Promotor : dr. P.R. Wiepkema, hoogleraar in de ethologie
Co-promotor: dr. G. van Putten, wetenschappelijk medewerker verbonden
aan het Instituut voor Veeteeltkundig Onderzoek "Schoonoord"
te Zeist

W.G.P. Schouten

REARING CONDITIONS AND BEHAVIOUR IN PIGS

Proefschrift
ter verkrijging van de graad van
doctor in de landbouwwetenschappen,
op gezag van de rector magnificus,
dr. C.C. Oosterlee,
in het openbaar te verdedigen
op woensdag 26 februari 1986
des namiddags te vier uur in de aula
van de Landbouwhogeschool te Wageningen

aan Yvonne

1 Bij onderzoek naar de mogelijkheid van groepshuisvesting voor zeugen dient de voorgeschiedenis van deze dieren als variabele meegenomen te worden (dit proefschrift).

2 Verliezerservaring is belangrijk voor de ontwikkeling van normaal sociaal gedrag.

3 In experimenten, waarbij het gedrag van sociaal geïsoleerde dieren wordt vergeleken met dat van een controlegroep van niet sociaal geïsoleerde dieren, dient men er zorg voor te dragen, dat de dieren in de controlegroep ook normaal sociaal gedrag kunnen uitvoeren.

4 Gedragsonderzoek aan laboratoriumdieren of landbouwhuisdieren in een (semi-)natuurlijke omgeving geeft vaak een verhelderende kijk op het gedrag van deze dieren onder laboratorium- of moderne houderij-omstandigheden.
Jensen, P. and D.G.M. Wood-Gush, 1984. Appl. Anim. Behav. Sci. 12: 327-337. Calhoun, J.B., 1962, Bethesda.

5 In een ethogram van ratten mogen naast hoorbare geluiden ultrasone niet ontbreken.

6 De weigering van tijdschriften om beschrijvende ethologische onderzoeken te plaatsen, vergroot de kans op experimenteel onderzoek waarin de dieren de verkeerde vragen gesteld worden.

7 Het welzijnsonderzoek bij landbouwhuisdieren is ermee gediend als welzijnsonderzoekers een meer dan minimale kennis van de ethologie bezitten.

8 Het strikt hanteren van de term afhankelijkheid in de statistische zin reduceert veel experimenten tot "case studies".

9 Voor veel wetenschappelijk personeel aan universiteit of hogeschool blijven alleen nog de ADV-dagen voor onderzoek.

10 Gezien de interpretaties van sommige onderzoeksresultaten bij ratten wordt Calhoun meer aangehaald dan gelezen.
Calhoun, J.B., 1962, Bethesda.

11 De voorkant van het varken compenseert in ruime mate de spreekwoordelijke domheid van zijn achterkant.

W.G.P. Schouten
Rearing conditions and behaviour in pigs.
Wageningen, 26 februari 1986

VOORWOORD

Als eerste wil ik Paul Timmermans bedanken die tijdens mijn dienstverband als dierverzorger op de afdeling Vergelijkende en Fysiologische Psychologie aan de K.U. te Nijmegen mijn belangstelling voor de ethologie heeft gewekt. Met zijn op- en aanmerkingen leverde hij ook een belangrijke bijdrage aan de totstandkoming van dit proefschrift.

Mijn promotor Prof. Dr P.R. Wiepkema dank ik voor de mogelijkheid dit onderzoek uit te voeren in het kader van een promotie-assistentschap. De discussies met hem en de vrijheid die hij mij tijdens het uitvoeren van het onderzoek liet heb ik altijd bijzonder weten te waarderen. In het bijzonder wil ik ook mijn co-promotor Dr G. van Putten danken voor de dicussies en suggesties tijdens mijn onderzoek en vooral voor het kritische en deskundige commentaar op het manuscript.

De in hoofdstuk 7 beschreven experimenten werden voor een groot deel uitgevoerd door Gerrit Lammers in het kader van zijn vervangende dienstplicht. Voor de prettige en vruchtbare samenwerking wil ik hem bijzonder danken. Peter Mekking en André de Lange dank ik voor de vele uren die zij vrijmaakten om mij in te wijden in het computer-gebeuren en voor het schrijven van de vele programma's. Hans Romberg dank ik voor de voortreffelijke wijze waarop hij grote data-bestanden tot voor mij "hapklare brokken" wist te verwerken. Wiebe Koops en Peter van Ewijk dank ik voor de vele statistische adviezen.

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Truus Gijsbertse dank ik voor het vele type- en correctiewerk en de layout van het proefschrift. Hanneke Receveur wil ik danken voor het corrigeren van de engelse tekst. Van haar hand is ook de tekening op de omslag. De heer W. Heije dank ik voor het tekenen van de vele figuren.

Het personeel van de proefaccommodatie "de Haar" was behulpzaam bij de bouwtechnische veranderingen van de stal en de verzorging van de dieren. Voor de verzorging van de mestvarkens en de vele koppen koffie met koek tijdens de avondwaarnemingen dank ik de familie Adams.

Tenslotte wil ik iedereen bedanken die aan dit proefschrift heeft bijgedragen, maar niet met name is genoemd.

CONTENTS

4 Development of diurnal activity in pigs from birth till week 24

CHAPTER 1

1. GENERAL INTRODUCTION

During the last 30 years the environment of our livestock has changed greatly. More animals then ever before are kept per m^2 and the environment has become very monotonous.

For pigs we have now substantial evidence that the actual situation in which the animals are kept, not only drastically changes their behaviour as compared with the former situation, but also leads to drawbacks in the animals' health and production (e.g. van Putten and Dammers, 1976; Ruiterkamp, 1985; Metz and Oosterlee, 1980; Hemsworth et al., 1981; Cronin, 1985; Cronin et al., 1982/1983).

However, not only the actual situation during adult life, but also the conditions present in early life may deeply influence the behaviour of adult animals. Experiments with - among others - rats, dogs and monkeys show that the social and physical environment in early life considerably influences adult behaviour. For instance social isolation in early life produced disturbed adult sexual and aggressive behaviour in Rhesus monkeys (Harlow and Harlow, 1962), Burmese Jungle Fowl (Kruijt, 1964) and rats (Peys, 1977; Timmermans, 1978; Koene and Van der Staak,1985). Further, an impoverished physical environment during the first months of life caused behavioural rigidity and a reduced learning ability in adult rats (Gardner et al., 1975).

It is therefore important to investigate whether or not early life conditions of piglets may influence their later behaviour. It will be clear that knowledge on this point is of practical interest, if, for instance, adult disturbed behaviour like highly aggressive or poor maternal behaviour appears to result from early life conditions. Insight in such relationships may indicate steps to be taken to prevent rather than fight undesirable behavioural symptoms of adult pigs.

Only recently the effect of early experiences on later behaviour in pigs obtained attention. Hemsworth and coworkers showed that a lack of physical or visual contact with other pigs in early life had a negative effect on sexual behaviour in boars and gilts (Hemsworth et al., 1977, 1982). However, the effect of an impoverished environment during rearing on later behaviour in pigs is still not well documented. Recently Ruiterkamp (1985) reported that the incidence of sitting, sham chewing and massaging penmates as found in fattening pigs was relatively high for pigs reared in an impoverished environment as compared with pigs reared in an enriched environment.

The present study was undertaken to investigate the different effects of impoverished and enriched environment during rearing on the behaviour of fattening pigs and on maternal behaviour of gilts. During rearing behavioural observations of individual animals were made. These observations were compared with those made during fattening and around farrowing of the same animals.

The development of piglet behaviour during the first 8 weeks of life, when kept in either an enriched or in an impoverished environment, is described and compared in chapter 3.

Knowledge of this development and of differences in behaviour of piglets raised in the two different environments is important in order to be able to explain possible differences found in behaviour during the fattening period. Chapter 4 focuses on this period: the effect of rearing conditions on the development of the diurnal rhythm and on the synchrony of activity will receive special attention. The effect of rearing conditions on later behaviour around farrowing is reported in chapter 5.

From several studies in pigs it is known that amongst others, bedding material strongly influences behaviour of piglets (van Putten and Dammers, 1976; Fraser, 1978; Schmidt and Adler, 1981; Buré, 1981). The significance of straw as bedding was studied by alternately offering the piglets straw or a bare concrete floor; the results are described in chapter 6.

A detailed description of the development of agonistic behaviour in piglets during the first 7 weeks of life is presented in chapter 7. The effect of floor space on the development of agonistic behaviour and its effect on adult behaviour is discussed in the same chapter. Finally, in chapter 8, the biological significance of early experience on adult pig behaviour and its significance for practical pig farming is discussed.

First, in chapter 2, I shall outline the general way in which the animals were kept and observed.

CHAPTER 2

2. MATERIAL AND METHODS GENERAL

Four litters of eight piglets each were reared in two different housing systems. The effects of these two rearing conditions on later behaviour were tested during:

A) the fattening period and B) in the adult phase around farrowing.
The same animals were followed during different stages of their life as described in chapters 3 to 5.

2.1 Experimental design

On four occasions, two pregnant gilts (sister pairs) were obtained from a commercial farm. Fourteen days before the expected farrowing date, one gilt of the pair was tethered in a farrowing crate by a breast girth. The other one was placed in a pen with straw bedding (straw pen) in which she could move around freely. The resultant litters were culled to eight piglets, if possible four males and four females. Observations began one day after the piglets were born. Within sister pairs, both farrowings occurred within four days. At the end of week 6, the litters were weaned by removing the sow. The piglets were observed for a further two weeks. At the end of week 8, four gilts (two from each litter) were put together in a small straw pen. These gilts were inseminated at their second oestrus and were individually housed in a small straw pen fourteen days before the expected farrowing. Observations on these gilts started five days before the expected farrowing and ended 13 days after farrowing. Farrowing was observed during six hours from the time of delivery of the first piglet.

The remaining six piglets from each litter were transferred to a commercial farm for fattening. The litters were not mixed and each one remained intact in a pen until the age of 24 weeks. Observations of the behaviour of these fattening pigs started one week after arrival at the commercial farm. An overview of the experimental design is presented in figure 2.1.

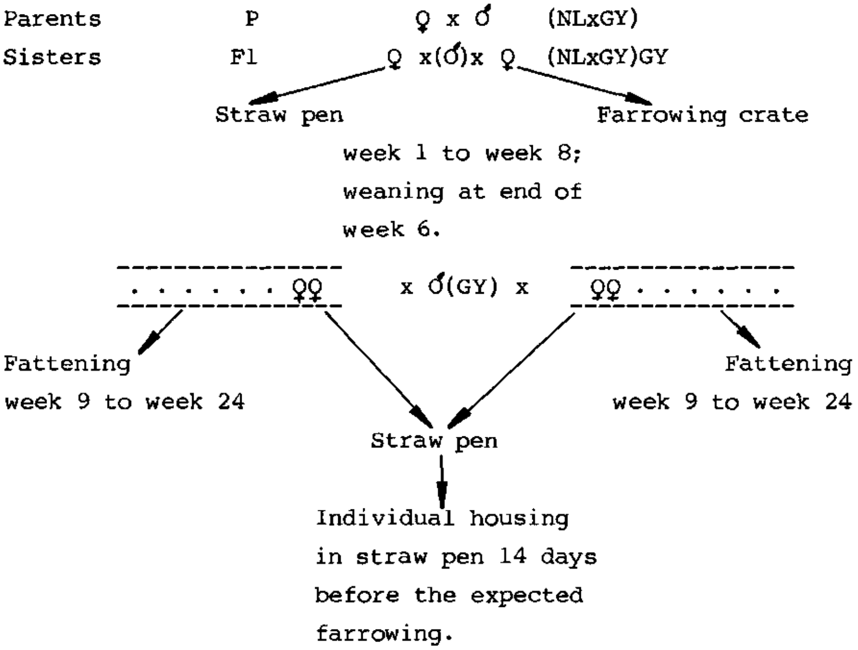


Figure 2.1. Experimental design

Table 2.1 shows the periods during which the observations took place and the number of animals involved.

Table 2.1. Number of animals involved and the date of observations

	Litter number	Piglets		Litter number	Piglets		Observation period
Sister-pair	Crate	♂	♀	Straw	♂	♀	
1	1	3	5	2	3	5	03-19-81 - 05-18-81
2	3	2	6	4	2	6	06-07-81 - 08-05-81
3	5	5	3	6	4	4	09-02-81 - 10-30-81
4	7	4	4	8	4	4	12-09-81 - 02-05-82
Total		14	18		13	19	

Gilts

	Litter number				Observation period
Sister-pair	Crate	♀	Straw	♀	
1	1	2	2	2	02-82 - 03-82
2	3	2	4	2	05-82 - 07-82
3	5	2	6	2	08-82 - 11-82
4	7	2	8	2	12-82 - 01-83
Total		8		8	

Fattening pigs

	Litter number						Observation period
Sister-pair	Crate	♂	♀	Straw	♂	♀	
1	1	3	3	2	3	3	05-26-81 - 08-27-81
2	3	2	4	4	2	4	08-13-81 - 11-16-81
3	5	5	1	6	4	2	11-10-81 - 02-17-82
4	7	4	2	8	4	2	02-18-82 - 05-26-82
		14	10		13	11	

2.2 Housing

2.2.1 Piglets

In the first eight weeks of their life the piglets were housed either in a farrowing crate or in a straw pen both of which were in the same stable and room of the experimental unit "De Haar" (Agricultural University in Wageningen). The crate measured 2 X 2 m^2 and had a fully slatted concrete floor, while the anterior part was covered with a rubber mat (figure 2.2). The sow was restrained between iron bars and tethered with a breast girth. The sides of the crate were 50 cm high multiplex partitions. The lying place of the piglets could be heated by an infra-red brood heater. The straw pen (figure 2.3) measured 28 m^2 and had a concrete floor covered with long straw. Approximately 5 m^2 was inaccessible to the sow. Twice a week part of the straw was replenished. Because all sows in the straw pen built nests, brood heaters were not used in the straw pen.

1 Bowl drinker
2 Nipple drinker
3 Trough (sow)
4 Creep feeder
5 Brood heater
6 Creep area
▨ Rubber mat
7 Nesting site
8 Dunging area

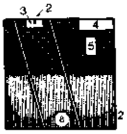


Fig. 2.2
Farrowing crate

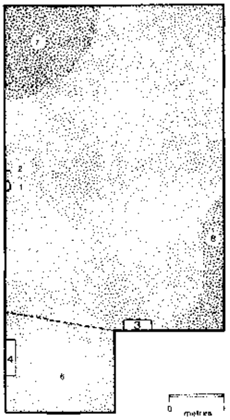


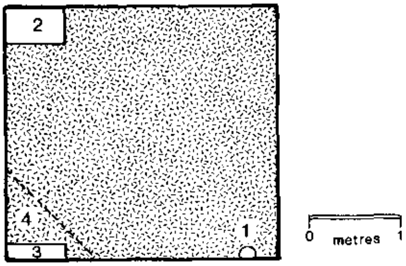
Fig. 2.3
Large straw pen

In the farrowing crate, nipple drinkers were situated in front of and behind the sow (for the piglets) (see figure 2.2). In the straw pen a bowl drinker and a nipple drinker were available for both sow and piglets. At the end of week 3 a creep feeder, with five feeding places, inaccessible to the sow, was placed in both pens.

2.2.2 Gilts around farrowing

After eight weeks, four gilts (two from the straw pen and two from the farrowing crate) were put together in a small straw pen (figure 2.4). The pens measured 3.0 x 2.8 m^2 and had a concrete floor covered with straw. Water was available via a drinker. Straw was replenished three times a week. Two weeks before the expected farrowing date the gilts were housed individually in the same kind of pens. These pens, the farrowing crate and the large straw pen, were situated in the same stable and room as before.

The light regime was held constant: 12/12 hr light/dark with lights on at 08.00 hours. In the dark period a 25 Watt bulb placed above the crate and the small straw pens provided enough light to make direct observations possible and to assist video recording. Above the large straw pen, two 25 Watt bulbs were used.



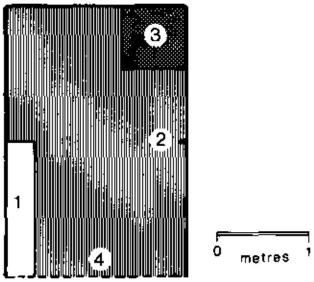
1 Drinker
2 Trough
3 Creep feeder
4 Creep area

Fig. 2.4. Small straw pen

The temperature was regulated by a combination of central heating and ventilation (mean 20°C, range 14.5 - 26.5°). The relative humidity averaged 67% (range 50.0 - 87.0%).

2.2.3 The fattening period

On the commercial farm of the Adams family in Bennekom four pens were adapted to allow for continuous observations of the animals. The front of the pens consisted of welded mesh gate. A plank on the inside of the front partition prevented the animals from dunging in the feeding passage. The pens measured 2 X 3 m^2 (figure 2.5) and had a fully slatted concrete floor. During the first three weeks a rubber mat of 1.2 m^2 provided the animals with a more comfortable lying area. Water was available via a nipple drinker and feed via an automatic feeder with five feeding places per pen.



1 Automatic feeder
2 Nipple drinker
3 Rubber mat
4 Welded mesh gate

Fig. 2.5. Fattening pen

The light regime was held constant: 12/12 hr light/dark with lights on at 08.00 hours. In the dark period each pen was illuminated by a 25 Watt bulb. The temperature in the stable, although not regulated thermostatically, was maintained above 10°C by means of two gas heaters (mean 16.2°C, range 7-30°C).

2.3 Feeding

Pregnant gilts were fed twice a day at 08.00 and 16.00 hours with 1 to 1.5 kg/day of sow feed, which was increased to 4.5 kg/day in the third week of lactation. From the end of week 3 creep feed was provided ad lib. for the piglets. Water was continuously available for gilts and piglets. The young gilts were fed restricted rations according to practical guidelines for growing gilts.

The fattening pigs on the commercial farm were fed ad lib.. The first two weeks with creep feed were followed by three weeks starting feed and fattening feed until the end of the fattening. Water was only available from 08.00-09.00 and 18.00-19.00 hours daily. On very hot days, additional water was given from 13.00 to 14.00 hours.

2.4 Health

The piglets received iron injections at day two and the males were castrated on day 14 or 15. Teeth clipping and tail docking were not performed. The health of the animals was checked daily and, if necessary, the animals were treated by the veterinarian.

2.5 Observations

During the first eight weeks of life and around farrowing the animals were observed directly; 24-hour video-recording were made at regular intervals, as described in the following chapters.

During the fattening period every three weeks 24-hour video-recordings were made. This resulted in five 24-hour recordings during fattening.

CHAPTER 3

3. BEHAVIOURAL DEVELOPMENT OF PIGLETS UNDER TWO DIFFERENT REARING CONDITIONS

3.1 Introduction

To investigate the effects of rearing conditions on later behaviour in pigs, the behaviour of piglets in two different housing systems was observed during the first 8 weeks after birth. Knowledge of the behaviour of individual piglets during this period might be important to explain differences in behaviour in different housing conditions during later life of these piglets. The difference between the housing systems was made as large as possible to enhance possible divergent effects on later behaviour of the subjects. The two rearing conditions were : A) a farrowing crate, typical for the ones commercially used and B) a large straw pen (see chapter 2).

In this chapter the development of behaviour of piglets under the two rearing conditions is described and compared.

3.2 Material and methods

The behaviour of 32 piglets from four litters kept on straw (straw animals) and of 32 piglets from four litters kept in a farrowing crate (crate animals) was observed for 8 weeks. The piglets were weaned at the end of week 6 by removing the sow. Each piglet was identified by an ear tattoo, and a large number painted on its back. Observations on individual piglets were taken from an observation post two metres above floor level. From this post the animals in both the straw pen and the farrowing crate were always visible. The behaviours were recorded via a so-called "ethopiano" (van Putten, 1976) and frequency and duration of individual behaviours were stored in a memory and punched on paper tape. All calculations were done with a DEC-10 computer.

3.3 Ethogram of the piglets

Resting behaviour

<u>Lying:</u> Lying on side or belly without performing any other behavioural element described. It is recognized that lying on the belly not always means that the animal is resting.

Lying at the udder: Lying with a nipple of the sow in its mouth without performing any other behavioural element described.

Active or activity

Active: The animal is performing any behaviour excluding resting behaviour. Note that this category is the sum of all active behaviour.

Activities at the udder

Sucking: More than half of the number of piglets are massaging or sucking the udder and the sow is in nursing position (lying down while exposing the udder). The behaviour of the individual piglet at the udder is scored as sucking.

Manipulating the udder: Massaging the udder when the sow is not in the nursing position, or when half or less of the number of piglets are massaging or sucking the udder. In this context the behaviour of the individual piglet is scored as manipulating the udder.

Feeding and Elimination

Eating: Eating or chewing creep feed.

Drinking: Drinking water.

Elimination: Urinating or defecating.

Exploration

Sniffing objects: Sniffing, touching, nibbling, sucking or chewing objects above floor level.

Sniffing substrate: Sniffing, touching, nibbling and sucking substrate.

Chewing: Chewing particles other than creep feed, e.g. straw, faeces, wood chips with the head not in contact with objects or floor.

Rooting: Moving the snout over the floor or objects with horizontal movements. The rooting disk is pressed with some force against floor or object.

Social behaviour between piglets

Nosing piglet: sniffing any part of the body of littermates.

Massaging or nibbling piglet: Rubbing the body of a littermate with rhythmical up and down movements of the snout. Mostly directed towards the belly and the soft tissue between fore and hind-legs. Nibbling, sucking or chewing any part of the body of a littermate. This element includes tailbiting.

Mounting: Placing both front hoofs on the partners back, with or without pelvic thrusts.

Social behaviour between piglets and sow

Nosing sow: Sniffing any part of the body of the sow.

Massaging or nibbling sow: Rubbing the body of the sow, excluding the udder, with rhythmical up and down movements of the snout. Nibbling, sucking or chewing any part of the body of the sow, excluding the udder.

Locomotion

Moving: Walking without performing any other described element, but obviously directed towards a given object.

Scampering: Scampering around the pen, including jumping and turning around the body axis.

Climbing: Climbing over lying littermates or sow.

Standing and sitting

Standing and sitting: All standing and sitting without performing any other described behavioural element.

Playful activities

Shaking objects: Vigorously shaking objects taken into the mouth.

Scampering: see locomotion.

Comfort behaviour

Scratching: Scratching the body with a hind leg.

Rubbing: Rubbing the body against fixed objects or penmates (including the sow) or rubbing the anal region, while in a sitting posture, against the floor.

Headshaking: Shaking the head, this is often seen after scratching the head and aggressive or playfull interactions.

Stretching and yawning: Stretching part of or whole body, often simultaneously yawning.

Agonistic behaviour

Ramming or pushing: Ramming or pushing littermates with the head, with or without biting. Only single knocks or bites were recorded as such.

Fighting: Mutual pushing parallel or antiparallel, ramming or pushing the opponent with the head, with or without biting in rapid succession. Lifting the opponent by putting the snout under its body.

3.4 Observations

The litters were observed 2 days per week: on the first observation day of a week from 09.00-10.00, 11.00-12.00 and 13.00-14.00 hours, and on the second observation day from 10.00-11.00, 12.00-13.00 and 16.00-17.00 hours. A pilot study had shown that during these periods high levels of activity and transitions from active to resting were most likely. The observations of the 2 days per week were summed and represented a week score. Per week and per piglet frequency and duration of the behaviours were then calculated.

Within an observation hour every piglet was followed continuously for a two minute period. Per hour each piglet was observed for three of such periods. After each two-minute period, some time was lost in punching the stored data on paper tape, clearing the memory and identifying the animal to be observed next. In every new hour, observations began with the piglet one number higher than the piglet started with in the preceding hour. The method of observing one piglet continuously for two minutes was preferred to a scanning method, in order to obtain a reliable estimate of the mean duration of the behaviours. Another advantage of continuous observation of individual animals is that even very short-lasting behaviours are recorded. The two minute period was chosen as a compromise between observing all the animals of a litter in a period as short as possible on the one hand, and on the other hand observing long enough to be able to make a good estimate of the mean durations of most behaviours. It is recognized that duration of behaviours which on the average last longer than two minutes e.g. sucking or sleeping, cannot be estimated adequately by the method chosen.

Because observations took place during a limited period of the day, statements about differences between activity levels of the piglets in the two housing systems cannot be made. In order to measure these differences more directly, 24-hour video-recordings were made in several weeks. From these records the proportion of piglets not lying (that is being active) was registrated at 10-minutes intervals. Measured over 24-hours, no difference in total activity levels were found between litters in the two housing systems (see chapter 4). However during the specific observation times differences in activity between both housing systems were found, especially after week four. The straw animals appeared to be observed more often in their active periods than the crate animals. To compensate for this effect the duration of all behaviours other than lying were expressed as percentages of the total activity during observation.

The mean durations of the separate behaviours were calculated by dividing total duration by total frequency. Because a behaviour could start before a two-minute observation period started and could outlast the observation period the mean duration of some behaviours may be underestimated.

3.5 Statistical analyses

The eight weeks of observation, including the six weeks during which the piglets were still with the sow, were taken as eight or six samples from the same piglet. Because the experimental unit was the litter, the mean values per litter over the eight or six weeks were used to test differences between housing systems and sister pairs. By means of orthogonal polynomials (Snedecor and Cochran,1967) linear trends over eight or six weeks were tested. The weekly percentage scores, after an arcsine square root transformation (Sachs,1984), were treated by a two-way analysis of variance (BMDP2V, BMDP Statistical Software, W.J. Dixon, 1983) (see appendix A for the p values of the analysis of variance).

Because some behaviours were not scored every week for each piglet changes of mean duration of the behaviours were tested by the Spearman Rank test (Siegel, 1956) using the mean values per housing system per week.

Anova model:

$Y_{ijk} = \mu + SP_i + H_j + e_{ijk}$

Y = dependent variable

μ = overall mean

SP = effect of sister pairs $i= 1, 4$

H = effect of housing system $j= 1, 2$

e = error

3.6 Results

To avoid an unreadable summing up of all results of the direct observations in detail, the behaviours are taken together in more or less coherent groups. These groups are presented successively, each followed by a discussion.

3.6.1.1 Active

- Percentage time spent on active

Mean activity over the eight weeks was higher in straw than in crate animals (F1,3=11.43; $p<0.05$) (figure 3.1).

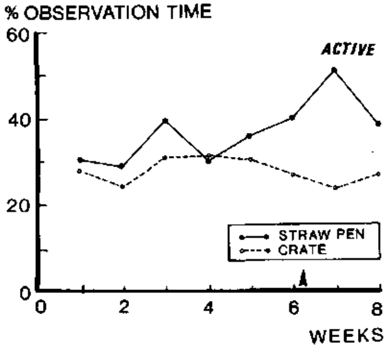


Fig. 3.1: Ordinate, percentage of total observation time piglets were observed active; Abscissa, age of the piglets in weeks; Arrow, time of weaning.

After week 5 the differences between both groups increased.

3.6.1.2 Discussion

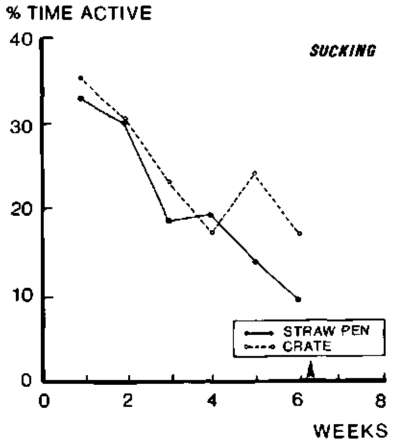
During the observation hours (09.00-14.00 and 16.00-17.00 hours) the activity of the piglets in the straw pen increased from week 1 to week 7 but decreased in week 8. The mean activity over the eight weeks was 37%. On the other hand, the piglets in the farrowing crate showed a fairly constant activity level over the eight weeks. Their mean activity over the eight weeks was 29.5%. However, measured over 24-hour periods in weeks 1, 2, 4, 6 and 8, the mean activity of the straw animals was 29.7 and of the crate animals 29.5% (see chapter 4).

Measurements over the same weeks during direct observations revealed an activity for straw animals of 33.8% and for crate animals 27.7%. These findings stress the importance of 24-hour observations in quantifying differences in behaviour due to housing systems. Statements about such differences in behaviour, based on a limited part of a 24-hour period and not corrected for potential deviations due to the chosen observation times, should be treated with caution (Troxler, 1979).

3.6.2.1 Sucking
Feeding and elimination

- Percentage time spent on sucking, feeding and elimination

One of the most dominant behaviours for the piglets is sucking (figure 3.2).



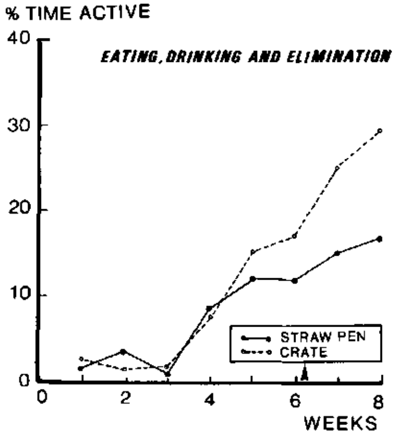


Fig. 3.2. Sucking

Fig. 3.3. Feeding and elimination

Ordinate, percentage of the total time active; Abscissa, age of the piglets in weeks; Arrow, time of weaning.

During the first two weeks approximately 30% of the activity of the piglets was devoted to this behaviour. No differences between housing systems were found in the mean percentages of time spent sucking over the six lactation weeks. Sucking decreased over the six lactation weeks in both housing systems ($F_{1,3}=30.33$; $p<0.05$). The differences found in week 5 and 6 are mainly due to longer sucking periods in the crate animals.

While sucking decreased with age of the piglets, the time spent on feeding, drinking and elimination increased (figure 3.3).

From week 4 onwards, eating formed the major part of the behavioural category feeding and elimination (straw animals 82%, crate animals 84.3%). Over the eight weeks no differences in time spent on feeding and elimination were found between housing systems. Feeding and elimination increased with age of the piglets ($F_{1,3}$=108.47; $p<0.01$). After weaning (week 7 and 8) the crate animals seemed to spend relatively more time on feeding and elimination than the straw animals.

The above mentioned behaviour mostly lasted longer than two minutes, and therefore the mean durations of these behaviour could not be calculated adequately.

3.6.2.2 Discussion

Essential behaviours like sucking, feeding and elimination were not influenced by the housing systems. In the first three weeks, a major part of the activity of the piglets was devoted to sucking. The time spent on sucking decreased over the six lactation weeks and after week 3, when the piglets received creep feed, eating became a dominant activity for the piglets. In the weeks 5 and 6 the crate animals spent more time on sucking than the straw animals. This was not only due to 1) longer nursings of the crate animals (see chapter 4) but also to 2) the relative low total activity of the crate animals. A similar reasoning holds for the differences in feeding time during week 5 to 8. In chapter 4 this will be discussed in more detail.

3.6.3.1 Exploration

- Percentage time spent on exploratory behaviours

Besides on behaviours that are essential for survival of the piglets, a lot of time was spent on behaviour directed to the environment. The piglets investigated (explored) their environment by sniffing, biting or rooting. Figure 3.4 shows the development of exploration over the eight weeks.

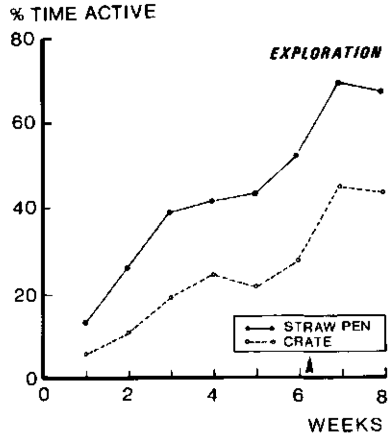


Fig. 3.4. Exploration
Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

Straw animals spent more time in exploration than crate animals (F1,3=37.67; p<0.01). In both housing systems, exploration increased with age of the piglets (F1,3=634.80; p<0.001).

Exploration consisted of several behaviours: sniffing object, sniffing substrate, rooting and chewing.

Crate animals showed more sniffing objects (figure 3.5) than straw animals (F1,3=15.58; p<0.05). In both housing systems this behaviour increased over the eight weeks (F1,3=55.66; p<0.01).

A large part of the total activity was spent sniffing substrate (figure 3.6). This behaviour increased from week 1 to 8 (F1,3=62.30; p<0.01). No differences between housing systems were found in the total time spent on this behaviour nor in the rate of development over the eight weeks.

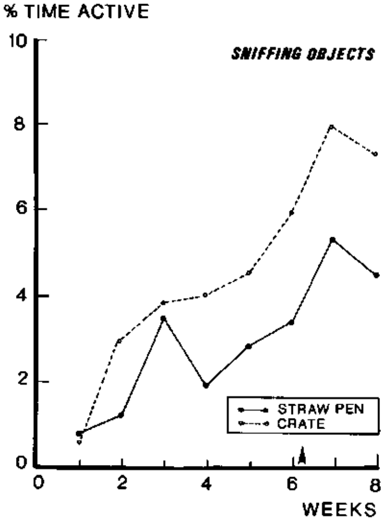


Fig. 3.5. Sniffing objects

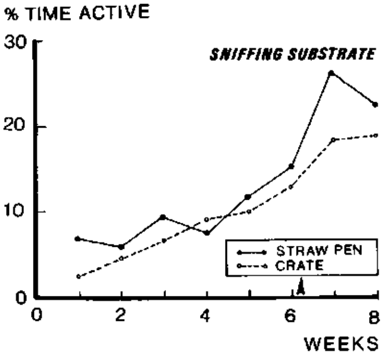


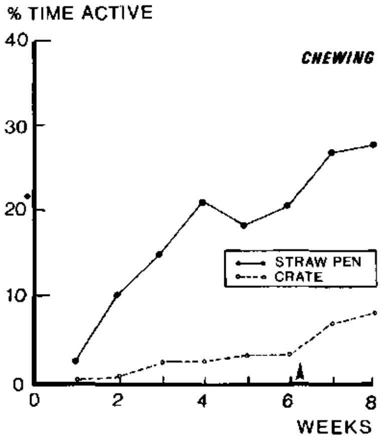
Fig. 3.6. Sniffing substrate

Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

Chewing appeared to be an important behaviour (figure 3.7), since after week 3 the piglets in the straw pen spent 20 to 30% of their activity chewing. The crate animals reached their maximum (8%) on week 8. The difference between housing systems in time spent on this behaviour was significant (F1,3=93.67; $p<0.01$). In both housing systems chewing increased from week 1 to week 8 (F1,3=132.64; $p<0.01$).

