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Comparison of pig behaviour when given a sequence of enrichment objects or a chain continuously

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Abstract

*Tail biting is a major problem in modern pig (*Sus scrofa*) production and results in a reduction of animal welfare and productive performance. Biting behaviour has been shown to be decreased by the use of enrichment objects. In this study, 108 pigs housed in a room with 12 pens were observed and a sequence of seven different enrichment materials was tested. Gilts and barrows were housed together and received a new enrichment object each week starting from three different points in the fattening period, ie 20, 40 or 70 kg bodyweight. Toy-contact and biting-penmate behaviour were observed during one hour at day of introduction and five days later. A continuous sequence of seven enrichment objects reduced biting-penmate behaviour and the number of wounds compared to providing only a single toy (chain). This study also confirmed that not every object was feasible as an enrichment object for growing pigs. Generally, the highest toy contact was observed together with the highest biting-penmate behaviour. Most toy-contact and biting-penmate behaviour was observed between 20 and 40 kg bodyweight and was decreasing over age. Providing a sequence of toys for the first time induced toy-contact behaviour while reducing biting-penmate behaviour but decreased after applying the same sequence for the second or third time. The presence of a single chain or a sequence of different toys had no effect on growth and feed conversion. The ideal sequence should maintain toy-contact behaviour without competition in order to avoid biting-penmate behaviour and reduced animal welfare.*

Keywords: *animal welfare, biting-penmate behaviour, enrichment objects, growth, pig, toy-contact behaviour*

Introduction

Exploratory behaviour represents an important need in pigs (*Sus scrofa*) (Studnitz *et al* 2007). Even in intensive husbandry systems, pigs seem to be highly motivated to explore, even when feed is available *ad libitum* (Van Putten & Dammers 1976; Lyons *et al* 1995). When it is difficult or impossible to express this behaviour, the pig may redirect it towards penmates (Beattie *et al* 2000; Kelly *et al* 2000; Scott *et al* 2006a), possibly resulting in tail- and ear-biting behaviour (Van de Weerd *et al* 2005; Scott *et al* 2006b). Tail biting is rarely observed under extensive, semi-natural or feral conditions and can consequently be defined as 'abnormal' behaviour (Moinard *et al* 2003).

Tail biting is a major problem in modern pig production, reducing animal welfare and productive performance (Bracke *et al* 2004). This abnormal behaviour is a multifactorial syndrome and influencing factors have often included environmental features. Risk factors for tail biting are genetics, gender, age and weight, health status, rearing environment, indoor climate, stocking density and pen size, floor, feeding systems, food, rooting materials and toys (Schrøder-Petersen & Simonsen 2001).

In an attempt to control tail biting, many farmers dock the tails of all newborn piglets. Controlled experiments show that docking is effective in reducing tail biting although, as these surveys show, not in eliminating it (Chambers *et al* 1995; Moinard *et al* 2003; Paul *et al* 2007). Moreover, in the European Union, routine docking of piglet tails is illegal (Commission 2001/93/EC of 9 November 2001), thus, alternative preventive strategies are needed.

Studies suggest that environmental enrichment can partly reduce tail biting through the provision of substrates (Arey 1993; Petersen *et al* 1995; Beattie *et al* 2000) which is in consensus with the current EU legislation (Directive 2001/93/EC). This Directive requires that pigs must have access to a sufficient standard of these materials to enable proper investigation and manipulation activities. Different forms of enrichment have been used in the past. Substrates such as peat, straw, sawdust and mushroom compost are effective types of enrichment (Beattie *et al* 1995). However, when these 'rooting' substrates are combined with slatted floors, potential problems with blockage of slurry systems occur (Van de Weerd *et al* 2006). Slatted floors are the most common husbandry systems in the EU

Table 1 Dimensions and mean destructibility of the objects used.

