The effect of environmental enrichment on the behaviour of caged rabbits (*Oryctolagus cuniculus*)

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Abstract

Behaviour and use of the cage area were studied in 96 rabbits (*Oryctolagus cuniculus*) kept in an enriched cage system — with access to shelter and raised height at the back of the cage — and in a conventional cage system to estimate the effects of the environmental enrichment on the rabbits' welfare. The rabbits' behaviour and placement in the cage were observed, using continuous video recording through 24 h and direct scan sampling during the daytime. In addition, an open-field test was carried out with each rabbit, and after every single test, the rabbits' timidity of being captured was recorded. Rabbits kept in the conventional cage system, especially the females, showed more restlessness, excessive grooming, bar-gnawing and timidity than rabbits kept in the enriched cage system. This indicates increased stress in the rabbits kept in the conventional cage system. All the rabbits performed most of the active behavioural elements in the daytime and were resting mostly at night that shows that the rabbits in both cage systems were adapted to the daily activity in the animal unit; the enrichment had no effect on the daytime activity.

Only a few rabbits, particularly the females, used the box as a shelter or resting-place. On the other hand, they more often used the roof of the box as a look-out or resting-place. Furthermore, the rabbits' behaviour showed that they utilised the raised height in the enriched cage system.

These results indicate that rabbits kept in an enriched cage system, particularly the females, had better welfare than rabbits kept in a conventional cage system because they had access to
shelter and a better chance of interacting with the environment. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Rabbit; Housing; Environmental enrichment; Welfare

1. Introduction

The rabbit is a commonly used laboratory animal and over the years they have, like other domesticated animals, been exposed to a more intensive husbandry and use. They have been housed in small, barren cages without any sort of stimuli. The behavioural and physiological states of an animal are influenced by the environment. The content and the construction of the cage, space available, social contact, food and physiological conditions are all important factors, and their handling and genetics may also play a part (Fox, 1986; Morton et al., 1993). The rabbit is a social animal and is able to utilise complex environments so housing in cages will hardly satisfy many of its behavioural needs (Morton et al., 1993). The performance of elements from the normal behaviour repertoire, i.e., foraging and social behaviour is often restricted in traditional cages. The temporal structure of their behaviour can be disrupted if the feedback from behaviour is not optimal because of environmental limitations on the full expression of the behavioural repertoire. This could result in an increased state of stress, in an animal being more restless, i.e., changing its behaviour more frequently (Lehmann, 1987; Metz, 1987) and in it showing several kinds of abnormal behaviours, such as bar-biting, excessive grooming and stereotypic activities (Morton et al., 1993; Love, 1994). Furthermore, morphological and histological investigations have shown that restriction of the natural patterns of movement can cause permanent abnormalities of the skeleton (Drescher and Loeffler, 1991; Drescher, 1992).

However, barren cage systems can be enriched by stimuli that will elicit patterns of behaviour, that are otherwise limited by these systems. The effect of stressors in the environment may also be mitigated, but the enrichment, e.g., access to a shelter can have different effects depending of the species (Clark and Garlef, 1980; Bantin and Sanders, 1989; Jeppesen and Pedersen, 1991). Lehmann (1987) and Podberscek et al. (1991) found that caged rabbits with no chance of escape or to hide were more restless than rabbits with a hiding place. An animal was designated as restless when it did not complete ongoing activities and this is a behavioural sign indicating increased stress in the animal (Lehmann, 1987; Hughes and Duncan, 1988).

The height of the cage is an important parameter since in the wild a vigilant rabbit will sit on its hindlegs with ears pricked (lookout position) and in addition utilise natural rises (Lockley, 1961; Batchelor, 1991; Gibb, 1993). Domesticated rabbits will climb onto objects, for instance a shelf or a nest box, to explore and rest if that is possible (Whary et al., 1993). The cage should be of sufficient height to allow the rabbit to sit upright without its ears touching the top of the cage and very few cage systems comply with this requirement (Morton et al., 1993).

The aim of this study is to investigate the behaviour and the utilisation of the cage by rabbits kept in enriched cages, with access to shelter and raised height at the back,
compared with conventional barren cages. In the light of these parameters will be discussed the effect of the enrichment.

2. Materials and methods

2.1. Subjects and cages

The 49 female and 47 male rabbits used in the experiment were a crossbreed of New Zealand White and French Lop and were between 11 and 25 months old at the beginning of the observations. The rabbits were used in antibody production and were equally distributed between the two cage systems regarding sex, age and type of immunisation. About 3 months before the beginning of the observations, half the animals were housed singly in the enriched cage system, but before that all rabbits had been housed singly in conventional cages since weaning.

