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PERFORMANCE AND BEHAVIOUR OF RABBIT DOES IN VARIOUS HOUSING CONDITIONS

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1. INTRODUCTION

In recent decades farmed rabbits have been kept mainly in intensive husbandry systems in wire-mesh cages. There is a growing interest worldwide about the animal welfare and well-being of farmed animals. Cage housing of rabbits is considered as not enough animal friendly system. New proposals are regularly announced by animal protection groups concerning housing of rabbits which are based on human way of thinking and emotions; and they are not based on the real needs of the animals and show lack of professional and practical experiences.

A special aim is to elaborate group housing of does, which provides near-to-nature environmental conditions for domestic rabbits. It is similar to the living of the ancestor European wild rabbit (*Oryctolagus cuniculus*) which lives in smaller or larger groups in burrow systems. Group-housing of does allows social contact among rabbits and more space for the expression of species-specific behavioural patterns. Another, newly developed system is semi-group housing of does which means that a pen system is used where the does are alternately housed during some weeks individually and some weeks in a group. These semi-group housing systems are required in some European countries (e.g. The Netherlands, Belgium). Undoubtedly, these systems are closer-to-nature, the main problems the aggressive behavior among rabbits and the injuries caused by antagonistic interactions have not been solved until now.

It seems that single housing of does remains the commonly used housing system in intensive rabbit production. Occasionally enlarged single cages are used which have to be equipped with foot rest and can be enriched with an elevated platform, hay rack or other environmental enrichment (e.g. wooden sticks).

It is clear that current housing of rabbits requires putting emphasis on the aspect of animal welfare but it is also important not to ignore the scientific results and aspects of hygiene, health and economy.

There is a recent example for wrong legal provision. In Germany, a special elevated platform is needed for rabbits which can have a maximum 15% perforation. Based on the results of German researchers (Masthoff *et al.*, 2017), this floor type is not appropriate because it causes hygienic and health problems. In cages equipped with this floor type 99.8% of rabbits were contaminated with faeces and urine and 25.3% of the animals suffered from sore hocks *(pododermatitis)*.

Before a new housing system is prescribed by the law the development and testing of new housing conditions for does with kits and for growing rabbits has an important role to take the specific needs of animals and all other possible aspects into account.

2. REVIEW OF THE LITERATURE

Domestic rabbits originated from the European wild rabbit which generally lives in territorial breeding groups consisting of an average of 2 to 9 does, 2 to 3 bucks and their progeny (Surridge *et al.*, 1999). Rabbit is considered a social speciesare, however during the establishment of a dominance hierarchy, does may attack, bite and chase each other during the fights, but once the hierarchy is established, aggression is markedly reduced (EFSA, 2005).

The *leporaria* were the origin of the game parks that subsequently developed in the Middle Ages (Lebas *et al.*, 1997). At the beginning of domestication rabbits were reared in groups. However, due to several problems, housing rabbit does in groups was abandoned in France at the late 1970's (Mirabito *et al.*, 2005a). Numerous advantages, for instance introduction of wire mesh cages, intensively selected genotypes, artificial insemination, cycled reproduction, balanced pelleted feed, and automatic feeders were important steps towards intensive rabbit production (Lebas *et al.*, 1997). Currently, rabbits kept for meat production are generally reared in several European countries in intensive husbandry systems in which does are housed individually (EFSA, 2005). However, there is an increasing demand for nature-like housing. There are some recommendations suggesting group-housing of rabbit does and rearing growing rabbits in large groups and some regulations exist making these systems compulsory (e.g. organic farming systems as Bio Suisse or Naturland).

2.1. European wild rabbit, the ancestor of the domesticated rabbit

Animal protection groups mostly suggest group housing system for rabbit does because it provides them conditions similar to those of the European wild rabbits, but it is important to study how rabbits live in the nature.

Aggressive behaviour is well known in different wild animal species (Kutsukake, 2009), mainly in group-living species, such as the European wild rabbits (Southern, 1948). There is a dominance hierarchy among males and females separately (von Holst *et al.*, 1999, 2002). Before the dominance hierarchy is established, especially in the spring, at the beginning of reproductive season, the fights are very intense. However, during the reproductive season its intensity decreases (von Holst *et al.*, 1999, 2002). After parturition the does stay near their burrows and are intolerant of other rabbit does (Southern, 1948). The average distance between two wild rabbit does in a large semi-natural enclosure is 20.7 m (Cornelissen *et al.*, 2011).

According to Mykytowycz and Dudzinski (1972) does tolerated their own kits, but attacked other young. Infanticide, the killing of conspecific young, has been observed in many animal species. For the European wild rabbits a doe-doe competition for a limited number of breeding burrows may result in infanticide (Künkele, 1992). According to Rödel *et al.* (2008) the occurrence rate of infanticide of the whole litter was 5 to 6%. Signs of biting were detectable on 68% of dead kits. In 17% of the infanticide, another doe built a new nest and gave birth inside the same chamber within few days. In 37% of the cases another

doe kindled within a distance of 30-50 cm. It can be concluded that when two European wild rabbit does kindle in the same nest, the second doe scrapes out the previous litter, and injures and kills the strange kits.

Social subordination leads to stress responses, which can greatly impair the reproductive functions of females (von Holst, 1998). Von Holst *et al*. (2002) reported a 45.7% kindling rate for the European wild rabbits. The fertility of dominant does was higher, they produced more litters and offspring, and the survival of kits was higher than for does with lower ranks. The average suckling mortality of the European wild rabbits was about 40%. The higher reproductive success of the dominant does was probably a result of their better physical condition. They had higher body weight, lower stress hormone levels and lower heart rates than subdominant females (von Holst *et al*., 1999). Rabbits having an inferior rank live under stress. The immune system functions are highly correlated to the social position of the animal, and it may be a mediator of diseases (Bohus *et al*., 1991). The individuals that gain a higher social position had 50% longer reproductive life-span than lower ranking counterparts (von Holst *et al.*, 1999).

The question is: Why then do the European wild rabbits live in groups despite the mentioned disadvantages? The advantages and disadvantages of living in groups were generally summarized by König (1997) and Kutsukake (2009), and for the European wild rabbits by Cowan (1987). The most important benefits for the European wild rabbits are decreased predation risk (many eyes, alarm calls with their hind legs, dilution effect) and cooperative construction of the warren. The most important costs are increased competition-aggressiveness

among group members, sub-dominant females live under stress and their productivity is lower, there is a higher probability of infection, the group is more visible to predators, and rabbits use energy for defence of their territory. Animals, including the European wild rabbits, form groups when the benefits of group-living exceed the costs.

Based on the relevant literature, Lombardini *et al.* (2003) concluded that European wild rabbits have been described as solitary or gregarious, cooperating or not regarding vigilance, living in warrens or aboveground, selecting open area or avoiding it. In a given habitat the disadvantages are minimized according to the costs and benefits. Thus, European wild rabbits are able to change their habits and behaviour depending on the risk of predation or the environmental conditions. At the same time, in nature, the European wild rabbits have the possibility for choosing a new habitat.

2.2. Housing systems for farmed rabbits

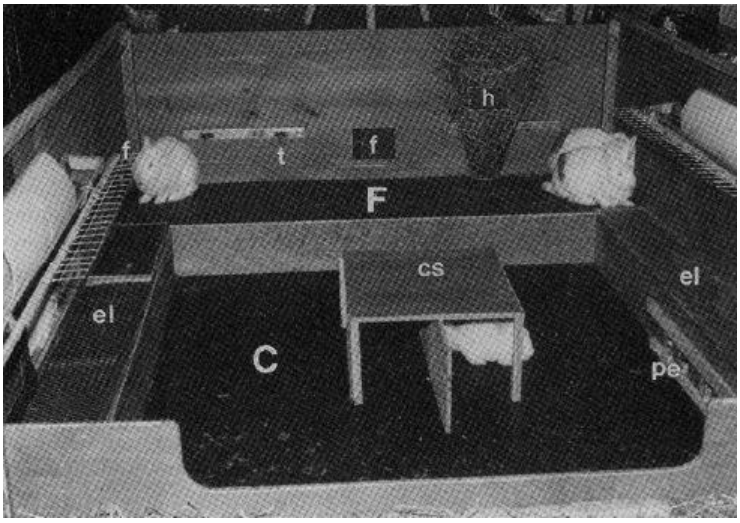
Nowadays, one of the most important animal welfare issues is the group or individual housing of rabbit does.

2.2.1. Group housing systems for rabbit does

2.2.1.1. Does housed continuously together

The first alternative housing system for rabbit does was published by Stauffacher (1992). In the basic group housing system, four does and one buck were kept permanently together in a 9 m^2 pen with areas for

feeding, for breeding, for kits, as well as a nest box for each doe with a tunnel-like entrance. Pens were enriched with raised platforms, hiding places, hay racks, gnawing sticks, etc. (Figure 1).