	Length (cm)	Width (cm)	Thickness (cm)	Diameter (cm)	Destructability*	Sort
Yellow ribbon	83	2.3	0.1	–	3	Non-commercial
Orange rope	80	–	1	–	3	Non-commercial
Yellow garden hose	96	–	1.6	–	2	Non-commercial
Purple ribbon	86	3.3	1	–	3	Non-commercial
Rubber bar	34	1.4	4	–	1–2	Commercial
Grey garden hose	89	–	1.6	–	2	Non-commercial
Rubber ball	–	–	–	7.5	1	Commercial

* Score 3: More than 50% of the toy was destroyed after 1 week of presentation; Score 2: 10–50% of the toy was destroyed after 1 week of presentation; Score 1: Less than 10% of the toy was destroyed after 1 week of presentation.

Table 2 Presentation order of the toys (1–7) per pen over weeks (W).

	Fattening period*							Fattening period*							Fattening period 3*		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17
Pen 2, 3 and 4	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3
Pen 6, 7 and 8					5	6	7	1	2	3	4	5	6	7	1	2	3
Pen 9, 10 and 11												5	6	7	1	2	3

Pen 1, 5 and 12 had a chain throughout. * Fattening period 1: 20–40 kg; Fattening period 2: 40–70 kg; Fattening period 3: 70–100 kg. 1: Yellow ribbon; 2: Orange rope; 3: Yellow garden hose; 4: Purple ribbon; 5: Rubber bar; 6: Grey garden hose; 7: Rubber ball.

(Hendriks *et al* 1998). Therefore, other types of enrichment are needed. On the one hand, point-source enrichment objects can be an effective alternative to reduce tail-biting behaviour (Van de Weerd *et al* 2006). On the other, Van de Weerd *et al* (2006) also described that in some cases point-source enrichment objects can stimulate tail-biting behaviour. More studies are still needed to investigate the kind of composition material of the objects, the position of the enrichment object in the pen and the playing behaviour in relation with the object. Habituation to point-source objects can occur very quickly in pigs (Van de Weerd *et al* 2003). Grandin *et al* (1983) and Trickett *et al* (2009) reported that rotation of enrichment objects can increase novelty. However, the effect of a continuous repeated sequence of different toys over the complete fattening period is yet, to our knowledge, to be investigated. Therefore, this study focuses on the sequential application of seven different 'point-source' enrichment objects (commercial and non-commercial) in relation to pigs' toy-contact and biting-penmate behaviour with age starting from 20 kg until slaughter weight.

Materials and methods

Study animals and housing

One hundred and eight crossbred (Piétrain × Hypor) pigs, heterozygous for the halothane gene, were used. Animals were housed under common conditions in a room with 12 pens and fully slatted floors at the Zootechnical Centre of the KU Leuven, Belgium from 18 June to 13 October 2008. The female piglets (n = 56) and male castrated piglets (n = 52) were housed together in equal groups of 8 to 10 piglets per pen (295 × 195 cm; length × width) at the age of 10 weeks (20 kg) until an age of 14 weeks (40 kg). Each pig was ear tagged for individual identification. Water and feed were available *ad libitum*. At the age of 14 weeks, the pigs were moved to a larger room (400 × 195 cm) until slaughter weight (110 kg). The pigs were maintained in their existing groups. Forced ventilation was temperature-controlled until the end of the trial in order to maintain dry air temperature within the pigs' thermoneutral zone. Chains (1-m long) were attached to the side wall in every pen in the middle of the walking path between the drinking nipple and the feeder. Studies have shown that this is the best place to attach objects so that the resting area in the pen is preserved (Geenen *et al* 2009). The chains were present from weaning to slaughter.

Environmental enrichment objects

Seven different materials, commercial (rubber bar and rubber ball) (supplied by Schippers BVBA, Arendonk, The Netherlands) and non-commercial (yellow ribbon, orange rope, yellow garden hose, purple ribbon and grey garden hose), were tested. The non-commercial materials were prepared by the technicians of the Zootechnical Centre. The dimensions of every toy are shown in Table 1.

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Experimental design

The experiments started at different weights (20, 40 or 70 kg) and were continued until slaughter weight. Pigs received seven different enrichment objects successively. At a weight of 20 kg, three pens received the first toy (Table 2). The object was attached to the chain in every pen. Pen 1 was taken as a control pen (only a chain). One week later, the toy was replaced by another type of toy. After seven weeks, when the seven toys were used, a new round of administering the same sequence of toy presentation was repeated in order to standardise the procedure in view of statistical power requirements. This action was repeated until the pigs reached their slaughter weight. Furthermore, at a weight of 40 kg, three other pens also received seven different enrichment objects successively, starting with the same object as given that week to the group of pigs which received toys starting at 20 kg. Pen 5 was the control pen. Finally, starting at a weight of 70 kg, three final pens received the same enrichment objects as the other pens, one-by-one. Pen 12 was taken as a control pen.

