

## Provision of straw as a foraging substrate reduces the development of excessive chain and bar manipulation in food restricted sows

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### Abstract

Pregnant sows fed at commercial levels remain highly food motivated for most of the day. The inability to express this behaviour appropriately may, under certain conditions, result in the development of abnormal oral activities such as stereotypic chain and bar manipulation. Ninety-six gilts, all between 1 and 3 weeks post service, were entered into a 2 × 2 factorial design comparing food level (low, 1.8 kg/23 MJ day<sup>-1</sup> (L); high, 3.2 kg/40 MJ day<sup>-1</sup> (H)) and the provision of a foraging substrate (S, straw; N, no straw). The gilts were loose housed in groups of six with individual stalls. A 70 cm chain loop was attached to the front of each stall. The sows were fed at 09:00 h, during which time S sows received straw (approximately 1.5 kg per sow). Behaviour was recorded over the first two parities, by time sampling for the 2 and 6 h after the start of feeding and over 24 h using video recordings. Activity levels were highest just after feeding, with L sows being more active than H sows (L vs. H, 79% vs. 49% for the second hour after the start of feeding,  $F_{1,12} = 41.5$ ,  $P < 0.001$ ). Most of the postprandial activity consisted of manipulating substrates. In LN sows, particularly in Parity 2, this behaviour was mainly directed towards chains and bars, resulting in levels three to four times higher than in other groups (26%, 7%, 4% and 4% for the second hour after feeding for LN, LS, HN and HS respectively; Tukey's HSD,  $P < 0.05$ ). LS sows directed their foraging behaviour mainly towards the straw. It is concluded that in food-restricted pregnant sows, abnormally high levels of chain and bar manipulation can be prevented by providing straw which apparently acts as a foraging substrate.

**Keywords:** Pregnant sow; Feeding; Stereotypies; Straw; Foraging

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## 1. Introduction

Chain and bar manipulation in pregnant sows are often regarded as stereotypic behaviours (e.g. Jensen, 1988; Terlouw et al., 1991b), as they are relatively invariant, repeated frequently and without an apparent goal (Ödberg, 1978). What causes stereotypies to develop in pigs is the subject of much current research, but a number of contributing factors such as physical restriction (Cronin, 1985), general lack of stimulation (Mason, 1991) and individual characteristics (Terlouw et al., 1990) have been identified.

Recently, Lawrence and Terlouw (1993) suggested that food restriction and the inability to express resulting foraging behaviour is one of the main causes for the development of stereotypies in sows. They argue that in food-restricted sows the positive feedback effects of feeding in the early stages of a meal (Wiepkema, 1971) overrules the negative feedback from ingestion of nutrients. This may result in higher levels of feeding motivation after the meal than before it, which would be expressed in higher levels of appetitive foraging behaviour. In an environment where this behaviour cannot be performed in a satisfactory way, where the animal's movements are restricted or where there is simply no available foraging substrate, the behaviour may be performed repetitively with a less appropriate substrate. This 'channelling' of complex behaviour into a few repeated sequences could be an important prerequisite stage in the sensitisation of underlying neural elements (Dantzer, 1986), which would allow stereotypies to be more easily elicited and maintained.

Lawrence and Terlouw (1993) hypothesise that there are two methods of preventing stereotypies from developing: by reducing the level of feeding motivation, or by allowing the expression of more complex behaviours to prevent the channelling process. The present study was designed to investigate this hypothesis. It compared the effects of food level and the presence of a foraging substrate (straw) on the development of behaviours in gestating sows during their first and second pregnancy. The effects on production parameters will be the subject of a report which is currently in preparation.

The sows' behaviour was observed over three different periods during the day. First, the 2 h after the start of feeding were studied, as activity levels should be highest during this period (Rushen, 1985; Jensen, 1988; Terlouw et al., 1991b) and the onset of stereotypic behaviour is triggered by food ingestion (Jensen, 1988; Terlouw et al., 1993). These scans may indicate how stereotypies develop over the two parities. Second, data were collected over a longer period during the day. Although stereotypies peak in the postprandial period, they are often sustained subsequently (Terlouw et al., 1991a). As food restricted sows are food motivated throughout most of the day (Lawrence et al., 1988), differences between treatments could be expected to be maintained in levels of foraging and other manipulative behaviours. Third, 24 h video recordings were sampled for the sows' posture, location and drinking behaviour. Posture was used to test the hypothesis that activity levels, indirectly measured as 'standing', are highest just after feeding (Rushen, 1985; Jensen, 1988; Terlouw et al., 1991b), and influenced by food level. The preference for bedding in the dunging area (Fraser, 1975) was tested by comparing the use of the stall and dunging area between treatments. Finally, Terlouw et al. (1991b) recorded drinking levels in food restricted sows which they considered abnormal. By estimating the levels of drinking behaviour over 24 h this study aimed to investigate whether drinking behaviour can be influenced by the food and straw treatments.

