COBISS: 1.01
Agris category code: L01

THE BEHAVIOUR OF INDIVIDUALLY HOUSED GROWING RABBITS AND THE INFLUENCE OF GNAWING STICKS AS ENVIRONMENTAL ENRICHMENT ON DAILY RHYTHM OF BEHAVIOURAL PATTERNS DURATION [1]

Dušanka JORDAN [2], Gregor GORJANC [3], Ajda KERMAUNER [4], Ivan ŠTUHEC [5]

Delo je prispelo 13. oktobra 2010, sprejeto 21. decembra 2010.
Received October 13, 2010; accepted December 21, 2010.

The behaviour of individually housed growing rabbits and the influence of gnawing sticks as environmental enrichment on daily rhythm of behavioural patterns duration

The aim of our study was to examine average duration and frequency of behaviour of growing rabbits and possible influence of gnawing sticks as environmental enrichment on their daily rhythm of behavioural patterns duration. For this purpose 16 males of Slovenian sire line SIKA for meat production were recorded 24 hours per day, between 45 and 48, 58 and 61, 72 and 75, and 86 and 89 days age of rabbits. Animals were housed individually in wire-mesh cages equipped with a feeder and a nipple drinker. Half of the cages were enriched with wooden sticks of Norway spruce (*Picea abies*). Animals had free access to the feed and water; the daily duration of lighting was 12 hours. Rabbits spent a major proportion of time resting (59.03%). They were lying most of the time in abdominal (38.84%) and abdominal – lateral position (18.05%). The most common active behavioural patterns were body care (sum of grooming and scratching; 20.16%), feeding (10.25%) and sniffing (4.60%). Rabbits changed their behaviour on average 53.55-times, from three to 197-times per hour. The difference in daily rhythm of individual behavioural pattern duration between rabbits in enriched and control cages was mostly expressed around the time lights were turned on or off.

Key words: growing rabbits / individual cages / animal behaviour / ethology / daily rhythms / environmental enrichment

Obnašanje individualno uhlevljenih pitovnih kuncev ter vpliv obogatitve okolja z lesom za glodanje na dnevni ritem trajanja posameznih oblik obnašanja

Proučevali smo povprečno trajanje in pogostost posameznih oblik obnašanja pri pitovnih kuncih ter možen vpliv obogatitve okolja z letvijo za glodanje na njihov dnevni ritem trajanja posameznih oblik obnašanja. V ta namen smo po 24 ur snemali 16 samcev slovenske mesne linije SIKA (očetovska linija) med 45. in 48., 58. in 61., 72. in 75. ter 86. in 89. dnem starosti. Kunci so bili uhlevljeni individualno v žičnih kletkah, opremljenih s krmilnikom na zalogo in kapljičnim napajalnikom. V polovico kletk smo kot obogatitev okolja namestili letev iz smrekovega lesa (*Picea abies*). Živali so imele krmo in vodo na razpolago po volji, trajanje osvetlitve je bilo 12 ur. Kunci so največ časa namenili mirovanju (59,03 %). Najdlje so ležali v trebušni (38,84 %) in trebušno-stranski legi (18,05 %). Od aktivnih oblik obnašanja so bile najbolj zastopane nega telesa (20,16 %), zauživanje krme (10,25 %) ter ovohavanje (4,60 %). Kunci so na uro obnašanje spremenili od tri do 197-krat, v povprečju pa 53,55-krat. Razlika v dnevnem ritmu trajanja posameznih oblik obnašanja med kunci z letvijo in brez nje se je običajno pokazala v urah pred nastopom svetlega oziroma temnega dela dneva in po njem.

Ključne besede: pitovni kunci / individualna uhlevitev / obnašanje živali / etologija / dnevni ritmi / obogatitev okolja

1 This article is part of a M.Sc. thesis entitled "Effect of gnawing wood as environmental enrichment on ethological, production and carcass traits of individually housed rabbits", issued by Dušanka Jordan, supervisor Prof. Ivan Štuhec, Ph.D. / Prispevek je del magistrskega dela Dušanke Jordan z naslovom »Vpliv obogatitve okolja z lesom za glodanje na etološke, pitovne in klavne lastnosti individualno uhlevljenih kuncev«, mentor prof. dr. Ivan Štuhec

2 Univ. of Ljubljana, Biotechnical Fac., Dept. of Animal Science, Groblje 3, SI-1230 Domžale, Slovenia, Assist., Ph.D., e-mail: dusanka.jordan@bf.uni-lj.si
3 Same address as 2, Assist., Ph.D.
4 Same address as 2, Lecturer, M.Sc.
5 Same address as 2, Prof., Ph.D.

1 INTRODUCTION

In intensive production systems rabbits are conventionally kept in wire-mesh cages without bedding, equipped only with a feeder and nipple drinkers (EFSA-AHAW Panel, 2005; McNitt *et al.*, 2000). Such systems represent a barren, unstructured and stimulus-poor environment where animals are additionally confronted with limited floor area (EFSA-AHAW Panel, 2005; Verga, 2000). Animal needs and welfare are neglected to a large extent (Baumans, 2005), the expression of numerous behavioural patterns animals are highly motivated to perform is thwarted (Gunn-Dore, 1997; Lehmann, 1987). Inability of full expression of the behavioural repertoire, which is in spite of years of domestication very similar to the behavioural repertoire of its wild counterpart (Kraft, 1979a, 1979b; Mykytowycz and Rowley, 1958), contributes to increased inactivity (Huls *et al.*, 1991; Morton *et al.*, 1993) and it may also result in stress expressed as restlessness with more frequent changes of their behaviour (Lehmann, 1987). As a sign of suffering, frustration, fear or even boredom they may also develop various abnormal kinds of behaviour (Baumans, 2005; Lehmann, 1987; Wemelsfelder, 1994), such as bar biting, excessive grooming, nose sliding etc. (Gunn and Morton, 1995; Morton *et al.*, 1993). The mentioned problems can be alleviated with appropriate environmental enrichment (e.g. Jordan *et al.*, 2003; Princz *et al.*, 2008; Verga *et al.*, 2005). There are numerous ways of how to enrich animal environment (e.g. enlargement of available floor area, establishment of suitable structure of the enclosure, provision of objects for manipulation, different kind of auditory, visual, olfactory and tactile stimuli). However, environmental enrichment that animals tend to be highly motivated to make use of is nutritional enrichment (Baumans, 2005). This is understandable if we consider the amount of time and effort animals in nature put into searching and handling their feed. In intensive production systems the situation is just the opposite. Feed is always dispensed in the same location and animals are usually fed with a single complete feed mixture offering no heterogeneity and possibility to choose (Newberry, 1995). Rabbits have a great need for gnawing wood (Grün, 2002), which in semi-natural enclosure they satisfy with gnawing roots and branches (Stauffacher, 1992). Therefore, sticks of soft wood could be an effective way to enrich their environment (Baumans, 2005).

