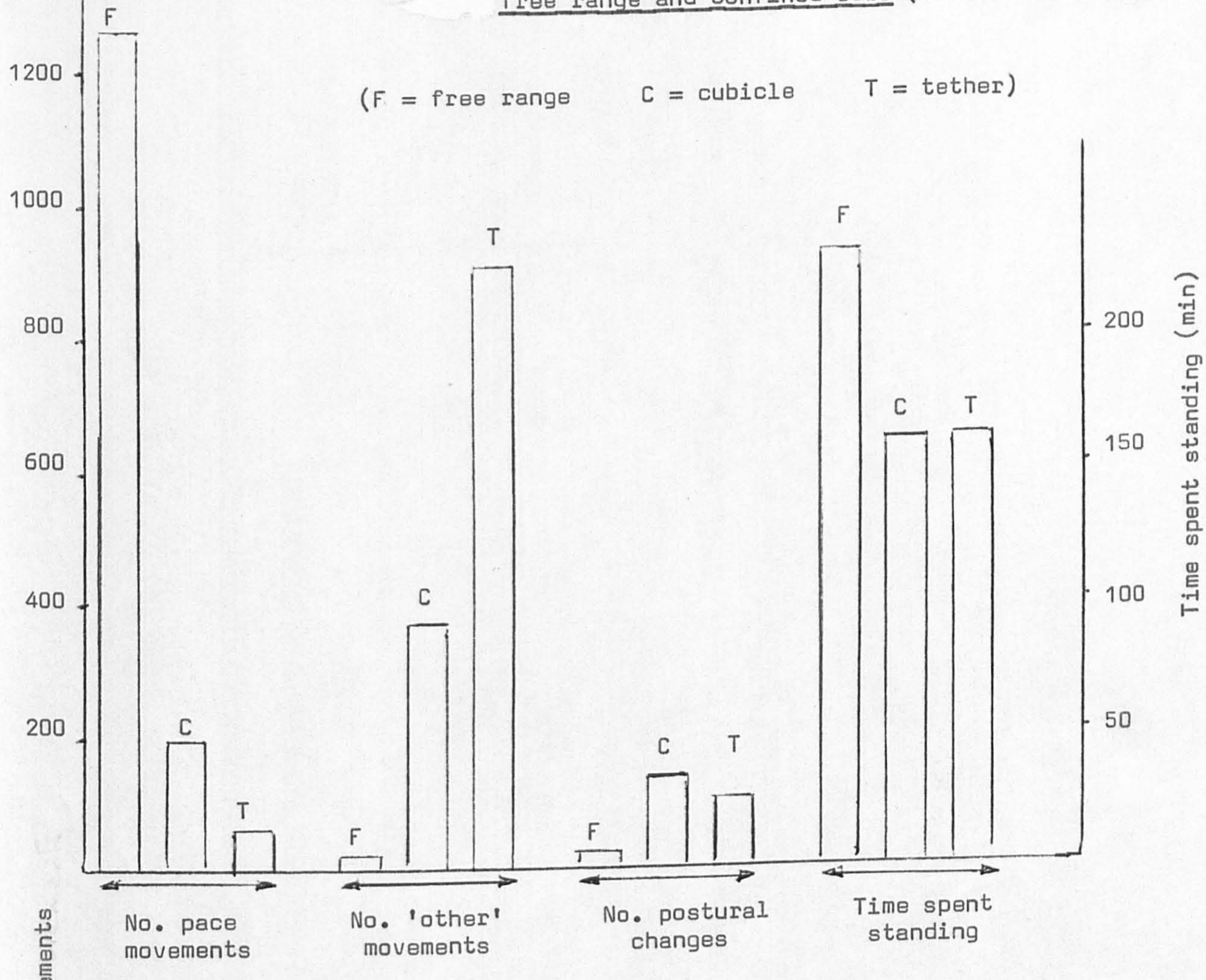


Fig. 14.19 Comparison of sow locomotor activity within the dunging and lying areas of the cubicle (ref. table 14.14)

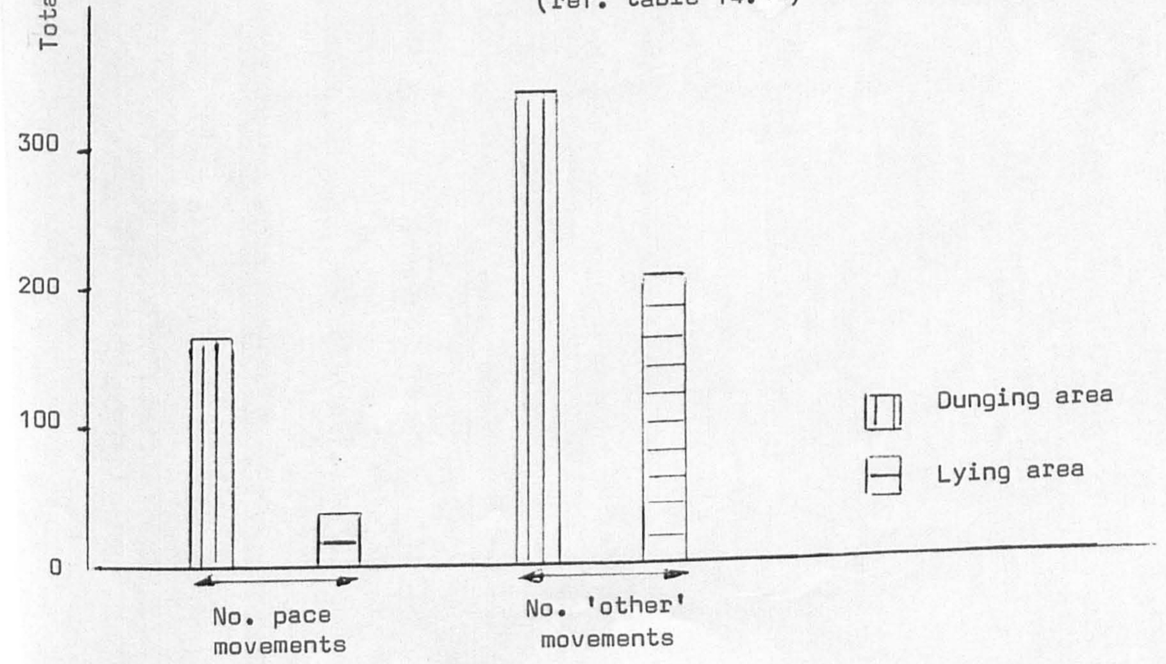


Table 14.15 Pattern of sow locomotor activity over the 6 hour observation period
(Figures refer to number of times activity occurred and values on the same horizontal line bearing different superscripts differ significantly from each other. Both treatments combined).

Activity	Time interval within observation period 0-2 hours (approx. 10-12.00)	 2-4 hours (approx. 12-14.00)	 4-6 hours (approx. 14-16.00)	Level of significance
No. postural changes	$2^{a} \pm 0.7$	$3.5^{ab} \pm 0.7$	$4.4^{b} \pm 0.7$	*
Total no. leg movements	$487^{a} \pm 49.2$	$233^{b} \pm 49.2$	$156^{b} \pm 49.2$	***
No. pace movements	$84^{a} \pm 11.2$	$36^{b} \pm 11.2$	$14^{b} \pm 11.2$	***
No. "other" movements	$403^{a} \pm 46.8$	$197^{b} \pm 46.8$	$141^{b} \pm 46.8$	***
Amount of time spent standing (min.)	$93.8^{a} \pm 6.8$	$41.2^{b} \pm 6.8$	$30.4^{b} \pm 6.8$	***

Fig. 14.20 Pattern of sow locomotor activity over the 6 hour observation period (ref. table 14.15)

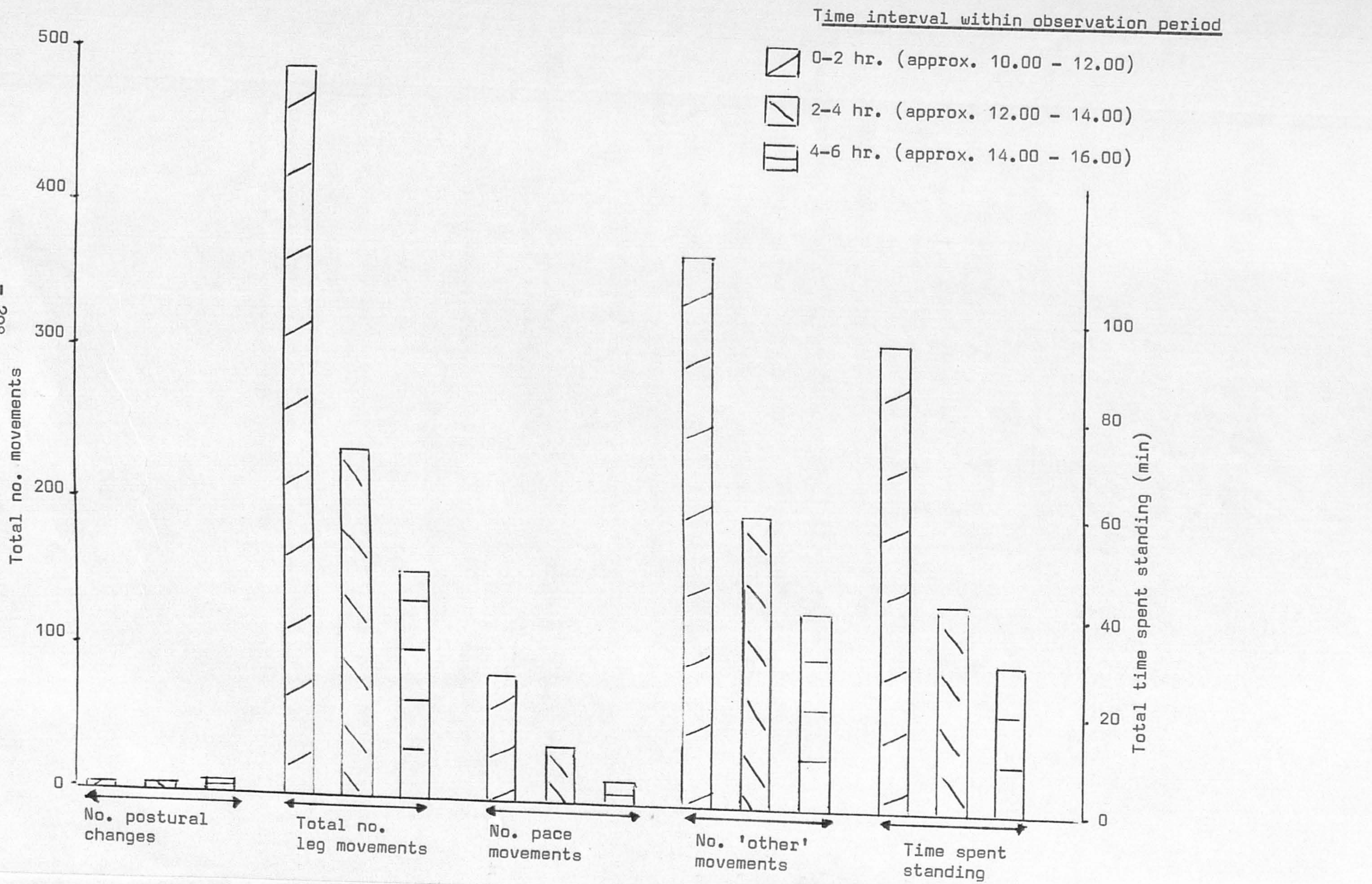


Table 14.16 Comparison of sow locomotor activity during the day and at night (Figures are means of treatment groups)

Activity	Day (10.00-16.00) Tethered	Day (10.00-16.00) In Cubicles	Night (22.00-04.00) Tethered	Night (22.00-04.00) In Cubicles
No. sows observed	8	9	1	1
Total time spent standing (min.)	164	162	6	0
No. pace movements	62	197	1	0
No. 'other' movements	912	369	21	0
No. postural changes	107	131	95	119

As the recordings were carried out over the course of 5 months (February-July 1983), the temperature in the dry sow house varied considerably (from 6°C to 25°C) and it might have been expected that this would influence sow behaviour such as the amount of time spent standing. In fact, as table 14.19 shows, this was not the case and there was no significant difference in the amounts of time spent standing by the sows at the various house temperatures.

Table 14.19 Effect of house temperature on time spent standing by sows during the 6 hour observation period

	House temperature (°C) 6-10	11-15	16-20	21-25	Level of significance
No. of observations	4	8	4	1	
Mean amount of time spent standing (min.)	196 ± 24	162 ± 20	156 ± 24	111 ± 48	n.s.

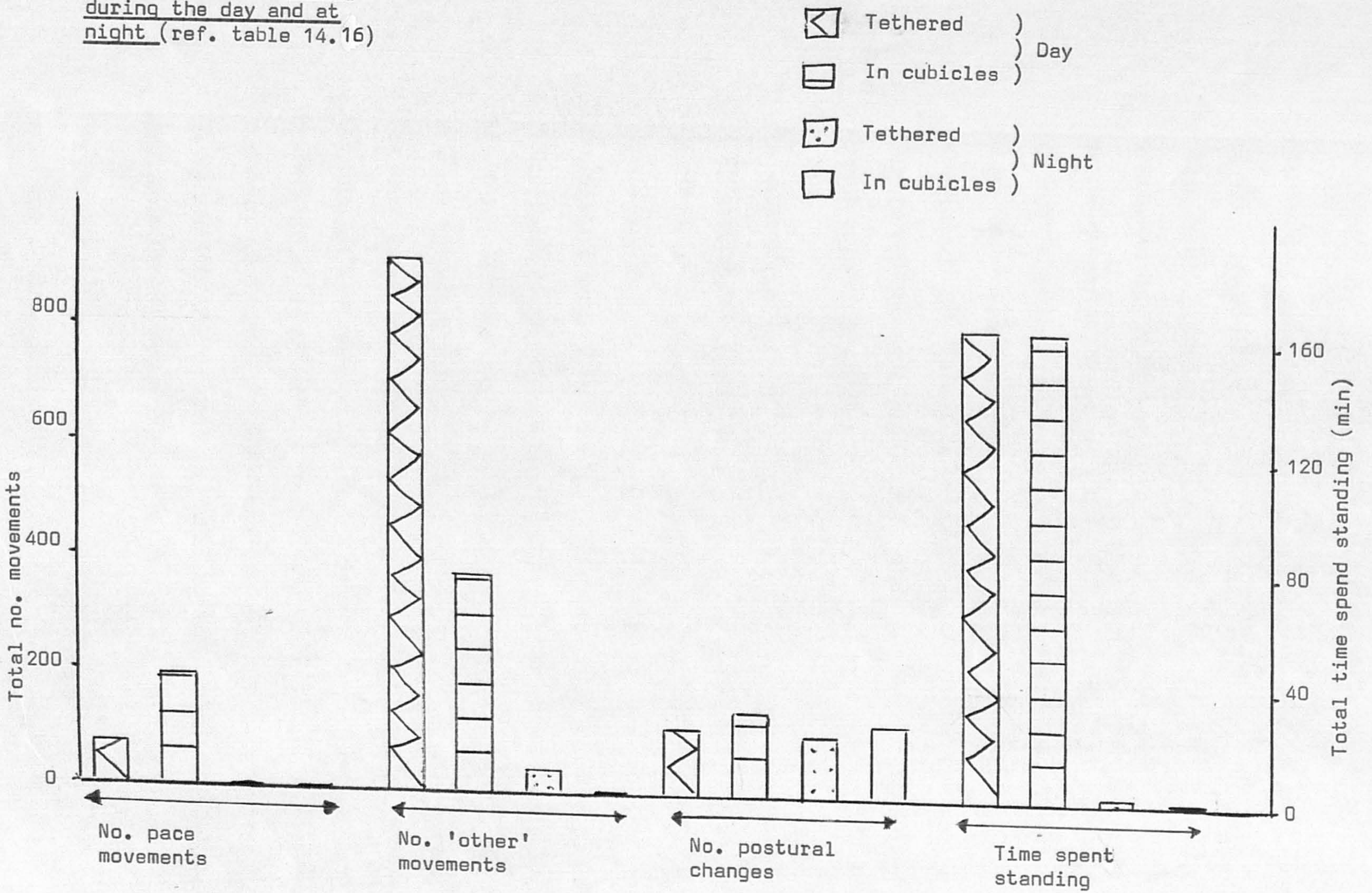
Table 14.17 SUMMARY OF SOW LOCOMOTOR ACTIVITY AT NIGHT

SOW		(TETHER)	Q		U	(CUBICLE)				
PREGNANCY DAY			81/82		83/84					
DATE			23 /	24 . 5 .	83					
RECORDING PERIOD			22.00	------------	04.00					
CUBICLE HOUSE TEMPERATURE /°C			16		16					
TIME SPENT STANDING/ MINUTE			6		0					
RIGHT HIND LEG MOVEMENTS – CUBICLE DUNGING AREA – PACE			–		0					
RIGHT HIND LEG MOVEMENTS – CUBICLE DUNGING AREA – OTHER			–		0					
RIGHT HIND LEG MOVEMENTS – CUBICLE /TETHER AREA – PACE			1		0					
RIGHT HIND LEG MOVEMENTS – CUBICLE /TETHER AREA – OTHER			21		0					
SUBTOTAL			22		0					
POSTURAL CHANGES – STANDING UP FROM DOG SITTING			1		0					
POSTURAL CHANGES – STANDING UP FROM LYING			0		0					
POSTURAL CHANGES – DOG SITTING FROM LYING			1		0					
POSTURAL CHANGES – DOG SITTING MOVING			0		0					
POSTURAL CHANGES – LYING MOVING			91		116					
POSTURAL CHANGES – ROLLING OVER			0		3					
POSTURAL CHANGES – DOG SITTING FROM STANDING			0		0					
POSTURAL CHANGES – LYING DOWN FROM STANDING			2		0					
POSTURAL CHANGES – LYING DOWN FROM DOG SITTING			0		0					
SUBTOTAL			95		119					
TOTAL			117		119					

