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APPLICATION OF GNAWING STICKS IN RABBIT HOUSING

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Abstract: Four experiments are described relating to gnawing sticks application in rabbit housing. In experiment 1 and 2, Pannon White rabbits, weaned at the age of five weeks, were placed into pens with wire net floor. In experiment 1, every pen (180 animals in 12 pens, surface per head: 571 cm^2) was provided with three gnawing sticks randomly chosen from White locust, Black elder, White willow, Little-leaf linden, European larch, Black poplar, European white birch, White buckeye and White mulberry species. In experiment 2 (150 animals in 10 pens, surface per head: 571 cm^2), only those tree species ingested by rabbits in the first experiment were used (White locust, White willow, Little-leaf linden, Black poplar and White buckeye). In the second experiment, rabbits showed the highest preference towards gnawing sticks of Little-leaf linden, while similar White willow and White buckeye consumption was observed. In the experiment 3, rabbits' preference to different types of wood and the influence on rabbits' behaviour of added wooden sticks as environmental enrichment was studied. At the age of 38 days, 48 male SIKA rabbits were housed individually in wire cages (surface per head: 1500 cm^2). According to the type of wood placed in the cage, rabbits were equally allotted to four groups: control, Common oak, Little-leaf linden and Norway spruce. Rabbits' preference to type of wood was studied on all the animals with wooden stick, while rabbits' behaviour was studied on 16 focus animals at the age of 5 and 13 weeks using continuous 24 hours video recordings. Rabbits preferred gnawing Little-leaf linden and Norway spruce compared to Common oak. Addition of gnawing sticks had no significant influence on duration of rabbits' behaviour, except for eating feed and gnawing wooden stick time. In experiment 4, the effect of housing and environmental enrichment on the performance and behaviour of growing rabbits was tested. 72 hybrid rabbits were housed after the weaning period in standard fattening cages at 2, 3, 4 animals per cage (surface per head: 1045 cm^2, 697 cm^2, 522 cm^2 respectively). Half cages were enriched using a wood stick (*Robinia pseudoacacia*) dangling from the ceiling of the cage. The environmental enrichment decreased the stereotypies (gnawing the bars of the cage). A tendency to lower aggressive behaviours in enriched caged rabbits was also found compared to the conventional caged rabbits. This might indicate a better satisfaction of the behavioural needs for the enriched caged rabbits.

Key words: Growing rabbits, gnawing sticks, tree species, performance, behavioural traits.

INTRODUCTION

During the recent years increasing importance was attached to the analysis of the rabbits' welfare. Several forms of environmental enrichment were tested in the conventional low level of stimulus cage system. Gnawing sticks were frequently placed into the rabbit cages (Hansen *et al*., 2000; Luzi *et al*., 2003; Princz *et al*., 2005) and their effect on the performance and behaviour was recorded.

Several authors (Lidfors, 1997; Jordan and Štuhec, 2003; Verga *et al*., 2004) defined the species of the applied gnawing sticks, but the exact tree species are not always given. Some suggestions were published about the recommended tree species by Ernte (www.ernte.at): apple, ash, willow, spruce, oak, however, they suggest the placement of leafy branches. In the present study some consequences when placing gnawing sticks in rabbit housing are shown.

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MATERIALS AND METHODS

Experiment 1 and 2 were carried out at the University of Kaposvár using Pannon White rabbits. Animals were placed into pens (1.71×0.50 m^2; 15 rabbits per pen; surface per head: 571 cm^2) with wire net floor in closed air-conditioned rabbitry. Experiments lasted between the age of 5-11 weeks. During the experiments the room temperature was 18 °C and the daily lighting was 16 hours. Rabbits were fed a commercial pellet *ad libitum* between the age of 5-9 (10.3 MJ digetible energy (DE)/kg, 14.5% crude protein, 2.0% fat, 17.5% crude fibre, 50 ppm Tiamulin, 500 ppm Oxitetracycline, 1 ppm Diclazuril) and 9-11 (10.6 MJ DE/kg, 16.0% crude protein, 3.0% fat, 16.0% crude fibre) weeks. Water was available *ad libitum* from nipple drinkers. The feeder was placed on the wall of the cage; the two drinkers were put on the opposite side (1.71 m from the feeder). After stripping the bark off, the gnawing sticks were placed horizontally 20 cm high on the wall of the adjacent pens (Figure 1).