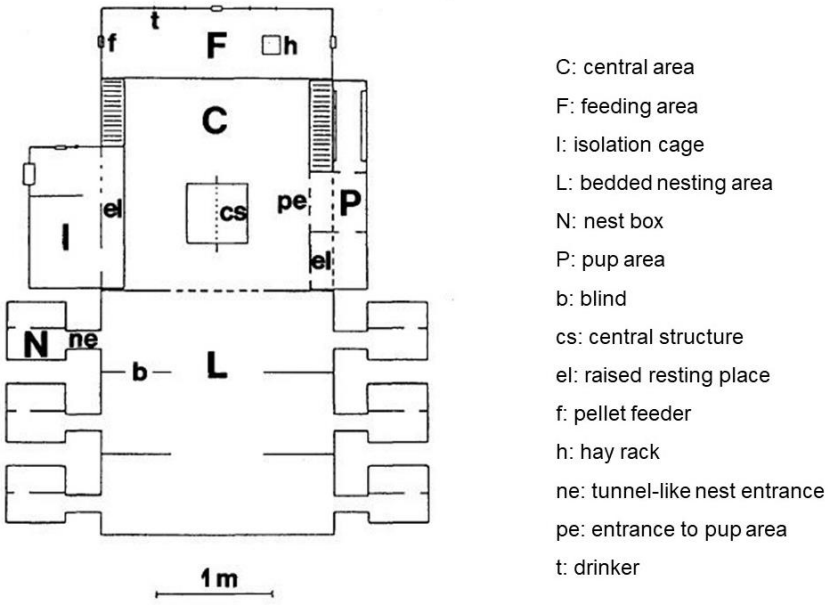


Figure 1: Stauffacher system

The fertility rate was satisfactory (89%), the litter size was 8.4 and the suckling mortality was 16%. It was observed that in 8% of cases, two does kindled in the same nest box, and aggressive conflicts leading to injury were rare. It should be noted that there was no control group (individually housed does) and nobody has been able to repeat these results.

During the past 20 years, several modified Stauffacher systems were investigated; mostly in Switzerland (Figure 2).

Figure 2: Modified Stauffacher system

(Graf *et al.*, 2011)

An average of 8 (5 to 9) does were housed in a group. Three reproductive methods were used: Does were mated naturally and the buck was usually introduced for 10 days, following a 33-d reproduction

rhythm (*post partum* mating). At commercial farms artificial insemination (AI) was applied with the 33-d or a 42-d reproduction system. Average kindling rate was 61% (64 and 60% if they were mated naturally or with AI, respectively). Litter size at birth was 9.6, and the suckling mortality was 15%. Lesions on the bodies occurred on all farms; 33% of the animals had at least one lesion, including 9% more severe injuries. These results show that about 20 years after Stauffacher's experiment, the problems of group-housing have not been solved.

In France, Mirabito *et al*. (2005a) compared single and group (4 does/pen) housing of rabbits. The design of the pen was similar to the Stauffacher system; however it was smaller (Figure 3). The group pens had a basic area of 4.5 m^2 and were divided into two parts: feeding, breeding and rearing the kits, and the area with 4 nest boxes with tunnels in front of them. The size of individual cages was 61x46 cm. A 42-d reproduction rhythm and free nursing was applied.

Mirabito *et al.* (2005a,b) reared four young females in a cage together from weaning until first kindling at 24 wk of age, then these rabbits were split into individual or group-housing treatments. Rearing of future does together was not successful, one-third of the rabbits were culled because of high incidence of fighting and injuries (wounds and abscesses).

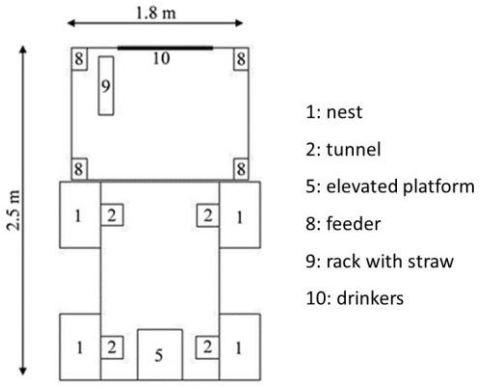


Figure 3: Group-housing system tested in France

(Mirabito *et al.*, 2005a)

No differences were found in kindling rate and litter size; however the suckling mortality was two times higher in grouped than in individually housed does (17.4 vs. 8.4%). One of the reasons for this could be the kindling of two or three does in the same nest box. The authors reported that one, two or three litters per box occurred in 62.4, 31.3 and 6.3% of the time, respectively. Rates of suckling mortality were very high compared to other experiments. Housing system did not affect doe

survival: 63% of females were still present in the fourth cycle of reproduction. No information was given about aggressiveness.

In The Netherlands a special system was developed (Ruis, 2006; Rommers *et al*., 2006). The pen (basic area 4.5 m^2) was divided into three parts: a breeding part with elevated floors and tunnel-like links to the nest box, a feeding area, and a kit area with small door where the does had no entrance (Figure 4).

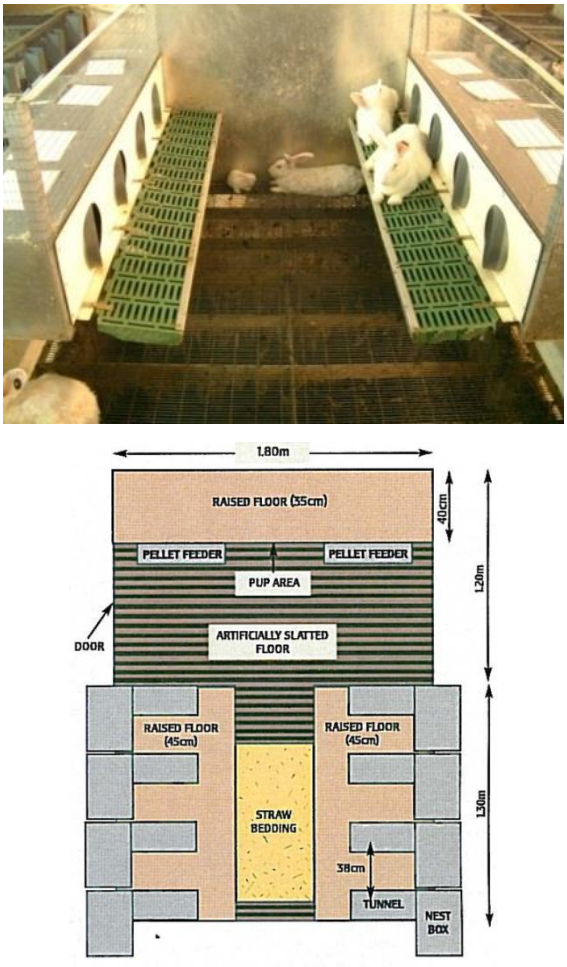


Figure 4: Dutch group-housing system

Unique to this system was the electronic individual nest-box recognition system (INRS). A clip (coded transponder) was attached to the ear of each doe, enabling only one doe to open the door to her nest box and excluding all other adults. Eight does were housed in each pen. In the beginning natural mating was applied, but later it was changed to AI at 11 d after parturition allowing a cycled reproduction system (Rommers *et al.*, 2006). Using this method, a lower kindling rate for group-housed does (55.6 *vs.* 84.2%) was reported than that of individual housed ones. High corticosterone concentrations were measured for group-housed rabbits, and the ratio of pseudopregnant does was 23%, which may have contributed to the unfavourable kindling rate. Litter size, kit mortality and kit weight at 14 d of age were similar in both groups. At weaning, the weight of kits was lower in the group-housing system (841 *vs.* 720 g), because after leaving the nest box, kits had reduced chance to suckle. The percentage of does with injuries was between 17 and 21%.

In Germany a new system, combination of the individual and group housing was tested (Hoy and Matics, 2016). The housing system consisted of 4 single areas (with nest boxes) with 0.6 m² each and a group area of 1.92 m² (Figure 5). The free entrance of does to nest boxes was solved by a commercial individual electronic nest box recognition system, only allowing one doe to have access to her own nest box. The special feature was the use of commercial "cat flaps" at the entrance to nest and individual space. The animals hold a microchip which makes it possible for the does to get to their own assigned single area.

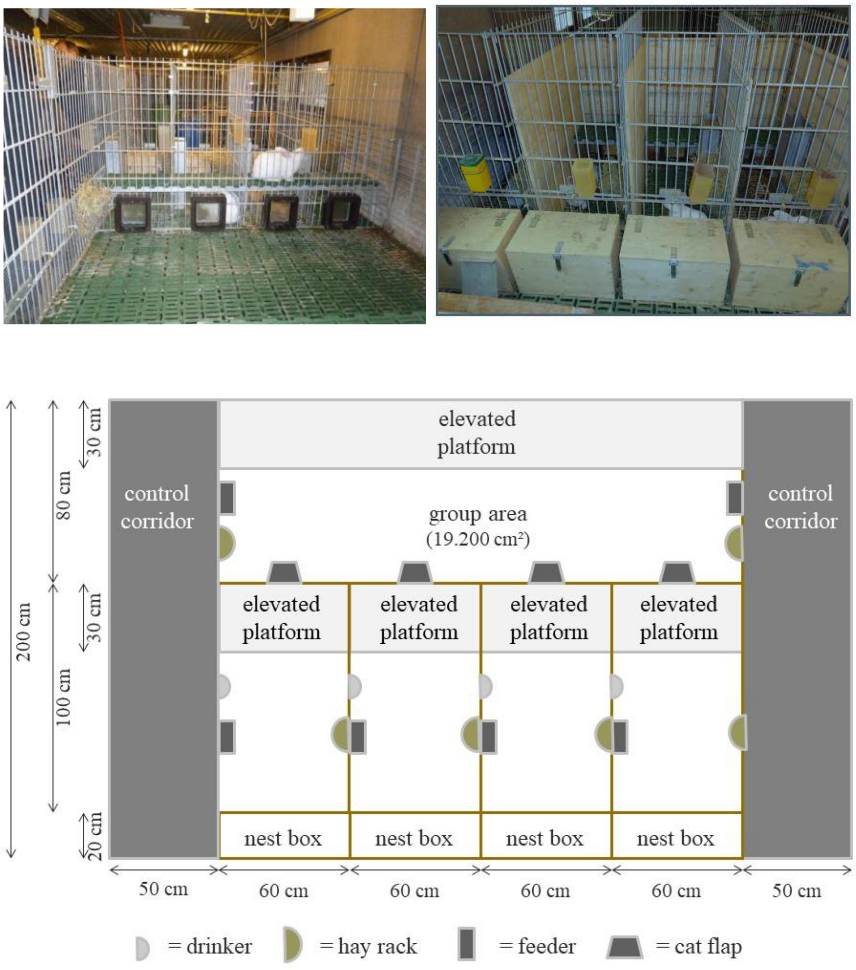


Figure 5: Combination of the individual and group housing (common area, single area, design of pen)

