

CAGE ENRICHMENT: RABBIT DOES PREFER STRAW OR A COMPRESSED WOODEN BLOCK

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Abstract: The effect of different food related materials on the behaviour of commercial meat rabbit does was investigated to provide them enrichment. Five different treatments were tested. Control (pens without additional enrichment, C) was compared with pens containing a pinewood stick (Pine), straw in a plastic bin (Straw), a compressed wooden block (Ply) or a combination of straw and a pinewood stick (Straw+Pine). The experiment was conducted on a commercial rabbit farm using 80 cages with multiparous lactating hybrid (Hycole) rabbit does. Behavioural observations were conducted in the first 4 wk of 2 successive lactations of 6 wk each, twice a week from 15:00 to 18:30 h. Once every week the consumption of gnawing materials and soiling of the cages was scored. More does were significantly occupied with Straw and Ply than with Pine (24 ± 20 , 11 ± 9 and $4\pm 3\%$ of does, respectively) for a longer duration (4 ± 4 , 2 ± 2 , $0.1\pm 0.2\%$ of observed time, respectively). In does of Straw+Pine group, the pinewood was barely touched and straw was preferred. It can be concluded that straw (loose material) and wooden block are used by the animals as enrichment material to gnaw or chew on. The materials remain attractive for the 2 lactations which were measured. The pinewood stick as provided in this study was rarely used and it may be questioned whether it is sufficient as enrichment material or if it should be provided in another way than hanging on the roof of the cage. This study provides a first step towards a positive list of enrichment materials that can be used in commercial rabbit farming in The Netherlands.

Key Words: animal welfare, rabbits, enrichment materials, behaviour.

INTRODUCTION

In nature rabbits spend much of their time searching for food, mainly during dusk and dawn (Lockley, 1961). In commercial rabbit farming concentrated food is offered, such that the animals are spending less time on feed intake and so other activities need to fill in the remaining time. However, conventional cages without any enrichment give rabbits little opportunity to perform other elements of their natural behaviour repertoire such as digging and gnawing. This may lead to frustration and abnormal behaviour as bar biting, excessive grooming and stereotypies (Love, 1994), which is undesirable for the animals' welfare. Providing enrichment material might help animals perform natural behaviour and ameliorate the effect of stressors in the environment. Rabbits kept in near-to-nature conditions gnaw branches and roots and gnawing also takes place during eating (Stauffacher, 1992). Besides, they have a basic need for chewing to wear down their open-rooted and continuously growing teeth (Poggiagliolmi *et al.*, 2011). If they don't have the opportunity to chew on appropriate materials, they may chew on any cage component (Stauffacher, 1992). This can lead to tooth abnormalities or abscesses (Poggiagliolmi *et al.*, 2011).

Different type of enrichment materials have been studied such as different types of wood (Pincz *et al.*, 2007; Pincz *et al.*, 2008a and b; Zucca *et al.*, 2012), hay (Lidfors, 1997; Berthelsen and Hansen, 1999; Maertens and Van Oeckel, 2001), grass cubes (Lidfors, 1997), straw (López *et al.*, 2004; Pol *et al.*, 2006), grass and coarse mix feeds (Leslie *et al.*, 2004), a variety of food items (Brown, 2009), metal can (Brooks *et al.*, 1993; Lopez *et al.*, 2003), bunny stick, bunny block, nylon rod, kong (Harris *et al.*, 2001), parrot toys, copper wire ball (Huls *et al.*, 1991), card board

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rings and balls, rubber ball (Poggiagiolmi *et al.*, 2011), stainless steel rabbit rattle on spring clips (Johnson *et al.*, 2003) and basal components, wood mash and chicory pulp (Maertens *et al.*, 2013). These studies showed that rabbits prefer food-related items over non-food related items and that enrichment materials increased chewing and reduced stereotypies as well as skin lesions (especially on the ears) (Prinz *et al.*, 2009). Rabbits preferred roughage over wood (Lidfors, 1997; Pol *et al.*, 2006), and they preferred soft wood over hard wood (Baumans, 2005; Prinz *et al.*, 2008b). However, Maertens and Van Oeckel (2001) reported higher mortalities when straw was provided to meat rabbits, as well as problems with evacuation of droppings. The authors recommended a wooden stick to meet the gnawing needs under optimal hygienic conditions.