In experiment 1 (n=180 rabbits in 12 pens) every pen was provided with three gnawing sticks randomly chosen from White locust *(Robinia pseudoacacia)*, Black elder *(Sambucus nigra)*, White willow *(Salix alba)*, Little-leaf linden *(Tilia cordata)*, European larch *(Picea abies)*, Black poplar *(Populus nigra)*, European white birch *(Betula pendula)*, White buckeye *(Aesculus hippocastanum)* and White mulberry *(Morus alba)* species (with a diameter of 3 cm and length of 20 cm). During the trial the preference of the rabbits (ingested *vs*. rejected species) was monitored to choice the main accepted species for examing their ingestion.

In experiment 2 (n=150 rabbits in 10 pens) only those gnawing sticks (tree species) were used that were ingested by the rabbits in the first experiment (White locust, White willow, Little-leaf linden, Black poplar and White buckeye). Every pen was applied with 3 gnawing sticks of different species (using all possible combinations). Size of the stick was the same as in the preceding trial. Prior to their placement into the cages the volumes of the gnawing sticks were determined by inserting them into a glass cylinder filled with water. Gnawing sticks fully ingested during the experiment were replaced. Gnawing stick consumption was determined (in cm^3) from the volume differences measured at the beginning and at the end of the experiment. The data of gnawing stick ingestion per pen (experiment 2) were evaluated by one way analysis of variance using SPSS 10.0 software package (SPSS, 1999).

Experiment 3 was carried out at the University of Ljubljana and lasted nine weeks, namely between the rabbits' age of 38 to 94 days. It included 48 male New Zealand White rabbits of Slovenian male line SIKA. Animals were housed individually in wire cages sized 37.5×40×30 cm, equipped with a feeder and nipple drinker. The rabbits were fed *ad libitum* with the complete feed mixture for fattening rabbits (10.4 MJ DE/kg, 17% crude protein, 14% crude fibre, 2% fat). 12 hours light:12 hours dark

Figure 1. Placement of gnawing stick on the wall of pen (experiment 1 and 2).

schedule was used, with the lights on from 6:00 am to 6:00 pm. During the experiment ambient temperature and relative humidity varied from 21 to 25°C and 35 to 57%, respectively. Right after the individual housing animals were allotted to four groups, each containing 12 rabbits, according to the type of wooden stick (dimensions: 2.1×4.4×50.3 cm) fixed horizontally right under the upper side of the rabbit's cage. For gnawing material the first group received Common oak (*Qercus robur)*, the second Little-leaf linden (*Tilia cordata*), and the third Norway spruce (*Picea abies*) sticks. The control group was left without wooden sticks.

To establish the amount of gnawed wood, wooden sticks were weighed once a week. During the experiment it was observed that the relative humidity of the wood was changing with regard to relative humidity of the air in the rabbitry, which caused oscillation in the weight of wooden sticks. For this reason it was impossible to determine the amount of gnawed wood from the weight of the wooden stick, therefore it was determined on the basis of 5 grades of visual evaluation (1 - visible marks of teeth or completely intact, 2 – slightly gnawed, 3 – moderately gnawed, 4 – severely gnawed, 5 – extremely gnawed).

To determine the influence of different type of wooden stick on rabbits' behaviour, 16 focus animals (4 from each group) were recorded for 24 hours by infrared video camera (WV-BP330/Panasonic) in the first and the last experimental week. Recordings were analysed by two observers with the "Observer 4.1" program (Noldus®), during which the duration of the behavioural elements was continually registered. Activities of rearing up (sitting with forepaws lifted from the floor), eating feed, drinking, caecotrophy, biting wire and feeder, wood gnawing, grooming, sniffing, hopping, stretching, inactivity, and contact with the neighbour rabbit were observed, but in this study only the results for behaviours important from the rabbits' welfare point of view (biting wire and feeder) and those, where there was a trend or significant difference between groups (inactivity, eating feed, wood gnawing) are presented in detail. Statistical data analysis was conducted using statistical program package SAS (2001). Data were not normally distributed and were therefore analysed with nonparametric Wilcoxon rank-sum test with Bonferroni-Holms correction for multiple comparison of groups.