Rabbit does spent 67-100% of their time in the single area; some of them did not go to the common area. It can be assumed that those females who did not or rarely visited the group area were subdominant animals. The mortality rate of kits was twice as high (18.1%) as in individual housing (9.2%). The reason could be that when kits left the

cage some of them have not found their way back to the nest in time for suckling.

In a similar system (Figure 6) Hungarian scientists observed the preference and aggressive behaviour of does (Matics *et al.*, 2017). At the beginning of the experiment the non-pregnant and non-lactating does were individually housed in the closed cages (4 does/pen) for 3 days, to train to use their own cages. After the adaptation period, the doors of the cages were opened to allow the does move freely. The experiment lasted for 14 days.

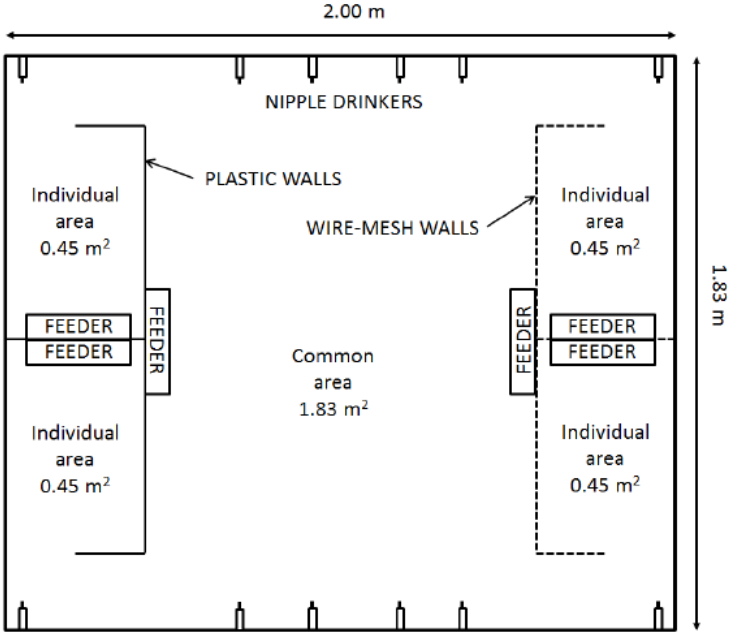


Figure 6: Combination of individual and group housing

During the whole experimental period the rabbit does located alone more frequently than together. Frequency of the behavioural patterns

(fighting, chasing, “mating attempts”) were the highest on day 1, and the frequency of “mating attempts” (similar to mating but between two does) was high until the end of the experiment. The occurrence of injuries on rabbits were between 17 and 50% in the whole experimental period.

In Hungary, a group housing system, recommended by the Four Paws’ (Vier Pfoten) animal protection organization was investigated (Figure 7). The results will be shown in “Chapter 5.1. Experiment 1”.

Figure 7: Group-housing system, recommended by the Four Paws

Szendrő *et al.* (2016) investigated the frequency of aggressiveness in group housed does. Four does and a buck were housed in a pen. The ages of female rabbits were the same (homogenous, HOM), or one of

them was almost 1 year old (heterogeneous, HET). The numbers of fights were 154 and 108 in groups HOM and HET, respectively. The dominant does had attacks against the other does 77 times and the doe in the last position 5 times in HOM group, the same figures were 92 and 5 in HET group. The number of attacks by does in position 2 and 3 were 35 and 37 in HOM group and they were 7 and 4 in HET group, respectively. In HET group the older doe clearly occupied the first rank position, in HOM group more competitors fought for a better position, so the group stability was better in HET than in HOM group. The mating behaviour of four does and a buck was observed during the month after the group was established (Gerencsér *et al.*, 2016). The buck attempted mating with does 206 times in HOM group and 56 times in HET group in total during one month. In the HOM group the number of successful matings was 59. In the HET group the mating was successful a total of 11 times. Based on the results of mating behaviour it can be concluded that the buck mated the preferred does more frequently than the others, meantime other does mated each other which could cause pseudopregnancy. Two mating peaks of activity of bucks were observed at the day of grouping and at the end of the period of pseudopregnancy.

Despite many attempts when does are continuously group housed there is little chance of preventing double littering in the same nest-box, pseudopregnancy, a higher rate of aggressiveness, stress, reducing mortality like infanticide and having performance similar to individual housing.

Because of double littering in the same nest box, killing or injuring kits by another does and pseudopregnancy mainly appear in the period of kindling, therefore a new idea has been implemented, housing rabbit does individually from some days before parturition till kits leave the nest box (3 weeks) and regroup the does for the next 3 weeks (together their kits). The method was initially called park system (which was misleading), but later a more correct name was given, semi-group housing system.

2.2.1.2. Semi-group (part-time) housing of rabbit does

In continuous grouping systems does are together for longer times and only the dead or culled rabbits have to be replaced, or when the numbers of does in the groups are too low, new groups are established. In case of semi-group housing systems, pregnant does before kindling are grouped, so in each reproductive cycle mainly unfamiliar does are in a group.

Mugnai *et al*. (2009) housed four pregnant does for five days prior to kindling in a 1.52 m^2 pen with four nest boxes (Figure 8). After weaning, the does were placed into individual cages and they were artificially inseminated.

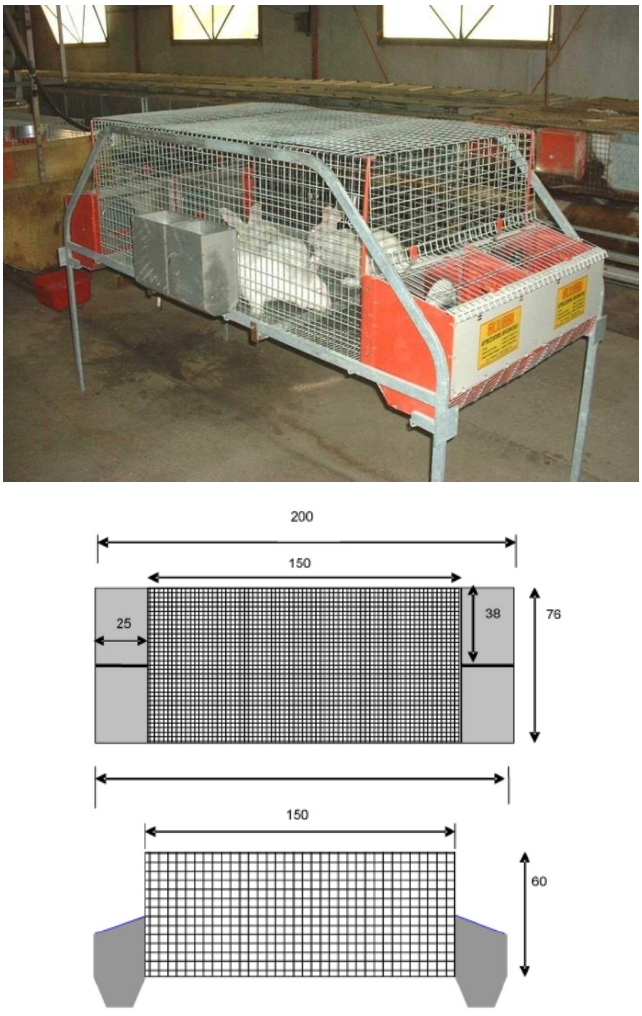


Figure 8: Italian semi-group housing system

Two subgroups were formed: trained (TC) and not trained (UC) to recognize their own nest box. In the TC group, during the first two days after grouping (five days before kindling), the does were put into their own nest for 10 min. A lower fertility rate for group-housed does (41, 61 and 76% in the UC, TC and S /single housing/ groups, respectively) and a decreased litter size (by 1.3 kits/litter) compared to singly housed

does, but the suckling mortality was not different among groups. The annual replacement was 21 and 13% higher in the UC and TC groups, respectively, than in the S group. Number of rabbits sold/year/doe was significantly lower in group-housed does (17.7, 24.9 and 30.8 kits in groups UC, TC and S, respectively). The interactions between animals were sometimes aggressive, particularly in the UC group (attack: 27 *vs* 14%, in comparison to TC does). The ratios of severely injured does were 8.3 and 3.8% in the UC and TC groups, respectively.