Studying animal behaviour, which is one of the main welfare indicators, and determination of possible deviations from the species-specific behaviour, is important in order to evaluate animal welfare. Therefore, the aim of our study was to determine basic behavioural parameters (duration, frequency) of individually housed growing rabbits. Additionally, because we found almost no influence of wooden sticks as environmental enrichment on average duration or frequency of certain behavioural pattern in growing rabbits housed individually in wire-mesh cages – gnawing sticks influenced only the duration of feeding (Jordan *et al.*, 2008), a question arose whether the influence of wooden sticks on the behaviour of individually housed growing rabbits would come to a greater expression if observed on the some parts of daily rhythm.

2 MATERIAL AND METHODS

2.1 ANIMALS AND HOUSING

Rabbit behaviour was studied in 16 males of Slovenian sire line SIKA for meat production. Animals were weaned at the 35 days of age and housed individually at the age of 44 days in the upper tier of two tier wire-mesh cages measuring 40 × 37.5 × 30 cm equipped with a feeder and a nipple drinker. Half of the cages (experimental treatment) were enriched with wooden sticks for gnawing (dimension 2.2 × 50 × 4.4 cm) made of Norway spruce (*Picea abies*), firmly fixed horizontally under the ceiling of the cage. The other half of the cages were not provided with wooden sticks (control treatment). Placement of the experimental and the control cages within rabbitry was randomised.

Water and food were available ad libitum. Animals were fed once a day, usually between 8–9 a.m., with pelleted complete feed mixture for growing rabbits (10.4 MJ DE/kg, 17% crude protein, 14% crude fibre and 2% fat). Throughout the trial the ambient temperature in rabbitry varied from 11 to 18 °C and the relative humidity between 25 and 50%. The rabbitry had two partially shaded windows. To standardize the length and intensity (148 lx) of lighting throughout the trial period, two cool white fluorescent tubes OSRAM L 58W/20 were on between 6 a.m. and 6 p.m..

During the trial four rabbits died; three in cages with and one in a cage without a wooden stick. Those dead animals were not included in the statistical analysis; therefore the analysis of behaviour included 12 rabbits.

2.2 BEHAVIOURAL OBSERVATIONS

Rabbit behaviour was recorded by infrared video camera (WV-BP330/Panasonic) 24 hours a day. The camera was placed on the rabbitry ceiling above the cages, together with a LED infrared reflector (WFC-I/LED-60W, λ = 800 nm), which automatically turned on when the lights were switched off and turned off when the

lights were switched on. Four animals could be captured simultaneously, so four recording days were needed to complete one observation day for all 16 rabbits. During the trial four observation days were carried out between 45 and 48, 58 and 61, 72 and 75, and 86 and 89 days of rabbits' age.

Video recordings were analysed with »Observer 4.1« software (Noldus Information Technology, Wageningen), where the start and the end of individual behavioural pattern was continuously registered for each rabbit. All behavioural patterns were mutually exclusive. This recording method enabled to obtain precise duration and frequency of individual behavioural pattern. The following behavioural patterns were recorded:

- Resting, where we distinguished four variations according to the adopted body posture of a rabbit:
  - Resting – abdominal posture: resting with the belly on the ground, hind limbs tucked under the body and forelimbs either tucked beneath the body or stretched forward and the head in an upright position.
  - Resting – abdominal-lateral posture: the same as resting in abdominal posture but with the hind limbs more or less stretched away from the body and with the head usually in upright position.
  - Resting – lateral posture: resting on the side with all four legs stretched away from the body and the head lying on the ground.
  - Resting – other: usually appeared as a transition from one behavioural pattern to another. In this posture rabbits were either sitting or standing.
- Body care, where the following behavioural patterns were separately recorded:
  - Grooming: licking and nibbling the fur, washing face with forelimbs, licking ears held in front of the snout with forelimbs.
  - Scratching: the hind feet were used to scratch the body, neck, face, ears. Scratching was usually followed by licking the end of the foot used for scratching (lasting a few moments).
- Stretching, where two variations were recorded:
  - Rabbit stretching: rabbits extended the front paws forwards with the front part of the body lying on the floor and then they pushed the hind part backwards with the head often tipped back. Stretching occurred also in the opposite direction, where the whole body was pushed forward and up with the hind legs stretching backwards.
  - Cat-like stretching: rabbits arched the back as a stretching cat does.
- Feeding: rabbits stood next to the feeder, taking out pellets and chewing them.
- Drinking: consumption of water from the nipple drinker.
- Wood gnawing: nibbling or gnawing a wooden stick.
- Caecotrophy: rabbits bowed down, pushed the head between hind legs and ingested caecotrophs directly from anus, then raised head and chewed intensively for a few moments.
- Sniffing: rabbits sniffed the air or the cage itself (walls, floor, feeder etc.)
- Rearing up: sitting on the hind legs with body in an upright position.
- Jumping: rapid jumping in the cage or circling. Rabbits often turned for 180° with only one jump.
- Contact with the neighbour rabbit, where we distinguished between:
  - Contact with the neighbour rabbit – one-sided: rabbit sniffed his neighbour who did not show any response to it.
  - Contact with the neighbour rabbit – two-sided: the observed rabbit and his neighbour touched each other with their snouts.
- Biting parts of the cage: depending on the part of the cage rabbits bit, nibble or pull, we recorded biting of wire, feeder and nipple drinker.
- Behavioural changes: transition from one behavioural pattern to another or at resting a change of body posture or position in the cage.

2.3 STATISTICAL ANALYSIS

For the purpose of statistical analysis some of the behavioural patterns were aggregated due to low frequency:

- Resting – together included: resting – abdominal posture, resting – abdominal-lateral posture, resting – lateral posture, and resting – other.
- Body care included grooming and scratching.
- Stretching included rabbit and cat-like stretching.
- Contacts with the neighbour rabbit included: one-sided and two-sided contacts with the neighbour rabbit.
- Activity represents a sum of all behavioural patterns except resting.