At the age of 10, 14, 20 and 24 weeks the pigs were weighed and daily growth and feed conversions were calculated. Feed conversion was calculated on pen level.

Behavioural measurements

Toy-contact behaviour (Table 3) was recorded individually per pig every 2 min during 1 h for the seven different enrichment objects, from 1300 to 1400h since studies indicated that pigs were more active in the afternoon (Olsen *et al* 2000), without interference from the farmer. During toy-contact observations, biting-penmate behaviour (Table 3) of the pigs in the enriched pens and their respective control pen(s) was also recorded. The toy-contact and biting-penmate behaviours were observed on the day of introduction of the environmental enrichment and five days after introduction. On the first observation day toys were hung up and we waited 15 min before taking measurements, in order to ensure the pigs were calm again. We also repeated this 15-min wait on day five in order for similar levels of calmness after entering the pig-house. This time was taken to restore pigs' normal behaviour after having entered their pen or room. No cameras were used because direct visual observations are more precise and detailed than observation via a camera.

Lesion scores

During the entire experiment each pigs' tail (Zonderland *et al* 2008) and ears were scored for all 12 pens using two parameters: tail/ear damage (three classes) and blood freshness (four classes) (Table 4). All pens which did not receive any toys were treated as control pens. These observations were taken at the end of observation days 0 and 5.

Statistical analysis

The data were analysed using SAS software (version 9.2, SAS Institute Inc, USA 2008). Data were checked for normality and univariate analysis was performed. The behavioural data (toy contact and biting penmate) did not have a normal distribution and were dichotomised. The third quartile (Q3) was used as the cut-off value. Every observation lower than Q3 was designated as 0, higher was 1. This cut-off value yielded a classification that corresponded best with the original behavioural observations.

The data were analysed using mixed models which accounts for the clustering of the data within pens and pigs and hence do not assume measurements from pigs within pens to be independent. Indeed, measurements from the same animal, or measurements from different animals in the same pen are not independent and social facilitation is to be expected. Similarly, Fraser (1978) analysed the behaviour of group-housed piglets with the individual piglets being regarded as the experimental unit. In the analysis of differences in behavioural data, logistic mixed models were used with animal and pen as random factors to cover the potential correlation of the observations within animals and pens. For toy-contact behaviour, the fixed effects were observation day, type of toy, fattening period (20–40, 40–70 and 70–110 kg) (age) and observation period (first, second or third 20 min of the observation hour). The fixed effects for biting-penmate behaviour were the presence of toys, gender, observation day, type of toy, fattening period (age). For both behaviours, the number of times the toy was presented was also taken into account and was nested within the fattening period when the toys were given first. For the analysis of differences in frequency scores, when only a chain or a sequence of toys was present, again logistic mixed models were used with pen as well as animal as random effects. The reported mean percentages in this survey are from the

Table 3 Ethogram of the behaviours observed.

Behaviour	Description
Toy-contact behaviour	Nose or mouth in contact with an enrichment device
Biting-penmate behaviour	Chewing or biting tail, ear of another pig

Table 4 Scores for the two tail/ear parameters (Zonderland *et al* 2008); tail/ear damage and blood freshness (Zonderland *et al* 2008).