In the experiment of Trocino *et al*. (2016) multiparous pregnant rabbit does were housed in individual cages or in groups of 2 or 4 animals. The most frequently observed aggressive interactions were biting and attacking, the next frequent were threatening, boxing and carousel fights, the least observed interaction was chasing. The frequencies of ripping and mount attempts were very low. More aggressions and longer periods for establishing hierarchy were observed on the first group formation and with does close to the kindling, while less aggressions and shorter periods for group stabilisation were noticed at the re-introduction in group and at the end of the lactation period.

In Switzerland rabbit does are housed in modified Stauffacher systems (Andrist *et al*., 2013). Using AI and a 42-day reproductive rhythm, does are held in individual cages from the 30th day of pregnancy until 12 days after birth. After AI, does are grouped in open top pens (5.7m^2) furnished with elevated areas, hiding places, and eight nest boxes. The kit areas of the unit are also created, where kits can move through a small hole to gain access.

In Belgium and The Netherlands cages with elevated platforms are used (Figure 9).

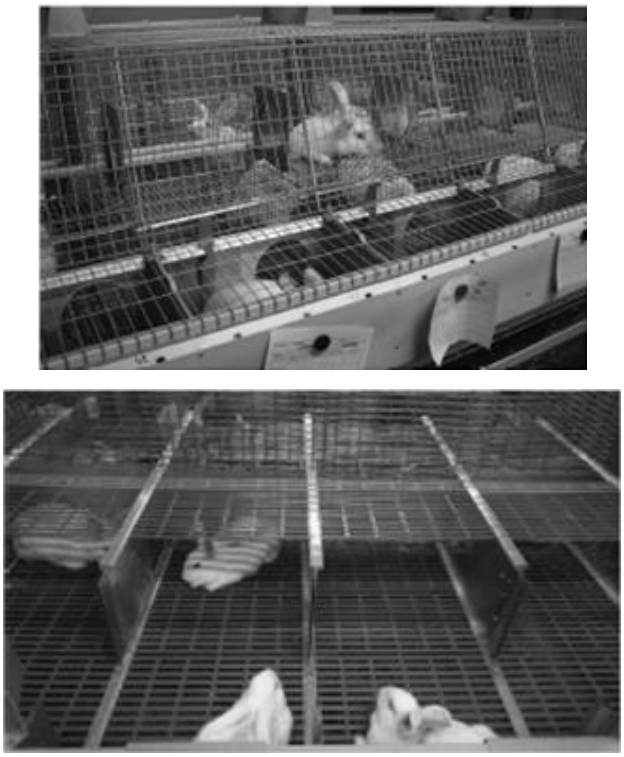


Figure 9: Dutch-Belgian system

The sizes of semi-group pens are 1.0 m × 1.5 m × 0.6 m (length × width × height) which consist of 4 individual cages, and the 3 walls are taken out to create the group-pen (Maertens *et al*., 2011; Buijs *et al*., 2014). In these systems does are housed individually from some days before the kindling till 18th day of lactation (during 3 weeks) while they are housed in groups during the subsequent 3 weeks. After regrouping, in the pens there are small openings into the nest boxes where the kits can escape from the does, similar to the kit's area in the Stauffacher system.

Using AI and a 42-day reproductive rhythm, after weaning the pregnant does are mixed in a new group and the kits stay in a large group in the semi-group pen, and the all-in, all-out system is accomplished (Maertens and Buijs, 2013).

Maertens and Buijs (2016) compared the individual and semi-group housing systems. In the period immediately after grouping, hopping and sniffing/allo-grooming took up 1.3-4.3%, whilst in cages these behaviours took up 0-0.7%. However, 4 and 11 days after grouping, treatment differences were much smaller. It was interesting that the semi-group does did not spend significantly more time in body contact than the individually caged does. Immediately after grouping, agonistic behaviour took up 7.3% of semi-group does' time, whilst – of course - it was absent in the cages. Although agonistic interactions decreased very rapidly after grouping, they resulted in skin lesions in many does (58% showed slight lesions and 20% more severe lesions).

The main problem with these systems is that after regrouping of does, a high incidence of aggressive interactions and injuries were observed. According to Andrist *et al*. (2013) on farms without or with regrouping the percentages of does with lesions were significantly higher in case of regrouping (28 vs. 40%, respectively). This is why some researchers tried to find methods for reducing the occurrence of aggression and related injuries and stress in the semi-group system.

In the experiment of Rommers *et al*. (2014) all combinations of the following enrichments were randomly assigned: hiding places (platform and PVC pipe), straw and territory (i.e. familiarity with the cage before grouping) (Figure 10). On average, 52% of the does had

injuries on the body and ears, and the percentages of severe injuries were 13-39%.

Figure 10: Pen enriched with platform, tube and straw

In another experiment (Rommers *et al*., 2013) four possibilities for escaping and hiding in pens with different installations were compared: does could jump on a platform, PVC pipes or wooden panels were placed under the platform, and a hidden dark corridor was established at the front side of pen. The conclusions were that wooden panels and PVC pipes seemed to be the best opportunities for escape but the dark corridor was unsuitable for this purpose.

In Switzerland rabbit does were regrouped in the home or a novel pen (Graf *et al.,* 2011). Two unfamiliar rabbits were allocated to each group. The number and duration of agonistic interactions were not significantly affected by the treatments. Andrist *et al*. (2012) examined the effect of group stability: no new rabbits were introduced in the

group or 2 or 3 does were replaced by unfamiliar does after the isolation phase. They observed lesions on 46% of the does after regrouping. More lesions were found on new does compared to those that stayed in the same group. Authors suggested maintaining the group composition as long as possible. However, it is questionable what is better for a farmer: maintaining the group composition with a decreasing number of does or replacing the dead and culled animals. In another experiment Andrist *et al*. (2014) sprayed the rabbits with alcohol or vinegar when unfamiliar does were placed in the group after isolation. They found lesions on 60% of the does and that of 32% were severe lesions. According to the results, masking the group odours had little effect on lesions, stress and agonistic interactions.

Different strategies were tested without great success to reduce the number of injured rabbit does even if aggressive interactions decreased some days after the group formation (Maertens and Buijs, 2016b; Zomeno *et al*., 2017b). Surely the time of group formation (early or late lactation) may have a large influence on the aggression levels (Zomeno *et al*., 2017a,b). The little available information also shows the negative effect of the increase of group size on aggressiveness (Zomeño *et al*., 2017b; Buijs *et al*., 2016).

Despite under these systems the reproductive performance of does may be comparable with the individual housing (Maertens and Buijs, 2013, 2015, 2016b), still problems with aggressiveness, fighting and the percentage of injured rabbits after grouping remain an unsolved problem (Andrist *et al*., 2012, 2013; Maertens and Buijs, 2016a).

According to the Belgian scientists, part-time group housing systems of does have shown potential (some problems e.g. pseudopregnancy, double littering, low productivity were solved), but further research is necessary to better understand and avoid the high level of aggressive behaviour.

The main benefit of living together is that wild European rabbits have greater chance to survive the risk of predation. Since there are no predators in farms, in group housing systems almost all of the disadvantages remain, but most of the benefits are lost. Compared to the group housing system when does are continuously together, some problems are solved in the semi-group housing system. These systems fit with the actual good practices of large farms such as AI, batch and all-in all-out production systems. At the same time aggressive behaviour became a more serious problem. After the end of individual housing when rabbit does were grouped again, the frequency of aggressive behaviour and injuries significantly increased, which is against the animal welfare and contrary to two points of the five freedoms described by the Farm Animal Welfare Council (1992). The goal of group housing of does was to develop an animal friendly system; however the main problems (aggressiveness, injuries, stress) of group-housing of does have not been solved (summarized in Table 1).

Table 1: Frequency of injured rabbits in group housing systems

Housing systems	Injured does	Authors
Group housing systems when does were continuously together		
Stauffacher system	No information	Stauffacher, 1992
4 does/pen (4.5 m^2), AI	32 % during rearing	Mirabito *et al.*, 2005b
8 does/pen (4.5 m^2), clip in ear, AI	17 and 21 %	Rommers *et al.*, 2006
Swiss farms with different systems	33 % (9 % severe)	Andrist *et al.*, 2013
Semi group housing systems		
Trained and untrained does	3.8 and 8.3 %	Mugnai *et al.*, 2009
Familiar and novel pens	2 and 14 %	Graf *et al.*, 2011
Stable or mixed groups	55 % (14 % severe)	Andrist *et al.*, 2012
Isolation, no isolation, AI	40 and 28%	Andrist *et al.*, 2013
Alcohol or vinegar as odour	60 % (32 % severe)	Andrist *et al.*, 2014
Hiding place, straw, territory	52 % (13-39 % severe)	Rommers *et al.*, 2011
Without any treatment	58 % (20% severe)	Maertens and Buijs, 2016

According to our knowledge, individual housing of does is the only one which does not give the possibility for aggressive behaviour among the does which could lead to stress and injuries (serious wounding). Nevertheless, it is important to improve the comfort in individual housing system.

