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Comparison of pens without and with multilevel platforms for growing rabbits

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ABSTRACT

This experiment compared the productive performance and location of growing rabbits in pens without and with two-level platforms (wire-mesh or plastic-mesh). A total of 174 rabbits of both sexes weaned at 5 weeks of age were randomly divided into three groups ($n = 58$ rabbits/group, 2 pens/treatment, 29 rabbits/pen). The floor area of pens was 1.0×1.83 m, and the floor was made of wire-mesh. Two pens were equipped with wire-mesh (WP) and two pens with plastic-mesh elevated platforms (PP) on two levels, and two pens were without platforms (NoP). Treatment had no effect on the productive performance of growing rabbits. Based on video recordings, animal density (rabbits/m^2 in each location) was higher ($p < .001$) on the floor than on the platforms (in WP: 12.0 vs. 5.2, in PP: 10.2 vs. 7.4 rabbits/m^2, respectively). Animal density on the floor was higher ($p < .001$) in front of the platforms than under the platforms (in WP 15.7 vs. 9.8 rabbits/m^2 and in PP 13.3 vs. 8.3 rabbits/m^2, respectively). The animal density on platforms was 1.4 times higher in group of PP than in WP ($p < .001$). The animal density was 1.6 and 2.9 times higher on the second floor than on the first one ($p < .001$), in group of PP and WP, respectively. The concentration of cortisol metabolites in faeces and the ratio of injured rabbits were similar in the three groups. The rabbits showed higher preference staying on the floor compared to the platform. Pens with platforms were not influencing productive performance.

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Growing rabbit; pen; platform; production; welfare

Introduction

Nowadays, one of the most important aims of animal housing is to harmonise production with the animal welfare. This can be difficult because, in case of rabbit housing, there are often conflicts between people's expectations and the needs of rabbits. In previous years, in some countries (e.g. in Italy and Hungary) the common practice was to house growing rabbits in pairs in bicellular cages (Trocino and Xiccato 2006). In most experiments, housing two rabbits per cage gave better growth performance than housing them in larger groups (Trocino and Xiccato 2006; Princz et al. 2009; Szendrő and Dalle Zotte 2011; Xiccato et al. 2013). On the other hand, according to the recommendations of the European Food and Safety Authority (EFSA 2005), the benefits of group housing (>3 rabbits/cage) have been emphasised, because this allows the rabbits species-specific behavioural patterns to be expressed (social contact, hopping, uprising position, stretching, etc.). Also, in large groups and large size pens, stereotypic behaviour (i.e. cage biting) may be prevented. Despite group size, EFSA (2005) has also proposed a stocking density of maximum 16 rabbits/m^2 (40 kg/m^2). By installing an elevated platform in group cages for growing rabbits, the animals get indirectly more space and also the possibility for more movement. The usage of elevated platforms was also recommended to provide environmental enrichment (de Jong et al. 2011). Furthermore, they promote locomotion (e.g. jumping) and give rabbits the chance to choose the more comfortable part of the cage (on, under or in front of the platform) or to withdraw from aggressive cage-mates. The elevated platform in combination with a low stocking density resulted in a higher feed intake and better daily weight gain during early fattening period (Maertens et al. 2004). Results of

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another experiment (Lang and Hoy 2011) showed that the usage of an elevated platform did not affect the weight gain, mortality and occurrence of lesions on bodies of growing rabbits.

Nevertheless, the concept of the elevated platform is still under investigation and more information should be determined about the ideal technical characteristics (size, height from the floor, number of levels, material, etc.). Only a few papers have been published comparing different platform materials on productive performance and behaviour of growing rabbits (Lang and Hoy 2011; Szendrő et al. 2012; Matics, Szendrő, et al. 2014). The preference of rabbit does and their kits between wire-mesh and plastic-mesh platforms were investigated by Mikó et al. (2014). Research has been focused on the floor material of the cages, comparing wire-mesh, plastic-mesh, steel-slat and plastic-slat floors (Trocino et al. 2008; Princz et al. 2009). The main conclusion of these studies was that wire-mesh floor promotes better hygienic conditions for growing rabbits (reduced risk of infection), whereas plastic-mesh floor was found to be more preferable for the rabbits (Szendrő and Dalle Zotte 2011).

In this experiment the productive performance, cortisol metabolites in faeces and location (preference) of growing rabbits housed in different type of pens (without or with wire-mesh or plastic-mesh elevated platforms) were examined.

Materials and methods

The study was approved by the Ethical Committee of Kaposvár University. All animals were handled according to the principles stated in the EC Directive 86/609/EEC regarding the protection of animals used for experimental and other scientific purposes.