Table 14.18 SUMMARY OF CONTINUOUS OBSERVATION OF LOCOMOTOR ACTIVITY AT NIGHT

SOW	TETHER Q	CUBICLE U		Q	U		Q	U		MEAN
PREGNANCY DAY	81	83		82	84		82	84		
DATE	23.5.83			24.5.83			24.5.83			
RECORDING PERIOD	22.00 - 24.00			00.00 - 02.00			02.00 - 04.00			
CUBICLE HOUSE TEMPERATURE /°C	16	16		16	16		16	16		
TIME SPENT STANDING/ MINUTE	5	0		0	0		1	0		
RIGHT HIND LEG MOVEMENTS – CUBICLE DUNGING AREA – PACE	–	0		–	0		–	0		
RIGHT HIND LEG MOVEMENTS – CUBICLE DUNGING AREA – OTHER	–	0		–	0		–	0		
RIGHT HIND LEG MOVEMENTS – CUBICLE /TETHER AREA – PACE	1	0		0	0		0	0		
RIGHT HIND LEG MOVEMENTS – CUBICLE /TETHER AREA – OTHER	21	0		0	0		0	0		
SUBTOTAL	22	0		0	0		0	0		
POSTURAL CHANGES – STANDING UP FROM DOG SITTING	0	0		0	0		1	0		
STANDING UP FROM LYING	0	0		0	0		0	0		
DOG SITTING FROM LYING	0	0		0	0		1	0		
DOG SITTING MOVING	0	0		0	0		0	0		
LYING MOVING	35	42		30	36		26	38		
ROLLING OVER	0	3		0	0		0	0		
DOG SITTING FROM STANDING	0	0		0	0		0	0		
LYING DOWN FROM STANDING	1	0		0	0		1	0		
LYING DOWN FROM DOG SITTING	0	0		0	0		0	0		
SUBTOTAL	36	45		30	36		29	38		
TOTAL	58	45		30	36		29	38		

Fig. 14.21 Sow locomotor activity during the day and at night (ref. table 14.16)



3. Behaviour on entering farrowing treatment at approximately day 110 (parities 1-3)

The results are shown in tables A.15-A.17 under the final columns of the observations carried out in pregnancy. There were several significant differences in behaviour between sows on the various treatments and these are summarised in table 14.20. The nature of the pregnancy treatment (i.e. whether tethers or cubicles) appears to have no effect on behaviour but the farrowing treatment (i.e. whether sows enter a crate or a pen) produced marked behavioural differences, with the sows entering crates spending significantly longer lying down, while the sows in pens spent more time manipulating straw.

b) Behaviour at farrowing (parities 1-4)

1. Prepartum sow behaviour

In order to standardise the prepartum behavioural results, the number of times an activity occurred in the 2 hour period immediately prior to the birth of the first piglet was recorded. Unfortunately, there were 40 occasions (50% of the farrowings observed) on which the birth of the first piglet occurred less than 2 hours following commencement of observation or on which data was lost for other reasons and so there are no prepartum behaviour records in these cases. Similarly, on many occasions, continuous recordings of behaviour were made 12-15 hours before the first delivery, in which cases these early data have not been included in the statistical analysis of the 2 hour period immediately prepartum, although they are referred to on occasions.

The results for sow behaviour immediately prepartum are shown in table A.21. Observation and recording of postural changes and

Table 14.20 Differences in sow behaviour on entering farrowing treatment (Figures refer to mean percentage of time spent in that activity and parities are pooled. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly from each other).

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Manipulating straw	18.2^{a} (23.1^{a}	34.9^{b} 35.1^{b} (S.E.M. ± 3.1)	22.3^{ab} 27.2^{ab}	34.7^{b} 35.2^{b})			*
					20.3^{a} (25.1^{a} (S.E.M. ± 2.3)	34.8^{b} 35.1^{b})	**
Lying	59.9^{a} (50.7^{a}	41.5^{b} 39.3^{b} (S.E.M. ± 3.7)	56.7^{ab} 48.2^{ab}	34.6^{b} 34.6^{b})			*
					58.3^{a} (49.4^{a} (S.E.M. ± 2.8)	38.1^{b} 36.9^{b})	**
Standing	6.0 (13.1	6.0 12.3 (S.E.M. ± 2.4)	8.1 12.1	6.9 12.4)			n.s.

activities such as manipulating straw, urinating, eating etc. was a simple matter, but problems were encountered in the recording of activities such as tail twitching, quivering, straining and vocalising as these frequently occurred in very rapid succession and so the final score shown in table A.21 must be considered to be somewhat approximate.

The significance of the differences in sow behaviour prepartum is shown in table 14.21; where there were sufficient data, the results were analysed on the basis of 4 treatments (i.e. pregnancy and farrowing treatments), elsewhere data were pooled and analysed on the basis of the 2 farrowing treatments alone. Generally, housing during pregnancy had a negligible effect on behaviour prepartum and, as might be expected, it was the type of farrowing accommodation which was more important. There were differences in the amount of movement undertaken by the sows immediately before farrowing (in terms of both vigorous leg movements and standing), with the sows confined in crates being significantly more active than the animals in pens. With respect to nesting activity, those sows farrowing in crates which had previously been tethered made significantly more attempts to build a nest than did the other groups. There were significant differences in the amounts of straining and quivering shown by the sows, with both these behaviours being more common in the sows confined in crates. Otherwise, there were no significant differences in the frequency of the remaining behaviour patterns observed and likewise, no significant differences in the frequency of a particular behaviour pattern in different parities.

The major criticism of these results is that only data from the immediate prepartum period were analysed and thus much valuable information was lost from those sows which had not been observed

Table 14.21 Significance of differences in the prepartum behaviour of sows (Figures refer to the number of times an activity occurred in the 2 hour period immediately prepartum. Parities pooled. Values on the same horizontal line bearing different superscripts differ significantly from each other).

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Vigorous leg movements	$22.0^{a} \pm 5.0$	$5.7^{b} \pm 5.9$	$29.8^{a} \pm 5.0$	$12.7^{b} \pm 4.4$			*
					$25.9^{a} \pm 3.5$	$10.3^{b} \pm 3.5$	**
"Dog sitting" /rolling over	8.1 ± 2.1	4.0 ± 2.5	9.8 ± 2.1	5.6 ± 1.9			n.s.
					9.0 ± 1.5	5.1 ± 1.5	n.s.
Standing	6.6 ± 1.2	3.3 ± 1.5	5.9 ± 1.2	3.3 ± 1.1			n.s.
					$6.3^{a} \pm 0.8$	$3.3^{b} \pm 0.8$	*

Table 14.21 continued

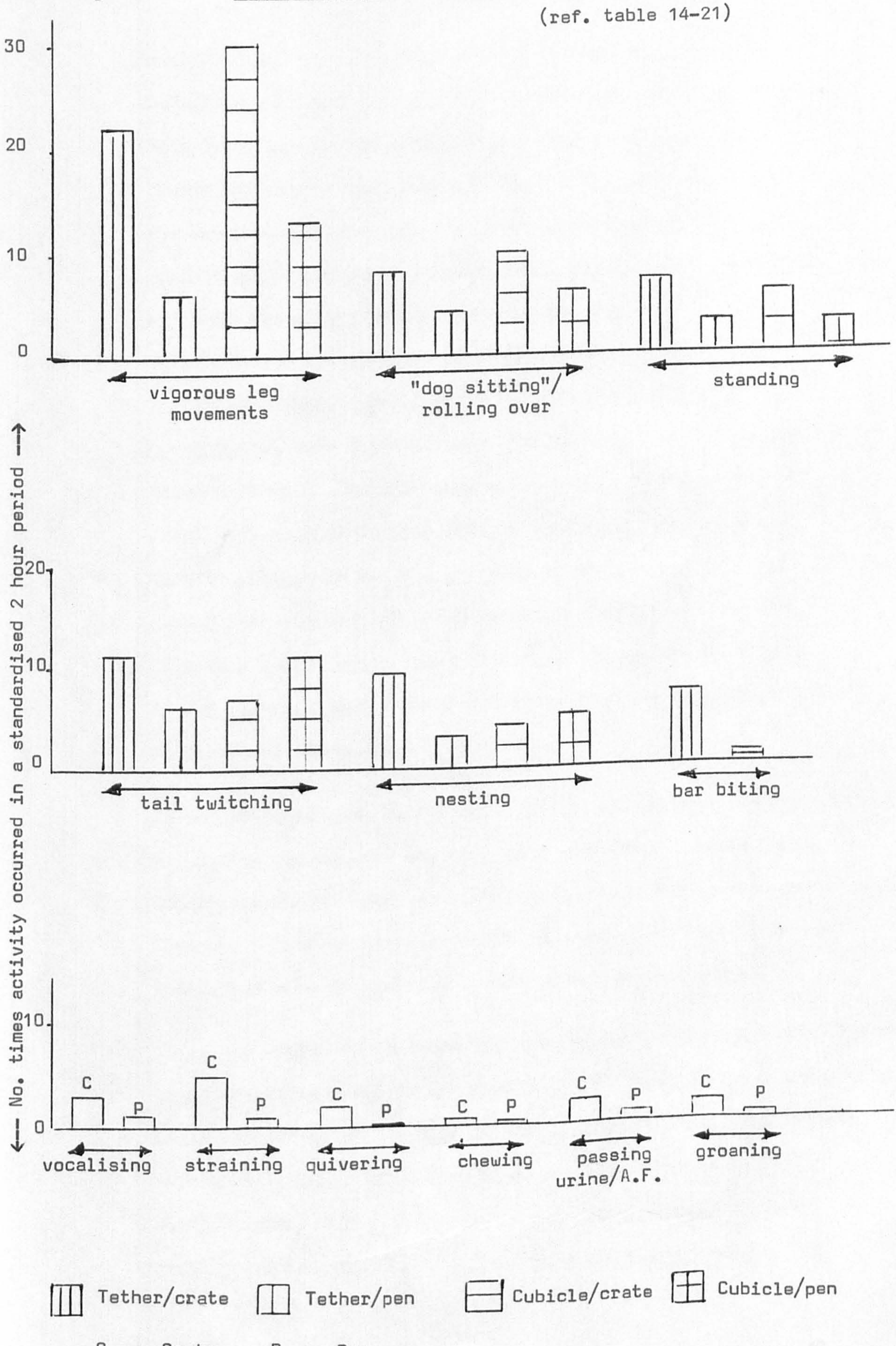
Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Tail twitching	10.9 ± 3.6	5.6 ± 4.2	7.1 ± 3.6	10.7 ± 3.1			n.s.
					9.0 ± 2.5	8.9 ± 2.5	n.s.
Nesting	9.2[a] ± 1.4	2.9[b] ± 1.6	3.9[b] ± 1.4	4.9[b] ± 1.2			*
					6.4 ± 1.1	4.2 ± 1.0	n.s.
Vocalising					2.7 ± 0.8	0.9 ± 0.8	n.s.
Straining					5.1[a] ± 1.2	0.5[b] ± 1.1	**
Quivering					1.8[a] ± 0.5	0.1[b] ± 0.5	*

Table 14.21 continued

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Chewing					0.6 ± 0.2	0.3 ± 0.2	n.s.
Passing urine/ amniotic fluid					1.7 ± 0.5	0.5 ± 0.5	n.s.
Groaning					1.5 ± 0.5	0.6 ± 0.5	n.s.
Bar biting/ gnawing	6.9 ± 2.5		0.8 ± 2.4				n.s.

Fig. 14.22 Differences in the behaviour of sows prepartum

(ref. table 14-21)



continuously for 2 hours prior to first delivery, likewise data collected at a much earlier time were not subjected to analysis. With reference to the latter data (which are shown in the farrowing records appendix table A.65), there were large differences between individual sows as to when a particular behaviour pattern was initiated. For example, sow S showed vigorous bar biting 31 hours before the onset of farrowing whereas sow P rubbed sores due to frenzied biting and kicking the trough at 17 hours prepartum, sow H did similarly at 7 hours prepartum but sow N did not show bar biting until 2 hours before first delivery. Similarly, with respect to nesting behaviour, there were wide variations between individual sows as B was seen to indulge in nesting activity at 56 hours prepartum, while sow D showed frenetic nesting behaviour at 36 hours and sow E only began nesting 2 hours before first delivery. On several occasions, it was apparent that increased nesting activity coincided with an increased production of colostrum.

In the confined sows in crates, 2 of the most common behaviours were bar biting and nesting and many sows alternated between these activities in the hours preceding farrowing. The sows in pens, however, failed to show any behaviour pattern comparable to bar biting and were generally less active during this period.

There was little evidence of the repeatability of a behaviour pattern in a particular sow from one parity to the next which was unfortunate since, had there been a high degree of repeatability, this would have greatly facilitated the judgement of whether or not a particular farrowing was imminent and would, therefore, have greatly reduced the time involved in observing prepartum sows!

2. Intrapartum sow behaviour

Data showing details of intrapartum sow behaviour are presented in table A.22. Since the duration of farrowing varied considerably, it was necessary to standardise the intrapartum behavioural results and this was achieved by noting the number of times an activity occurred in the period between delivery of the first and last piglets. This activity score was then adjusted so as to correspond to a 2 hour intrapartum period e.g. if a sow stood up on 15 occasions during a farrowing which lasted 3 hours, this was recorded as a score of 10 for standing.

Out of a possible total of 80, 74 (i.e. 92.5%) of the farrowings were recorded; the missing data resulting from instances where manual assistance had to be used, sows died or were culled. This very high recording rate bears tribute to the innumerable hours which were spent in continually observing the animals and waiting for farrowings to commence.

The significance of differences in intrapartum sow behaviour are given in table 14.22. Again, it is apparent that the type of housing in pregnancy has little effect on how a sow behaves during farrowing, whereas the type of farrowing accommodation has a profound influence. Thus, there was significantly more evidence of vigorous leg movements shown by the sows in crates, whereas the sows in pens stood and nested more frequently during the farrowing process. As was the case prepartum, the sows in crates showed significantly more straining and quivering and these sows also passed urine and/or amniotic fluid more frequently. The sows in pens, however, indulged in significantly more chewing activity,

Table 14.22 Significance of differences in the intrapartum behaviour of sows (Figures refer to the number of times an activity occurred in a standardised 2 hour period. Parities pooled. Values on the same horizontal line bearing different superscripts differ significantly).

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Vigorous leg movements	28.5[a] ± 4.0	11.7[b] ± 3.7	30.6[a] ± 3.6	15.8[b] ± 3.7			***
					29.5[a] ± 2.7	13.8[b] ± 2.6	***
"Dog sitting"/ / rolling over	5.8 ± 1.7	4.2 ± 1.5	4.0 ± 1.5	6.3 ± 1.5			n.s.
					4.8 ± 1.1	5.2 ± 1.1	n.s.
Standing	0.9[a] ± 0.7	3.3[ab] ± 0.6	1.4[a] ± 0.6	5.0[b] ± 0.6			***
					1.1[a] ± 0.5	4.2[b] ± 0.5	***

14.22 continued

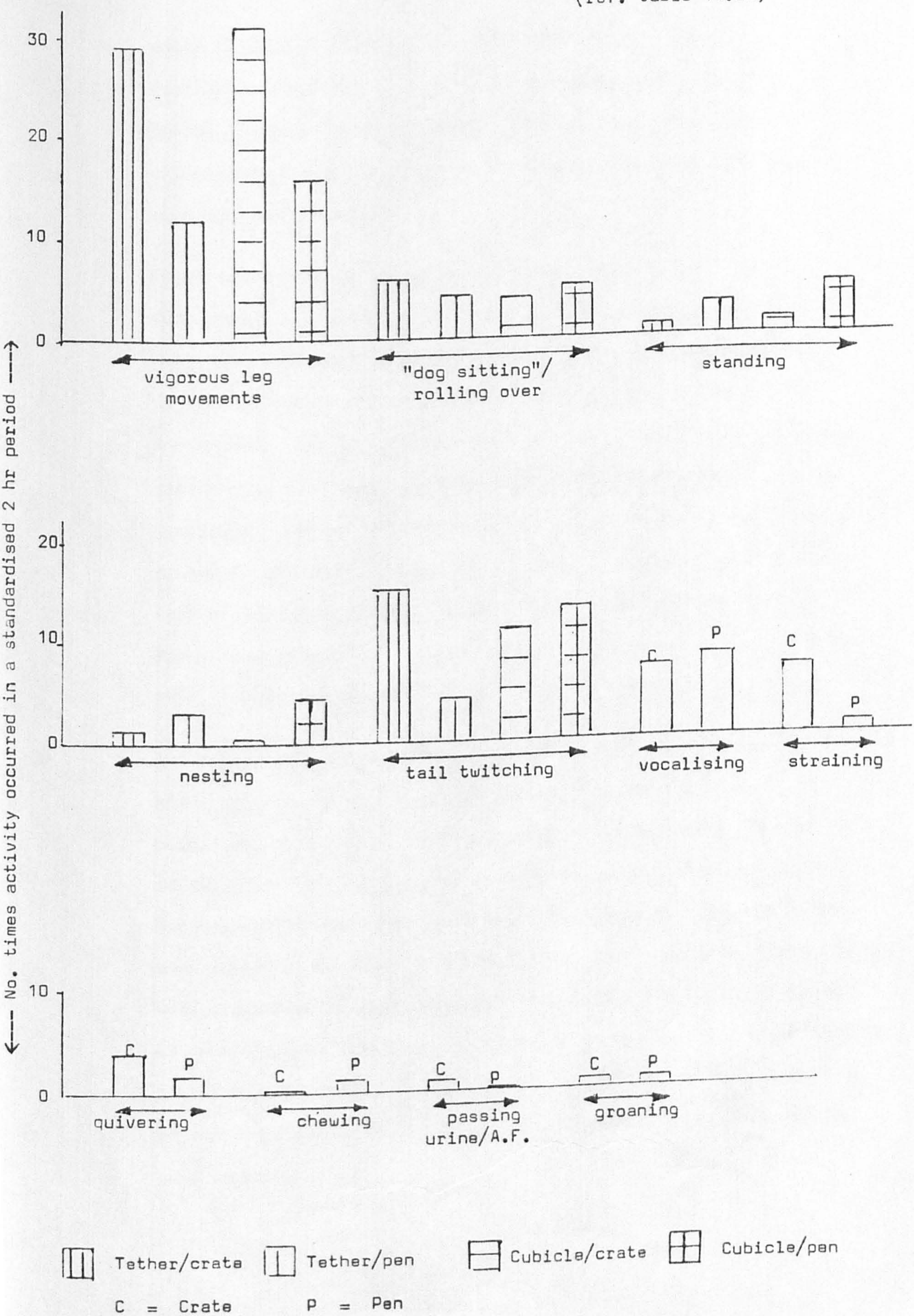
Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Nesting	$0.8^{a} \pm 0.5$	$2.7^{a} \pm 0.5$	$0.3^{a} \pm 0.5$	$4.0^{b} \pm 0.5$			***
					$0.5^{a} \pm 0.3$	$3.3^{b} \pm 0.3$	***
Tail twitching	14.5 ± 3.1	4.3 ± 2.9	10.6 ± 2.8	12.9 ± 2.9			n.s.
					12.3 ± 2.2	8.6 ± 2.1	n.s.
Vocalising					7.0 ± 1.9	8.0 ± 1.8	n.s.
Straining					$6.7^{a} \pm 1.1$	$1.2^{b} \pm 1.1$	***

Table 14.22 continued

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Quivering					4.3[a] ±0.6	1.5[b] ±0.6	**
Chewing					0.1[a] ±0.3	0.9[b] ±0.3	*
Passing urine/ amniotic fluid					0.7[a] ±0.2	0.1[b] ±0.2	*
Groaning					0.9 ±0.3	0.9 ±0.3	n.s.