The conventional cage was a wire cage, measuring 46 (width) × 77 (length) × 40 (height) cm with a food hopper, a water bottle and a brick of wood attached to the front of the cage. On the grid floor, a perforated plate of plastic was placed to avoid leg injury. The plate covered the entire floor except for approximately 16 cm at the front of the cage to prevent the drinking water from pooling. The enriched cage had the same construction, but except that at the back 40 cm of the cage was raised to 80 cm in height and a box (44 × 25 × 19 cm) made of wood with a roof of perforated plastic like the bottom plate was inserted (Fig. 1). Twelve cages were placed in rows perpendicular to the central gangway in the animal room.

Rabbits were given 120-g pelleted rabbit food at 0730 h and tap water was always available. Ambient temperature varied between 11°C and 25°C during the experiment. Light remained on between 0700 and 1600 h and consisted of 12 fluorescent tubes that averaged 0.8 W/m². The light intensity was further affected by daylight from nine windows which measure 0.67 m² each. Between 1600 and 0700 h, the light came from three bulbs that averaged 0.08 W/m².

![Fig. 1. The enriched cage (a) and the conventional cage (b).](image-url)
2.2. Observations

The observations were carried out from June till November. Video recording scan sampling and an open-field test were used. Observations were adjusted around blood sampling and cage cleaning to minimise behavioural disturbances caused by these procedures. Other normal daily activities of technicians continued in order to monitor the husbandry system as whole. Both behaviour and position of the rabbit was recorded.

The video recording covered 24 rabbits; 12 from each cage system. By using video recording, it was possible to study both duration and frequency of the behavioural element for 24 h. The recording was carried out in two periods within 10 weeks. Rabbits from the two systems in the same row were recorded during the same 24 h. Red light was used — throughout the dark cycle, as this should not affect the behaviour of the rabbits Horton et al., 1974. The recordings were analysed in OBSERVER (version 3.0) during which both duration and frequency of the behavioural elements were continually registered.

Scan sampling was used through the day observations in order to observe a large number of animals. The behaviour was recorded by scanning the rabbits one by one, every 5 min for 1 h, five times a day between 0800 and 1600 h, over 3 consecutive days. The registration was carried out in three periods with 13-week intervals. The observer waited in the animal room for approximately 10 min before walking slowly along the rows of cages and recording the behaviour and position of the animals. Recordings were made on animals that were approximately four cages away from the observer in order to minimise disturbance of the animal.

Between the periods of video recording and scan sampling, each animal was exposed to an open-field test over 3 consecutive days. In an open-field test the behaviour of animals that are otherwise housed in different cage systems, can be compared under the same stimuli and environment. Another advantage is that the exposing to a new environment is a strong stimulus that does not induce any physical pain. The animal was caught in its home cage and transferred to an open-field area, measuring 2.0 (width) × 2.0 (length) × 1.23 (height) m. The open-field was divided equally into 25 squares. The animal was placed in an enclosed corner of the field and here it was kept for 1-min habituation. Behaviour, latency to move (rabbit staying in the start area more than 5 s before leaving it), number of crossed lines and the time spent in the edge- or central squares were recorded over a period of 10 min. Afterwards, the animal was captured and the rabbit’s fear of being captured was recorded. The area was cleaned for urine and feces after each test.

The recordings of the scan sampling and of the open-field test were carried out with a PSION HC110.

2.3. Ethogram

The references are Black and Vanderwolf (1969), Meijsser et al. (1989), Morton et al. (1993) and Gunn and Morton (1995).

Active-head — the rabbit sniffing the surroundings with movement of the head and/or forelimbs. The hindlimbs staying at the same place.
Active-other¹ — is divided into four variations:

- Active, side to side — movement of the forelimbs from side to side, the hindlimbs stay at the same place.
- Active, circle — hopping in circles around itself.
- Active, quickly — quickly running around in the cage.
- Parallel running — two rabbits running parallel with elevated gait and tail erect.

Ambulate — forward movement achieved by alternate extension of fore and hindlimbs.
Bounding² — moving upwards or forwards with all feet from floor. This can be accompanied by sideward or upward swinging of the rear.

Consumption¹ — eating rabbit pellets from the hopper, drinking or ingesting feces directly from anus (coprophagy).

Defecation² — defecation.