## 2. Materials and methods

### 2.1. Animals

Ninety-six nulliparous sows (PIC Camborough; mean  $\pm$  SD body weight,  $147.7 \pm 10.5$  kg; age,  $238.3 \pm 16.4$  days) entered the experiment in 16 groups of six animals at a rate of two groups per month. All animals had been in their groups for at least 2 months, and were between 1 and 3 weeks post service.

### 2.2. Treatments

The experiment was a  $2 \times 2$  factorial design, comparing food level (high (H)  $3.2$  kg/40 MJ day<sup>-1</sup> vs. low (L)  $1.8$  kg/23 MJ day<sup>-1</sup>) and the provision of straw as a foraging substrate (straw (S) vs. no straw (N)). Groups were randomly assigned to one of the four treatments. The straw treatment started on entry to the building: S sows received approximately  $1.5$  kg of fresh long barley straw in their stalls during feeding. The straw was usually removed from the dunging passage during cleaning the following day. The food treatment started in both parities after a preliminary habituation period of 2 weeks, during which all the sows received the same daily ration of  $2.4$  kg/30 MJ.

### 2.3. Housing and care

The sows were loose housed in a solid floor pen ( $3.6$  m  $\times$   $4.1$  m), consisting of six free-access stalls raised  $15$  cm above a communal dunging area ( $3.6$  m  $\times$   $2.0$  m). Each stall had a ground level trough and a  $70$  cm loop of chain which was attached to the front bars. The animals had access to two drinkers and two additional chains ( $70$  cm in length) in the dunging area. They were shut in the stalls between  $09:00$  and  $10:00$  h every morning, to allow for the daily cleaning out of the dunging passage. Feeding started at  $09:00$  h using a semi-automatic feeder which dispensed fixed rations of the same gestation diet to each individual. Chemical analyses of the diet indicated an average content of  $151$  g protein,  $55$  g oil,  $60$  g neutral detergent fibre,  $64$  g ash, and  $6.9$  g lysine kg<sup>-1</sup>. The digestible energy content calculated from proximate analyses using a standard prediction equation was  $12.6$  MJ kg<sup>-1</sup>. Any food left in the trough at  $10:00$  h was removed and weighed.

Pregnancy was tested for in both parities, around days 28 and 42 after service. Oestrus detection was carried out daily by examination of the vulva. Any animal which returned for service was served, but sows which had expected farrowing dates more than 30 days later than the rest of the group were rejected from the experiment after the rest of the group had moved to the farrowing house.

Sows were taken to the farrowing house one to two weeks prior to their expected farrowing date. The building had a controlled environment and solid floor farrowing crates. Chopped straw was provided to all sows every day after cleaning out. The animals were fed  $2$  kg of a lactation diet ( $184$  g protein,  $87$  g oil,  $54$  g fibre,  $71$  g ash,  $9.7$  g lysine and a calculated digestible energy of  $13.8$  MJ kg<sup>-1</sup>) twice a day. After farrowing the daily ration was increased by  $0.5$  kg per piglet born alive to a maximum of  $8.0$  kg.

Weaning occurred at  $24 \pm 2$  days. Sows were taken to the service house and reunited in their original groups. They were housed in solid floor straw pens with six individual feeders, and fed a daily ration of 3.0 kg (41 MJ) of the lactation diet until service. Eight sows in three groups had their services delayed by 3 weeks to allow for synchronisation of their reproductive cycle with other group members. After service, sows received 3.0 kg (38 MJ) of the pregnancy diet.

Two to five days after the last animal had been served the group was moved back to the experimental building, where they returned to their experimental food levels 2 weeks later.

#### *2.4. Behavioural observations*

All sows in a group were marked with a sprayed pattern to facilitate identification. The sows' behaviour was recorded over both pregnancies using three different methods.

##### *2.4.1. Two hour time sampling*

The sows were observed on 3 days evenly spaced over each pregnancy, at approximately 3, 7 and 11 weeks after entry to the experimental building. The observation periods started at 09:00 h (feeding time) and finished at 11:00 h, 1 h after the sows had been released from their stalls. Every 5 min an observer recorded posture, behaviour and the substrate used for each sow. A description of the behavioural categories used can be found in Table 1. Data were recorded on to an Atari portfolio computer (Atari Co, Sunnyvale, CA), using the data collection program Keybehaviour (Deag, 1990).

##### *2.4.2. Six hour time sampling*

Sows were observed for a total of 6 h after the start of feeding on 5 days evenly spaced over each pregnancy (approximately 3, 5, 7, 9 and 11 weeks after entry to the experimental building). The interval between samples was 20 min, resulting in 18 samples for each animal per observation day. The ethogram and data collection program used were similar to those given above.