The above mentioned studies were performed with non-lactating (laboratory) does or meat rabbits. To the best of our knowledge, data on reproductive (lactating) does are lacking, although they form a considerable part of the animals at a rabbit farm.

It is not clear if and when habituation to enrichment materials occurs. Brooks *et al.* (1993) did not observe a decline in interest of adult laboratory rabbits towards wooden sticks over a period of 2 yr. Other studies investigated enrichment during shorter periods of time. López *et al.* (2004) reported that 70% of the animals were occupied with the straw immediately after its distribution and that the frequency decreased to only 10% one hour after the material was provided. Zucca *et al.* (2012) reported that the interest of meat rabbits for a wooden stick declined during the fattening period up to 11 wk of age as the animals became older.

On commercial meat rabbit farms different materials are provided, such as pinewood sticks and plastic balls. The aim of this study was to examine the effect of different food-related enrichment materials as used on commercial meat rabbit farms (a pinewood stick, straw, a compressed wooden block, and straw given in addition to a pinewood stick) on the behaviour of commercial rabbit does. The ultimate goal of this study was to provide commercial rabbit farmers with a list of enrichment materials that fulfil the gnawing needs of the rabbits.

MATERIALS AND METHODS

Animals and husbandry

The experiment was performed on a commercial rabbit farm which had 200 does. The farm had 2 identical compartments where 80 multiparous lactating experimental does (Hycote) were housed, alternating in one of the 2 compartments for 6 wk (one lactation) following an all-in/all-out procedure. We chose lactating does, because they form a considerable part of the animals on a rabbit farm. Does were housed individually in wire cages designed to comply with the welfare regulations for commercial meat rabbits in The Netherlands. The wire cages were 37.5×100×60 cm (l×w×h) and had an elevated wire platform (900 cm²: 37.5×22 cm) at a height of 25 cm above the floor of the cage. The bottom of the cage had a plastic mat (20×30 cm) to reduce footpad injuries. The cages were placed in 2 rows of 40 cages, which were placed back to back.

During the first 21 d of lactation, a nest box was provided in the front part of the cage (22×37.5 cm, 700 cm² of floor surface in total, height 40 cm). Sawdust and straw were provided as nest box material. Does had reduced access (in the morning) to the nest box until artificial insemination (11 d post-partum) as a standard procedure at the farm. Nest boxes were closed 24 h prior to insemination to stimulate receptivity (Theau-Clément *et al.*, 2006) and remained open afterwards. At 21 d of lactation the nest box was removed to stimulate food intake of the kits. Does and kits were fed a standard commercial pelleted diet *ad libitum*, using an automated feeding system. Water was also provided *ad libitum*, from a drinking nipple. The does were kept in a 14 h light and 8 h dark lighting scheme (light on from 5:00 until 19:00 h). Kits were weaned at 35 d of age. Does that were not pregnant or that had to be removed due to diseases or death were not replaced.

Treatments

Five treatments were applied to test 4 different gnawing materials during the whole litter. The treatments were: a) Pine wooden stick, without bark (11.5×3.5×2 cm) (Pine). This material is widely used in practice on Dutch farms. b) Bar of pressed wood (Plywood, *Miscanthus giganteus*, 15×10×6 cm) (Ply). This material is on the market and can

be an alternative to straw. c) Straw in a plastic bin (22×37.5×11 cm) (Straw). d) Both Straw and pine wooden stick (i.e. a combination of treatments a and c; Straw+Pine). e) No gnawing material (control treatment, C).