The straw piglets showed more rooting over the eight weeks than the crate piglets (F1,3=18.86; $p<0.05$) (figure 3.8).

In both housing systems rooting increased from week 1 to week 8 (F1,3=63.52; $p<0.01$). The straw piglets performed already much rooting in week 2, whereas the crate piglets showed substantial rooting only from week 3 onwards. After weaning, the differences between the housing systems seemed to disappear.



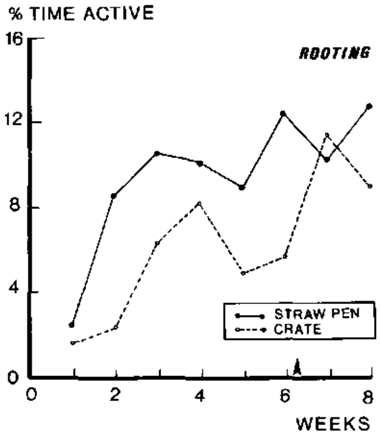


Fig. 3.7. Chewing

Fig. 3.8. Rooting

Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

- Mean duration of bouts of separate exploratory behaviours

Sniffing objects was performed longer by the crate piglets than by the straw piglets ($F1,3=13.37$; $p<0.05$).

No differences between the housing systems were found in mean duration of sniffing substrate and rooting. Straw piglets chewed for longer periods than the crate piglets ($F1,3=41.30$; $p<0.01$).

The mean durations over the eight weeks of bouts of separate exploratory behaviours in straw and crate piglets are shown in table 3.1.

Table 3.1. Mean durations of bouts of separate exploratory behaviours over eight weeks. The values presented are seconds.

	Sniffing objects	Sniffing substrate	Chewing	Rooting
Crate	5.72	4.77	4.87	6.08
Straw	4.21	4.34	9.91	5.32

The mean durations of exploratory behaviours either increased or did not change over the eight weeks (table 3.2).

Table 3.2. Spearman Rank correlation with age of the piglets

	Sniffing substrate	Sniffing objects	Chewing	Rooting
Crate	0.762^{*}	-0.131	0.786^{*}	0.667^{*}
Straw	0.905^{**}	0.429	0.595	0.320

* p=<0.05; ** p<0.01; n=8

3.6.3.2 Discussion

Exploration increased very rapidly over the first eight weeks of life in both housing systems. This behaviour obviously is very important for the piglets as indicated by its substantial contribution to the total activity of the piglets. Over the eight weeks, straw piglets spent on average 44% of their active time exploring, the crate piglets only 24.9% . In a comparison of the behaviour of straw and flatdeck piglets van Putten and Dammers (1976) found an average of 32.4% exploration (expressed as percentage of the total activity, and calculated from their original data) in straw piglets aged 4-6 weeks. Flatdeck piglets showed an average of only 16.2% exploration. These percentages are lower than the present ones for piglets of the same age, probably due to the fact that van Putten and Dammers based their findings on 24-hour observations including the dark period when exploration per activity time is low. The exploration-ratios for straw piglets/crate piglets and straw piglets/flatdeck piglets over the same weeks are remarkably similar in both studies, namely 1.83 and 2.0 respectively. This similarity is even more striking, since the observation methods were quite different. Van Putten and Dammers used a two-minute point-sampling method, while I used continuous observations of 2 minutes on individual piglets.

The development of exploration over the 8 weeks was the same for both housing systems; with increasing age the piglets spent more time exploring. Van Putten and Dammers also found an increase in exploration from week 4 to week 6 in straw piglets with an unrestrained sow. The piglets in the straw pen started to leave the nesting site frequently on day 4 or 5 and soon thereafter utilized the whole pen. Piglets of the European wild boar also leave the nesting site at this age, depending on ambient temperature, and start exploring their environment (Gundlach, 1968). The piglets in the farrowing crate were near the brood heater most of the time in the first week, but nevertheless used the whole farrowing crate area. Already during the first week straw piglets performed more exploration than crate piglets. Immediately after weaning there seemed to be an extra increase in exploration in both housing systems. This is probably induced by weaning as shown by Fraser (1978) and Schmidt and Adler (1981).

There were large differences for the separate exploratory behaviours between straw and crate piglets. The behaviour of straw piglets was more orientated towards the substrate than that of the crate piglets. Of course the substrate (straw) offered good opportunities for rooting and chewing. Chewing appeared to be a dominant behaviour in straw piglets. A lot of time was spent chewing on straw, especially when the piglets were lying down together before falling asleep. Bouts of chewing lasted for an average of 9.91 seconds in straw piglets. Crate piglets also showed chewing but only for a small proportion of their active time. Bouts of chewing were very short; an average 4.87 seconds. Crate piglets chewed pieces of the rubber mat and sometimes faeces of the sow, objects which were probably not the most preferred ones. Sniffing substrate did not differ between crate and straw piglets. Over the eight weeks, the piglets in both conditions spent increasingly more time sniffing the substrate. The average duration of such sniffing bouts was almost the same for crate and straw piglets. However, crate piglets paid more attention to objects above floor level as compared to the straw piglets. They were strongly attracted to the breast girth and the chain of the sow, on which they could chew. However, only one or two piglets at a time could manipulate this girth and chain. After weaning, the girth and chain were not removed from the crate, and in week 7 and 8, sometimes all piglets could be seen manipulating these objects simultaneously. Thus the girth and chain compensated at least partially for the lack of opportunity to chew on substrate.

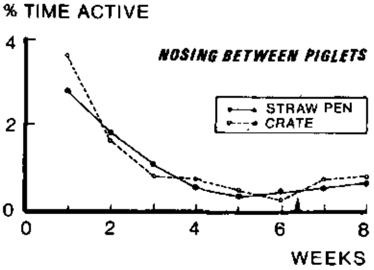
Crate piglets showed a delayed development of rooting. Straw piglets already performed much rooting in week 2, whereas the crate piglets did so from week 3 onwards. Taking this phase shift of one week into account, the development over time of rooting was almost the same for crate and straw piglets. After weaning, the difference in time spent rooting between straw and crate piglets was very small. Furthermore, the average duration of a rooting bout appeared to be very consistent over the entire eight weeks and did not differ between straw and crate piglets. Rooting is a very important behaviour for piglets, since it makes food in the soil accessible. Wood-Gush and Stolba (1983) reported that domesticated pigs held in a "pig park" of approximately 1.4 ha, spent 51% of their daytime rooting.

Apparently, the substrate in the straw pen gave the piglets enough stimulation to enhance rooting and maintain its performance at a high level. In the farrowing crate, with no suitable substrate to root in, the piglets still performed this species-specific behaviour. The reduced opportunity to perform chewing of and rooting in suitable substrate was probably an important cause of the intensive massaging or nibbling of penmates recorded for crate piglets.

3.6.4.1 Social behaviour between piglets

- Time spent on social behaviour between piglets

Nosing piglet is probably important for individual recognition between piglets.



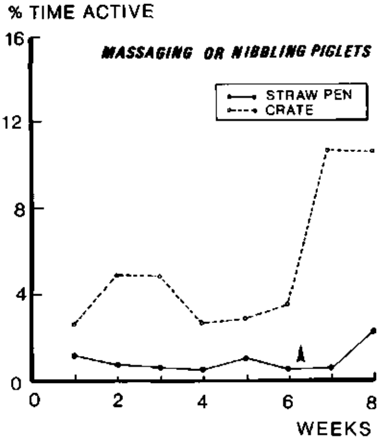


Fig. 3.9. Nosing between piglets

Fig. 3.10. Massaging or nibbling piglets

Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

The time spent on this behaviour and its development over the first eight weeks of life of the piglets was not influenced differently by the housing systems (figure 3.9). Nosing piglets decreased with age of the piglets (F1,3= 197.80; p<0.001).

Clear differences between housing systems were found for massaging and nibbling piglets (figure 3.10). This form of very intensive contact between littermates was seldom recorded for straw piglets, but it was very common for crate piglets, (F1,3=71.89; p<0.01), and increased sharply after weaning in crate piglets.

Mounting was rarely observed, 18 times in straw piglets and 9 times in crate piglets.

- Mean duration of bouts of separate social behaviours between piglets

There were no housing differences for the average duration of nosing piglet (table 3.3). In both housing systems, the average bout length decreased over the first six weeks (Spearman rank correlation crate piglets $r_s= -1$, $p<0.01$; straw piglets $r_s=-0.94$, $p<0.01$; $n=6$) (figure 3.11).

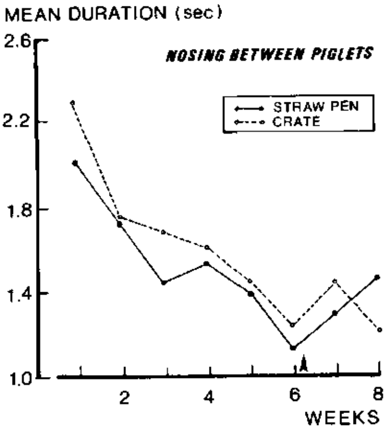


Fig. 3.11. Nosing between piglets.
Ordinate, mean durations of bouts in seconds; Abscissa, age of the piglets in weeks; Arrow, time of weaning.

After weaning, the average duration of nosing littermates increased in both housing systems (Wilcoxon matched pairs test, crate piglets $z=2.02$, $p<0.05$, $n=26$; straw piglets, $z=2.00$, $p=0.05$, $n=31$, two-tailed).

Table 3.3. Mean duration of bouts of social behaviour between piglets over eight weeks. The values are presented in seconds.

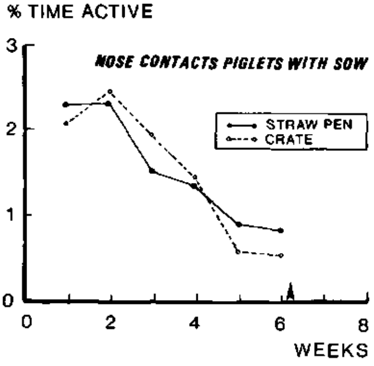
	Nosing between piglets	Massaging or nibbling piglets
Crate	1.58	6.44
Straw	1.52	4.01

Over the eight weeks, the average duration of massaging or nibbling piglets (table 3.3) was longer in crate piglets than in straw piglets ($F1,3=12.93$; $p<0.05$). Straw piglets also showed a fairly constant average duration over the same period (range: 3.39 - 4.39 seconds). The crate piglets varied with a weekly average between 4.91 and 7.63 seconds.

3.6.4.2 Social behaviour between piglets and sow

- Time spent on social behaviour between piglets and sow

Apart from activities at the udder, the piglets had little physical contact with the sow. In both housing systems, the time spent by piglets in nosing the sow was similar (figure 3.12).



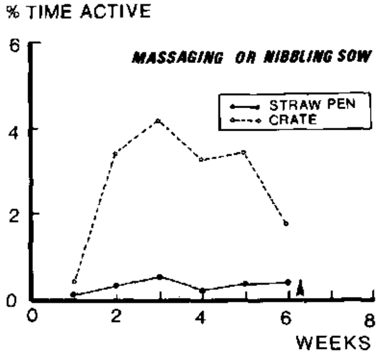


Fig. 3.12. Nosing sow   Fig. 3.13. Massaging or nibbling sow

Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

Nosing the sow decreased as lactation progressed ($F1,3=152.83$; $p<0.01$).

Massaging or nibbling the sow was most frequent in crate piglets ($F1,3=55.68$; $p<0.01$). Straw piglets on the average never spent more than 1% of their active time on this behaviour (figure 3.13).

Manipulating the udder of the sow was performed more by the crate piglets than by the straw ones ($F1,3=21.37$; $p<0.05$). However, in both housing systems a large proportion of active time was devoted to this behaviour (figure 3.14).

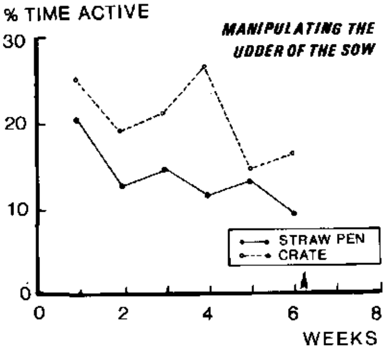


Fig. 3.14. Manipulating the udder of the sow
Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

The crate piglets spent on the average 20.5% and the straw piglets 13.8% of their active time on this behaviour.

- Mean duration of bouts of separate social behaviours between piglet and sow

No differences between housing systems were found in the average duration of nosing the sow (table 3.4). The mean duration of this behaviour decreased over the lactation period, although this decrease was only significant for the crate piglets (figure 3.15).
(Spearman rank correlations of nosing the sow with age of the piglets: Crate piglets $r_s=-0.83$, $p=0.05$; straw piglets $r_s=-0.61$, NS.)

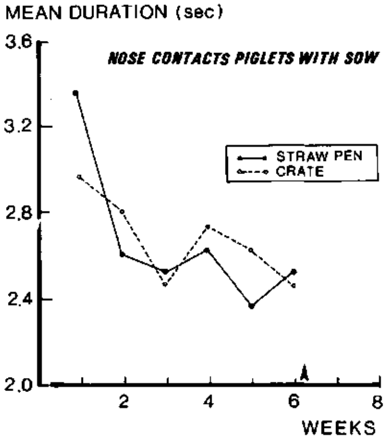


Fig. 3.15. Nosing between piglets and sow.
Ordinate, mean duration of bouts in seconds; Abscissa, age of piglets in weeks; Arrow, time of weaning.

Table 3.4 shows the average duration in seconds over six weeks of separate bouts of nosing sow, massaging nibbling sow and manipulating the udder.

Table 3.4. Mean duration of bouts of separate social behaviours between piglets and sow and manipulating the udder of the sow over the first six weeks in seconds.

	Nosing sow	Massaging or nibbling sow	Manipulating the udder
Crate	2.69	9.14	29.28
Straw	2.75	3.59	23.39

The mean duration of massaging or nibbling sow was always longer for the crate piglets than for the straw piglets ($F_{1,3}=16.40$; $p<0.05$). In crate piglets this behaviour showed an increase in mean duration from week 1 to week 4. Over week 4 to week 6 the mean duration was stable (figure 3.16). In straw piglets, the mean duration of massaging or nibbling the sow was fairly constant.

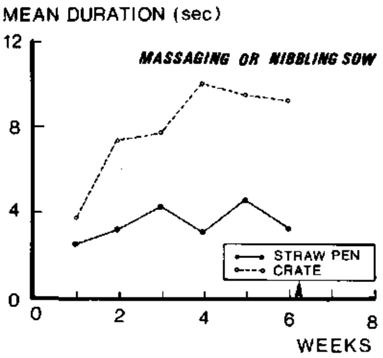


Fig. 3.16. Massaging or nibbling the sow

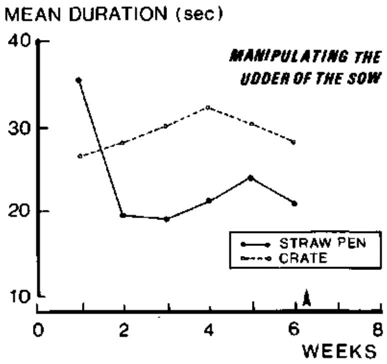


Fig. 3.17. Manipulating the udder of the sow

Ordinate, mean durations of bouts in seconds; Abscissa, age of the piglets in weeks; Arrow, time of weaning.

Manipulating the udder could last more than half a minute (figure 3.17). No significant difference was found between straw and crate piglets in this behaviour. In crate piglets its mean duration was always longer than 25 seconds, while in straw piglets, except for week 1, it was always shorter than 25 seconds.

3.6.4.3 Discussion

No differences between both housing systems were found in time spent in, or the mean duration of nosing piglets. In view of the difference in floor space, it was expected to find more nosing piglets in the farrowing crate; a smaller floor space should enhance the chance of encounters. Although pigs have good visual capacities (Graf, 1976), smell appears to dominate in individual recognition. Investigations by Ewbank, Meese and Cox (1974) make this plausible. Blinding pigs by means of opaque contact lenses did not influence the establishment of a hierarchy in 8 to 15-week old unfamiliar pigs; as under normal conditions, within 48 hours the hierarchy was established, (Meese and Ewbank, 1973). When the heads of the pigs were covered with hoods, unfamiliar pigs were not able to establish a hierarchy. After removing the hoods the pigs started to fight and to nose each other intensively. Smell seemed to play an important role in individual recognition. After adapting the hoods to allow vision, pigs were able to establish a hierarchy within a few days. Thus smell and vision, and probably also sound (Klingholz und Meynhardt, 1979) all play a role in individual recognition in pigs. This fits the present findings. During the first two weeks the piglets spent relatively much time nosing each other, and the mean duration of nosing bouts was long. Both the time spent nosing as well as the mean duration of nosing bouts decreased rapidly with increasing age of the piglets. Apparently, the piglets came to know each other with time. However, since it is unlikely that piglets within a group recognize a littermate at distance on smell only, it is to be expected that with increasing age (i.e. increasing familiarity) piglets recognize group members also by sight and sound. This may explain why no difference for nosing was found between housing systems.

In addition, no differences were found in time spent on, and mean duration of, nosing sow. These contacts between piglets and sow mostly occurred around nursing periods. Because the nursing frequency decreased over the lactation period, nose contacts between piglets and sow also decreased. The nose contacts with the sow, which were always longer than those with littermates, are important for the piglets. Within one or two days after farrowing the sow recognizes her piglets by smell and will attack unfamiliar piglets (Meese and Baldwin, 1975). In free moving domesticated or wild sows that have a nest, intensive contact between sow and piglets is ensured, since the piglets do not leave the nest before four or five days after birth. In tethered sows almost all interactions with the sow are initiated by the piglets and these are determined only by the high frequency of nursing in the first week. One should, therefore, expect more nosing sow in the straw pen. However, nosing sow was only recorded if a piglet took the initiative to nose the sow and not the other way around. These nose contacts with the sow were apparently not influenced by the housing system but rather depended on the nursing frequency. In the present study, the frequency was the same in both housing systems (see chapter 4). Indeed, Metz and Oosterlee (1981) using similar housing systems also found no differences in nosing sow initiated by the piglets. However, they reported more nosing sow initiated by the sow in the straw pen.

Crate piglets spent more time on massaging or nibbling littermates or sow than the straw piglets. In the straw piglets no change was found over the eight weeks, as was reported also by Van Putten and Dammers (1976), Fraser (1978) and Schmidt and Adler (1981). The mean duration of these behaviours was always longer in crate piglets. Massaging or nibbling littermates or sow was mostly seen during transitions from activity to resting when some piglets were already lying down and others still exploring. The transition period from being active to rest of the entire litter could last several minutes in crate piglets; this contrasts with straw piglets which usually lay down simultaneously and started chewing straw. As mentioned before, the crate offered few suitable objects to manipulate, and only a limited number of piglets could do so simultaneously. In the second week, the crate piglets developed a pattern in which some piglets manipulated the favourite object, while the others rested. In that situation exploring piglets often encountered lying littermates and started massaging or nibbling them; mostly these lying piglets rose up after being manipulated. This often caused a lot of disturbance in the farrowing crate (see also chapter 4). After the second week, crate piglets spent approximately the same amount of time massaging and nibbling littermates as massaging or nibbling sow. The sow appeared to be more tolerant to massaging or nibbling by her piglets, since the mean duration of this behaviour was longer than the duration of massaging or nibbling piglets. Straw piglets spent little time of all this massaging or nibbling. A similar result was reported for straw piglets by Van Putten and Dammers (1976), Fraser (1978), and Schmidt and Adler (1981).

Very high scores were found on the behaviour manipulating the udder. Because crate piglets showed more post sucking massage and did not simultaneously start or end a nursing period as did the straw piglets, the scores for this behaviour were rather high in the crate group. The mean duration of manipulating the udder was always longer for crate piglets than for straw piglets, except in week 1. The high score for the straw piglets in the first week may be explained by the fact that sow and piglets shared the same nesting site. This meant that the udder of the sow was always within reach of the piglets and could be manipulated very easily. In the farrowing crate, the piglets were mostly lying under the heater well away from the sow. In week 4, massaging and nibbling littermates and sow decreased for crate piglets. This may be due to the presence of the creep feeder, in which the crate piglets often rooted without eating. Therefore, the creep feeder presented an enrichment of the environment that directly reduced massaging and nibbling littermates and sow. This is one argument that suggests that massaging or nibbling littermates or sow is a redirected exploratory behaviour, as previously stated by Van Putten and Dammers (1976). Another argument is that after weaning this behaviour strongly increased in the crate piglets but not in the straw piglets. An important source of exploration, the sow, had disappeared from the farrowing crate. The difference between straw and crate piglets in the time spent massaging and nibbling littermates and sow, and manipulating the udder, partly compensated for the difference in time spent on exploration between straw and crate piglets. There are therefore, good reasons to believe that there exists a norm or 'Sollwert' for exploration in piglets (Wiepkema, 1981). At least in the impoverished environment there was no change in the development of exploration over the first eight weeks of life of crate piglets as compared with straw piglets. Furthermore the lack of suitable substrate to chew on or to root in did not fully suppress this behaviour (in the case of rooting, the development was only delayed) and the piglets readily accepted alternatives such as littermates and sow. However, one should keep in mind that by comparing enriched and impoverished environments, we do not prove a causal relationship between exploration on the one hand, and massaging or nibbling littermates or sow on the other. Experiments in which suitable substrate is offered and taken away successively might give a more decisive answer (see chapter 6).

3.6.5.1 Locomotion, Standing and Sitting, Playful activities and Comfort behaviour

- Time spent on locomotion, and standing and sitting

Although the straw piglets had much more floor space available than the crate piglets, no differences in locomotion were found (figure 3.18).

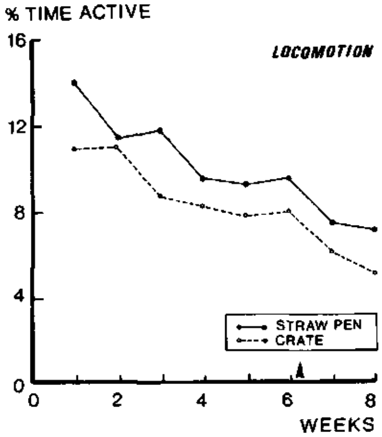


Fig. 3.18. Locomotion

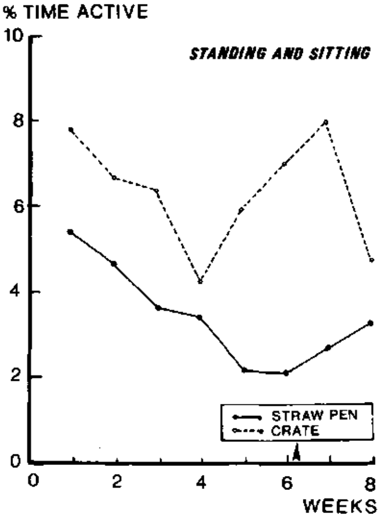


Fig. 3.19. Standing and sitting

Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

In both housing systems locomotion decreased over the eight weeks ($F1,3=103.75$; $p<0.01$).

The time spent on standing and sitting (figure 3.19) was always higher in crate piglets than in straw piglets ($F1,3=21.43$; $p<0.05$).

- Mean duration of bouts of locomotion, and standing and sitting

The mean duration of bouts of locomotion also did not differ between straw and crate piglets and was very constant over the eight weeks (table 3.5).

Table 3.5. Mean duration of bouts of locomotion, and standing and sitting over eight weeks in seconds.

	Locomotion	Standing and sitting
Crate	2.84	3.37
Straw	2.93	2.48

The mean duration of bouts of standing and sitting was longer in crate piglets than in straw piglets ($F_{1,3}=12.63$; $p<0.05$).

- Time spent on playful activities

Scampering (included under locomotion) is considered to be a playful activity. Together with shaking object, it was added to the playful activity score. These were the only activities for which unambiguously could be decided whether they were play or not. This contrasted with agonistic encounters, in which play easily merged into aggression and vica versa. Only after an interaction had occurred one could decide whether it had been play or not.

With respect to playful activities, no significant differences were found between straw and crate piglets. Straw piglets spent 1.4% of their active time on playful activities, while crate piglets did so for 0.8%, as calculated over the entire eight weeks.

- Time spent on comfort behaviour

No differences were found for comfort behaviour between the housing systems. Comfort behaviour decreased with age of the piglets in both systems ($F_{1,3}=18.69$; $p<0.05$) (figure 3.21).

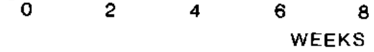


Fig. 3.21. Comfort behaviour
Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

3.6.5.2 Discussion

Moving was the behaviour scored most frequently under locomotion. This behaviour took up locomotion almost completely. Moving was rather similar in straw and crate piglets. The mean duration of bouts of locomotion was the same for straw and crate piglets, 2.9 and 2.8 seconds respectively. The crate piglets often performed sniffing substrate and rooting while standing whereas straw piglets were more often moving while sniffing substrate and rooting.

Standing and sitting were observed more in crate than in straw piglets. In both groups of piglets, standing and sitting decreased from week 1 to week 4 . In week 5 and week 6, standing and sitting increased, however, in crate piglets. Presumably one of the reasons for this was the decreasing floor space per piglet, since they were growing fast. The lying area, the rubber mat, became too small to offer a comfortable resting place to all the piglets. Much disturbance resultated from piglets climbing over littermates in search for a good resting place. This, in turn, often led to standing or sitting of piglets already lying and sometimes also to short agonistic interactions. This source of disturbance adds to that induced by massaging or nibbling littermates, as already mentioned. In week 7, directly after weaning, standing and sitting continued to increase. Although removing the sow afforded extra lying space for the piglets, they continued to use their part of the rubber mat as a lying site. This implies that the increase in standing and sitting from week 6 to week 7 was due to the increase in massaging or nibbling of littermates in the same period. However, in week 8 the piglets in the farrowing crate used the entire rubber mat. This reduced the amount of standing and sitting due to disturbances as induced by littermates in search for a good resting place. However, during week 8, standing and sitting were lower than was to be expected on the basis of the high level of massaging or nibbling piglets. One possible explanation might be that after weaning the crate piglets increasingly reacted to massaging or nibbling with ramming or pushing rather than with standing and sitting (see page 35).

Playful activities. Play was difficult to define and almost impossible to score reliably during direct observations. Especially during interactions between piglets, play and fight gradually merged. There is some controversy over the relevance of play in mammals. According to Smith (1982) "....the primary function of animal play is to provide indirect practice for certain skills when direct or optimal practice is unlikely or unsafe". Other authors approach play as immature and incomplete adult behaviour that has direct effects and a function during development (Lazor and Bechhorn, 1974). However, both theories lead to the same conclusion, namely that early social experience is essential for normal social behaviour later in life.

The definition of playful activities used in this study excludes social play. Social play, especially that part that often is called "play-fighting" was scored under agonistic behaviour, since it contained most of the agonistic elements found in adult pigs.

One of the arguments to use the term "play-fighting" is that this agonistic behaviour is not yet structured in the same way as in adult pigs. However, the effects of "play-fighting" might be the same as fighting, and can also have its function in establishing social relations between piglets.

In chapter 7 the development of agonistic behaviour is described by approaching "play-fighting" as immature agonistic behaviour.

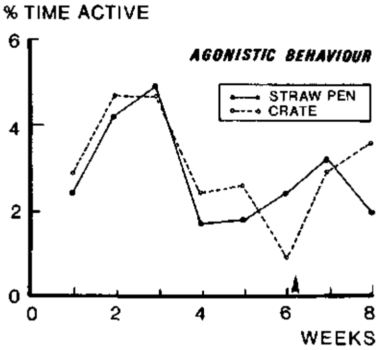
Comfort behaviour. Straw piglets showed a lot of comfort behaviour in week 1. This was mainly due to a high level of rubbing, which may be caused by the prickling of straw. Although the crate piglets were dirtier than the straw piglets, they did not perform more scratching or rubbing.

3.6.6.1 Agonistic behaviour

- Time spent on agonistic behaviour

In both housing systems the piglets spent the same proportion of active time on agonistic behaviour (figure 3.22).

Agonistic behaviour increased from week 1 to week 2; it did not change much in week 3 and decreased again in week 4. In both housing systems agonistic behaviour seemed to increase immediately after weaning. Agonistic behaviour was divided into fighting and ramming or pushing. No differences were found between straw and crate piglets in the time spent fighting over the eight weeks; fighting (figure 3.23) comprised most of the total agonistic behaviour.



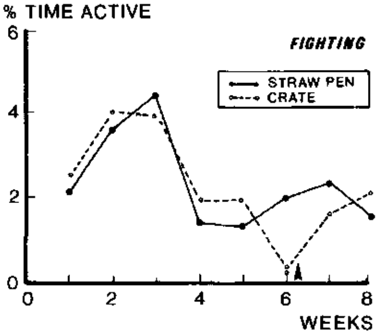


Fig. 3.22. Agonistic behaviour Fig. 3.23. Fighting
Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

After the second week the crate piglets tended to perform more ramming or pushing than the straw piglets (figure 3.24).

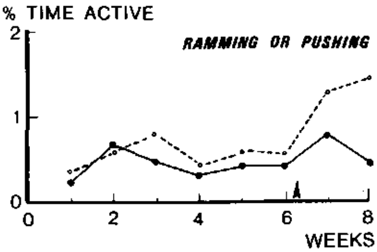


Fig. 3.24. Ramming or pushing
Ordinate, percentage of total time active; Abscissa, age of piglets in weeks; Arrow, time of weaning.

- The mean duration of bouts of separate agonistic behaviours

There were no differences in the average duration of bouts of fighting and bouts of ramming or pushing between straw and crate piglets during the eight weeks (table 3.6).

Table 3.6. The mean duration of bouts of separate agonistic behaviours over the eight weeks in seconds.

	Fighting	Ramming or pushing
Crate	4.92	1.00
Straw	4.47	0.87

The average duration of fighting bouts decreased over the eight weeks in both housing systems (Spearman rank correlation; crate piglets, $r_s = -0.93$, $p < 0.01$; straw, $r_s = -0.83$, $p = 0.01$).

3.6.6.2 Discussion

No differences were found in the amount of agonistic behaviour performed by straw and crate piglets during the first eight weeks of life. According to Gundlach (1968), who describes the development of behaviour in the European wild boar, the agonistic behaviour of piglets in their first week of life is not yet complete and very variable. In the second week of life, the number of agonistic elements increases and by the fourth week the pattern of agonistic behaviour is very much the same as that of adult pigs. Threat behaviour is clearly present from week 4 onwards. Although the present ethogram of agonistic behaviour was rather limited, our findings fit the description of Gundlach. In the first week of this experiment, agonistic behaviour was seldom observed. In the second and third weeks, agonistic behaviour increased. In week 4, however, very little agonistic behaviour was observed. Presumably in the fourth week the repertoire of agonistic behaviour was complete and physical interactions could be mostly avoided by threat and submission. Directly after weaning there seemed to be an increase in agonistic behaviour in both housing systems. The piglets seemed to be irritated and easily started agonistic interactions. This was also found after early weaning in week 3 by Fraser (1978) and Schmidt and Adler (1981). Weaning at an age of six weeks also induced an increase in agonistic behaviour. This increase, then, was not so much due to age factors as to the weaning as such. After weaning, many agonistic interactions occurred at the creep feeder. The weaned piglets ate for longer periods and, because of the limited number of feeding places, their was much pushing which easily led to an agonistic interaction. From week 3 onwards, crate piglets showed somewhat more frequent and longer bouts of ramming or pushing. In the farrowing crate it was sometimes very difficult for the piglets to avoid an interaction or to withdraw after fighting. Therefore, it might not always have been clear for the opponent whether the other piglet had given up. This often led to head knocks to the flanks or hindquarters of the piglet that tried to escape. During these observations it became apparent, that by using a limited ethogram, essential differences in agonistic behaviour between the piglets in the two housing systems were missed. To what extend a limited floor area influences the way of fighting will be discussed in chapter 7.

3.7 General conclusions

An impoverished environment does not influence essential behaviours, like sucking and feeding of piglets during the first eight weeks of life.

Such an environment, however, reduces exploratory behaviours directed towards the inanimate environment, and enhances those directed towards littermates or sow.

Exploratory behaviours directed towards littermates contribute to the high restlessness found in piglets living in an impoverished environment.

CHAPTER 4

4. DEVELOPMENT OF DIURNAL ACTIVITY IN PIGS FROM BIRTH TILL WEEK 24

4.1 Introduction

The diurnal activity of pigs under different housing conditions has been described by several authors (Deckert, 1968; Gunster, 1972; Marx, 1973; Achebe, 1975; Schrenk, 1981; Bergenthal-Menzel-Severing, 1982). However, these observations were made over a limited period of the life of the pigs, and only few behaviours were scored.

In this chapter the development of the diurnal activity of pigs from birth until the time of slaughter will be described. During the first eight weeks two different housing conditions were used (either a large straw pen or a farrowing crate, see chapter 2); during fattening (week 9 to week 24) all pigs stayed in fattening pens with fully slatted concrete floor. The aim of this experiment was to investigate the effect of different housing systems on diurnal activities of piglets and pigs.

Synchrony of activity within a group of pigs might indicate that the housing system reconciles more or less the behavioural needs of the pigs (Burè, 1981). In this study a measure of synchrony of activity is defined; also, the development of this synchrony over time and its relation with the housing condition is described.