	Description
Tail/ear damage	
1 No	No tail/ear damage visible
2 Bite marks	Small damages/bite marks are visible and individual bite marks are the size of a pinhead
3 Wound	Clearly visible wound
Blood freshness	
1 No	No blood visible
2 Dried	Old dried black blood in the form of a scab
3 Sticky	Sticky dark red blood, mainly a half day to a day old
4 Fresh	Fresh bleeding wound

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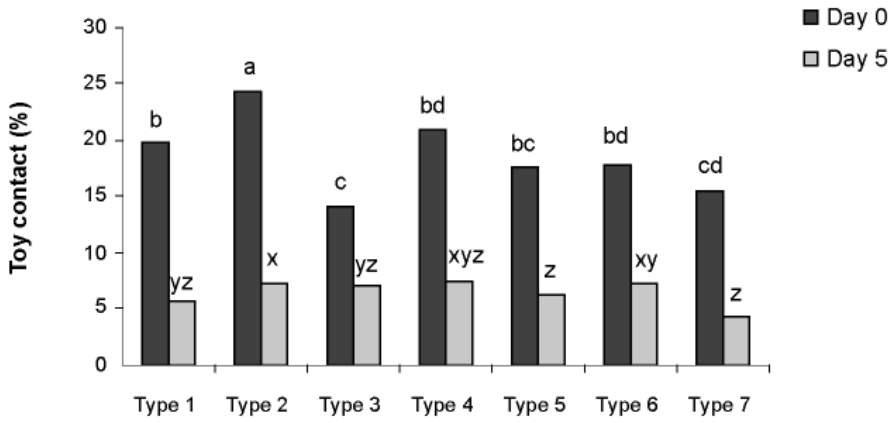
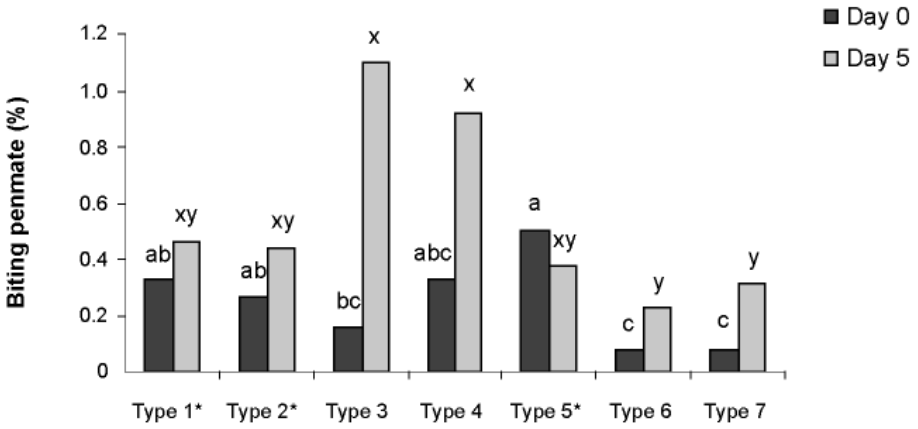
Figure 1



Mean percentage toy-contact behaviour at observation day 0 and 5 for the seven different types of environmental enrichment during the complete experiment for all pens and fattening periods together. Toy-contact behaviour was always significantly higher ($P < 0.0001$) for observation day 0. Type 1 = yellow ribbon; Type 2 = orange rope; Type 3 = yellow garden hose; Type 4 = purple ribbon (no observations during fattening period 1: 20–40 kg and 3: 70–100 kg); Type 5 = rubber bar (no observations during fattening period 1); Type 6 = grey garden hose (no observations during fattening period); Type 7 = rubber ball (no observations during fattening period 1). Statistical comparisons are carried out on the dichotomised data. [abcd] Significant differences ($P < 0.05$) for day 0; [xyz] Significant differences ($P < 0.05$) for day 5. Columns with the same superscript do not differ significantly.

Figure 2



Mean percentage biting-penmate behaviour at observation day 0 and 5 for the seven different types of environmental enrichment during the complete experiment for all pens and fattening periods together. Type 1 = yellow ribbon; Type 2 = orange rope; Type 3 = yellow garden hose; Type 4 = purple ribbon (no observations during fattening period 1: 20–40 kg and 3: 70–100 kg); Type 5 = rubber bar (no observations during fattening period 1); Type 6 = grey garden hose (no observations during fattening period 1); Type 7 = rubber ball (no observations during fattening period 1). Statistical comparisons are carried out on the dichotomised data. [abc] Significant differences ($P < 0.05$) for day 0; [xy] Significant differences ($P < 0.05$) for day 5; * No significant ($P < 0.05$) difference between observation day 0 and 5. Columns with the same superscript do not differ significantly.

original non-transformed data. Significant differences were obtained after analysis of the dichotomised data. Associations between growth and feed conversion on the one hand, and presence of enrichment (sequence or only permanent chain) on the other were studied using linear mixed models, with fixed effects being the presence of toys, gender and fattening period, and with pen as a random effect. Animal was also added as extra random effect for the growth analyses. These data had a normal distribution and lsmeans values (± SEM) are reported.