Fig. 14.23 Differences in the behaviour of sows intrapartum

(ref. table 14.22)



which frequently occurred as they were lying on their side during the farrowing. There were no significant differences in the frequency of a behaviour pattern between the various parities with the exception of vocalising which was significantly more frequent in parity 2.

There was more evidence of a degree of repeatability in the intrapartum behaviour of the sows than was the case with their prepartum behaviour and this appeared to be more a characteristic of the individual sow than related to a particular treatment. For example, sow D was active in the early part of each farrowing, standing up and making nesting attempts until delivery of the 4th (parities 2 and 3) or 6th (parity 4) piglet, when she lay down and remained settled. Likewise sow K remained quiescent throughout each of her (3) farrowings while sow C showed signs of panic in the first farrowing and of extreme agitation in the 2nd and 3rd farrowings, before she eventually settled down in each case.

A comparison of sow behaviour both before and during farrowing is given in table 14.23. When the data from both stages of parturition are pooled, there are significant treatment effects on the number of leg movements (with the sows farrowing in crates making significantly more than those farrowing in pens, while the sows farrowing in crates which had previously been housed in cubicles, made significantly fewer attempts at nesting. In terms of amount of straining and quivering, the sows in crates showed a significantly higher incidence than the sows in pens, while the tether/crate sows passed significantly more urine and/or amniotic fluid than did the sows in pens.

<u>Table 14.23</u> <u>Comparison of sow behaviour pre- and intrapartum</u> (Figures refer to the number of times an activity occurred in the 2 hour period immediately <u>prepartum</u> or in a standardised 2 hour intrapartum period. Values on the same horizontal line bearing different superscripts differ significantly. Parities pooled).

Activity	Treatment (both stages combined)				Stage of farrowing		Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Pre-	Intra	
Vigorous leg movements	$26.0^{a} \pm 3.2$	$10.1^{b} \pm 3.2$	$30.3^{a} \pm 3.0$	$14.6^{b} \pm 2.9$			***
					18.1 ± 2.6	21.5 ± 1.9	n.s.
"Dog sitting"/ rolling over	5.6 ± 1.2	4.1 ± 1.2	5.9 ± 1.1	6.0 ± 1.1			n.s.
					$7.0^{a} \pm 0.9$	$4.6^{b} \pm 0.7$	*
Standing	3.1 ± 0.6	3.3 ± 0.6	2.9 ± 0.6	4.3 ± 0.6			n.s.
					$4.8^{a} \pm 0.5$	$2.7^{b} \pm 0.4$	**

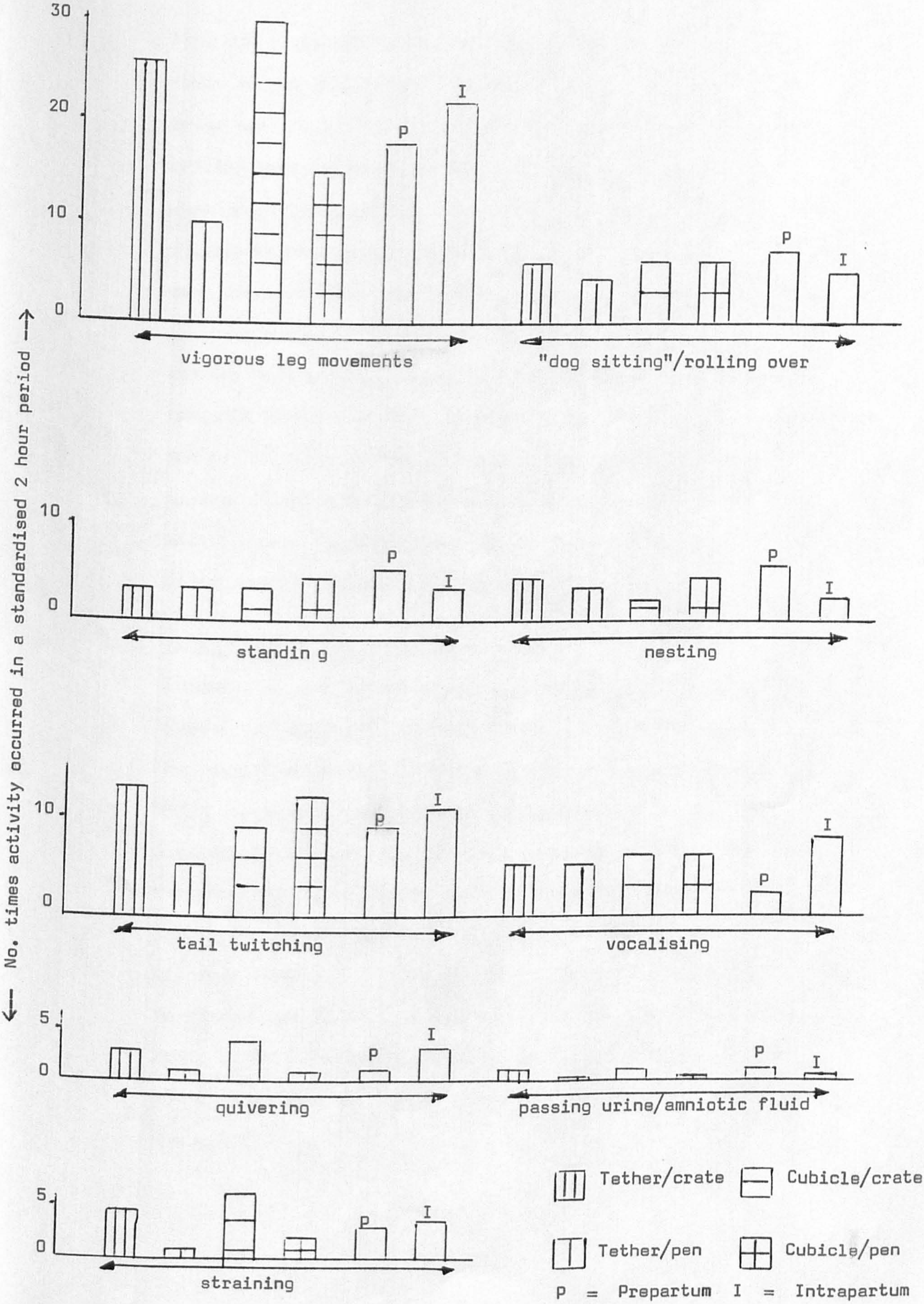
Table 14.23 contined

Activity	Treatment (both stages combined)				Stage of farrowing		Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Pre-	Intra	
Nesting	3.7^{b} ± 0.6	2.7^{ab} ± 0.6	1.5^{a} ± 0.6	4.3^{b} ± 0.5			**
					5.1^{a} ± 0.5	2.0^{b} ± 0.4	***
Tail twitching	13.2 ± 2.4	4.7 ± 2.4	9.3 ± 2.2	12.0 ± 2.2			n.s. but approaching *
					8.7 ± 1.9	10.5 ± 1.4	n.s.
Vocalising	4.9 ± 1.8	5.3 ± 1.8	6.0 ± 1.7	6.1 ± 1.7			n.s.
					1.8^{a} ± 1.5	7.7^{b} ± 1.1	**

Table 14.23 contined

Activity	Treatment (both stages combined)				Stage of farrowing		Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Pre-	Intra	
Straining	$5.3^{b} \pm 1.2$	$1.3^{a} \pm 1.2$	$7.1^{b} \pm 1.2$	$1.8^{a} \pm 1.1$			**
					3.1 ± 1.0	4.3 ± 0.7	n.s.
Quivering	$3.4^{b} \pm 0.6$	$1.2^{a} \pm 0.6$	$3.5^{b} \pm 0.6$	$0.9^{a} \pm 0.6$			**
					$1.0^{a} \pm 0.5$	$2.9^{b} \pm 0.4$	**
Passing urine/ amniotic fluid	$1.3^{a} \pm 0.3$	$0.2^{b} \pm 0.3$	$0.9^{ab} \pm 0.3$	$0.3^{b} \pm 0.3$			*
					$1.1^{a} \pm 0.3$	$0.4^{b} \pm 0.2$	*

Fig. 14.24 Comparison of sow behaviour pre- and intra- partum (ref. table 14.23)



When sow behaviour before and during farrowing is compared, there was no significant difference in the number of leg movements made, but the sows showed significantly more dog sitting/rolling over movements in the prepartum period and they also stood more frequently at this stage. The standing was frequently associated with nesting behaviour which was also significantly more frequent before farrowing. During the farrowing process, the sows tended to be less active but they showed significantly greater vocalisation. Straining and quivering were also more frequent during farrowing than before it, although the difference was not significant for the former activity. Conversely, the passage of urine and/or amniotic fluid was significantly more common before farrowing while there were no significant differences in the amount of tail twitching between the 2 stages.

c) Post partum sow behaviour

A summary of sow behaviour on day 5 post partum can be found in tables A.16 and A.17 (parities 2 and 3) and A.23 (parity 4). The significance of the results is presented on table 14.24 which shows that there were no significant differences between treatments in any of the behaviour patterns studied. There were, however, significant differences between parities when the results for the treatments were pooled (table 14.25) which showed that the sows stood more frequently during the third parity, while lying in sternal recumbency was more common in the second parity and lying in the suckling position in the fourth parity. All the other differences between behaviours in different parities were non significant.

Table 14.24 **Differences in postpartum sow behaviour** (Figures refer to mean percentage of time spent in that activity while those in brackets are arcsin transformed values with their standard errors. Parities pooled).

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Standing	1.1 (4.4 ±2.0)	1.9 (5.6 ±1.8)	3.5 (6.8 ±1.8)	3.2 (7.0 ±1.9)			n.s.
					2.4 (5.7 ±1.3	2.6 (6.2 ±1.3)	n.s.
Lying (sternal recumbency)	36.3 (35.6 ±5.1)	23.3 (25.4 ±4.5	23.4 (25.5 ±4.5	34.9 (33.9 ±4.9)			n.s.
					29.1 (29.9 ±3.5)	28.7 (29.3 ±3.4)	n.s.

Table 14.24 continued

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Lying (suckling position)	31.1 (29.9 ±5.4)	41.2 (37.7 ±4.8)	37.5 (34.5 ±4.8)	29.1 (29.0 ±5.2)			n.s.
					34.7 (32.4 ±3.8	35.6 (33.6 ±3.7)	n.s.
Lying suckling	9.8 (15.1 ±3.4)	13.9 (21.2 ±3.1)	15.0 (18.8 ±3.1)	13.2 (19.3 ±3.3)			n.s.
					12.7 (17.2 ±2.2)	13.6 (20.3 ±2.2)	n.s.

Table 14.24 continued

Activity	Treatment						Level of significance
	Te/Cr	Te/Pen	Cu/Cr	Cu/Pen	Crate	Pen	
Manipulating straw	10.9 (15.8 $\pm$4.0)	11.5 (14.2 $\pm$3.6)	6.9 (11.9 $\pm$3.6)	4.7 (9.5 $\pm$3.9)			n.s.
					8.7 (13.6 $\pm$2.6)	8.3 (12.0 $\pm$2.6)	n.s.
Chewing/ gnawing					0.2 (0.9 $\pm$0.4)	0.1 (0.4 $\pm$0.3)	n.s.

Fig. 14.25 Differences in post partum sow behaviour (ref. table 14.24)

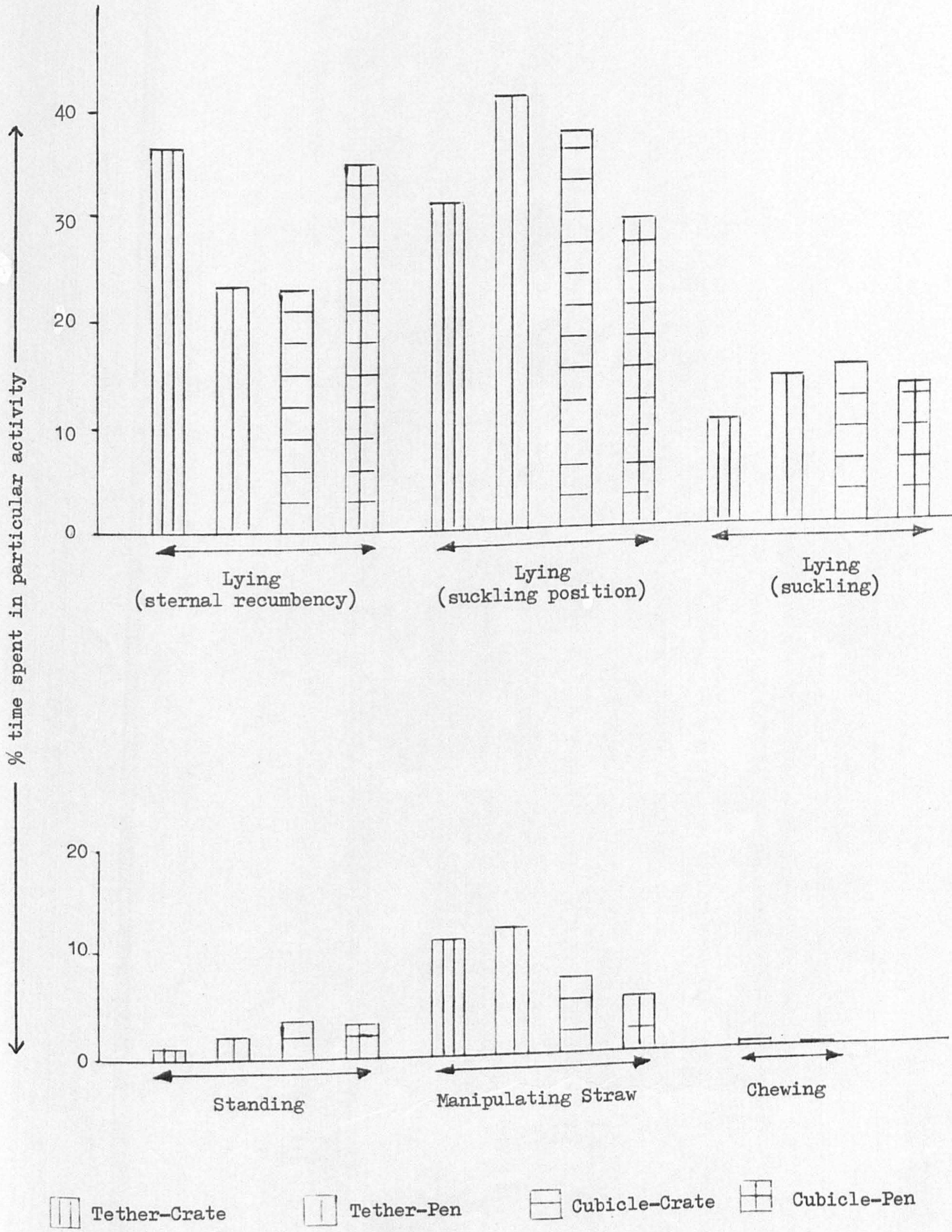
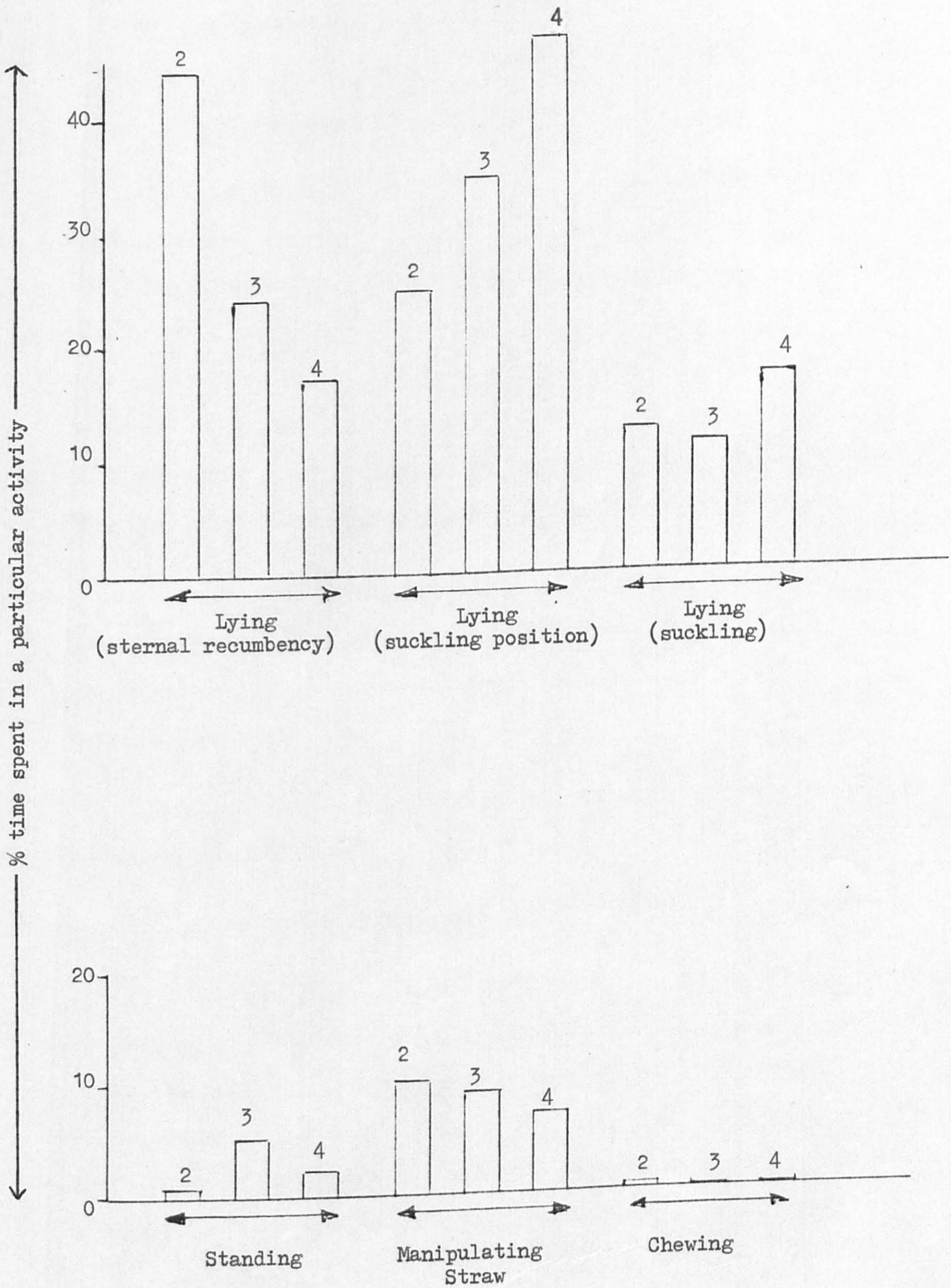


Table 14.25 **Effect of parity on postpartum sow behaviour** (Figures refer to mean percentage of time spent in that activity while those in brackets are arcsin transformed values with their standard errors. Figures on the same horizontal line bearing different superscripts differ significantly from each other. Treatments pooled).