##### *2.4.3. Twenty-four hour time sampling*

Around day 50 of pregnancy a 48 h video recording was made of each group's behaviour using a video camera (Ikegami ICD-42E, Ikegami Tsushinki Co., Tokyo, Japan) with a wide angled lens and a time lapse video recorder (Panasonic AG6720, Matsushita Electric Industrial Co., Osaka, Japan) set on 72 h recording mode. An uninterrupted 24 h section was then selected from the tape and for each sow, posture (lying, kneeling/sitting or standing), use of area (dunging area or stalls) and drinker activity (using the drinker or not) were recorded every 10 min.

#### *2.5. Statistical methods*

The percentages of time each sow spent in the different behavioural categories were estimated. As feeding behaviour was performed over a relatively large part of the first hour, the levels of all other behaviours during this hour were calculated as a percentage of the observation period minus the time spent feeding. This correction was not applied to data of

Table 1  
List of behavioural categories used for 2 and 6 h time sampling

Standing	Body supported by all four legs
Other postures	Lying, sitting or kneeling
Feeding	Chewing and ingesting feed or licking the inside of the trough while food still in trough
Sleeping	Lying with eyes closed without apparently performing any behaviour
Inactive	Lying, sitting or standing with eyes open, without apparently performing any other behaviour
Drinking	Drinking water from the drinker nipples in the dunging area
Oral activities	Non-manipulative oral activity (as described by Cronin and Wiepkema 1984): vacuum chewing (continuous and rhythmical chewing in the absence of any substrate or feed in the mouth), tongue sucking (apparent sucking and subtle jaw movements with the cheeks slightly involuted and the front of the lower lip drawn in a V-shape) and mouth stretching (continual and rhythmical mouth opening and closing with the emphasis on stretching the lower jaw whilst open, rather than on chewing)
Manipulating substrates	Nosing, chewing, rooting, biting, lifting or licking any available substrate in the stalls or dunging area other than feed or pen mates
Chains	Nosing, chewing, rooting, biting, lifting or licking the chain loops in the feeding stalls or in the dunging area
Bars	Nosing, rooting, biting or licking any of the bars of the stalls
Trough	Nosing, rooting or licking any part of the feeding trough
Floor	Nosing or licking any part of the floor in the feeding stalls or the dunging area
Straw	Nosing, chewing or rooting straw, either in the stalls or in the dunging area
Other	Manipulating any other substrate (e.g. pen mates, walls, drinkers)
Other behaviours	Any other behaviours (e.g. excretion, locomotion, agonistic)

the 6 and 24 h scans. Feeding time (min) in the first hour of the 2 h scans was estimated as the number of times a sow was observed feeding multiplied by five. Feeding rate ( $\text{g min}^{-1}$ ) was calculated by dividing the ration by the feeding time. Data were tested for treatment effects using Genstat 5 (1987), by analyses of variance for repeated measures (nested for pig and group) with two factors (food and straw). Data on straw directed behaviour were tested in S groups only, with one factor (food). Where data could not be normalised, the Mann–Whitney test was used (Minitab 9 for Windows, 1993), with only one factor (food or straw). Three factors (food, straw and parity number) were used where data were tested for effect of parity. Time of day effects were tested for per parity, by analysis of variance, using feed, straw and hour as factors. Tukey's HSD (Minitab 9 for Windows, 1993) was used for pairwise comparison of the means of the four treatments (or of the 6 h, when time of day effects were tested for) but only after an interactive effect or time of day effect had been found. Regression analysis was used to investigate effects of stage of pregnancy on development of behaviours. Where appropriate angular, square root or logarithmic transformations were used.

### 3. Results

Out of the original 96 sows that started on the treatments, 95 sows completed the first parity and 79 the second. This was mainly due to the large number of sows which no longer

had synchronous reproductive cycles with their group mates due to returns to service. Rejected sows came from all four treatments, and were regarded as missing values in the data analyses.

### 3.1. Effects of parity and time of day

Levels of standing increased on all treatments before feeding (Fig. 1). Over the 6 h following the start of feeding the level of standing decreased (Parity 1,  $F_{5,460} = 238.3$ ,  $P < 0.001$ ; Parity 2,  $F_{5,375} = 138.1$ ,  $P < 0.001$ ) as well as the level of substrate manipulation (Fig. 2; Parity 1,  $F_{5,460} = 55.0$ ,  $P < 0.001$ ; Parity 2,  $F_{5,375} = 43.9$ ,  $P < 0.001$ ). Levels of sleeping and inactive (Parity 1,  $F_{5,460} = 144.3$ ,  $P < 0.001$ ; Parity 2,  $F_{5,375} = 120.3$ ,  $P < 0.001$ ) increased.