Results

During the experiment, tail- and ear-biting wounds were rarely observed. However, in 1 of the 12 pens there was a biting problem for approximately three weeks, which resulted in multiple wounds. Ear- and tail-biting behaviour, ie biting-penmate behaviour, was observed in all pens. In general, the two presentation orders (Table 2) used in this survey had no significant effect on the mean values of toy-contact behaviour (respectively biting-penmate behaviour) observations for the different toys. This was in contrast with

Table 5 Mean percentage of biting-penmate and toy-contact behaviour of pigs per fattening period for both observation days together when a sequence of toys or one single toy (chain) was present.

Fattening period	Period 1 (20–40 kg)	Period 2 (40–70 kg)		Period 3 (70–110 kg)		
Start the sequence of toys at	20 kg	20 kg	40 kg	20 kg	40 kg	70 kg
% *Biting*						
Sequence of toys	1.10^{a} (n = 25)*	0.28^{ax} (n = 24)	0.34^{ax} (n = 27)	0.22^{ax} (n = 24)	0.15^{ax} (n = 27)	0.12^{ay} (n = 30)
Only chain	2.03^{b} (n = 8)**	0.59^{bx} (n = 17)**	0.59^{bx} (n = 17)**	0.28^{ax} (n = 27)**	0.28^{ax} (n = 27)**	0.28b^{x} (n = 27)**
% *Playing*						
Sequence of toys	17.93 (n = 25)*	12.16^{x} (n = 24)	15.05^{y} (n = 27)	6.67^{x} (n = 24)	9.53^{x} (n = 27)	14.34^{y} (n = 30)

Statistical comparisons are carried out on the dichotomised data.
* One pig died; ** Mean percentage of biting-penmate behaviour of the pigs in the control pen(s) (1 pen for period 1, 2 pens for period 2 and 3 pens for period 3).
^{ab} Scores in the same column, for a sequence of enrichment toys and only one toy (chain), with different superscripts differ significantly ($P < 0.05$).
^{xy} Scores in the same row, within the same fattening period, with different superscripts differ significantly ($P < 0.05$).

the other included fixed effects which all had a significant ($P < 0.05$) contribution to the statistical model.

The numerical ranking of the toys for toy-contact and biting-penmate behaviour was not a statistically supported difference in most cases. Therefore, Figures 1 and 2 need to be consulted.

Toy-contact behaviour

Results of toy-contact behaviour for the seven different types of environmental enrichment, for both observation days separately, are shown in Figure 1. Differences between the toys were found ($P < 0.05$). In general, toy-contact behaviour was significantly higher ($P < 0.0001$) for observation day 0 (18.19%) than for observation day 5 (6.27%). Overall, the following numerical ranking for the different toys in toy-contact behaviour can be made: the orange rope was the most popular toy followed by the yellow ribbon and the purple ribbon for observation day 0, while the yellow garden hose was the least popular. The same numerical ranking can be made for observation day 5: the orange rope was the most popular toy followed by the purple ribbon and the grey garden hose, while the rubber ball and rubber bar were the least popular.

For both observation days the following results were found. The percentage of toy-contact behaviour decreased ($P < 0.001$) from period 1 (0–20 min) (14.94%) to period 2 (20–40 min) (12.03%) and period 3 (40–60 min) (10.58%). No significant difference ($P > 0.05$) between periods 2 and 3 was observed.