2.2.2. Individual housing of rabbit does

Does are still exclusively housed in individual wire cages together with their offspring till weaning age. In most actual management systems, weanlings remain in the cage while the does are transferred to cleaned and desinfected cages for the next reproduction cycle. Cages are predominantly "dual purpose" thus suitable for reproducing does and after weaning for fattenners which facilitates the all-in, all-out approach (EFSA, 2005). Cages are equipped with feeder, nipple drinker and nest facility but no other structural objects are provided in classical cages.

2.2.2.1. Size of cages

Farmed rabbit does were mainly housed in small cages with a minimum 38 cm of shorter side, a height of 30 cm and a total surface of about 3000 cm^2 (EFSA, 2005). However, rabbit does in small cages have limited space for moving; that may cause mental distress such as boredom, frustration, stereotypical behaviour (Verga *et al.*, 2007).

When females had the choice between pens or cages (i.e. group *vs.* singly housed), they tended to prefer a solitary pen regardless of their social rank (Held *et al.*, 1995). Finzi *et al.* (2010) showed that in separate cages, rabbits were able to maintain a visual relationship by looking at each other. They also showed that an olfactory relationship

could have a similar effect. This could be important in case of individually housed rabbit does.

Increasing the size of breeding cages**,** horizontally or vertically (using an elevated platform), could offer more comfortable housing, and more possibility for locomotion for rabbit does (EFSA, 2005). However, conclusive results whether the enlarged or enriched cages provide the expected advantages are not provided by the experiments conducted thus far. In larger (0.30 vs. 0.60 m^2, 0.34, 0.45 vs. 0.59 m^2) or higher cages (0.30 vs. 0.60 m) the reproductive performance of the does did not improve (Rommers and Meijerhof, 1998; Mirabito *et al.,* 2005a). Bignon *et al.* (2012) compared two different sized cages: standard (25 x 46 x 28.5 cm) and larger (33 x 68.5 x 40 cm). They did not find any difference in reproductive performance of young does, however the does in the larger cages were more active (sitting, standing, moving) and they spent less time in lying position compared to the standard cage. Larger cages would offer more comfortable housing, and more possibility for locomotion to rabbit does (Szendrő and McNitt, 2012). Indeed, performance was not affected by cage size (Mirabito *et al.*, 2005; Rommers and Meijerhof, 1998), whereas Prola *et al.* (2013) observed higher faecal corticosterone levels in smaller cages than in the larger ones (83 x 38 x 32 cm vs. 113 x 46 x 46 cm) which could be related with the stress level. Selzer *et al.* (2004) examined the nursing behaviour of does in relation to the cage size. Nursing activity of does tended to decrease with increasing cage size: the mean numbers of nursing events a day were 1.37, 1.26 and 1.25 in in standard, and two and three times larger cages and 1.32, and 1.25 and 1.11 in standard, and two and three times larger enriched cages, respectively.

Negretti *et al.* (2010) found that in case of adult rabbits only 0.5% of the total time was employed in postures which required more than 40 cm height. In another experiment (at Kaposvár University, unpublished results), the preferences of adult does were observed among cages with differing heights. Compared to the random preference (25%/cage), the frequency of rabbits staying in cages with 30, 40, 50 cm heights or open tops were 26, 31, 32 and 11%, respectively. It appears that adult rabbits do not like staying in open-top cages, and a 40 or 50 cm high cage seems to be preferable.

Housing the does in larger or higher cages had little or no effect on their performance, but they had more space for moving which is beneficial from animal welfare point of view.

2.2.2.2. Cages with platforms

The size of cages can also be increased in the third dimension, by inserting elevated platforms. Although, it seems that rabbits are motivated to gain access to a platform (Seaman *et al*., 2008), advantages and disadvantages are claimed. Advantages of the platform are the larger floor size (two levels), more moving possibility (jumping up and off the platform), and possibility for does to escape from the suckling attempts of kits when they leave the nest box (Mirabito *et al.*, 1999; Selzer, 2000), whereas no (Mirabito, 2002, 2003) or limited effects on doe's performance were observed.

Mirabito *et al.* (1999, 2005a) and Mirabito (2002) did not observe any differences in kindling rate, litter size, suckling mortality, or survival of does between groups with and without platforms or with and without

tubes. According to Barge *et al*. (2008), litter size (6.58 vs 7.33), body weight of the does, and litter weight (2.07 vs 2.31 kg) and individual weights of the kits (747 vs 647 g) were significantly higher in cages with a platform, however the kindling rate (87.7 vs 77.6%) substantially decreased, and the number of kits at 19 d per AI was larger in the cages without a platform (575 and 547 kits at 19 days /100 AI). Alfonso-Carillo *et al*. (2014) observed 4.5% higher litter weights at 21 days of age and 5% better feed conversion ratio in cages with elevated platforms.

Different disadvantages are also mentioned from the point of view of daily health-check because the animals below the elevated platform are less visible.

Mirabito *et al*. (1999) observed that rabbit does preferred to use the platform during the light period. Non-lactating does (27%) and lactating does (20%) at the second week of lactation spent less time on the platform than after their kits left the nest boxes (35%), although kits between ages of 25-35 days also stayed on the platform (16%). Similar observations were made by Mirabito (2002) when, after nursing, kits were moved into another cage or kits and does were in the same cages, because does spent less time (12-16%) on the platform when the kits were in another cage than when they were housed together (32-42%).

2.2.2.3. Floor type

One of the most important elements of cages is the floor where animals stay (rest or move).

Under farmed conditions, because of hygienic reasons, rabbits are almost exclusively housed on wire mesh flooring. In contrast with fattening rabbits, sore hocks problems are frequently observed in does (Rosell and de la Fuente, 2013). Because of the weight of does and the long-time living in cages or pens on wire-mesh floor sore hocks (pododermatitis) formation could be very frequent (Rosell and de la Fuente, 2009; de Jong et al., 2008). The incidence rates of sore hocks were 71.5 and 15.1% and that of plantar hyperkeratosis were 100 and 64.5% in cages without and with plastic footrests. The serious form of sore hocks can cause chronic pain and suffering (Rosell and de la Fuente, 2013) as well as doe culling (Rossel and de la Fuente, 2004). De Jong *et al*. (2008) established that the percentages of does with different footpad injury scores were independent of the wire thickness of the floor (2 or 3.02 mm). Plastic mats seemed to have a positive effect against sore hocks. In another study, based on the 0 (none) to 4 (wounds) scoring system, the average sore hocks score increased between parity 0 and 4 from 0.04 to 0.75 and from 0.04 to 0.43 in cages without and with foot rests, respectively (Rommers and de Jong, 2011). Buijs *et al.* (2014) observed the incidence of sore hocks in individual cage with footrest, semi-group housing with footrest, semi-group housing with plastic slatted floor. Severe sore hocks were not observed, although after reproductive cycle 4 the appearance of hair loss and callus formation was the lowest in pens with plastic slatted floors (5 vs 65 and 68%, respectively). Several experiments demonstrated that equipping the cages and pens with plastic footrests on wire-mesh floors or plastic-mesh elevated platforms played a significant role in the prevention and alleviation of sore hocks. Because of the clear

advantages of footrest, the percentage of farms using footrests increased from 27.8% in 2001 to 75.2% in 2012. At the same time the percentage of does with sore hocks decreased from 11.4% to 6.3% (Rosell and de la Fuente, 2013).

It can thus be concluded that plastic footrests and/or plastic-mesh platforms in conventional or enlarged cages have the potential to improve animal welfare.

There are always appearing new proposals and expectations of animal welfare organizations concerning the housing of farmed rabbits. The cage manufacturers continuously develop the technology (size, material, equipment) to meet these requirements. In literature data, experiments in different housing systems for rabbit does revealed both advantages and disadvantages, although, some results were contradictory depending on the viewpoint of examination. The investigation of newly developed housing systems from different aspects is inevitable, because these have to serve the well-being of animals and the expectations of the farmers simultaneously.

3. AIMS OF THE PHD RESEARCH

Due to the demands from the side of the consumers and animal protection organizations searching for animal friendly conditions in intensive rabbit housing systems has a growing interest. New ideas and developments emerge from time to time which have to be thoroughly investigated before using them in the practice of rabbit farms.

The aim of this PhD thesis was to study newly developed housing systems, cage equipment and elements.

The objective of the first study was to compare the generally used individual-housing system of rabbit does (single-caged) with the group-housing system recommended by an animal protection group to identify the most important differences, with a special emphasis on animal welfare.

The aim of the second experiment was to specify the space requirement of non-pregnant and lactating rabbit does based on location preference between different sized cages.

The objective of the third experiment was to examine the effects of four commercial cages with or without footrests and equipped or not with platforms on productive performance, nursing behaviour, the occurrence of sore hocks and the platform utilization of rabbit does and kits.

4. GENERAL MATERIAL AND METHODS

The applied materials and methods are presented in the following scientific papers in details. Presenting the data in this separate chapter is not justified and would cause unnecessary repetitions.

5. RESULTS

Based on the aim of my PhD research the results of the experiments are presented in three published scientific papers.