Freezing² — the forelegs are forward, the hindlegs staying in place and the heels are visible behind the body.

Gnawing¹ — gnawing of the rabbit’s immediate environment such as bars, wooden brick, box and plastic plate occasionally interrupted by rapid scratching with the forelegs.

Grooming — licking, scratching or nibbling of the body.

Lying¹ — resting with trunk on ground, hindlimbs tucked under the body, the forelimbs lying under the body or stretched forward from the body.

Lying stretched¹ — resting with body trunk on ground, hindlimbs outstretched and belly exposed.

Marking — can be performed in two ways:

- Chin-marking — rubbing the chin over an object.
- Urine squirt — with hindlimbs typically extended and tail erect, the rabbit squirts a short jet of urine out behind.

Pawscraping² — rapid scratching with the forelegs on the floor or wall.

Rearing — standing/sitting on hindlimbs with both forepaws off the ground (in the open-field test this element was divided in, respectively, ‘standing rear’ and ‘sitting rear’).

Sitting — rear end and forepaws on ground with the forelimbs straight, the thorax and abdomen clear of the floor and visible. Ears down or erect.

Thumping² — rapid movement of the hindlegs, raised and brought downward sharply on the ground.

2.4. Placing possibilities

It was observed whether the rabbit was at the front, middle or back of the cage, and in the enriched system it was observed whether the rabbit was in the box or on the roof of the box.

¹ Used only in scan sampling and video recording.
² Used only in the open-field test.
2.5. Statistics

Data were analysed by ANOVA (Statistical Analysis Systems, version 6.10) to compare the frequency and the duration (only in the video recording) of behaviours, position, latency and timidity of rabbits from the two systems. In addition, the effects of gender and time (throughout a 24-h recording) were analysed. The majority of the data had to be transformed (using a power transformation inherent in the SAS program) to meet the requirements for the parametric test. If these could not be met, then Mann–Whitney U-test or Wilcoxon signed ranks tests were performed on the untransformed data. In the experiments, age, types of immunisation and location of the cages in the row were tested for significant differences. In the video recording, a significant difference between the three placements of the cage in the row was found (Section 3.3). Significant differences were occasionally found between age groups and types of immunisation, but they were not general which indicates random variation. Differences found between observation periods and between days within a period were not related to the difference in cage systems and are not reviewed in this article.

3. Results

3.1. Behaviour

3.1.1. Video recording

The mean values for the behavioural elements observed in the two cage systems are presented in Table 1. The rabbits in the enriched cage system performed the behavioural

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Video recording (min)</th>
<th>Scan sampling (frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enriched</td>
<td>Conventional</td>
</tr>
<tr>
<td>Active-head</td>
<td>54.0 ± 5.4*</td>
<td>50.0 ± 3.5</td>
</tr>
<tr>
<td>Active-other</td>
<td>1.0 ± 0.3</td>
<td>3.7 ± 1.1**</td>
</tr>
<tr>
<td>Ambulate</td>
<td>20.0 ± 2.7</td>
<td>42.1 ± 4.6**</td>
</tr>
<tr>
<td>Consumption</td>
<td>166.3 ± 6.4</td>
<td>160.5 ± 4.1</td>
</tr>
<tr>
<td>Gnawing</td>
<td>28.4 ± 4.1</td>
<td>42.9 ± 7.9</td>
</tr>
<tr>
<td>Grooming</td>
<td>264.3 ± 10.8</td>
<td>294.7 ± 10.9*</td>
</tr>
<tr>
<td>Lying</td>
<td>627.7 ± 23.0</td>
<td>605.9 ± 14.8</td>
</tr>
<tr>
<td>Lying stretch</td>
<td>119.8 ± 21.8</td>
<td>87.0 ± 16.4</td>
</tr>
<tr>
<td>Marking</td>
<td>15.1 ± 3.1*</td>
<td>27.0 ± 11.4*</td>
</tr>
<tr>
<td>Rearing</td>
<td>3.7 ± 0.9*</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Sitting</td>
<td>142.7 ± 10.6</td>
<td>152.7 ± 11.8</td>
</tr>
<tr>
<td>In the box</td>
<td>12.1 ± 4.6</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>1440.0 ± 1.1</td>
<td>1439.2 ± 0.1</td>
</tr>
<tr>
<td>Total frequency in video recording</td>
<td>1453.8 ± 109.0</td>
<td>2021.9 ± 134.4**</td>
</tr>
</tbody>
</table>

*a Frequency.
elements ‘active-head’ and ‘rearing’ with longest duration ($P < 0.05$) while these had the shortest duration of ‘active-other’ ($P < 0.01$), ‘ambulate’ ($P < 0.01$); and ‘grooming’ ($P < 0.05$). There was no significant difference between cage systems for the other behaviours. The rabbits in the enriched cage system changed their pattern of behaviour less frequently than rabbits in the conventional cage ($P < 0.05$).