Activity	Parity 2	Parity 3	Parity 4	Level of significance
Standing	0.6^{a} (2.9 ± 1.5)	5.0^{b} (9.9 ± 1.6)	2.1^{a} (5.4 ± 1.6)	**
Lying (sternal recumbency)	44.1^{a} (41.1 ± 4.1)	23.9^{b} (24.9 ± 4.3)	16.5^{b} (21.1 ± 4.4)	**
Lying (suckling position)	24.7^{a} (23.5 ± 4.4)	35.2^{ab} (33.9 ± 4.6)	47.4^{b} (43.3 ± 4.7)	*
Manipulating straw	9.5 (12.4 ± 3.1)	9.2 (15.1 ± 3.3)	6.6 (10.8 ± 3.4)	n.s.
Suckling	11.6 (17.7 ± 2.7)	11.3 (17.3 ± 2.8)	16.9 (21.6 ± 2.9)	n.s.
Chewing/ gnawing	(1.3 ± 0.4)	(0.3 ± 0.4)	(0.3 ± 0.4)	n.s.

Fig. 14.26 **Effect of parity on post partum sow behaviour** (ref. table 14.25)



N.B. Figures refer to parity numbers.

ii) Sow reproductive performance

a) Farrowing characteristics

1. First appearance of colostrum

Details of the time before farrowing at which colostrum was first detected are given in tables A.24 and 14.26. There were no significant differences between the four housing treatments but sows in the tether-crate system were found to produce colostrum considerably later than all the other sows. Analysis of the results according to housing at farrowing, however, showed highly significant ($P < 0.01$) differences with the sows which were in pens producing colostrum much earlier than those in crates.

There were also significant differences in time of colostrum detection between parities (table 14.26b), with the older sows (parities 3 and 4) producing colostrum sooner than the younger sows (parities 1 and 2).

In virtually every case, a straw coloured serous fluid was produced before the advent of the true milk.

2. Duration of gestation

As shown in tables A.25 and 14.26, there were no significant differences in length of gestation between treatments or parities; in fact the mean farrowing dates were remarkably similar. With the exception of gilt B in parity 1, all the sows farrowed between days 112 and 117 of gestation, which is within the normal range of gestation lengths. Gilt B was unusual in that she exhibited the

Table 14.26a **Differences in farrowing characteristics between treatments**

/Parities pooled. Figures on the same horizontal line bearing different superscripts differ significantly from each other/

Farrowing parameter	Treatment								significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	
First appearance of colostrum (hr. before farrowing)	52.7 ±8.0	68.4 ±7.3	61.9 ±7.1	78.7 ±7.3					n.s.
					61.2 ±5.5	70.1 ±5.2			n.s.
							57.8[a] ±5.1	73.5[b] ±5.0	* *
Length of gestation (days)	114.5 ±0.4	115.2 ±0.4	115.3 ±0.4	115.3 ±0.4					n.s.
Total duration of farrowing (min.)	276 ±164	240 ±150	523 ±146	222 ±150					n.s.
					257 ±109	376 ±104			n.s.
							413 ±106	231 ±103	n.s.
Mean interval between successive births (min.)	32.3 ±13.1	20.0 ±11.6	44.4 ±11.3	21.6 ±11.6					n.s.
					25.7 ±8.2	32.3 ±7.7			n.s.
							39.2 ±8.3	20.8 ±8.0	n.s.

Table 14.26b Differences in farrowing characteristics between parities

[Treatments pooled. Figures on the same horizontal line bearing different superscripts differ significantly from each other]

Farrowing Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Colostrum appeared (hr. before farrowing)	42.3^{a} ±7.5	57.8^{a} ±7.1	86.4^{b} ±7.3	77.4^{b} ±7.7	* * *
Length of gestation (days)	115.3 ±0.4	114.8 ±0.4	115.2 ±0.4	115.1 ±0.4	n.s.
Total duration of farrowing (min.)	197 ±154	225 ±146	244 ±150	644 ±158	n.s.
Mean birth interval (min.)	20.9 ±12.0	29.8 ±11.3	22.0 ±11.6	48.4 ±12.7	n.s.

normal behaviour patterns associated with farrowing on days 112 - 115 (ref. farrowing records table A.65), but these then disappeared and she suddenly produced 1 dead pig on day 124! No explanation can be offered for this phenomenon and her 3 following gestations were all of a normal length.

Finally, there was no obvious relationship between gestation length and season of the year with both short (i.e. 112 days) and long (i.e. 117 days) gestations occurring in summer as well as winter; neither was there any relationship between litter size and gestation length.

3. Duration of farrowing

As can be seen in table A.26, this was extremely variable ranging from 35 to approximately 5700 minutes, but statistical analysis failed to reveal any significant differences between treatments or parities (table 14.26). In 14.9% of the farrowings, 1 or more piglets were born after the period of continuous observation had ended, in several cases many hours after the expulsion of the placenta. Difficulties sometimes arose in judging the completion of a farrowing based on the number of piglets delivered and the weight of expelled placenta; in many cases (i.e. 85.1% of the farrowings) the completion of parturition was evident, but the small number mentioned above represented an error of judgement on the part of the observer.

Since the total duration of farrowing could be considered to be a function of litter size, the mean interval between successive births was also calculated (table A.27). Mean birth intervals between litters varied from 6 minutes to 384 minutes but again, there were no significant differences between treatments or parities (table 14.26) although, as with the total duration of farrowing, the mean birth interval was considerably shorter in pens compared to crates and in tethers compared to cubicles. Within a particular litter, the interval between successive births also varied considerably and it was common for an interval of 1-2 hours to be followed by the simultaneous birth of 2, 3 or even 4 piglets, all of which added to the difficulties of collecting individual piglet data. As tables A.59 - A.62 indicate, there was no definite pattern of birth intervals within a farrowing, with both long and short intervals occurring at all stages, although there was a tendency for the longer intervals to be more common towards the end of the birth process.

Within a treatment, there was no obvious increase in the duration of farrowing over the parities (other than due to an increase in litter size) but it is interesting that in parity 4, both the farrowings taking longer than 800 minutes were from sows housed in crates although, if these sows are ignored, there was no greater increase in mean birth interval between sows housed in crates than those in pens.

With reference to the timing of farrowing, although from the purely subjective viewpoint of the observer it seemed as if the majority of births occurred in the early hours of the morning, analysis of the data actually revealed a random distribution of farrowings! There was also no relationship between the time of day at which farrowing occurred and its duration (fig. 14.27).

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Fig. 14.27 Timing and duration of farrowings

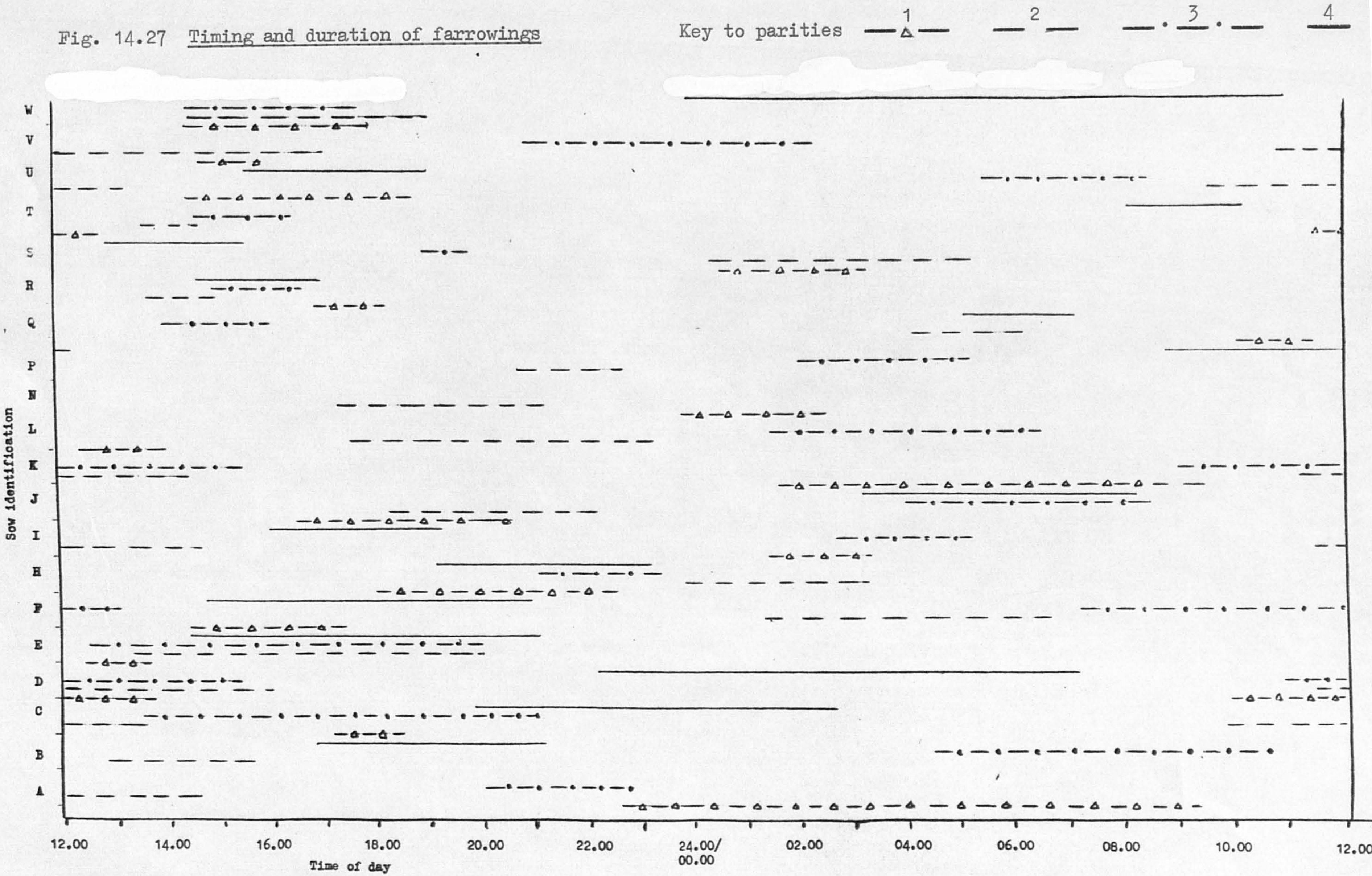


Table 14.27a Differences in litter sizes between treatments

[Parities pooled. Figures in brackets are arcsin transformed values]

Parameter	Treatment								Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	
Nos. piglets born alive	10.1 ±0.7	11.6 ±0.7	11.0 ±0.7	11.0 ±0.7					n.s.
					10.9 ±0.5	11.0 ±0.5			n.s.
							10.5 ±0.5	11.3 ±0.5	n.s.
Nos. piglets born dead	0.9 ±0.3	0.6 ±0.3	0.6 ±0.3	0.4 ±0.3					n.s.
					0.8 ±0.2	0.5 ±0.2			n.s.
							0.8 ±0.2	0.5 ±0.2	n.s.
Still birth rate (% total births)	7.1 (8.3 ±3.6)	9.2 (10.9 ±3.3)	5.9 (7.6 ±3.3)	3.0 (4.1 ±3.4)					n.s.
					8.3 (9.7 ±2.4)	4.7 (5.9 ±2.4			n.s.
							6.5 (7.9 ±2.5)	6.2 (7.6 ±2.5)	n.s.

Table 14.27b — Differences in litter sizes between parities

[Treatments pooled. Figures in brackets are arcsin transformed values]

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Nos. piglets born alive	8.9^{a} ±0.7	11.3^{b} ±0.7	11.9^{b} ±0.7	11.9^{b} ±0.7	* *
Nos. piglets born dead	0.8 ±0.3	0.3 ±0.3	0.4 ±0.3	1.1 ±0.3	n.s.
Stillbirth rate (% total births)	11.0 (12.3±3.3)	2.3 (3.8±3.3)	4.2 (5.4±3.4)	7.8 (9.5±3.6)	n.s.

b) Litter size

1. Number of piglets born alive

Details are presented in tables A.28 and 14.27 which show that there were no significant differences between treatments (which was probably due to the relatively small numbers of sows involved), although the treatments offering less restriction resulted in slightly greater numbers of piglets being born alive. Surprisingly, perhaps, the relatively longer period of increased freedom offered by the cubicle housing during pregnancy seemed to have less effect on numbers born alive than the relatively short period of increased freedom which was experienced by sows farrowing in pens as opposed to crates. When the treatments were pooled, analysis of the data revealed a highly significant ($P < 0.01$) increase in numbers of piglets born alive over parities 2 - 4 compared with parity 1 (which would be expected when comparing litter sizes in gilts and multiparous sows).

2. Number of piglets born dead

Again, the differences were non-significant although the trend of the results shown in tables A.29 and 14.27 is to favour the less restricted treatments, with lower numbers of dead pigs being born to sows housed in cubicles and pens. Similarly, there were no signigicant differences between parities when the treatments were pooled, although the numbers of stillborn pigs were highest in parities 1 and 4 (table 14.27b).

3. Stillbirth rate

The overall stillbirth rate of 6.4% is in agreement with many other workers (ref. chapter 4 of the literature review) but further analysis of the data revealed a range of 0 - 100% for individual sows (table A.30) and from 3 - 9.2% for the various treatments (table 14.27a). There appears to be a degree of repeatability in the production of stillborn pigs with 15% of the sows giving birth to dead piglets in 3 out of their 4 farrowings, while 30% of the sows had stillborn pigs in 2 of the 4 farrowings. Likewise, 45% (9/20) of the sows produced no stillborn piglets at any stage and of these sows, 44% (i.e. 4/9) were in the minimum restriction (cubicle-pen) treatment and had the lowest overall stillbirth rate. Surprisingly, perhaps, the tether-pen treatment had the highest stillbirth rate even though the tether-crate sows (i.e. minimum exercise group) had the highest number of piglets born dead.

From the results, it appears that it is the pregnancy housing treatment which had the greatest (although non significant) effect on stillbirth rate since the tethered sows averaged 8.3% while the sows in cubicles had a stillbirth rate of 4.7%. Housing at farrowing (i.e. crate or pen) had little effect (unlike its effect on the number of liveborn piglets).

There was a marked (although non significant) effect of parity on stillbirth rate, with the highest rate being in parity 1 before falling dramatically in the next 2 parities and increasing again in parity 4 (table 14.27b).

c) Appearance of the piglets at birth

1. Presentation

All the deliveries observed involved either an anterior or a posterior presentation; piglets were never delivered laterally. As tables A.31 and 14.28 show, although the percentage of piglets born anteriorly ranged from 7.1 - 88.8%, an anterior presentation was more common. There were no significant differences between treatments or parities in terms of presentation of piglets although, when parities 1 and 4 were compared for all treatments, there were fewer anterior presentations in the older sows.

There was little evidence of any repeatability of presentation between individual sows; just because a particular sow delivered most of her litter anteriorly in 1 farrowing, she did not necessarily do so in the succeeding farrowings.

2. State of the umbilical cord

The majority of piglets were delivered with the umbilical cord in an intact condition (tables A.32 and 14.28a) and significantly ($P < 0.05$) more piglets were born with intact cords on the tether-crate and cubicle pen treatments i.e. the minimum and maximum exercise treatments respectively. There were no significant differences in the state of the cord of piglets born to sows which had been housed in tethers rather than cubicles during pregnancy or in crates rather than pens at farrowing.

Table 14.28a Differences in appearance at birth between piglets on varying treatments

[Parities pooled. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly from each other]

Parameter	Treatment								Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	
Presentation (% piglets born anteriorly)	57.4 (49.5 ±2.8)	59.0 (50.2 ±2.4)	54.6 (47.7 ±2.4)	60.9 (51.8 ±2.4)					n.s.
State of umbilical cord (% piglets born with intact cord)	90.0 (76.8^{bc} ±3.7)	73.6 (62.6^{ac} ±3.3)	80.7 (68.0^{c} ±3.2)	89.1 (73.1^{bc} ±3.3)					*
					80.8 (68.2 ±2.6)	84.8 (70.5 ±2.4)			n.s.
							84.7 (71.8 ±2.6)	81.4 (67.8 ±2.5)	n.s.
Meconium staining (% piglets with 0 amount meconium)	13.2 (16.4^{a} ±3.9)	40.4 (38.8^{b} ±3.5)	10.4 (14.5^{a} ±3.4)	20.2 (22.9^{a} ±3.5)					***
					29.2 (31.8^{a} ±3.0)	15.1 (18.6^{b} ±2.7)			**
							11.9 (16.3^{a} ±3.0)	30.3 (30.9^{b} ±2.8)	***

Table 14.28a cont.