Collected data (the duration of behavioural patterns) generally did not follow the normal (Gaussian) distribution. Therefore, we postulated binomial distribution and fitted models in the context of Generalized Linear Models (McCullagh and Nelder, 1989). Statistical model included the following factors: treatment, observation hour, interaction of treatment and observation hour, observer, individual rabbit and rabbit's age as inde-

pendent variable. Bayesian approach with "non-informative" prior distributions for all parameters in the model (e.g. Gelman *et al.*, 2004; Gelman and Hill, 2006) using MCMC methods was used for the estimation and inference. All calculations were performed with R (R Development Core Team, 2005) and BUGS software (Spiegelhalter *et al.*, 2003; Sturtz *et al.*, 2005).

3 RESULTS AND DISCUSSION

3.1 BEHAVIOUR

High standard deviations and large differences between minimum and maximum values in duration (Table 1) and Frequency (Table 2) of recorded behavioural patterns show there is a great variability between individual hours of the day, which is seen also in presented daily rhythms (Fig. 1–4).

3.1.1 RESTING

Rabbits were active 40.97% of time (Table 1), the rest of the day they spent resting (59.03%). These results confirmed findings of previous studies, where growing rabbits were housed in wire-mesh cages either individually (Jordan *et al.*, 2004, 2005; Pečlin, 2002; Štuhec *et al.*, 2005) or in groups (Dal Bosco *et al.*, 2002; Metz, 1987; Morisse and Maurice, 1997; Morisse *et al.*, 1999). They

Table 1: *Descriptive statistics for duration of individual behavioural pattern expressed as percentage of used time (data were calculated from hourly values)*
Preglednica 1: *Opisna statistika trajanja posameznih oblik obnašanja izraženih v odstotku porabljenega časa (podatki so izračunani iz urnih vrednosti)*

Behavioural pattern	Average	Standard deviation	Minimum	Maximum
Resting				
Resting – abdominal posture	38.84	27.34	0	99.79
Resting – abdominal-lateral posture	18.05	17.85	0	85.18
Resting – lateral posture	0.74	4.10	0	78.79
Resting – other	1.41	3.23	0	70.03
Resting – together	59.03	21.66	1.32	100.00
Activity	40.97	21.66	0	98.68
Comfort behaviour				
Grooming	19.40	11.62	0	63.23
Scratching	0.76	0.66	0	8.40
Body care	20.16	11.81	0	64.74
Stretching	0.16	0.21	0	1.59
Feeding, drinking and wood gnawing				
Feeding	10.25	9.32	0	42.22
Drinking	2.10	2.21	0	12.42
Wood gnawing	0.27	1.18	0	12.57
Caecotrophy	1.94	3.35	0	23.90
Exploratory behaviour				
Sniffing	4.60	4.92	0	43.75
Rearing up	0.03	0.17	0	3.56
Locomotion				
Jumping	0.15	0.53	0	5.56
Social behaviour				
Contact with the neighbour rabbit	0.10	0.38	0	7.22
Abnormal behaviours				
Biting parts of the cage	1.37	3.12	0	26.88

Table 2: *Descriptive statistics for frequency of individual behavioural patterns expressed as a number of repetitions per hour*
Preglednica 2: *Opisna statistika pogostosti izvajanja posameznih oblik obnašanja izraženih v številu ponovitev na uro*

Behavioural pattern	Average value	Standard deviation	Minimum	Maximum
Resting				
Resting – abdominal posture	4.71	3.16	0	26
Resting – abdominal-lateral posture	2.29	2.39	0	16
Resting – lateral posture	0.13	0.44	0	5
Resting – other	2.95	4.29	0	40
Resting – together	10.07	5.50	1	44
Activity	43.48	27.77	0	173
Comfort behaviour				
Grooming	14.77	8.03	0	49
Scratching	6.11	4.34	0	28
Body care	20.89	11.48	0	77
Stretching	0.98	1.17	0	8
Feeding, drinking and wood gnawing				
Feeding	2.83	2.74	0	22
Drinking	2.30	3.12	0	34
Wood gnawing	0.41	1.16	0	8
Caecotrophy	1.71	2.36	0	15
Exploratory behaviour				
Sniffing	11.20	9.62	0	63
Rearing up	0.08	0.39	0	6
Locomotion				
Jumping	1.03	3.31	0	28
Social behaviour				
Contact with the neighbour rabbit	0.46	1.21	0	10
Abnormal behaviours				
Biting parts of the cage	1.83	3.47	0	32
Behavioural changes	53.55	30.00	3	197

rested during the light as well as the dark period of the day (Fig. 1a), and as reported by several authors (Pečlin, 2002; Podberscek *et al.*, 1991; Turk, 2004) the highest values were observed around noon and the lowest values in the morning around the time lights were turned on and in the evening around the time lights were turned off. Rabbits were mostly lying in abdominal (38.84%) and abdominal-lateral (18.05%) posture (Table 1). That is why the identity of daily rhythms resting – together (Fig. 1a) and resting in abdominal posture (Fig. 1b) is not surprising. In abdominal-lateral posture (Fig. 1c) rested rabbits mostly in the afternoon and in the first half of the night when they spent less time in the abdominal posture. Resting, regardless the posture, was observed 10.07 times per hour (Table 2), which is comparable with our previous findings (Jordan *et al.*, 2004).

3.1.2 COMFORT BEHAVIOUR

Comfort behaviour includes body care (sum of grooming and scratching) and stretching. In our study the major part of body care represented grooming (19.40%), while scratching was observed only in 0.76% of time. Body care presented the most common active behavioural pattern (20.16%, Table 1), which rabbits performed more than 20 times per hour (Table 2). Metz (1987) and Jordan *et al.* (2004) reported for about 3 to 4% lower values in duration, while observed frequency sup-