Animals and experimental design

The experiment was conducted at the rabbit farm of Kaposvár University using the maternal line (Pannon Ka) growing rabbits of the Pannon breeding program (Matics, Nagy, et al. 2014). The rabbits were housed in a room with temperature ranging between 15 and 18 °C and humidity between 65 and 70%. The lighting period was 16L:8D (light: 6:00–22:00 hours). The rabbits were fed commercial pelleted diets *ad libitum* (between 5 and 9 weeks of age: 9.6 MJ DE/kg, 16.1% CP, 2.7% EE, 18.5% CF and medicated with 1 ppm Clinacox (diclazuril), 500 ppm oxytetracycline, 50 ppm tiamulin; and between 9 and 11 weeks of age: 9.7 MJ DE/kg, 17.0% CP, 3.0% EE, 18.0% CF, without medication). Water was available from nipple drinkers (five drinkers/pen).

A total of 174 rabbits of both sexes (1:1) were weaned at 5 weeks of age. They were randomly divided into three groups (58 rabbits/group) and distributed into six pens (1.0 × 1.83 m) with wire-mesh floor and walls (29 rabbits/pen, 2 pens/treatment). The hole size of rectangle and thickness of wire-mesh floor were 10.7 mm × 49.6 mm and 2.5 mm, respectively. The pens differed only in the presence or absence of platforms and the material of the platforms.

- **Pen without platform (NoP)**: The stocking density was 16 rabbits/m^2.
- **Pens with wire-mesh platforms (WP,** Figures 1 and 2) were equipped with seven elevated platforms which were placed on two levels: three platforms inserted 25 cm above the floor (one of 0.35 m^2 and two of 0.165 m^2 surface area), and four platforms placed 50 cm above the floor (each 0.165 m^2). The total area of platforms was 1.34 m^2, the floor area under the platforms was 1.15 m^2, and in front of the platforms, it was 0.68 m^2. Stocking density was 16 rabbits/m^2 (calculated on the floor area) and 9.14 rabbits/m^2 (when the areas of platforms were included). The platforms were made of wire-mesh (hole size of rectangle: 10.9 × 23.5 mm and the wire thickness 2.05 mm).
- **Pens with plastic-mesh platforms (PP,** Figures 1 and 2). The number, size and position of plastic-mesh platforms were similar to platforms in the WP pens (diagonal hole size of rhombus: 14.5 × 23 mm, and the plastic thickness 4.5 mm). The stocking density was similar to WP pens.

Measurements and sampling

Individual body weights and feed intakes per pen were measured weekly between 5 and 11 weeks of age, and the daily weight gain and feed conversion ratio were calculated. Injuries (scratch and bite on the ears, body and genitals) and morbidity (animals with health problems, e.g. diarrhoea) were recorded once a week, at the time of weighing. Mortality was registered daily.

Twenty-four-h pooled faeces samples from each pen were collected at 7, 9 and 11 weeks of age to evaluate the corticosterone metabolite concentration. Assays were done at the Veterinary Faculty of Szent István University, using a slight modification of the method described by Palme et al. (1999). For this, 0.5 g of faeces was dispersed in 0.5 ml of double distilled water in