Experiment 4 was carried out in a commercial farm located in North West of Italy. Over the trial, the room temperature was about 15 °C and the daily lighting was 16 hours. 72 hybrids rabbits were housed in standard cages with the same dimension during the gnawing period from 35 to 75 days of age. The animals were housed in 2, 3 or 4 per cage (surface per head: 1045 cm^2, 697 cm^2 and 522 cm^2, respectively). Half cage were enriched using a Black locust stick (*Robinia pseudoacacia*) 24 cm length and 8 cm of diameter, hanging from the ceiling of the cage, to study the effect of the environmental enrichment. Animals were fed *ad libitum* a commercial feed (9.62 MJ DE/kg, 15.8% crude protein, 3.0% fat, 16.5% crude fibre from 35 till 50 days of age; 10.25 MJ DE/kg, 16.5% crude protein, 3.5% fat, 16.0% crude fibre from 50 days of age till slaughtering). Weight and daily weight gain were recorded at weaning (35 days of age), at 53 days of age and at slaughter (75 days of age).

Behaviours were video recorded at the beginning (1st period) and at the end of the fattening period (2nd period), for 24 hours each period, using 3 cameras connected to a Multiplexer and VCR tape recorder. Thus each cage was observed for 48 hours in total. Behaviour was recorded using a scan sampling method (Martin and Bateson, 1993) every 10 min during the whole observation time (288 scans per image). The following behaviours were recorded: lying, lying stretched, sniffing another rabbit, sniffing the object, self and allo-grooming, movement, drinking, eating feed, caecotrophy, hopping, standing, gnawing the bars of the cage, gnawing the wood stick, motor stereotypies, aggressive behaviours. The following behaviours were performed very seldom, so they were excluded form the analysis: lying, lying stretched, sniffing the object, self-grooming, movement, drinking,

Table 1: Overview of the experiments

	Experiment			
	1	2	3	4
Country	Hungary	Hungary	Slovenia	Italy
Breed	Pannon White	Pannon White	SIKA	Hybrid
Age (days)	35-77	35-77	38-94	35-75
No. of rabbits	180	150	48	72
No. of rabbits per placing unit	15	12	1	2-3 or 4
Surface per head (cm^2)	571	571	1500	522-1045
Temperature (°C)	18	18	21-25	15
Daily lighting (hours)	16	16	12	16
Applied gnawing stick species	White locust, Black elder, White willow, Little-leaf linden, European larch, Black poplar, Europen white birch, White buckeye, White mulberry	White locust, White willow, Little-leaf linden, Black poplar, White buckeye	Common oak, Little-leaf linden, Norway spruce	Black locust
Examined behaviour	Preference	Consumption	Biting wire and feeder, Inactivity, Eating feed, Stick gnawing	Sniffing another rabbit, Allo-grooming, Gnawing the cage, Aggressive behaviour
Statistical method	Analysis of variance	Analysis of variance	Wilcoxon rank-sum test	Principal component analysis

eating feed, caecotrophy, hopping, standing, gnawing the wood stick and motor stereotypies. Data were evaluated by Analysis of Variance using SAS package (2001) placing environmental enrichment and housing as main effects. Behaviours were also analysed by the Principal Component Analysis (PCA, Todeschini, 1998), and by their frequencies, according to the considered independent variables. An overview about the experiments is presented in Table 1.

RESULTS

Based on the results of experiment 1 rabbits showed preference towards White locust, White willow, Little-leaf linden, Black poplar and White buckeye as they consumed the gnawing sticks of these species in various amount. Black elder, European larch, European white birch and White mulberry species were rejected as no ingestion of these species could be observed (regardless of the different combinations).

Table 2: Consumption of gnawing stick depending on the tree species (Experiment 2)

Consumption	Species					SE	*P*-value
	Little-leaf linden	White willow	White buckeye	Black popular	White locust		
Per pen, cm^3 (35-77 d)	278^c	132^b	128^b	7^a	3^a	23.9	0.001
Per rabbit, cm^3 (per day)	0.44	0.21	0.20	0.01	0.005	-	-

Means in a row with different superscripts indicate significant differences ($P<0.05$).