4.2 Material and Methods

During the nursing, growing and fattening periods several 24-hour video registrations were made. The recordings were made on a Sony U-matic time-lapse recorder TVO-9000. The speed of the recorder was set at 1:48 which made continuous recording possible for about 40 hours. The camera (Sony AVC-3250CE) was very light-sensitive which enabled recording under poor lighting conditions. By means of a date-time generator (FOR.A Video Timer VTG-33) date and time were written in the video picture. The recordings were worked out in three ways.

Method A: Time sampling at 10-minute intervals

Every 10th minute the tape was stopped and the number of animals performing certain behaviours in the next one minute was noted down. Each animal could perform only one behaviour: its first one observed during that minute.

Method B: Time sampling at 1-minute intervals

Start and finish of each nursing period were recorded with a precision of one minute.

Method C: Time sampling at 3-minute intervals

Every third minute the number of animals active at the feeder was noted down.

Tables 4.1 to 4.3 give the number of 24-hour recordings per housing condition in relation to the method of sampling used.

Table 4.1. Ten-minute sampling

Week	1	2	4	6	8	11	14	17	20	23
Straw	3	3	3	3	3	4	4	4	4	4
Crate	1	3	3	3	3	4	4	4	4	4

Table 4.2. One-minute sampling

Day	1+2	7	14	28	42
Straw	5	3	4	4	4
Crate	3	4	4	4	4

Table 4.3. Three-minute sampling

Week	4	6	8	11	14	17	20	23
Straw	2	2	3	4	4	4	3	4
Crate	3	3	3	4	4	4	3	4

4.2.1 Method A: Time sampling per ten minutes

The ethogram:

Resting	(Rest)	Lying on the side or belly without performing any other behaviour.
Exploration	(Expl)	Sniffing, touching, rooting, biting or chewing substrate or objects in the pen.
Snoutwork pigs	(Snpig)	Nibbling, massaging, rooting or sucking penmates (including the sow, but excluding sucking).

Standing/ sitting	(Sdsit)	Standing and sitting without performing any other behaviour. Including transitions from lying to sitting and standing and vice versa.
Feeding/ drinking/eliminating	(FDE)	Feeding, drinking, defeacating and urinating.
Sucking	(Suck)	Sucking was scored when at least 5 piglets were active at the udder and the sow was in nursing position (lying down with fully exposed udder).
Locomotion	(Loc)	Any displacement without performing any other mentioned behaviour.
Fighting	(Fight)	All agonistic or "playfull" interactions between littermates.
Others	(Oth)	All not mentioned behaviours or ambiguous situations.
Active or Activity	(Act)	The difference between the total number of animals in the pen and the number of animals resting.

Using the 10-minute time sampling, 144 samples per 24 hours were obtained. Per two-hour period these samples were summed; the behaviour scores were expressed as percentage of the summed samplings (12 times the number of animals in the pen). According to Stempel (1977, cited in Schrenk, 1981), a two hour grating offers the clearest picture of diurnal activity in pigs. To test for different levels of behaviour between the light and dark periods the frequencies of behaviours of the litters were summed per rearing condition. These frequencies were compared with the expectation of equal frequencies for light and dark periods with a X^2 test (Siegel, 1956). Differences between rearing conditions were also tested with a X^2 test. Because in week 1 we obtained only one video recording in the crate condition, the frequencies of behaviours in the straw condition were divided by three.

4.2.1.1 Measurement of synchrony of activity

For every 10-minute sampling the number of animals active was noted down. During the first eight weeks nine states of activity could be distinguished: at the one end of the scale none of the animals was active, at the other end of the scale all were animals active. Of course maximal synchrony is present when all animals are either resting or active. Because we were only interested in the synchrony of active behaviour we concentrated on eight classes of activity, leaving out class 0 (all animals resting). The mean frequencies of occurrence of the eight classes of activity were calculated per week for the two rearing conditions separately. As a measure of synchrony of activity the frequency of class 8 (all animals active) was devided by the sum of the frequency of all classes possible (minus class 0). This means that the synchrony of activity is 1 when all animals are active over a given time interval and 0 when they are not. This stringent definition needs some comment. Using the definition of synchrony of activity we might run into problems when the frequency distribution over the eight classes differs greatly for straw and crate animals. For instance, if in crate animals class 7 would be very high and in straw animals low in comparison with class 8, straw animals should show a high synchrony of activity and crate animals a low one. It is plausible, however, to assume that with seven out of eight animals often active at the same time the litter also shows a high level of synchrony in activity. It appeared that the sampling distribution over the eight classes was almost similar for crate and straw animals respectively and that the frequencies of the classes 5, 6 and 7 were low in both straw and crate animals.

Since the synchrony measure could vary between 0 and 1, the problem arises at which level of this measure is assumed to indicate synchrony in activity. If the occurrence of the eight classes were merely due to chance a score of 12.5% per class would be expected. We decided that synchrony of activity occurred as soon as the frequency of class 8 is higher than 12.5%; this equals a synchrony measure of 0.125. In the fattening period there were six animals in a pen and of course only six classes of activity. Thus, during the fattening period we assumed synchrony if the measure was more than 0.167.

The number of animals per class was calculated per week and per rearing condition (frequency of the class times number of the class). Moreover, per class we calculated the percentage of animals that performed snoutwork pig.

4.2.2 Method B: Time sampling per one minute

Definition of a nursing period and of the intervals between them.

Nursing. Scoring of nursing started when at least five piglets were active at the udder of the sow at the same time and the sow was in nursing position (lying on the side with the udder fully exposed). A nursing score ended when at least five piglets had left the udder, or had fallen asleep at the udder, or when the sow ended a nursing period by standing up or shifting on the belly.

Nursing interval. A nursing interval was the time between the end of a nursing period and the start of the next nursing period.

From every nursing period it was noted down whether it was ended by the sow or by the piglets.

4.2.3 Method C: Time sampling per three minutes

Every third minute the number of animals active at the feeder was recorded. The total number of these animals was summed over two hours and expressed as the number of animals active at the feeder per hour and per pen.

Definition of a feeding period and feeding period duration.

A feeding period was scored as such if at least four animals were feeding. Its minimal duration is, of course, three minutes (the sampling accuracy). The total time of one feeder occupation was defined as a feeding period duration (a multiple of three minutes).

4.3 Results

4.3.1 Method A: Time sampling per ten minutes

Figure 4.1 gives an overview of the distribution of different behaviours over a 24-hour period over the weeks measured. Since there were no large differences in these distributions during the weeks 4 and 6, 14 and 17 and 20 and 23, the data from the weeks were combined. Remember that the weeks equal the age of the animals.

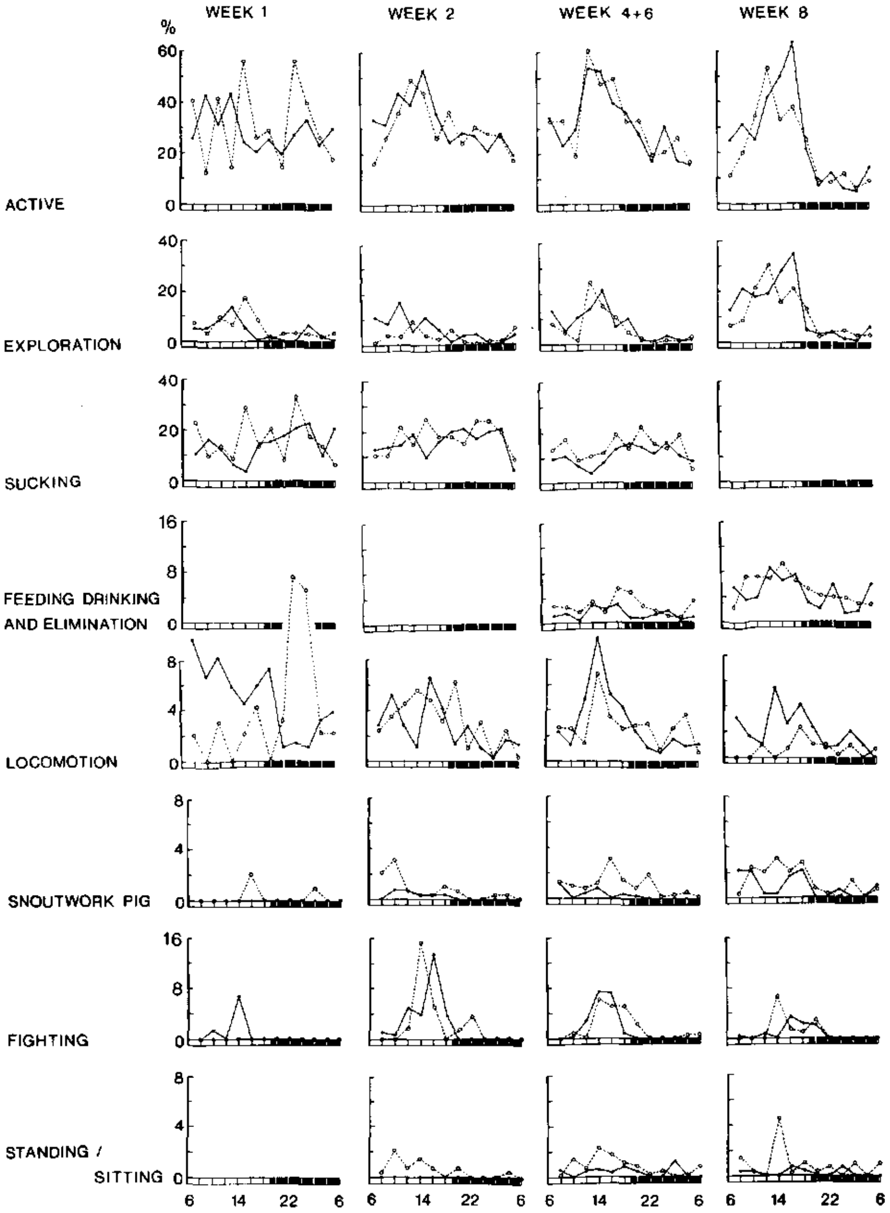
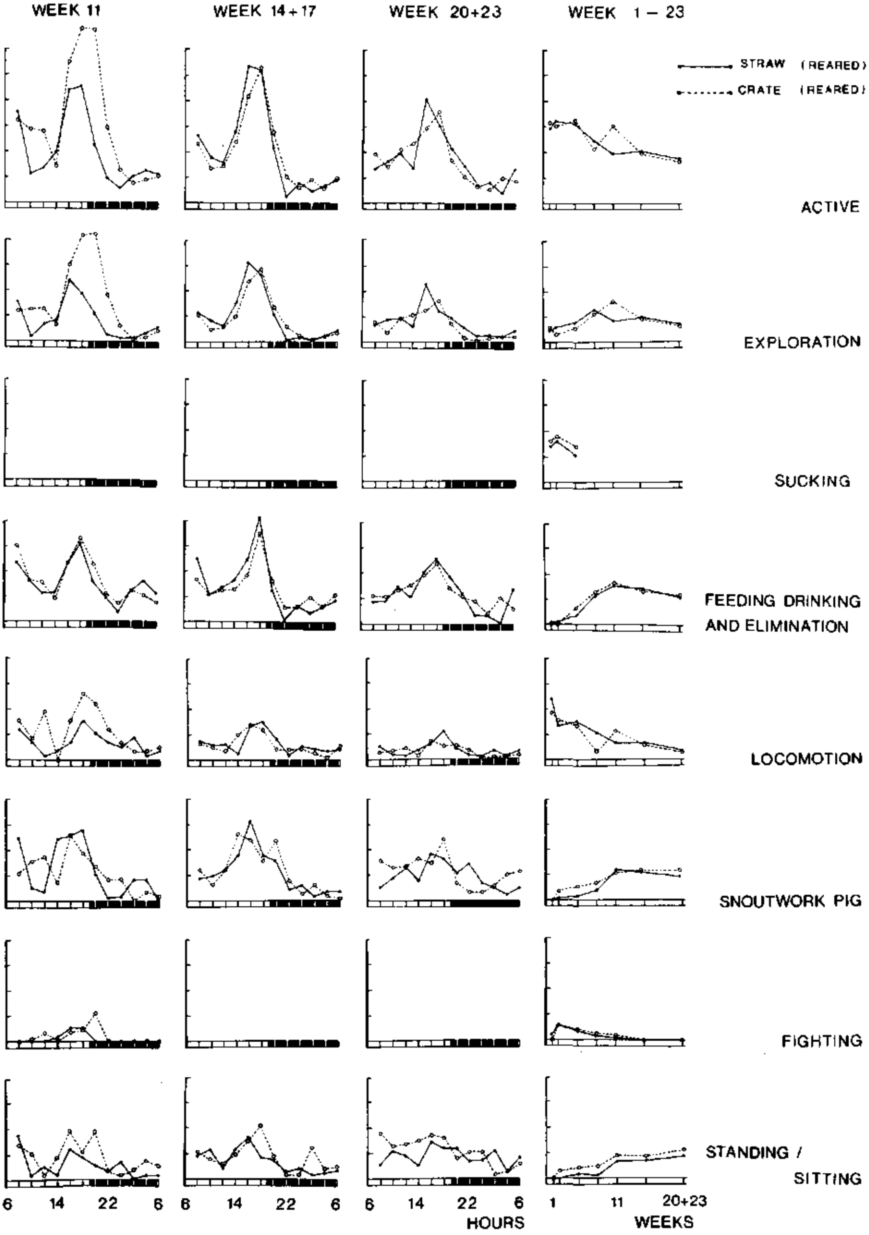


Fig. 4.1. Columns 1 to 7 show the percentages of time spent on the various behaviours during the 24-hour period. Column 8 shows the percentage of time of a 24-hour period spent on the various behaviours from week 1 to week 20+23. Note that the vertical scale varies.


WEEK 11
WEEK 14+17
WEEK 20+23
WEEK 1 – 23
STRAW (REARED)
CRATE (REARED)
ACTIVE
EXPLORATION
SUCKING
FEEDING DRINKING AND ELIMINATION
LOCOMOTION
SNOUTWORK PIG
FIGHTING
STANDING / SITTING
6 14 22 6
6 14 22 6
6 14 22 6
HOURS
1 11 20+23
WEEKS

4.3.1.1 The distribution of the behaviours over a 24 hour period

Clear differences were found in time spent on certain behaviours during the light and dark periods. Table 4.4 shows these differences over the weeks.

Table 4.4. Differences between light and dark scores were tested by x^2.

Weeks	1		2		4+6		8		11		14+17		20+23	
Straw/ Crate	S	C	S	C	S	C	S	C	S	C	S	C	S	C
Act	NS	NS	***	***	***	***	***	***	***	***	***	***	***	***
Expl	***	***	***	*	***	***	***	***	***	***	***	***	***	***
Suck	***	NS	**	NS	***	NS	#	#	#	#	#	#	#	#
FED	/	/	/	/	***	NS	***	***	***	***	***	***	***	***
Loc	***	***	***	***	***	**	***	NS	NS	*	***	***	*	*
SNpig	#	/	/	***	***	***	***	***	***	***	***	***	**	*
Fight	***	#	***	**	***	***	***	***	***	NS	/	/	#	/
SDsit	#	#	/	*	NS	***	/	*	***	NS	***	***	NS	***

* $p<0.05$; ** $p<0.01$; *** $p<0.001$; / Ei(expected value) <5; # empty.

In the first week there were no differences between light and dark scores on activity in both housing conditions. From week 2 onwards both the straw and crate animals were more active in the light than in the dark period. With the exception of sucking all behaviours from their first appearance on were more often scored in the light period than in the dark period. In both housing systems sucking was more often scored in the dark than in the light period. However, for this behaviour significance was reached only by the straw animals. From week 11 to week 20 to 23 two maxima in active behaviour were found in both straw and crate animals. These occurred at the beginning and at the end of the light period. In straw animals and, less clearly, also in crate animals two maxima of activity were already appearing at week 2. The maximum at the end of the light period was always the highest of the two. Similar observations were reported by Schrenk (1981) for piglets on straw with the sow. In week 8 the crate animals showed no maximum at the start of the light period but a gradually increase in activity till 14.00 - 16.00 hour.

From week 4 to 6 to week 20 to 23 the distribution of exploration over a 24 hour period was similar to that of activity. This is, of course, not surprising, since the animals spent much of the time exploring; after weaning (at the end of week 6) almost half of the active time was devoted to exploring. From week 11 to week 20 to 23 high levels of Feeding, Drinking and Elimination at the start and the end of the light period were observed. In straw animals this pattern appeared already in week 8. Feeding was always scored more often at the end of the light period than at its start. For the behaviours Standing and Sitting, Snoutwork pig and Fighting the relation with the activity score was not as clear. Fighting was almost exclusively scored in the afternoon. Standing and Sitting and Snoutwork pig were comparatively often scored in the dark period, particulary during the fattening period (week 11 to 20 to 23).

4.3.1.2. The development of the behaviours over the weeks

The percentage of the time spent on the different behaviours over the weeks is shown in the last column of figure 4.1. In table 4.5 changes of these percentages (except for sucking) over time are expressed as rank correlates.

Table 4.5. Spearman rank correlations between age and behaviour of the animals (for fighting, week 1 was excluded).

	Act	Exp	SNpig	Sdsit	FDE	Loc	Fight
Crate	-0.750^{*}	0.500	1.000^{**}	0.963^{**}	0.750^{*}	-0.893^{**}	-0.943^{**}
Straw	-0.857^{**}	0.678	0.839^{*}	0.955^{**}	0.821^{*}	-0.964^{**}	-0.957^{**}

* $p<0.05$, ** $p<0.01$.

Both in straw and crate animals activity decreased with age. In the lactation weeks almost 50% of the activity of the piglets was spent on sucking. With increasing age exploration and Feeding, Drinking and Elimination became more and more the dominant activities of the animals. Exploration increased from week 1 to week 8 in straw animals and to week 11 in crate animals. During the fattening period in straw animals exploration did not change anymore whereas in crate animals it decreased. The high level of activity in crate animals in week 11 was almost completely due to exploration. Standing and Sitting, Snoutwork pig and Feeding, Drinking and Elimination increased with age but the changes during the fattening period were small. In crate and straw animals fighting increased from week 1 to week 2, but thereafter decreased. Locomotion decreased with age in both the straw and crate animals.

Clear differences in time spent on the various behaviours were mainly found during the first eight weeks.

Differences between rearing conditions were tested for three age periods: 1) sucking and growing period, in which the two different housing conditions were in effect; 2) week 11, the start of the fattening period, in which both groups of pigs were changed to the same housing condition; and 3) week 14 - 23, the fattening period, in which long term effects of the two different rearing conditions might be revealed.

Table 4.6 shows the X^2-values for the differences between rearing conditions in the three age periods.

Table 4.6. X^2-values of differences between rearing conditions observed in the frequencies of behaviours in three age periods.

	Sucking and growing period		Week 11 start fattening		Week 14 - 23 fattening	
	X^2	higher	X^2	higher	X^2	higher
Act	1.90	S	84.05^{***}	C	0.15	S
Expl	16.70^{***}	S	84.05^{***}	C	7.79^{**}	S
Suck	204.04^{***}	C				
FDE	25.94^{***}	C	0.73	C	0.47	C
Loc	4.78^{*}	S	8.00^{**}	C	2.56	C
SNpig	44.74^{**}	C	0.23	S	2.25	C
Fight	0.84	C	4.12^{*}	C	//	
Sdsit	37.79^{***}	C	4.94^{*}	C	6.59^{*}	C

S=straw, C=crate; // expected value <5; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; df=1.

- The sucking and growing period, week 1 to week 8

No difference in activity was found between straw and crate animals. However, large differences were found in the behaviours that made up the activity-score. Straw animals showed more exploration and locomotion than the crate animals. The crate animals, on the other hand, scored higher on Snoutwork pig, Standing and Sitting, Sucking and Feeding, Drinking and Elimination.

- Week 11, start fattening period

In week 11 the crate animals were more active than the straw animals, which was almost completely due to a higher exploration score. Crate animals showed also more locomotion, Standing and Sitting and fighting than the straw animals.

- Week 14 to week 23, fattening period

Both straw and crate animals showed again the same activity-score. The straw animals performed more exploration and the crate animals more Standing and sitting.

4.3.1.3 Synchrony of activity

Measured over the 23 weeks synchrony of activity appeared to be higher in the straw than in the crate animals (Sign test, $p<0.05$, two-tailed). Figure 4.2 shows the development of synchrony of activity over the 23 weeks for straw and crate animals. The shaded area reflect asynchrony of activity (0.125 or 0.167 level).

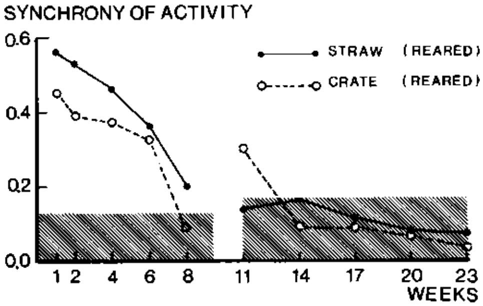


Fig. 4.2. Synchrony of activity during the sucking/growing period (week 1 to 8) and during the fattening period (week 11 to 23). Ordinate: measure of synchrony; Abscissa: age in weeks.

Straw animals behaved asynchronously after week 11, whereas the crate animals were asynchronous in week 8, synchronous in week 11 and thereafter asynchronous again. Both crate and straw animals showed a significant decrease in synchrony of activity with age (Straw $r_p= -0.92$, $p<0.001$; Crate $r_p= -0.86$, $p<0.05$).

4.3.1.4. The relation between Snoutwork pig and synchrony of activity

In crate and straw animals Snoutwork pig and synchrony of activity increased and decreased respectively with age of the animal. This implies that age might be an important determinant for the correlation between synchrony and Snoutwork pig. By means of partial correlation (Sachs, 1984) the age effect was held constant and the correlation between synchrony and Snoutwork pig was calculated over the first eight weeks (different housing conditions) and over the weeks 11 to 23, the fattening period (same housing conditions). Table 4.7 shows the product moment correlations of synchrony of activity and Snoutwork pig and the partial product moment correlations eliminating the age effect.

Table 4.7. Correlations and partial correlations (age held constant) between synchrony of activity and Snoutwork pig for straw and crate animals together.

		Sucking and growing period	Fattening period	df
Straw and crate	corr.	-0.9302^{***}	-0.8061^{**}	8
	partial corr.	-0.8721^{**}	-0.8096^{**}	7

** $p<0.01$, *** $p<0.001$.

In both periods we found a clear negative correlation between synchrony of activity and Snoutwork pig before as well as after the elimination of the age effect. Thus, a high level of synchrony of activity implies a low score on Snoutwork pig, and vice versa. Snoutwork pig was scored mostly during situations in which some pigs were active and others were lying down. Therefore, it might be interesting to look at the relation between the number of animals active at the same time and the performance of Snoutwork pig (SNpig). Figure 4.3 shows this for the sucking/growing period.

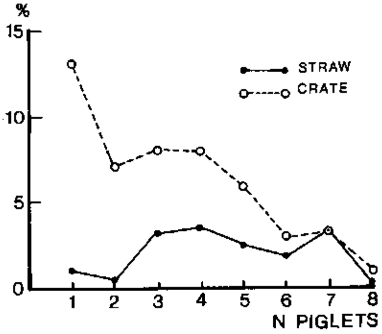


Fig. 4.3. The sucking/growing period
Ordinate: the percentage of animals performing SNpig; Abscissa: classes of N animals active at the same time.

In the crate animals the relation was most remarkable; when one animal was active the probability of Snoutwork pig was more than 13%. When all the animals (8) were active simultaneously the probability of Snoutwork pig was less than 1%. In straw animals no relation was found. Independently of the number of animals active simultaneously, the probability of Snoutwork pig was always below 4%.

During the fattening period straw and crate animals showed the same relation between the number of animals active at the same time and the probability of Snoutwork pig (figure 4.4).

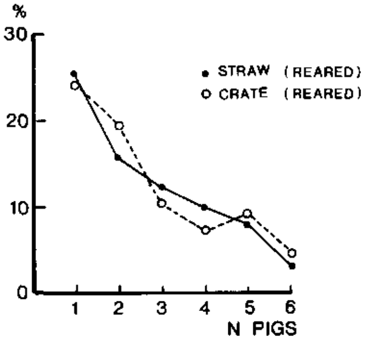


Fig. 4.4. The fattening period.
Ordinate: the percentage of animals performing SNpig; Abscissa: classes of N animals active simultaneously.

When one animal was active, the probability of Snoutwork pig was about 25% , for all animals active it was only 4.3% (crate) and 2.7% (straw).

Table 4.8 gives the mean percentages of Snoutwork pig and the synchrony of activity during the two main periods of age.

Table 4.8. The percentage SNpig and the synchrony of activity. Differences between straw and crate animals were only found during the sucking /growing period (different housing conditions).

	Sucking/growing period		Fattening period	
	SNpig	Synchro.	SNpig	Synchro.
Straw	1.1%	0.43	11.3%	0.13
Crate	3.5%	0.33	11.3%	0.14

4.3.2 Method B: Time sampling per one minute; sucking behaviour

Since sucking behaviour was measured per one minute only, the different phases of this behaviour as described by Fraser (1980) could not be distinguished. Only the beginning and the end of sucking were noted down. Figure 4.5A and 4.5B show the number of nursing periods and the duration of the intervals between successive nursings respectively.

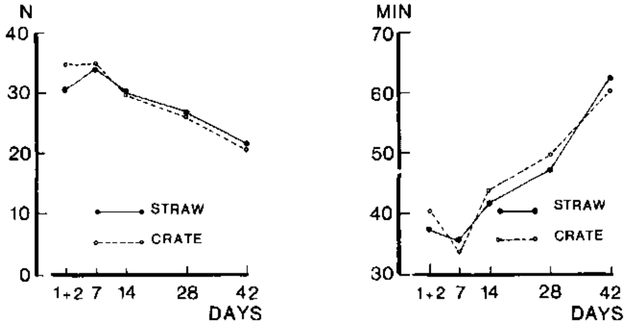


Fig. 4.5A and 4.5B. Left panel represents the number of nursings per 24-hour over days; right panel represents the duration of intervals between successive nursings per 24-hour over days.

No differences between the two rearing conditions were found on these parameters. After an initial increase in the number of nursings within the first week, the number of nursings decreased with age of the piglets. Correspondingly, after an initial decrease, interval time increased with age of the piglets. Nursing periods were also divided into those ended by the piglets and those ended by the sow. Nursings ended by the sow appeared to be rather stable in duration and lasted from 3.8 to 6.4 minutes. However, the duration of nursings ended by the piglets was very variable; besides, they always lasted longer than nursings ended by the sow (mean values for straw as well as crate piglets between 6.4 and 14.6 minutes). These long nursing periods were mainly found during the dark period. In figure 4.6 the percentages of nursings ended by the piglets during the light and dark periods are shown. Because of the minor differences between the days 7 and 14 and the days 28 and 42, the scores of these days were summed.

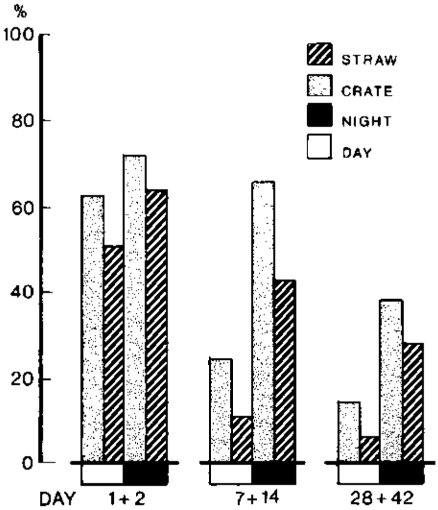


Fig. 4.6. Percentages of nursings ended by the piglets in the light and dark period

Differences between light and dark scores for the number of nursings ended by the piglets were found for straw as well as crate piglets on day 7 +14 and day 28 +42 (table 4.9).

Table 4.9. X^2 values (df=1) of the differences between the light and dark scores of nursings ended by the piglets.

	Day 7 + 14	Day 28 + 42
Straw	$X^2=43.00$, $p<0.001$	$X^2=16.00$, $p<0.001$
Crate	$X^2=10.38$, $p<0.01$	$X^2=13.52$, $p<0.001$

The percentage of nursings ended by the piglets decreased with age in straw as well as crate piglets. Crate piglets tended to end a nursing period more often than straw piglets did. This difference was significant on day 7 + 14 ($X^2=5.85$, $p<0.05$, df=1).

4.3.3 Method C: Time sampling per three minutes; feeding behaviour

From the end of the third week until the end of the fattening period (week 24) the pigs received food *ad lib.*. Water was given *ad lib.* during the first eight weeks only, but thereafter (fattening period) it was provided twice a day for one hour.

Rearing conditions did not influence the number of feeding periods as defined before (fig. 4.7A). The number of feeding periods increased from week 4 to week 8, (from about 5 to 15 feeding periods per 24 hours) but decreased to about six feeding periods per 24 hours in the last weeks of fattening. The mean duration per feeding period increased with age of the pigs (Spearman rank correlation: Crate pigs $r_s=0.89$, $p<0.05$; Straw pigs $r_s=1.00$, $p<0.001$; see figure 4.7B).

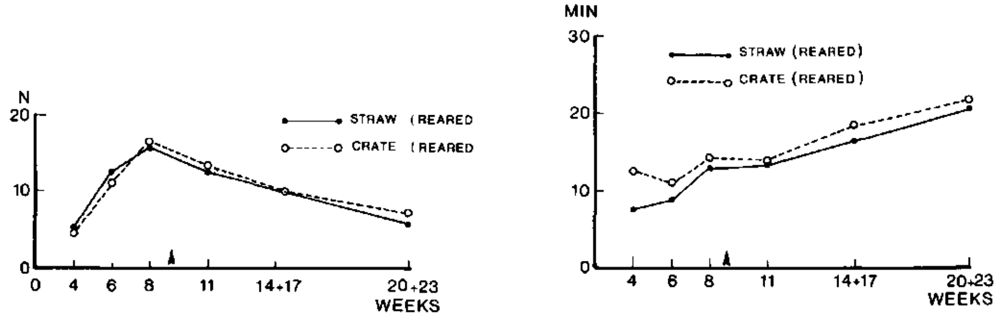


Fig. 4.7A and 4.7B. Left panel the number of feeding periods per 24-hours over weeks; right panel the mean duration in minutes of a feeding period per 24-hours over weeks. Abscissa, age of the pigs in weeks. Arrow, shift to the fattening house.

The mean duration of a feeding period appeared to be somewhat longer in crate than in straw pigs (Sign-test: $p<0.05$, two-tailed).

To find out whether the pigs fed differently during the light and dark periods, the mean number of pigs at the feeder per hour was calculated over the light and dark period (figure 4.8).

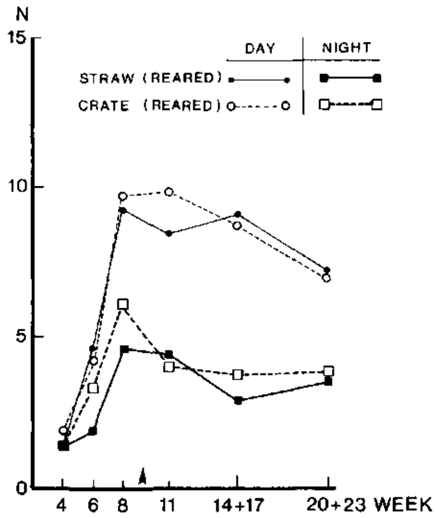


Fig. 4.8 Ordinate, the mean number of pigs at the feeder per hour for the light and dark period separately. Abscissa, the age of the pigs in weeks. Arrow, change to the fattening house.

In week 4 no differences were found between both housing systems. In week 6 the straw piglets were more at the feeder during the light period than during dark period. For the crate piglets this difference became clear also at week 8. When the 10-minutes interval sampling method was used (see page 45) essentially the same was found for the behaviours Feeding, Drinking and Elimination. During the fattening period there were always more pigs at the feeder during the light period than during the dark period. In the dark period only three to four pigs per hour were found at the feeder.

As shown before (fig. 4.5B) sucking was performed at certain intervals over a 24-hour period. It might be interesting to know whether feeding showed a similar distribution over a 24-hour period. This was expected to be the case, since direct observations had revealed that, in the weeks 4 to 6, the pigs went to the feeder immediately after a nursing period. In figure 4.9 the development of interval length between two successive feeding periods during the light and dark periods is presented.

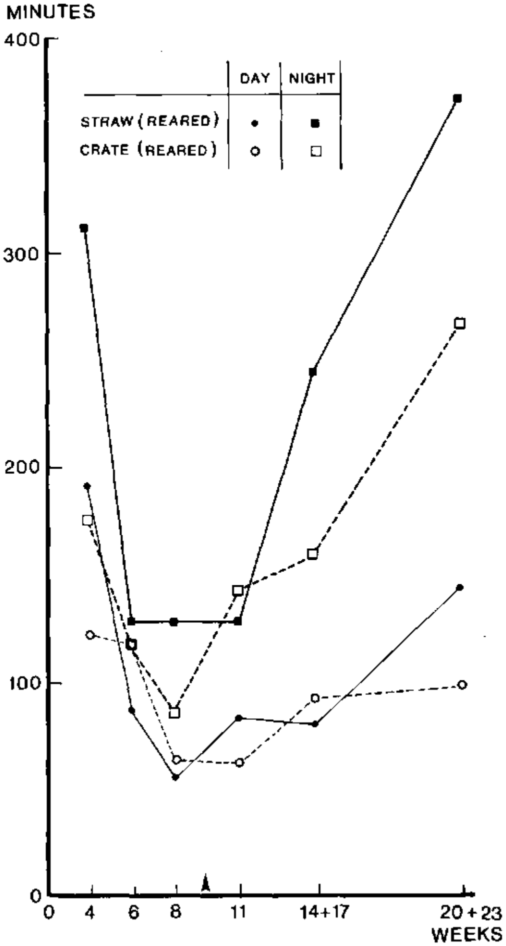


Fig. 4.9 Ordinate, mean duration of an interval between feeding periods in minutes. Abscissa, age of the pigs in weeks. Arrow, change to the fattening house.