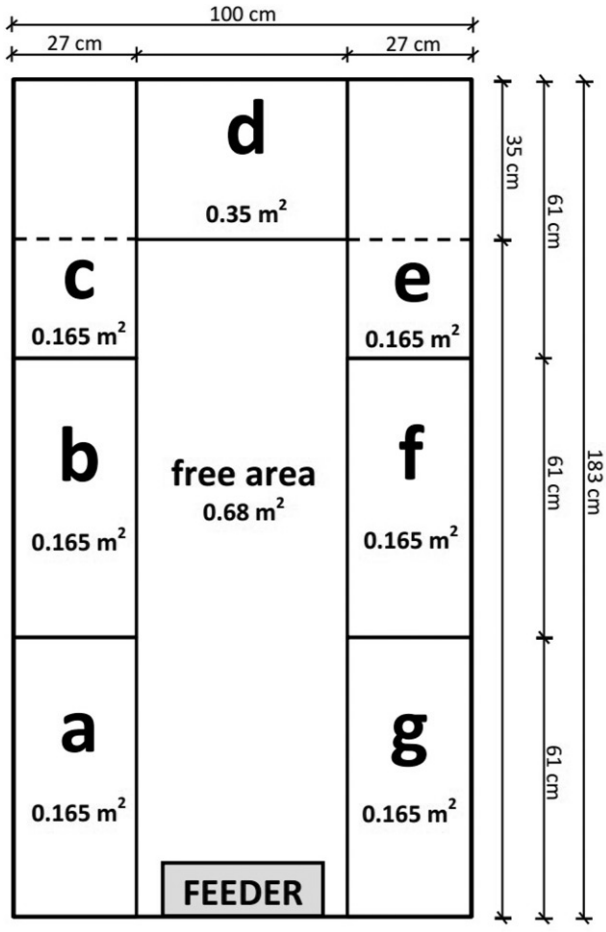

Figure 1. Layout of pens with elevated platforms (first level: b, d, f; second level: a, c, e, g).

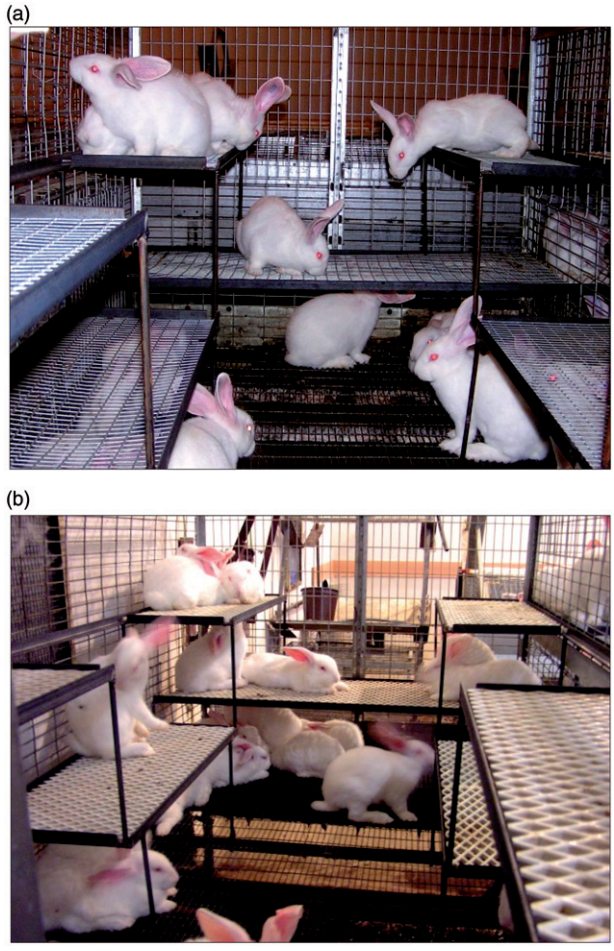

Figure 2. Pens with wire-mesh platforms (a) and plastic-mesh platforms (b).

thick-walled glass tubes suitable for centrifugation, 4 ml methanol (80%) was added, and samples were shaken for 3 min with a multi-tube vortex. After centrifugation (3600 g, 30 min, +48 °C), the samples were cooled (−50 °C, 30 min) to separate the phases, methanol (above) and frozen water with the extracted faeces (below). Then, 1 ml of the methanol phase was pipetted into clean tubes and 1:10, 1:20 or 1:50 working dilution solutions were prepared with phosphate-buffered saline buffer (pH 7.4). Concentrations of cortisol metabolites were measured in triplicate 20-ml aliquots of faecal extracts with H3-RIA method. Standards were as follows: 3.9, 7.81, 15.625, 31.25, 62.5, 125, 250, 500, 1000 and 2000; B/T%: 28.

Evaluation the usage of platforms

In the pens equipped with platforms (PP and WP), 24-h video recordings were made once a week. The recording was achieved by using infrared cameras (KPC-S50 NV, B/W CCD) and specialised software (GeoVision GV-800 System, Multicam Surveillance System 6.1.). Number of rabbits was counted every half an hour in the different locations of the pens: on the floor (in front of the platforms and under the platforms) and on the platforms (on the first and on the second level). Since the area of the different parts of the pens was different, the number of rabbits in each location could be dependent on its size. That is why the comparison of preference of rabbits was based on the animal density (rabbits/m^2). The 24-h observations were divided into four 6-h periods: 5:00–11:00, 11:00–17:00, 17:00–23:00 and 23:00–5:00.

Statistical analysis

Location preference among the parts of the pens (in front of the platforms, under the platforms, on the first or second level of the platform, and on the floor or on the platforms) and the period of day within the different parts of the pens were evaluated by multi-factor ANOVA in case of each pen type:

$$Y_{ij} = \mu + L_i + R_j + e_{ij}$$

Table 1. Location of rabbits (in rabbits/m^2) among different parts of pens depending on the type of platform (wire-mesh or plastic-mesh).