Table 3: Grade of gnawed wood and the influence of environmental enrichment on mean duration (percentage per hour) of rabbits' behaviours (Experiment 3)

	Group				*P*-value
	Control	Common oak	Little-leaf linden	Norway spruce	
Grade of gnawed wood[1]	-	1.0[a]	2.95[b]	2.77[b]	0.0021
Behaviour, %					
Inactivity	60.15	56.37	55.69	59.79	0.0580
Eating feed	7.99[ab]	8.49[a]	7.86[ab]	6.91[b]	0.0342
Biting wire and feeder	1.62	2.16	1.15	1.21	0.8759
Wood gnawing	-	0.00[a]	0.01[b]	0.21[b]	0.0005

Means in a row with different superscripts indicate significant differences ($P<0.05$). [1]Five grades of visual evaluation from 1=visible marks of teeth or completely intact to 5=extremely gnawed.

According to experiment 2 (Table 2) the rabbits showed the highest preference towards Little-leaf linden gnawing sticks, while similar amount of White willow and White buckeye ingestion was experienced. The gnawing stick consumption of White locust and Black poplar was relatively small.

In experiment 3 rabbits showed significantly higher preference to Little-leaf linden and Norway spruce sticks than to Common oak sticks (Table 3). The average score of gnawed wood was almost the same for Little-leaf linden and Norway spruce gnawing sticks (2.95 and 2.77) although Little-leaf linden sticks received more often grade 5 (extremely gnawed) than Norway spruce sticks (Figure 2), where the amount of gnawed wood was most often evaluated with grade 3 (moderately gnawed). Common oak sticks were almost all intact. Enrichment of cages with different types of wooden sticks had no significant influence on duration of observed behaviours, except eating feed and wood gnawing (Table 3). Rabbits with Norway spruce sticks ate feed significantly less time than rabbits in Common oak group. Rabbits spent significantly greater percentage of time gnawing Little-leaf linden and Norway spruce sticks in comparison with Common oak sticks. Difference in duration of wood gnawing between Norway spruce and Little-leaf linden group was not significant, although mean

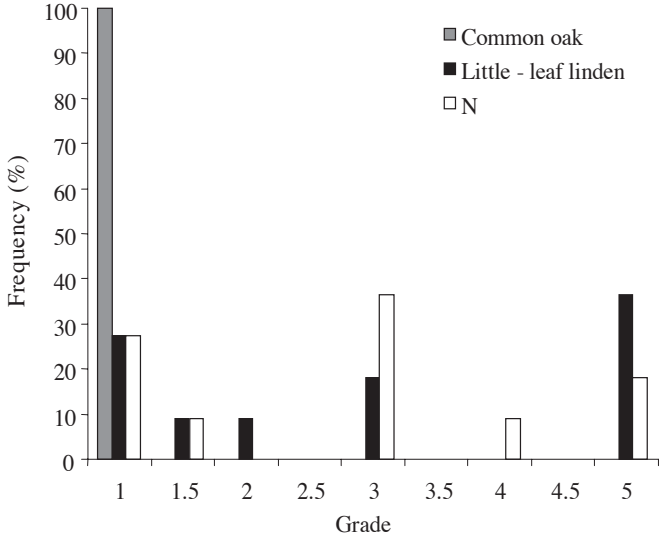

Figure 2: Distribution of the grade of gnawed wood (Experiment 3)

values differed substantially. In the enriched cages a trend of decrement of inactivity (P=0.058) was noticed, but in wire and feeder biting no significant decrement was observed.

In experiment 4, the effects of presence of a wood stick inside the cage and of the housing systems (2, 3, 4 animal per cage) were not statistically significant on the rabbit performance. Weight gain between 35 and 75 days and body weight at 75 days of age were not affected by treatment. The means of these traits were between 38.0 and 39.5 g/day, and 2540 and 2626 g, respectively. As far as the behaviour is concerned, the enriched caged rabbits performed significantly more allo-grooming and sniffing the other rabbits, while the control animals performed significantly more gnawing the bars of the cage. A trend was also found in these latter rabbits to show higher alert and aggressive behaviours (Figure 3).