In week 4 the piglets showed no regular feeding pattern; the intervals between the feeding periods were long, particularly in the dark period. In week 6 the piglets visited the creep feeder for a substantial amount of time and the intervals between the feeding periods became shorter. No differences between light and dark period were found in crate piglets and only a small one in straw piglets. In week 8 the intervals between the feeding periods were shorter than in week 4 and 6. The interval length in the light period was almost as short as the intervals between nursing period during week 6, namely 60 to 70 minutes. In the dark period straw piglets showed larger intervals between feeding periods than crate piglets.

During the fattening period the interval length between feeding periods and the differences between light and dark scores increased for both straw and crate pigs. At the end of the fattening period the pigs showed feeding periods every 1.2 to 2 hours during the light period and every 4 to 6 hours during the dark period. During the dark period straw pigs showed longer intervals between feeding periods than crate pigs.

- The distribution of feeding over a 24-hour period

The 10-minute time sampling brought to light two distinct periods of high Feeding, Drinking and Elimination activity during the fattening period. By using a 3-minute time sampling method we hoped to find a clearer distribution of feeding activity over a 24-hour period. In the following pages the development of feeding behaviour over the weeks will be described (see also table 4.3, page 40).

Figure 4.10 represents the distribution of feeding over a 24-hour period. During week 4 in both housing systems a relative high number of pigs were found feeding between 18.00 and 22.00 hour. During the dark period there were long periods in which no feeding occurred. In week 6 in both housing systems two periods of high feeding activity were found; one at the end of the dark period (06.00 - 08.00 hr) and one at the end of the afternoon (straw, 16.00 - 18.00 hr) or the start of the evening (crate, 18.00 - 20.00 hr). During the dark period comparatively much feeding occurred, especially with the crate pigs. Feeding activity was higher at the end of the light period than at its start; this phenomenon was observed during the entire fattening period.

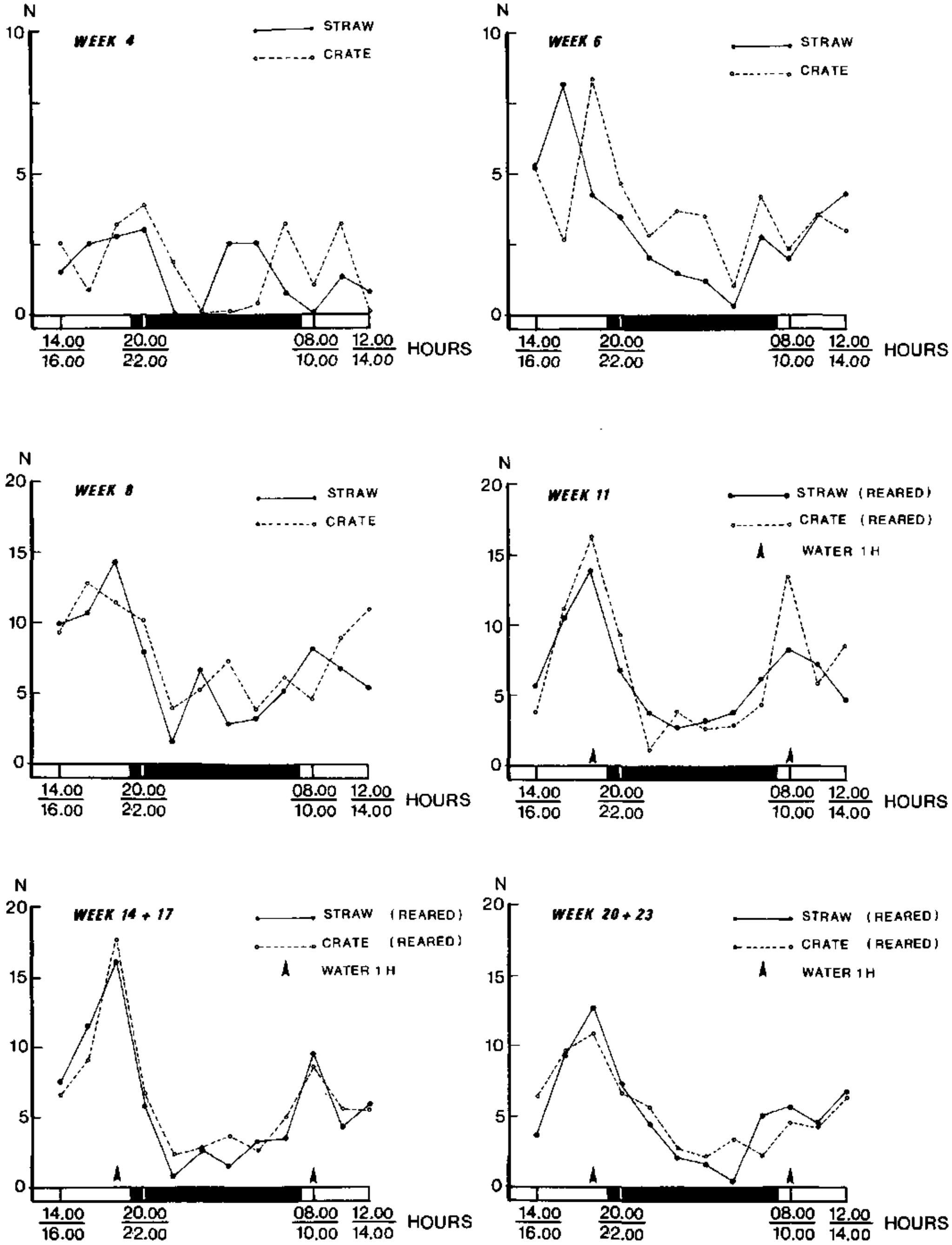


Fig. 4.10. Ordinate, number of piglets feeding per hour Abscissa, 24-hour period divided into two hour periods.

In the straw pen two periods of high feeding activity were found in the light period during week 8: one at the start (08.00 - 10.00 hr) and one at the end (18.00 - 20.00 hr) of the light period. Crate pigs showed a high feeding activity from 12.00 to 22.00 hr, but no clear increased feeding activity was found in the morning. During the dark period there was still some feeding activity.

During the start of the fattening period (week 11) both the crate and straw pigs showed two clear periods of feeding activity: one in the morning (08.00 -10.00 hr) and one in the evening (18.00 - 20.00 hr). Both periods coincided with the availability of water. Feeding activity during the dark period was low in both groups.

During week 14+17 the distribution of the number of pigs feeding over the 24-hour period was similar to the results from week 11. Straw and crate pigs showed largely similar feeding patterns over the 24 hours.

During week 20+23 both straw and crate pigs still demonstrated high feeding activity around the period in which water was available, but they showed also a lot of feeding during the dark period.

4.4 Discussion

4.4.1 Method A: The 10-minutes time sampling

- The distribution of the behaviours over a 24-hour period

In the second week after birth the piglets in the straw pen and in the farrowing crate showed a clear difference in activity between light and dark periods. This finding is in agreement with those of Marx (1973) and Schrenk (1981). Bergenthal-Menzel-Severing (1982) found a clear difference in activity between light and dark periods already on the second or third day after birth of the piglets. Although we did not find a diurnal activity rhythm in the first week after birth, the different behaviours composing the activity score (exploration, locomotion and fighting) showed such a fluctuation. However, sucking behaviour was found mostly in the dark period; since it comprises more than 50% of the total activity score during the light period and even more than that during the dark period, total activity was almost the same during the light and dark periods. Thus, the finding of a diurnal activity depends on the definition of activity. Marx and Schrenk (1973) defined activity as all behaviour minus resting, thus including sucking. Bergenthal-Menzel-Severing did not include sucking into her activity score. This may explain why she found a diurnal activity already on the secod and third days after birth, and Marx and Schrenk not before in the second week. It is in agreement with the findings of Schrenk (who observed week 2 to 6) and Bergenthal-Menzel-severing (who observed week 1 to 4) that in week 2 we found the emerging of two maxima in the activity scores, one in the morning and one in the afternoon. With increasing age of the pigs the afternoon maximum shifted to the beginning of the evening. From week 2 to week 4+6 the activity maxima coincided with the feeding of the sows (between 08.00 - 09.00 and 16.00 - 17.00 hr).

At the age of eight weeks (two weeks after weaning) the activity maximum in the morning was still found between 08.00 and 10.00 hour for straw piglets, that is, directly after the lights went on. The evening maximum of activity shifted more towards the end of the light period. However, the crate piglets showed in week 8 a disturbed distribution of activity. The highest activity was found between 14.00 and 16.00 hours and a lower peak was seen between 18.00 and 20.00 hour. The direct causation of this disruption of activity is unknown. It is conceivable that in the impoverished environment the sow forms an important part of the social and physical environment, and that her removal at the time of weaning, therefore, represents a more stressful experience for the piglets in the crate than those in the straw pen. As shown in chapter 3 , after weaning the crate piglets spent a lot of time on Snoutwork pig which resulted in much restlessness; this, of course, directly influenced the pattern of activity. Dantzer (1973) showed that ten weeks old pigs placed in a new environment had a disturbed diurnal activity and needed at least eight days to arrive at their former activity distribution. Even 14 days after weaning our piglets in the farrowing crate still showed a disturbed activity pattern as compared with the piglets in the straw pen. This might mean that six weeks old piglets are more susceptible to environmental changes than ten weeks old piglets.

During the fattening period the two distinct activity maxima occurred around the transitions from light to dark and vice versa. However, these maxima also corresponded with the time of the water gift. Therefore, the present observations cannot establish whether either feeding time of the sows, or time of water gift or the transitions from light to dark and vice versa determined the time of the activity maxima. However, Schrenk (1981) found that this biphasic activity pattern in piglets was endogeneous and that the transition from light to dark and vice versa only synchronized this rhythm. Especially the transition from dark to light fixed the first activity maximum and, more or less independent of the light regime, a second and more pronounced maximum occurred 8 to 10 hours later. This fits the present findings. At the end of the fattening period crate and straw pigs became more active between the two activity maxima. This was mainly caused by the decrease of space available per animal, as the pigs were growing fast. Because when pigs walked over other pigs to go to the feeder or to the dunging area much restlessness in the pen resulted. A disturbed diurnal activity was also found by Schrenk (1981) in two to six weeks old piglets that had a small area per piglet (0.11 m^2).

Exploration, Feeding, Drinking and Elimination and locomotion showed almost the same distribution over a 24-hour period as the total activity score. This is not surprising since these behaviours largely determine total activity. For feeding (which formed the largest part of our Feeding, Drinking and Elimination score) this finding is in agreement with the data of other authors (Schrenk, 1981; Bergenthal-Menzel-severing, 1982).

Fighting was scored almost exclusively during the light period and especially during the afternoon activity maximum. This fighting included playfull activities. Assuming that play only occurs when all basic needs of an animal (e.g. feeding and resting) are fulfilled (Eibl-Eibesfeldt, 1969), this might explain the low level of (play) fighting during the first activity maximum; at the start of the light period the pigs spent relatively more time on sucking and Feeding, Drinking and Elimination than at the end of a light period. Moreover, during the light period changes in environment can be monitored continuously and if necessary reacted on. In a relatively consisted environment the animal can allow himself to spent some time on (play)fighting; in our pigs this occurred during the afternoon activity maximum. Snoutwork pig and standing and sitting occurred relatively independent of the total activity score. However, in crate piglets during the first eight weeks and in both straw and crate pigs during the fattening period, the distribution of these behaviours during day time was closely and positively related with the distribution of exploration. This supports the idea that part of Snoutwork pig is redirected exploratory behaviour (see chapter 3 and 6).

- The development of the behaviours over the weeks

During the first six weeks the total activity of the piglets in both housing systems did not change very much. Straw piglets and crate piglets were active during 31.7% and 31.3% respectively of the 24-hour period. This fits the findings of Schremmer and Deckert (1967) who found a mean percentage of activity of 28.2% over the first six weeks. Marx(1973) calculated activity values of 23.8 to 30.4% during the first six weeks of life for piglets kept with the sow. Bergenthal-Menzel-Severing (1982) found higher activity, namely 38.2% scores (calculated from her data as 100% minus resting) during the first four weeks of life of piglets. She used a 1- minute interval sampling from video recordings, whereas Marx used photographs taken at intervals of 7.5 minutes. Bergental-Menzel-Severing obtained therefore a more accurate score which might explain the higher levels.

In week 8 the activity score was 21.4% for the crate piglets and 24.9% for the straw piglets. Schremmer and Deckert (1977) obtained similar values (24.9%) at week 8 in nonweaned piglets. In straw and crate pigs activity decreased with age. However, the crate pigs showed a high activity level at the start of the fattening period. Over the entire fattening period straw pigs were active during 18.9% and crate pigs during 24.3% of a 24-hour period. These findings agree neatly with those of other authors. Knap (1965) and Lips (1965), both cited by Schwahn (1982), obtained a score of 24.8% and Porzig and Liebenberg (1977) of 21.1%.

Exploration, Feeding, Drinking and Elimination, Snoutwork pig and Standing and sitting increased during the sucking/growing period, but did not change very much during the fattening period. Apparently, all these behaviours reached a maximum in week 11. Only standing and sitting still increased during the fattening period. This standing and sitting was, as already noted, partly due to the reaction on Snoutwork pig. However, Snoutwork pig appeared to be fairly constant over the fattening period. This means that Snoutwork pig alone can not account for the increase in standing and sitting. Particularly at the end of the fattening period part of standing and sitting was also induced by the decreasing area per pig. Ruiterkamp (1985) also found an increase in sitting during the fattening period but a decrease in Snoutwork pig.

In both straw and crate pigs locomotion decreased with age of the pigs. During the six lactation weeks locomotion consisted mainly of walking to and from the udder, in association with sucking. After weaning mainly moving to and from the feeder or drinker and displacements during exploratory behaviour determined the score of locomotion. This explains why during the lactation weeks locomotion followed the decrease of sucking and from week 8 onwards the trend of exploration.

During the sucking/growing period straw and crate piglets showed the same amount of activity over the 24-hour periods. This is in agreement with the findings of most authors and supports the idea that the activity of pigs, at least in situations with clear light/dark periods (van Putten and Elshof, 1984), is only slightly influenced by the environment (Marx and Schuster, 1982; Van Putten and Dammers, 1976; Buré, 1981).

Differences in behaviour between straw and crate piglets were mainly found during the sucking/growing period. These differences were all in the same direction and comparable to those found by direct observation during a limited observation period in day time (see chapter 3). In week 11 (the first measuring point in the fattening period) the crate pigs showed about 10% more activity than the straw pigs. This higher activity was almost completely due to exploration and to a much lesser degree to locomotion,standing and sitting and fighting. The crate pigs arrived in a relatively rich environment as compared with the farrowing crate; the floor area was larger (6 m^2 versus 4 m^2 of the crate) and the front of the pen in contrast with the farrowing crate was open. This open front enabled the pigs to overlook a great part of the stable. The crate pigs indeed spent a lot of time just looking trough the open front while biting the fence. Moreover, the plank at the bottom of the fence appeared to be very attractive. Sometimes all pigs were simultaneously rooting, biting or chewing parts of this plank. Especially during the first weeks the crate pigs spent a considerable amount of time on these behaviours.

On the other hand, the straw pigs came from a rich environment into a relatively impoverished one; they only showed a minor decrease in exploration. In all, crate pigs spent 53% of their activity exploring and straw pigs 44.1%. The crate pigs changed from an environment of lower complexity to one with a relative high complexity. These pigs started exploring their new environment and because of their experience with simple environments needed more time to assimilate this environment than the straw pigs did (Inglis, 1983). Because of their experiences in an enriched environment straw pigs could assimilate the new environment faster than crate pigs.

However, both straw and crate pigs spent an equal amount of time on Snoutwork pig. This may mean that the environment did not meet the expectation of the pigs, because the pigs still redirected part of their exploratory behaviour towards penmates (Van Putten, 1977) (see also chapter 6). Furthermore, because straw pigs showed as much Snoutwork pig as crate pigs, Snoutwork pig might be considered a consequence of the actual situation rather than being an effect of early experience (Ruiterkamp. 1985). Especially rooting, in the study of Wood-Gush and Stolba (1982) performed for about 51% of the active time, cannot be very rewarding in a pen with a concrete floor. Both straw and crate pigs redirected this type of behaviour towards penmates. Standing and sitting was always highest in the crate pigs, but in the straw pigs it increased also. The permanently high level of standing and sitting in crate pigs might be an consequence of the sucking/growing period. During the sucking/growing period standing and sitting in crate pigs was mainly caused by Snoutwork pig (chapter 3). Being approached by a littermate while lying often resulted in becoming a subject of Snoutwork pig. During the sucking/growing period the crate piglets learned to escape from Snoutwork pig by standing and sitting. This preventive behaviour apparently persisted during the fattening period. Crate pigs more readily performed standing and sitting while being approached by a penmate than the straw pigs. Apart from exploration and standing and sitting no great differences in behaviour between straw and crate pigs were found during week 14+17 and 20+23.

4.4.2 Synchrony of activity

Figure 4.2 shows that during the sucking/growing period the straw piglets were more synchronous in their activity than the crate piglets. In other words, with the straw piglets the litter acted as a whole more often than with the crate piglets. In both the straw and crate pigs the synchrony of activity decreased with age.

During the first six weeks a large part of the total activity of the piglets was devoted to sucking, which is mostly performed by all animals simultaneously. This sucking determined the synchrony of activity for the greater part especially during the first four weeks when about 45 to 55% of the active time was spent on this behaviour. During week 6 only 28% of the active time was spent on sucking; that is probably why the synchrony of activity decreased in both straw and crate piglets. During week 8, when the main synchronizer (sucking) had stopped occurring, synchrony of activity became low. In crate piglets activity must even be considered asynchronous, according to the definition. This asynchrony of activity directly influenced the activity pattern during the light period.

After weaning both straw and crate pigs showed a feeding rhythm comparable to the one for sucking before weaning. Because of the restricted feeding places only five piglets could feed simultaneously. This implied that, although the piglets showed distinct feeding periods, feeding behaviour could influence the synchrony of activity to a lesser degree than sucking did.

During the sucking/growing period both in crate and straw piglets a strong correlation between synchrony of activity and Snoutwork pig was found. In crate piglets a clear relation was found between the number of animals active simultaneously and the probability of Snoutwork pig. The more animals were active simultaneously the lesser the probability of Snoutwork pig. In straw animals no such relation was found mainly because of the low occurrence of Snoutwork pig (1.1%). The environment of the straw piglets offered ample opportunity to explore all sorts of objects apart from conspecifics. At the beginning of the fattening period (week 11) the synchrony of activity in crate pigs increased and by definition the crate pigs were synchronous in their activity. This may be a direct consequence of the relatively rich environment of the fattening pen as compared with the farrowing crate. As already mentioned the fattening pen offered opportunity for all animals to perform exploration simultaneously.

The straw animals became asynchronous in their activity and started performing as much Snoutwork pig as the crate animals. This caused an increase in standing and sitting in straw animals and diminished the synchrony of activity. During the fattening period five out of six animals could feed simultaneously; because there were still distinct feeding periods, feeding did have a positive effect on the synchrony of activity. After the first weeks the crate animals became again asynchronous in their activity. The relative enrichment had only a temporary effect on the synchrony of activity in crate animals. During the remainder of the fattening period the crate animals were more asynchronous in their activity then the straw animals. In both straw and crate animals the synchrony of activity decreased from week 14+17 to 20+23. As stated before this was probably caused by the decreasing area per animal for the fast growing pigs, which induced restlessness because of pigs walking over lying penmates in order to reach the feeder or the dunging area. In both straw and crate animals the relation between the number of animals active simultaneously and Snoutwork pig was the same. The more animals were active simultaneously, the lesser the probability of Snoutwork pig. During the sucking/growing period as well the fattening period the correlation between number of animals active at the same time and Snoutwork pig was high. Therefore, in an impoverished environment with few opportunities for species-specific behaviours the probability of Snoutwork pig (redirected exploratory behaviour) becomes high.

Environmental conditions have a direct effect on the synchrony of activity in pigs as indicated, first, by the differences in the first eight weeks between straw and crate piglets and, secondly, by the temporary effect of relative enrichment seen in crate pigs in week 11. Moreover, high synchrony of activity in early life seems to have some positive effect on synchrony of activity in later (sub)adult life even under less ideal circumstances.

4.4.3 Sucking behaviour

A substantial literature exists about the nursing and sucking behaviour of the domesticated pig. Extensive reviews are given by Achebe (1975), Schwahn (1982) and Bergenthal-Menzel-Severing (1982). A review of the behavioural mechanism of milk ejection is given by Fraser (1980). Generally our findings correspond with those reported in the literature.

Nursing behaviour was only slightly altered by housing conditions. The number of nursings and the interval between them were not different for straw and crate piglets. The number of nursings was on the average higher than reported elsewhere (e.g. Barber et al., 1955; Schalbert, 1972). The use of gilts and the definition of a nursing period in the present study might explain this difference. Deckert (1968) found more nursings when gilts were used then when sows were used. The durations of the intervals between nursings were on the average shorter but still within the range of those reported by most authors. In both housing systems the number of nursings ended by the piglets decreased with age of the piglets; most of these nursings were found during the dark period. However, the first two days during which most nursings were ended by the piglets, these light/dark differences were still absent. At this age the massaging by the piglets after drinking is not so vigorous and long lasting. This enhances the probability that the sows keep their lying position and will not stop the nursing themselves. With increasing age of the piglets they become stronger and the massaging after drinking gets more vigorous. The piglets are now able to massage the udder for a considerable amount of time. This causes the sows to shift on the belly or to stand up and, in free moving sows, to walk away. During the dark period the sow often was in a state of drowsiness when nursing and was less likely to change position than in the light period. This explains the higher amount of nursings ended by the piglets during the dark period. With increasing age of the piglets the massaging after drinking seemed to become an annoyance for the sow and for this reason she now more often ended a nursing period even during the dark period. The tethered sows in the crate could only escape from the massaging after drinking by shifting on the belly or standing up. However, after the second week standing up was not sufficient anymore, because the piglets could reach the udder of the sow while she was standing. Moreover, the concrete floor appeared to be not a good substrate to ly on with a sensitive udder; the tethered sows avoided this position as long as possible. The decrease of number of nursings ended by the piglets and the differences between the dark and light periods explain why the duration of nursings decreased with age (nursings ended by the sow have a shorter duration) and why nursings in the dark period were longer than those in the light period (more nursings were ended by the piglets in the dark period, those having a longer duration).

4.4.4 Feeding behaviour

The housing systems had only a minor effect on the feeding behaviour of the piglets. The same conclusion holds for the effect of rearing on feeding during the fattening period. A diurnal rhythm in feeding was found in straw pigs from week six onwards and in crate pigs from week eight onwards. Acheba (1975) and Schrenk (1981) also found a diurnal rhythm in feeding at week 6. In both crate and straw animals the number of feeding periods increased from week 4 to week 8 and decreased again towards the end of the fattening period.

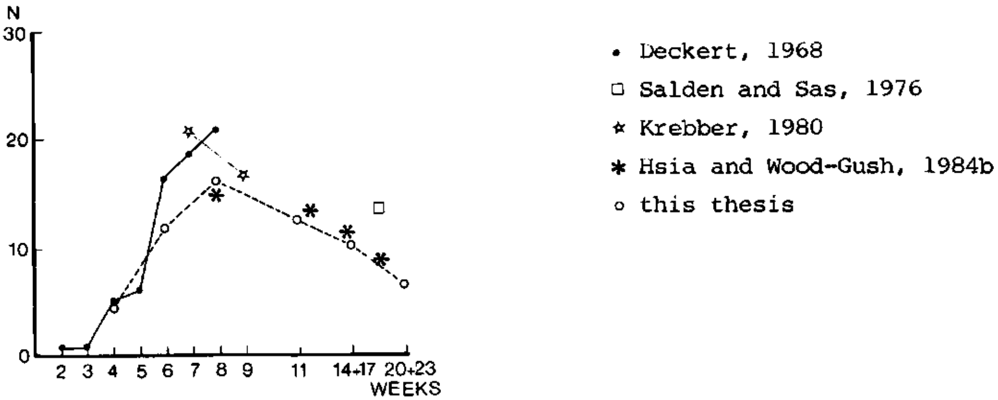


Fig. 4.11. Ordinate, mean number of feeding periods per 24-hours. Abscissa, age in weeks.

The values correspond with the data of other authors (fig. 4.11): Deckert (1968), for sucking piglets from week 4 to week 8, Krebber (1980), for weaned piglets during week 7 and week 9, Salden and Sas

(1976), for fattening pigs about week 19 and Hsia and Wood-Gush (1984b) for pigs from 20 to 80 kg, which corresponds with an age of seven to 19 weeks (as calculated from weight-curves).

The feeding periods are as defined in the present experiment not identical with definitions of meals. Although due to social facilitation a group of pigs normally shows a synchronized feeding behaviour (Hsia and Wood-Gush, 1984a), meals of the present pigs overlap. This will cause feeding periods to be longer than an actual meal of an individual pig. The development of the duration of the feeding period as observed here appear to be comparable with other reports (see figure 4.12).

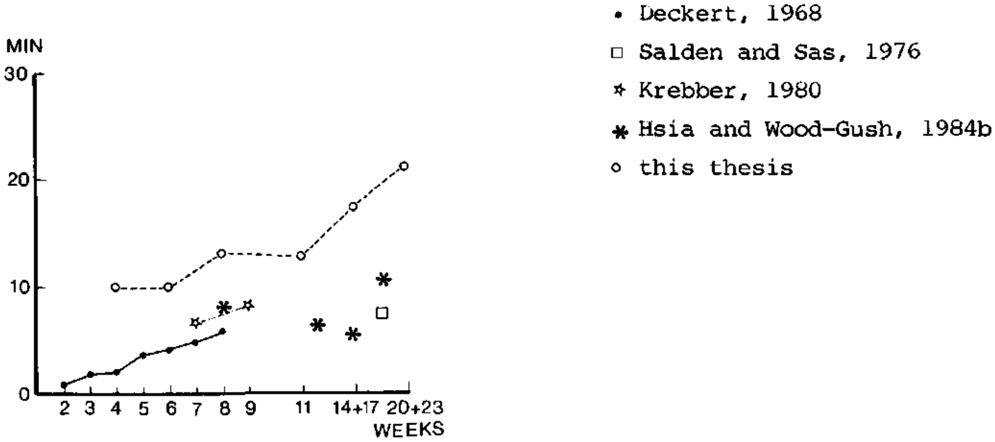


Fig 4.12 Ordinate, mean duration of a feeding period. Abscissa, age in weeks.

The duration of a feeding period was found to be longer in crate animals than in straw animals. One possible explanation might be that crate animals used the food as rooting material and therefore spent more time at the trough. Wood-Gush and Beilharz (1983) found that piglets on flatdecks often performed rooting in a trough containing soil before eating pellets. An alternative explanation might be that low synchrony of activity in crate animals may cause feeding to be also less synchronous; this in turn results in an increase in feeding period duration.

Two clear feeding periods, one in the morning and one in the afternoon, emerged in straw animals in week 6 and in crate animals during week 8. As already mentioned, the activity pattern in crate animals during week 8 was very much disturbed, which also influenced their feeding pattern. During this week the two feeding periods were not very clear in the crate animals. In contrast, the straw animals still showed two distinct feeding periods. Krebber (1980) also found two clear feeding periods, one at the beginning and one at the end of the light period. From week 11 to week 14+17 the two feeding periods again were very clear. This might be the result of the presence of water in the morning and in the evening. However, in week 8 when water was given *ad lib.*, these two feeding periods were already present. As already mentioned, Schrenk (1981) found that the endogeneous biphasic rhythm of pigs was entrained by light/dark changes and not by feeding time. This might mean that the presence of water was not the main cause of the existence of distinct feeding periods during fattening; apparently, though, water was supplied at the most favourable time. Probably because of low synchrony of activity during week 20+23 the two feeding periods became less distinct.

4.5 Conclusions

From the second week of life onwards, piglets show a clear diurnal rhythm.

In an enriched environment piglets shows more exploration than in a impoverished environment and less snoutwork pig and standing and sitting (restlessness).

Enrichment of the evironment increases exploration in pigs only temporarely. Impoverishing the environment decreases the exploratory behaviour in pigs, but to a lesser extent.

Effects of rearing on later behaviour are found in standing and sitting. High levels of standing and sitting (restlessness) during the first eight weeks of life are persistent during the fattening period.

Snoutwork pig(let) is caused by the actual situation. Rearing condition did not effect this behaviour during fattening.

A rich environment enhances synchrony of activity of pigs. This in turn reduces snoutwork pig and hence restlessness (less standing and sitting in reaction to snoutwork pig).

An impoverished environment does not change the amount of nursing in piglets nor feeding behaviour.

CHAPTER 5

5. THE EFFECTS OF REARING CONDITIONS ON THE BEHAVIOUR OF GILTS AROUND FARROWING

5.1 Introduction

The behaviour of gilts or sows around farrowing has drawn considerable attention (e.g. Jones, 1966; Gundlach, 1968; Randall, 1972; Pflug, 1976; Meynhardt, 1980 and Baxter, 1982, 1983). Most of the studies on domesticated sows have been carried out to assess behavioural changes due to tethering or other restrictions of movement during pregnancy and farrowing (e.g. Hansen and Curtis, 1980; Baxter,1982; Lammers and de Lange, 1985). The effects of housing condition during pregnancy, farrowing and lactation on behaviour have been investigated by Vestergaard and Hansen (1984). These authors found a reduced activity in both loose and tethered pregnant sows that had been kept tethered during their previous farrowing/lactation period. Tethering during pregnancy prolonged duration of farrowing in both loose and tethered sows. This points to the relevance of exercise during pregnancy with respect to farrowing parameters (Hale and McCormick, 1980).

Until now the effect of rearing conditions of piglets on their adult behaviour around farrowing has not been investigated. However, from studies in other species we know that early experience has a great influence on adult behaviour. Social isolation from birth (or from weaning) resulted in disturbed sexual and aggressive behaviour in monkeys (Harlow and Harlow, 1962), rats (Hansen, 1977; Peys, 1977; Timmermans, 1978; Day et al., 1982) and Burmese jungle fowl (Kruijt, 1964). Female monkeys, isolated from birth, showed disturbed maternal behaviour (Harlow, 1962; Seay et al., 1964). Sexual behaviour of boars and gilts appeared to be influenced by the social rearing conditions existing at an age of three weeks (Hemsworth, 1977, 1978, 1979, and 1982). Early social environment thus appears to be very important for a normal social behaviour in later life.

Enriched environments are known to increase brain weight in rats irrespective of social grouping (Rosenzweig et al., 1978). Rats reared in enriched environments showed a better behavioural adaptability and problem solving capability than rats reared in an impoverished environment (Gardner et al., 1975; Rosenzweig and Bennet, 1977). It is, therefore, not unlikely that in pigs also an impoverished environment in early life will cause relatively lower brain weights. If, like in rats, enrichment of the environment during early life increases adaptability in pigs, a greater behavioural plasticity would be expected in straw reared pigs than in crate reared ones. This should become apparent when the animals have to solve new problems; the first farrowing may represent such a problem.

In this chapter the behaviour during the first farrowing of gilts, reared in either an impoverished or an enriched environment, is described. Do they show a different behavioural plasticity as might be expected from the foregoing?

5.2 Materials and methods

On four occassions two gilts reared in straw and two gilts reared in a farrowing crate were housed together in a straw pen at an age of eight weeks. The gilts were daily checked for oestrus by means of a vasoectomized boar; they were inseminated in their second oestrus. All gilts were inseminated with the sperm of the same boar. On average the straw reared gilts were inseminated five days earlier then crate reared gilts. Two weeks before the expected farrowing date the gilts were housed individually in similar straw pens (see chapter 2).

One gilt reared in straw aborted and one reared in a farrowing crate did not become pregnant. These gilts were left out of the analyses. See table 5.1 for general data on the gilts.

One crate-reared gilt did not stop attacking her piglets and was injected with azaperon and oxytocine after the delivery of her fourth piglet.

Observations of the gilts took place from an observation post two metres above floor level. The behaviours were recorded in a "MORE" event recorder (Observational system Inc., Seattle, Washington) in which frequency, duration and sequences of the behaviours were stored. All computations were done on a DEC-10 computer.

Table 5.1. General data of the gilts

	Straw reared gilts	Crate reared gilts
N	7	7
Age at insemination in days	250.8 (23.0)*	255.6 (17.5)*
Mean duration of pregnancy in days	114.4 (1.3)*	114.9 (0.7)*
Mean duration of farrowing in minutes	144.7 (83-195)**	123.2 (53-242)**
Duration of intervals between delivery of successive piglets	22.3 (3.7)#	18.9 (4.6)#
Number of piglets born	55	53
Still born	0	2
Killed by the gilts	2	3
Crushed	2	2
Unknown cause of death	1	1
Number of piglets alive at week 8	50	45

* mean (sd),** mean (range), # mean (sem; N=39)

5.2.1 Ethogram

The gilts were always performing one out of four possible postures which could be combined with several behavioural elements.

Postures

Lying on the belly: The animal is lying on its belly with at least two legs folded under the body.

Lying on the side: The animal is lying on the side with all four legs stretched out. Head on the floor in lateral position.

Sitting: The animal is sitting with the forelegs stretched.

Standing: The animal contacts the floor with the hoofs only. This posture also includes getting up or lying down and moving around.

Behavioural elements

Nestbuilding

Gathering: The animal carries bundles of straw in its mouth and deposits these on the floor or on the nesting site.