	Parts of the pens						Parts of the pens Together		
	On the floor		On the platform						
Age, week	In front of the platforms	Under the platforms	First level	Second level	SE	*p*-value	On the floor	On the platforms	*p*-value
Wire-mesh platforms (WP)									
5–6	18.5a^{D}	8.9c^{C}	3.5c^{A}	5.9c^{B}	0.27	<.001	12.4c	4.7	<.001
6–7	16.9a^{D}	10.1^{C}	2.4c^{A}	6.5b^{B}	0.22	<.001	12.6c	4.4c	<.001
7–8	15.3a^{C}	9.8c^{B}	2.5c^{A}	8.6b^{B}	0.21	<.001	11.8c	5.5c	<.001
8–9	14.6c^{D}	10.7^{C}	2.4c^{A}	7.9^{B}	0.17	<.001	12.1c	5.1c	<.001
9–10	15.5c^{D}	10.0b^{C}	2.5c^{A}	8.0^{B}	0.16	<.001	12.0c	5.2c	<.001
10–11	13.3b^{C}	9.7a^{B}	3.2c^{A}	10.0b^{B}	0.16	<.001	11.1c	6.5c	<.001
5–11	15.7c^{D}	9.8c^{C}	2.7c^{A}	7.8b^{B}	0.14	<.001	12.0c	5.2c	<.001
Plastic-mesh platforms (PP)									
5–6	16.2^{C}	5.3^{A}	5.9^{A}	12.0^{B}	0.28	<.001	9.3	8.9	.474
6–7	14.9^{C}	9.2^{B}	4.3^{A}	8.2^{B}	0.22	<.001	11.3	6.2	<.001
7–8	13.2^{D}	7.9^{B}	5.8^{A}	10.5^{C}	0.23	<.001	9.9	8.1	<.001
8–9	11.4^{D}	10.0^{C}	5.6^{A}	7.6^{B}	0.17	<.001	10.5	6.6	<.001
9–10	12.4^{C}	8.8^{B}	6.5^{A}	7.5^{A}	0.17	<.001	10.2	7.0	<.001
10–11	11.5^{C}	8.8^{B}	6.5^{A}	8.6^{B}	0.17	<.001	9.8	7.5	<.001
5–11	13.3^{C}	8.3^{B}	5.8^{A}	9.1^{B}	0.15	<.001	10.2	7.4	<.001

Significant differences among the number of rabbits/m^2 in the parts of the WP and PP pens within week of age (a: $p < .05$; b: $p < .01$; c: $p < .001$).
^{A,B,C,D}Different superscripts within a row show significant differences ($p < .05$).
SE: standard error of the mean.

$$Y_{ij} = \mu + P_i + \ R_j \ + e_{ij}$$

where μ: overall mean; L_i: effect of the location (i = among the four parts of the pen: 1, 2, 3, 4; between the floor and the platform: 1, 2; fixed factor); P_i: effect of the period of day ($i = 1, 2, 3, 4$; fixed factor); R_j: effect of the repetition (Pen) ($j = 1, 2$; random factor); and e_{ij}: random error.

The productive traits were also evaluated by means of multi-factor analysis of variance including interaction between pen type and age:

$$Y_{ijk} = \mu + P_i + \ A_j \ + (PA)_{ij} + e_{ijk}$$

where μ: overall mean; P_i: effect of pen type ($i = 1, 2, 3$; fixed factor); A_j: effect of age (j = 1–6; fixed factor); $(PA)_{ij}$: the effect of the interaction of level i of factor pen type with level j of factor age; and e_{ijk}: random error.

Concentration of corticosterone metabolites in faces, the effect of the date of faces collection (age of rabbits) within different pen types, and the feed intake and feed conversion ratios were evaluated by one-factor ANOVA:

$$Y_i = \mu + Pt_i \ + e_i$$
$$Y_i = \mu + Age_i \ + e_i$$
$$Y_i = \mu + \ Pt_i \ + e_i$$

where μ: overall mean; Pt_i: effect of the pen type ($i = 1, 2, 3$; fixed factor); or Age_i: effect of the age at sampling ($i = 1, 2, 3$; fixed factor); or Pt_i: effect of the pen type ($i = 1, \ldots 3$; fixed factor); and e_i: random error.

Morbidity, mortality and ratio of injured rabbits were evaluated by chi-square test. All data were evaluated with the SPSS 10.0 software package (SPSS Inc., Chicago, IL).