DISCUSSION

The highest level of gnawing stick consumption was observed for Little-leaf linden. Considerable amount of consumption was found for White buckeye and White willow. All these species are soft (hardness) (Kovács, 1979). The mechanical and chemical characteristics of the tree species (hardness, smell and taste) may determine which of the investigated species is suitable for gnawing stick.

Consumption of White locust and Black poplar was small. The White locust is a tough tree and has indelicate fibres that may explain its consumption level. Although Black poplar is a soft tree its consumption was also small. According to rabbits' preference for wood species, the results of the experiment 3 were quite similar to results of experiment 2. Rabbits preferred sticks made of Little-leaf linden and Norway spruce wood compared to Common oak. The possible reason of this finding could be, as in experiment 2, mechanical and chemical characteristics of used three species. Common oak is very dense and hard in comparison with Norway spruce and Little-leaf linden (Čermak, 1998; Pipa, 1990) and it also contains a large amount of tannin, about 10% (Pipa, 1990). Occupation of rabbits with environmental enrichment did not significantly reduced animals' inactivity, as it was reported in several studies investigating environmental enrichment (Metz, 1987; Huls *et al.*, 1991). In neither group was observed any significant decrement of biting wire and feeder, which is one of the

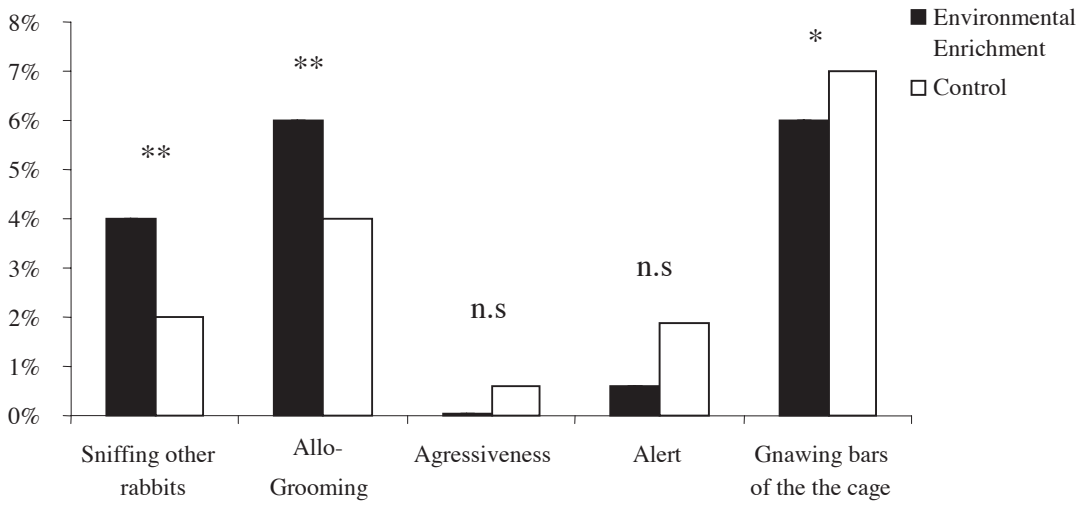

Figure 3: Behaviour of rabbits with and without environmental enrichment. (Average values - % of total scans) (Experiment 4).

most common behavioural abnormalities in cage systems (Gunn and Morton, 1995; Laboratory Animals, 1993; Love, 1994). This last result is surprising as studies using different kind of environmental enrichment reported significant decrement of these kinds of behaviours (Lidfors, 1997; Jordan *et al.*, 2003).

Contrary to experiment 3, in experiment 4 the environmental enrichment affected the behaviour (but not the rabbits' performance). It significantly increased social activities, such as sniffing the other rabbit and allo-grooming. On the contrary, it decreased the behaviour of gnawing the bars of the cage, which may be an oral stereotypy, as well a trend was found to decreased alert and aggressive behaviours. The growth and carcass traits were not statistically significantly affected by environmental enrichment in agreement with other previous results (Luzi *et al.*, 2002). These results support that environmental enrichment and housing have no effect on the production of the rabbits.

CONCLUSIONS

Based on our results the following suggestions can be made:

a) Unsuitable for gnawing stick: Black elder, European larch, European white birch tree, White mulberry and Common oak.

b) Suitable for environment enrichment: Black poplar and White locust tree.

c) Suitable for gnawing stick: White willow, White buckeye, Little-leaf linden and Norway spruce.

d) Our results can be utilised in further experiments connected with the gnawing stick application and determining the suitable tree species.