Building: The animal is standing in the nesting site and shovels the straw to the edge of the nest, often circling in the nest. Nesting material is scraped with the forelegs into the nest and often the animal presses the material down with her head.

Shaping: The animal is making a shallow pit in the collected straw by rotating movements of the head. Often vigorous movements of the head are seen.

Moulding: The animal is filling the interior of the nest with straw. No shoveling or scraping is performed.

Sliding into: The animal carefully enters the nest making sideward movements with the head; if necessary piglets are moved away and the animal gently lies down.

Maternal behaviour

Sniffing piglet: Sniffing any part of the body of a piglet.

Licking piglet: Licking any part of the body of a piglet.

Biting piglet: Biting a piglet

Snapping: Making biting movements towards a piglet without really touching it.

Drive away piglet: Removing a piglet with the snout without biting, some times with considerable force.

Nursing: Lying on the side with fully exposed udder while more than half of the number of piglets is active at the udder. During farrowing nursing was recorded as long as one piglet got hold of a nipple.

Exploration

Sniffing substrate: Sniffing, touching, nibbling, rooting or chewing the substrate.

Sniffing objects: Sniffing, touching, nibbling, rooting or chewing object above floor level.

Ingestion and Elimination

Feeding: Eating and chewing pellets from the trough.

Drinking: Drinking water from the drinker.

Eating placenta: Eating (part of) the placenta or the umbilical cord of a piglet.

Cannibalism: Eating (part of) a piglet.

Elimination: Urinating or defeacating.

Comfort behaviour

Shaking: Shaking the head or the entire body.

Scratching: Scratching the body with one of the hindlegs.

Rubbing: Rubbing any part of the body against objects or floor.

Stretching and yawning: Stretching part of or whole body, often simultaneously yawning.

Delivery

Delivery: Delivery of a piglet began when either the animal showed undulating movements of the body, rowing of the legs and violent swishing of the tail, or when part of the piglet became visible.

Expelling the placenta: Expelling (part of) the placenta.

Resting/activity

Resting: Lying on side or belly without performing any other described behaviour. It is recognized that lying on the belly not always means that the animal is resting.

Activity: Performing any behaviour excluding resting.

5.2.2 Observations

Observations began five days before the expected date of farrowing an ended 13 days after farrowing. The animals were observed during four hours a day between 09.00 and 17.00 hours in a alternating scheme of one hour observation and one hour rest. The start of the observations alternated between 09.00 or 10.00 hour on consecutive days. Farrowing itself was observed during six hours continuously, beginning with the delivery of the first piglet.

Because of shortage of man power one farrowing of a straw reared animal and one of a crate reared animal were not observed. For the same reason four animals, two straw and two crate reared animals, were observed until four days after farrowing only (see table 5.2).

Table 5.2. Number of animals observed around farrowing. Day 0 is the day of farrowing.

	Observation days							
	-5,-4,-3	-2	-1	0	1	2	3,4	5,7,9,11,13
Straw reared	6	7	7	6	7	7	7	5
Crate reared	7	7	7	6	6	7	7	5

5.2.3 Statistical Analyses

The duration of the various behaviours of the individual gilts was expressed as percentage of the total observation time. For the observations of combined days (-5,-4,-3; 3,4 and 5 - 13) the mean percentage scores of the behaviour of the gilts were calculated. Because of the low number of animals per condition and the sometimes large differences between animals within rearing conditions, medians are computed rather than means. Differences between rearing conditions were tested with the Mann-Whitney U test or the X^2 test, while for differences within the same rearing conditions the Wilcoxon matched pairs test was used (Siegel, 1956).

The data from the six hours continuous observation during farrowing were submitted to a cluster analysis and a sequential analysis. For the two latter analyses some behaviour elements were combined resulting in a ethogram of 13 elements or groups of behaviours.

Abbreviations

1.	SN	Structural nestbuilding (gathering, building, shaping and moulding)
2.	SI	Sliding into
3.	L	Lying on side or belly, without performing any other described behaviour
4.	EXP	Exploration
5.	STD	Standing and moving, Sitting without performing any other described behaviour
6.	NURS	Nursing
7.	MCS	Maternal contact seeking (sniffing or licking piglets)
8.	BS	Biting of or Snapping at piglets
9.	DA	Drive away piglets
10.	EP	Expelling (part of) placenta
11.	COM	Comfort behaviour
12.	FDE	Feeding, Drinking and Elimination
13.	DEL	Delivery

For both the straw and crate reared gilts the 13 x 13 matrix of the frequencies of the first order transitions between the behaviours was analyzed. Because a behaviour could not be followed by itself the matrix was corrected for so-called structural zero's on the diagonal and also for five impossible transitions (Van Hooff, 1982). The standardized residuals $q_{ij}=(o_{ij} - e_{ij})/ \sqrt{e}_{ij}$ were calculated with the BMDP4F program (Dixon, 1983). Only positive transitions with a q value greater or equal to 3 were regarded as transitions that occurred more than expected. Appendices B and C give the observed and expected values, as well as the standardized residuals per cell of the 13 X 13 matrix.

The standardized residuals were used as a measure for the association between two behaviours. Since for the present cluster analysis the direction of a transition (a to b or b to a) was not important, the greater of the two transitions was used as an index for temporal association. The same method was used by Malafant and Tweedie (1982) and Ruiterkamp (1985). The cluster analysis was performed with the BMDP1M program (Dixon, 1983) using the single linkage method (Van Hooff, 1982; Morgan et al., 1976). The association level at which the clusters were regarded meaningful was arbitrarily set at 5. To compare situational differences such a set-point is useful.

5.3 Results

The observation period was divided into 1) the pre-farrowing period (day -5 to -1), 2) farrowing (day 0) and 3) the post-farrowing period (day 1 to 5 - 13). Since changes in behaviour were expected to occur closely around farrowing, the observations of the two days before and after farrowing were analyzed per day. Since within rearing conditions no great differences in behaviour were found between days -5,-4,-3 and 3,4 , the observations of these three or two days resectively were combined. Because only five animals per group were observed during day 5 to 13 these five days were combined also. Behavioural changes over the days observed and differences in behaviour between gilts with different rearing backgrounds, will be presented first (figure 5.1-5.8, page 82). The analysis of frequencies of behaviour and the temporal organization of behaviour from the six hours observation during farrowing will be presented next.

No behavioural differences between straw and crate reared gilts were found during the pre- and post-farrowing periods, with the exception of nursing during the post-farrowing period. However, changes in behaviour pre- and post-farrowing were manifold.

The results are presented as median percentages of the total observed time and will be presented per above mentioned periods.

5.3.1 The pre-farrowing period (day -5,-4,-3 to -1)

In both straw and crate reared gilts the percentage of time spent active increased towards farrowing. In crate reared gilts this increase seemed to be more gradual while in straw reared gilts a peak (60%) was found on day -1 (fig. 5.1). In straw reared gilts virtually all active behaviours tended to increase from day -2 to -1. In both straw and crate reared gilts the greater part of the activity was devoted to exploration and nestbuilding (fig. 5.2 and 5.3). In straw reared gilts the latter was recorded for the first time on day -2 in three gilts and again on day -1 in all gilts. In crate reared gilts nestbuilding was recorded for the first time on day -1, whereas one crate reared gilt did not perform nestbuilding at all. Ingestion and elimination (fig. 5.4) tended to increase from day -2 to -1 in crate reared gilts and increased significantly in straw reared gilts (Wilcoxon, $T=0$, $p<0.05$, $n=7$). In crate reared gilts standing and sitting (fig. 5.5) increased from day -5, -4, -3 to -1 (Wilcoxon, $T=2$, $p<0.05$, $n=7$).

5.3.2 The farrowing period

Farrowing induced great changes in behaviour in straw as well as crate reared gilts. In both groups exploration sharply decreased from day -1 to 0 (crate reared: from 29.7 to 3.8% ; straw reared: 40.3 to 3.1%; in both cases Wilcoxon, $T=0$, $p=0.05$, $n=6$; fig. 5.2). Nestbuilding and feeding, drinking and elimination tended to decrease in crate reared gilts (fig. 5.3 and 5.4). The decrease in both behaviours was significant in straw reared gilts (Wilcoxon, $T=0$, $p=0.05$, $n=6$). From day -1 to 0 lying on the side or belly (fig. 5.6) increased in straw as well as crate reared gilts (Wilcoxon, $T=0$, $p=0.05$, $n=6$). No differences were found in total farrowing duration between straw and crate reared gilts. The mean durations were 2,4 hr for straw reared animals and 2,0 hr for crate reared gilts, these data are in accordance with Jones (1966), Randal (1972) and Bergenthal-Menzel-Severing

(1982), but were shorter than those reported by Signoret (1975), Kräuslich et al. (1979), Pflug (1976) and Vestergaard and Hansen (1984). The mean interval between the delivery of successive piglets was 22.3 minutes for straw reared gilts and 18.9 minutes for crate reared gilts. This is somewhat longer than the time reported by other authors for loose sows (Jones, 1966) 15.3 minutes; Randal: (1972) 16.0 minutes), but shorter than the time reported by Pflug (1976) and Kräuslich et al. (1979). Besides the farrowing itself, nursing was the most important activity straw and crate reared gilts showed at the day of farrowing (fig. 5.7). Straw reared gilts and crate reared gilts spent a median of 28.9% and 21% respectively of the six observation hours on this activity. Because of the great individual differences between the gilts, this difference in nursing did not reach significance. Straw reared gilts tended to perform more maternal contact seeking behaviour (sniffing and licking piglet) (fig. 5.8) than the crate reared gilts (MWU, U=8, $p=0.132$, n=6). Straw reared gilts performed more lying on side or belly (fig. 5.6) than crate reared gilts (MWU, U=5, $p<0.05$, n=6). Crate reared gilts were more often observed standing and sitting (without performing any other behaviour; fig. 5.5) than straw reared gilts (MWU, U=5, $p<0.05$, n=6).

5.3.3 The post-farrowing period (day 1 to 5 - 13)

Activity (fig. 5.1) of straw and crate reared gilts decreased from day 0 to day 1, as expected (Wilcoxon, Straw reared: T=1, $p<0.05$; Crate reared: T=2, $p=0.05$, n=6, one tailed). From day 1 to day 5-13 the activity of crate reared gilts increased again (Spearman rank correlation, r=1.0, n=4, $p=0.05$). A large part of the activity of straw and crate reared gilts was devoted to nursing (fig. 5.7). Nursing decreased in both straw and crate reared gilts from day 0 to day 5-13 (Spearman rank correlation, Straw reared gilts: r=1.0, $p=0.01$, n=5; Crate reared gilts: r=0.95, $<p<0.05$, n=5). Exploration (fig. 5.2) increased from day 0 to day 5-13 in both straw and crate reared gilts (Spearman rank, r=1.0, $p=0.01$, n=5). However, in both the straw and crate reared gilts exploration did not reach the former pre-farrowing level on day 5-13 (20% of total observation time on day 5-13 and 30% on day -5,-4,-3).

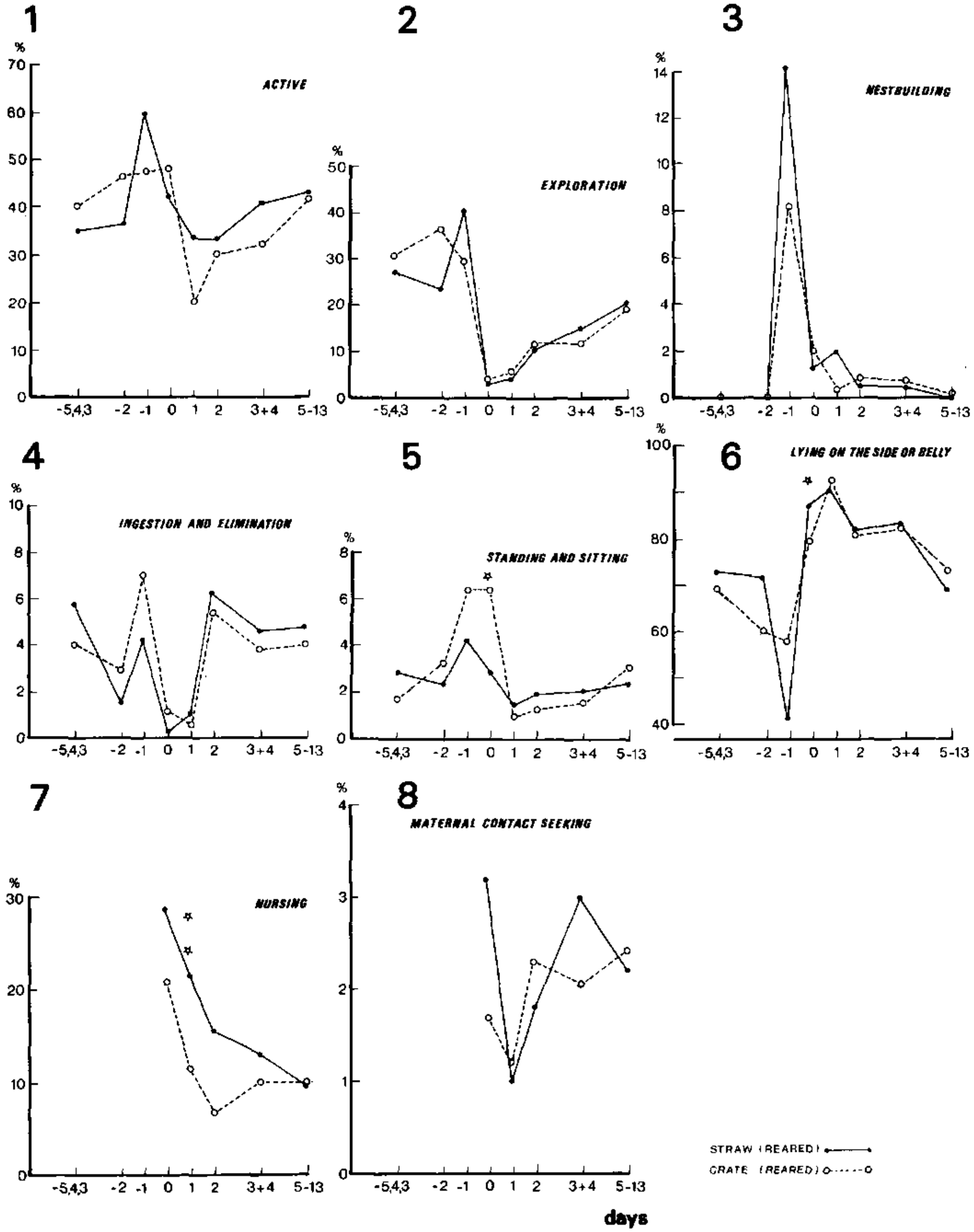


Fig. 5.1 - 5.8. Various behaviours observed in the straw and crate reared gilts around farrowing.

Ordinate: median percentage of the total observation time (note that the scales vary). Abscissa: days before and after farrowing on day 0.

$* \; p < 0.05$; $** \; p < 0.01$

Apparently, part of the time normally spent on exploration was now taken up by by nursing.

Standing and sitting (fig. 5.5) decreased from day 0 to day 1. However, this decrease was only significant for the straw reared gilts (Wilcoxon, T=0, $p<0.05$, n=6). In straw and crate reared gilts standing and sitting were scored at a low level and did not change very much from the pre-farrowing level of the days -5, -4 and -3.

The first day after farrowing (day 1) the gilts spent only a small amount of time on feeding, drinking and elimination (fig. 5.4). From day two onwards a substantial amount of feeding, drinking and elimination was observed, which was almost at the same level as on the days -5,-4,-3 pre-farrowing. The same holds for lying on the side or belly (fig. 5.6).

From day 0 to day 1 maternal contact seeking (sniffing and licking piglets; fig. 5.8) decreased in straw reared gilts and increased again from day 1 to day 3,4 (Wilcoxon, day 0 to 1; T=0, $p<0.05$, n=6, day 1 to 3,4; T=0, $p<0.05$, n=7). In both straw and crate reared gilts nestbuilding (fig. 5.3) was found till day 5 - 13. The time spent on nestbuilding decreased from day -1 to day 5 - 13 (Spearman rank correlation, Straw reared: r=-0.99, $p<0.01$, n=6; Crate reared: r=-0.98, $p<0.01$, n=6). From day 1 to day 3, 4 straw reared gilts tended to perform more nursing (fig. 5.7) than crate reared gilts. The difference was significant on day 1 (MWU, U=2, $p<0.01$, $n_1=6$, $n_2=7$).

5.4 Results of the analysis of frequencies of behaviours and the temporal organization of behaviour during farrowing by means of cluster and sequential analysis

- Analysis of frequencies of behaviour

During the six hours of observation of farrowing, straw and crate reared gilts still performed nestbuilding (straw reared gilts 61.3 times and crate reared gilts 63.2 times per animal per six hours). Nestbuilding can be divided into structural building and sliding into the nest site. Elements of nestbuilding like gathering, building, shaping and moulding are used in constructing the nest. These behaviours, although important in constructing a nest, must not be performed during farrowing, because of the risk for the just born piglets. Sliding into, another element scored under nestbuilding, is important in preventing the crushing of the piglets. Comparing the ratio of structural nestbuilding and sliding into, structural nestbuilding tended to be scored more in the crate reared gilts (X^2 =2.52, $p<0.10$, df=1).

The total frequency of maternal behaviour, excluding nursing, was not different for straw and crate reared gilts (straw reared gilts 150.7 times and crate reared gilts 164.8 times per animal per six hours). However, crate reared gilts showed maternal aggression (biting piglets, snapping and drive away piglets) more often (69.0 times and 28.7 times respectively per animal per six hours; X^2=144,15, $p<0,001$, df=1). This maternal aggression can be divided into 1) biting of and snapping at piglets and 2) driving away of the piglets. Biting of and snapping at piglets is a very aggressive behaviour, and it easily leads to wounding or killing of a piglet. Drive away a piglet is a more gentle form of maternal contact avoidance behaviour, which seldom causes damaging of a piglet. The distribution of frequencies of biting of and snapping at piglets and drive away piglets differed between crate and straw reared gilts. Crate reared gilts more often showed biting and snapping at piglets than straw reared gilts (X^2=6.34, $p<0,05$, df=1).

5.4.1 Cluster analysis

The sequential matrices are given in appendices B and C. In every cel the observed (o) and expected (e) frequency and the standardized residuals ($(q) = (o - e)/\sqrt{e}$) are given.

The standardized residuals were used as a measure for association between behaviours. The dendrograms constructed from the cluster analysis for straw and crate reared gilts respectively showed two clusters, at an association level of 5.0 (fig. 5.9 and 5.10).

In straw reared gilts the behaviours nestbuilding, standing and sitting and exploration formed the first cluster. The other cluster included the behaviours sliding into, lying, nursing, delivery and expelling the placenta. All these behaviours directly are involved in the farrowing process. The other behaviours were more or less non-associated.

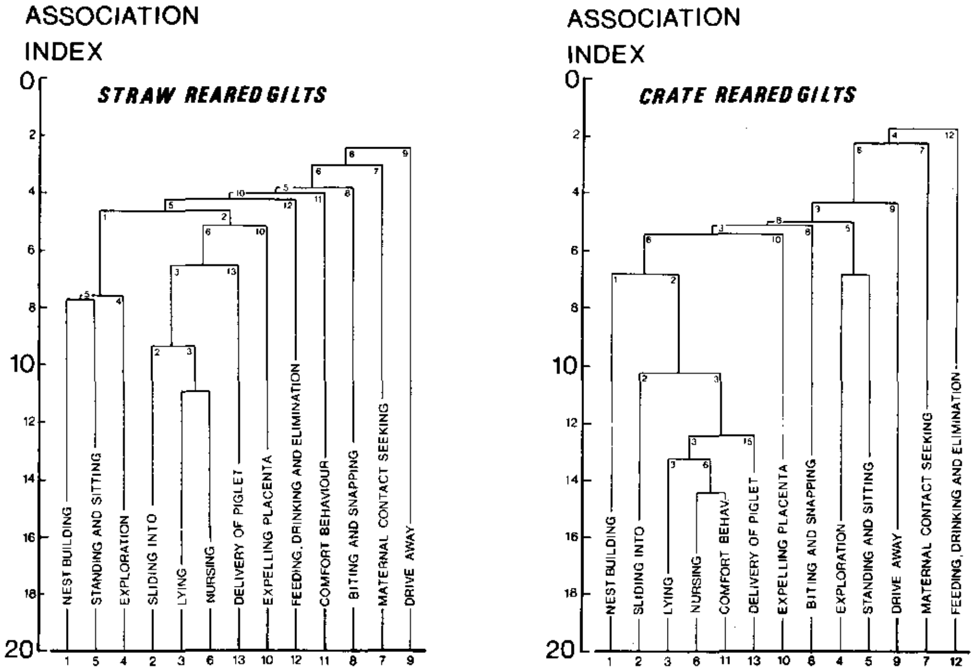


Fig. 5.9 and 5.10. Dendrograms from the cluster analysis on the behaviour of straw and crate reared gilts.
Ordinate, association index. Abscissa, numbers of the behaviours.

In crate reared gilts, exploration and standing and sitting were highly associated. Besides, another cluster of eight behaviours was found. Five of these behaviours were also associated in straw reared gilts, namely sliding into, lying, nursing, delivery and expelling the placenta. In crate reared gilts nestbuilding, comfort behaviour and biting and snapping were added to this cluster. In crate reared gilts only three behaviours were more or less non-associated.

5.4.2 Sequential analysis

The figure 5.11 and 5.12 give a schematic representation of the main positive within-animal first-order transitions during farrowing for crate and straw reared gilts respectively. Only the positive transitions with standardized residuals ≥ 3.00 are drawn; these are further referred to as clear transitions.

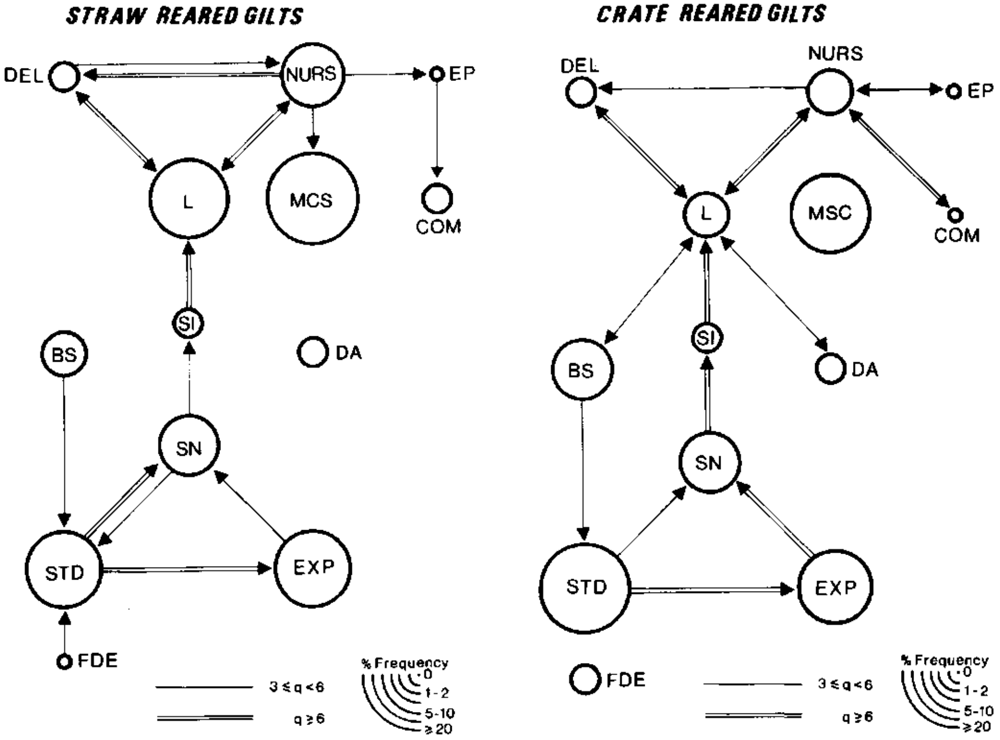


Fig. 5.11 and 5.12. Positive first order transitions with standardized residuals greater than or equal to 3.00, for straw and crate reared gilts separately, q= standardized residual. The radius of the circles reflects the frequency of behaviour as a percentage of the total frequency. For explanation of the abbreviations see page 78.

One hundred fifty-one transitions were possible: 169 cells minus 18 structural zero's. In crate reared gilts and in straw reared gilts 50 and 51 positive transitions respectively were found; 19 and 17 of these positive transitions respectively had a standardized residual $\geqslant$ 3.00. The absence of a clear transition does not mean that this transition does not occur. It might mean that the behaviours concerned occurred at a low frequency and/or were followed randomly by many other behaviours. An example is maternal contact seeking behaviour. This behaviour occurred relatively often but was not followed by any other behaviour more often then expected.

- Straw reared gilts

Starting with the delivery of a piglet, the probability that this is followed by nursing or lying was high for straw reared gilts. There appeared to be a strong relation between these behaviours, which was also evident from the cluster analysis. From nursing there was a clear transition to maternal contact-seeking behaviour. From lying and also from maternal contact-seeking behaviour a random transition to biting of and snapping at piglets could occur. If biting or snapping at piglets followed the gilts performed this behaviour mainly while standing or sitting. The cluster analysis showed a high association between these two behaviours. Once standing or sitting, the gilts were most likely to perform exploration and nestbuilding behaviours. These behaviours, directed towards the physical environment, changed into lying via sliding into. In the dendrogram, the two clusters revealed for straw reared gilts (fig. 5.9) were linked by nestbuilding and sliding into.

- Crate reared gilts

In the crate reared gilts the most likely behaviour after delivery of a piglet was lying. As in straw reared gilts lying was most likely followed by nursing, but in crate reared gilts the transition from lying to biting of or snapping at piglets appeared to be very likely also. As in straw reared gilts this increased the probability of standing and sitting mostly followed by exploration and nestbuilding. From the cluster analysis it appeared that biting and snapping was associated with lying and standing and sitting almost at the same level. As in straw reared gilts, crate reared ones came into the lying posture via sliding into.

5.5 Discussion

Crate reared and straw reared gilts did not show large differences in behaviour during the pre- and post-farrowing period. However, during farrowing some surprising behavioural differences between crate and straw reared gilts were found.

During the pre-farrowing period the activity of the straw reared gilts became very high on the last day before farrowing. In crate reared gilts this activity more gradually increased during the pre-farrowing period. An increase of activity towards farrowing was also found by Hansen and Curtis (1980), Baxter (1982), Vestergaard and Hansen (1983) and Lammers and de Lange (in press). One day before farrowing straw and crate reared gilts spent most of their activity on exploration and nestbuilding. This finding agrees with earlier reports that gilts and sows start nestbuilding mostly about 48 to 24 hours before farrowing (Van Putten, 1978; Baxter, 1982; Vestergaard and Hansen, 1983; Lammers and de Lange, in press). During observations it was noticed that exploration gradually merged into coordinated nestbuilding. The same observation was made by Baxter and Petherick (1980), Stingson (1981) and Baxter (1982). Exploration before farrowing might represent a searching for suitable nesting material and for a nesting site. The searching for a nesting site is seen in sows of the wild boar a few days before farrowing (Gundlach, 1968; Meynhardt, 1980). Searching behaviour was not very clear in the gilts observed; but then the gilts did not have much choice in the relative small pen. All nests were built in a corner of the pen as far from the dunging site as possible. Once the gilts had decided were to build their nests, nestbuilding behaviour was seldom interrupted by exploratory behaviour. Especially straw reared gilts were consistent in their nestbuilding. Crate reared gilts interrupted nestbuilding more often with standing and sitting and exploration. The direct consequence of this was that crate reared gilts performed less actual nestbuilding than straw reared gilts. One crate reared gilt did not even start nestbuilding. The amount of nestbuilding performed is probably important in reducing nestbuilding motivation. However, Hinde (1958) showed that in canaries the performance of nesting behaviour was not sufficient to reduce the nesting motivation. Hinde (1965) proved that tactile stimulation from the nest reduced nesting motivation in canaries. Richards (1965) reported the same for golden hamsters. Baxter (1982) proposed that this might be the case also for nesting behaviour in the sow. In sows the udder comfort given by the nest might be important. This may partly explain the higher nestbuilding activity during farrowing observed in the crate reared gilts. Because of the interrupted nestbuilding pattern one day before farrowing, nests of crate reared gilts may not be finished and therefore may not give the wanted udder comfort. This may again induce nestbuilding in crate reared gilts. The restlessness of crate reared gilts became even more clear during farrowing. While straw reared gilts spent most of the observation time lying on their side or bellies, crate reared gilts often interrupted this posture by standing and sitting.

The behaviour of crate and straw reared gilts during farrowing differed in organization. One important feature of cluster and sequential analyses is that they can give us an impression of how behaviour is organized. From the results of the cluster and sequential analysis the difference in organization of behaviour during farrowing between straw and crate reared gilts became clear indeed. Behaviours which obviously have a positive effect on farrowing, like lying, nursing, delivery of a piglet, expelling of the placenta and sliding into, belong in one cluster in straw reared gilts. To the above-mentioned behaviours crate reared gilts added nestbuilding and biting of and snapping at piglets, behaviours that are likely to interfere with farrowing. Another cluster of behaviours found in straw reared gilts contained behaviours directed towards the environment; exploration, nestbuilding and standing and sitting. In crate reared gilts nestbuilding and exploration formed a cluster. The two clusters were linked by sliding into and nestbuilding in straw reared gilts, and by biting of and snapping at piglets, and standing and sitting, in crate reared gilts. From the sequential analysis it became clear that for straw reared animals transitions from behaviours that have a positive effect on farrowing to behaviours directed towards the environment were rare, while in crate reared gilts these transitions were more likely to occur, especially via the biting of and snapping at piglets.

An interesting question is, of course, why the crate reared gilts were so restless the day before and during farrowing. To answer this, I believe we have to go back to the first eight weeks of life of the gilts. During this period straw reared gilts experienced an enriched environment, in contrast with crate reared gilts. From experiments with rodents, mostly rats, we know that animals reared in impoverished environments show fear in a open field and have problems with learning tasks (Woods, 1964; Morgan, 1973 and Gardner et al., 1975). Rats reared in an enriched environment show more behavioural flexibility than rats reared under standard laboratory conditions (Gardner et al., 1975). Recent investigations of Grandin (Curtis, pers.com.) showed that pigs reared from four weeks of age in a barren environment, but together with littermates, showed the same symptoms of fear and behavioural rigidity as found in rats. Direct effects were demonstrated by Stolba and Wood-Gush (1980, 1981): pigs in a barren environment reacted fearfully at the presentation of a novel object, while pigs in an enriched environment did not.

In crate reared gilts similar effects came to light in the period just before and during farrowing. Growing up in a barren environment probably made these gilts less capable to cope with the new situation, than gilts reared in an enriched environment.

For at least two reasons these findings are surprising. First, pregnancy and farrowing are known to be almost completely under endocrine and neural control. Nestbuilding in sows, for instance, coincides with a rise of prolactine and a decrease in progesterone (Taverne et al., 1979). Nestbuilding in sows can be induced by prostaglandine F2$_{\alpha}$ possibly mediated through the release of prolaction (Blackshaw and Blackshaw, 1982). The onset of parturition is probably largely under control of the foetus (First et al., 1982), and only fright and anxiety are known to delay farrowing in pigs as well as other mammals (Naaktgeboren, 1979). Secondly, from experiments with rats it is known that enriched environments in early life have a great influence upon brain size and the amount of neural connections (the wiring of the brain) and hence behaviour (Ferchmin et al., 1975; Rosenzweig and Bennet, 1977). Rats reared in an impoverished environment had smaller brain weights and less neural connections, especially in the cortex than rats reared in an enriched environment. This could also be the case for the crate reared gilts that experienced an impoverished environment during their first eight weeks of life. However, Rosenzweig (1967) found that in rats the cerebral effects of early-life impoverishment could be overcome by subsequent enrichment. From the age of eight weeks onwards, the crate reared gilts were kept in a pen with straw and three penmates. Thus before farrowing the crate reared gilts experienced an enriched environment for at least ten months. The effects of early rearing in an impoverished environment, if any, should have been compensated for during these ten months.

During the first eight weeks in the barren environment the piglets showed less synchrony of activity and more restlessness than piglets in the enriched environment (see chapter 3 and 4). Furthermore, the behaviour of the littermates in the barren environment appeared to be less predictable than the behaviour of those in the rich environment (see chapter 6 and 7). Although no physiological measures (e.g. cortisol levels) were taken, the situation in the barren environment appeared to be more stressful for the piglets. By standing and sitting the piglets in the barren environment could prevent unpleasant experiences, like being massaged or nibbled on by littermates (see chapter 3 and 6). In the barren environment standing and sitting behaviour, therefore, was adaptive. It seems likely that the crate reared gilts in a novel stressful situations, as their first farrowing probably was, started performing standing and sitting, which in early life had proven to be successful in preventing or ending an unpleasant situation; such a strategy might be called a regression (Freud, 1938; Hinde, 1966). This line of reasoning implies that the restlessness of the crate reared gilts during farrowing represents a form of coping, although, it cannot be considered adaptive in terms of survival value for the offspring. The duration of farrowing is known to increase in sows under stressful situations (Naaktgeboren, 1979 and Vestergaard and Hansen, 1984). Because no differences were found in farrowing duration between straw and crate reared gilts, there is no reason to believe that the crate reared animals were more stressed during farrowing than the straw reared gilts. However, straw and crate reared gilts do cope with the new situation in a different way. Littermates of the crate reared gilts that went to a fattening system, also performed more standing and sitting behaviour than the straw reared pigs in the same fattening system (see chapter 4). This supports the idea that standing and sitting is a way of coping behaviour typical for crate reared pigs.