All materials were only accessible from the platform. Straw was provided in a bin that was put upside down on the top of the cage above the platform. Pine was attached hanging to the roof of the cage above the platform, as recommended by Dutch farmers. Ply was attached to the side wall at 20 cm above the platform. Materials were renewed whenever the material had been eaten completely. The caretaker checked daily if any material had to be replaced. At start of the second lactation the enrichment materials were all renewed. The experiment was set up as a randomised block design; one block consisted of 5 adjacent cages. The 5 treatments were randomly assigned to 5 adjacent cages, using 16 repetitions per treatment.

Observations

Behavioural observations were conducted in the first 4 wk of 2 successive lactations of 6 wk each to determine if the materials continued to be attractive. From the first until the fourth week of lactation, 2 observers performed the behavioural observations twice a week from 15:00 to 18:30 h (as gnawing behaviour appears to be best observed at dusk or at dawn, (Princz *et al.*, 2008; Berthelsen and Hansen, 1999) to observe whether there were differences between treatments. Each observer watched one row of cages (4 replicates per treatment) on one afternoon per week. The fifth week of lactation was left out because in this last week of lactation kits could jump onto the platform and could also consume enrichment materials, so it was not possible to determine which part was consumed by the does. Each afternoon of observations every doe was observed for 4 consecutive min, while the observer was sitting in front of a cage and after having taken a 1 min habituation period into account before starting the observations. Durations of the following behaviours were recorded, according to the definition of behavioural patterns of Gunn and Morton (1995):

a) Normal behaviours: comfort behaviour (e.g. self-grooming, yawning, stretching), eating, drinking, resting and locomotion (which included raising and jumping on and off the platform). b) Abnormal behaviours: biting the wire, biting the drinking nipple and digging on the wire. c) Behaviours related to the enrichment object: sniffing, gnawing and eating the material and dragging the straw through the cage to the nest box if straw was available. d) Other behaviours (e.g. eating of caecotrophes).

Once every week the consumption of the gnawing material was scored (visual) by one (the same) observer throughout the experiment. In addition to the time spent interacting with the material consumption levels, these material consumption levels may also be useful to assess the impact on animal welfare. Weighing of the wood seems inaccurate, as the relative humidity of the wood seems dependent on the relative humidity of the air in the rabbitry, which can cause oscillation in

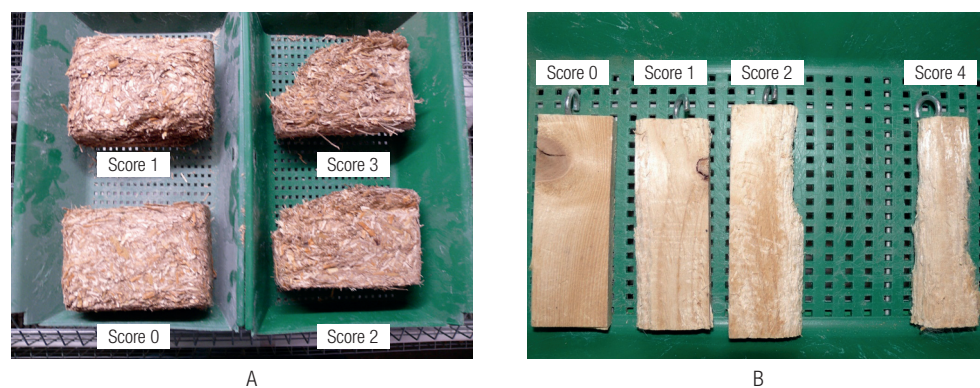


Figure 1: Scores used for material consumption levels of a pressed wooden block made of ply wood (treatment 'Ply', A) and pine wooden stick (treatment 'Pine', B) for scoring the amount of material that had been gnawed/eaten. Score 0: material is intact; Score 1: $\leq 10\%$ of the material has disappeared; Score 2: $>10\%$ and $\leq 25\%$ of the material has disappeared; Score 3: $>25\%$ and $\leq 50\%$ of the material has disappeared; Score 4: $>50\%$ of the material has disappeared. For Ply wood score 4 and in Pine score 3 were missing.