Housing and environmental enrichment did not affect significantly the growth rate contrary to some rabbit behaviours. However in this case the results are not always consistent. In fact in experiment 3 the addition of wooden stick as environmental enrichment did not decrease wire and feeder biting, which is one of the most common behavioural abnormalities in cage systems. The type of wood significantly influenced only the duration of feed eating. On the contrary, in experiment 4 environmental enrichment significantly decreased gnawing the bars of the cage and increased some social behaviours, such as sniffing the other rabbit and allo-grooming. A trend was shown also to reduced, alert and aggressive behaviours. Thus further research is needed in order to understand how environmental enrichement may affect rabbits' behaviour, possibly reducing oral stereotypies and increasing the behavioural repertoire.

REFERENCES

Čermak M. 1998. Tehnologija lesa 1. Ž *elezniki, Pami*. 205.

Gunn D., Morton D.B. 1995. Inventory of the behaviour of New Zealand White rabbits in laboratory cages. *Appl. Animal Behaviour Science,* 45, 277-292.

Hansen L.H., Berthelsen H. 2000. The effect of environmental enrichment on the behaviour of caged rabbits (*Oryctolagus Cuniculus*). *Appl. Animal Behaviour Science*, 68, 163-178.

Huls W.L., Brooks D.L., Bean-Knudsen D. 1991. Response of adult New Zealand White rabbits to enrichment objects and paired housing. *Lab. Anim. Sci.*, 41, 609-612.

Jordan D., Štuhec I., Pečlin G., Gorjanc G. 2003. The influence of environmental enrichment on the behaviour of fattening rabbits housed in individual wire cages. *13. Arbeitstagung über Haltung und Krankheiten der Kaninchen, Peltztiere und Heimtiere, Celle, 14.-15. Mai,* 119-126.

Kovács I. 1979. Wood properties, *Mezőgazdasági Kiadó, Budapest*

Laboratory Animals. Refinements in rabbit husbandry. Second report of the BVAAWF/RSPCA/UFAW Joint working group on refinement. *Lab. Anim.*, 27(1993), 301-329.

Lidfors L. 1997. Behavioural effects of environmental enrichment for individually caged rabbits. *Appl. Animal Behaviour Science*, 52, 157-169.

Love J.A. 1994. Group housing: Meeting the physical and social needs of the laboratory rabbit. *Lab. Anim. Sci.*, 44, 5-11.

Luzi F., Ferrante V., Heinzl E., Verga M., 2003. Effect of environmental enrichment on productive performance and welfare aspects in fattening rabbits. *Italian J. Animal Science, 2: Suppl. 1*, 438-440.

Martin P., Bateson P. 1993. Measuring behavior: an introductory guide. *2° Ed., Cambridge*.

Metz J.H.M. 1987. Behavioural problems of rabbits in cages. In: *Agriculture: Rabbit production systems including welfare (Ed.: Auxilia, T.), Luxemburg, Commission of the European Communities,* 221-230.

Pipa R. 1990. Anatomija in tehnologija lesa. *Tehnologija tvoriv. Ljubljana, Zveza inženirjev in tehnikov gozdarstva in lesarstva, Lesarska Založba,* 136 p.

Princz Z., Szendrő Zs., Dalle Zotte A., Radnai I., Biró-Németh E., Metzger Sz., Gyovai M., Orova Z. 2005. Effect of different housing on productive traits and on some behaviour patterns of growing rabbits; In Proc.: *17th Hungarian Conference on Rabbit Production, Kaposvár,* 95-102.

SAS. 2001. SAS/STAT. User's guide. (Release 8.02). SAS Institute Inc., Cary, NC, USA.

SPSS for Windows 1999. Version 10.0, Copyright SPSS Inc.

Todeschini R., 1998. Introduzione alla Chemiometria. EdiSES, Napoli, Italia.

Verga M., Zingarelli I., Heinzl E., Ferrante V., Martino P.A., Luzi F. 2004. Effect of housing and environmental enrichment on performance and behaviour in fattening rabbits. In Proc.: *8th World Rabbit Congress, Puebla City*, 1283-1288.