Pigs received a sequence of enrichment objects at three different weights. Most toy-contact behaviour was observed when the pigs received a sequence of enrichment toys for the first time at fattening period 1 (20–40 kg) compared to fattening period 2 (40–70 kg) or 3 (70–110 kg) ($P < 0.05$) (Table 5). Toy-contact behaviour decreased significantly ($P < 0.05$) with age and repetition of the sequence. Presenting a toy and consequently the sequence of toys for the first time caused a significant ($P < 0.001$) increase in toy-contact behaviour compared to pigs of the same age who received the toy(s) for a second or third time. No differences in toy-contact behaviour were found when pigs of 70 to 110 kg received toys from 20 and/or 40 kg bodyweight. No differences in toy-contact behaviour between gilts and barrows were found.

Ear- and tail-biting behaviour

Biting-penmate behaviour for the seven different types of environmental enrichment, for both observation days separately, are shown in Figure 2. Differences between the toys were found ($P < 0.05$). More specifically, biting-penmate behaviour was significantly ($P < 0.001$) higher for observation day 5 (0.49%) than observation day 0 (0.24%). Although, no differences between observation day 0 and 5 were found for the yellow ribbon, orange rope and the rubber bar. Overall, the following numerical ranking for the different toys in biting-penmate behaviour can be made: the rubber bar, orange rope, yellow ribbon and purple ribbon could be associated with the most biting-penmate behaviour for observation day 0, while the rubber ball and the grey garden hose were associated with the least biting-penmate behaviour. The same numerical ranking can be made for observation day 5: biting-penmate behaviour was highest for the purple ribbon and the yellow garden hose, while the grey garden hose and the rubber ball caused the least biting-penmate behaviour.

For both observation days the following results were found. The percentage of biting-penmate behaviour was not influenced by the observation period ($P > 0.1$). Biting percentage was 0.43% for period 1, 0.46% for period 2 and 0.35% for period 3.

The presence of a continuous sequence of toys being attached to a chain reduced the risk of biting-penmate behaviour significantly (0.36%) vs one single toy (chain)

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Table 6 Percentage of pigs observed with score* 1, 2, 3 (or 4) for tail and ear damage/blood freshness for a sequence of toys versus only one toy (chain).

	Score 1	Score 2	Score 3	Score 4
Tail damage				
Only chain[a]	94.63	3.71	1.66	
Sequence of toys[b]	97.34	2.15	0.5	
Ear damage				
Only chain[a]	91.05	3.32	5.63	
Sequence of toys[b]	98.96	0.74	0.3	
Tail blood freshness				
Only chain[a]	97.63	0.77	0.32	1.28
Sequence of toys[b]	98.07	0.90	0.24	0.78
Ear blood freshness				
Only chain[a]	91.3	4.35	2.75	1.6
Sequence of toys[b]	98.92	1.02	0.06	0.00

* Scores are ascending with severity.
[ab] Scores in the same column, within the same parameter, with different superscripts differ significantly ($P < 0.05$).

(0.58%) ($P < 0.05$). Most biting-penmate behaviour was observed when the pigs received a sequence of toys for the first time at fattening period 1 compared to fattening period 2 or 3 (Table 5) ($P < 0.0001$). Biting-penmate behaviour decreased significantly ($P < 0.001$) with age. Presenting a toy and consequently the sequence of toys for the second or third time to pigs of the same age caused a significant ($P < 0.001$) increase in biting-penmate behaviour compared to presenting the toy(s) for the first time at that same age. No differences in biting-penmate behaviour were found when pigs of 70 to 110 kg received toys from 20 and/or 40 kg bodyweight. During the first four weeks of biting-penmate observation only one control pen was used. The mean percentage of biting-penmate behaviour for this control pen (0.56%) did not differ ($P > 0.1$) with the other control pen (0.62%) during fattening period 2. Also, no differences ($P > 0.05$) in biting-penmate behaviour were found between the control pens (0.25, 0.32 and 0.26%) during fattening period 3. The mean values of biting-penmate behaviour of the pigs in the control pens per fattening period are presented in Table 5. During the experiment, the gilts expressed significantly higher biting-penmate behaviour (0.47%) than the castrated males (0.35%) ($P < 0.05$).

Tail and ear damage

Overall, lower tail and ear damage scores were found when a sequence of enrichment toys was offered in the pens (Table 6) ($P < 0.05$). The same results were found for the presence of blood on the ears ($P < 0.0001$). No significant relationship was found between the presence/absence of a sequence of toys and the freshness of blood on the tails ($P > 0.05$). The highest tail/ear damage wounds scores 2 and 3 and blood scores 2, 3 and 4 were seen in fattening period 2 when only a chain was present in the pen ($P < 0.05$).