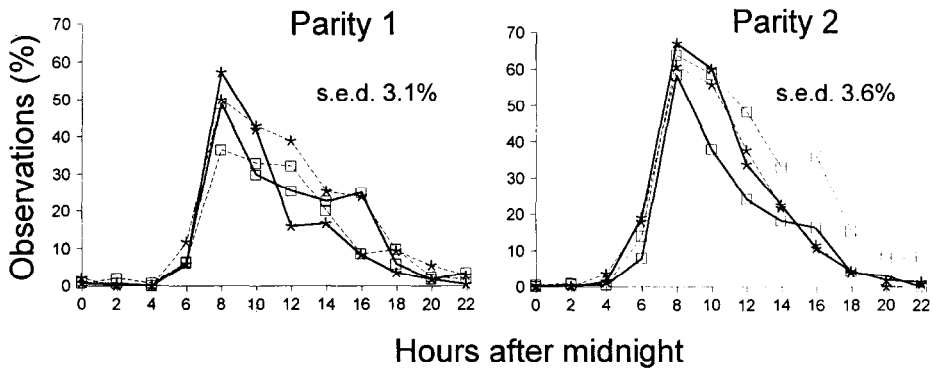


Fig. 1. The percentage of observations spent standing. Values shown are treatment means with standard errors of the differences of means (SED) over all four treatments: LN (open squares and dashed line), HN (open squares and solid line), LS (asterisks and dashed line) and HS (asterisks and solid line).

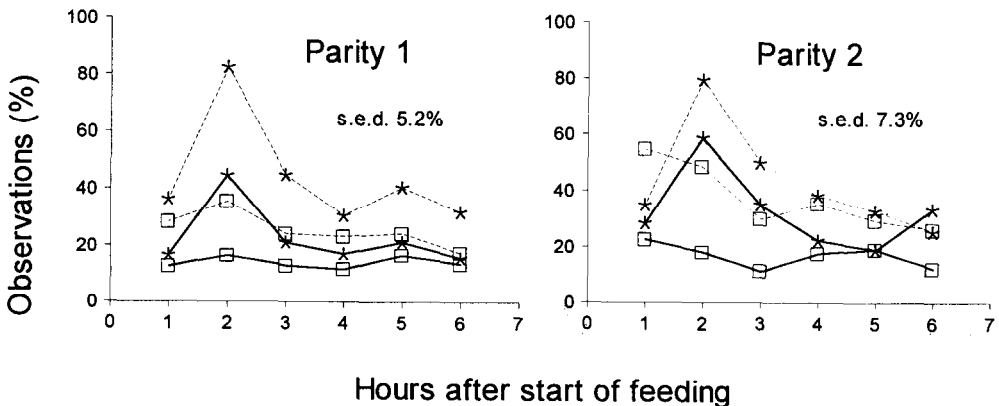


Fig. 2. The percentage of observations spent manipulating substrates. Values shown are treatment means with standard errors of the differences of means (SED) over all four treatments: LN (open squares and dashed line), HN (open squares and solid line), LS (asterisks and dashed line) and HS (asterisks and solid line).

Table 2  
Analyses of variance on the percentages of time treatment groups spent standing, drinking and in the dunging area across parities 1 and 2 (24 h data)

	Parity 2													
	Parity 1						Parity 2							
	Means per treatment		SED	P-values		Means per treatment		SED	P-values		F × S			
LN	LS	HN	HS	F	S	F × S	LN	LS	HN	HS	F	S	F × S	
Standing	13	18	15	12	0.538	0.128	24	20	14	16	3.6	0.091	0.787	0.413
Dunging area	7	18	8	37	0.080	0.125	8	32	8	18	8.8	0.079	<0.001 <sup>a</sup>	–
Drinking	1	0	1	2	0.033	0.813	0.492	2	1	2	0.4	0.528	0.472	0.965

<sup>a</sup>Data could not be normalised. The statistical test used was Mann–Whitney for Food and Straw effect. Values in bold indicate significant effects at  $P < 0.05$ .

Table 3  
Analyses of variance on the percentages of time treatment groups spent in different behavioural categories across parities 1 and 2 (6 h data)

	Parity 2													
	Parity 1						Parity 2							
	Means per treatment		SED	P-values		Means per treatment		SED	P-values		F × S			
LN	LS	HN	HS	F	S	F × S	LN	LS	HN	HS	F	S	F × S	
Standing	36	49	26	35	4.6	0.002	0.467	52	54	32	46	7.5	0.024	0.142
Feeding	5	5	9	9	1.3	0.001	0.671	3	5	8	8	0.9	<0.001	0.053
Sleeping + inactive	50	41	59	54	3.8	0.001	0.409	42	38	57	47	6.3	0.017	0.131
Drinking	3	1	4	4	0.9	0.018	0.127	0.380	4	6	5	1.5	0.360	0.478
Oral activities	4	1	1	0	1.4	0.021	–	3	2	1	1	1.2	0.333	0.064 <sup>a</sup>
Manipulating substr.	27	45 <sup>c</sup>	15	23	4.4	0.001	0.180	41	44	18	33	6.2	0.002	0.054
Man. straw	–	32	–	14	3.6	0.003	–	–	33	–	19	3.5	0.045	–
Man. trough + floor	14 <sup>b</sup>	7 <sup>a</sup>	8 <sup>a</sup>	6 <sup>a</sup>	1.4	0.003	0.027	15 <sup>b</sup>	5 <sup>a</sup>	10 <sup>a</sup>	7 <sup>a</sup>	2.1	0.384	0.002
Man. bar + chain	8	4	3	2	2.3	0.049	0.253	0.644	22 <sup>b</sup>	6 <sup>a</sup>	5 <sup>a</sup>	4.2	0.019	0.096