Parameter	Treatment								Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	
Meconium staining (% piglets with +++ amount meconium)	10.7 (14.4[ab] ±3.7)	5.2 (9.0[a] ±3.3)	14.9 (19.6[b] ±3.2)	5.1 (7.3[a] ±3.3)					*
					7.7 (11.3 ±2.6)	10.1 (13.6 ±2.4)			n.s.
							13.1 (17.3[a] ±2.4)	5.2 (8.1[b] ±2.3)	**

Table 14.28b **Differences in appearance at birth of piglets born to sows farrowing in different parities**

[Treatments pooled. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly from each other]

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
% pigs born anteriorly	59.5 (50.9±2.5)	59.4 (50.7±2.4)	60.2 (51.0±2.4)	51.8 (45.9±2.7)	n.s.
% pigs born with intact cords	87.7 (73.0±3.4)	86.4 (72.9±3.2)	81.0 (68.3±3.3)	75.6 (63.7±3.6)	n.s.
% pigs with 0 meconium staining	31.4 (30.0±3.6)	23.0 (25.5±3.4)	12.9 (16.4±3.5)	17.7 (21.8±3.8)	n.s. but approaching *
% pigs with +++ meconium staining	7.7 (10.8±3.4)	7.1 (8.9±3.2)	15.1 (19.9±3.3)	5.6 (10.3±3.6)	n.s.

As the sows aged, there was a progressive decrease in the number of piglets born with intact cords over the course of the 4 parities, but, again, the differences were non significant (table 14.28b).

3. Degree of meconium staining

The method outlined previously of immediately allocating a score depending on the amount of meconium present worked well with the 0 and +++ categories, although difficulty was occasionally experienced with allocation of + and ++ scores, particularly if several piglets were born simultaneously and there was overall staining rather than the presence of discrete pellets.

The degree of staining may be taken as an indicator of a period of hypoxia or anoxia either pre- or intrapartum and it is apparent from the data in tables A.33, A.34 and 14.28a that the piglets born to sows in the less restricted environment of a pen showed less evidence of prenatal anoxia or hypoxia since significantly ($P< 0.001$) more of these piglets were born with no staining and fewer of them had the heaviest degree of staining, compared with piglets born to sows farrowing in crates.

In contrast, however, there were significantly ($P< 0.01$) more piglets born without meconium staining to sows which had been tethered during pregnancy rather than being free in cubicles i.e. it seems that tethering during pregnancy and farrowing in pens is desirable in order to achieve the maximum number of non-stained piglets.

With reference to the heaviest level of staining (indicating a considerable anoxic or hypoxic stress), the data suggest that the more favourable housing environment at farrowing is that of a pen since this produced a significantly ($P < 0.01$) lower number of heavily stained piglets. In this connection, the pregnancy housing treatment had no significant effect although there were more heavily stained piglets born to the sows in cubicles than to those in tethers.

At both levels of staining, there was a reduction in the number of piglets born with that degree of meconium in parity 4 as compared with parity 1, but it was not a progressive reduction as shown in table 14.28b.

d) <u>Behaviour of piglets at birth</u>

1. <u>Time taken to achieve regular breathing</u>

After delivery, there was frequently a period of apnoea followed by coughing which was in turn followed by a period of dyspnoea before a regular pattern of breathing was finally achieved. Difficulties were experienced in the judgement of exactly when regular breathing had been achieved and so the figures shown in tables A.35 and 14.29 are somewhat approximate. There were no significant differences between treatments and, as tables A.59 - A.61 show, there were considerable variations between members of 1 litter. In certain litters, there was a tendency for the last one or two piglets to take a long time to establish a regular breathing pattern, but in other litters, long time intervals were characteristic of piglets in the middle or even at the start of the birth order, so that there was no obvious trend. There were also no significant differences between parities.

Table 14.29a **Treatment differences in piglet behaviour at birth**

[Parities pooled. Figures refer to means of treatment groups and those on the same horizontal line bearing different superscripts differ significantly]

Parameter	Treatment						Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Crate	Pen	
Time to achieve regular breathing (sec.)	47.3 ±6.3	56.2 ±6.1	43.1 ±5.9	49.3 ±5.9			n.s.
					45.1 ±4.2	52.7 ±4.1	n.s.
Time taken to stand (sec.)	63.3[a] ±5.6	79.8[b] ±5.4	58.5[a] ±5.2	67.3[ab] ±5.2			*
					60.7[a] ±3.8	73.3[b] ±3.7	*
Time taken to break cord (min.)	6.8 ±0.7	5.2 ±0.6	6.1 ±0.6	5.9 ±0.6			n.s.
					6.4 ±0.5	5.5 ±0.4	n.s.
Time taken to suckle successfully (min.)	25.4 ±4.3	34.6 ±3.7	37.1 ±3.6	37.6 ±3.7			n.s.
					32.3 ±2.9	36.1 ±2.7	n.s.

Table 14.29b **Parity differences in piglet behaviour at birth**

[Treatments pooled. Figures on the same horizontal line bearing different superscripts differ significantly]

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Time to achieve regular breathing (sec.)	41.4 ± 5.4	52.1 ± 5.1	52.7 ± 5.2		n.s.
Time taken to stand (sec.)	$63.1^{a} \pm 4.8$	$61.2^{a} \pm 4.5$	$77.2^{b} \pm 4.6$		*
Time taken to break cord (min.)	6.1 ± 0.6	6.4 ± 0.6	6.4 ± 0.6	4.6 ± 0.7	n.s.
Time taken to suckle successfully (min.)	$38.4^{b} \pm 3.9$	$23.5^{a} \pm 3.6$	$42.0^{b} \pm 3.7$	$34.1^{ab} \pm 4.0$	* *

2. <u>Time taken to stand</u>

Piglets were expelled through the vulva with varying degrees of force but after delivery they usually remained immobile for a period before shaking their heads and making several attempts to stand. Although there is a relationship between the viability of a piglet at birth and the time it takes to stand, other factors may act to confound this relationship; for example a perfectly viable piglet may make innumerable attempts to stand (and therefore take a long time to achieve this) simply because it is unable to obtain a sure footing amongst a mass of expelled placenta or because it was delivered in such a position that it only has very limited manoeuvrability (e.g. if the sow is lying with her vulva pressed close to the rear of the crate or against a pen wall). The position adopted by a farrowing sow in a pen may well have contributed to the significantly ($P < 0.05$) longer time taken by these piglets to stand (compared with piglets born in a crate) and this was particularly true of those piglets born in pens to sows which had been previously tethered (table 14.29a). It was noticeable that these sows frequently farrowed with their vulva pressed tight to the corner of the pen.

In addition to the treatment differences, there was a significant difference between parities, with the piglets in parity 3 (the last one recorded with respect to this characteristic) being the slowest to stand.

3. Time taken to break umbilical cord

Among the piglets which were born with intact cords, the time taken for cord breakage was extremely variable, ranging from less than 1 minute to 91 minutes (tables A.59 - A.62). On several occasions, the reason for cord breakage was due to the sow standing or sitting, rather than to the efforts of the piglet itself. This was particularly true of the sows farrowing in pens and may have helped to account for the shorter time taken to break the cord in the pen treatments compared with the crates (table 14.29a). The differences were not significant, however, and neither were those between parities (table 14.29b). In 3 of the 4 treatments (i.e. tether-crate, tether-pen and cubicle-crate) there was a reduction in cord breakage time in parity 4 compared with parity 1.

4. Time taken to suckle successfully

Again, there were wide variations between individual piglets in how long they took to achieve their first successful suckling (from 3 minutes to more than 365 minutes, tables A.59 - A.62). Observation of suckling behaviour showed that, although a vigorous piglet generally suckled sooner than a less vigorous one, the actual time taken to suckle was affected by circumstances such as the sow's lying position (whether in sternal recumbency or lying with her udder pressed against the wall of the pen) and her apparent willingness to allow suckling to take place. This latter characteristic varied according to the individual temperament of the sow and was also influenced by her state of health, as several sows with slight cases of mastitis were most reluctant to allow suckling. Thus it frequently happened that apparently vigorous piglets failed to achieve a successful suckle for a long period after birth although they made repeated attempts to do so and were simply unsuccessful due to the behaviour of the sow.

As shown in table 14.29a, there were no significant differences between treatments although, when parity was considered, the piglets born to second parity sows suckled more quickly ($P < 0.01$) for some reason (table 14.29b).

Since it was considered that there may have been an interaction between the mean interval between successive births and various aspects of the piglet's appearance and behaviour at birth, correlation coefficients were calculated between pairs of variables. For example, a piglet which had been subjected to a longer farrowing might have been suffering from a degree of hypoxia and so could be expected to have a higher intensity of meconium staining in addition to taking longer to achieve regular breathing, standing etc. However, as table 14.29c shows, all the correlation coefficients proved to be low and none reached statistical significance.

e) Characteristics of piglet blood

1. Serum lactic acid levels at birth

The technique used for the collection of blood (i.e. tail docking) proved reasonably satisfactory and in most cases it was possible to collect 2 micro-capillary tubes of blood within 1-2 minutes of delivery. Problems were encountered in cases where

Table 14.29c **Relationship between mean birth interval and selected aspects of the piglet's appearance and behaviour at birth**

Variables	Correlation coefficient (r)	Level of significance
M.b.i.v. % pigs with 0 meconium staining	- 0.014	n.s.
M.b.i.v. % pigs with +++ meconium staining	- 0.012	n.s.
M.b.i.v. time taken to breathe	0.074	n.s.
M.b.i.v. time taken to stand	- 0.166	n.s.
M.b.i.v. time taken to break cord	0.21	n.s.
M.b.i.v. time taken to suckle successfully	- 0.175	n.s.

Table 14.30 Differences in characteristics of piglet blood

(Figures refer to means of litters and those on the same horizontal line bearing different subscripts differ significantly. Values in brackets are arcsin transformed figures).

a) Differences between treatments (parities pooled)

Parameter	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Crate	Pen	Level of significance
Serum Lactic acid level at birth (m.I.U/ml)	157 ± 11	141 ± 7	158 ± 7	139 ± 8			n.s.
					158[a] ± 6	140[b] ± 5	*
Haematocrit at 36hr p.p. (% r.b.c.)	30.5 (33.5 ± 0.5)	30.3 (33.3 ± 0.5)	31.1 (33.9 ± 0.4)	27.6 (32.9 ± 0.4)			n.s.
IgG concn. at 36hr. p.p. (mg/ml)	40.3 ± 4.2	36.5 ± 4.2	43.6 ± 4.1	46.5 ± 4.1			n.s.
					41.7 ± 3.8	41.5 ± 4.0	n.s.

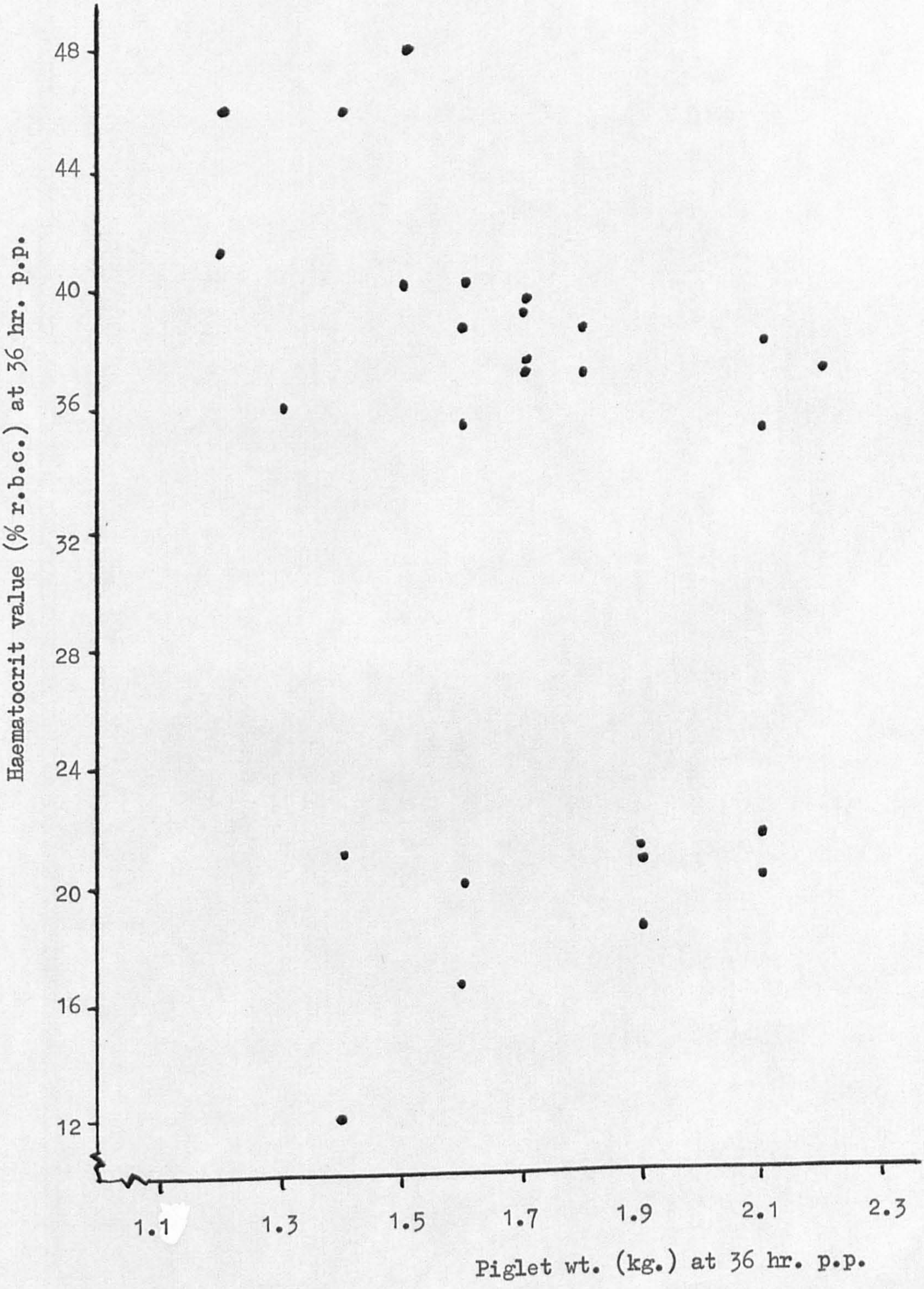
b) Differences between parities (Treatments pooled)

Parameter	Parity 1	Parity 2	Parity 3	Level of significance
Haematocrit at 36 hr. p.p. (% r.b.c.)	28.4 (33.2 ± 0.4)	31.1 (33.9 ± 0.4)	29.8 (33.1 ± 0.4)	n.s.
IgG concn. at 36hr. p.p.(mg/ml)	17.2 ± 3.6 [a]	33.9 ± 3.6 [b]	74.8 ± 3.6 [c]	* * *

2 or 3 piglets were born in very rapid succession (meaning that the time interval for collection had to be extended accordingly) and also where sows in farrowing pens suddenly became agitated by the close proximity of the observer. The technique certainly had advantages in that it minimised handling stress compared with collection of blood from puncture of the heart or anterior vena cava, although there was the disadvantage that blood could not be collected from stillborn piglets in which the circulation had ceased. The major disadvantage, however, became apparent later when the chemical analysis was performed, for it became obvious that the volume of serum produced by this technique was minimal and in certain cases (i.e. those piglets which bled poorly) was insufficient to allow analysis to be carried out. Rather than use another technique of collecting blood, however, it was decided to continue with this method as it was considered preferable to lose some of the data, rather than to change to another method of blood collection which would involve more handling stress for the piglets and so could affect other recordings such as the time taken to break the cord and suckle successfully.

The other disadvantage of the technique employed related more to the method of chemical analysis rather than to the collection of blood and this was that the lactate concentration was expressed as milli-International units of 1-lactate : NAD oxidoreductase activity per ml. of serum which, although a valid measure of lactate concentration, made it difficult to compare these results with other published work which measured lactate levels in terms of mg per 100 ml of either whole blood or plasma. Despite this, the results of

Fig. 14.28 Relationship between haematocrit value and piglet weight at 36 hours post partum



individual piglets within a litter and of piglets born to sows on different treatments could be compared, which was the most important consideration.

Details of the results are given in tables A.39 and A.62 and are summarised in table 14.30. There was a considerable range in serum lactate concentration between individual piglets (75 - 292 m.I.u./ml) and the lactate level was not directly related to position in the birth order, interval preceding delivery or the intensity of meconium staining. There were also no significant differences between the four treatments but piglets born into pens had a significantly lower lactic acid level in their peripheral blood (table 14.30).

2. Haematocrit value at 36 hours post partum

Details of this are presented in table A.40 and there were no significant differences between treatments or parities as shown in table 14.30. It might have been expected that the % of red blood cells (i.e. the haematocrit value) at 36 hours after birth would be related to the weight of the piglet at that time but analysis of tables A.60 and A.61 revealed no relationship between either a high (i.e. $>$ 35) or low ($<$22) haematocrit and piglet weight (fig. 14.28). Neither was there a direct relationship between haematocrit and position in the birth order or degree of meconium staining.

3. Plasma IgG concentration at 36 hours post partum

The assay technique proved to be a simple method in terms of actual practicality but, as tables A.41 and A.59 - A.61 show, there were wide variations in IgG concentration both between and within litters. Samples were always assayed in duplicate, and on occasions, there was even a considerable discrepancy between the duplicate samples. The assays were performed over the period of a year (i.e. from parity 1 - parity 3) which involved the use of different batches of plates but, as each batch of assay plates was calibrated against a known standard concentration of IgG before use, these discrepancies cannot be readily explained.

As shown in table 14.30, there were no significant differences between treatments but a very highly significant ($P < 0.001$) difference between parities which was considered to be more likely due to experimental error as mentioned above, rather than to reflect a true increase in IgG absorption by the piglets of the older sows.