5.1. EXPERIMENT 1

Comparison of performance and welfare of single-caged and group housed rabbit does

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Comparison of performance and welfare of single-caged and group-housed rabbit does

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Although rabbit does are generally single housed on rabbit farms worldwide, it has been suggested by some specialists and recommendation of organic rabbit production systems that group housing of does is more comfortable and similar to the living conditions of the European wild rabbits. The aim of this experiment was to compare production of single-caged (S) and group-housed does (G). The S does were housed in commercial rabbit cages (floor area 0.32 m² and 0.3 m high). In treatment G, four does and one buck were housed in four pens measuring 7.7 m² (half of the floor was deep litter and the other half was plastic slat), with four nest boxes in each pen (n = 16). In treatment S, approximately half of the does (n = 18) were inseminated 2 days after kindling (S-33), whereas in the remaining does (n = 16) AI was done 11 days after kindling (S-42). A single-batch system (all of the does in the group were inseminated on the same day) was used in both S treatments. Kindling rates were 77.6%, 85.2% and 45.6% in treatments S-33, S-42 and G, respectively (P < 0.05). During the experiment, the percentage of does that kindled 0, 1, 2, 3, 4 and 5 times were 17%, 25%, 17%, 25%, 17% and 0% (G); 0%, 0%, 0%, 8%, 69% and 23% (S-33); and 0%, 0%, 17%, 58% and 25% (S-42, in this treatment does had a maximum of four kindlings). There were no significant differences among treatments for litter size. In treatments S-33, S-42 and G, suckling mortality was 14.0%, 15.2% and 38.5%, respectively (P < 0.001); survival of does was 71%, 81% and 50% (P = 0.084); and faecal corticosterone concentrations were 61, 54 and 175 nmol/g (P < 0.001). The high mortality of kits was associated with stress and aggressive behaviour of does, including scratching, biting or killing the kits, which resulted in the high rates of mortality and culling, as well as shorter lifespan of does. Because of high stress, increased mortality and morbidity, and low productivity, group housing of rabbit does resulted in poorer animal welfare and increased production costs, and therefore is not recommended.

Keywords: rabbit does, single housing, group housing, performance, welfare

Implications

Rabbit does are generally housed individually. Recently, some welfare organizations and researchers are in favour of group housing of does, because they believe that this system resembles the living conditions of the European wild rabbit. In this study, a housing system offered by an animal welfare organization was compared with individual housing of rabbit does. The results of the experiment, the related literature and the ethological studies of European wild rabbits justify that in group housing and group living aggression, stress and related injuries, higher mortality and shorter lifespan are observed more frequently, all of which are unfavourable from the welfare aspect. At the same time, production decreases substantially, which makes the production more expensive in group-housing systems.

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Introduction

When they were first domesticated and raised intensively, rabbits were reared in groups. In the 19th century, cage rearing became widespread. However, because of several problems, housing rabbit does in groups was abandoned in France in the late 1970s (Mirabito *et al.*, 2005a). Numerous advances including introduction of wire mesh cages, intensively selected genotypes, artificial insemination, cycled reproduction, balanced pelleted feed and automatic feeders were important steps towards intensive rabbit production (Lebas *et al.*, 1997). Nowadays, rabbit does are generally housed individually (European Food Safety Authority (EFSA), 2005). However, there

is an increasing demand for products originating from rabbits reared using natural systems. There are recommendations suggesting group housing of rabbit does or even regulations that make this system compulsory (such as Bio Suisse /www.bio-suisse.ch/, Naturland/www.naturland.de/). Some principles of group housing rabbit does is similar to those of the European wild rabbits. In this regard, rabbits are group-living social animals, exhibiting several social behaviours (aggressive or friendly); mating is natural, and maternal behaviour is not restricted (EFSA, 2005). In rabbit farms, some does are housed together with a buck and the does can freely choose their place of kindling (there is at least one nest box for each doe) and the does can freely nurse their kits.

Various group-housing systems have been evaluated. In the following sections, we summarize the key features of these systems. In one of the first experiments, one buck and four does were housed in a pen having a basic area of 9 m^2, which was split into various areas: feeding (feeder, drinker and hay rack), breeding (deep litter floor and four nest boxes with tunnel-like entrances) and resting places, with various elements to enrich the environment (Stauffacher, 1992). In this system, does could freely nurse their kits. However, there was no control group as a basis of comparison. In another study (Baumann *et al.*, 2003), one buck was kept with 8 to 10 does in a structured multi-level pen, with areas for withdrawal, feeding, nesting and for the kits. It is noteworthy that natural mating was replaced by artificial insemination (AI) in several studies (Mirabito *et al.*, 2005a and 2005b; Mugnai *et al.*, 2009). Mirabito *et al.* (2005a) reared together four young females and when these rabbits became adults they were housed in groups. The pens had a basic area of 4.5 m^2 and were split into two parts: feeding, breeding and rearing the kits, and the area with four nest boxes. Free nursing was applied. Mugnai *et al.* (2009) placed four does in a cage of 1.14 m^2. Two subgroups were formed: trained or not trained to recognize their own nest box. They were housed in groups 5 days before kindling, and after weaning they were inseminated in individual cages. The does nursed their kits once a day. In Switzerland, the rabbit does are generally group housed (G). The buck is usually placed into the pen *postpartum* (33-day reproduction rhythm) for 10 days. Nowadays, many breeders start to apply artificial insemination using 33- or 42-day reproduction rhythm. In the 42-day rhythm, the does are housed individually in a separate compartment with a nest within their group pen from day 30 of pregnancy until insemination at day 12 after parturition, when they are inseminated (Andrist *et al.*, 2011).

Ruis and Coenen (2004) summarized the main problems of group housing of rabbit does as follows: (1) high suckling mortality, basically caused by the free entrance of does to nest boxes of other does; (2) problems with the replacement and introduction of new does in groups, owing to high aggression in group housing during the breeding period; (3) labour-intensive system, owing to monitoring and cleaning; (4) the need for a high hygienic standard; (5) the inability to conclusively identify the dam, making selection of breeding does more difficult; and (6) higher production costs in group-housing *v.* individual-housing systems. To overcome previous problems and deficiencies, a new group-housing system, similar to the Stauffacher system, was developed (Rommers *et al.*, 2006; Ruis, 2006). The pen (basic area: 4.5 m^2) was divided into three parts: breeding part with elevated floor and a tunnel-like link to the nest box, feeding area and kit area where the does could not enter. Unique to this system was the individual electronic nest box recognition system (INRS). A clip was attached to the ear of each doe, enabling only her to open the door to her nest box (and excluding all other adults, as well as her kits, once they left the box). First, natural mating was applied, but later it was changed to artificial insemination (Rommers *et al.*, 2006).

Despite the problems and limitations with group housing of does, this system is widely recommended and there are efforts to make its use obligatory. Therefore, the objective of this study was to compare the generally used individual-housing system (single-caged) with the group-housing system recommended by an animal protection group.

Material and methods

This experiment was conducted at the Kaposvár University using maternal line rabbit does of the Pannon Rabbit Breeding Program. The temperature in the room was 15°C to 17°C, and it was illuminated by natural light (windows), with artificial lighting used to achieve 16 h of light. Rabbits received a commercial pellet *ad libitum*. The G does and kits had access to hay and litter material (straw). Water was available *ad libitum* from nipple drinkers.

From 10 weeks of age, female rabbits were housed individually and at the age of 17 weeks they were randomly allocated to three treatments. In two treatments (S-33 and S-42), does were housed individually in wire mesh cages. The size of the cage was 84 × 38.5 cm, including the nest box (26 × 38.5 cm). The individually housed rabbits were inseminated artificially (AI). The litters were equalized only within treatments. In case of individual housing, does that died or were culled during the experiment were not replaced. The characteristics of the three experimental treatments were as follows:

Treatment S-33 ($n = 18$): a reproduction rhythm of 33 days was used; does were inseminated 2 days after kindling, applying a single-batch system. This reproduction rhythm corresponded to group housing where the buck was kept continuously with the does and could mate with the does immediately after kindling. The does could freely nurse, and the kits were weaned at 28 days of age.

Treatment S-42 ($n = 16$): a reproduction rhythm of 42 days was used. Does were inseminated 11 days after kindling, applying a single-batch system, the system most frequently used on large-scale rabbit farms. Does could freely nurse their kits. However, for 3 days before AI, does were allowed to nurse their kits only once a day (in the morning). Kits were weaned at 35 days of age.

Treatment G ($n = 16$): does were housed according to the recommendation of an animal protection group (Vier Pfoten; Supplementary Photo S1). Four does and one buck were placed in each of the four pens, with a basic area of 7.7 m^2. Within the pen, one part of the basic area (2.8 × 1.5 m) was covered with straw (replaced as needed), whereas the floor of the other part (2.8 × 1.25 m) was plastic mesh. Every pen was equipped with a 40-cm-wide feeder, five nipple drinkers, hay rack, four wooden nest boxes (30 × 40 × 30 cm) and a plank tube for hiding. The does could build their own nests. Before the first kindling, straw was placed in the nest boxes; this material was removed by the does and they collected the nest material in the pen. Daily observations and management procedures (including putting kits back into nest boxes) were made with the least possible disturbance. Kits were weaned at 28 days (all treatments). In group housing, to maintain the group size, does that had died or were culled were replaced on a single occasion (126 days after the start of the study) with females of similar age (production of these does were not evaluated). The duration of the experiment was 193 days. Throughout the experiment, the does of the G and S-33 treatments had five kindlings, whereas S-42 does had four kindlings.