<sup>a</sup>Data could not be normalised. The statistical test used was Mann–Whitney for Food and Straw effect. Values in bold indicate significant effects at  $P < 0.05$ . Means of a category within each parity followed by different letters differ significantly (Tukey,  $P < 0.05$ ).

Levels of standing over the 24 h day were higher in the second than in the first parity (Table 2;  $F_{1,77}=10.5$ ,  $P=0.002$ ), and so were levels of drinking (Table 2;  $F_{1,77}=7.7$ ,  $P=0.007$ ). The 6 h data confirm this (Table 3; standing,  $F_{1,75}=45.2$ ,  $P<0.001$ ; drinking,  $F_{1,75}=14.9$ ,  $P<0.001$ ). It also shows an increase in chain and bar manipulation (Table 3;  $F_{1,75}=45.2$ ,  $P<0.001$ ), and a decrease in sleeping and inactive (Table 3;  $F_{1,75}=9.1$ ,  $P=0.003$ ) in Parity 2 relative to Parity 1. Average feeding rates were higher in Parity 2 than in Parity 1 ( $F_{1,77}=39.8$ ,  $P<0.001$ ).

### 3.2. Effects of food level

The H fed sows spent more time feeding in both parities (Parity 1, H vs. L, 30.9 vs. 14.9 min,  $F_{1,12}=47.4$ ,  $P<0.001$ ; Parity 2, H vs. L, 24.8 vs. 11.1 min,  $F_{1,12}=63.4$ ,  $P<0.001$ ). Feeding rates in high fed sows averaged 112 g min<sup>-1</sup> in Parity 1, with no significant change over pregnancy. Regression analyses showed that L fed sows increased their rate of feeding from 115 g min<sup>-1</sup> in the first month to 151 g min<sup>-1</sup> at the end of Parity 1 ( $T=4.3$ ,  $P<0.001$ ). By the end of Parity 1, average feeding rates differed significantly between the two food treatments ( $F_{1,12}=7.8$ ,  $P=0.017$ ), a difference that was maintained in Parity 2 (L vs. H, 181 vs. 133 g min<sup>-1</sup>,  $F_{1,12}=5.5$ ,  $P=0.037$ ).

Levels of standing over the 24 h day did not differ between the food treatments in Parity 1, but, in Parity 2, L fed sows tended to spend more time standing than H fed animals (Table 2;  $F_{1,12}=3.4$ ,  $P=0.091$ ). H fed sows spent more time drinking than L fed animals in Parity 1, an effect which was absent in Parity 2 (Table 2; Parity 1,  $F_{1,12}=5.5$ ,  $P=0.033$ ; Parity 2,  $F_{1,12}=0.4$ ,  $P=0.528$ ). During the first 6 h after the start of feeding, L sows spent more time standing (Table 3; Parity 1,  $F_{1,12}=14.9$ ,  $P=0.002$ ; Parity 2,  $F_{1,12}=6.7$ ,  $P=0.024$ ) and manipulating substrates (Table 3; Parity 1,  $F_{1,12}=28.9$ ,  $P<0.001$ ; Parity 2,  $F_{1,12}=15.2$ ,  $P=0.002$ ) than H sows, both in the first and in the second parity. They spent less time feeding, and less time sleeping or inactive. Data from the first 2 h after feeding are summarised in Table 4. In both Parities 1 and 2, levels of standing and bar and chain manipulation are higher in the L sows than in the H sows (e.g. Table 4; bar and chain manipulation, second hour, Mann–Whitney  $W=1667.5$ ,  $P=0.001$ ). Straw manipulation was higher in L than in H sows in the second hour after feeding (Table 4; Parity 1,  $F_{1,6}=29.7$ ,  $P=0.002$ ; Parity 2,  $F_{1,6}=7.5$ ,  $P=0.034$ ). Neither trough nor floor manipulation was influenced by food level.