Results

Evaluation of the usage of platforms

The results of the preference test are shown in Tables 1 and 2. During the whole experimental period, and regardless of the platform material, rabbits were found more frequently on the floor than on the platforms. The animal density was 2.3 and 1.4 times higher on the floor than on the platforms in WP and PP pens, respectively ($p < .001$). The animal density on the floor in front of the platforms was 1.6 times higher than under the platforms ($p < .001$) both in WP and PP pens. However, with increasing age, rabbits more frequently chose the less used areas, and the animal density decreased on the floor in front of the platforms in both types of pen. The animal density on the plastic-mesh platforms was 1.4 times higher than that on wire-mesh ones ($p < .001$). The second (higher) level of platforms was more frequently used than the first level: the animal density was 2.9 and 1.6 times higher on the second level than on the first level in WP and PP pens, respectively ($p < .001$).

The distribution of rabbits was affected by time of day (Table 2). The animal density under the platforms was the highest between 11:00 and 17:00 (resting period) in both pen types, and lowest between 23:00

Table 2. Effect of time of the day on the location of growing rabbits among different parts of pens (rabbits/m^2).

	Parts of the pens									
	On the floor		On the platform				Parts of the pens Together			
Periods of the day	In front of the platforms	Under the platforms	First level	Second level	SE	*p*-value	On the floor	On the platforms	SE	*p*-value
Wire-mesh platform										
5:00–11:00	11.8^{bA}	10.1^{bB}	3.6^{aC}	10.4^{bB}	0.28	<.001	10.8^{A}	6.9^{B}	0.29	<.001
11:00–17:00	14.3^{dB}	12.5^{cC}	1.7^{aA}	5.6^{bA}	0.17	<.001	13.2^{B}	3.6^{A}	0.14	<.001
17:00–23:00	15.9^{cB}	8.9^{bAB}	2.9^{aBC}	9.1^{bB}	0.16	<.001	11.5^{A}	5.9^{B}	0.16	<.001
23:00–5:00	20.7^{dC}	7.9^{cA}	2.7^{aB}	6.2^{bA}	0.14	<.001	12.6^{B}	4.4^{A}	0.15	<.001
SE	0.22	0.17	0.10	0.21			0.10	0.14		
p-value	<.001	<.001	<.001	<.001			<.001	<.001		
Plastic-mesh platform										
5:00–11:00	9.2^{aA}	8.3^{aB}	7.8^{aC}	11.2^{bC}	0.26	<.001	8.6^{A}	9.5^{B}	0.20	.041
11:00–17:00	11.7^{bB}	10.5^{bC}	5.8^{aB}	6.9^{aA}	0.27	<.001	10.9^{B}	6.3^{A}	0.26	<.001
17:00–23:00	14.4^{dC}	7.7^{bAB}	5.3^{aAB}	9.4^{cB}	0.14	<.001	10.2^{B}	7.4^{A}	0.13	<.001
23:00–5:00	17.7^{dD}	6.9^{bA}	4.1^{aA}	8.7^{cB}	0.15	<.001	10.9^{B}	6.4^{A}	0.18	<.001
SE	0.28	0.13	0.18	0.21			0.11	0.15		
p-value	<.001	<.001	<.001	<.001			<.001	<.001		

^{A,B,C,D}Means with unlike superscripts within a column differ ($p < .05$).
^{a,b,c,d}Means with unlike superscripts within a row differ ($p < .05$).
SE: standard error of the mean.

Table 3. Effect of housing system on productive performance of growing rabbits between 5 and 11 weeks of age.

	Groups				
Traits	NoP	PP	WP	SE	*p*-value
Number of rabbits	58	58	58		
Body weight at 11 weeks, g	2426	2387	2408	17.5	.646
Weight gain, g/day	36.6	35.9	36.4	0.36	.703
Feed intake, g/day	139	139	135	0.84	.119
Feed conversion ratio	3.8	3.9	3.7	0.04	.258
Morbidity, %	26.9	25.0	21.4	–	.879
Mortality, %	6.9	3.4	3.4	–	.594
Rabbits under 2 kg at slaughter, %	11.5	5.4	17.5	–	.129

NoP: pens without platform; PP: pens with plastic-mesh platforms; WP: pens with wire-mesh platforms; SE: standard error of the mean.

and 5:00 (active period) ($p < .001$). Opposite tendencies were observed in front of the platforms; the animal density was the lowest between 5:00 and 11:00, and the highest between 23:00 and 5:00 in both pens ($p < .001$). The use of plastic-mesh or wire-mesh platforms was independent of the time of day.