the weight of wooden sticks (Princz *et al.*, 2007). For Pine and Ply, the following scale was used (Figure 1): 1: $\leq 10\%$ of the material had disappeared; 2: $>10\%$ and $\leq 25\%$ of the material had disappeared; 3: $>25\%$ and $\leq 50\%$ of the material had disappeared; 4: $>50\%$ of the material had disappeared. For the Straw treatment, the number of times that the bin was emptied and refilled was registered.

Once every week, the soiling levels of the floors and the platforms of the cages were recorded using the following scale: 0: Clean; 1: $\leq 10\%$ of the floor or platform is covered with material and/or droppings; 2: $>10\%$ and $\leq 25\%$ coverage; 3: $>25\%$ and $\leq 50\%$ coverage; 4: $>50\%$ coverage. Cage floors and platforms were only cleaned between lactations, i.e. at the start of the second lactation, all cages were cleaned.

Statistical analysis

The experiment was set up as a randomised block design. It comprised 16 blocks, where one block consisted of 5 adjacent cages. The treatments were randomised over the 5 adjacent cages. Data from the behavioural observations were transformed to log scale before analysis. Data were analysed with the following model:

$$Y_{ijklm} = \alpha_i + \beta_k + \chi_l + (\alpha\beta)_{ik} + (\alpha\chi)_{il} + (\beta\chi)_{kl} + \varepsilon + \varepsilon_w + \varepsilon_{ijklm}$$

With: Y_{ijklm} Response (on log scale) of parameter Y of treatment i in block j in week number k of lactation l and on date m. (observation day within weeks in the experiment); α_i Effect of treatment i; β_k Effect of week number k; χ_l Effect of lactation l; $\varepsilon \sim N(0, \sigma^2)$ variance-components of respectively block j, cage ij, cage_week no. ijk, cage_lactation no. ijkl, cage_lactation_week no. ijkl; $\varepsilon_w \sim N(0, \sigma_w^2)$ variance-components for observer effects; $\varepsilon_{ijklm} \sim N(0, \sigma_{ijklm}^2)$ rest variance.

As analysis was performed on log scale, we present means and standard deviations (s.d.) of the raw data.

Data on the consumption of the enrichment material were analysed with the GLM procedure from Statistical Analysis System (SAS 9.2). The analysis had block, lactation, week, treatment and their interactions (lactation and week, lactation and treatment, week and treatment, lactation and week and treatment) in the model. When an interaction was not significant, it was left out of the model.

First we investigated if there was a difference between data of all does in the first lactation and data of the first lactation from does that had a first and a second lactation. There were no differences in the outcome of the analysis of the behavioural data between these groups. Therefore, we included in the analysis data of all the does in the first lactation.

RESULTS

During the first lactation one doe (Straw+Pine) died. At start of the second lactation there were 60 does left. Nineteen does were culled at the end of the first lactation due to disease or non-pregnancy (2, 6, 3, 4, and 4 for C, Ply, Straw+Pine, Straw and Pine, respectively).

Duration of behaviours

No significant differences were found in duration of the normal behaviours between the first and second litter. Therefore the average of the 2 litters is presented. Overall, does were resting for $59 \pm 39\%$ of the observed time, eating/drinking and comfort behaviour were observed for 12 ± 24 and $11 \pm 20\%$ of the time, respectively. No significant differences were found between treatments or weeks of lactation for these behaviours. On average, little time (less than 2%) was spent on the other behaviours during the observations (Table 1).