### 3.3. Effects of straw provision

Over the 24 h period, sows on straw spent more time in the dunging area than sows without straw (Table 2; Parity 1,  $F_{1,12}=19.1$ ,  $P<0.001$ ; Parity 2, Mann–Whitney  $W=895.5$ ,  $P<0.001$ ). No effect of straw was found on standing over the 24 h day. During the 6 h post feeding in Parity 1, sows on straw stood more than sows without straw (Table 3;  $F_{1,12}=11.7$ ,  $P=0.005$ ). In both parities S sows also manipulated substrates more than N sows (Table 3; Parity 1,  $F_{1,12}=17.6$ ,  $P=0.001$ ; Parity 2,  $F_{1,12}=4.6$ ,  $P=0.054$ ) but spent less time manipulating pen components such as trough and floor (Table 3; Parity 1,  $F_{1,12}=19.0$ ,  $P<0.001$ ; Parity 2,  $F_{1,12}=16.4$ ,  $P=0.002$ ). In the first hour immediately following the start of feeding no effects of straw were apparent (Table 4). In the second



Table 4  
Analyses of variance on the percentages of time treatment groups spent in different behavioural categories (corrected for feeding time) across Hours 1 and 2 after the start of feeding (2 h data)

	Hour 1										Hour 2																			
	Means per treatment					SED					P-values					Means per treatment					SED					P-values				
	LN	LS	HN	HS	HS	LN	LS	HN	HS	HS	F	S	F × S	LN	LS	HN	HS	HS	F	S	F × S	LN	LS	HN	HS	HS	F	S	F × S	
<i>Parity 1</i>																														
Standing	35	41	21	28	28	8.0	8.0	0.029	0.280	0.986	50	88	32	53	9.9	0.002	0.001	0.247												
Sleeping + inactive	48	43	64	54	54	7.1	7.1	0.019	0.133	0.614	41	8	55	8.0	0.001	<0.001	0.147													
Drinking	-	-	-	-	-	-	-	-	-	-	8	5	9	3.0	0.140	0.756	0.227													
Oral activities	7	3	1	2	2.4	0.065	0.475 <sup>a</sup>	-	-	-	5	0	1	2.1	0.049	0.002 <sup>a</sup>	-													
Manipulating substr.	38	43	26	33	8.7	8.7	0.106	0.374	0.922	32b	80c	20a	40b	6.4	0.001	<0.001	0.010													
Man. straw	-	14	-	12	5.3	5.3	0.724 <sup>a</sup>	-	-	-	75	-	30	8.2	0.002	-	-													
Man. trough + floor	24	22	17	19	4.8	4.8	0.171	0.947	0.561	18	4	12	7	2.3	0.802	<0.001 <sup>a</sup>	-													
Man. bar + chain	9	9	4	1	3.9	3.9	<0.001	0.438 <sup>a</sup>	-	6	1	3	1	1.1	0.247	<0.001 <sup>a</sup>	-													
<i>Parity 2</i>																														
Standing	71	56	31	40	13.3	13.3	0.005	0.686	0.142	79cb	89c	34a	68b	7.4	0.001	0.002	0.040													
Sleeping + inactive	20	30	52	47	8.3	8.3	0.002	0.636	0.250	17ab	9a	52c	26b	5.4	<0.001	<0.001	0.030													
Drinking	-	-	-	-	-	-	-	-	-	-	14	7	10	2.8	0.981	0.121	0.105													
Oral activities	4	4	5	1	2.7	0.640	0.185 <sup>a</sup>	-	-	4	2	2	0	1.2	0.235	0.008 <sup>a</sup>	-													
Manipulating substr.	71	60	36	41	8.5	8.5	0.001	0.575	0.215	51	79	21	49	10.0	0.001	0.002	0.924													
Man. straw	-	12	-	7	3.8	3.8	0.252	-	-	67	-	39	10.5	0.034	-	-	-													
Man. trough + floor	27	24	22	21	6.3	6.3	0.409	0.725	0.821	21	5	12	5	2.7	0.368	<0.001 <sup>a</sup>	-													
Man. bar + chain	43	21	8	13	8.6	8.6	0.006	0.197	0.053	26	7	4	4	5.2	0.001	0.011 <sup>a</sup>	-													

<sup>a</sup>Data could not be normalised. The statistical test used was Mann-Whitney for Food and Straw effect. Values in bold indicate significant effects at  $P < 0.05$ . Means of a category within each hour followed by different letters differ significantly (Tukey,  $P < 0.05$ ).

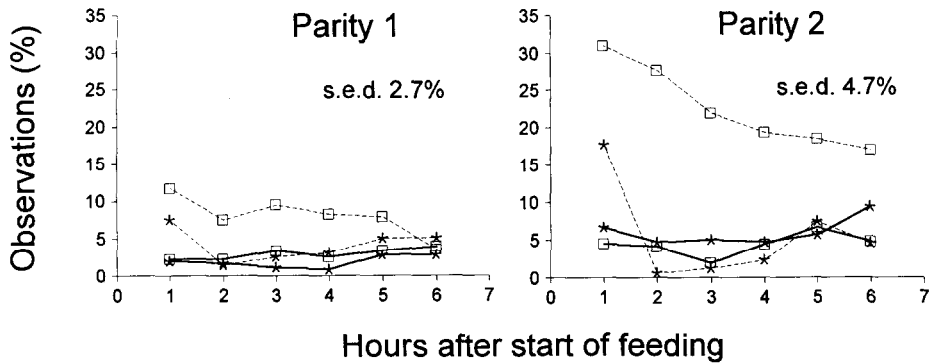


Fig. 3. The percentage of observations spent manipulating bars and chains. Values shown are treatment means with standard errors of the differences of means (SED) over all four treatments: LN (open squares and dashed line), HN (open squares and solid line), LS (asterisks and dashed line) and HS (asterisks and solid line).