The total activity of the rabbits (all behavioural elements except ‘sitting’; ‘lying’ and ‘lying stretch’) were performed with highest frequency and longest duration from 0400 to 1600 h ($P < 0.01$) (Fig. 2). The total in-activity of the rabbits were performed with lowest frequency ($P < 0.05$) from 1600 to 0400 h (Fig. 2).

The males performed the behavioural elements ‘active-other’ and ‘grooming’ with longest duration ($P < 0.05$) and performed ‘marking’ with highest frequency ($P < 0.01$) (Table 2). ‘Gnawing’ was performed with longest duration by the females ($P < 0.01$).

### Table 2

Mean duration and frequency (± S.E.) of the behaviours per rabbit during video recording and scan sampling. The elements are divided in sex ($N = 24$ (video recording) and $N = 96$ (scan sampling))

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Video recording (min)</th>
<th>Scan sampling (frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Active-head</td>
<td>53.2 ± 3.7</td>
<td>48.6 ± 6.8</td>
</tr>
<tr>
<td>Active-other</td>
<td>2.9 ± 0.8*</td>
<td>1.2 ± 0.5</td>
</tr>
<tr>
<td>Ambulate</td>
<td>30.2 ± 3.7</td>
<td>33.5 ± 5.5</td>
</tr>
<tr>
<td>Gnawing</td>
<td>25.7 ± 3.2</td>
<td>65.6 ± 11.9*</td>
</tr>
<tr>
<td>Grooming</td>
<td>286.2 ± 9.2*</td>
<td>263.5 ± 14.5</td>
</tr>
<tr>
<td>Lying</td>
<td>618.5 ± 16.8</td>
<td>611.4 ± 21.6</td>
</tr>
<tr>
<td>Marking</td>
<td>28.2 ± 7.3*</td>
<td>4.2 ± 1.0*</td>
</tr>
<tr>
<td>Siting</td>
<td>157.9 ± 8.4</td>
<td>117.2 ± 16.5</td>
</tr>
</tbody>
</table>

*a Frequency.
(Table 2), there was no significant difference between the sexes in the remaining behaviours.

3.1.2. Scan sampling

Rabbits in the enriched cage system performed the behaviours ‘grooming’, ‘lying’ and ‘rearing’ more frequently ($P < 0.01$) and ‘active-head’, ‘active-other’, ‘ambulate’, ‘gnawing’, ‘lying stretched’ and ‘sitting’ less frequently compared with rabbits kept in the conventional cage ($P < 0.01$) (Table 1). There was no significant difference between the two cage systems for the remaining behaviours (Table 1).

Males performed the behaviours ‘ambulate’ ($P < 0.01$), ‘active-head’ ($P < 0.05$), ‘marking’ ($P < 0.01$) and ‘sitting’ ($P < 0.05$) with highest frequency (Table 2). ‘Gnawing’ and ‘lying’ ($P < 0.01$) were performed with highest frequency by the females. In the remaining behaviours, there was no significant difference between the two sexes (Table 2).

3.2. Position in the cage

From the video recording animals remaining in one part of the cage occurred with highest frequency in the conventional cage system ($P < 0.01$) (Table 3). The duration was not significantly different between the two cage systems (Table 3). There was no significantly difference between the two sexes.

In the scan sampling the time spent at the front and in the middle of the cage occurred with highest frequency in the conventional cage system ($P < 0.01$). Staying at the back of the cage occurred with highest frequency in the enriched cage system ($P < 0.01$) (Table 3).

When rabbits kept in the enriched cage system were at the back of the cage they were nearly always on the roof of the cage ($P < 0.01$) (Fig. 3a and b). In the scan sampling the males stayed at the back of the cage more frequently than the females ($P < 0.01$), but when the females were at the back they stayed in the nest box more than the males ($P < 0.01$) (Fig. 3b).