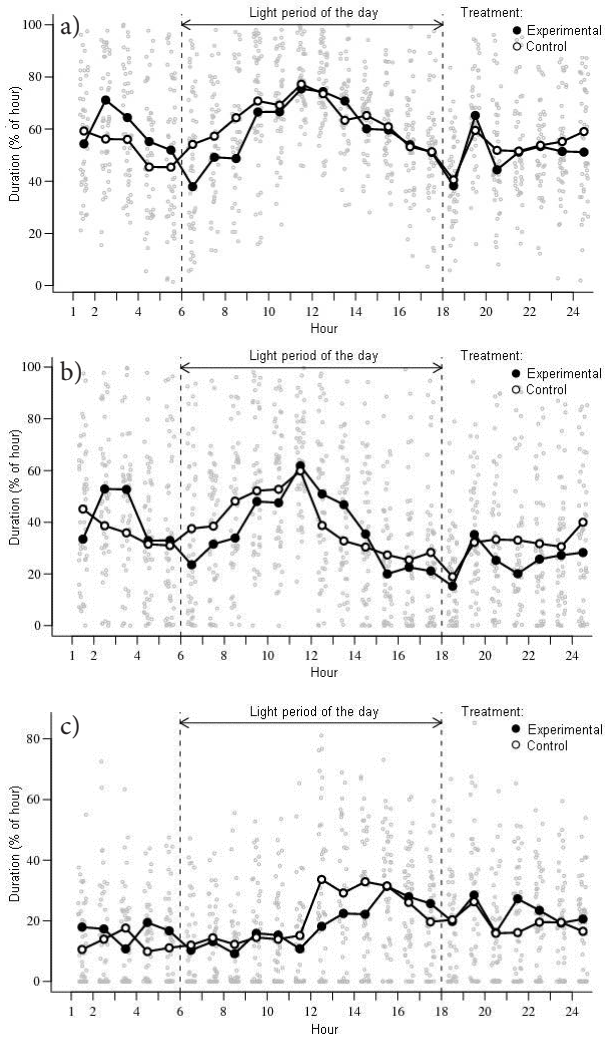

Figure 1: *Daily rhythm of resting - together (a), resting – abdominal posture (b) and resting – abdominal-lateral posture (c) duration per hour by treatment (lines with dots) and raw data (dots)*
Slika 1: *Dnevni ritem trajanja mirovanja – skupaj (a), mirovanja – trebušna lega (b) in mirovanja – trebušno-stranska lega (c) po skupinah (črte s točkami) in surovi podatki (točke)*

ported our earlier findings (Jordan *et al.*, 2004). As previously described by Turk (2004) and Gunn and Morton (1995) rabbits in our study too devoted to body care the largest percentage of time in the hours before and after lights were turned on and the least around noon (Fig. 2a). This presents practically a mirror image of resting – together daily rhythm (Fig. 1a). Daily rhythm of grooming (Fig. 2b) corresponded to body care daily rhythm, while scratching was more or less equally distributed throughout the 24 hours (Fig. 2c). The stretching was observed only 0.16% of time (Table 1) and 0.98 times per hour (Table 2). This is even less than recorded in our previous study (1.43–1.88 times per hour, 0.25%) (Jordan *et al.*, 2004) or reported by Metz (1987) (0.50%). According to the findings of Podberscek *et al.* (1991) rabbits spent more time stretching (Fig. 2d) in the afternoon, when they became more active (Fig. 1a, Fig. 4d).

3.1.3 FEED AND WATER CONSUMPTION

Rabbits spent 10.25% of time feeding pellets and around 2% of time drinking (Table 1). These findings are comparable with the results of Postollec *et al.* (2006), who reported that group housed growing rabbits spent for feeding and drinking together 12.3% of time. On the contrary, several other authors (Dal Bosco *et al.*, 2002; Hoy, 1999; Morisse *et al.*, 1999) reported greater values (12–19%) for the sum of time spent feeding and drinking. Because of specific characteristics of their digestive tract, rabbits have to consume feed frequently and in small amounts (Grün, 2002). This was demonstrated also in our study, where we recorded feeding 2.83 times per hour and drinking 2.30 times per hour (Table 2). These results are comparable with our previous findings (Jordan *et al.*, 2004) and findings of Hoy (1999). Rabbits consumed feed (Fig. 3a) and water (Fig. 3b) throughout the day, but mostly in the hours before and after the lights were turned off. This results support earlier findings of several authors (Gunn and Morton, 1995; Lebas *et al.*, 1997; Podberscek *et al.*, 1991), at least regarding the daily rhythm of feeding.

3.1.4 CAECOTROPHY

Caecotrophy was observed 1.71 times per hour (Table 2) and occupied rabbits for 1.94% of observation time (Table 1), which is similar to results observed in our previous study (2.31%) (Jordan *et al.*, 2004). Rabbits spent the greatest amount of time for caecotrophy in the hours before and after the lights were turned on (Fig. 3d). Similar daily rhythm was described by Turk (2004). This was expected because daily rhythm of caecotrophy is regulated by feeding, which is primarily influenced by the light regime. In rabbits fed ad libitum caecotrophy usually starts eight to 12 hours after the peak in feeding (Lebas *et al.*, 1997), which was observed also in our study. According to the findings of Jilge (1979), caecotrophy started 45 minutes after lights were turned on and this was also demonstrated in our study with the peak in the first hour of the light period.