hour however, standing and manipulating substrates were higher in S than in N sows (e.g. Table 4; standing,  $F_{1,12} = 17.9$ ,  $P = 0.001$ ). S sows spent less time performing oral activities, and less time manipulating substrates other than straw (e.g. Table 4, second hour, oral activity, Mann–Whitney  $W = 2531.5$ ,  $P = 0.002$ ).

### 3.4. Interactive effects of food level and straw provision

Interactive effects of food and straw were found during the 6 h post feeding in the levels of chain and bar manipulation (Table 3; Parity 2,  $F_{1,12} = 8.3$ ,  $P = 0.014$ ) and trough and floor manipulation (Table 3; Parity 1,  $F_{1,12} = 6.4$ ,  $P = 0.027$ ; Parity 2,  $F_{1,12} = 5.8$ ,  $P = 0.033$ ). LN sows spent more time performing these behaviours than sows on the other three treatments (Fig. 3, Tukey,  $P < 0.05$ ). Chain and bar manipulation in the 2 h data was non-parametrically distributed, and a straw  $\times$  food interaction could not be tested for. However, average levels of chain and bar manipulation were up to four times higher in LN sows than in any of the other groups (Table 4), but there was a large variation between individual sows (Fig. 4).

## 4. Discussion

This study demonstrates that activity in food restricted group housed sows peaks during and just after feeding and that sows on a low feed level are more active than sows on a high feed level. Most of the active time was spent manipulating straw and other pen components, straw being the preferred substrate. In its absence, levels of chain and bar manipulation increased significantly between Parities 1 and 2 in low fed animals.

High activity levels of pregnant sows in the periods immediately post feeding are also reported by other authors (Rushen, 1985; Jensen, 1988; Terlouw et al., 1991b). The present study (6 h data) shows a more gradual decline in levels of standing in the first 6 h after feeding than Terlouw et al. (1991b) and Rushen (1985) who worked with individually

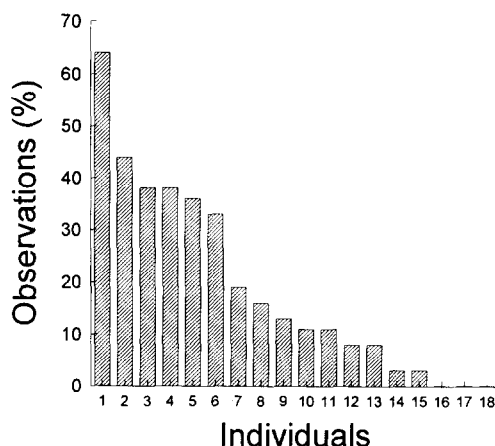


Fig. 4. The percentage of observations in which individual NL sows were engaged in chain manipulation during the second hour after feeding in Parity 2.

confined sows. The data, particularly in the second parity, are more comparable with the findings of Jensen (1988), who observed the sows confined in stalls during feeding. The relatively sustained levels of activity in the present experiment may, therefore, have been caused by the release of the sows from their feeding stalls, by the positioning of the drinkers in the dunging passage and also by the novelty factor of the fresh straw for those groups receiving straw.

Le Magnen and Devos (1980) found a positive correlation between feeding rate and duration of food deprivation in rats, *Rattus norvegicus*. The present study showed an increase in average feeding rate in Parity 1 in the low fed sows, but not in the high fed sows. Terlouw et al. (1991b), who found similar results, suggests that the increase over time in feeding rate in low fed sows may be caused by increasing feeding motivation. In addition, the present study found average feeding rates to remain higher for L than for H sows throughout Parity 2. A possible explanation for this difference may be that given a constant decline in feeding rates during any meal, shorter meals would result in higher average feeding rates compared to longer ones. Evidence in rodents suggests however, that feeding rates show an initial increase in intake, rather than a constant decrease. Wiepkema (1971) found that mice, *Mus musculus*, increase the length of their feeding bouts during the initial stages of a meal. This would suggest that ingestion of food has positive effects on feeding motivation, which in later stages of the meal is overruled by the negative effects of increasing satiety. In the present study the sows on the low fed treatments received a meal insufficient to induce satiation (Lawrence et al., 1988; Lawrence and Illius, 1989) and the positive feedback of the meal ingested may have left them with a stronger motivation to feed after, than before the meal. This could explain the differences in activity levels found in the postprandial period when food restricted sows were significantly more active than the high fed sows. This effect of food restriction on post feeding activity has also been reported by other authors (e.g. Appleby and Lawrence, 1987; Terlouw et al., 1991b). In this study, most of the activity was directed towards the available substrates, with a preference for straw: low fed sows on straw rooted and chewed straw for over 70% of the time they were manipulating substrates.