<table>
<thead>
<tr>
<th>Placement in the cage</th>
<th>Video recording</th>
<th>Scan sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Duration (h)</td>
</tr>
<tr>
<td>Front</td>
<td>134.9±15.9</td>
<td>234.8±19.1*</td>
</tr>
<tr>
<td>Middle</td>
<td>166.7±13.4</td>
<td>307.2±31.9*</td>
</tr>
<tr>
<td>Back</td>
<td>126.5±21.6</td>
<td>253.5±26.9*</td>
</tr>
</tbody>
</table>

Table 3
Mean duration and frequency ( ± S.E.) of position in the cage per rabbit in the two cage systems during video recording and scan sampling ($N = 24$ (video recording) and $N = 96$).
3.3. Location of cages in the row

The video recording showed that the rabbits in both cage systems, in the four cages located nearest the central gangway, had a significantly higher frequency of total activity (all behavioural elements except ‘sitting’, ‘lying’ and ‘lying stretched’) than rabbits further away from the gangway \((P < 0.01)\) (Table 4). There was no significant difference in the duration of the total activity.

3.4. The open-field test

3.4.1. Behaviour

The rabbits from the enriched cage system performed the behavioural element ‘sitting’ with longest duration \((P < 0.05)\) while they had the shortest duration of ‘standing rear’ \((P < 0.01)\) and ‘pawscrapping’ \((P < 0.05)\). ‘Bounding’ was performed more frequently by these rabbits \((P < 0.01)\). There were no significant differences between the two cage systems for the remaining behaviours (Table 5).

The males performed the behavioural elements ‘active-head’ and ‘pawscrapping’ with longest duration and ‘defecation’ and ‘marking’ with highest frequency \((P < 0.01)\) (Table 5). The behavioural elements ‘standing rear’: ‘sitting rear’ and ‘sitting’ were performed with longest duration by the females \((P < 0.01)\). In the remaining behaviours, there were no significant differences between the two sexes (Table 5).

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean frequency and duration (± S.E.) of total activity (including all behaviours except ‘sitting’, ‘lying’ and ‘lying stretch’) per rabbit in the three locations of the cages in a row during video recording ((N = 24))</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cage system</th>
<th>Frequency</th>
<th>In the middle</th>
<th>At the wall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>enriched</td>
<td>1158.3 ± 127.1**</td>
<td>678.8 ± 37.0</td>
</tr>
<tr>
<td></td>
<td>conventional</td>
<td>1147.6 ± 117.9**</td>
<td>955.8 ± 45.1</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>enriched</td>
<td>10.0 ± 0.3</td>
<td>8.6 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>conventional</td>
<td>9.8 ± 0.4</td>
<td>10.1 ± 0.4</td>
</tr>
</tbody>
</table>

\(**P < 0.01\)
Table 5

Mean duration and frequency (±S.E.) per rabbit of behaviours and other recordings in the open-field test in the two cage systems and sex (N = 96)