Significant differences ($P < 0.05$) were found between treatments in the duration that does were occupied with the enrichment material (Table 1). Does were least occupied with Pine ($0.1 \pm 0.2\%$ of observed time) and were most occupied with Straw and Straw+Pine (4 ± 4 and $3 \pm 3\%$ of observed time, respectively) followed by the Ply ($2 \pm 2\%$ of observed time). Differences were seen in sniffing and gnawing and/or eating of the material. However, when Straw+Pine were offered together, does were mainly occupied with the Straw and barely touched the Pine.

Table 1: Percentages of does (means \pm s.d.) that were performing the different behaviours and the duration (D in s, means \pm s.d. in % of observed time) that behaviours were performed for the control (C), ply wood block (Ply), Pine wood Stick (Pine), Straw and Straw with pine wood stick (Straw+Pine) treatment (n=16 does/treatment) in 2 subsequent lactations.

| Treatments | C | | Ply | | Pine | | Straw | | Straw+Pine | |
|------------|-------------|-------------|-------------------------|------------------------|------------------------|----------------------------|--------------------------|------------------------|--------------------------|-------------------------|
| | % | D | % | D | % | D | % | D | % | D |
| Behaviour | | | | | | | | | | |
| Resting | 85 \pm 5 | 60 \pm 6 | 81 \pm 9 | 59 \pm 10 | 85 \pm 10 | 59 \pm 11 | 85 \pm 9 | 59 \pm 8 | 85 \pm 5 | 58 \pm 5 |
| Eat&drink | 38 \pm 14 | 13 \pm 5 | 35 \pm 8 | 11 \pm 5 | 38 \pm 9 | 12 \pm 4 | 35 \pm 18 | 11 \pm 7 | 40 \pm 21 | 14 \pm 6 |
| Comfort | 53 \pm 10 | 11 \pm 5 | 49 \pm 11 | 9 \pm 3 | 55 \pm 10 | 11 \pm 4 | 45 \pm 10 | 10 \pm 4 | 55 \pm 9 | 12 \pm 3 |
| Locomotion | 47 \pm 12 | 1 \pm 0.3 | 45 \pm 12 | 1 \pm 0.6 | 40 \pm 12 | 1 \pm 0.5 | 52 \pm 9 | 2 \pm 0.4 | 40 \pm 11 | 1 \pm 0.6 |
| Enrichment | - | - | 11 \pm 9 ^d | 2 \pm 2 ^a | 4 \pm 3 ^d | 0.1 \pm 0.2 ^b | 24 \pm 20 ^e | 4 \pm 4 ^c | 22 \pm 20 ^e | 3 \pm 3 ^{ac} |
| Abnormal | 9 \pm 7 | 2 \pm 1 | 10 \pm 11 | 2 \pm 4 | 9 \pm 9 | 1 \pm 2 | 11 \pm 4 | 2 \pm 2 | 7 \pm 7 | 2 \pm 2 |

^{abc}Duration: Means with different letters in a row differ significantly ($P<0.05$).

^dPercentage of animals: Means with different letters in a row differ significantly ($P<0.05$).

Locomotion behaviour and occupation with enrichment material differed significantly between weeks of observation (Table 2). Does showed significantly more locomotion behaviour in the second week of lactation (2 \pm 0.4%, $P<0.05$, Table 2) compared to the other 3 wk. In the fourth week of lactation, does were significantly more occupied with the enrichment material (4 \pm 4%) compared to the other 3 weeks ($P<0.05$, Table 2).

An interaction was found between treatment and week ($P<0.05$) for being occupied with the enrichment material. In Straw and Straw+Pine does were significantly more gnawing and/or eating straw in the fourth week of lactation compared to the other treatments.

Number of does performing the behaviours

No differences were found between the first and second lactation in the percentage of does that performed the normal behaviours. Overall, 84 \pm 8, 52 \pm 10 and 45 \pm 12 of the does were displaying resting, comfort and locomotion, respectively. Significantly more does were occupied with enrichment materials Straw+Pine and Straw compared to Pine and Ply (22 \pm 20, 24 \pm 20, 4 \pm 3 and 11 \pm 9%, respectively; $P<0.05$, Table 1). These differences were due to the percentage of animals sniffing at the material and gnawing and/or eating the material. In the Straw and Straw+Pine some does (0.8 \pm 2 and 1 \pm 2%, respectively) were observed dragging straw from the bin into the nest boxes.