During farrowing some gilts, straw as well as crate reared animals, showed signs of fear for the first piglets. When after delivery a piglet approached the head of the gilt, some gilts stood up and drew back while uttering deep grunts. Often biting and snapping at the piglets followed. The same course of events is also described by Pflug (1976), Brummer (1978) and Van Putten (1978). The crate reared gilts attacked their piglets more often during farrowing. The high frequency of biting and snapping of the piglets, as found in crate reared gilts, was enhanced by the high level of standing and sitting and nestbuilding, since this increased the likehood of encountering piglets. During their first eight weeks of life the piglets in the barren environment had showed more biting and snapping (pushing and ramming) than the piglets in the enriched environment (see chapter 3). Particularly after weaning this was often performed by the piglets when they were approached by a littermate. Unlike the piglets in large pens, piglets in small pens did not show much threat behaviour; moreover, an agonistic interaction often started without warning (see chapter 7). All this might explain why crate reared gilts more readily attacked their piglets than straw reared gilts did.

During the post-farrowing period the behaviour of the straw and crate reared gilts appeared to be very similar. The first day after farrowing, straw and crate reared gilts were observed lying on the side or belly for about 90% of the observation time. During the first day after farrowing the main activity of the gilts was nursing. The first two days post-farrowing, straw reared gilts spent more time nursing than crate reared gilts. This might be an effect also of the early rearing condition. During their own rearing period the crate piglets had tried to escape from being massaged and nibbled on by littermates. The tendency of the gilts to withdraw from being massaged and the need to suckle their piglets may now have put the gilts into a conflict situation. After the milk letdown these gilts were more likely to withdraw from being massaged by their piglets. However, this was only a temporary effect, because at the third day after farrowing crate and straw reared gilts did not differ in nursing anymore.

Only after recovery from farrowing on the first day did the gilts start feeding again and did they show some interest in their inanimate environment. However, exploration did not reach the pre-farrowing level. Obviously, the gilts spent a large part of their activity on nursing, probably at the cost of exploration time. Straw and crate reared gilts both still performed nestbuilding behaviour during the entire post-farrowing period observed. After an initial decrease in maternal contact-seeking on the first day after farrowing, the gilts showed an increased interest in their piglets. The restlessness of the crate reared gilts just before and during farrowing, completely disappeared in the post-farrowing period. This might mean that the crate reared gilts, if given the time, still are capable of adapting to new situations. The gilts were familiar with the pen in which they farrowed and the environment was relatively rich. It is likely that both these factors enhances the probability that the gilts were quickly put at ease. It would, therefore, be interesting to find out whether the restlessness found on the day before and during farrowing for the crate reared gilts, will be found again during subsequent farrowings. Crate reared animals that went to the fattening house (a relatively impoverished environment) continued to perform restlessness over the entire fattening period. This might be an indication that the restlessness, once acquired in an impoverished environment during early life, is likely to reoccur in later life under specific circumstances e.g. impoverished environment or farrowing.

5.6 Conclusions

Effects of rearing in a barren environment during the first eight weeks of life are revealed just before and during farrowing in gilts, even after the gilts have had about ten months of experience in an enriched environment.

Crate reared gilts apparently have learned to avoid or withdraw from an unpleasant situation by standing and sitting. This may be an adaptive strategy during the first weeks of life, but not so during farrowing, because it may have detrimental effects on the piglets.

Crate and straw reared gilts were probably stressed equally during their first farrowing, as no differences were found in farrowing duration.

CHAPTER 6

6. THE INFLUENCE OF BEDDING (STRAW) ON THE BEHAVIOUR OF PIGLETS

6.1 Introduction

A bedding of straw or woodshavings influence the behaviour of piglets in a positive way, since it reduces the amount of massaging or nibbling penmates; this has been shown many times (e.g. Van Putten and Dammers, 1976; Fraser, 1978; Buré, 1981 Schmidt and Adler, 1981). In the studies concerned, however, the bedding of the pens was not the only factor that varied. In some cases the behaviour of sucking piglets in a straw-bedded pen was compared with that of (early-)weaned piglets in a pen without any bedding at all (flatdeck or fully slatted floor). In these comparisons the area available per piglet was often not the same, pens with bedding being larger than those without bedding. This implies that other factors than bedding alone might have influenced the results.

In chapter 3 it was shown that in a pen without straw (farrowing crate) sucking as well as weaned piglets performed much massaging of or nibbling at littermates and sow. Furthermore, the exploratory behaviour of these piglets as compared with that of piglets living on straw appeared to be suppressed. This is not surprising, as the latter ones had more floor area per piglet than those in the farrowing crate. Moreover, the sow in the straw-bedded pen could move around freely and interact with her piglets. Thus, at least three factors might have influenced the results obtained in chapter 3. Klöppel et al. (1983) showed that sucking piglets in pens without straw also performed more massaging or nibbling littermates or sow than sucking piglets in straw-bedded pens of the same size. Algers (1979), who compared the behaviour of piglets weaned at three weeks and kept in a flatdeck, with that of piglets weaned at the same age but kept on straw found similar differences in behaviour as Klöppel et al. (1983) and Van Putten and Dammers (1976). These results indicate that the behavioural differences found between piglets on straw or in systems without any bedding, certainly have to do with the presence or absence of straw. However, in the above mentioned studies the developmental effect cannot be ruled out: during the entire observation period the piglets were kept either with or without straw. It is possible that in the course of successive weeks piglets without straw developed a habit of massaging of and nibbling at littermates or sow.

The following experiment was conducted to test the influence of straw, as an immediate and primary cause, on behaviour patterns of piglets. The size of the pens was held constant and the sows were always tethered. To exclude a confounding developmental effect all litters experienced alternating periods with and without straw.

6.2 Materials and Methods

Four pregnant gilts (GY X NL) served by a GY boar were used. Fourteen days before the expected farrowing the gilts were tethered by a breast girth in the farrowing pens. The gilts were fed at 08.00 and 16.00 hour according to usual standards. At the end of the third week of live, the piglets were fed creep feed. Water was available *ad lib.* via a nipple drinker. The light regime was 12/12 hr. light/dark, with lights on at 07.45 hour. The mean temperature in the stable varied between 17 and 23°C and the relative humidity oscillated between 55 and 71%. The farrowing pens measured 2.00 X 2.18 m^2 and had a concrete floor. In one of the corners of the pen a rubber mat was presented in the no-straw condition only to give the piglets some lying comfort.

The litters were culled to eight piglets. The piglets were individually marked by numbers in the ear and the back. Two litters were given straw during the first two weeks and two other litters were not. After the second week, the bedding was changed each week; litters without straw obtained straw and from the pens with straw all straw was carefully removed (see table 6.1).

Table 6.1. Experimental design

	Week				
Litter	1/2	3	4	5	6
1	Straw	Bare	Straw	Bare	Straw
2	Bare	Straw	Bare	Straw	Bare
3	Straw	Bare	Straw	Bare	Straw
4	Bare	Straw	Bare	Straw	Bare

Observations began in the third week. The litters were observed for four days on either straw or bare concrete. The change from straw to bare floor or vice versa took place on Thursday at 08.00 hr. After this change the litters were observed for two consecutive days. These days are referred to as S1 days (first two days on straw) or B1 days (first two days on bare concrete floor). After a two days interval the litters were again observed for two consecutive days. These days are referred to as S2 and B2 days respectively. The S1 and S2 days taken together form the straw weeks; likewise the B1 and B2 days were combined to represent the bare floor weeks. Per observation day the litters were observed for two 30-minutes periods; one between 09.00 and 13.00 hour and one between 13.00 and 17.00 hour. These observation periods differed in time from day to day in order to minimize the effect of a diurnal rhythm on the behaviour scores. Every two minutes the behaviour of each piglet was once recorded, which results in 30 samples per piglet per day. The behaviour of the piglets was stored in a "MORE" (Observational Systems, Seattle) by a two-digit code. All computations were made in a DEC-10 computer.

6.2.1 Ethogram of the piglets

Lying:	Lying on the side or belly without performing any other behaviour described or lying with a teat of the sow in the mouth without massaging or sucking it; the piglet often is asleep.
Standing and sitting	Standing or sitting without performing anyother behaviour described.
Sucking:	At least 5 piglets being active at the udder while the sow is lying in the nursing posture (lying on the side with fully exposed udder).
Activity at the udder:	Being active at the udder when the sow is not in nursing posture or when no more than four piglets are active at the udder with the sow in nursing position.
Agonistic behaviour:	All agonistic interactions like headknocks, biting or fighting.
Massaging and nibbling littermates:	Massaging, nibbling, rooting or sucking any part of the body of a littermate. This category includes tail-biting.

Nosing littermates:	Nosing any part of the body of a littermate.
Massaging and nibbling sow:	Massaging, nibbling, rooting or sucking any part of the body of the sow, excluding the udder.
Nosing sow	Nosing any part of the body of the sow.
Exploration:	
Sniffing objects:	Sniffing, nibbling, rooting or sucking any object in the pen above floor level.
Sniffing substrate:	Sniffing, nibbling or sucking the substrate or bedding.
Chewing:	Chewing straw or other particles with the head free from the floor.
Rooting:	Moving the snout over the floor or objects with horizontal movements. The rooting disc is pressed with some force against floor or object.
Others:	All not-mentioned behaviours.
Activity:	Activity is defined as the total frequency (sum of all samples per piglet) scored minus lying.

In the analysis the behaviours massaging or nibbling littermates and sows were combined with activities at the udder and exploration. This combination represents the total of exploratory and "redirected" exploratory behaviours (van Putten and Dammers, 1976). This was done to find out whether the redirected exploratory behaviours compensate for the reduced opportunity to explore in a barren environment.

The frequency scores of the separate active behaviours of the piglets were expressed as percentages of the total frequency of activity of the piglets. The differences in behaviour of the piglets on straw or on bare floor were tested by the Wilcoxon Matched-Pairs test (Siegel, 1956).

6.3 Results

For each piglet the mean score of the behaviours during straw weeks and during bare floor weeks were calculated separately. The differences between these means were tested with the Wilcoxon matched-pairs test. Table 6.2 shows the median of these mean scores for the 32 piglets during straw and bare floor weeks.

Table 6.2. Median scores expressed as percentages of total activity.

	Straw weeks	Bare floor weeks	$p \leqslant$
Standing and Sitting	1.1	4.3	0.0001
Activities at the udder	7.0	10.2	NS
Agonistic behaviour	5.0	6.4	NS
Sniffing objects	2.6	6.6	0.0001
Sniffing substrate	35.0	14.7	0.0001
Chewing	2.6	0.8	0.0001
Rooting	8.3	3.2	0.005
Massaging and nibbling littermates	0.7	2.2	0.0001
Massaging and nibbling sow	0.0(0.6)	1.5	0.005
Nosing littermates	0.9	1.3	NS
Nosing sow	1.2	1.9	NS
Massaging and nibbling littermates or sow	1.5	4.3	0.0001
Exploration	45.6	27.7	0.0001
Exploration + massaging and nibbling littermates or sow	47.8	35.2	0.0001
Exploration + massaging and nibbling littermates or sow + activities at the udder	56.6	43.9	0.0001
Lying*	58.7	58.6	NS

* Expressed as percentage of the total frequency; () mean value.

No differences were found between straw and bare floor weeks in the amount of lying. Except for sniffing at objects all exploratory behaviours were scored more often during straw weeks than during bare floor weeks. Massaging and nibbling at littermates and/or sow, and standing and sitting (restlessness) were scored more frequently during the bare floor weeks than during the straw weeks. Nosing littermates and sow, activities at the udder, and agonistic behaviour did not differ significantly between either straw or bare floor weeks.

To find out whether the differences in behaviours between both groups of piglets were already apparent shortly after the change in the environment, the scores were tested for differences between successive B2 and S1 days and S2 and B1 days. Possible changes in behaviour during a week on straw or on bare floor were assessed by testing differences in the mean scores between S1 and S2, and B1 and B2 days respectively. Table 6.3 and 6.4 summarize the findings. Note that the values of the same behaviours in table 6.3 and 6.4 are not the same, for table 6.4 all observation days were used in contrast to table 6.3: in the latter only those days just before and after a change in substrate could be used.

Table 6.3. Effects of changing the substrate. Medians of the mean score of behaviour from 32 piglets are given for the transition from bare to straw condition (B2-S1, first three columns) and vice versa (S2-B1, last three columns).

	B2	S1	p	S2	B1	p
Standing and sitting	4.5	0.0(1.1)	***	0.0(1.8)	3.5	*
Agonistic behaviour	7.3	7.1	NS	3.8	7.9	*
Sniffing objects	6.1	3.0	*	3.5	6.5	**
Sniffing substrate	17.0	34.6	***	29.3	20.7	*
Chewing	0.0(1.4)	5.1	***	1.9	0.0(0.8)	**
Rooting	4.2	8.3	NS	10.8	3.7	***
Massaging or nibbling littermates	3.3	0.0(0.9)	***	0.0(1.4)	3.0	**
Massaging or nibbling sow	0.0(2.2)	0.0(0.6)	*	0.0(0.9)	0.0(0.9)	NS
Nosing littermates	0.6	0.0(1.2)	NS	0.0(1.3)	3.1	*
Massaging or nibbling littermates or sow	6.1	0.0(1.4)	***	0.0(2.3)	3.2	*
Exploration	34.6	48.8	***	53.5	34.1	***

* $p<0.05$; ** $p<0.01$; *** $p<0.001$ ( )mean value

Table 6.4. Development of behaviour per condition. The medians of mean score of behaviour from 32 piglets for the straw condition (S1, S2) and for the bare floor condition (B1, B2) are given.

	S1	S2	p	B1	B2	p
Standing and sitting	0.0(1.5)	1.6	NS	3.3	4.5	*
Agonistic behaviour	6.2	3.2	**	6.4	6.4	NS
Rooting	6.2	9.6	*	3.4	3.7	NS
Massaging or nibbling sow	0.0(0.5)	0.0(0.7)	NS	0.0(1.0)	2.0	**

* $p<0.05$; ** $p<0.01$; ( ) mean value

Most of the changes in the behaviour scores as found between straw and bare floor conditions were apparent immediately after the change in environment took place. Standing and sitting, sniffing objects, massaging and nibbling sow, and massaging and nibbling littermates increased instantly after the change from straw to bare floor, and decreased again soon after the reverse change. Sniffing substrate, chewing and the total score of all exploratory behaviours (exploration) decreased instantly after the change from straw to bare floor, and increased soon after the reverse.

Within a bare floor week standing and sitting, and massaging and nibbling the sow increased. Within a straw week agonistic behaviour decreased but rooting increased. Furthermore, agonistic behaviour and rooting changed significantly only during changes from straw to bare floor: agonistic behaviour increased and rooting decreased. Nosing littermates, for which no effect of condition was found, increased only after a change from straw to bare floor. Massaging or nibbling sow decreased only after a change from bare floor to straw.

6.4 Discussion

Repeatedly changing the environment from rich to barren and vice versa resulted in consistent changes in behaviour of sucking piglets. The differences in behaviour between piglets in either an enriched or barren environment proved to be independent from the stage of development of the piglets, at least until an age of six weeks. Thus, the differences in behaviour in the two conditions were mainly caused by the presence or absence of suitable bedding in casu straw.

In accordance with earlier reports (Buré, 1981; Van Putten and Dammers, 1976; Schmidt and Adler, 1981) and the results presented in chapter 3, the total amount of activity was not influenced by the environment. However,the occurrence of specific behaviours was dependent upon the absence or presence of straw. Exploratory behaviours, standing and sitting, and intensive contacts between littermates and sow were strongly influenced by environmental conditions. On straw, the piglets performed more exploratory behaviours that were directed towards the straw. Except for rooting the effects were found immediately after both changes from straw to bare floor or vice versa; within the straw or bare floor conditions changes did not occur. However, within a straw week rooting increased, whereas after the change from straw to bare floor it immediately decreased. Rooting, a species-specific behaviour of pigs, is always performed, irrespective of the environmental conditions. Even on a bare concrete floor rooting still occurs at a relative high level (see chapter 3). The change to a system with a bedding suited to root in, increases this behaviour but only gradually. After the change from straw to bare floor rooting is not reinforced any more and, therefore, it decreases rapidly.

Sniffing objects was the only exploratory behaviour performed more in bare floor conditions than in straw conditions. Exploratory behaviour was generally directed toward the bedding and only for a small part towards other objects in the pen. Presumably when the bedding does not offer enough stimulation the piglets explore objects in the pen more intensively. However, the increased level of sniffing objects in the bare floor situation did not entirely compensate the decrease in exploration of the bedding. Perhaps the objects in the pen did not match the expectations of the piglets; this might have induced a search for more suitable objects to explore. In this context, then, it is not surprising that almost immediately after the change from straw to bare floor the animals showed an increase in massaging of or nibbling at littermates and sow.

Nosing littermates increased after the change from straw to bare floor and might be considered introductory to massaging of and nibbling at littermates. Massaging of and nibbling at sow, although not performed very frequently, increased during a bare floor week. This might mean that the amount of massaging of or nibbling at littermates alone was not sufficient to match the exploratory needs of the piglets; consequently, in their search for further exploration of the environment the sow became the last goal area. A second reason why piglets started to use the sow as a substrate, might be the fact that during a bare floor period the piglets gradually avoided being massaged and nibbled at by their littermates. This promoted the piglets using the sow who could not as easily prevent this behaviour of the piglets. Massaging of or nibbling at littermates and/or sow can indeed be considered as redirected exploratory behaviour, as explained by van Putten and Dammers (1976) and Ruiterkamp (1985). Nevertheless, during bare floor weeks the total score of exploratory behaviours, including the behaviours considered redirected exploratory behaviours, was still much smaller than during the straw weeks (35.2% versus 47.8%). This indicates that redirected exploratory behaviours are actually second choice and are unable to maintain the level of exploration normally found in a relatively rich environment.

Agonistic behaviour tended to be more frequent (p=0.064) during bare floor weeks than during the straw weeks. A direct effect of changing from straw to bare floor was found also: immediately after this change the piglets showed an increase in agonistic behaviour. The piglets seemed to be irritated. During a straw week the agonistic behaviour decreased again. This was mainly due to a high level of scampering and related "play-fighting" immediately after the change from bare floor to straw, which behaviours decreased gradually in the course of the straw week. Interestingly, the score for activity at the udder did not differ greatly between bare floor and straw weeks. This implies that the difference for this behaviour between straw pen and farrowing crate as described in chapter 3 was induced by the confinement of the sow.

6.5 Conclusions

The behaviour pattern of active piglets strongly depends on the presence or absence of suitable bedding.

If no suitable bedding is present, piglets redirect their exploratory behaviour towards littermates and sow.

However, exploratory behaviour in a barren environment cannot be fully satisfied by alternatives used by the piglets.

There is more standing and sitting and thus restlessness in the animals in an impoverished environment than in an enriched environment.

In an impoverished environment piglets are more likely to perform agonistic behaviour.

CHAPTER 7

7. EFFECT OF PEN SIZE ON THE DEVELOPMENT OF AGONISTIC BEHAVIOUR IN PIGLETS

7.1 Introduction

Besides the lack of substrate that can be manipulated by the piglets (e.g. straw) the floor area per piglets appears to influence the behaviour of piglets.

During the observation of piglets in either a spacious pen or a farrowing crate (chapter 3) it was observed that the piglets in the farrowing crate showed agonistic behaviour different from that of the piglets in the spacious pen. Because of the concise ethogram of agonistic behaviour used in these observations, no quantitative differences in agonistic behaviour between the two housing systems could be demonstrated.

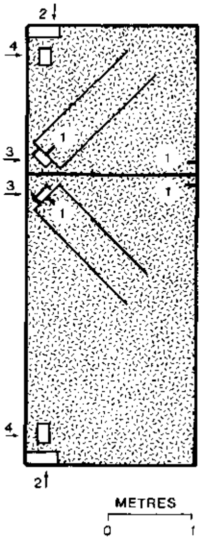
The present experiment was carried out to analyse this point in more detail and to investigate the effects of pen size on the development of agonistic behaviour in piglets.

7.2 Material and methods

A pen of 28 m^2 is used as a reference housing system (Van Putten, 1977b). In such a pen the piglets should have ample opportunity to develop a normal agonistic behaviour. The development of agonistic behaviour in piglets in a pen of 3.5 m^2 and 6.7 m^2 respectively is compared with that occuring in the reference condition. The 3.5 m^2 pen resembles the smallest pens used in farm-practice.

In the 28 m^2 pen one litter of nine piglets ((NL X GY) x GY) was observed during the first five weeks of life. In the 6.7 m^2 pen one litter of eight piglets (NL x GY); in the 3.5 m^2 pen two litters of seven and eight piglets respectively (NL x GY) were observed during the first eight weeks of age of life (see fig. 7.1 for the ground plan of the 3.5 and 6.7 m^2 pens and figure 2.3 on page 5 for the groundplan of the 28 m^2 pen).

All pens were provided with straw that was replenished once a day. The pens were all in the same room. The light regime was on a 12/12 hr light/dark scheme with lights on at 08.00 hr. The sows were fed twice a day according to practical standards. The piglets were fed creep feed from day 21 onwards. For both sows and piglets water was available *ad lib.*. The temperature in the stable varied between 16-20^{o}C. The sow in the 28 m^2 pen could move around freely, in the other pens the sows were tethered by a breast girth. On several post partum days video recordings were made of interactions between piglets (see table 7.1).



1. Nipple drinker
2. Creep feeder
3. Trough (sow)
4. Brood heater

Fig. 7.1. Groundplan of the 3.5 and 6.7 m^2 pen

Table 7.1. Days after birth of the piglets on which video recordings were made.

	Weeks					
Pen size	1		2	3	5	8
28 m^2	1,2,3	4,5,6,7	13,14	20,21	34,35	
6.7 m^2	2,3	5,8	12,15	19,22	33,36	50,51
3.5 m^2	2,3	5,6,7,8	12,13,14	20,21	33,34,35	50,51,52

When the video recordings were made, the pens were illuminated by one or two 800 Watt film spots. The recordings were made with a Sony color video camera DXC-1640p and a Sony SL-C7E Betamax recorder. By means of a date-time generator (FOR.A VTG-33) date and time were written into the video picture with a exactness of 0.1 second. During the active periods of the piglets as many interactions as possible were recorded.

Interactions during sucking or during which one of the piglets was lying or standing for more than 50% of the time were not analysed. After all recordings were gathered a selection of interactions to be analysed was made. Only interactions of the same pairs of piglets that were available over the entire five or eight weeks were selected. For the 28 m^2 pen nine pairs and for the 6.7 m^2 and 3.5 m^2 pens ten pairs could be selected. An interaction between piglets was operationally defined as follows: an interaction started two seconds before the first physical contact between the piglets and ended two seconds after the last physical contact. The last physical contact was the contact not followed within ten seconds by a physical contact between the same piglets. If during an interaction the two piglets had contact with another piglet for more than three seconds the interaction was not analysed. The video recordings were played back in slow motion and every second the behaviour of the two piglets was registrered. When within a second more behaviours were observed, the behaviour with the longest duration was noted down. The behaviour of both piglets in the interaction was stored in a "More" (observational systems, Seattle) and analysed with a DEC-10 computer.

7.2.1 The ethogram

The ethogram was based on the ethograms of Gundlach (1968), Jensen (1980) and Dijk (1983). A total of 39 different behavioural elements were scored. For the sake of brevity only those elements or groups of elements used in the final analysis will be discussed.

Nosing piglet. Nosing any part of the body of a piglet.
Standing in front. Two animals are standing in front of each other, head to head. The head is down and sniffing substrate or bedding is possible.
Walk to. Moving towards a piglet.
Retreat. Moving or turning away from a piglet.
Exploration. Sniffing, touching, rooting or nibbling substrate, bedding or objects in the pen.

Standing. The animal is standing without performing any other behaviour described.

Headknock. A horizontal or vertical knock with the head or a forward thrust with the snout toward another piglet.

- Headknocks were further divided into:

1) Headknocks with biting and 2) Headknocks without biting.

- Headknocks could be directed at various parts of the body of a piglet:

3) Headknocks directed towards the anogenital region or the back and
4) Headknocks directed towards the head or shoulders of a piglet.

- The position of the piglets with respect to each other during an interaction with headknocks was also noted.

The piglets were either standing (anti-)parallel or not (anti-) parallel while performing a headknock.

Others. All not described behaviour or behaviour in ambiguous situations.

7.2.2 Analyses

Differences between pens were tested by the Mann-Whitney U test. Differences between weeks within pens were tested by the Wilcoxon Matched-pairs test (Siegel, 1956).

7.3 Results

The development of agonistic interactions in piglets. Table 7.2 shows the number of interactions analysed for the three different pen sizes.

Table 7.2. Total number of physical interactions analysed per week of age for each of the three pen sizes.

Pen sizes	1	Weeks	2	3	5	8	Pen total
28 m^2	53	68	59	43	17		240
6.7 m^2	61	57	58	59	57	58	350
3.5 m^2	54	57	53	55	50	53	322
						Total	912

During week 5 only a few interactions between the piglets in the 28 m^2 pen were found. The mean duration of the physical interactions week is presented per week in fig. 7.2.

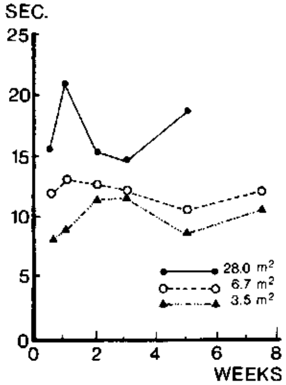


Fig. 7.2. The mean duration of the physical interactions. Abscissa: age of piglets in weeks. Ordinate: mean duration in seconds.

The mean duration of the physical interactions was always longer in the 28 m^2 than in the 3.5 or 6.7 m^2 pen per week (Man-Whiteney U, MWU; 28 m^2 versus 6.7 m^2 and 3.5 m^2, $U = 0$, $p < 0.05$, $n1 = 5$, $n2 = 6$).

The mean duration of physical interaction was longer in the 6.7 m^2 pen than in the 3.5 m^2 (MWU, $U = 4$, $p < 0.05$, $n1 = n2 = 6$). In the 3.5 m^2 pen the mean duration of physical interactions increased from the first half of week 1 to week 3 (Wilcoxon, $T = 7$, $p < 0.05$, $n = 10$). The most frequent behaviours recorded during the interactions were: nosing, headknocks, standing in front and exploration.

Nosing was frequently scored during the first week and decreased sharply during the later observed weeks. No differences were found between the different pen sizes (fig. 7.3).

Headknocks were most frequently recorded at the end of week 1 in the pens of 6.7 m^2 and 28 m^2. In the pen of 3.5 m^2 the maximum frequency of headknocks was found in week 2 (figure 7.4).

Fig. 7.3 and 7.4. Percentages of total observation time nosing and headknock were scored. Abscissa, age of the piglets in weeks; Ordinate, percentage of total observation time.

In the first week piglets in the 28 m^2 pen performed more headknocks than piglets in the 3.5 m^2 (MWU, first three days of week 1, U = 17, $p < 0.05$; other days of week 1, U = 11, $p < 0.05$, n1 = 9, n2 = 10). At the end of week 1 more headknocks were scored in the 6.7 m^2 pen than in the 3.5 m^2 (MWU, U = 18, $p < 0.05$, n=10). In the 6.7 and 28 m^2 pen the frequency of headknocks tended to increase within the first week. Only in the 3.5 m^2 pen the increase in frequency of headknocks from the first three days of week 1 to week 2 was significant (Wilcoxon, T = 4, $p < 0.05$, n = 10). In all pens the relative frequency of headknocks decreased from week 3 to week 5 (Wilcoxon, both 3.5 m^2 and 6.7 m^2, T = 7, $P < 0,05$, n = 10: 28 m^2, T = 3, $p < 0.05$, n=9).

During the entire observation period standing in front was scored at a very low level in the 3.5 m^2 pens. This behaviour was scored for the first time in week 2 in the 3.5 as well as 6.7 m^2 pen. In the 28 m^2 pen it was already scored during week 1 (fig. 7.5).

Standing in front occurred always more often in the 28 m^2 than in the 3.5 m^2 pen (MWU, U = 0, p=0.05, n1 = 5, n2 = 6). Only in week 5 and 8 the differences in standing in front between the 3.5 and 6.7 m^2

pen became significant (MWU, week 5: U = 11.5, p<0.05, n=10; week 8: U = 1.5, p<0.001, n=10). In week 5 more standing in front was found in the 28 m^2 pen than in the 6.7 m^2 pen (MWU, U = 11.5, p<0.05, n1 = 9, n2 = 10).

Fig. 7.5 and 7.6. Percentages of total observation time standing in front and standing were scored.
Abscissa: age of the piglets in weeks. Ordinate: percentage of total observation time.

During the first two weeks no differences were found in the relative frequency of standing (fig. 7.6). From week 3 onwards standing was always more frequent in the 3.5 m^2 pen than in either the 6.7 m^2 or the 28 m^2 pen (MWU, 3.5 m^2 versus 6.7 m^2 week 3, U = 11.5, p<0.05; week 5, U = 21, p<0,05; week 8, U = 16, p<0.05, n=10) (MWU 3.5 m^2 versus 28 m^2, week 3, U = 16, p<0.05; week 5, U = 10, p<0.05, n1 = 9, n2=10). In the 6.7 m^2 and the 28 m^2 pen standing decreased with age of the piglets (Spearman Rank correlation, 6.7 m^2 r_s = -0,96, p< 0.01, n=6; 28 m^2, r_s = -0.90, p=0.05, n = 5).

The relative frequency of exploration during interactions between piglets did not differ per pen size. On the average exploration was higher after week 2 than before (see table 7.3).

Table 7.3. Mean relative frequency of exploration before and after week 2.

	Week 1 to 2	Week 3 to (5) 8	Wilcoxon		
Pen size			T	P <	N
3.5 m^2	5.4%	19.5%	0	0.01	10
6.7 m^2	8.4%	16.2%	0	0.01	10
28 m^2	6.0%	11.3%	3.5	0.05	9

The amount of headknocks associated with biting (fig. 7.7) decreased with age of the piglets in the 6.7 and 28 m^2 pen (Spearman Rank correlation, 6.7 m^2, $r_s = -0.93$, $p<0.05$; 28 m^2 pen: $r_s = -0.90$, $p=0.05$).

Fig. 7.7A and 7.7B. Left panel the percentage of all headknocks that are associated with biting over the age of the piglets in weeks; right panel the percentage of all headknocks not from the (anti-)parallel position over the age of the piglets in weeks. Abscissa, age of the piglets in weeks.

In the 3.5 m^2 pen headknocks associated with biting decreased from week 2 to week 8 (Spearman Rank correlation, $r_s = -1$, $p=0.05$).

The position from which the piglets performed a headknock was mostly (anti-)parallel, particularly so in the 6.7 and 28 m^2 pen. In the 3.5 m^2 pen there was relatively much head-knocking from a not (anti-) parallel position (fig. 7.7B). From week 2 onwards in the

3.5 m^2 pen about 32% of the headknocks were performed from the non (anti-) parallel position. These headknocks increased sharply from the end of week 1 to week 2 (Wilcoxon, $T = 0$, $p<0.01$, $n=10$).

In the 6.7 m^2 and the 28 m^2 pen, the part of the headknocks placed on the back or ano-genital region decreased sharply with age of the piglets (Spearman rank correlation, 6.7 m^2: $r_s = -0.94$, $p=0.01$; 28 m^2: $r_s = -1$, $p=0.01$; fig. 7.8).

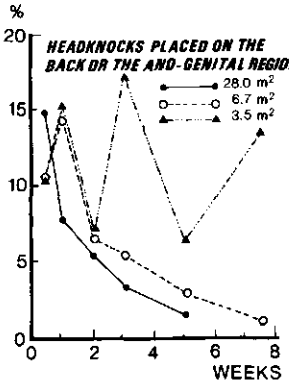


Fig. 7.8. Percentage of all headknocks placed on the back or the ano-genital region. Abscissa: age of the piglets in weeks.

Less than 2% of the headknocks were placed on the back or ano-genital region during week 5 in the 28 m^2 pen and week 8 in the 6.7 m^2 pen. In the 3.5 m^2 pen the percentage of headknocks placed on the back or ano-genital region was on the average 12%; it did not show a decrease during development of the piglets.

The development of standing in front and the differences between the pen sizes suggested that standing in front might be regarded as a threat behaviour. If this were true, it might be expected that within a piglet it would often preceed a headknock. Table 7.4 gives the percentages of the frequency of all behaviours preceding a headknock within a piglet during week 1 and the weeks 2 + 3 and 5 + 8 (for the 28 m^2 pen data from week 8 were not available).

Table 7.4. Proportion of behaviours immediately preceding headknocks.

	Weeks		
Pen size	1	2 + 3	5 + 8
$3.5\ m^2$			
Nosing	26.6%	11.0%	6.3%
Standing in front	--	4.3%	3.9%
Walk to	7.3%	12.3%	15.5%
Standing	33.0%	36.3%	32.4%
Exploration and others	33.0%	36.0%	42.0%
$6.7\ m^2$			
Nosing	18.9%	10.3%	3.8%
Standing in front	--	8.8%	29.5%
Walk to	7.0%	12.2%	7.6%
Standing	44.3%	35.3%	25.4%
Exploration and others	29.9%	33.4%	33.7%
$28\ m^2$			
Nosing	11.1%	6.8%	4.4%
Standing in front	2.8%	9.2%	37.8%
Walk to	4.6%	8.8%	4.4%
Standing	50.0%	49.0%	31.1%
Exploration and others	31.5%	26.2%	22.2%

Within the first week a headknock was mostly preceeded by standing, exploration and others (behaviours not specified) or nosing. During the weeks 2 and 3 standing and exploration and others still often preceded a headknock, but now walk to became more prominent. During week 2 in the 3.5 m^2 and 6.7 m^2 pen standing in front became part of the physical interactions between piglets for the first time. However, only to a small extent did it precede a headknock. In the 28 m^2 pen standing in front preceded a headknock more often than nosing. During week 5 and 8 in all pens standing and exploration and others, still often preceded a headknock, but in the 6.7 and 28 m^2 pen standing in front increasingly preceded a headknock. In the 28 m^2 pen standing in front preceded a headknock even in 37.8% of all cases. In the 3.5 m^2 pen standing in front hardly developed at all and only in 4% of all cases preceded a headknock. In the 3.5 m^2 and 6.7 m^2 a headknock was mostly preceded by exploration plus others, while in the 28 m^2 pen exploration and others preceded a headknock in only 22.2% of the cases.