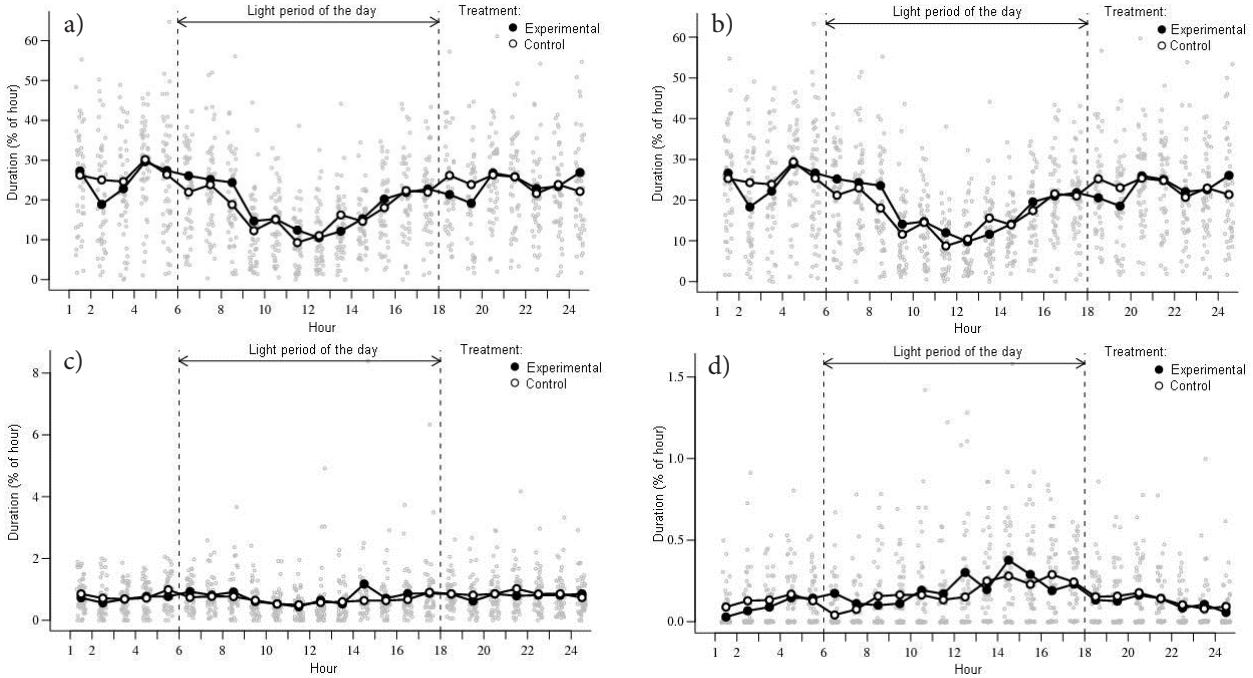

Figure 2: *Daily rhythm of body care (a), grooming (b), scratching (c) and stretching (d) duration per hour by treatment (lines with dots) and raw data (dots)*
Slika 2: *Dnevni ritem nege telesa - skupaj (a), nege telesa - lizanje (b), nege telesa - praskanje (c) in pretegovanja (d) po skupinah (črte s točkami) in surovi podatki (točke)*

3.1.5 EXPLORATORY BEHAVIOUR

3.1.5.1 Sniffing

Rabbits explored their environment with sniffing the air or cage itself 11.20 times per hour (Table 2) and for 4.6% of time (Table 1). In our previous study (Jordan *et al.*, 2004), sniffing was noticed more often (around 15 times per hour) and in a greater extent (9.6%). Sniffing was mostly observed at the start of the light and at the start of the dark period (Fig. 4a), which to a large extend corresponds to findings of Turk (2004) and Štuhec *et al.* (2005).

3.1.5.2 Rearing up

Behavioural patterns such as rearing up and contact with the neighbour rabbit (daily rhythms are not shown) were performed very seldom throughout the day. Rearing up was behavioural pattern rabbits performed the least often (0.08 times per hour, Table 2) and devoted the least of observed time (0.03%) (Table 1). Reason for this is probably inadequate cage height (Gunn and Morton, 1995; Martrenchar *et al.*, 2001), which prevent rabbits to take this position. Adult New Zealand White rabbit needs for rearing up at least 75 cm (Morton *et al.*, 1993), while in our study the cage height was only 30 cm.

3.1.6 LOCOMOTION

Although hopping and jumping are the basic rabbit movements (Kraft, 1979a), rabbits in our study spent only 0.15% of time jumping (Table 1) and were observed to jump only around once per hour (Table 2). This is in accordance with our previous study (Jordan *et al.*, 2004), while Metz (1987) in group hosed growing rabbits reported a bit greater percentage (0.4%). Rabbits were jumping mostly after the lights were turned on, while in the other parts of the day this behavioural pattern was hardly ever noticed (Fig. 4b). Similar daily rhythm of jumping was described also by Turk (2004), while Podberscek *et al.* (1991) reported that hopping in adult rabbits housed in cages appears most often early and late in the day. In conventional wire-mesh cages, performance of jumping and hopping is restricted to a large extent due to the lack of space. In spite of this, rabbits do not give up entirely in their attempts to hop and jump although the frequency of these behavioural patterns is not very high due to a limited floor area (Lehmann, 1987). This has shown also in our study.

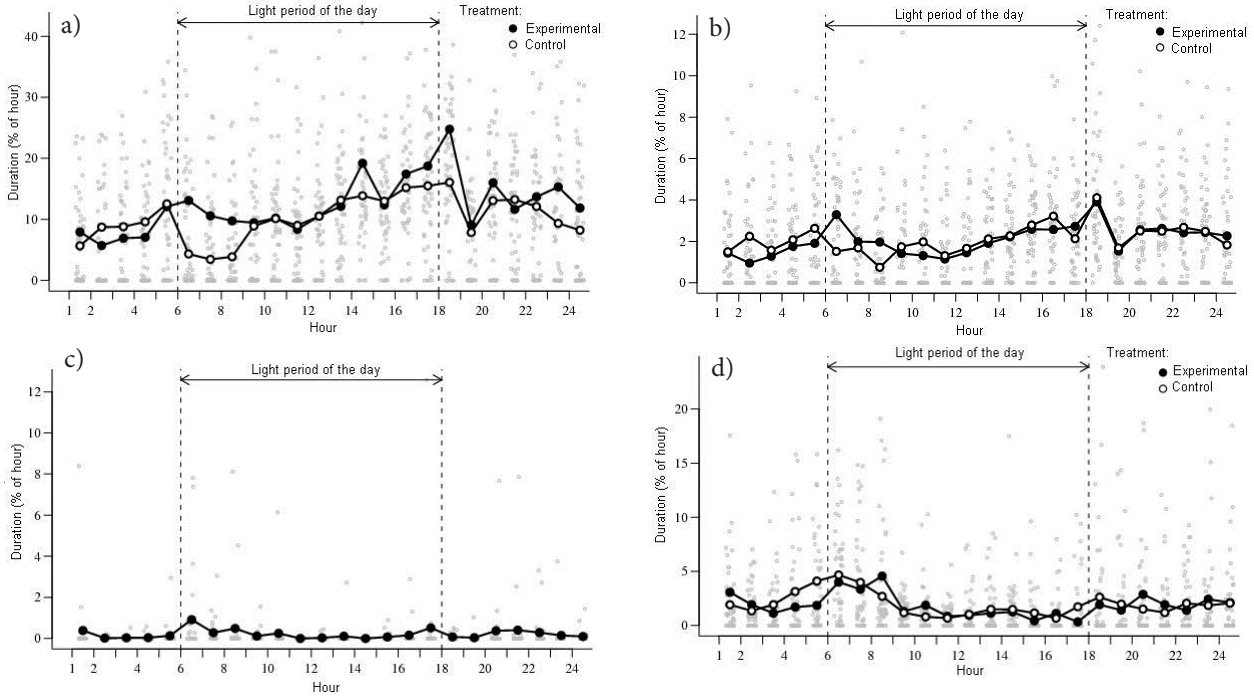

Figure 3: *Daily rhythm of feeding (a), drinking (b), wood gnawing (c) and caecotrophy (d) duration per hour by treatment (lines with dots) and raw data (dots)*
Slika 3: *Dnevni ritem trajanja zauživanja krme (a), pitja (b), glodanja letve (c) in cekotrofije po skupinah (črte s točkami) in surovi podatki (točke)*