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Cage</th>
<th></th>
<th>Sex</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enriched</td>
<td>Conventional</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>States (duration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active-head</td>
<td>246.3 ± 6.6</td>
<td>243.1 ± 6.6</td>
<td>278.8 ± 5.6**</td>
<td>209.9 ± 6.2</td>
</tr>
<tr>
<td>Ambulate</td>
<td>176.5 ± 6.3</td>
<td>194.7 ± 7.3</td>
<td>185.9 ± 7.2</td>
<td>184.8 ± 6.4</td>
</tr>
<tr>
<td>Freezing</td>
<td>7.7 ± 1.4</td>
<td>9.2 ± 1.4</td>
<td>8.5 ± 1.4</td>
<td>8.3 ± 1.4</td>
</tr>
<tr>
<td>Grooming</td>
<td>9.1 ± 0.9</td>
<td>8.4 ± 0.8</td>
<td>9.7 ± 0.9</td>
<td>7.8 ± 0.7</td>
</tr>
<tr>
<td>Pawscraping</td>
<td>2.7 ± 0.9</td>
<td>6.3 ± 1.3*</td>
<td>7.2 ± 1.5**</td>
<td>1.6 ± 0.5</td>
</tr>
<tr>
<td>Sitting</td>
<td>95.1 ± 6.4*</td>
<td>73.8 ± 5.8</td>
<td>54.6 ± 4.6</td>
<td>115.5 ± 6.4**</td>
</tr>
<tr>
<td>Sitting rear</td>
<td>40.2 ± 2.3</td>
<td>42.4 ± 2.7</td>
<td>37.7 ± 2.3</td>
<td>45.1 ± 2.3**</td>
</tr>
<tr>
<td>Standing</td>
<td>15.6 ± 1.1</td>
<td>20.2 ± 1.5**</td>
<td>15.3 ± 1.3</td>
<td>20.3 ± 1.3**</td>
</tr>
<tr>
<td>Events (frequency)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bounding</td>
<td>2.5 ± 0.3**</td>
<td>1.2 ± 0.2</td>
<td>2.4 ± 0.4</td>
<td>1.3 ± 0.2</td>
</tr>
<tr>
<td>Defecation</td>
<td>5.8 ± 0.5</td>
<td>4.9 ± 0.4</td>
<td>7.2 ± 0.5**</td>
<td>3.4 ± 0.3</td>
</tr>
<tr>
<td>Marking</td>
<td>11.7 ± 1.4</td>
<td>15.3 ± 1.6</td>
<td>21.0 ± 1.6*</td>
<td>5.8 ± 1.1</td>
</tr>
<tr>
<td>Thumping</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Urinating</td>
<td>0.7 ± 0.1</td>
<td>0.5 ± 0.1</td>
<td>0.5 ± 0.1</td>
<td>0.7 ± 0.1</td>
</tr>
<tr>
<td>Placement (seconds per time)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td>22.9 ± 0.8</td>
<td>21.1 ± 1.3</td>
<td>23.1 ± 1.3</td>
<td>20.9 ± 0.9</td>
</tr>
<tr>
<td>Middle</td>
<td>5.6 ± 0.2</td>
<td>5.4 ± 0.2</td>
<td>5.6 ± 0.2</td>
<td>5.4 ± 0.2</td>
</tr>
<tr>
<td>Lines crossed</td>
<td>175.1 ± 4.4</td>
<td>183.9 ± 4.3</td>
<td>172.2 ± 4.3</td>
<td>186.7 ± 4.2**</td>
</tr>
<tr>
<td>Latency (mean number of rabbits)</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
</tr>
</tbody>
</table>

Rabbits that were recorded as not timid after the open-field test had a higher frequency of ‘bounding’ (P < 0.01) (not timid: 10.33 (S.E.: 1.4) per rabbit; timid: 0.89 (S.E.: 0.2) per rabbit).

3.4.2. Other recordings in the open-field test

There were no significant differences in the position in the open-field arena, or in the number of rabbits with latency to move either between the two cage systems or between

Fig. 4. The mean number of times (±S.E.) per rabbit, showing timidity of being captured after the open-field test. The element is divided into cage system and sex (N = 96).
the sexes (Table 5). There was no significant difference in the number of lines crossed between the two cage systems, but females crossed more lines than males ($P < 0.01$) (Table 5).

Rabbits from the conventional cage system showed more timidity to capture than from the enriched system ($P < 0.05$) with females being more timid, although the males in both cage systems showed no significant difference (Fig. 4).

4. Discussion

The rabbits in the enriched cage system had fewer changes in behaviours as well as in the open-field test compared with the conventional cage system (Tables 1 and 5). Lehmann (1987) found an increased number of activity-changes per hour in cages compared with rabbits housed under semi-natural conditions and this was interpreted as restlessness. An animal is designated ‘restless’ when it does not complete ongoing activities and this is a behavioural sign of increased stress in the animal (Lehmann, 1987; Hughes and Duncan, 1988). These results, therefore, indicate that rabbits in the conventional cage system seemed to be more easily affected by the environment.

In the video recording, rabbits housed in cages near the gangway changed their behaviour more frequently (Table 4), as they were disturbed because of the daily activity. One could expect that these rabbits would gradually habituate to the activity, but perhaps because of irregular disturbances this was not the case. As the disturbances affected in both cage systems, it may have overshadowed the effect of enrichment on these rabbits.

Several differences were seen in the rabbits’ behaviour when comparing the two cage systems. Rabbits kept in the conventional system performed the behaviour ‘ambulate’ with longest duration that can be seen in relation to their more frequently changing of the behavioural elements. The difference could also be caused by rabbits being kept in a more restricted albeit enriched cage system, as they would be limited in the performance of continuous jumps. In scan sampling where the rabbits were most active, the frequency of ambulation was 3% (enriched) and 6% (conventional) out of 60 observations. This is lower than what Gibb (1993) found in wild rabbits during their active period (14%). The behaviour ‘ambulate’ made up, respectively, 1% (enriched) and 3% (conventional) in the video recording through 24 h, whereas Mykytowycz and Fullagar (1973) found that wild rabbits were moving about for 7% of 24 h. These differences are probably caused by the lack of space in both cage systems to perform several continuous jumps.