Suckling mortality was noted on a daily basis. In group housing, the occurrence of 'abnormal' behaviours (e.g. two does kindling in the same nest box, or locating the kits outside the nest box) was also recorded. The litter sizes of the G treatment were known only while the kits remained in the nest boxes. In addition to comparison of production traits, the number of rabbits weaned annually in each treatment was related to each doe. In the G treatment, infrared cameras (placed above the pens) enabled 24-h recordings throughout the experiment. The does were marked (to allow individual identification), and their behaviour before and after kindling (e.g. nest building, nursing) was assessed.

At 145 to 146 days after the start of the experiment, faecal samples were collected to determine corticosterone concentrations. Individual samples were easily collected from single-caged (S) does, whereas from G treatment mix faeces, as pooled samples, were collected. 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 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, +4°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 diluted with phosphate-buffered saline buffer (pH 7.4). Corticosterone concentrations were measured in triplicate 20-μl aliquots of faecal extracts with H3-RIA method. Standards were: 3.9, 7.81, 15.625, 31.25, 62.5, 125, 250, 500, 1000, 2000, B/T%: 28.

Data were evaluated with the SPSS 10.0 software package. Production traits were evaluated by means of one-factor ANOVA. The applied model was as follows:

$$Y_i = \mu + G_i + e_i$$

where μ is the general mean and G_i the effect of the treatment ($i = 1–3$). Kindling rate and suckling mortality were analysed by χ^2-test and doe survival was evaluated by survival analysis using the SPSS 10.0 software.

Results

For the whole period (193 days), G does had lower ($P < 0.05$) kindling rates than S-33 and S-42 treatments (45.6%, 77.6% and 85.2%, respectively; Table 1). The kindling rate never exceeded 50% in the G treatment. The kindling rate was highest for S-42 does (81.3% to 87.5%), and overall the S-33 treatment was also high, except for the primiparous does where it was low. Twenty-three and 25% of does that survived until the end of the experiment in the S-33 and S-42 treatments, respectively, kindled at every occasion (5 times and 4 times, respectively), although none of the G treatment does had similar performance. None of the does in the S-33 or S-42 treatments kindled only once or twice during the experiment, whereas that occurred in 41.7% in the G treatment. Litter size was not significantly different among treatments (Table 2). However, the number of kits born dead was the highest for the S-42 treatment ($P < 0.05$); this was consistent among kindlings. Suckling mortality was

Table 1 *The effect of housing system on kindling rate (%) of does*

	Treatments				
Kindling order	S-33	S-42	G	χ^2	*P*-value
1	88.3^{b}	87.5^{b}	50.0^{a}	8.56	<0.05
2	56.3^{ab}	87.5^{b}	46.7^{a}	6.15	<0.05
3	81.3^{b}	81.3^{b}	30.0^{a}	9.14	<0.05
4	92.3^{b}	84.6^{ab}	50.0^{a}	5.60	<0.05
5	76.9	–	50.0	1.54	ns
1 to 4/5	77.6^{b}	85.2^{b}	45.6^{a}	25.65	<0.05

S-33 = single-housed does, reproduction rhythm of 33 days; S-42 = single-housed does, reproduction rhythm of 42 days; G = group-housed does.
^{a,b}Means within a line with different superscripts differ ($P < 0.05$).

Table 2 *The effect of housing system on litter size (1 to 4/5 kindlings)*

	Treatments				
Litter size	S-33	S-42	G	s.e.	*P*-value
Total	9.10	9.44	9.88	0.26	0.534
Alive	8.77	8.58	9.69	0.25	0.246
Stillborn	0.33^{ab}	0.86^{b}	0.19^{a}	0.11	0.034

S-33 = single-housed does, reproduction rhythm of 33 days; S-42 = single-housed does, reproduction rhythm of 42 days; G = group-housed does.
^{a,b}Means within a line with different superscripts differ ($P < 0.05$).

Table 3 *The effect of housing system on suckling mortality (%)*

	Treatments				
Kindling order	S-33	S-42	G	χ^2	*P*-value
1	24.2^{ab}	20.0^{a}	36.2^{b}	10.74	<0.05
2	10.9^{a}	9.3^{a}	47.1^{b}	41.29	<0.05
3	10.0^{a}	15.4^{a}	35.5^{b}	12.39	<0.05
4	3.2^{a}	18.2^{b}	44.2^{c}	27.59	<0.05
5	18.8	–	23.1	0.38	ns
1 to 4/5	14.0^{a}	15.2^{a}	38.5^{b}	73.63	<0.001

S-33 = single-housed does, reproduction rhythm of 33 days; S-42 = single-housed does, reproduction rhythm of 42 days; G = group-housed does.
^{a,b,c}Means within a line with different superscripts differ ($P < 0.05$).

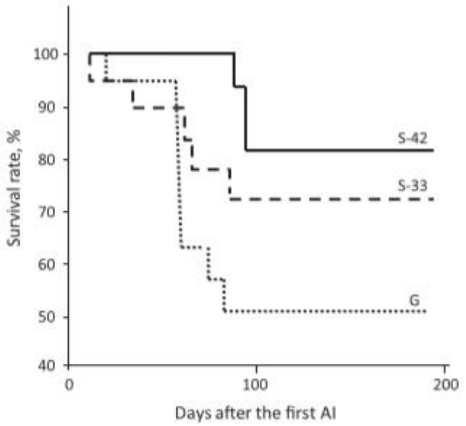

Figure 1 The effect of housing system on survival of the does. S-33 = single-housed does, reproduction rhythm of 33 days, S-42 = single-housed does, reproduction rhythm of 42 days, G = group-housed does.

more than twofold in the G treatment compared with the S-33 or S-42 treatments ($P < 0.001$; Table 3).

The frequency of multiple kindling in the same nest box was 7.7% for the does housed in groups. For example, on one occasion, a doe gave birth to 10 well-developed kits. Four days later, another doe kindled 15 kits in the same nest box. Up to 20 days of age, 80% of the kits born into this nest box were dead. In addition, two does kindled in deep litter, and all kits died within 1 or 2 days (as exact litter sizes could not be determined for the does, these kits were not used for calculating suckling mortality). In the G treatment, 49 young rabbits (<14 days old) were found outside the nest box, either on the plastic slats or in deep litter. Many of these kits had injuries attributed to biting or chewing, some of which may have incurred when kits were removed from the nest box. On one occasion, kits were scraped out of the nest box by a buck and this buck also chewed some kits.

Survival rates of does are shown in Figure 1. At the end of the experiment, the survival rates of the S-33, S-42 and G does were 71%, 81% and 50%, respectively ($P = 0.084$). Most of the G does that died were emaciated, although one died subsequent to fighting (confirmed by the video recording) and was in good body condition.

Table 4 *The effect of housing system on corticosterone level in does*

	Treatments				
	S-33	S-42	G	s.e.	*P*-value
n	10	12	4		
Mean (nmol/g)	61.0^{a}	53.6^{a}	174.6^{b}	10.2	<0.001
s.d. (nmol/g)	14.6	7.9	77.9		

S-33 = single-housed does, reproduction rhythm of 33 days; S-42 = single-housed does, reproduction rhythm of 42 days; G = group-housed does.
^{a,b}Means within a line with different superscripts differ ($P < 0.05$).

The 'kit index' (kindling rate times litter size total born kits) led to large differences between treatments, calculating the number of total born kits per 100 inseminated does at 706, 804 and 451 in S-33, S-42 and G treatments, respectively. During the entire experiment (193 days), the number of weaned rabbits per doe (calculated on the basis of the number of reproductive cycles (five or four in treatments G and S-33 *v.* S-42, respectively), kindling rate, litter size (number of kits born alive) and suckling mortality in the S-33, S-42 and G treatments were 29.3, 24.9 and 13.6, respectively.

Faecal corticosterone concentration of does housed in groups was approximately 3 times higher than for does caged individually (174.6 and 56.9 nmol/g, $P < 0.001$; Table 4).

Discussion

Kindling rate and litter sizes (total, alive, weaned) of rabbit does mated naturally or inseminated artificially did not differ significantly (Alabiso *et al.*, 1996); therefore, the differences between G and S-33 or S-42 treatments were independent of the reproductive method.

Kindling rates of S does were 77.6% and 85.2% in the S-33 and S-42 treatments, respectively. The best results were achieved in the S-42 treatment, which was expected, but the results of S-33 treatment was excellent compared with our former results (Szendrő *et al.*, 1999). *Postpartum* mating or insemination typically results in low kindling rates (Poujardieu and Theau-Clèment, 1995). Only primiparous does in the S-33 treatment had a reduced kindling rate (56.3%), which was attributed to a negative energy balance during the first pregnancy and lactation (Xiccato, 1996). The kindling rate (45.6%) of the G treatment was in contrast to a previous report (Stauffacher 1992) of excellent fertility in group-housed does. Similarly, Mirabito *et al.* (2005a) found no significant differences between the kindling rates of G and S does, whereas Rommers *et al.* (2006) and Mugnai *et al.* (2009) reported a lower kindling rate for G does, although the rates were not suppressed to the extent that they were in the present study. Compared with our study, these authors found smaller differences to the advantage of the S rabbits. Both of these studies used AI 11 days after

kindling (Rommers *et al.*, 2006) or after weaning (Mugnai *et al.*, 2009). Rommers *et al.* (2006) kept the does in groups until AI, but Mugnai *et al.* (2009) after weaning moved the does into a single cage and submitted to AI. Andrist *et al.* (2011) also reported a low kindling rate, which was independent of the mating system (natural mating or AI).