Since it was considered that the time a piglet took to achieve its first successful suckle might be expected to affect the plasma IgG level, the correlation coefficient between these 2 variables was calculated but this proved to be both negative ($r = - 0.039$) and non significant.

f) Weight of placenta

Since the complete expulsion of the placenta was used to determine the end of farrowing and thus the period of continuous observation, it was decided to collect the expelled placenta and to weigh it, since a higher placental weight per piglet would presumably lead to a higher birth weight and a higher growth rate subsequently. The time taken for complete expulsion varied greatly between sows, frequently being within 2 hours of the last delivery but also on occasions taking as long as 24 hours (ref. farrowing records table A.65).

Table 14.31 Differences in placenta weight

[Figures refer to means of litters and those on the same horizontal line bearing different superscripts differ significantly]

a) Differences between treatments (parities pooled)					
Parameter	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Level of significance
Total placental weight (g)	2325 ±180	2560 ±180	2374 ±165	2063 ±186	n.s.
Placental weight/ piglet (g)	232 ±15	199 ±15	213 ±14	179 ±16	n.s.

b) Differences between parities (treatments pooled)					
Parameter	Parity 1	Parity 2	Parity 3	Parity 4	
Total placental weight (g)	1795^{a} ±170	2361^{b} ±165	2605^{b} ±175	2729^{b} ±208	* *
Placental weight/ piglet (g)	177 ±14	217 ±14	220 ±15	214 ±18	n.s.

Complete recovery of the placenta was possible in all cases where sows farrowed in crates, but when a sow which had farrowed in a pen took a long time to expel her placenta, continuous observation had often finished and so it was possible that the placenta which was eventually collected did not represent the total amount, the remainder having been eaten by the sow. This definitely occurred with sows F, I and R on occasions and is the explanation for the missing data in tables A.42 and A.43.

As shown in table 14.31, there were no significant differences between sows on different treatments in terms of either the total placental weight or the placental weight per piglet. There was, however, a significant ($P < 0.01$) increase in the total placental weight in the later parities when compared with the first, but as there was no corresponding significant increase in the weight of placenta per piglet, the overall increase in placental weight must have been due to the increase in litter size over the course of parities 1 - 4. This was confirmed when the correlation coefficient between litter size and total placental weight was calculated and proved to be very highly significant ($r = 0.552$, $P < 0.001$).

g) <u>Piglet weights and growth rates</u>

Details of litter weights together with mean piglet weights and growth rates are given in tables A.44 - A.50 and summarised in table 14.32, while individual piglet data are presented in table A.63.

With reference to the mean piglet birthweight, this was only recorded in parity 4 and there were no significant differences between piglets born to the various sows when any of the housing treatments were considered. Within a litter, there was no apparent relationship between birth order and birthweight with the lightest weight piglets being born at all stages of the farrowing (table A.63).

In parities 1 - 3, since blood sampling was carried out at 36 - 40 hours post partum, it was more convenient to weigh the piglets then rather than at birth, in order to minimise handling stress. As shown in table 14.32, there were no significant differences in piglet weight at this time between the treatments (although the heaviest piglets were those born into the 2 extreme treatment groups i.e. maximum and minimum restriction of exercise!) or between parities. The slightly lower piglet weights in parity 3 are probably a reflection of increased litter size (ref. table 14.27b).

The piglets were also weighed at day 7 post partum when once more there were no significant differences between treatments but the weights of piglets in parity 1 were significantly ($P < 0.01$) less than in the succeeding parities.

Since the initial weighings were carried out at variable times (i.e. at birth or 36 hours p.p.) and the sows were weaned at slightly different times (i.e. the nearest Thursday to day 35), it was decided to calculate growth rate on the basis of daily liveweight gain from day 7 (when all piglets were weighed again) to weaning. When the results were analysed, there were no differences in piglet growth rates between treatments but again, the animals in parity 1 grew less quickly ($P < 0.001$) than those in parities 2 - 4.

Table 14.32a **Differences in piglet weights and growth rates between treatments**
/Parities pooled/

Parameter	Treatment								Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Te	Cu	Crate	Pen	
Mean piglet birthweight (kg)	1.46 ±0.1	1.45 ±0.08	1.47 ±0.08	1.47 ±0.09					n.s.
					1.46 ±0.06	1.47 ±0.06			n.s.
							1.47 ±0.06	1.45 ±0.06	n.s.
Mean piglet weight at 36 hr p.p. (kg.)	1.72 ±0.1	1.65 ±0.1	1.63 ±0.1	1.73 ±0.1					n.s.
Mean piglet weight at 7 days p.p. (kg.)	2.62 ±0.1	2.48 ±0.1	2.65 ±0.1	2.56 ±0.1					n.s.
							2.6 ±0.08	2.5 ±0.08	n.s.
Mean piglet DLWG from day 7 - weaning (kg.)	0.27 ±0.01	0.25 ±0.01	0.24 ±0.01	0.26 ±0.01					n.s.
							0.25 ±0.007	0.25 ±0.007	n.s.

Table 14.32b **Differences in piglet weights and growth rates between parities**

[Treatments pooled. Figures on the same horizontal line bearing different superscripts differ significantly]

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Mean piglet weight at 36 hr p.p. (kg)	-	1.72 ±0.08	1.64 ±0.08	-	n.s.
Mean piglet weight at 7 days p.p. (kg)	2.23^{a} ±0.1	2.69^{b} ±0.1	2.80^{b} ±0.1	2.62^{b} ±0.1	* *
Mean piglet DLWG from day 7 - weaning (kg)	0.20^{a} ±0.01	0.27^{b} ±0.01	0.27^{b} ±0.01	0.27^{b} ±0.01	* * *

Table 14.33a Differences in litter size and preweaning mortality between treatments

[Parities pooled. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly]

Parameter	Treatment								Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	
Litter size at day 7 *p.p.*	8.5 ±0.6	10.0 ±0.6	9.5 ±0.6	9.2 ±0.6					n.s.
							9.0 ±0.4	9.6 ±0.4	n.s.
Litter size at weaning (approx. day 35 *p.p.*)	8.6 ±0.7	9.6 ±0.6	9.2 ±0.6	9.1 ±0.6					n.s.
					9.1 ±0.4	9.2 ±0.4			n.s.
							8.9 ±0.4	9.4 ±0.4	n.s.
Piglet mortality from birth to weaning (% live pigs born)	16.8 (21.2 ±3.5)	20.0 (24.8 ±3.2)	17.2 (20.6 ±3.2)	15.9 (20.2 ±3.3)					n.s.
					18.5 (23.1 ±2.4)	16.6 (20.4 ±2.3)			n.s.
							17.0 (20.8 ±2.3)	18.0 (22.5 ±2.3)	n.s.

Table 14.33b Differences in litter size and preweaning mortality between parities

/Treatments pooled. Figures in brackets are arcsin transformed values and those on the same horizontal line bearing different superscripts differ significantly/

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Litter size at day 7 p.p.	7.8^{a} ±0.6	9.5^{b} ±0.6	10.0^{b} ±0.6	10.1^{b} ±0.6	*
Litter size at weaning (approx. day 35 p.p.)	7.7 ±0.6	9.3 ±0.6	9.6 ±0.6	10.0 ±0.6	n.s.
Piglet mortality from birth to weaning (% live pigs born)	19.2 (23.2 ±3.3)	16.1 (18.5 ±3.2)	19.7 (24.5 ±3.3)	15.1 (20.9 ±3.4)	n.s.

h) Pre-weaning piglet mortality

Details of litter sizes at day 7 *post partum* and at weaning, together with the total mortality from birth to weaning are given in tables A.51 - A.53 and are summarised in table 14.33. Seven days after farrowing, there were the maximum number of piglets surviving in the tether-pen treatment and the minimum in the tether-crate treatment. When the litter size at day 7 is compared with the number of piglets alive at birth (table 14.27a), the mortality during the first week of life for the 4 treatments was 14.7% (T/C), 18.3% (T/P), 13.0% (C/C) and 15.5% (C/P), while the corresponding mortality rates in crates and pens were 13.8% and 16.9% respectively; a slight (but non significant) advantage in favour of crates.

(With reference to table 14.33a, the apparent anomaly of the litter size at weaning in the tether-crate treatment being greater than the litter size at day 7, is due to the circumstances surrounding the first farrowing of gilt V. At day 7 *post partum* there were still 5 piglets surviving but 4 days later, the gilt became very sick and the litter had to be cross fostered onto another sow which was not on the trial. Consequently, any remaining data was lost and so V's litter was excluded from the calculation of litter size at weaning, leading to the seemingly paradoxical result mentioned above).

With respect to the litter size at weaning, although there were no significant differences between treatments, the general trend of the results (albeit based on small numbers of sows) was to favour housing systems which allowed some degree of free movement at the expense of those in which the sow was kept in very restricted conditions i.e. both cubicles and pens resulted in slightly more piglets weaned than did the tether and crate systems and in terms of the 4 housing treatments, the minimum litter size was obtained in the maximum restriction (i.e. tether-crate) treatment.

The overall figure for piglet mortality from birth to weaning was 17.5% and details are shown in table 14.33a where it can be seen that there were no significant differences between any of the treatment combinations although the lowest mortality rate was actually achieved by sows on the cubicle-pen treatment i.e. those animals which were subjected to the minimal degree of restriction at all stages of the production cycle. Tethering during pregnancy seemed to produce a slightly higher mortality rate than loose housing in cubicles, while at farrowing and during lactation, crates had a marginal advantage over pens.

There were no significant effects of parity on pre-weaning mortality, although the general trend was to decrease from parity 1 onwards; it is not known why the mortality rate increased so sharply in parity 3 before decreasing again in parity 4 (table 14.33b).

The pre-weaning mortality rates in litters of individual sows ranged from 0 - 55.6% and although it was sometimes possible to relate a particularly high or low rate to temperament of a specific sow (e.g. the highest mortality rate of 27.4% which was found in the cubicle-pen treatment, was most definitely related to the aggressive temperament of sow R), there was usually no apparent relationship.

Since it was considered that there may have been a relationship between the mean interval between successive births and postnatal mortality, correlation coefficients were calculated between the mean birth interval and mortality in the immediate postnatal (i.e. 72 hours p.p) period as well as the entire preweaning period, but neither of these proved to be significant (table 14.33c).

Table 14.33 c <u>Relationship between mean birth interval and mortality at various stages in the post partum period</u>

Variables	Correlation coefficient (r)	Level of significance
M.b.i. v. mortality in 72 hr *p.p.*	- 0.15	n.s.
M.b.i. v. total preweaning mortality	- 0.142	n.s.

The causes of pre-weaning mortality were investigated in some detail over a 12 month period (August 1982 - August 1983) as a result of a request from the local A.D.A.S. adviser to supply data for a regional survey. This involved recording mortality data on the 3rd and 4th litters of the sows and an attempt was made to ascribe the causative factors on a pro-forma sheet (table A.64). The results are shown in table 14.33d where it can be seen that the major cause of death in both pens and crates was crushing of piglets by the sow, followed by scouring of piglets in crates and the birth of non-viable runts in both systems. It is also obvious that the bulk of the mortality (79.7% in the pens and 70.4% in the crates) occurred within the first 72 hours *post partum* and the majority of this was due to crushing.

Table 14.33d Causes and timing of preweaning mortality in farrowing crates and farrowing pens over a 12 month period

Farrowing System	Farrowing Pens		Farrowing Crates	
No. of litters	24		19	
Total no. deaths (birth-weaning)	59		27	
Reasons for death	**No. deaths**	**% total mortality**	**No. deaths**	**% total mortality**
Small non-viable	7	12.1	5	18.5
Other non-viable	3	5.2		
Starved	1	1.7	2	7.4
Savaged	1	1.7		
Crushed	46	79.3	11	40.7
Scour			5	18.5
Runt			1	3.7
Bloated			3	11.1
Unknown	1	1.7		
Timing of deaths	**No. deaths**	**No. crushed**	**No. deaths**	**No. crushed**
Day 1	35	29	10	5
2	6	3	8	4
3	6	3	1	1
4	5	5		
5	1	1	1	
6	1	1	1	
7	2	1		
8	1	1		
10			2	1
11			1	
12	1	1		
16			2	
17			1	
26	1	1		

i) Sow condition throughout the production cycle

1. Gestation

The weight gain of individual sows over the course of gestation from days 24 - 110 is shown in table A.54 and summarised in table 14.34. In the first 4 months of the trial it proved difficult to obtain an accurate reading of a sow's weight due to the type of weighing machine employed, but the subsequent purchase of a new machine designed especially for weighing sows (C & H Engineering Ltd., Willenhall, West Midlands) solved this problem.

As shown in the data, the overall weight gain of the sows was fairly consistent, with the result that there were no significant differences between treatments. With reference to the condition of the sows at the end of gestation (i.e. on day 110), there were no differences between the sows which had been in either tethers or cubicles, but, when the 4 housing treatments were considered, there was a significant ($P < 0.05$) reduction in the body condition score of the sows which had been in cubicles but were about to enter crates, compared with the other 3 treatments (table A.34a). Similarly, there was no significant effect of parity on gestation weight gain (although the mean weight gain increased over the course of the 4 parities) whereas the condition score of the sows at day 110 was significantly ($P < 0.001$) lower in parities 3 and 4 than it had been in parities 1 and 2.

When all the treatments and parities were pooled, there was found to be a highly significant correlation ($r = 0.92$, $P < 0.001$) between the weights of sows at days 24 and 110 i.e. those sows which were the heaviest at the beginning of gestation were also the heaviest at the end.

Table 14.34a **Differences in sow body condition between treatments**

[Parities pooled. Figures on the same horizontal line bearing different superscripts differ significantly]

	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	Tether	Cubicle	Crate	Pen	Level of significance
Wt. gain of sows from day 24-110 (kg.)	37.9 ±3.0	40.6 ±2.6	39.0 ±2.6	46.7 ±2.7					n.s.
					39.4 ±1.9	43.5 ±1.8			n.s.
Condition score of sows at day 110.	3.2^{b} ±0.1	3.2^{b} ±0.1	2.9^{a} ±0.1	3.3^{b} ±0.1					*
					3.2 ±0.08	3.1 ±0.07			n.s.
Wt. loss of sows from day 110 - weaning (kg.)	29.2 ±3.5	25.1 ±3.1	28.0 ±2.8	30.4 ±3.1					n.s.
					26.9 ±2.3	29.1 ±2.1			n.s.
							28.5 ±2.1	27.7 ±2.1	n.s.
Condition score of sows at weaning	2.7 ±0.1	2.8 ±0.1	2.7 ±0.1	3.0 ±0.1					n.s.

Table 14.34b Differences in sow body condition between parities

[Treatments pooled. Figures on the same horizontal line bearing different superscripts differ significantly]

Parameter	Parity 1	Parity 2	Parity 3	Parity 4	Level of significance
Sow wt. gain from day 24-110 (kg)	35.5 ±2.8	40.2 ±2.6	44.1 ±2.6	44.6 ±2.8	n.s.
Sow condition score at day 110	3.4^{b} ±0.1	3.3^{b} ±0.1	2.9^{a} ±0.1	2.9^{a} ±0.1	* * *
Sow wt. loss from day 110-weaning (kg)	15.9^{a} ±3.3	24.5^{a} ±3.1	35.7^{b} ±3.0	34.4^{b} ±3.1	* * *
Sow condition score at weaning	2.9 ±0.1	2.8 ±0.1	2.7 ±0.1	2.7 ±0.1	n.s.

2. Farrowing and lactation

There were no significant treatment differences in sow weight loss over the course of farrowing and lactation (i.e. from day 110 to weaning) as can be seen in table A.56 and the condition scores of the sows at weaning were also very similar, irrespective of treatment (tables A.57 and 14.34a). Parity appeared to have a negligible effect on body condition at weaning although the sows in parities 3 and 4 lost significantly ($P < 0.001$) more weight throughout farrowing and lactation than did the younger sows (table 14.34b).

By pooling all the results, it was found that there was a significant correlation ($r = 0.432$, $P < 0.01$) between gestation weight gain and lactation weight loss i.e. those sows which gained the most weight during pregnancy also lost the most during lactation.

j) Interval from weaning to remating

Details of the weaning - remating intervals for individual sows are given in table A.58 and are summarised in table 14.35 where it can be seen that neither treatment nor parity had any significant effect on this, although it is apparent that both a decrease in the amount of restriction imposed over the course of the production cycle and an increase in sow age acted to reduce this interval. The overall mean of 5.5 days is consistent with what would be expected commercially when weaning at approximately 35 days.

Table 14.35 Treatment and parity differences in the length of time between weaning and remating

Weaning to remating interval (days)	Treatment				Level of significance
	Te-Cr	Te-Pen	Cu-Crate	Cu-Pen	
	6.0 ±0.4	5.6 ±0.4	5.5 ±0.4	4.9 ±0.4	n.s.

Weaning to remating interval (days)	Parity			Level of significance
	1 - 2	2 - 3	3 - 4	
	6.0 ±0.3	5.5 ±0.3	4.9 ±0.3	n.s.

14.5 DISCUSSION

i) Introduction

The aim of this discussion is to differentiate between the effects of housing on sow behaviour and reproductive performance during gestation, farrowing and lactation. In addition, the effect of individual sow temperament and adaptation to a particular environment will be considered and finally, the implications of this research for commercial practice will be discussed.

Before discussing individual results, it is pertinent to consider the limitations of this trial in terms of numbers of animals and the methods of data collection which were involved. Apart from the limited observational data on post partum sow behaviour and locomotor activity, it is felt that the study of behaviour in this trial involved adequate numbers of animals and provided sufficient data for reasonable conclusions to be drawn. With reference to reproductive performance, however, in some instances, the results did not achieve statistical significance, even though the actual treatment differences were considerable. It is probable that much of this apparent anomaly was due to the relatively small sample size of 20 sows. This number was chosen as it was considered important that both the 2 gestation housing treatments and the 2 types of farrowing accommodation should each be in one building (i.e. the dry sow house and the farrowing house). This was done to standardise as many variable factors as possible. With this requirement in mind, a herd size of 20 sows seemed appropriate as this was the maximum number that could be accommodated in the 2 experimental buildings.