Productive performance

Body weight, weight gain, feed intake, feed conversion ratio, morbidity, mortality and percentage of underweight rabbits were not significantly affected by the housing system (Table 3). The interaction between pen type and age was not significant.

Concentration of corticosterone metabolites and injured rabbits

No significant differences were found in concentration of corticosterone metabolites in faeces among the groups (Table 4). However, significantly higher values were measured at the ages 7 and 9 weeks than at 11 weeks in NoP and WP pens ($p < .05$ and $p < .001$, respectively). The tendencies were similar in the PP group, but the differences were not significant. The percentage of injured rabbits was not affected by the pen type, and no sign of aggressiveness was observed at 6, 10 and 11 weeks of age in any group (Table 5).

Discussion

Preference among different platforms

The platforms increased the possibility for movement and enriched the environment for growing rabbits; however, they more frequently stayed on the floor. This could be explained by the fact that European wild rabbits during the active period of the day stay on the ground, tend to like stay under scrubland (protected area), and they move into the warren during daytime, the resting period of the day (Kolb 1986). Jumping up to a higher place is not part of the behaviour of wild rabbits. According to our previous experiment, rabbits

Table 4. Effect of housing system on concentration of cortisol metabolites in faeces, nmol/g.

	Groups				
Age, week	NoP	PP	WP	SE	*p*-value
7	27.4[b]	27.6	27.4[b]	0.64	.994
9	28.6[b]	28.2	28.3[b]	0.46	.947
11	23.7[a]	25.0	23.6[a]	0.42	.341
SE	0.80	0.60	0.62		
p-value	.021	.068	<.001		

NoP: pens without platform; PP: pens with plastic-mesh platforms; WP: pens with wire-mesh platforms.
[a,b]Means with unlike superscripts within a column differ ($p < .05$).
SE: standard error of the mean.

Table 5. Effect of housing system on injured rabbits, %.

	Groups			
Age, week	NoP	PP	WP	*p*-value
Number of rabbits	58	58	58	
6	0	0	0	1.000
7	5.2	3.4	3.4	.862
8	0	1.7	0	.368
9	0	1.7	0	.368
10	0	0	0	1.000
11	0	0	0	1.000

NoP: pens without platform; PP: pens with plastic-mesh platforms; WP: pens with wire-mesh platforms.

like staying under platforms made of solid material (Szendrő et al. 2012), which is similar to a protected area for them as the warren or scrubs for the European wild rabbits (Lombardini et al. 2003, 2007; Palomeras 2003; Beja et al. 2007). Princz, Radnai, et al. (2008) also observed that growing rabbits preferred staying more frequently in the parts of a cage block with a top than in the open-top cage. In contrast, in the present experiment the rabbits less frequently stayed under the platforms than in front of the platform, because the rabbits on the platforms may urinate on the pen-mates underneath them. This statement was proven, when rabbits were observed in pens with wire-mesh platforms, more rabbits stayed under it when a manure tray was inserted under the platform than in pens without manure tray (Szendrő et al. 2012). Growing rabbits most often stayed under the platform during the resting period (11:00–17:00) when fewer rabbits were on the platforms so there was less chance of being urinated upon. The reason could be the same for finding more on the second level than on the first. At the same time, rabbits stayed more frequently on the plastic-mesh platforms than on the wire-mesh ones any time of the day, which was in accordance with Mikó et al. (2014), who found that rabbit does and their kits spent more time on plastic-mesh platforms then on wire-mesh ones. The plastic-mesh floor was more comfortable for the growing rabbits than the wire-mesh one (Princz et al. 2009; Szendrő et al. 2012; Gerencsér et al. 2014); however, their preference depended on the temperature and the age (Bessei et al. 2001; Gerencsér et al. 2014). In both WP and PP pens, the highest animal density on platforms was observed in the morning (5:00–11:00) and was the lowest between 11:00 and 17:00 when more rabbits rested under the platform.

Productive performance

In the present study, three factors could have affected the productive performance: stocking density which was lower in pens with elevated platforms, the difference in ability to move between pens without and with platform and the material of platforms (wire-mesh or plastic-mesh). The stocking density in pens without platforms was 16 rabbits/m^2. It was lower in pens with platforms depending on how many rabbits stayed on them.

According to other authors (Maertens and De Groote 1984; Verga et al. 2004; Trocino et al. 2008; Princz, Dalle Zotte, et al. 2008; Princz et al. 2009; Szendrő, Princz, et al. 2009), the majority of productive traits did not change significantly when the stocking density was lower than 16 rabbit/m^2. Similarly, the stocking density in the present experiment (pens with or without platforms) did not modify the performance.