In the 6.7 m^2 pen and the 28 m^2 pen the frequency of standing and exploration and others preceding a headknock decreased with age of the piglets. In the 3.5 m^2 the frequency of exploration and others preceding a headknock increased with age of the piglets, while standing preceding a headknock was not different for between week 1 and 5 + 8. In the 6.7 m^2 and the 28 m^2 pen standing in front increasingly preceded a headknock during the development of the piglets. However, this still does not show that standing in front is a threat behaviour. To demonstrate the effectiveness of standing in front as a threat, the behaviour of the opponent might give an answer. However, transitions of frequencies of behaviour between piglets was not considered in this study.

However, also from the transitions of behaviour within a piglet one can also get an impression as to whether standing in front may be a threat behaviour.

If standing in front is a threat behaviour, one might expect that within an animal it is followed either by a headknock if the opponent does not retreat, or by exploration plus others, if the opponent retreats; in the latter case the threatening animal continues its former behaviour. Table 7.5 gives the percentages of the frequencies of behaviours following standing in front in the same animal.

During week 2 + 3 and 5 + 8 in the 6.7 m^2 as well as 28 m^2 pens standing in front indeed was followed mostly by a headknock or exploration and others. During week 2 + 3 in the 3.5 m^2 pen standing in front was mostly followed by a headknock or standing and during week 5 + 8 by a headknock and, exploration and others.

Table 7.5. Proportion of behaviours immediately following standing in front in the same animal.

Behaviour	Pen size	Weeks 1	Weeks 2 + 3	Weeks 5 + 8
	m^2	%	%	%
Headknock	28	16.7	31.4	43.7
	6.7	--	50.0	51.9
	3.5	--	39.0	50.0
Exploration and others	28	9.3	27.9	32.7
	6.7	--	22.4	23.4
	3.5	--	9.1	25.0
Standing	28	31.5	20.9	18.4
	6.7	--	19.0	19.0
	3.5	--	18.2	18.8
Retreat	28	3.7	11.6	12.2
	6.7	--	5.2	7.0
	3.5	--	9.1	0
Nosing	28	38.9	8.1	2.0
	6.7	--	3.4	1.3
	3.5	--	4.5	6.3
Number of interactions	28	54	86	49
	6.7	0	58	158
	3.5	0	22	16

After the first week in all pens the percentage of the frequency of standing following standing in front was fairly constant (18-20%). Retreat followed standing in front at a low but with age in the 6.7 m^2 and 28 m^2 pens increasing frequency.

The analysis of interactions between piglets in the way described in the material and methods section, is very time consuming. I shall discuss a simplified method to obtain an impression of the development of agonistic behaviour between piglets. Using the same data as described above, five types of interactions were distinguished. The types of interactions were named after the behaviours that had to be present during the interaction; see table 7.6.

Table 7.6. Classification of types of interactions.

	Behaviours				
Type of interaction	Standing in front	Nosing	Headknocks	Gallop	All other behaviours
1 Standing in front	+	o	o	o	o
2 Nosing	-	+	-	o	o
3 Headknocks	-	-	+	-	o
4 Headknocks + nosing	-	+	+	-	o
5 Headknocks + gallop	-	o	+	+	o

+ Behaviour must be present during interaction

- Behaviour must be absent during interaction

o Behaviour may be present during interaction.

Table 7.7 gives the percentages of the five types of interactions over weeks and per pen sizes.

Table 7.7. Percentages of types of interactions

		Weeks		
Type of interaction	Pen size	1	2 + 3	5 + 8
1. Standing in front	28 m^2	13.2	33.3	64.7
	6.7 m^2	---	17.9	51.3
	3.5 m^2	---	9.3	6.8
2. Nosing	28 m^2	30.6	19.6	11.8
	6.7 m^2	40.8	16.2	7.0
	3.5 m^2	49.5	17.6	13.6
3. Headknocks	28 m^2	11.6	15.6	0
	6.7 m^2	10.8	25.6	19.1
	3.5 m^2	15.3	28.7	43.7
4. Headknocks plus nosing	28 m^2	43.0	22.5	17.6
	6.7 m^2	36.7	26.5	13.0
	3.5 m^2	27.0	27.8	26.2
5. Headknocks plus galop	28 m^2	1.7	8.8	5.9
	6.7 m^2	11.7	13.7	9.6
	3.5 m^2	8.1	16.7	9.7

The type of interaction containing only nosing (type 2) decreased with age of the piglets. Pen size hardly influenced this type of interactions. In the 6.7 and 28 m^2 pen the type of interactions with only headknocks or headknocks plus nosing (type 3+4) decreased with age. In the 3.5 m^2 pen interactions containing only headknocks (type 3) increased with age, and interaction with headknocks plus nosing (type 4) were very stable over age. The type of interactions containing standing in front (type 1) increased sharply over the weeks in the 6.7 m^2 and 28 m^2 pens. In the 3.5 m^2 pen the amount of this type of interactions was low. In week 2 + 3 in all pen sizes the highest percentage of interactions with headknocks plus gallop (type 5) was found. These interactions decreased from week 2 + 3 to week 5 + 8 in all pens.

7.4 Discussion

The duration of a physical interaction between piglets appeared to be longer with increasing pen size. The shorter duration of the interactions in pens of 3.5 and 6.7 m^2 were mainly due to obstacles in the pen and the close proximity of littermates, since interacting piglets often lost contact because of these obstacles (iron bars which confined the sow) or because littermates came in their way. In the 28 m^2 pen the piglets could choose and indeed preferred to interact with each other in open space. The same was observed in piglets in the pens of 3.5 and 6.7 m^2, but their open space apparently was too small to enable them to avoid littermates or obstacles.

Agonistic interactions between piglets must not be too short. When these are very short, the possibility exists that nothing is learnt from the reaction of the opponent and the effects of the piglet its own behaviour. If, for instance, piglets are engaged in mutual headknocks and one of the piglets suddenly disappears behind a littermate or an obstacle, both piglets often go on performing headknocks. Neither of the animals may have learnt anything, except that littermates can vanish into thin air when headknocks are given. When the piglets have enough room, after some time one of the piglets is likely to give up. It stops performing headknocks and turns away. This will be noticed by the opponent, who in most cases will also stop performing headknocks. Over time the animals will have learned that: 1) by turning away or stopping the headknocks, interactions are controllable, 2) turning away or stopping headknocks can be signals from the opponent to end the interaction.

As described in chapter 3, mutual recognition (nosing) was not influenced by pen size. Headknocks increased within the first week in the pens of 6.7 and 28 m^2. In the pens of 6.7 m^2 and 28 m^2 the maximum of headknocks was found at the end of week 1, and in the 3.5 m^2 pen in week 2.

This delayed development of headknocks in the 3.5 m^2 pen is probably caused by the short duration of physical interactions in this pen. As stated before, interactions were often interrupted by objects or littermates. The delayed development of headknocks may also be of influence on the amount of headknocks accompanied with biting. Within the first week the piglets in the 6.7 m^2 and 28 m^2 pens already learnt the effect of biting. During this first week biting was mostly elicited by biting and this may induce pain in both piglets. It is likely that piglets will avoid painful stimulation and change their behaviour from headknocks with biting to headknocks without biting. Maybe because in the 6.7 m^2 and the 28 m^2 pens the piglets experienced more biting in the first week than the piglets in the 3.5 m^2 pen, biting was inhibited earlier in piglets in the larger pens than in piglets of the 3.5 m^2 pen. Further support for this idea is the finding that in all pens biting decreased sharply after the maximum of headknocks was reached. In the 3.5 m^2 pen, however, the headknocks with biting were not as strongly inhibited as in the larger pens. This might be due to the fact that after week 2 the piglets in the small pens more often performed headknocks from the non (anti-) parallel position. In this position the receiver of a headknock was often not able to return a headknock. This could have delayed the inhibition of biting. The performance of headknocks from a non (anti-) parallel position was probably induced by a orienting problem due to the limited floor space.

In the 6.7 and 28 m^2 pens the amount of headknocks placed on the back or ano-genital region decreased sharply with age of the piglets, while standing in front increased. In the 3.5 m^2 pen standing in front was rarely scored and the piglets continued placing headknocks on the back and ano-genital region. During the observations it was noticed that this was not only an orienting problem, but also was caused by the unclear reactions of the receiver. Because of obstacles and littermates, the piglet that obviously wanted to withdraw from an interaction was often hindered to do this; so, the opponent continued to give headknocks. Mostly the receiver was just standing, but as soon as he saw an opportunity he turned around and fled. However, this did not stop his attacker from going on giving headknocks, which then mostly hit the back or ano-genital region of the escaping animal. It might be that in a physical interaction between piglets retreat has to occur within a certain time limit to be effective.

Great differences between the various pen sizes were found in standing in front. This standing in front is the same as that described by Gundlach (1968: "Frontalstellung") in piglets of the European wild boar. Gundlach classified this behaviour as threatening. Jensen (1980) described standing nose to nose as a possible threat behaviour in domesticated sows. Standing in front as defined here is partly the same as standing nose to nose defined by Jensen. From our results we obtained some indication that standing in front indeed is a threat behaviour that develops with age of the piglets, at least in the 6.7 and 28 m^2 pens. One argument is that the headknocks in the 6.7 m^2 and the 28 m^2 pens are increasingly preceded by standing in front. Furthermore, within piglets standing in front was, in week 5 + 8, mostly followed by a headknock or exploration plus others (behaviours not specified).

In the 3.5 m^2 pen standing in front hardly developed at all and a headknock was often preceded by exploration plus others. This means that in the 6.7 m^2 and 28 m^2 pens interactions became more predictable for the piglets with increasing age, while in the 3.5 m^2 pen an interaction could come out of nowhere.

During week 5 and 8 in the 6.7 m^2 pen and during week 5 in the 28 m^2 pen, during the majority of interactions standing in front was scored (51.3 and 64.7% respectively; table 7.7). This contrasts with the findings for the 3.5 m^2 pen, where only 6.8% of the interactions contained standing in front. In the 3.5 m^2 pen most of the interactions with headknocks started apparently without warning (43.7%) or with nosing (26.2%; table 7.7). It may be that because of space limitations standing in front just could not develop normally in the 3.5 m^2 pens and that nosing became an alternative threat behaviour for the piglets.

Beuerle (1975) found that in adult European wild boar submissive males either retreated after nosing or that threatening could follow ("Imponierauftritt"). This is an interesting finding, because it might mean that nosing often introduces threat behaviour. Going back to the classification of physical interactions (table 7.7, page 117), we see that in the 6.7 and 28 m^2 pens the percentage of interactions of type 4 (headknocks with nosing) decreases with age and in the 3.5 m^2 pen it does not change. Furthermore, the percentage of interactions with standing in front (type 1) increases with age in the 6.7 m^2 and 28 m^2 pens but not in the 3.5 m^2 pen. This might mean that in the 3.5 m^2 pen the step from nosing to standing in front (threatening) is not made. Therefore, the agonistic behaviour of piglets in the 3.5 m^2 pens might be classified as infantile agonistic behaviour.

By definition in all interactions physical contact occurred. With increasing age of the piglets a lot of interactions were avoided by very subtile movements of the head. Especially in the 28 m^2 pen this threatening at distance was noticed. A typical sequence of behaviour was as follows. A piglet exploring the substrate was approached by a littermate. When the latter was at a distance of about two meters, the exploring animal raised its head and turned it towards the approaching littermate. This was often sufficient to make the approaching littermate change its mind. Sometimes just stopping the ongoing behaviour made an approaching littermate change its direction. This threatening from a distance looks very much the same as the behaviour "aiming" described by Jensen and Wood-Gush (1984). This aiming was not observed in group-housed sows (Jensen, 1980, 1983/1984). Jensen and Wood-Gush argue that aiming is only used by pigs at distance and for this reason it will not be seen in small pens. Frädrich (1965) noticed threatening at distance also and proposed that it is an intention movement evolved from a snout thrust ("Schnauzenstoss").

There is still much work to be done to unravel causes and effects of the often subtile threat and submissive behaviour in pigs. The topic is undoubtedly of interest with respect to group housing of pigs. In a stable group of animals threat and submission are behaviours that maintain several relations between animals without injury and energy consuming fighting. However, we should not focus on such behaviours alone. Other cues, out of range of our sense organs, may be very important. For example, in rats ultrasound vocalization appeare to be crucial in maintaining several relations (Sales, 1972; Lore et al., 1976; Schouten, 1980). In pigs pheromones might be such cues (McGlone, 1985). McGlone (1985) found some evidence that in pigs a smell released towards the end of a fight signals submission.

From other experiments we obtained some evidence that infantile fighting of piglets reared in small pens did not change after subsequent rearing in spacious pen (Lammers and Schouten, 1985). Therefore, it seems important to give piglets enough space early in life to ensure normal agonistic behaviour in adult life. This might be of great importance for the development of group-housing systems for sows.

7.5 Conclusions

The development of agonistic behaviour in pigs strongly depends on the available free floor space.

Normal threat behaviour (standing in front) does not develop in very small pens.

In small pens biting does not get as strongly inhibited as in large pens during the course of development.

Headknocks performed on the back or ano-genital region, in large pens frequently performed during the first week of life only, persisted over the entire observation period (eight weeks) in small pens.

In the smallest pen (3.5 m^2) infantile fighting, normally found until an age of two or three weeks, was still found at an age of eight weeks.

CHAPTER 8

8. GENERAL DISCUSSION

In the present investigation piglets experienced either an enriched or an impoverished environment during their first eight weeks of life. As expected, these rearing conditions differentially influenced the development of several behaviours (Van Putten and Dammers, 1976; Fraser, 1978 and Schmidt and Adler, 1981). Particularly exploratory and social behaviours proved strongly dependent upon environmental conditions. In the impoverished environment sow and littermates do not only interact socially, but they also become significant parts of the environment to which much exploratory behaviour is directed. This fading of the borders between exploratory and social behaviour appeared to effect subsequent behaviour during the fattening and farrowing phases.

Two important points concerning early rearing conditions as related to later behaviour will be selected for a more detailed discussion. First, the immediate changes in behaviour due to an impoverished and small floor space and their implications for the welfare of the piglets are discussed. Secondly, the effects of rearing conditions on adult behaviour around farrowing are elaborated. The practical significance of the results of this research will be discussed.

8.1 Immediate behavioural effects of impoverished environment

A few minutes after birth a piglet is already able to perform a great variety of behaviours. One of the first is sucking. Besides resting, sucking is one of the most essential behaviours of piglets; it is a very complex behaviour (Fraser, 1980). The occurrence of these fundamental behaviours was not differentially influenced by the two rearing conditions. In the first week social contact behaviour between piglets occurs mainly around the sucking periods and during lying together. In this period the piglets get to know their littermates by intensively nosing each other. This intensive nosing was also not influenced by rearing conditions. From the second week onwards social interactions do not exclusively take place around the sucking periods and when they are lying together anymore. At all sorts of moments the piglets engage in very intensive contact behaviour like playing or agonistic interactions. Because of the high level of these behaviours and the well organized fighting after the third week, the second and third week (chapter 3 and 7) may be called the socialization period (Scott et al., 1974; Peys, 1977). During this period the piglets learn to react adequately to the behaviour of conspecifics. The social behaviour of the piglets not only becomes more organized, but real threat behaviour now occurs for the first time (chapter 7; Gundlach, 1968). During the socialization period the behaviour of the littermate becomes, in fact, more predictable than before. As noted in chapter 3, the total time spent on agonistic interactions was not influenced by rearing conditions. However, the ways of fighting differed strongly in the enriched or impoverished environment. It appeared that the start of an agonistic interaction was less predictable for the piglets in the impoverished environment than for those in the enriched environment.

Both environments differed in several aspects. Besides the lack of suitable bedding that could be manipulated, the floor space per animal of the impoverished environment was much smaller than in the enriched environment. These two variables had different effects on the behaviour of the piglets, as shown in chapter 6 and 7.

I shall first focus on the effects of reduced floor space on the behaviour of piglets. As it turned out, this factor mainly influenced the structure of agonistic behaviour (chapter 7).

During the socialization period and by being in a spacious environment, the piglets learn to react adequately to the behaviour of littermates and to predict the reactions of a conspecific. They gradually gain control over their social environment. However, this was not the case in piglets reared in pens with small floor space. As shown in chapter 7, for these piglets agonistic interactions remained highly unpredictable. Especially standing in front, which must be considered a threat behaviour, hardly developed at all in small pens and agonistic interactions could arise "out of the blue". Such threat behaviour is important to maintain a stable dominance hierarchy within a group of animals without dangerous and energy consuming fighting (Alcock,1975; Lore et al., 1976).

The agonistic behaviour of piglets in the small pens was abnormal in several aspects compared to that of the piglets in a large pen.

One of these aspect was the threat behaviour as described above. Other aspects were the high frequency of biting and the fact that biting directed towards the back or ano-genital region of the opponent that persisted over the entire observation period. In large pens biting became gradually inhibited in the course of the eight weeks and bites directed at the back or anogenital region were rare. An important question is, of course, whether this abnormal way of fighting is reversible or not. Experiments of Lammers and Schouten (1985) indicate that subsequent housing of the animals in large pens for a period of two weeks did not change the abnormal agonistic behaviour of piglets reared in small pens. Very little is known about the long term effects of reduced floor space during rearing on adult agonistic behaviour in domesticated animals. Nevertheless, the importance of social interactions in early life is generally accepted (e.g. Hemsworth et al., 1977, 1978; Ruiterkamp, 1985).

Indirect evidence for long term effects of different social interactions during early life has been found in, among others, rats. Generally young rats have been isolated from conspecifics during different periods of age and for different lengths of time. Although our piglets were not socially isolated, reduced floor space resembles the effects of isolation in so far that it prevents the development of normal intense social interactions. Both the isolated rat and the floor space restricted piglet are handicapped in the learning of specific skills and rules for social interactions. Rats go through a socialization period that is essential for normal adult behaviour (Peys, 1977; Einon et al., 1981).

Like the piglets, socially isolated rats show much biting and fight very vigorously with conspecifics (Day et al., 1982). Einon et al. (1978) demonstrated that intensive contacts with a conspecific for one hour a day during the socialization period (between day 25 and 45) completely counteract the effects of isolation in rats. This emphasizes the significance of the socialization period. From the results of chapter 3 and 7, I conclude that in piglets the socialization period falls in the second and third week of age. Not only from the biological point of view, but also for practical pig breeding and animal welfare it is important to determine: first, the exact period during which piglets acquire their skills for species-specific agonistic behaviour and, secondly, to what extend the effects of reduced floor space on agonistic behaviour are irreversible.

The effects of reduced floor space on agonistic behavour in piglets were still present at an age of ten weeks. The findings in experiments with rats and monkeys clearly point to long term effects. Sackett (1974) suggested that ,at least in monkeys, the results of the restricted experience in early life are very persistent. That means that the animals fail to inhibit isolation-learned repertoires which are maladaptive in later social settings. Day et al. (1982) finding long term effects of social isolation of rats during early life especially on aggressive behaviour, proposed that this may result from deficiencies in the inhibition of inappropiate aggression responses. If this also holds for piglets, then rearing piglets in small pens produces animals that are not well equipped to function socially in a group. In practical pig breeding floor space is a high cost factor and it is, therefore, important to find out how much floor space piglets need during their socialization period to ensure the normal development of their agonistic behaviour.

The next important question is whether in animals that have developed normal agonistic behaviour, a subsequent reduction of floor space alters this behaviour. This point has much practical value as during fattening and even for group-housed sows reduction of floor space seems inevitable. Research on this point is urgently needed. From the welfare point of view it is important that piglets have sufficient floor space to learn how to gain control over their social environment, since controlability and predictability of the (social) environment reduce stress in animals (Weinberg and Levine, 1980; Cronin, 1985; Wiepkema, 1985) and thus improve their welfare. Although group housing of, for instance, dry sows is considered a better way of pig keeping than individual housing, it will only contribute to a better welfare of these sows if the sows involved are equipped with skills to perform normal social behaviour. Otherwise group housing might be even more stressfull than individual housing.

Not only the floor space but also the contents of the environment differed greatly between the enriched and impoverished environment. The terms enriched and impoverished indicate this already. In the impoverished environment the piglets had no bedding that could be manipulated (chapter 3) and only a few objects that lent themselves to this use. Favourite objects were the chain and the breast girth by which the sow was tethered. As shown in chapter 3 and 6, absence or presence of suitable bedding strongly determined exploratory behaviour and massaging, rooting or nibbling at piglets. The presence of suitable bedding induced much exploratory behaviour directed towards this bedding and a strong decrease in massaging, rooting or nibbling at littermates. Nevertheless, the absence of massaging, rooting or nibbling at littermates during rearing in an enriched environment proved to be no garantee for not performing this behaviour in later life under barren conditions (chapter 4). However, in a complicated way massaging, rooting or nibbling at littermates contributed to the long lasting effect of restlessness. In the impoverished environment only a few piglets could manipulate the favourite objects, chain and breast girth, at the same time. The piglets in the impoverished environment soon adapted themselves to this situation by being active in shifts. This was evident from the synchrony of activity which during the eight rearing weeks was always less in the impoverished than in the enriched environment. However, being active in shifts had some drawbacks. Lying littermates were often used as objects on which exploratory behaviours could be performed. These piglets, however, gradually learned to prevent being a target by standing or sitting and/or giving a headknock. This, in turn, induced much disturbance and restlessness and further contributed to the unpredictability of the behaviour of littermates.

In the impoverished environment, for another piglet whether active or lying down, an approaching littermate always might mean trouble; the approaching animal might start an agonistic interaction without warning or it might start massaging, rooting or nibbling. Presumably, all these behaviours are experienced as unpleasant. To avoid these actions, the piglets had to be constantly alert; they often showed avoidance behaviour (standing and sitting) when a littermate approached. This permanent alertness and the associated low predictability of the littermates' behaviour must be a stress-inducing factor for the piglets even if by avoiding contact the piglets can deal with it.

From the practical point of view such a situation is undesirable, not only because massaging, rooting and nibbling at littermates may lead to serious wounds, but also because stress does not improve feed conversion and growth rate. Moreover, the welfare of the animals is clearly at stake. From the experiments discussed in chapter 3 and 6, I concluded that there has to be sufficient bedding material to be manipulated by all littermates at the same time. Besides that suitable bedding satisfies the exploratory needs of the piglets, it also enhances the synchrony of activity within a litter (chapter 4). The occurence of synchrony implies that all littermates are likely to be tired at the same time. This shortens the interval between the condition "all animals active" and "all animals resting". Since it is during this interval that most of the massaging, rooting or nibbling at littermates occurs, the shorter this period the lesser the opportunity to perform massaging, rooting or nibbling at littermates. If the environment and especially the bedding material is of sufficient quality to fulfill the exploratory needs of the piglets, redirected exploration towards littermates becomes less likely. The statement that the impoverished environment is more stressfull for piglets than the enriched one is mainly supported by behavioural differences in standing and sitting and agonistic behaviour. However, physiological evidence points in the same direction. Worsaae and Schmidt (1980) found high plasma cortisol levels in early weaned piglets housed in barren environments (cages), as compared to non-weaned piglets in a straw pen. They concluded that early weaning is a stressor. But they also found an effect of floor space of the cages on the plasma cortisol levels. The smaller the floor space the higher the plasma cortisol level.

8.2 Effects of rearing condition upon farrowing behaviour

The restlessness acquired during rearing appeared to be a long lasting effect. Pigs reared in the impoverished environment showed much restlessness during the subsequent fattening period (chapter 4). Even more surprising was the effect of rearing condition on the behaviour around farrowing (Timmermans; pers. com.) reports that Wistar rats isolated from birth and bottle-fed, showed no problems during parturition and raised their pups normally. These female rats had difficulties only with copulatory behaviour. In monkeys, growing up in complete social deprivation has a detrimental effect on maternal behaviour. They were uncapable of rearing their young, because they avoided contact and were hyperaggressive towards their young (eg. Seay et al., 1964; Harlow and Seay, 1966). Recent findings of Kemps and Timmermans (1984) showed that monkeys growing up in peer groups (groups of animals of the same age) did not differ in behaviour around parturition from monkeys reared in a harem group. These authors concluded that parturition itself is hardly influenced by rearing conditions, it is almost entirely under endocrine and neural control. However, the handling of the young after parturition depends on the skill of the mothers. With increasing number of parturitions the females became more skillfull mothers.

As stated above rearing conditions influenced the behaviour of gilts around farrowing. Differences in behaviour between the gilts reared in the enriched environment and those having grown up in the impoverished were found on the day before and during farrowing. Again the most striking difference was the higher restlessness of the gilts reared in the impoverished condition (chapter 5). This restlessness directly influenced nestbuilding behaviour and the farrowing process. While the gilts reared in the enriched situation showed more structured nestbuilding (i.e. gathering, building and moulding), the gilts reared in the impoverished situation often interrupted this behaviour with, among others, standing and sitting. During farrowing the same phenomena were again observed. Gilts reared in impoverished condition more often avoided contact with and reacted more aggressively to their piglets. In this respect the behaviour of these gilts resembles that of the totally isolated monkeys. However, the gilts only showed maternal aggression during farrowing; they showed perfect maternal behaviour after farrowing. It is tempting to draw parallels between the isolation experiments in monkeys and the impoverished rearing of gilts in this study. Although the piglets were not isolated but reared in a group, the environment in which they grew up resembled somewhat the isolation conditions. Rearing in isolation results in not acquiring social skills and if the isolation period incorporates the socialization period, the effects are irreversible (Peys, 1976; Einon et al., 1981). When animals reared in isolation are forced to interact with either another isolated animal or a group reared one, they are unable to react adequately to the behaviour of the opponent. The situation appears to be totally unpredictable for them and they seem to be unable to gain control over it. The same may hold for the piglets reared in the impoverished environment where floor space was limited. These piglets may also encounter many unpredictable situations. However, they more or less managed to cope with this situation by showing avoidance or escape behaviour. These avoidance or escape reaction during rearing (standing and sitting) are closely associated with the situation in which the piglets found themselves in and which, as discussed before, was probably experienced as stressfull. For this reason the restlessness and avoidance reactions of the gilts might became apparent only close around farrowing, when there is a novel stressfull situation.

In this way early rearing conditions may indeed have large effects on later behaviour. Small floor space and lack of suitable bedding material influence behaviour of piglets during rearing; it is possible that even after subsequent enlargement and enrichment of the environment some aspects of this behaviour persist. Thus, for practical pig breeding the rearing situation is very important; it may for a great part determine subsequent sexual (Hemsworth et al., 1978, 1979), social (Ruiterkamp, 1985), and maternal behaviour. Even when gilts or sows are tethered around farrowing, the acquired restlessness will become apparent during farrowing and may interfere with the farrowing process itself and with subsequent maternal behaviour. In brief, it is not a good strategy to prevent during rearing the development of social skills pigs need in adult life. It is appropriate to fight the causes (in appropiate rearing conditions) and not the symptoms (acquired restlessness and abnormal agonistic behaviour).

SUMMARY

During the last three decades the housing conditions of our livestock have been changed drastically (chapter 1). Amongst others, reduced floor space per animal and the monotony of the environment are the most striking changes.
As in other animals, the actual situation strongly influences the behaviour of pigs. However, the effects of early experience on later behaviour in pigs are still not well documented. The aim of this exploratory study was to investigate these effects.

In chapter 2 the design, the general material and methods of the entire series of investigations are described. To be able to distinguish the effects of early experiences (in casu rearing environment) on later behaviour, as clearly as possible, rearing conditions were chosen that differ greatly. Four litters of eight piglets each were reared in either a farrowing crate (the impoverished environment) or in a large straw pen (the enriched environment). The behavioural development during the first eight weeks of life and the differences therein for the two rearing conditions are described in chapter 3. The behaviour of the piglets was assessed by the focal animal observation method of individual piglets. Observations were made at fixed hours during day time.

It was found that vital behaviours like ingestion (feeding, drinking and sucking) and resting were not strongly influenced by rearing condition. The same holds for nosing littermates, a behaviour that presumably plays an important role in mutual recognition. On the other hand, great differences between rearing conditions were discovered in exploratory and redirected exploratory behaviour (massaging or nibbling at littermates or sow). Piglets in the enriched environment showed more exploration than those in the impoverished condition. However, the development of exploration over the first eight weeks of life of the piglets was similar in both housing conditions; exploration increased with age. This might mean that the development of exploration is under endogenous control, while the level of exploration depends on the relative enrichment of the environment. Piglets in the impoverished environment performed much more massaging of or nibbling at littermates or sow than the piglets in the enriched condition. These behaviours are generally considered as redirected exploratory beha-

viours. The high amount of massaging of or nibbling at littermates and the restricted lying area presumably are the main causes of the high level of restlessness (standing and sitting) of the piglets in the impoverished environment.

After eight weeks of rearing, six piglets per litter went to a commercial fattening farm and two gilts per litter were kept for breeding. The fattening pens had a full slatted concrete floor. For the pigs reared in the farrowing crate these pens embodied a relatively enrichment; the floor space was larger and a plank at the bottom of a welded mesh gate proved to be an excellent object for biting, nibbling or chewing. For the straw reared pigs the fattening pens were a relative impoverishment of the environment. During fattening the behaviour of the pigs was assessed by means of 24 hour time-lapse video recordings (chapter 4), which were also made during rearing. From an age of two weeks onwards a diurnal activity rhythm was found independent of rearing conditions. The similarities and differences in behaviour in the two rearing conditions obtained by means of the focal animal observation, described in chapter 3, were found also by means of these video recordings. The relative enrichment of the fattening pens increased exploration in the crate reared pigs. In straw reared pigs the opposite was found. It was argued that because of the experience with a simpler environment the crate reared pigs needed more time than the straw reared pigs to assimilate the new environment. In spite of the low level of redirected explorative behaviour during rearing, the straw reared pigs showed as much of this behaviour during the fattening period as did the crate reared piglets. Thus, massaging of or nibbling at littermates appeares to be almost completely determined by the actual situation. The high level of restlessness found in crate piglets persisted over the entire fattening period (till the age of 24 weeks). Although restlessness increased in straw reared pigs during fattening, these animals' score was always lower than that of the crate reared ones.

In chapter 4, a measure for the synchrony of activity is defined; if n is the number of animals in a pen, than n states or classes of activity are possible namely 1, 2, 3.....n animals being active simultaneously. The measure of synchrony of activity was defined as the ratio of the occurrence of class n (all animals active) divided by the sum of occurrence of all classes (1+2+3+.....+n).

During the first eight weeks of life straw piglets showed a higher synchrony of activity than the crate piglets. Thereafter this difference was not as clear. A strong negative correlation was found between massaging of or nibbling at littermates (SN-pig) and the synchrony of activity. After ruling out the age effect, this correlation was still high; in the first eight weeks r=-0,87 and in the fattening period r=-0,81. Thus, a high synchrony of activity reduces the probability of SN-pig and hence of restlessness.

After having been reared for eight weeks in the two different housing systems, two crate reared gilts and two straw reared ones were housed in a large straw pen and inseminated in their second oestrus. Fourteen days before the expected farrowing date the gilts were housed individually in a straw pen. The behaviour of these gilts during day time was observed from five days before till 13 days after farrowing (chapter 5).

With respect to nursing (that is, the animal is lying on the side with fully exposed udder and more than half of the total number of piglets is active at the udder) on the first day after farrowing more nursing in straw reared gilts than in the crate reared ones was found. No further differences in behaviour were found between crate or straw reared gilts before and after farrowing.

During farrowing crate reared gilts showed more restlessness than the straw reared gilts. This difference was already visible on the first day before farrowing. Obviously, the acquired restlessness persisted even after having been housed in an enriched environment for ten months.

Data from six hours continuous observation during farrowing were submitted to a sequential and cluster analysis. Straw reared gilts showed two clear clusters of behaviour:

1) Behaviours directly involved in the farrowing process: sliding into, lying, nursing, delivery and expelling of the placenta.

2) Behaviours directed towards the physical environment: nestbuilding, standing and sitting, and exploration.

In crate reared gilts one great cluster was found in which sliding into, lying, nursing, delivery of the piglets and expelling of the placenta were taken together; this cluster also contained nestbuilding, comfort behaviour and biting and snapping.

Another cluster was formed by standing and sitting, and exploration. From the sequential analysis it was clear that crate reared gilts more easily switched from behaviours involved in the farrowing process itself to behaviours that interfere with the farrowing process.

During the first eight weeks of life standing and sitting appeared to be good strategies to avoid or to escape from being massaged or nibbled at; the animals also learned that unpleasant or stressfull situations can be avoided this way. However, this standing and sitting behaviour which also occurred during farrowing as reaction to a novel stressfull situation, is not very adaptive in terms of survival value for the offspring. Because the duration of farrowing did not differ between crate and straw reared gilts, both groups of gilts were probably equally stressed. If this is so, the differences in behaviour found during farrowing can not be attributed to differences in amount of stress experienced by crate and straw reared gilts respectively.

From the results of the study presented in chapter 3 (differential rearing) it appeared that two major factors - bedding and floor space - influenced the behaviour of the piglets.