Growth and feed conversion

No difference ($P > 0.05$) in growth was found when a sequence of toys (0.7067 [± 0.0131] kg day^{-1}) or only a chain was present (0.7073 [± 0.0107] kg day^{-1}). Growth was highest ($P < 0.05$) during fattening period 2 (0.794 [± 0.011] kg day^{-1}). In general, growth was higher ($P < 0.05$) for barrows (0.7340 [± 0.0094] kg day^{-1}) than for gilts (0.6801 [± 0.0096] kg day^{-1}).

No difference ($P > 0.05$) in feed conversion was found when a sequence of toys (3.0327 [± 0.0547]) or only the chain was present in the pens (2.9529 [± 0.0443]). No associations were found between growth or feed conversion and tail/ear damage or tail/blood freshness.

Discussion

Current EU legislation (Directive 2001/93/EC) requires that pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities. Studies indicated that 'point-source' materials can reduce penmate-directed behaviours (Sambraus & Kuchenhoff 1992; Van de Weerd & Day 2009). In the present study, a continuous sequence of enrichment objects being attached to a chain reduced biting-penmate behaviour in comparison to only a single toy (chain). Consequently, the presence of a sequence of enrichment materials decreased the number of damage/blood scores (Table 6). The highest wound and blood scores were seen between 40 and 70 kg, while most biting-penmate behaviour was seen between 20 and 40 kg (Table 6). The difference in time between the observation of the biting-penmate behaviour and the severity of wounds is because 'the injury phase' is proceeded by the 'pre-injury phase' (Fraser 1987). Also, the gilts expressed a significantly higher biting-penmate behaviour than the castrated males and is in consensus with literature (Taylor *et al* 2010).

At the first observation day, for every toy, there was a significantly higher proportion of animals showing toy-contact behaviour compared to observation day 5 (Figure 1). Habituation to point-source objects occurs very quickly in pigs (Van de Weerd *et al* 2003). This can consequently reduce their usefulness in stimulating exploration (Wemelsfelder & Birke 1997). An exposure time of less than two days may help to preserve the exploratory value of the objects (Gifford *et al* 2007). Moreover, not every object is equally feasible as an enrichment object. Important characteristics for intense use are complexity, ingestibility, odour, chewability and destructibility (Van de Weerd *et al* 2003; Studnitz *et al* 2007) or a combination of flexibility and destructibility (Zonderland *et al* 2001, 2008). The outcomes of the present study confirm these results for both observation days, namely that the most interesting enrichment objects (orange rope, yellow ribbon, purple ribbon and

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grey garden hose) were ingestible, chewable, flexible and destructible. The commercial toys were hardly destructible. Colour might also play a role in the popularity of the toy and could explain the significant difference in toy-contact behaviour between the grey and the yellow garden (least popular) hose for observation day 0. More experiments are needed to test the impact of the colour characteristic. In general, no effect of presentation order on pigs' behaviour was found for the different toys. The toys were always presented in the same sequence relative to each other, although the first one presented could be different (Table 2). Consequently, there could be a confounding effect of toy and sequence such that the attractiveness of individual toys could be questioned (a toy presented after a boring one is likely to receive more attention). The difference in attractiveness was only known at the end of the experiment, so that the original design of experiment was not changed. Therefore, more research is needed to examine the effect of changing the presentation order since only two presentation orders were used in this survey. As reported by Docking *et al* (2008) no differences in toy-contact behaviour between gilts and barrows were found.