In our experiment, the group sizes were the same, so only the elevated platforms could affect the locomotor activity of rabbits. Since the productive traits were similar in pens without and with platforms, the elevated platforms probably did not substantially modify the locomotor activity, since rabbits also could move quite freely in pens without platforms. In the present experiment, the floor type of the platforms had no significant influence on productive traits. These results confirm the findings of Matics et al. (2003), Trocino et al. (2004) and Princz et al. (2009) who pointed out that floor type had no effect on productive traits of rabbits. The reason of the high morbidity rate may be explained by the higher risk of contamination in large groups (Szendrő and Luzi 2006).

Stress and injured rabbits

The aggressiveness of growing rabbits occurs at the age when starting their sexual maturity, and the frequency of aggressive rabbits could be between 1 and 2% (Szendrő and Dalle Zotte 2011). In the present experiment, the concentration of corticosterone metabolites in faeces decreased with age and no injured rabbits were observed at the end of fattening period. Opposite to the previous trials, in which higher percentages of injured rabbits were observed in larger

groups (Bigler and Oester 1996; Szendrő, Matics, et al. 2009), we did not see injured rabbits at 10 and 11 weeks of age. These results were not related to the treatments because similar results were achieved in pens without platforms.

Conclusions

It can be concluded that the pens with platforms were not influencing the productive traits independently the material of the platform.

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References

Beja P, Pais M, Palmo L. 2007. Rabbit *Oryctolagus cuniculus* habitats in Mediterranean scrubland: the role of scrub structure and composition. Wildl Biol. 13:28–37.

Bessei W, Tinz J, Reiter K. 2001. Die Präferenz von Mastkaninchen für Kunststoffgitter und Tiefstreu bei unterschiedlichen Temperaturen. In: Matthes S, Martens H, editors. Proceedings of the 12. Arbeitstagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere [12th Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals]; May 9–10; Celle, Germany. p. 133–140.

Bigler L, Oester H. 1996. Group housing for male rabbits. In: François L, editor. Proceedings of the 6th World Rabbit Congress; Jul 9–12; Toulouse, France. Vol. 2, p. 411–415.

[EFSA] European Food and Safety Authority. 2005. Scientific Report "The impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits". EFSA-Q-2004-023. p. 1–137. Annex to EFSA Journal 267, 1–31.

Gerencsér Z, Szendrő K, Szendrő Z, Odermatt M, Radnai I, Nagy I, Dal Bosco A, Matics Z. 2014. Effect of floor type on behaviour and productive performance of growing rabbits. Livest Sci. 165:114–119.

De Jong IC, Reuvekamp BFJ, Rommers JM. 2011. A welfare assessment protocol for commercially housed rabbits. Lelystad: Wageningen UR Livestock Research. Report 532, p. 1–23. http://edepot.wur.nl/197480.

Kolb HH. 1986. Circadian activity in the wild Rabbit (*Oryctolagus cuniculus*). Mamm Rev. 16:145–150.

Lang C, Hoy S. 2011. Investigations on the use of an elevated platform in group cages by growing rabbits. World Rabbit Sci. 19:95–101.

Lombardini L, Fernández N, Moreno S. 2007. Habitat use and spatial behaviour in the European rabbit in three Mediterranean environments. Basic Appl Ecol. 8:453–463.

Lombardini L, Fernández N, Moreno S, Villafuerte R. 2003. Habitat-related differences in rabbit (*Oryctolagus cuniculus*) abundance, distribution and activity. J Mammal. 84:26–36.

Maertens L, De Groote G. 1984. Influence of the number of fryer rabbits per cage on their performance. J Appl Rabbit Res. 151–155.

Maertens L, Tuyttens F, Van Poucke E. 2004. Group housing of broiler rabbits: performances in enriched vs. barren pens. In: Proceedings of the 8th World Rabbit Congress; Sep 7–10; Puebla, Mexico. p. 1189–1194. http://world-rabbit-science.com/WRSA-Proceedings/Congress-2004 Puebla/Papers/Welfare%20%26%20Ethology/W-Maertens.pdf

Matics Z, Nagy I, Gerencsér Z, Radnai I, Gyovai P, Donkó T, Dalle Zotte A, Curik I, Szendrő Z. 2014. Pannon breeding program in rabbit at Kaposvár University. World Rabbit Sci. 22:287–300.