3.1.7 SOCIAL BEHAVIOUR

Contacts with the neighbour rabbit were in our study recorded only 0.46 times per hour (Table 2), which corresponds to 0.1% of observation time (Table 1). This is rather surprising because rabbits are social beings, spending as much time in contact with each other as possible (Boers *et al.*, 2002; Brooks *et al.*, 1993; Huls *et al.*, 1991). However, we did not record time rabbits spent e.g. resting next to each other as contact with the neighbour rabbit. In our previous study (Jordan *et al.*, 2004), duration and frequency of contacts with the neighbour rabbit were a bit higher (0.93 – 1.31 times per hour, 0.26%).

3.1.8 ABNORMAL BEHAVIOUR

Biting parts of the cage is one of the most common behavioural abnormalities in rabbits in cage systems (Gunn and Morton, 1995; Morton *et al.*, 1993). In our study, rabbits spent biting parts of their cage 1.37% of observation time (Table 1) and have been observed to be engaged in this behavioural pattern almost two times per hour (Table 2). This is in accordance with our previous findings (Jordan *et al.*, 2004). Gunn and Morton (1995), who observed adult rabbits, reported even higher values (3.5%). Rabbits bit parts of the cage regardless of wooden sticks for gnawing were provided (Fig. 4c), which corresponds to the results of Stauffacher (1992). Biting parts of the cage was observed throughout 24 hours with a well-marked peak after the lights were turned on (Fig. 4c), which is comparable to the findings of Turk (2004).

Rabbits changed their behaviour from three to 197 times per hour and on average 53.55 times (Table 2), with well expressed peaks after the lights were turned on and off (Fig. 4d). Frequent behavioural changes and changes in posture and position during resting indicate that rabbits were restless and they were showing displacement activities. Lehmann (1987) suggested that frequent changes of behaviour indicate poor welfare and that rabbits were under stress. However, if increased activity occurs during a period when higher activity is normally expected, more frequent behavioural changes can not be considered as a relevant indicator of poor animal welfare.

3.2 THE INFLUENCE OF ENVIRONMENTAL ENRICHMENT

In our study, most of the rabbits had almost no interest in Norway spruce gnawing sticks despite the fact that in previous studies (Brooks *et al.*, 1993; Huls *et al.*,

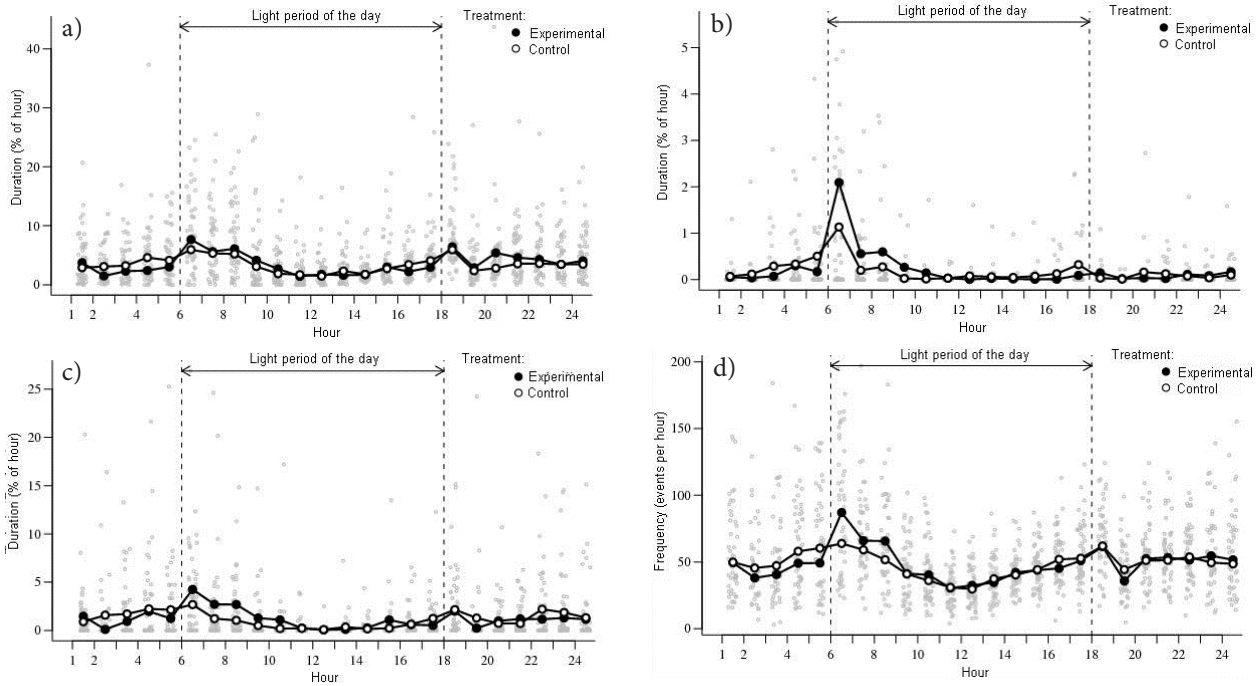

Figure 4: *Daily rhythm of sniffing (a), jumping (b), biting parts of the cage (c) duration and number of behavioural changes (d) per hour by treatment (lines with dots) and raw data (dots)*
Slika 4: *Dnevni ritem trajanja ovohavanja (a), skakanja (b), grizenja delov kletke (c) ter število sprememb v obnašanju (d) po skupinah (črte s točkami) in surovi podatki (točke)*

1991; Jordan *et al.*, 2004) they showed the greatest interest in the wood of *Pinaceae*. We hardly ever noticed them gnawing (Fig. 3c), except in the hour after the lights were turned on and before the lights were turned off. We recorded similar values as in our previous study (Jordan *et al.*, 2004): they gnawed only 0.41 times per hour (Table 2), which corresponded to 0.27% of the observed time (Table 1). Low interest in gnawing is unusual regarding the assumed great need of rabbits for gnawing (Grün, 2002) and findings that when kept in semi-natural conditions they gnaw branches and roots (Stauffacher, 1992). However, Berthelsen and Hansen (1999) and Jordan *et al.* (2004) also reported low interest of individually housed rabbits in gnawing wood. In our study, rabbits' lack of interest could not have been caused by the type of wood. The possible reason for rabbits' low interest in gnawing sticks might lie in the fact that sticks were constantly present. Under these conditions, they lost their effect of novelty, which is an important aspect of environmental enrichment (Johnson *et al.*, 2003).