In addition, even though a larger number of animals would have been preferable for statistical reasons, the labour intensive nature of the trial prevented the inclusion of any more sows. In practical terms, the greatest problem was the time involved in recording prepartum and intrapartum sow behaviour. It was decided not to use hormonal induction of farrowings since it is commercial practice for the hormone to be administered on day 112 of gestation and it was felt that some of the sows would have farrowed naturally by this time. This would have meant that comparisons would have to be made between various characteristics of induced <u>versus</u> non-induced farrowings i.e. a variable other than a differing degree of confinement would have been introduced and the comparison would have been less valid as a result. In retrospect, it is felt that the decision not to induce farrowings was correct, but it did greatly add to the time involved in recording. An initial attempt to utilise an early warning system (appendix A.66) was not successful and in any case, such a system would have reduced the amount of prepartum behavioural data that was collected, since recording would only have commenced with delivery of the first piglet. Therefore it is considered that the system of continuous observation which was employed provided the most comprehensive method of recording data at farrowing. The presence of an observer may have influenced the behaviour of the sow or piglets (although every care was taken to avoid this) but as an observer was present at each farrowing, this effect has been ignored.

ii) Sow behaviour

a) Behaviour during gestation

One noticeable difference between the tethered sows and those in cubicles concerned their general behaviour patterns throughout gestation. The loose housed sows spent a far larger proportion of the time (64% v. 43%) being "active" i.e. indulging in activities other than purely lying, sitting or standing (table 14.6). In particular, they spent much longer in straw based activities such as chewing and rooting. Even though straw was also available to the tethered sows, these animals spent far less time in straw based activities and significantly longer lying down (45% of the time v. 25% for the sows in cubicles). This agrees with the observations of others such as Jensen (1981a, b), Ekesbo (1981a) and Gravas (1982). These results show that tethered sows adapt to their confined conditions and do not exhibit the same level of activity as the sows in cubicles.

With reference to the amount of aggression in dry sow housing, it was found that when pairs of gilts were first introduced into the cubicles, they showed more aggressive interactions than did the tethered gilts. However, this difference in level of aggression between the 2 groups disappeared in later parities, illustrating the adaptation of sows to the presence of others. Aggression was frequently triggered by competition at feeding time and could be most clearly seen in the service pen when 4 or 5 animals were fed simultaneously from a 2m trough. This aggression was virtually eliminated by the installation of individual feeders and demonstrated their importance in a group housing situation.

None of the aggressive encounters seen in this trial caused serious (or even moderate) injury to the animals, which is in agreement with the observations of Sambraus (1980). However, group size is important in a loose housing system and only very small group sizes were involved in this trial i.e. pairs of sows in the cubicles and groups of 3-5 in the service pen.

One interesting observation in this trial concerned the effect of tethering gilts. Dantzer and Mormede (1981) showed that the stressful effect of introducing pigs into a new environment resulted in higher cortisol levels than when the pigs had previously been subjected to electric shocks. Similarly, Thorpe (1969) stated that "confinement is the most potent of all stressors since it restricts what is physiologically and ethologically one of the most basic activities". During this trial there was some evidence of a stress reaction when gilts were tethered for the first time but the extent of this varied considerably between individual animals and became much less apparent over the course of the first gestation. Initial stress was exhibited as body contortions, dilatation of pupils, loud vocalisation and violent pulling on the tether, but this behaviour disappeared almost completely in the later stages of pregnancy. It was also observed that the symptoms of stress decreased with retethering in successive parities, so that whereas the gilts spent 3.3% of their time pulling on the tether and vocalising loudly in parity 1, this was reduced to 0.4% on the occasion of the third tethering. Both these observations illustrate the adaptability of the sow to her situation.

When they were first tethered, some of the gilts developed lesions around the neck as a result of rubbing but, with prompt treatment, these soon healed. There was no evidence of any injury inflicted by tethering in later parities, although by the fourth parity, there was a noticeable increase in the amount of callus tissue which had been deposited at the sides of the neck and the base of the ears.

The observations on the locomotor activity of sows under 3 housing systems showed very considerable differences (ref. table 14.13). The number of pace movements shown by the free-range sows (1265) was considerably more than the sows in cubicles (197) which in turn was more than the tethered sows (62). In terms of minor movements, however, (i.e. moving the leg up and down or from side to side over a distance of a few centimetres) the order was completely reversed with the tethered sows making 912, the cubicle housed sows 369 and the free-range sows only 13. This could indicate that increased confinement of sows leads to an increase in stereotypy or a high level of displacement activity as a result of the desire for true locomotion being frustrated. It also suggests that the amount of locomotor activity which takes place depends on the space available. In this study it was not possible to measure the actual distance covered by the sows but other workers have managed to do this by the use of a video camera and have calculated that loose housed dry sows walked an average of 206m per day (Jeppson et al, 1980). It is likely that a similar figure would have been obtained for the cubicle housed sows in the present trial.

There was a very definite circadian pattern of locomotor activity with most movement occurring in the morning, decreasing throughout the afternoon and virtually ceasing at night (ref. tables 14.15 and 14.16). The observations taken at night in this trial were very limited but Jeppson et al (1980) were able to collect data from a large number of observations over a much longer period (17.00–06.00 compared with 22.00–04.00 in this study) and their results demonstrated a similar trend i.e. that all sows showed minimal activity at night.

b) Behaviour on entering the farrowing accommodation

The differences in sow behaviour on entering the farrowing accommodation (table 14.20) showed that sows entering the confines of a crate spent a significantly longer (58%) amount of time lying compared with sows entering a pen (38%). Conversely, the sows entering pens spent more time manipulating straw (35% of the time) compared with those entering crates (20%). It was also apparent from table 14.20 that the housing system during gestation did not have a significant effect on the behaviour of sows entering the farrowing accommodation (i.e. both sows which had been tethered or kept in cubicles reacted in the same manner when they entered a crate or a pen). This may again illustrate the rapid adaptation of a sow to her environment.

Reluctance to enter the crates was shown by certain animals despite the presence of inducements such as bedding and food. This reluctance did not appear to diminish over the succeeding parities and it was not related to the housing treatment during gestation. Rather, it seemed to depend on the temperament of the individual animal. Sows always reluctant to enter a crate included A (tethered) and U (cubicle housed) whereas other sows such as E (cubicles) and H (tethered) rarely showed any hesitation. There was never any reluctance to enter a farrowing pen.

c) Behaviour at farrowing

During the prepartum period, virtually all animals showed an increase in restlessness as farrowing approached. This was possibly a reflection of the changes in hormone balance which were occurring at that time (First, 1978). The timing of the increased restlessness depended very much on the individual sow (ref. farrowing records table A.65) whereas the way in which it was exhibited depended on the type of farrowing accommodation. Sows confined in crates showed a greater degree of restlessness than those in pens (table 14.21) which agrees with other reports e.g. Hansen and Curtis (1980). The restlessness was exhibited in various forms including lying making vigorous leg movements, standing up frequently, bar biting, kicking the food trough and pacing backwards and forwards. On some occasions, the activity was so intense that it was continued past the point of injury (e.g. the rubbing of sores on the tail head and snout as a result of pacing and bar biting). No comparable behaviour was seen in the farrowing pens. There, the closest approximation was the occasional outburst of vigorous nest building shown by certain sows which involved tossing straw into the air and even over a 1.5m wall into the adjacent pens. This lower general level of activity shown by the sows in pens did not depend on the housing during gestation (table 14.21).

With regard to nest building, all sows exhibited this behaviour even when in the confined conditions of a crate and, in fact, the most closely confined of all sows (those on the tether-crate treatment) made the most frequent attempts at nest building (table 14.21). This agrees with the observations of Naaktgeboren (1979) that the instinct to build a nest is part of the genetic characteristic of this species. Despite the difficulties of nest building within a crate, sows spent long periods attempting to scoop up and rearrange the straw, behaviour which has previously been reported by Signoret et al (1975). Such behaviour illustrates that the nest building instinct is still present in the sow despite generations of artificial selection for life in much more intensive conditions.

It was also noted that increased nest building activity often coincided with an increased production of colostrum (ref. farrowing records table A.65). This is understandable as both are controlled by prolactin and the levels of this hormone rise sharply just before farrowing (Naaktgeboren, 1979). The older sows produced colostrum sooner than the younger animals (table 14.26b) which could indicate that, having experienced the hormonal changes once (as gilts), the endocrinological mechanisms are initiated more quickly at each subsequent parturition.

Once farrowing had commenced with the delivery of the first piglet, the behaviour which had characterised the immediate prepartum period was, to a large extent, continued intrapartum. Thus, the sows in crates continued to make more kicking movements while lying recumbent and they also continued to show significantly more straining and quivering than did the sows in pens (table 14.22). This could indicate that they were experiencing greater difficulty in expelling the piglets. During farrowing, the sows in pens stood up and rearranged their nest more frequently, thus incurring a greater potential risk of crushing the piglets.

There were no significant differences between the behaviour of individual sows in successive parities although it has been suggested (English, 1969) that multiparous animals are less restless. However, the only recorded case of parturient psychosis similar to that recorded by Henry (1969) did occur in a gilt and involved excessive salivation, pupillary dilatation, loud vocalisation and struggling to escape. It is possible that the older sows were less restless in the immediate post partum period as the piglet mortality was lower in these animals, but there was no collection of behavioural data to support this speculation.

When sow behaviour both pre- and intra partum was compared it was apparent that, irrespective of treatment, all sows showed more restlessness before farrowing than during it (table 14.23). This was demonstrated by more postural changes and greater nest building activity. With the delivery of the first piglet, sows generally become less active but vocalisation increased as suckling commenced. The incidence of straining and quivering was also greater during farrowing than before it. This would be expected since the muscular contractions of the uterus were at their maximum forcing the foetuses along the reproductive tract. These contractions were augmented by contractions of the voluntary abdominal muscles which were manifested as straining.

d) Post partum behaviour

The observations of sow behaviour on the 5th day *post partum* (table 14.24) showed few differences between treatments which suggests that sows were no longer so influenced by their physical environment. Instead, they had all settled into the characteristic pattern of maternal behaviour; findings which agree with those of Strangby and Gustafsson (1971). The high incidence of lying in sternal recumbency which was recorded in parity 2 (table 14.25) could have been due to the presence of mastitis since sows were reluctant to allow suckling. Other behavioural differences between sows of different parities are more likely to have been the result of sampling error since recording of post partum behaviour was based on just 4 observation periods of limited duration on the 5th day following parturition. In retrospect, it would have been more conclusive had a greater quantity of data been collected e.g. from observations carried out on additional days such as day 15 and day 30 *post partum*.

iii) Sow reproductive performance

a) Duration of farrowing

The results in table 14.26a show that there were no significant differences between treatments in terms of duration of farrowing and the mean interval between successive births although both these parameters were reduced when sows farrowed in pens. This observation agrees with other published data (table 14.36).

Table 14.36 Effect of housing on duration of farrowing

Author	Year	Duration of farrowing (min) Confined at farrowing	Loose housed at farrowing	Signific.
Sommer	1979	306	192	* *
Svendsen & Andreasson	1980	432	276	* *
(Parry	1984	413 (crates)	231(pens)	n.s.)

With reference to the type of gestation housing, the tethered animals which had been kept under restricted conditions had an apparently shorter farrowing time than did the cubicle housed sows. Since these differences were not statistically significant, it is not possible to draw definite conclusions but the suggestion from the results that restriction of exercise during gestation leads to a shorter farrowing is in contrast to much of the published work reviewed earlier (e.g. Backstrom, 1973; Hale et al, 1981). Similarly, it is only possible to speculate as to the reason for the prolonged farrowings shown by sows in crates. Various authors (e.g. Shabanah et al, 1965; Naaktgeboren, 1972b; Taverne et al, 1979) have reported that psychological stress can lead to an inhibition of uterine activity and so it is possible that the close confinement afforded by a crate conflicted with the increased activity levels in the prepartum sows, thus creating a state of stress. The sows in the cubicle-crate treatment showed the greatest degree of restlessness in terms of leg movements and postural changes (table 14.21) and they also had the longest farrowing times (table 14.26a). However, the trial would need to be repeated with a larger number of sows before definite conclusions could be drawn.

There was no significant effect of parity on the birth interval (table 14.26b) nor were there any significant interactions between parity and treatment. Since the average age of a sow at culling is only 5th parity (Meat and Livestock Commission, 1980), it might have been expected that any treatment producing a cumulative adverse effect on farrowing time would have become apparent over the course of the 4 parities recorded in this study.

b) Litter size

As shown in table 14.27a, there were no significant differences between treatments in terms of the numbers of piglets born dead or alive and stillbirth rate.

The effect of housing during gestation might have been expected to have had an effect on litter size, particularly when gilts were tethered in early pregnancy at a time when embryonic development was especially vulnerable. The fact that there were no significant differences in litter size could be explained if the behaviour patterns associated with initial tethering (e.g. struggling, vocalisation etc.) were not indicative of a genuine stress reaction. Certainly, Baldwin and Stephens (1973) have shown that apparently emotional behaviour in a pig (such as loud vocalisation) is not necessarily correlated with a physiological response such as the release of adrenocortical hormones. It is also possible that tethering, at day 24, did represent a stressful situation, but the stressor was being applied after the most suceptible stage of embryonic development which ends with the completion of implantation around day 23-24.

The effect of sow housing at farrowing also showed no significant differences on litter size, although there were more piglets born alive in the pens (table 14.27a). It might have been expected that confinement during gestation and/or at farrowing would have increased the numbers of stillborn pigs (table 14.37). The fact that although this occurred, the increase was not significant, could only be investigated further by repeating the trial with a larger number of sows.

Table 14.37 Effect of housing on stillbirth rate and numbers of piglets born dead

		Type of housing during gestation and/or at farrowing		
Author	Year	Confined	Loose	Signific.
Bille et al	1974 a	6.9%	5.6%	*
Gustafsson	1982	5.4%	4.1%	* * *
Svendsen & Andreasson	1980	8.6%	6.9%	*
Svendsen et al	1981	5.4%	3.4%	*
(Parry	1984	8.3% (tethers)	4.7% (cubicles)	n.s.
		6.5% (crates)	6.2% (pens)	n.s.)
Gravas	1982	0.2 pigs/litter	0.6 pigs/ litter	n.s.
Strangby & Gustafsson	1971	1.5 pigs/litter	0.5 pigs/ litter	*
(Parry	1984	0.8 pigs(tethers)	0.5 pigs (cubicles)	n.s.
		0.8 pigs (pens)	0.5 pigs (crates)	n.s.)

With reference to the effect of parity on litter size (table 14.27b), numbers born alive increased over the 4 parities, from 8.9 to 11.9. This would be expected since a sow normally reaches maximum fecundity around the 4th parity and it agrees with the results of workers such as Rasbech (1969) and the Meat and Livestock Commission (1980) who reported increases of 8.7 to 11.4 and 9.3 to 10.6 respectively over the first 4 parities. The numbers of stillborn piglets in this trial showed a similar pattern to that described elsewhere in the literature (table 14.38) although the differences between parities were not significant.

Table 14.38 Relationship between number of stillborn piglets and parity

Author	Year	No. stillborn pigs/litter			
		Parity 1	2	3	4
Pour & Hovorka	1978	0.4	0.3	0.4	0.6
Rasbech	1969	0.5	0.5	0.6	0.8
Simensen & Karlberg	1980	0.7	0.7	1.0	0.8
Stepulenkova & Sukhorukov	1977	0.6	0.8	1.1	1.8
(Parry	1984	0.8	0.3	0.4	1.1)

c) Piglet appearance and viability at birth

The results in table 14.28a show that most piglets were born with an anterior presentatinn with percentages of piglets born in this way ranging from 54.6% to 60.9% depending on treatment. These figures agree with other published data such as 58% (Randall, 1968), 55% (Randall, 1972a) and 62% (Reimers et al, 1973). The percentage of piglets born posteriorly was very similar in the first 3 parities (40.5%, 40.6% and 39.8% respectively) but increased considerably in parity 4 (48.2%) although this was not significant. As the mean birth interval and numbers of piglets born dead increased similarly (from 20.9 to 48.4 minutes and from 0.8 to 1.1 pigs/litter over the course of the 4 parities), it is possible that there was a relationship between the 3 factors. It might be speculated that it is more difficult to give birth to a piglet which is presenting posteriorly, with the result that it takes longer for each piglet to be delivered and so more are born dead. Authors such as Randall (1968) and Sovljanski et al (1972) both found that it was more common for posterior presentations to be stillborn than it was for anteriorly born piglets, but the reason why older sows should have more posterior presentations is not known.

With reference to the state of the umbilical cord at birth, most piglets were born with intact cords while the minimum result of 73.6% for the tether-pen treatment and maximum of 90.0% for the tether-crate sows showed that there was relatively little difference between any of the treatments. In particular, the figure of 89.1% obtained for the cubicle-pen sows is very close to that recorded for the tether-crate animals even though these 2 treatments represented the extremes of confinement and loose housing in the trial. This result was surprising as experiment 1 had indicated that significantly more piglets with intact cords were born to unrestricted sows, but the fault of this experiment was that restriction of exercise was not the only variable and the difference could have been due to factors such as breed or diet.

As the sows aged over the course of experiment 3, there were progressively more piglets born with broken cords (table 14.39), although the differences were not significant. This might indicate a relationship with the increase in numbers of piglets born dead that has been described earlier. However, it was not a direct relationship since the numbers of stillborn piglets decreased in parities 2 and 3 and only increased again in parity 4, while the mean birth interval increased steadily from parity 1 to 4 (with the exception of parity 3).

Table 14.39 <u>Relationship between parity, birth interval, state of umbilical cord and number of stillborn piglets</u>

	Parity			
Parameter	1	2	3	4
Mean birth interval (min)	20.9	29.8	22.0	48.4
% pigs born with broken cords	12.3	13.6	19.0	24.4
No. stillbirths/litter	0.8	0.3	0.4	1.1

It would seem reasonable to suppose that there is some relationship between the birth interval, state of the cord and whether a piglet is born alive or dead, but it is a very complex one. In his 1968 study of stillbirths in pigs, Randall concluded that prolongation of farrowing, per se did not necessarily result in stillbirths, although it may have contributed to their aetiology. Likewise, premature rupture of the umbilical cord may have been a contributory factor in some stillbirths although on occasions piglets may be born dead with intact cords (Bjorklund, 1981). Thus, the interrelationships between the various factors which may result in the birth of a dead piglet cannot be precisely explained and the results obtained in this experiment do not allow further conclusions to be drawn.