The higher biting-penmate behaviour at observation day 5 may be explained by the reduced interest for the applied objects (Figure 2). Moreover, studies showed that some enrichment objects could be responsible for stimulating biting behaviour (Wemelsfelder & Birke 1997; Van de Weerd *et al* 2006). A numerical high (respectively, low) biting-penmate behaviour for observation day 0 (respectively, day 5) was observed when the rubber bar (respectively, grey garden hose) was present in the pens despite the numerical low (respectively, high) toy-contact behaviour (Figures 1 and 2). However, the most popular toys mostly caused the highest biting-penmate behaviour in our study for observation day 0, probably due to spatially limited access to the particular object (Docking *et al* 2008). Simultaneous presentation of multiple high value toys might reduce competition and consequent redirected biting behaviour between penmates. The presence of fewer pigs per enrichment device (Scott *et al* 2007) and/or the presentation of the toy in a more central position in the pen allowing more access to the object might also be a solution. For observation day 5, the same trend as for observation day 0 was found but this was less explicit. At fattening period 3, the orange rope was sometimes completely destroyed after three days and replaced. The almost completely destroyed orange rope stimulated toy-contact behaviour less at observation day 5 and resulted in lower than expected biting behaviour. However, Trickett *et al* (2009) showed that replacement of a used object with an identical new one still stimulates a significant increase in interest, so that the interpretation of the results must take into account a possible replacement effect. Again, a difference between the grey and yellow garden hose was observed for observation day 5.

Most toy-contact and biting-penmate behaviour was observed during fattening period 1 followed by fattening period 2 and 3 (Table 5). This might be caused by an age effect, since the activity of pigs decreases over age (Stolba & Wood-Gush 1989). Toy-contact (respectively, biting-penmate) behaviour was significantly higher (respectively, lower) when the sequence of toys was provided for the first time compared to pigs of the same age who received the toys for a second or third time (Table 5). When the same toys were provided for a second or third time, toy-contact behaviour decreased and did not have much effect on biting-penmate behaviour. These findings suggest that, next to age, novelty might also play an important role. Pigs probably recognised the repeatedly encountered object and did not interact as they would normally do with a novel object (Gifford *et al* 2007). Pigs might retain a memory for the seven-day sample object. A longer sequence of different toys, faster change of toy and/or change in presentation order might maintain novelty. Renewing of the same toy within the sequence could also boost novelty (Trickett *et al* 2009). Further work is required in this field.

Generally, the percentage of toy-contact and biting-penmate behaviour tended to decrease with the observation periods. This could be explained by the fact that when the observer had to enter the room, pigs became more active. This activity decreased over the observation hour and the pigs became calm resulting in less toy-contact and biting-penmate behaviour.

Conflicting results of earlier studies on the influence of environmental enrichment on productive performance were found (Schaefer *et al* 1990; Horrell 1992; Pearce & Paterson 1993; Blackshaw *et al* 1997; Morgan *et al* 1998; Beattie *et al* 2000; Day *et al* 2002; Van de Weerd & Day 2009). In our study, growth and feed conversion did not differ in relation to the presence of a single enrichment object (chain) or a sequence of toys during the three fattening periods. This is probably due to the low levels (less than 1% for both observation days together) of penmate-directed behaviours in the pens. Consequently, no associations between growth or feed conversion with tail/ear damage or tail/blood freshness were found. High levels of penmate-directed behaviours (eg biting-penmate behaviour) can result in more wounds and in negative effects on the productivity (growth, feed intake, feed conversion) (Ruiterkamp 1987; Wallgren & Lindahl 1996). More detailed information about feed conversion could be found when an individual electronic pig feed monitoring system was used, so feed conversion could be calculated at pig level.

Animal welfare implications and conclusion

Biting lesions are considered to have a detrimental effect on animal welfare and can be reduced by environmental enrichment. Therefore, knowledge about the proper use of environmental enrichment is very important. The results of this study show that a continuous sequence of seven different enrichment objects reduced biting-penmate behaviour, which resulted in less severe damage/blood scores on ears and tails, compared to providing one single toy (chain). However, not every object was feasible as an enrichment object. Moreover, very popular toys seem to induce competition for toy contact enhancing biting-penmate behaviour, which stops when the toy is removed,

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while pigs do not compete for less popular toys. Next to age, the novelty of the toy also determined pigs' behaviour. The ideal sequence of toys should maintain toy-contact behaviour in order to avoid biting-penmate behaviour. Therefore, further work should focus on the impact of, eg a longer sequence of different toys, a faster replacement of toys within the sequence, colour of the toy, renewing the same toy within the sequence and/or a change in presentation order on pigs' behaviour.

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