Matics Z, Szendrő Z, Odermatt M, Gerencsér Z, Nagy I, Radnai I, Dalle Zotte A. 2014. Effect of housing conditions on production, carcass and meat quality traits of growing rabbits. Meat Sci. 96:41–46.

Matics Z, Szendrő Z, Radnai I, Biró-Németh E, Gyovai M, Orova Z. 2003. Freie Platzwahl der Kanninchen unter verschieden grossen Käfigen. In: Matthes S, Martens H, editors. Proceedings of the 13th Arbeitstagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere [13th Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals]; May 14–15; Celle, Germany. p. 102–108.

Mikó A, Matics Z, Gerencsér Z, Odermatt M, Radnai I, Nagy I, Szendrő K, Szendrő Z. 2014. Performance and welfare of rabbit does in various caging systems. Anim. 8:1146–1152.

Palme R, Robia C, Messmann S, Hofer J, Möstl E. 1999. Measurement of faecal cortisol metabolites in ruminants: non-invasive parameter of adrenocortical function. Wien Tierärztl Monatsschr. 86:237–241.

Palomeras F. 2003. Warren building by European rabbits (*Oryctolagus cuniculus*) in relation to cover availability in a sandy area. J Zool. 259:63–67.

Princz Z, Dalle Zotte A, Metzger S, Radnai I, Biró-Németh E, Orova Z, Szendrő Z. 2009. Response of fattening rabbits reared under different housing conditions. 1. Live performance and health status. Livest Sci. 121:86–91.

Princz Z, Dalle Zotte A, Radnai I, Biró-Németh E, Matics Z, Gerencsér Z, Nagy I, Szendrő Z. 2008. Behaviour of growing rabbits under various housing conditions. Appl Anim Behav Sci. 111:342–356.

Princz Z, Radnai I, Biró-Németh E, Matics Z, Gerencsér Z, Nagy I, Szendrő Z. 2008. Effect of cage height on the welfare of growing rabbits. Appl Anim Behav Sci. 114:284–295.

Szendrő Z, Dalle Zotte A. 2011. Effect of housing conditions on production and behaviour of growing meat rabbits. A review. Livest Sci. 137:296–303.

Szendrő Z, Luzi F. 2006. Group size and stocking density. In: Maertens L, Coudert P, editors. Recent advances in rabbit science. Melle: ILVO, p. 121–126.

Szendrő Z, Matics Z, Nagy I, Odermatt M, Gerencsér Z, Szendrő É, Radnai I, Dalle Zotte A. 2009. Examination of growing rabbits housed in pens without or with platform. In: Hoy S, editor. Proceedings of the 16. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere [16th International Symposium on Housing and Diseases of Rabbits, Furbearing Animals and Pet Animals]; May 13–14; Celle, Germany. p. 3–12.

Szendrő Z, Princz Z, Romvári R, Locsmándi L, Szabó A, Bázár G, Radnai I, Biró-Németh E, Matics Z, Nagy I. 2009. Effect of group size and stocking density on productive, carcass and meat quality traits and aggression of growing rabbits. World Rabbit Sci. 17:153–162.

Szendrő Z, Matics Z, Odermatt M, Gerencsér Z, Nagy I, Szendrő K, Dalle Zotte A. 2012. Use of different areas of pen by growing rabbits depending on the elevated platforms' floor-type. Animal. 6:650–655.

Trocino A, Xiccato G. 2006. Animal welfare in reared rabbits: a review with emphasis on housing system. World Rabbit Sci. 14:77–93.

Trocino A, Xiccato G, Majolini D, Fragkiadakis M. 2008. Effect of cage floor and stocking density on growth performance and welfare of group-housed rabbits. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings of the 9th World Rabbit Congress; Jun 10–13; Verona, Italy. p. 1251–1255.

Trocino A, Xiccato G, Queaque PI, Sartori A. 2004. Group housing of growing rabbits: effect of stocking density and cage floor on performance, welfare and meat quality. In: Proceedings of the 8th World Rabbit Congress; Sep 7–10; Puebla, Mexico. p. 1277–1282.

Verga M, Zingarelli I, Heinzl E, Ferrante V, Martino PA, Luzi F. 2004. Effect of housing and environmental enrichment on performance and behaviour in fattening rabbits. World Rabbit Sci. 13:139–140.

Xiccato G, Trocino A, Filiou E, Majolini D, Tazzoli M, Zuffellato A. 2013. Bicellular cage vs. collective pen housing for rabbits: growth performance, carcass and meat quality. Livestock Sci. 155:407–414.