By contrast, the results concerning the degree of meconium staining in the piglets do show significant differences. The presence of meconium on the body can be taken as an indication of hypoxic stress according to various authors (e.g. Browne and McClure-Browne, 1964; Fujikura and Klionsky, 1975; Wrathall, 1971) and so the absence of such staining suggests that the piglets have not been subjected to hypoxia. Table 14.28a shows that significantly more piglets were born without any staining in the pens compared with the crates (30.3% v. 11.9% respectively), so it is likely that it was the farrowing accommodation which was important in this respect. This could be explained if the sows in pens suffered less stress with the result that they farrowed more quickly and their piglets suffered from less hypoxia. Similarly, at the other extreme, sows farrowing in pens also produced fewer piglets with the highest degree of staining which again agrees with the general hypothesis outlined above.

However table 14.28a also shows a significant reduction in meconium staining in piglets born to sows which had been tethered.

This result is difficult to explain and is perhaps an area for further investigation.

If a piglet is born with meconium staining, it does not necessarily mean that it has been under oxygen stress during the birth process (it could, for instance, have suffered from hypoxia at an earlier stage) but it does indicate a hypoxic episode at some time (Randall, 1968) which could be expected to have implications for the subsequent viability of the piglet.

In addition to observing the appearance of piglets at birth, various behavioural characteristics were also recorded to provide further evidence of piglet viability. Since evidence has already been presented which suggests a greater likelihood of hypoxic stress in piglets born into crates rather than pens, (i.e. there were fewer piglets with no staining and more heavily stained piglets in crates), it might have been expected that piglets in crates would have taken longer to breathe than those born into pens. In fact, they breathed more quickly although the differences were non-significant (table 14.29a). It is probable that the answer lies in the difficulties experienced in accurately measuring this time interval and so it is suggested that the results may be inaccurate. This may also be the explanation for the parity effect whereby the piglets apparently took longer to breathe in parities 2 and 3 than they did in parity 1 (table 14.29b), even though other behavioural measures of piglet viability (such as the time taken to stand and to suckle) which <u>could</u> be measured accurately, showed the reverse trend.

From the suggestions above about the reduced incidence of hypoxia in piglets born into pens, it might also be expected that these animals would stand more rapidly after birth but they were actually significantly slower to do this than the piglets in crates (table 14.29a). This seeming paradox is thought to be more a result of the position adopted by the sow during farrowing, than it is an indicator of depressed piglet viability. The figure actually recorded was when the piglet achieved a full standing position and it did not show the timing of attempts to achieve standing prior to this. Sows in pens very often farrowed with their vulva pressed close against a wall and they frequently lay diagonally so that their vulva was pressed into the corner of the creep and pen walls (a farrowing position which has also been observed by Gravas, 1982). This orientation may have had advantages in that the piglets were not expelled into the dirty conditions of the dunging area as occurred with sows farrowing in crates, but it did have a disadvantage in that the piglets frequently took longer to achieve a standing position, purely due to the awkwardness of the situation into which they were delivered.

Table 14.29b shows that the piglets born to third parity sows (the oldest sows to be observed for this characteristic) were significantly slower to stand, although the reason for this is not known. However, the increased time taken was caused by the piglets born in pens which registered times of 60, 67 and 91 seconds for parities 1-3 respectively, compared with 66, 55 and 62 seconds for the piglets born in crates.

In addition to recording the time taken for a piglet to stand, measurements were also made of the time taken for an intact cord to break. These showed that piglets in crates took longer to break their cords than did the piglets in pens, although the differences were not significant (table 14.29a). The time to cord breakage is the most difficult to evaluate of all the appearance and behavioural recordings that were taken at birth. It is very difficult to assess the exact significance of a short time to cord breakage; it could be a beneficial trait in that it suggests a vigorous piglet which soon breathes, stands and moves away seeking a teat. However, it could also represent a deleterious trait suggesting that the attachment between the foetus and placenta has weakened during farrowing and so the cord is already partially severed, even though it may appear intact at the moment of birth. As a result of the many observations carried out in this trial (ref. tables A.59 - A.61), it is believed that a short time to cord breakage can represent both circumstances and so it cannot be used to judge viability on its own but rather, it needs to be considered in conjunction with all the other recorded characteristics.

The strength of the cord definitely varied between individual piglets with the result that some very vigorous piglets had a long recorded time to cord breakage as the cord appeared to be very strong and resisted breaking. On a few occasions, it even appeared to impede the efforts of the piglet to suckle although it was usually sufficiently long to allow a piglet to suckle the rear teats of a sow with an intact cord (observations which agreed with those of Jones, 1966b and Randall, 1972a). Since there appeared to be no direct relationship between the mean birth interval and the time taken to break an intact cord ($r = 0.21$, $p > 0.05$), it is difficult to suggest what could govern the strength of the cord.

The piglet suckling behaviour observed in this trial agrees with other reports in the literature (e.g. Jones, 1966b; Randall, 1968) and there was no difference between piglets in pens and crates in terms of their behaviour. The time taken to achieve the first successful suckle was slightly longer in a pen than in a crate (table 14.29a) which, again, is thought to reflect the sow's behaviour and lying position during suckling. In a farrowing pen, sows frequently lay with their udders pressed alongside a pen wall which made it difficult for the piglets to suckle, even if the sow responded to their suckling cries and rotated her abdomen so as to expose all the teats. In a crate, due to the absence of a solid wall, this delay in suckling was less likely to occur so that if a vigorous piglet took a long time to suckle, it was probably due to the reluctance of the sow to expose her udder fully.

Other workers (e.g. English, 1969) corrected the time taken to suckle according to the lying position of the sow. This obviously produces a more accurate result and eliminates the criticism above but in the current study, so many other recordings of piglet appearance and behaviour at birth were being made simultaneously, it was felt to have to record sow lying position in addition to everything else would have caused unnecessary complications.

As well as recording piglet appearance and behaviour at birth, various blood measurements were also taken to try to obtain further

Table 14.40 <u>Relationship between various birth characteristics of piglets born in pens and crates</u>

Birth characteristic	Farrowing accommodation Pen	Crate	Level of significance
Mean interval between births (min.)	21	39	n.s.
No. stillborn pigs/litter	0.5	0.8	n.s.
Serum lactic acid level at birth (m.I.u/ml.)	140	158	*
% pigs showing 0 level of meconium staining	30	12	***
% pigs showing +++ level of meconium staining	5	13	**
% pigs born with intact cords	81	85	n.s.
Time taken to breathe (sec.)	53	45	n.s.
Time taken to stand (sec.)	73	61	*
Time taken to suckle (min.)	36	32	n.s.

information about the viability of the piglets. There is a consensus of opinion in the literature (e.g. Randall, 1968; English and Smith, 1975) that increasing levels of lactic acid in the blood at birth indicate an increasing degree of hypoxia. Despite the problems involved in collecting and analysing the serum samples described earlier, the results obtained show that there were significantly higher lactic acid levels in the piglets born in crates than those born in pens (table 14.30), i.e. the type of farrowing accommodation seemed to have a marked effect on the degree of asphyxiation of piglets at birth. (It is also possible that the elevated foetal lactic acid levels in piglets born in crates reflect a higher maternal lactate level, since these sows showed more restlessness during farrowing). Housing during gestation, however, had no effect.

Table 14.40 summarises the results concerning piglet viability which have been discussed above. The significant differences in meconium staining and serum lactic acid levels do indicate an increase in hypoxia for the piglets born in crates. However, the remaining results which do not show significant differences can only lead to the conclusion that this apparent increase in hypoxia does not seem to affect the other viability characteristics.

The measurement of haematocrit levels in piglet blood was not considered of prime importance and data were only collected as a by-product of centrifuging blood samples to obtain plasma for the immunoglobulin assay. Certain piglets had very high haematocrit levels which could have been due to the effects of stress during blood sampling (Kornegay, 1967) for it is likely that the last piglets to be sampled in a litter would have been under considerable stress. However, sampling was carried out randomly and there is no record of the order in which it occurred.

The results concerning immunoglobulin levels in piglet blood at 36 hours after farrowing are difficult to explain. Wide variations in IgG concentrations were found both between and within litters (tables A.59 - A.61). These could be explained if there was a correlation between IgG level and other indicators of piglet viability such as time taken to suckle. For example, as Bourne (1969c) has shown, piglets which suckle later will obtain colostrum with a lower IgG content and so can be expected to have lower IgG levels at 36 hours post partum. However, when the correlation coefficient between time taken to suckle and IgG level was calculated ($r = -0.039$), it was not statistically significant. This result warrants further investigation.

Another factor which may be considered is the effect of stress at birth on IgG levels. Halliday (1965) working with lambs showed that the presence of a stressor at birth (such as hypoxia) caused the production of corticosteroids and this in turn led to a reduction in the absorption of immunoglobulins. A similar effect has been demonstrated in calves born per vaginam compared with those born by Caesarian section (Kruse and Buus, 1972). However, in the current study there was no apparent relatinnship between a low IgG level and a long interval preceding delivery or between any of the other behavioural characteristics indicative of hypoxia. Thus, it is only possible to conclude that the form of sow housing during gestation or at farrowing has no influence on the uptake of colostral antibodies by the piglet.

d) Piglet growth rates

The weights of piglets at birth and 36 hours post partum showed an effect of litter size (table 14.32a), since the treatments producing the smallest litter size also had the heaviest piglets. With reference to the daily liveweight gain of the piglets (which is the most important commercial measure of growth), this was identical in crates and pens and there were only very slight differences between the 4 housing treatments. There were, however, considerable parity differences with the piglets in parity 1 (table 14.32b) growing significantly slower than piglets in later parities. This was mainly due to the very poor growth rates of the tether-crate and cubicle-crate litters which only averaged 0.195 and 0.173 kg/day compared with 0.209 and 0.215 kg/day for the tether-pen and cubicle-pen litters. It is possible that these poor results were due to a stress reaction on the part of the gilts in response to being confined in crates and they certainly cannot be explained as a result of these animals having the largest litters. It is also possible that other factors such as a reduction in the amount of bedding available in crates compared to pens may have had a part to play in this, although this is only speculation as there was no systematic recording of the temperature in crates and pens. By the second and subsequent parities, however, there were no differences between treatments which might suggest that the sows in crates had adapted to these conditions by then.

e) Preweaning piglet mortality

The overall preweaning mortality was typical of other recent estimates in the literature (table 14.41) even though it is rather high in terms of modern commercial practice.

Table 14.41 Recent estimates of preweaning mortality

Author	Year	% mortality
Aumaitre *et al*	1975	19.8
Bille *et al*	1974b	18.3
Bille *et al*	1976	22.5
Maksimovic	1976	14.7
Simensen & Karlberg	1980	22.2
(Parry	1984	17.5)

As shown in table 14.33a, although the differences between treatments were not significant, the lowest mortality rate (15.9%) was obtained on the cubicle-pen (i.e. minimum restriction) treatment while in terms of sow housing at farrowing, crates had a marginal advantage over pens (17.0% v. 18.0%)

The results also show (table 14.33d) that the bulk of the mortality occurred very early in life and was due to traumatic injuries inflicted by the sow. The worst offenders were the sows in the tether-pen treatment and observation of their behaviour showed that they seemed unable to adapt to the extra space when they were transferred into a pen from the confinement of a tether. Several piglet deaths were caused by their frequent standing and nest building during the birth process. In fact, the sows on the cubicle-pen treatment stood and nested more frequently but these animals appeared to be more careful where they walked and how they lay down, frequently lowering themselves into a "dog sitting" position first and then running their snouts through the straw to expose any hidden piglets, before finally lowering their abdomen. This behaviour is similar to that described by Signoret et al (1975). In contrast, several of the tether-pen sows tended to lie straight down from a standing position which meant that piglets buried in the straw were frequently crushed. It was probably the care with which most changes of posture were accomplished in a farrowing pen that accounted for the very small difference in mortality between crates and pens. This is all the more remarkable when it is realised that crates are especially designed to reduce death by crushing whereas there was no physical protection afforded to the piglets in pens, other than by the straw bedding itself.

Pen size (and particularly width) also affected mortality. As the farrowing house was formed from the conversion of a former bacon house, this meant that there was a definite limit set for pen width in order to accommodate 4 crates and 4 pens in the pre-existing space. The pens were 1.33m wide which allowed the gilts in parity 1 to turn freely but which meant that, as the sows increased in body weight over the course of the remaining 3 parities, the pens became progressively too narrow and began to impede free turning as the sows rubbed the walls with both snout and rear quarters. Other workers (e.g. Backstrom, 1973; Simensen, 1971) have also commented on the incidence of higher mortality rates in smaller pens compared with larger ones and Simensen, in particular, reported how mortality decreased as pen width increased.

In common with the findings of others (e.g. England et al, 1976), there was no significant effect of mean birth interval on subsequent postnatal mortality (table 14.33c). Mean birth interval is only one of many factors which interact to affect mortality in the preweaning period but it would be expected that a hypoxic piglet exhibiting depressed viability as a result of being subjected to an extended farrowing would be more likely to fall victim to either overlying by the sow, or to hypothermia and starvation. Workers such as Randall (1968), Svendsen and Bille (1980) and Bjorklund (1981) have shown a relationship between high lactic acid levels (indicative of hypoxia) and increased postnatal mortality. In the current trial, however, there was no relationship between mean lactic acid levels and preweaning mortality ($r = 0$, $p > 0.05$). Neither were the correlation coefficients between the minimum and maximum amounts of meconium staining and mortality significant ($r = 0.062$, $r = 0.153$ respectively). Thus the current data does not permit definite conclusions to be drawn regarding the relationship between various viability characteristics and preweaning mortality.

f) Sow weight gain and body condition

Table 14.34a shows that sows housed in cubicles throughout gestation had a slightly (although non significantly) greater weight gain over this period relative to those in tethers even though they were both fed the same amounts of food. Although the aim was to keep the dry sow house temperature at 17°C, there were periods when it fell far below this and despite all the sows having a thick layer of straw bedding, it is likely that the tethered sows became colder than those in cubicles as they were unable to reduce their heat loss by huddling and thus they were forced to metabolise body fat.

The older sows in parities 3 and 4 had a significantly lower body condition score at farrowing than the younger sows and gilts (table 14.34b). This was possibly because they were carrying larger litters of piglets and so more of their dietary intake was channelled towards foetal growth at the end of gestation than was directed into body fat reserves.

Over the course of farrowing and lactation, there were only small differences in amount of weight lost by the sows on different treatments (table 14.34a), which was to be expected as the differences between sows in terms of numbers and growth rates of piglets weaned were similarly small (tables 14.32a and 14.33a). There were significant differences between parities (table 14.34b), i.e. the third and fourth parity sows lost more weight than the first and second parity animals. Since all sows were fed on the same feeding scale throughout lactation (2kg/sow and 0.5kg/piglet per day), the differences were unlikely to be due to this. Instead, they were probably a reflection of the faster growth rate shown by the piglets born to older sows i.e. the higher weight loss represented a greater milk yield produced by the older animals.

The length of time a sow takes to come back on heat after weaning has a profound commercial significance since it is an indicator of sow fertility and is one of the major factors limiting the number of litters a sow may produce in the course of a year

(English et al, 1977). One important factor affecting the weaning to conception interval is the body condition score of the sow at weaning and so it was not surprising in the current study that there was little difference in this time interval between sows on different treatments.

iv) Implications for commercial practice

As stated in the conclusion to the literature review, the aim of the experiments and observations described in chapters 12 - 14 was to examine the hypothesis that close confinement of sows during farrowing could lead to stress which in turn could prolong farrowing and thus cause a reduction in piglet viability.

The results obtained can be summarised as follows:

1. From a behavioural viewpoint, the most important finding was that sows are able to adapt to their environment, both in dry sow and farrowing accommodation. The main exception to this was the prepartum behaviour of both gilts and sows in crates.

2. In terms of duration of farrowing, there was no significant effect of confinement either during pregnancy or at parturition.

3. Other measures of piglet viability (such as meconium staining and lactic acid levels at birth) did show significant differences as a result of sow housing during farrowing but these did not appear to affect preweaning mortality or daily liveweight gain. Similarly, the design of the farrowing accommodation did not affect preweaning mortality and growth rate.

It must therefore be concluded that the treatments compared in these experiments were not sufficiently different to affect commercially important production factors. Both types of farrowing accommodation suffered from deficiencies in their design so that the trial should really be repeated with better designed housing.

In terms of dry sow housing, it is apparent that the main objection to tethering is a welfare argument and there does not appear to be any disadvantage in terms of sow productivity. A commercial producer needs to balance the necessity of providing a controlled environment and the arguments of the welfarists against the lower labour requirement and easier management of confining sows. Work carried out at the National Agricultural Centre during 1979 - 1980 showed a total cost of 20.7p/piglet produced in an intensive stall system compared with 48.2p/piglet in a straw yard system (Peet, B. 1982, Personal Communication). If productivity is not affected by confinement during gestation, these lower running costs will make such systems seem more attractive to the producer.

With reference to farrowing accommodation, there are 2 main implications. The first is that the design of the modern crate, while frustrating the natural instincts of the sow, does not appear to affect the birth process sufficiently to impair subsequent piglet performance. Secondly, the farrowing crates used in this study do not appear to reduce piglet mortality when compared with simple strawed pens. The main advantages of using crates in a commercial system concern the ease of management and reduction in labour requirement although low rates of mortality are also claimed for certain types of crate. If crates are considered unacceptable from a welfare viewpoint, then it would seem that a compromise in farrowing accommodation could perhaps be achieved without too great an increase in mortality. However, more research would be needed in order to combine freedom of movement for the sow with ease of management within a farrowing system.

The latest Codes of Recommendation for Welfare (Ministry of Agriculture, Fisheries and Food, 1983) advise that straw should be provided for all classes of stock. Observations in this study emphasised the importance of straw and the sow's ability to use it for creating an optimal environment (both for herself and her litter), in addition to its providing an outlet for a wide behavioural repertoire. The use of straw in an intensive housing system may act as a compromise to moderate the welfare objections to confinement.

To conclude, the types of sow housing used by commercial producers vary from the free-range system described in experiment 1 to the maximum restriction provided by tethers and crates. Both these extremes of housing can produce successful results and this is indicative of the sow's ability to adapt to a variety of conditions. Whether or not such systems of housing are morally acceptable is a subject for continuing debate.

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