An interaction was found between week and treatment in the percentage of does being occupied with the enrichment material. In the Straw and Straw+Pine, more does were occupied with the straw in the fourth week of lactation (52 \pm 20 and 41 \pm 0.7%, respectively; $P<0.05$).

Abnormal behaviour

Abnormal behaviour was seen in the form of biting the wire and digging (often on the wire floor/walls of the cage). Digging was mostly seen in combination with biting on the wire, usually around the opening of the nest box or on the platform above the nest box. On average 9 \pm 8% of the animals showed abnormal behaviour. No differences between lactations, weeks and treatments were found. Although abnormal behaviour did not differ between weeks, it was

Table 2: Duration of behaviours (Means \pm s.d., in % observed time) in the first 4 wk of 2 lactations (n=80 does).

| Behaviour | Weeks of lactation | | | |
|---------------------|----------------------------|--------------------------|----------------------------|--------------------------|
| | 1 | 2 | 3 | 4 |
| Locomotion | 1 \pm 0.5 ^a | 2 \pm 0.4 ^b | 0.9 \pm 0.3 ^a | 1 \pm 0.4 ^a |
| Enrichment material | 0.8 \pm 0.8 ^a | 0.9 \pm 1 ^a | 2 \pm 3 ^a | 4 \pm 4 ^b |

^{ab}Duration: Means with different letter in a row differ significantly ($P<0.05$).

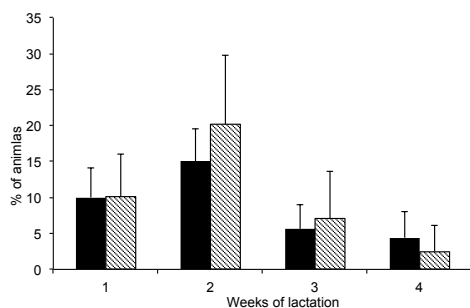


Figure 2: Percentage of animals performing abnormal behaviour during the first 4 wk of lactation of 2 lactations (n=80 does). ■ lactation 1, ▨ lactation 2.

mainly seen in the first 2 wk of lactation (Figure 2). In the first and second lactation, 15±5 and 20±10% of the animals, respectively displayed abnormal behaviour in the second week of lactation. The average duration was low (≤2% of the observed time). However, animals performing this behaviour, could do so for a considerable period of time. The maximum observed duration was 2 min and 54 s out of the standard observation time of 4 min (72.5%).

Consumption of the enrichment material

Figure 3A shows the average consumption score of Ply, Pine and Pine in Straw+Pine. Because the enrichment materials were not replaced until they were consumed completely, the averages in the successive weeks were progressive. In Straw+Pine only the consumption of

Pine was scored. There were significant differences between treatments in the different weeks in lactation 1 and in the first week of lactation 2. Overall, Ply had the highest consumption scores (1.45±0.07), followed by Pine (1.0±0.07) and Pine in Straw+Pine (0.5±0.06) ($P<0.001$). An interaction between lactation and week was found. In the first lactation the consumption of Pine in Straw+Pine was significantly lower than in the second lactation (0.4±0.08 vs. 0.7±0.1, $P<0.05$). The materials did not need to be replaced during a lactation, except for 2 cages (one plywood block in the Ply treatment and one pine wooden stick in the Pine treatment) where the material has been replaced once, because the ply wooden block was found dirty on the floor of the cage and the pine wooden stick was found dirty in the nest box.