Low fed sows without straw directed their manipulative behaviour towards other pen components, such as bars and chains. The recording method did not allow for a detailed assessment of these behaviours. However, the occurrence of bar and chain manipulation in Parity 2 was very frequent in low fed sows that were not provided with straw, and individuals could often be identified by their behavioural routines. Together with the absence of an apparent goal, this suggests that, at least in these animals, chain and bar manipulation were performed stereotypically.

The provision of straw did not have an effect on the 24 h levels of activity as measured through levels of standing, but it did alter the time spent in the dunging area with sows on straw spending significantly less time in their stalls than sows without straw. During the course of the day most of the straw went from the stalls into the communal dunging area, providing it with a thicker bedding than the stalls. The difference in use of the two areas was consistent over the day, suggesting that the straw in the dunging area was not only used as a foraging substrate (during the active hours of the day), but also preferred for lying.

Sows on a high food level drank significantly more in Parity 1 in the first 6 h after feeding, as well as measured over the 24 h day, probably reflecting an increased physiological water requirement due to their higher food intake (Agricultural Research Council, 1981). However, in Parity 2, levels of drinking in L sows rose to a value similar to that in the high fed sows, although the differences in food intake remained the same, suggesting that normal regulatory mechanisms were not operating. Terlouw et al. (1991b) found levels of drinking in low fed gilts rising beyond those in high fed animals, and considered the excessive drinking stereotypic. The levels reported here were well below the 12% and 10% found by Terlouw et al. (1991b) in their loose-housed low-fed gilts in months 1 and 3 of gestation, respectively. However, the positioning of the drinkers in their experiment (above the trough in the feeding stalls) may well have facilitated the development of excessive drinking in sows who spent about 92% of the day in stalls (average of the non-straw groups in the present study: 24 h data).

Similar to the results in the present experiment, Fraser (1975) found that straw was preferred to chains and bars, and that provision of straw reduces stereotypic manipulation of these pen components. This preference can at least in part be explained by comparing the decrease after feeding of the two behaviours. Between 14:00 and 15:00 h, second parity LS sows only manipulated straw at 20% of the peak time levels, whereas LN sows still manipulated chains at over 50%. Thus, on the one hand use of straw, the preferred substrate, declines rapidly, whereas chain and bar manipulation, which is less preferred, is more persistent. The most likely factors to explain the more rapid decline in fresh straw manipulation are the decreasing novelty factor due to exploration, and the reduced foraging motivation due to ingestion. The latter is not easy to support as Lawrence and Illius (1989) found that ingestion of straw did not reduce operant responding for food. Both factors however, suggest the presence of a purpose, which is by definition absent in stereotypic behaviour.

Whether the development of stereotypies, reflected in excessive levels of drinking or manipulation of pen components, constitutes a welfare problem is still a matter of considerable debate. Mason (1991) concludes in her review that animals develop stereotypies when the environment is inadequate, and therefore presumably aversive. It is unclear, however, if this means that the animal is under stress (Dantzer and Mittelman, 1993) or

suffering. Although some authors suggest that the performance of abnormal behaviours indicates that an animal is suffering (e.g. Fraser, 1984), Dantzer (1986) argues that stereotyping animals temporarily suspend the use of their higher nervous functions. This view would make the question of suffering irrelevant, but “it provides no excuse for the design and use of facilities that result in such abnormal behavior” (Dantzer, 1986).

Enriching the sows environment with straw appears to reduce the performance of stereotypies. However, straw manipulation itself may be of a very compulsive nature, and provision may not necessarily improve the sow’s well-being. Further investigation into the motivations of manipulating straw, for example by separating the time of feeding and the time of fresh straw provision, and closer analysis of the manipulative behaviour involved, are required to reveal the extent to which straw provision provides real improvement to sow welfare.

## 5. Conclusion

In their review, Lawrence and Terlouw (1993) suggest that the development of stereotypies in food restricted sows is largely based on an inability to express foraging behaviour. The present study supports this conclusion, and offers a practical solution. It was found that higher levels of manipulative behaviour (appetitive foraging behaviour) were observed in low fed gilts. This behaviour was, in the absence of straw, channelled towards relatively invariant pen components like bars and chains and over a period of time, abnormal high levels of chain and bar manipulation resulted. Where straw was present however, equally food motivated animals did not show a dramatic increase in overall levels of manipulative behaviour between parities, and levels of chain and bar manipulation remained comparable to those in the high fed animals. Therefore, daily provision of fresh straw may represent a simple and effective means of preventing the development of abnormal levels of chain and bar manipulation in food restricted group-housed sows.

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