The behaviour ‘sitting’ occurred in two variants: resting with ears down or sitting with ears erect and attentive to its surroundings. Rabbits kept in the conventional cage system were often observed sitting for a longer time during a disturbance, compared with rabbits kept in the enriched system that appeared to calm down more quickly to rest. There was no sign of apathy in any of the cage systems as found in many other experiments (Huls et al., 1991; Morton et al., 1993; Gunn and Morton, 1995).

Rabbits in both cage systems spent much of their time on grooming the fur. In studies of wild rabbits grooming made up 2% of their active period (Gibb, 1993) and in 24-h recording of the animals behaviour (Mykytowycz and Fullagar, 1973). This is much
lower than we recorded in scan sampling (E: 14% / C: 12%) and in video recording (E: 19% / C: 20%). The style of grooming varied: grooming with the mouth could occur with repeated, small licking/biting movements around the neck region, without using gland secretion, or as a more thorough fur keeping on larger parts of the body after rubbing fore- or hindlegs around the mouth region. When grooming is performed in short sequences it can be a displacement activity caused by disturbance (Guild and Dunn, 1982; Gunn and Morton, 1995) and it is possible that their shortened grooming was performed as a stereotyped behaviour as it had no distinct purpose. We did not observe any fur pulling as has been reported in other studies (Morton et al., 1993; Gunn and Morton, 1995). The excessive grooming in both cage systems can indicate an understimulation from the environment or as Gunn and Morton (1995) suggest, social deprivation. This further confirmed by another experiment where grooming activity decreased significantly when the rabbits had access to hay (Berthelsen and Hansen, 1999).

The behaviour ‘active-other’ included activity that resembled the parallel running that is seen in wild rabbits’ territorial behaviour and activity with repeated movements (‘active, side to side’) as a stereotypy. There was no difference found in the frequency of ‘marking’ and therefore it is unlikely that there should be a difference in ‘parallel running’ between the two cage systems (Table 1). Because of the other indications of increased stress in rabbits kept in the conventional system, it is possible that the higher frequency of the behaviour ‘active-other’ can be explained as stereotypic.

Enrichment had no overall effect on the activity of the rabbits over 24 h as no significant difference between the two cage systems was found. Rabbits were inactive most of the 24 h (Fig. 2) which Gunn and Morton (1995) also found with rabbits kept in cages of metal with solid walls. Mykytowycz and Fullagar (1973) found that wild rabbits were inactive for 61% of 24 h. This study does not indicate a diverging proportion between activity and passivity in caged compared with wild rabbits. During 24 h, rabbits in both cage systems were generally active and changed behaviour often between 0400 and 1600 h, i.e., a couple of hours before the rabbits were fed (at 0730 h) and until the keepers subdued the light (Fig. 3). In the wild, rabbits are active at dusk and night, but the recordings showed that the cage rabbits were adapted to the daily activity in the animal room. Until the caged rabbits are approximately 3 months old, they still have a natural 24-h activity as they eat during the evening and night (Hansen, S.R., personal communication, 1996). If the rabbits were fed ad libitum, they would probably retain a more natural 24-h activity as found by Horton et al. (1974), Hörnicke et al. (1984) and Gunn and Morton (1995).

Rabbits kept in the conventional cage system, particularly the females, showed a high frequency of timidity when being captured after the open-field test (Fig. 4). These rabbits also had a less frequency of ‘bounding’ (Table 5). This behaviour can be compared with buck in horses and calves and are therefore seen as an indicator of low level of timidity. Fear also shows as the animal is trying to escape during the test and hereby scores a high number of crossed lines or is sitting motionless (Munksgaard and Jensen, 1996; Pedersen, 1996). By this, both timid rabbits and curious rabbits could record a similar number of crossed lines, which could be the reason for no difference was found between the two cage systems.
Both in cages and in the open-field test, male rabbits were more territorial. In the
scan sampling, they had a high frequency of ‘active-head’ in the cages and spent much
of their time in the open-field investigating the nearby environment by performing this
behaviour. They also had more frequently marking of the environment (including
‘marking’, ‘pawscraping’ and ‘defecation’). Females performed more ‘sitting rear’ and
‘standing rear’; the latter being performed mostly frequently in the conventional cage
system (Table 5) and so it seems that their exploring — especially the females — were
not a territorial behaviour, but more a search for escape. Females also had a higher
number of crossed lines (Table 5). In the cages, females were recorded highly for
gnawing at the bars, which was mainly observed in the conventional cage system. This
behaviour was performed in a continuous and repetitive (or stereotypic) manner and that
kind of behaviour is often characterised as an abnormal behaviour (Morton, 1993;
Lidfors, 1997). This can totally indicate that the females were more affected by the
environment and therefore had more difficulties in coping.