In our previous study (Jordan *et al.*, 2008), we tested the effect of gnawing sticks as environmental enrichment on the level of whole-day observation. The only significant difference between the experimental and control group was observed in duration of feeding, with rabbits in enriched cages feeding significantly longer (2.08 ± 0.87%) compared to the rabbits in unenriched cages. However, if we examine daily rhythm of individual behavioural pattern duration, a difference between rabbits with and without gnawing sticks can be noticed in almost all observed behavioural patterns. This difference is of course not observed between average daily values, but only in certain parts of the day. In most of the observed behavioural patterns, i.e. resting regardless of the body posture, body care, grooming, stretching, feeding, drinking, caecotrophy, sniffing, jumping, biting parts of the cage and the number of behavioural changes, the difference in daily rhythm was observed in the hours before and after the lights were turned on. For body care, grooming and feeding the difference was observed also in the hours around the time lights were turned off. It seems that although the interest of rabbits in wooden sticks was low as inferred from the low frequency and duration of gnawing the wooden stick, it had an effect on the behaviour of growing rabbits. In general, gnawing sticks tended to decrease rabbits' activity in the hours before the lights were turned on and increase it after the lights were turned on (Fig. 1a, 4d).

4 CONCLUSIONS

Our study provides a basic data of individual behavioural pattern frequency, duration and the daily rhythm in male growing rabbits housed individually in wire-mesh cages. Our study also shows that the effect of environmental enrichment might not be evident on the level of whole-day observation (see Jordan *et al.*, 2008), but is revealed in daily rhythm. According to our results, it seems that the effect of Norway spruce gnawing sticks was mostly expressed in the period of high activity around the time lights were turned on or off.

5 REFERENCES

Baumans V. 2005. Environmental enrichment for laboratory rodents and rabbits: requirements of rodents, rabbits, and research. ILAR Journal, 46, 2: 162–170

Berthelsen H., Hansen L.T. 1999. The effect of hay on the behaviour of caged rabbits (*Oryctolagus cuniculus*). Animal Welfare, 8: 149–157

Boers K., Gray G., Love J., Mahmutovic Z., McCormick S., Turcotte N., Zhang Y. 2002. Comfortable quarters for rabbits in research institutions. In: Comfortable quarters for laboratory animals. Reinhardt V., Reinhardt A. (eds.). Washington DC, Animal welfare institute: 43–49. http://www.awionline.org/pubs/cq02/Cq-rabbits.html (15 May 2006)

Brooks D.L., Huls W., Leamon C., Thomson J., Parker J., Twomey S. 1993. Cage enrichment for female New Zealand White rabbits. Laboratory Animals, 22: 30–35

Dal Bosco A., Castellini C., Mugnai C. 2002. Rearing rabbits on a wire net floor or straw litter: behaviour, growth and meat qualitative traits. Livestock Production Science, 75: 149–156

EFSA-AHAW Panel 2005. The impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. EFSA-Q-2004-023. pp. 135. Annex to the EFSA Journal, 267: 1–31. http://www.efsa.europa.eu/en/science/ahaw/ahaw_opinions/1174.html (15 Feb. 2008)

Gelman A., Carlin J.C., Stern H., Rubin D.B. 2004. Bayesian data analysis. Boca Raton, Chapman&Hall\CRC: 668 p.

Gelman A., Hill J. 2006. Data analysis using regression and multilevel/hierarchical models. New York, Cambridge University Press: 625 p.

Grün P. 2002. Reja kuncev. Ljubljana, Kmečki glas: 134 p.

Gunn-Dore D. 1997. Comfortable quarters for laboratory rabbits. In: Comfortable quarters for laboratory animals. Reinhardt V. (ed.). Washington DC, Animal Welfare Institute: 46–54. http://www.awionline.org/pubs/cq/five.pdf (15 May 2006)

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

Hoy S. 1999. Tierschutz berücksictigen. DGS Magazin, 1: 45–47

Huls W.L., Brooks D.L., Bean-Knudsen D. 1991. Response of adult New Zealand White rabbits to enrichment objects and paired housing. Laboratory Animal Science, 41, 6: 609–612

Jilge B. 1979. Zur circadianen Caecotrophie des Kaninchens. Zeitschrift für Versuchstierkunde (Journal of Experimental Animal Science), 21, 5: 302–312

Johnson C.A., Pallozzi W.A., Geiger L., Szumiloski J.L., Castiglia L., Dahl N.P., Destefano J.A., Pratt S.J., Hall S.J., Beare C.M., Gallagher M., Klein H.J. 2003. The effect of an environmental enrichment device on individually caged rabbits in a safety assessment facility. Contemporary Topics in Laboratory Animal Science, 42, 5: 27–30

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. In: 13th Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals, Celle, Germany, 14–15 May 2003. Gießen, Verlag der Deutschen Veterinärmedizinischen Gesellschaft e.V.: 119–126

Jordan D., Varga A., Kermauner A., Gorjanc G., Štuhec I. 2004. The influence of environmental enrichment with different kind of wood on some behavioural and fattening traits of rabbits housed in individual wire cages. In: 12th International Symposium Animal Science Days. Animal production according to Ecological, Ethological and Ethical Norms, Bled, Slovenija, 2–4 Sept. 2004. (*Acta agriculturae slovenica*, Supplement 1: 73–79)

Jordan D., Kermauner A., Štuhec I. 2005. Behaviour of individually housed fattening rabbits of different age during the light and dark period of the day. In: 14th Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals, Celle, Germany, 11–12 May 2005. Gießen, Verlag der Deutschen Veterinärmedizinischen Gesellschaft e.V.: 30–37

Jordan D., Gorjanc G., Štuhec I. 2008. Effect of gnawing wood as environmental enrichment on behaviour of individually housed growing rabbits. Archiv für Geflügelkunde, 72, 4: 181–187