For Straw, the consumption was based on the number of times the bin in which the straw was offered had to be refilled (Figure 3B). Therefore the level of consumption of Straw cannot be compared with other materials. No differences in lactations and treatments were found, but there was a difference between weeks ($P<0.05$). In the second week of lactation, the bins were refilled more often than in the other weeks of lactation (1.1±0.12 vs. 0.6±0.12, respectively). On average the bins were refilled once a week (0.9±0.08 and 0.8±0.08 for Straw in Straw+Pine and Straw, respectively).

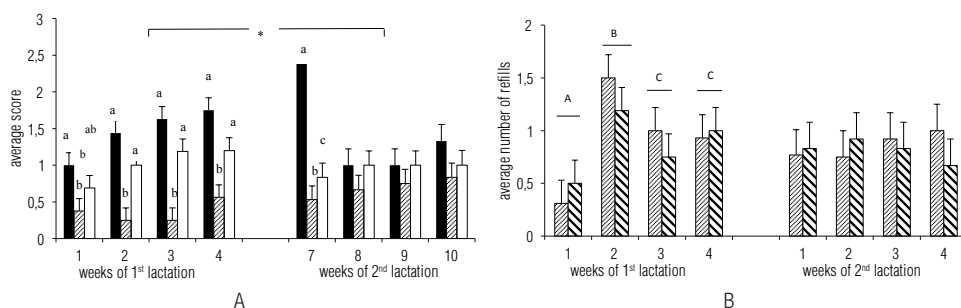


Figure 3: Average score (±s.d.) for the consumption of the Ply wood, Straw+Pine¹, and Pine (A), and Straw+Pine² and Straw (B) in the first 4 wk of lactation of lactation 1 and 2, (n=16 does/treatment). ■ Ply, ▨ Straw+Pine, □ Pine, ▩ Straw.

¹In the Straw+Pine the consumption of the pinewood stick was scored.

^{abc}Letters indicate a significant difference between the treatments within a particular week and lactation ($P<0.05$ at least).

^{*}Straw+Pine in lactation 1 is significant lower than Straw and Pine in lactation 2 ($P<0.05$).

²In the Straw+Pine the refill of the straw bin was scored.

^{ABC}Different letters within a lactation indicate a significant difference between weeks $P<0.05$.

Pollution of the cage floor

Pollution of enrichment materials, did not occur. Straw that landed at the bottom or plateau, was eaten or gnawed away by doe or kits and fell through the wire floor in the deep-pit. A considerable amount of straw was found in the deep-pit and must have been spilled.

DISCUSSION AND CONCLUSIONS

The purpose of this study was to examine the effect of different food related materials on the behaviour and welfare of commercial meat rabbit does in order to provide commercial meat rabbit farmers enrichment materials that fulfil the gnawing needs of the rabbits and remain attractive continuously. We chose only food related materials, as these materials had been described as most preferred in literature. Straw seems to be the preferred material and it was therefore used as "positive" control. Because of alleged problems with cage soiling, solid enrichment materials were suggested in the form of Plywood and Pine. Pine is considered soft wood, which is preferred above hard wood according to Baumans (2005) and Princz *et al.* (2008b). However, the bark should be removed to prevent possible poisoning. To our knowledge, the use of *Miscanthus* as gnawing material for rabbits has not been described yet. Straw+Pine were included to investigate if there is any added value if they are both given.

During the observations, not many animals were occupied with the enrichment materials. Nevertheless, clear differences between treatments ($P < 0.001$) and between weeks of lactation ($P < 0.05$) were found. The animals that were offered Straw and Straw+Pine were occupied the most with the enrichment material, followed by Plywood. Pine was the least attractive, although statistically there was no difference in duration between the Pine and Plywood. Interestingly, when Pine is given in addition to Straw, the Pine is barely touched and it does not seem to have any additional value. It might be that the taste of the wood is not attractive or that way it was attached to the roof of the cage (swinging), which made it harder for the does to grab it, was not suitable. Perhaps attaching the Pine to the side of the cage might have given a different outcome.