The rabbits rarely utilised the possibility to crawl into the box (1%) and only a few
animals used the box as a place for rest or escape (Fig. 3). Batchelor (1991) also found
that group housed rabbits did not utilise a nest box for sleep/rest, but only as a hiding
place from a dominant rabbit. Whary et al. (1993) found that the area under a shelf in
daytime was utilised as a resting-place for only 3% of time, but at the appearance of
humans, the rabbits took flight under the shelf. Compared with the present study it
seems that rabbits under undisturbed conditions use the hide very little. We found
females more often stayed in the box than the males (Fig. 3) and in the wild females stay
more often in burrows than the males (Kolb, 1991, 1994). The fact the females showed
more timidity and more ‘gnawing’ in the conventional cage system could indicate that,
particularly, females in the enriched cage system had a need fulfilled by having access to
a hide. The box can, therefore as a potential flight possibility, contribute to improved
welfare of the animals.

Sudden disturbances often caused rabbits to jump up on the roof of the box and rear.
It seems to give the advantage of being able to survey the surroundings. Rabbits in the
enriched cage system performed ‘rearing’ significantly more than the rabbits in the
conventional cage system (Table 1) and it was furthermore observed several times that
the rabbits utilised the full height in the enriched cage by standing upright. The
possibility of stretching out to full height may also, presumably, reduce the incidence of
skeleton abnormalities and strengthen the bones of the rabbits in the longer term
(Drescher, 1992; Drescher and Loeffler, 1991).

In the scan sampling studies, the rabbits in the enriched cage system stayed at the
back of the cage with a significantly higher frequency than rabbits in the conventional
cage system (Table 3). Here, particularly, the bigger rabbits did not have the same
possibility to lay outstretched that resulted in a low frequency of that behaviour. In the
video recording the major part of the rabbits in both cage systems lay at the back of the
cage at night and over 24 h, the duration of the stay was not significantly different. It
cannot be concluded whether it was the actual box (they rested on the roof) or a
preference to lie at the back of the cage that was important to the animals. In the video
recording it was observed that rabbits, when resting during the night on the roof of the
box fell off on several occasions: the roof steeped slightly. But the rabbits still continued
to use the roof as a resting-place. In order to evaluate if rabbits lie on the roof of the box to be at a higher level or because they preferred to lie at the back of the cage, the box could be replaced with a horizontal shelf. Whary et al. (1993) found that rabbits with access to a shelf utilised this to explore and rest. A shelf would at the same time provide more floorage and would in this context be preferable for the box as the box reduced the area where the rabbit could move and lie stretched out. Furthermore, as the plastic plate did not cover the front 16 cm and it was observed as Gunn and Morton (1995), that the rabbits rarely lay directly on the grid floor. These conditions made the usable length of the cage too short for the rabbit to stretch out full length. The rabbits were, in addition, never observed lain stretched out diagonally even if there was room (Gunn and Morton, 1995). Moreover, even if the box is replaced by a shelf the length of the cage, it will still not be long enough for the rabbit to perform a normally hop.

A substantial factor that can influence the utilisation of the cage is the age of the rabbit. If the rabbits were moved to the enriched cage system earlier in life or directly after weaning, they would perhaps react and utilise the cage differently. Other studies which have shown that the rabbits have a preference to shelter have been performed with younger animals (Lehmann, 1987).

5. Conclusion

The needs of an animal can change according to its age, learning, diurnal rhythm, season and genetic relations. Environmental enrichments must consider the needs of animals to avoid creating, despite good intentions, more problems for the animal. This study indicates that the investigated enrichments fulfilled a need for the rabbits. It supports the concept of how environmental enrichment can reduce abnormal activity, timidity and disruption of behavioural elements. Rabbits kept in a conventional cage system, especially the females, had more excessive grooming, gnawing bars, changed behaviour more often and showed a higher degree of timidity.

This indicates difficulties in coping with the environment and are behavioural signs of stress in the animals.

We hereby conclude that access to shelter and a possibility to attend the environments should be considered as environmental enrichments in the attempts to improve the welfare of rabbits.

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