In chapter 6 the effect of bedding (straw) on the behaviour of piglets is described. Four litters of eight piglets each were housed in farrowing pens; the sows were tethered. During the first two weeks of life two litters were provided with a straw bedding while two other litters were not. From the third week on the substrate was exchanged every week from straw to bare floor and vice versa. It appeared that active behaviour of the piglets strongly depended on the presence or absence of straw. When straw was not available, the piglets immediately directed their exploratory behaviour towards littermates and sow. The piglets also became more restless (more standing and sitting) and started agonistic behaviour more easily. Furthermore, it became clear that the total amount of exploratory and redirected exploratory behaviour performed on a bare floor did not reach the level of exploratory behaviour of piglets of the same age on straw. This suggests that exploratory behaviour in a barren environment cannot be satisfied fully by alternatives or redirected behaviours as used by the piglets.

In chapter 7 the effect of pen size on the development of agonistic behaviour in piglets is described. Three different pen sizes were used: 1) 28 m^2 with a loose sow; 2) 6.7 m^2 and 3) 3.5 m^2; in the latter two the sow was tethered. All pens contained straw bedding. By using a fine grained ethogram of agonistic behaviour and applying sequential analysis, several differences between the pen sizes were found in the development of agonistic behaviour.

As already shown in chapter 3, pen size did not influence the development of individual recognition (nosing littermates). However, there were significant differences in the development of agonistic behaviour. Piglets housed in pens of 3.5 m^2 did not develop threat behaviour (standing in front), did not learn to inhibit biting and to place headknocks exclusively on the head or shoulders of other piglets. Typical sequences of agonistic behaviour were also different for the three sizes. After week 4, in the largest pen 37.8% of all headknocks were preceded by threatening, in the 6.7 m^2 pen it was 29.5% and in the 3.5 m^2 only 3.9%. In the 3.5 m^2 pen more than 40% of headknocks were preceded by exploration or other unspecified behaviour. Because threat behaviour lacked almost entirely in the piglets in the smallest pens, the start of an agonistic interaction was highly unpredictable for this group of animals. This unpredictability of the behaviour of littermates further contributed to the restlessness in these cages. Unlike the piglets in the 6.7 m^2 and 28 m^2 pens, the piglets in the smallest pen did not change the pattern of their agonistic behaviour anymore after week 3. Therefore, the agonistic of the latter piglets may be classified as infantile; presumably, this will not improve later in life. Therefore, these piglets must be considered to be not very well equiped for social grouping as adults.

In the general discussion (chapter 8), two main points are selected for a more detailed discussion: first, the immediate effects of rearing in different environments on the behaviour of piglets and secondly, the effects of this differential rearing on later behaviour around farrowing.

The amount of floor space mainly influenced the development of agonistic behaviour. The complexity of the environment and especially the presence of bedding proved to be an important factor in preventing the occurrence of redirected explorative behaviour and restlessness. From the findings described in chapter 3 and 7, it is argued that the socialization period of piglets falls in the second and third week of life. The effect of reduced floor space, increased unpredictability of the behaviour of conspecifics, and strongly resembles the effect of social isolation as found in other species. In both situations the animals do not learn to control their social environment.

Impoverishment of the environment causes redirected exploratory behaviour. The piglets learn to deal with this behaviour of their peers conspecifics by avoidance or escape reactions, mainly consisting of standing and sitting. In later life the same animals showed regression of this behaviour, in that they performed the same response in reaction to a novel and stressfull situation like farrowing. This type of response is maladaptive in this situation because of possible detrimental effects for the piglets.

Environments inducing redirected exploratory behaviour and preventing the development of social skills do not contribute in a positive way to the welfare of the animals. For practical pig breeding the rearing situation might be very important because of its effects upon the behaviour in later life of the animals.

SAMENVATTING

Gedurende de laatste 30 jaar zijn de omstandigheden waaronder onze landbouwhuisdieren worden gehouden sterk veranderd. Naast andere factoren zijn het vooral de verminderde oppervlakte per dier en de monotone omgeving die het meest in het oog springen.

Uiteraard beïnvloedt de actuele situatie (d.i. de situatie waarin het dier zich op dat moment bevindt) in belangrijke mate het gedrag van het varken. Echter, ook in de vroege jeugd opgedane ervaringen kunnen het gedrag verregaand beïnvloeden (hoofdstuk 1). Tot voor kort bestond er maar een zeer fragmentarische kennis van effecten van vroege jeugdervaringen op het gedrag van varkens gedurende latere fasen in het leven. Het hier beschreven onderzoek biedt een eerste aanzet naar een beter inzicht in de mogelijke effecten van vroege jeugdervaringen op het latere gedrag van het varken.

In hoofdstuk 2 vinden we de experimentele opzet en de gebruikte materialen en methoden voor de in de hoofdstukken 3 tot en met 5 beschreven experimenten.

Als variabele tijdens de vroege jeugd van de biggen werd de wijze van huisvesten gekozen. Om de kans op mogelijke effecten op gedrag gedurende latere levensfasen van deze dieren te vergroten werd voor relatief grote verschillen in huisvestingscondities gekozen. Vier tomen van elk acht biggen groeiden op in een kraamopfokhok (de zgn. arme omgeving) en een gelijke groep dieren groeiden op in een ruim ingestrooid hok, het strohok (de zgn. rijke omgeving). Het kraamopfokhok was 2 x 2 m^2 groot en de vloer bestond uit betonroosters. De zeug was aangebonden door middel van een borstband (zie figuur 2.2, pag. 6). Het strohok was 28 m^2 groot en de betonnen vloer was bedekt met lang stro dat tweemaal per week gedeeltelijk werd vervangen. De zeug kon zich vrij in het hok bewegen (zie figuur 2.3, pag. 6).

De ontwikkeling van het gedrag van de biggen in beide huisvestingssystemen gedurende hun eerste acht levensweken wordt vergeleken in hoofdstuk 3. Het gedrag van de individuele big werd beschreven op basis van directe waarnemingen op vaste uren gedurende de lichtperiode.

Het bleek dat de totale tijd besteed aan essentiële gedragingen zoals eten, drinken, zuigen en rusten nauwelijks beïnvloed werd door de wijze van huisvesten. Ook het elkaar besnuffelen van biggen, dat vermoedelijk een belangrijke rol speelt bij de individuele herkenning, werd niet door de wijze van huisvesten beïnvloed. Er werden echter grote verschillen gevonden in exploratief (onderzoekend) gedrag en omgericht exploratief gedrag (het masseren, bewroeten, besabbelen of beknabbelen van hokgenoten).

Biggen in de rijke omgeving vertoonden meer exploratief gedrag dan biggen in de arme omgeving. De ontwikkeling van dit gedrag bleek bij beide groepen vrijwel parallel te verlopen. In beide huisvestingssystemen nam het exploratief gedrag met de leeftijd van de biggen toe. Dit zou kunnen betekenen dat de ontwikkeling van het exploratief gedrag endogeen geregeld wordt (vanuit het dier zelf komende) en dat de omgeving alleen het niveau ervan bepaalt.

De biggen in de arme omgeving vertoonden meer masseren, bewroeten, besabbelen en beknabbelen van toomgenoten en zeug dan biggen in de rijke omgeving. Het veel voorkomen van deze omgerichte exploratieve handelingen en de zeer beperkte ligruimte zijn waarschijnlijk belangrijke oorzaken van de hoge mate van onrust (gemeten als staan en zitten) bij biggen in de arme omgeving.

Na het verblijf van acht weken in één van beide huisvestingssystemen werden per toom zes van de acht dieren overgebracht naar een mestbedrijf. De mesthokken waren 6 m^2 groot en de vloer bestond uit betonroosters. Voor de biggen uit het kraamopfokhok betekende de overgang een relative verrijking van hun omgeving. De hokken waren groter (6 m^2 tegen 4 m^2) en een plank, aangebracht aan de onderzijde van het hekwerk aan de voorkant van het hok, bleek een zeer geschikt object te zijn om op te bijten, te knabbelen of te kauwen. Voor de biggen uit het strohok betekende de overgang naar het mesthok een relatieve verarming van de omgeving. Het mesthok was aanzienlijk kleiner (6 m^2 tegen 28 m^2) en strooisel ontbrak.

Gedurende de mestperiode werd het gedrag van de varkens vastgelegd door middel van 24-uurs time lapse video-opnames (zie hoofdstuk 4). Ook tijdens de opgroeiperiode (de eerste acht levensweken van de biggen) waren op gezette tijden 24-uurs time lapse video-opnames gemaakt. Uit deze opnamen bleek dat onafhankelijk van het huisvestingssysteem de biggen vanaf een leeftijd van twee weken een dag/nacht ritme in hun aktiviteit vertoonden. De video-opnamen en de directe observaties tijdens de opgroeiperiode (week 1 tot en met 8) leverden dezelfde overeenkomsten en verschillen in gedrag van de biggen op.

De relatieve verrijking van de omgeving voor biggen die van van het kraamopfokhok naar het mesthok gingen, resulteerde in een verhoogde mate van exploratief gedrag van deze dieren. Voor de dieren die van het strohok kwamen resulteerde de relatieve verarming van de omgeving in een verlaging van exploratief gedrag. Een verklaring voor dit verschil zou kunnen zijn dat de dieren die van het kraamopfokhok kwamen en dus alleen maar ervaring hadden met een relatief weinig complexe omgeving meer tijd nodig hadden de nieuwe en relatief complexe omgeving in zich op te nemen.

Ondanks het feit dat de biggen die opgroeiden in het strohok weinig omgericht exploratief gedrag vertoonden, bleken deze dieren gedurende de mestperiode evenveel omgericht exploratief gedrag te vertonen als de dieren die opgroeiden in het kraamopfokhok. Dit zou dus betekenen dat omgericht exploratief gedrag vrijwel geheel door de actuele situatie bepaald wordt. De hoge mate van onrust (staan en zitten) gevonden gedurende de opgroeiperiode bij de biggen in het kraamopfokhok bleef bestaan gedurende de gehele mestperiode. Alhoewel de onrust van de dieren die van het strohok kwamen sterk toenam gedurende de mestfase bleef deze toch altijd lager dan bij de dieren van het kraamopfokhok.

In hoofdstuk 4 wordt een maat voor de synchronisatie in aktiviteit van de biggen gedefiniëerd. Als n het aantal dieren in een hok is, dan zijn er n verschillende toestanden van groepsaktiviteit mogelijk, namelijk 1, 2, 3....,n dieren tegelijkertijd aktief. Tijdens een 24-uurs periode werd per 10 minuten genoteerd in welke aktiviteitstoestand de toom zich bevond. De mate van synchronisatie van de aktiviteit van de toom werd gedefiniëerd als de verhouding tussen het aantal malen voorkomen van toestand n (alle dieren aktief) en de som van het voorkomen van alle mogelijke toestanden (1+2+3+...+n).

Gedurende de opgroeiperiode (week 1 tot en met 8) vertoonden de biggen in het strohok een hogere mate van synchronisatie van aktiviteit dan de biggen in het kraamopfokhok. Gedurende de mestfase waren de verschillen in synchronisatie van aktiviteit tussen beide groepen dieren klein. Er werd een sterke negatieve correlatie gevonden tussen de hoeveelheid omgericht exploratief gedrag (masseren, bewroeten, besabbelen of beknabbelen van hokgenoten) en de synchronisatie in aktiviteit. Na het uitschakelen van het leeftijdseffect was deze negatieve correlatie nog steeds hoog; gedurende de eerste acht levensweken r=-0.87 en gedurende de mestperiode r=-0.81. Een hoge mate van synchronisatie in aktiviteit verkleint de kans op masseren, bewroeten, besabbelen of beknabbelen van liggende hokgenoten en vermindert derhalve de onrust in het hok.

Na een opgroeiperiode van acht weken in de twee verschillende huisvestingssystemen werden per huisvestingssysteem twee gelten (vrouwelijke varkens) uit het strohok en twee uit het kraamopfokhok samen in een strohok van 3x2,8 m^2 geplaatst (zie figuur 2.4, pagina 7). De gelten werden geïnsemineerd in hun tweede bronstperiode. Veertien dagen voor de te verwachte werpdatum werden de gelten individueel gehuisvest in eenzelfde type strohok. Vanaf vijf dagen voor de geboorte van de biggen tot 13 dagen erna werd gedurende de lichtperiode het gedrag van de gelten geobserveerd (hoofdstuk 5). In totaal werden er 7 gelten per opgroeiconditie geobserveerd.

Behalve dat de gelten die opgroeiden in het strohok op de eerste dag na het werpen hun biggen langer lieten zuigen dan de gelten die opgroeiden in het kraamopfokhok, werden er tussen de twee groepen gelten geen verschillen gevonden in het gedrag voor of na de geboorte.

Tijdens het werpen waren de gelten die opgroeiden in het kraamopfokhok onrustiger dan de gelten die opgroeiden in het strohok. Dit verschil in gedrag kwam de dag voor het werpen al naar voren.

De gegevens van zes uren continue waarnemingen aan de zeugen gedurende de geboorte van de biggen werden onderworpen aan een volgorde- en een clusteranalyse. Gelten die opgroeiden in het ruime strohok vertoonden twee duidelijke clusters in hun gedrag (zie pag. 85).

1) Gedragingen die direct met het geboorteproces te maken hebben of het vergemakkelijken: het voorzichtig in het nest stappen en gaan liggen (sliding into), liggen (lying), zogen (nursing), de geboorte van een big (delivery) en het uitdrijven van de placenta (expelling of the placenta).

2) Gedragingen die gericht zijn op de fysische omgeving of interfereren met het geboorte proces : nestbouw (nestbuilding),lopen, staan en zitten (standing and sitting) en exploreren (exploration).

Bij de gelten die opgroeiden in het kraamopfokhok werden in het eerste cluster naast gedragingen zoals gevonden bij de in het strohok opgegroeide gelten, ook gedragingen opgenomen zoals nestbouw, comfortgedrag (comfort behav.) en moederlijke agressie (biting and snapping). Een tweede cluster werd gevormd door de gedragingen lopen,staan en zitten en exploratie.

Uit de volgorde-analyse bleek dat de gelten die opgroeiden in het kraamopfokhok tijdens het werpen makkelijker overgingen van gedragingen die direct met het geboorteproces te maken hebben naar gedragingen die het geboorteproces negatief kunnen beïnvloeden of de biggen in gevaar brengen.

Opvallend was met name het vele staan en zitten dat de in het kraamopfokhok opgegroeide gelten vertoonden. Gedurende de opgroeiperiode, week 1 tot en met 8, vertoonden de biggen in het kraamopfokhok ook al veel staan en zitten. In deze eerste acht levensweken van de biggen bleek dit een werkzame strategie om masseren, bewroeten, besabbelen of beknabbelen van toomgenoten te vermijden. Dus, door te gaan staan of zitten wisten de dieren onplezierige of belastende situaties te vermijden. Dit gaan staan en zitten gedurende het werpen (wat een nieuwe en waarschijnlijk belastende situatie is voor de gelten) is niet erg adaptief in termen van overlevingskansen voor de pasgeboren biggen. Omdat de duur van het werpen van gelten, opgegroeid in het kraamopfokhok of strohok, niet verschilde, mogen we aannemen dat de gelten eenzelfde mate van stress ondervonden. Mocht dit zo zijn dan kunnen de verschillen in gedrag tussen de gelten opgegroeid in het kraamopfokhok of strohok niet toegeschreven worden aan het meer of minder belastend zijn van het werpen.

Uit de resultaten van het experiment beschreven in hoofdstuk 3 (twee verschillende opgroeicondities) bleek dat twee belangrijke factoren - het aanwezig zijn van stro dat gemanipuleerd kan worden en de vloeroppervlakte per dier - het gedrag van de biggen beïnvloedden.

In hoofstuk 6 en 7 worden de effecten van deze twee factoren op het gedrag van de biggen apart onderzocht.

In hoofstuk 6 wordt het effect van stro op het gedrag van biggen tot een leeftijd van zes weken beschreven. Vier tomen van elk acht biggen werden gehuisvest in kraamhokken waarin de zeug aangebonden stond. Gedurende de eerste twee levensweken werden twee hokken voorzien van stro en in de andere twee hokken zaten de biggen op een dichte betonvloer. Vanaf de derde week werd het substraat wekelijks gewisseld; kale beton hokken werden voorzien van stro en uit de strohokken werd het stro verwijderd. Het bleek dat het aktieve gedrag van de biggen sterk afhankelijk was van de aan- of afwezigheid van stro. In stroloze hokken richtten de biggen vrijwel onmiddellijk hun exploratieve gedrag op hun toomgenoten en de zeug. De biggen werden ook onrustig (meer staan en zitten) en gingen eerder vechten. Bovendien bleek dat bij de biggen op het kale beton het totaal aan exploratief en omgericht exploratief gedrag niet het niveau bereikte van exploratief gedrag van biggen over hetzelfde leeftijdstraject op stro. Dit wijst erop dat exploratief gedrag van de biggen in een arme omgeving (kale beton) niet volledig vervangen kan worden door de alternatieven (meer exploratie van objecten boven bodemniveau en omgericht exploratief gedrag) gekozen door de biggen.

In hoofdstuk 7 wordt het effect van vloeroppervlakte op het gedrag van biggen gedurende de eerste acht levensweken beschreven.

Er werden drie verschillende hokgrootten gebruikt: 1) 28 m^2 met vrijlopende zeug, 2) 6,7 m^2 en 3) 3,5 m^2; in de laatste twee hoktypen werd de zeug aangebonden. Alle hokken werden ruim voorzien van stro.

Door het gebruik van een gedetailleerd ethogram van agonistisch gedrag (offensief en defensief gedrag) en het gebruik van volgorde-analyse werd duidelijk dat er verschillen in ontwikkeling van dit gedrag afhankelijk van de hokgrootte optraden.

Zoals ook al getoond in hoofdstuk 3 had de grootte van het hok geen invloed op de individuele herkenning (besnuffelen van toomgenoten (nosing littermates)). In de ontwikkeling van agonistisch gedrag werden echter duidelijke verschillen gevonden.

Biggen in de hokken van 3.5 m^2 ontwikkelden nauwelijks dreiggedrag (frontaal staan (standing in front)), en leerden niet om kopslagen (headknocks) uitsluitend te richten op kop of schouders van tegenstanders. Bovendien bleven deze dieren veel bijten, terwijl in de grotere hokken bijten afnam met de leeftijd van de biggen.

Ook de volgorde waarin de agonistische gedragingen voorkwamen verschilde in de 3 hoktypen.

Na de vierde week werd in het grootste hok 37,8% van alle kopslagen voorafgegaan door dreigen. In het 6,7 m^2 hok was dit 29,5% en in het 3,5 m^2 hok slechts 3,9%. In het 3,5 m^2 hok bleek dat meer dan 40% van de kopslagen voorafgegaan werden door exploratief of door ander niet nader gespecificeerd gedrag. Omdat dreigen bijna niet voorkwam in het 3,5 m^2 hok was het begin van een agonistische interactie in hoge mate onvoorspelbaar voor deze biggen. Deze onvoorspelbaarheid van het gedrag van toomgenoten draagt weer bij tot de onrust in kleine hokken. In tegenstelling tot de biggen in de 6,7 en 28 m^2 hokken veranderde het patroon van agonistisch gedrag van biggen in het 3,5 m^2 hok niet meer na de derde levensweek. Het agonistisch gedrag van biggen in het 3,5 m^2 hok zou dan ook geklassificeerd kunnen worden als infantiel. Bovendien zijn er aanwijzingen dat dit infantiele agonistische gedrag niet meer verandert tijdens het leven van de dieren. Dit zou betekenen dat biggen die opgroeien in te kleine hokken niet goed toegerust zijn om op latere leeftijd met normaal sociaal gedrag te functioneren in een groep.

In de algemene discussie (hoofdstuk 8) worden twee belangrijke punten wat meer belicht. Ten eerste, de directe effecten van het opgroeien in een arme of rijke omgeving op het gedrag van biggen en ten tweede de effecten van opgroeien in een arme of rijke omgeving op het latere gedrag rond het werpen.

Het bleek dat de hoeveelheid ruimte die de biggen tot hun beschikking hadden voornamelijk de ontwikkeling van het agonistische gedrag beïnvloedde. De complexiteit van de omgeving en vooral de aan- of afwezigheid van substraat dat te manipuleren valt, bleek een belangrijke factor te zijn in het al dan niet optreden van omgericht exploratief gedrag en onrust.

De resultaten beschreven in de hoofdstukken 3 en 7 duiden op een socialisatieperiode in de tweede en derde levensweek van de biggen.

Het effect van gereduceerde vloeroppervlakte resulteerde in de toename van onvoorspelbaarheid van het gedrag van toomgenoten. Dit komt sterk overeen met de effecten van sociale isolatie gevonden bij andere diersoorten. In beide situaties leren de dieren niet hun sociale omgeving onder controle te krijgen.

Kort samengevat kan worden gezegd dat een verarming van de omgeving omgericht exploratief gedrag oproept wat dan meestal gericht wordt op liggende hokgenoten. Biggen leren met dit gedrag van toomgenoten om te gaan door het te vermijden of zich er aan te onttrekken, voornamelijk door te gaan staan of te gaan zitten. In hun latere leven vertonen de dieren regressie van dit gedrag doordat ze dit gedrag gaan vertonen in reactie op een nieuwe of belastende situatie zoals bijvoorbeeld het werpen. Dit gedrag is in deze situatie niet adaptief meer vanwege de mogelijke beschadigende gevolgen voor de biggen.

Houderijsystemen die omgericht exploratief gedrag in de hand werken en de ontwikkeling van normaal sociaal gedrag in de weg staan, beinvloeden het welzijn van het dier in ongunstige zin.

Voor de praktische varkenshouderij is de opgroeiconditie van biggen uitermate belangrijk gezien de effecten van deze opgroeicondities op het gedrag van varkens in hun latere leven.

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Appendix A: p values of the analyses of variance.

	Percentage of time spent on various behaviours					Mean duration of bouts of behaviour		
	Level		Linear trend			Level		
	Housing effect	Sister-pair effect	Slope linear	Housing effect	Sister-pair effect	Housing effect	Sister-pair effect	
Resting	4		6	3	7			
Lying	2	10		4	10			
Lying at the udder			1					§
Active	4		6	3	7			
Sucking	15		1					§
Manipulating the udder	2		5		9	17		§
Feeding,Drinking and Elimination			0.2	14				
Exploration	0.9		0.0	11	12	3		
Sniffing objects	3	7	0.5			4	20	
Sniffing substrate		9	0.4		10		17	
Chewing	0.2		0.1	8		0.7		
Rooting	2	11	0.4			7	5	
Nosing piglet		6	0.0		10		5	
Massaging or nibbling piglet	0.3		0.3	5		4	8	
Mounting			11					
Nosing sow			0.1		17		20	§
Massaging or nibbling sow	0.5					3		§
Locomotion	10		0.2					
Standing and sitting	2		0.2	16	8	4		
Playful activities	8							
Comfort behaviour			2			8		
Agonistic behaviour								
Ramming or pushing			0.0	0.5	5	9	12	
Fighting		20	6		18			

The p values are presented as percentages, only p values less or equal to 20% are shown.

§ The levels and linear trend are calculated over the first 6 weeks of life of the piglets (lactation weeks), otherwise levels and linear trend are calculated over the first 8 weeks of life of the piglets.

Appendix B

STRAW REARED GILTS

Following behaviour Preceeding behaviour	Structural nestbuilding	Sliding into	Lying	Exploration	Standing and sitting	Nursing	Maternal contact seeking	Biting or snapping of piglets	Drive away piglets	Expelling placenta	Comfort	Ingestion and elimination	Delivery	Total
Structural nest-building	a* b c	18 6,3 4,6	28 54,0 -3,5	42 47,4 -0,8	96 56,9 5,2		77 84,6 -0,8	5 11,9 -2,0	3 2,5 0,3	0 1,4 -1,2	5 4,3 0,4	0 1,5 -1,2	0 3,2 -1,8	274
Sliding into	2 4,5 -1,2		37 9,0 9,3	1 7,9 -2,5	6 9,5 -1,1	0 3,8 -1,9	7 14,1 -1,9	0 2,0 -1,4	0 0,4 -0,7	0 0,2 -0,5	0 0,7 -0,8	0 0,3 -0,5	0 0,5 -0,7	53
Lying	2 51,3 -6,9			60 90,0 -3,2	63 108,0 -4,3	114 42,9 10,9	179 160,7 1,4	36 22,6 2,8	6 4,8 0,5	6 2,6 2,1	10 8,1 0,7		21 6,0 6,1	497
Exploration	81 44.1 5.6	16 10,3 1,8	71 88,2 -1,8		116 92,9 2,4	2 36,9 -5,7	141 138,2 0,2	5 19,5 -3,3	3 4,1 -0,6	0 2,2 -1,5	10 7,0 1,1	5 2,5 1,6	1 5,2 -1,8	451
Standing and sitting	109 52,8 7,7	16 12,4 1,0	24 105,8 -8,0	166 92,7 7,6		2 44,2 -6,3	156 165,6 -0,7	33 23,3 2,0	5 5,0 0,0	0 2,6 -1,6	5 8,4 -1,2	6 3,0 1,8	0 6,2 -2,5	522
Nursing	0 19,3 -4,4		87 38,7 7,8	1 33,9 -5,7	6 40,7 -5,4		84 60,6 3,0	6 8,5 -0,9	5 1,8 2,4	6 1,0 5,1	4 3,1 0,5	0 1,1 -1,0	12 2,3 6,4	211
Maternal contact seeking	73 78,0 -0,6	3 18,3 -3,6	168 156,3 0,9	155 137,0 1,5	166 164,5 0,1	64 65,3 -0,2		41 34,5 1,1	4 7,3 -1,2	3 3,9 -0,5	11 12,3 -0,4	2 4,4 -1,1	1 9,2 -2,7	691
Biting or snapping of piglets	3 11,2 -2,4	0 2,6 -1,6	32 22,4 2,0	11 19,6 -1,9	42 23,5 3,8	3 9,3 -2,1	36 35,0 0,2		2 1,0 0,9	0 0,6 -0,7	0 1,8 -1,3	0 0,6 -0,8	0 1,3 -1,1	129
Drive away piglets	2 2,4 -0,3	0 0,6 -0,8	5 4,9 0,1	1 4,3 -1,6	7 5,1 0,8	5 2,0 2,1	7 7,6 -0,2	2 1,1 0,9		0 0,1 -0,3	0 0,4 -0,6	0 0,1 -0,4	0 0,3 -0,5	29
Expelling placenta	0 1,3 -1,1	0 0,3 -0,5	7 2,5 2,8	0 2,2 -1,5	1 2,6 -1,0	4 1,1 2,9	1 3,9 -1,5	0 0,6 -0,7	0 0,1 -0,3		2 0,2 4,0	0 0,1 -0,3	0 0,1 -0,4	15
Comfort	2 4,0 -1,0	0 0,9 -1,0	16 8,0 2,9	12 7,0 1,9	8 8,4 -0,1	5 3,3 0,9	3 12,5 -2,7	0 1,8 -1,3	0 0,4 -0,6	0 0,2 -0,4		1 0,2 1,6	0 0,5 -0,7	47
Ingestion and elimination	0 1,4 -1,2	0 0,3 -0,6	0 2,7 -1,6	1 2,4 -0,9	10 2,8 4,2		4 4,2 -0,1	0 0,6 -0,8	0 0,1 -0,4	0 0,1 -0,3	0 0,2 -0,5		0 0,2 -0,4	15
Delivery	0 3,8 -1,9	0 0,9 -0,9	25 7,6 6,3	1 6,7 -2,2	2 8,0 -2,1	13 3,2 5,5	4 11,9 -2,3	0 1,7 -1,3	0 0,4 -0,6	0 0,2 -0,4	0 0,6 -0,8	0 0,2 -0,5		45
Total	274	53	500	451	523	212	699	128	28	15	47	14	35	2979

* per cell:

a observed frequency

b expected frequency

c standardized residuals

Empty cells are structural zero's.

$X^2 = 1290,1$

$p < 0,000$

$df = 126$

Appendix C

CRATE REARED GILTS

Following behaviour	Structural nestbuilding	Sliding into	Lying	Exploration	Standing and sitting	Nursing	Maternal contact seeking	Biting or snapping of piglets	Drive away piglets	Expelling placenta	Comfort	Ingestion and elimination	Delivery	Total
Preceding behaviour														
Structural nest-building	a* b c	18 4,1 6,8	32 40,7 -1,4	56 53,7 0,3	131 112,8 1,7		52 54,7 -0,4	13 28,8 -2,9	3 2,9 0,0	0 1,0 -1,0	1 2,0 -0,7	0 2,9 -1,7	1 3,4 -1,3	307
Sliding into	0 3,2 -1,8		27 4,8 10,2	2 6,3 -1,7	7 13,3 -1,7	0 1,2 -1,1	2 6,4 -1,7	0 3,4 -1,8	0 0,3 -0,6	0 0,1 -0,3	0 0,2 -0,5	0 0,3 -0,6	2 0,4 2,6	40
Lying	7 39,9 -5,2			39 77,6 -4,4	102 163,1 -4,8	64 14,3 13,2	96 79,1 1,9	74 41,7 5,0	13 4,2 4,3	3 1,4 1,3	7 2,9 2,4		24 4,8 8,7	429
Exploration	83 51,0 4,5	10 7,6 0,9	65 75,3 -1,2		245 208,7 2,5	0 18,2 -4,3	78 101,2 -2,3	40 53,4 -1,8	4 5,4 -0,6	0 1,8 -1,4	2 3,7 -0,9	8 5,5 1,1	3 6,2 -1,3	538
Standing and sitting	145 108,9 3,5	11 16,3 -1,3	48 160,7 -8,9	311 211,9 6,8		0 38,9 -6,2	249 216,0 2,2	124 113,9 0,9	8 11,6 -1,0	2 3,9 -1,0	2 7,9 - 2,1	13 11,6 0,4	2 13,2 -3,1	915
Nursing	0 8,6 -2,9		50 12,7 10,5	0 16,7 -4,1	3 35,2 -5,4		26 17,0 2,2	1 9,0 -2,7	3 0,9 2,2	2 0,3 3,0	12 0,6 14,4	1 0,9 0,1	5 1,0 3,9	103
Maternal contact seeking	55 52,8 0,3	2 7,9 -2,1	88 77,9 1,1	91 102,8 -1,2	229 216,0 0,3	23 18,9 0,9		61 55,2 0,8	1 5,6 -1,9	4 1,9 1,5	0 3,8 -2,0	8 5,6 1,0	2 6,4 -1,7	555
Biting or snapping of piglets	11 28,6 -3,3	0 4,3 -2,1	67 42,2 3,8	34 55,6 -2,9	171 116,9 5,0	0 10,2 -3,2	40 56,7 - 2,2		3 3,0 0,0	0 1,0 -1,0	0 2,1 -1,4	1 3,1 -1,2	0 3,5 -1,9	327
Drive away piglets	2 3,1 -0,6	1 0,5 0,8	12 4,5 3,5	4 6,0 -0,8	10 12,5 -0,7	3 1,1 1,8	3 6,1 -1,3	3 3,2 -0,1		0 0,1 -0,3	0 0,2 -0,5	0 0,3 -0,6	0 0,4 -0,6	38
Expelling placenta	0 0,7 -0,8	0 0,1 -0,3	1 1,1 -0,1	1 1,4 -0,3	4 3,0 0,6	3 0,3 5,4	0 1,4 -1,2	0 0,8 -0,9	0 0,1 -0,3		0 0,1 -0,2	0 0,1 -0,3	0 0,1 -0,3	9
Comfort	0 1,9 -1,4	0 0,3 -0,5	5 2,9 1,3	1 3,8 -1,4	4 7,9 -1,4	10 0,7 11,2	3 3,8 -0,4	0 2,0 -1,4	0 0,2 -0,5	0 0,1 -0,3		0 0,2 -0,5	1 0,2 1,6	24
Ingestion and elimination	1 2,7 -1,0	0 0,4 -0,6	3 3,9 -0,5	9 5,2 1,7	11 10,9 0,0		6 5,3 0,3	2 2,8 -0,5	0 0,3 -0,5	0 0,1 -0,3	0 0,2 -0,4		1 0,3 -0,6	32
Delivery	1 3,6 -1,4	0 0,5 -0,7	34 5,4 12,4	0 7,1 -2,7	7 14,9 -2,0	2 1,3 0,6	0 7,3 -2,7	0 3,8 -2,0	0 0,4 -0,6	1 0,1 2,4	0 0,3 -0,5	0 0,4 -0,6		45

* per cell:
a observed frequency
b expected frequency
c standardized residuals

Empty cells are structural zero's.

$X^2 = 1336.4$
$p < 0{,}000$
df = 126

CURRICULUM VITAE

Wilhelmus Gerardus Petrus Schouten werd geboren op 28 september 1947 te Bemmel. Na lager onderwijs en 4 jaar U.L.O. te Bemmel, werd in 1964 het diploma U.L.O.-A en -B behaald. Daarop volgde een opleiding als electronicus bij de Koninklijke Marine en een dienstverband van 8 jaar bij de Marine Luchtvaartdienst. In 1972 trad hij in dienst bij Z.W.O. als technicus-A op een beleidsruimte project Hersenen en Gedrag. Hij werd gedetacheerd bij de vakgroep Vergelijkende en Fysiologische Psychologie van de K.U. te Nijmegen. Hij participeerde in onderzoek naar ontwikkeling van gedrag bij ratten en java-apen. Van 1972 tot 1975 volgde hij een atheneum-opleiding op de Avondscholengemeenschap "Craneveldt" te Nijmegen en in 1975 werd het diploma Atheneum-B behaald. Daarna studeerde hij Biologie aan de K.U. te Nijmegen. In 1976 werd het propaedeuse-examen behaald en in 1978 het Kandidaatsexamen. De studie werd in 1981 afgerond met als hoofdvak Dierfysiologie en als bijvakken Vergelijkende en Fysiologische Psychologie en Dieroecologie. In aansluiting hierop volgde een aanstelling als promotie-assistent bij de vakgroep Veehouderij, sectie Ethologie, van de Landbouwhogeschool te Wageningen.

Sinds 1 juli 1984 is hij verbonden als universitair docent aan bovengenoemde vakgroep.