Kraft R. 1979a. Vergleichende Verhaltensstudien an Wild- und Hauskaninchen: I. Das Verhaltensinventar von Wild- und Hauskaninchen. Zeitschrift für Tierzüchtung und Züchtungsbiologie, 95: 140–162

Kraft R. 1979b. Vergleichende Verhaltensstudien an Wild- und Hauskaninchen: II. Quantitative Beobachtungen zum Sozialverhalten. Zeitschrift für Tierzüchtung und Züchtungsbiologie, 95: 165–179

Lebas F., Coudert P., de Rochambeau H., Thebault R.G. 1997. The rabbit – husbandry, health, and production. Rome, Italy, FAO: 205 p. http://www.fao.org/docrep/t1690E/t1690E00.htm (12 June 2006)

Lehmann M. 1987. Interference of a restricted environment – as found in battery cages – with normal behaviour of young fattening rabbits. In: Agriculture. Rabbit production systems including welfare. A seminar in the Community programme for the coordination of agricultural research, 6–7 Nov. 1986. Auxilia T. (ed.). Luxembourg, Commission of the European Communities: 257–268

Martrenchar A., Boilletot E., Cotte J.P., Morisse J.P. 2001. Wire-floor pens as an alternative to metalic cages in fattening

rabbits: influence on some welfare traits. Animal Welfare, 10: 153–161

McCullagh P., Nelder J.A. 1989. Generalized Linear Models. Boca Raton, FL, Chapman and Hall/CRC

McNitt J.I., Patton N.M., Lukefahr S.D., Cheeke P.R. 2000. Rabbit production. Danville, Illinois, Interstate Publishers: 493 p.

Metz J.H.M. 1987. Behaviour problems of rabbits in cages. In: Agricuture. Rabbit production systems including welfare. A seminar in the Community programme for the coordination of agricultural research, 6–7 Nov. 1986. Auxilia T. (ed.). Luxembourg, Commission of the European Communities: 221–230

Morisse J.P., Maurice R. 1997. Influence of stocking density or group site on behaviour of fattening rabbits kept under intensive conditions. Applied Animal Behaviour Science, 54: 351–357

Morisse J.P., Boilletot E., Martrenchar A. 1999. Preference testing in intensively kept meat production rabbits for straw on wire grid floor. Applied Animal Behaviour Science, 64: 71–80

Morton D.B., Jennings M., Batchelor G.R., Bell D., Birke L., Davies K., Eveleigh J.R., Gunn D., Heath M., Howard B., Koder P., Phillips J., Poole T., Sainsbury A.W., Sales G.D., Smith D.J.A., Stauffacher M., Turner R.J. 1993. Refinements in rabbit husbandry. Second report of the BVAAWF/FRAME/RSPCA/UFAW joint working group on refinement. Laboratory Animals, 27, 4: 301–329

Mykytowycz R., Rowley I. 1958. Continuous observations of the activity of the wild rabbit, Oryctolagus cuniculus (L.), during 24 hour periods. C.S.I.R.O. Wildlife Research, 3: 26–31

Newberry R.C. 1995. Environmental enrichment: Increasing the biological relevance of captive environments. Applied Animal Behaviour Science, 44: 229–243

Pečlin G. 2002. Vpliv obogatitve okolja z lesom za glodanje na obnašanje pitovnih kuncev v individualnih žičnih kletkah. Diplomska naloga. Domžale, Biotehniška fakulteta, Oddelek za zootehniko: 45 p.

Podberscek A.L., Blackshaw J.K., Beattie A.W. 1991. The behaviour of group penned and individually caged laboratory rabbits. Applied Animal Behaviour Science, 28: 353–363

Postollec G., Boilletot E., Maurice R., Michel V. 2006. The effect of housing system on the behaviour and growth parameters of fattening rabbits. Animal Welfare, 15: 105–111

Princz Z., Zotte A.D., Radnai I., Biro-Nemeth E., Matics Z., Gerencser Z., Nagy I., Szendro Z. 2008. Behaviour of growing rabbits under various housing conditions. Applied Animal Behaviour Science, 111, 3–4: 342–356

R Development Core Team. 2005. R: a language and environment for statistical computing. Vienna, Austria, R Foundation for Statistical Computing

Spiegelhalter D., Thomas A., Best N., Gilks W., Lunn D. 2003. BUGS: Bayesian inference using Gibbs sampling. 1.4 edition. Cambridge, UK, MRC biostatistics unit.

Stauffacher M. 1992. Group housing and enrichment cages for breeding, fattening and laboratory rabbits. Animal Welfare, 1: 105–125

Sturtz S., Ligges U., Gelman A. 2005. R2W in BUGS: a package for running WinBUGS from R. Journal of Statistical Software, 12, 3: 1–18

Štuhec I., Kermauner A., Gorjanc G., Jordan D. 2005. Einfluss des Alters auf den Tagesrhythmus des Verhaltens bei Mastkaninchen in Einzelkäfigen. In: 14th Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals, Celle, Germany, 11–12 May 2005. Gießen, Verlag der Deutschen Veterinärmedizinischen Gesellschaft e.V.: 7–16

Turk M. 2004. Vpliv obogatitve okolja z letvami za glodanje iz različnih vrst lesa na obnašanje kuncev. Diplomsko delo. Domžale, Biotehniška fakulteta, Oddelek za zootehniko: 41 p.

Verga M. 2000. Intensive rabbit breeding and welfare: development of research, trends and applications. In: Proceedings of the 7th World Rabbit Congress, Valencia, Spain, 4–7 Jul. 2000, Vol. B: 491–509

Verga M., Zingarelli I., Heinzl E., Ferrante V., Martino P.A., Luzi F. 2005. Effect of housing and environmental enrichment on performance and behaviour in fattening rabbits. In: Proceedings of the 8th World Rabbit Congress, Puebla, Mexico, 7–10 Sept. 2004. Corronsac, France, World Rabbit Science Association: 1283–1288. http://www.dcam.upv.es/8wrc/docs/Welfare%20and%20Ethology/Short%20Papers/1283-1288_vermarp_mod.pdf (13 Sept. 2005)

Wemelsfelder F. 1994. Animal boredom – a model of chronic suffering in captive animals and its consequences for environmental enrichment. Humane innovations and alternatives, 8: 587–591. http://www.psyeta.org/hia/vol8/wemelsfelder.html (15 May 2006)