Providing enrichment materials does not seem to influence the reproductive behaviour of the does. During lactation, the contact with kits is limited. Does only suckle their kits once or twice a day. Substrate (straw) will be used during the couple of days before parturition when the does are building their nests. After the kits are born, some dragging of straw into the nest box was observed. At week 4, the animals seemed more occupied with the enrichment materials compared to the first 3 wk of lactation. Kits were out of the nest box at that age, but could not reach the platform yet, where the enrichment material was provided. When the nest boxes are removed at 21 d of lactation, does stayed on the platform (personal observations), presumably to avoid suckling by kits. As does were staying more on the platform, this might have stimulated them to consume more of the enrichment materials. Although the platform enables the does to get away from the kits, it cannot be concluded from this study if increased consumption of enrichment material is due to being 'confined' to the platform, as it may itself be a sign of frustration (redirected behaviour).

The consumption of Pine and Plywood was in line with the outcome of the behavioural observations. This suggests that, in practice, a good impression can be obtained of the extent to which the enrichment material is used on the basis of its consumption. The use of straw might have been overestimated, as a lot of the straw was spilled and fell through the cage floor in the deep-pit.

The Straw and Plywood remained attractive during the 10 wk period that the observations were performed. Therefore, it can be stated that these materials remain attractive for a considerable amount of time.

In this experiment we found no cage pollution caused by the enrichment materials, especially Straw. During the observations it was noted that small parts of the material that fell onto the cage floor were immediately eaten by does and/or kits. However, a considerable amount of straw was found in the deep-pit and must have been spilled. Rabbit farmers in the Netherlands declare that this might cause problems in the sales of the droppings. Application of hay or straw is only recommended if the quality can be guaranteed, because it can be polluted with toxins that can be detrimental for the rabbit's health (personal communication). These reasons might hinder the use of roughage as enrichment material on commercial rabbit farms in the Netherlands. By the same token, processed materials such as

pressed plywood may contain chemicals that are not safe for rabbits or consumers. Absolute safety guarantees are needed for such non-natural materials. However, natural materials can also present problems, e.g. pinewood that is too dry may cause problems with splinters (so fresh wood is preferred).

Abnormal behaviour was observed in the form of biting and digging on the wire, but only during a limited amount of time. Perhaps this is related to the fact that on this farm the does had reduced access (in the morning) to the nest box until insemination (11 d post-partum). The day before insemination, nest boxes remained closed for 24 h to stimulate receptivity of the does before insemination (Theau-Clément *et al.*, 2006). It has been shown that the best fertilisation results are obtained if does are receptive at insemination (Boiti *et al.*, 1996). One of the observations during week 2 took place at that time. Although rabbit does only nurse their kits once or twice a day (Hoy, 2006), it seems that closing the nest box leads to frustration, resulting in biting and digging of the wire around the nest box or at the platform above the nest box. This would suggest that the welfare of these does might be at stake through this commonly applied management procedure. Although this method is considered to fall within the natural nursing conditions in rabbits (Jilge, 1995), it may lead to frustration expressed as abnormal behaviours. After insemination on day 11 of lactation, does got free access to the nest boxes. After the second week of lactation, the duration as well as the amount of does that were occupied with the abnormal behaviours was limited.

Based on the findings of this experiment, it can be concluded that Straw (loose material) and Plywood are better used by the does than Pine. These materials remain attractive for the 2 lactations which were measured. Providing these enrichment materials will help the animals to better perform their natural behaviours such as gnawing and exploration and will therefore contribute to their welfare. Pine as provided in our study is used less and the question remains of whether Pine is sufficient as enrichment material, or if it should be provided in another way as recommended by Dutch farmers (not hanging from the roof of the cage), but other studies would be needed to definitely conclude this.

In the Netherlands, commercial rabbit farmers are required to offer roughage or other kinds of gnawing material to their animals and a list is needed with materials that can be used. Our study provides a first step towards such a positive list.

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