The percentage of does surviving until the end of the experiment and within one kindling of the maximum number was 92%, 83% and 16.7%, respectively, for S-33, S-42 and G does. Furthermore, in the S-33 and S-42 treatments, none of the does had only one or zero kindlings, whereas this was the case for 41.7% of G does. The low kindling rate in the G treatment was attributed to aggressive behaviour and stress, consistent with faecal corticosterone concentrations ~3 times higher in the G treatment does than in the other two treatments. These findings are in line with the publications of Holst *et al.* (1999 and 2002) on wild rabbits. Similarly, Rommers *et al.* (2006) and Mugnai *et al.* (2009) reported high corticosterone concentrations for G rabbits. Rommers *et al.* (2006) reported 23% pseudopregnant does, which could also contribute to the unfavourable kindling rate. Andrist *et al.* (2011) evaluated 28 Swiss rabbit farms and reported that 33% of 661 rabbit does had injuries, with severe injuries in 9%. The mean lesion score was higher on farms with an isolation period between littering and AI than in farms without the isolation phase. These results demonstrated that group housing was associated with stress, aggressive behaviour and more injuries.

With regard to litter size, the total number of kits born and the number of kits born alive were not significantly different among treatments. Similarly, other authors (Mirabito *et al.*, 2005a; Rommers *et al.*, 2006; Ruis, 2006) reported no effect of group housing on litter size, except for Mugnai *et al.* (2009) who reported a decreased litter size.

In G rabbits, suckling mortality was very high (~40%), which was 2.5 to 2.7 times higher compared with S rabbits. Similarly, in another study (Mirabito *et al.* 2005a), suckling mortality was approximately doubled when four does were housed in a pen. The high suckling mortality could be related to several factors. One of them is more than one doe kindling in a single nest box. In our study, the prevalence was 8%, similar to a previous report (Stauffacher, 1992). On the contrary, in the experiment of Mirabito *et al.* (2005a) the frequencies of double and triple kindlings to the same nest box were 31.3% and 6.3%, respectively. When there is a time gap between successive litters kindled in the same nest box, the older kits are more likely to find teats and nurse during the short suckling time; therefore, they consume more milk (at the expense of the younger kits). In our study, two does kindled 25 kits in one nest box, 4 days apart, and the suckling mortality in this box was 80%. Suckling mortality could be also increased by does scraping out the kits of other does from the nest box. According to Stauffacher (1992), neither the doe nor the buck showed aggressive behaviour towards the kits. On the contrary, in our study, does (and in one case, a buck) often scraped out other does' kits (and litter material) from the nest box. As a result, 49 young kits were found on the plastic slat or in the deep litter. If the kits are removed at night, they could be out of the nest box for several hours, reducing the chance of survival, as their body temperature quickly decreases when they are out of the nesting box. Furthermore, they were occasionally covered with bites, and in one litter ears and legs were missing.

In our experiment, the survival of G treatment does was substantially lower than that of the S-33 and S-42 does. Similarly, Mugnai *et al.* (2009) reported that the annual replacement was 13% to 15% higher in G does. The substantial differences in faecal corticosterone concentrations were a clear indicator of stress in G rabbits. The association between the stress and health status is well known. In previous studies, 8% to 33% of G does were injured (Rommers *et al.*, 2006; Mugnai *et al.*, 2009; Andrist *et al.*, 2011). In our study, several times does sought refuge from aggression by going into the narrow space between the side wall of the pens and the nest boxes. Furthermore, nearly all G does that died or were culled were in poor body condition, which was attributed to stress.

Group housing of does is against some points of 'five freedoms' (Farm Animal Welfare Council, FAWC, 1992) and the rabbit welfare recommendation (Hoy and Verga, 2006). From the economic viewpoint, the annual number of weaned rabbits per doe is important. This parameter was best for the S-42 treatment, ~12% lower for the S-33 treatment and more than 50% lower for the G does. Furthermore, when the number of weaned rabbits was calculated per 100 m^2 basic area of rabbitry, the difference between the S-42 and S-33 treatments remained constant, but the efficiency of the group-housing system was only 12.4% than that of the S-42 treatment, making it extremely inefficient and likely not cost-effective for meat production.

The disadvantage of group housing of domesticated rabbit does (competition, aggressiveness, fightings, injuries, stress, lower productivity, high mortality of kits, shorter lifespan of does) are well known in the European wild rabbits. Aggressive behaviour is common in different animal species (Kutsukake, 2009), mainly in group-living species, such as the European wild rabbits (Southern, 1948). A dominance hierarchy exists between the females and a separate one between the males in European wild rabbits (Holst *et al.*, 1999 and 2002). Dominant does had higher BW, lower corticosterone level and lower heart rate than subdominant females (Holst *et al.*, 1999). Social subordination leads to stress responses that can greatly impair the reproductive functions of females (Holst, 1998). Holst *et al.* (2002) reported 45.7% kindling rate for the European wild rabbits. The fertility of dominant does was higher, they produced more litters and offspring and the survival of kits was higher than for does with lower ranks. The average suckling mortality of the European wild rabbits was about 40%. The individuals that gained a higher social position had 50% longer reproductive lifespan than lower ranking counterparts (Holst *et al.*, 1999). According to Mykytowycz and Dudzinski (1972), does tolerated their own kits but attacked other young kits. For the European wild rabbits, a

doe–doe competition for a limited number of breeding burrows may have been resulted in infanticide, the killing of conspecific young (Künkele, 1992). According to Rödel *et al.* (2008), the occurrence rate of infanticide for the whole litter was 5% to 6%. Signs of biting were detectable on 68% of dead kits.

On the basis of these findings, it can be concluded that the disadvantages of G domesticated rabbit does also exist for the group-living European wild rabbits. It may be asked why the European wild rabbits live in groups contrary to the mentioned disadvantages, The advantages and disadvantages of living in groups were generally summarized by König (1997) and Kutsukake (2009), and for the European wild rabbits by Cowan (1987). The most important benefits for the European wild rabbits include decrease in predation risk and cooperative construction of warren. Most important costs include increased competition aggressiveness among group members, subdominant female lives under higher stress, increased probability of infection and visibility of predator, defence of territory and vigilance. Animals and also European wild rabbits form groups when the benefits of group living exceed its costs. For domesticated rabbits, there are no predators, there is no need to pay attention to predators and dig a warren, which are the most important benefits of the living in groups; thus, the remaining benefits are the larger available space and the possibility of social interactions. On the contrary, all costs of living in groups remain.

Conclusions

In conclusion, the production of G rabbit does was substantially lower than that of the S does. From the aspect of animal welfare, group housing of rabbit does had several disadvantages: stress related to aggressive behaviour, frequent and harmful injuries, high suckling mortality and short lifespan. Therefore, there was no advantage to the group housing management.

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Supplementary materials

For supplementary material referred to in this article, please visit http://dx.doi.org/10.1017/S1751731112001760

References

Alabiso M, Bonanno A, Alicata ML, Leto G and Todaro M 1996. Productivity of rabbit does subjected to artificial insemination and natural mating. Proceedings of the 6th World Rabbit Congress, Toulouse, France, vol. 2, pp. 29–32.

Andrist CA, Bigler L, Buchwalder T and Roth BA 2011. The extent of lesions in group housed rabbits and potential risk factors. Proceedings of the 17th International Symposium on Housing and Diseases of Rabbits, Furproviding Animals and Pet Animals, Celle, Germany, May 11–12, pp. 34–42.

Baumann P, Bigler L, Buchwalder T and Huber-Eicher B 2003. Recherche pour le bien-être de la volaille et des lapins. Magazine de l'OVF 1, 13–16.

Cowan DP 1987. Group living in the European rabbit (*Oryctolagus cuniculus*): mutual benefit or resource localization? Journal of Animal Ecology 5, 779–795.

European Food Safety Authority (EFSA) 2005. The impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. EFSA Journal 267, 1–137.

Farm Animal Welfare Council (FAWC) 1992. FAWC updates the five freedoms. Veterinary Record 131, 357.

Holst D von 1998. The concept of stress and its relevance for animal behaviour. Advances in the Study of Behavior 27, 1–131.

Holst D von, Hutzelmayer H, Kaetze P, Khashei M and Schönheiter R 1999. Social rank, stress, and life expectancy in wild rabbits. Naturwissenschaften 86, 388–393.

Holst D von, Hutzelmayer H, Kaetze P, Khashei M, Rödel HG and Schrutka H 2002. Social rank fecundity and life time reproductive success in wild European rabbits (*Oryctolagus cuniculus*). Behavioral Ecology and Sociobiology 51, 245–254.

Hoy St and Verga M 2006. Welfare indicators. In Recent advances in rabbit sciences (ed. L Maertens and P Coudert), pp. 71–74. ILVO, Melle, Belgium.

König B 1997. Cooperative care of young in mammals. Naturwissenschaften 84, 95–104.

Künkele J 1992. Infanticide in wild rabbits (*Oryctolagus cuniculus*). Journal of Mammalogy 73, 317–320.

Kutsukake N 2009. Complexity, dynamics and diversity of sociality in group-living mammals. Ecological Research 24, 521–531.

Lebas F, Coudert P, Rochambeau H de and bault RG 1997. The rabbit – husbandry, health and production. FAO Animal Production and Health Series No. 21. Retrieved September 14, 2012, from www.fao.org/docrep/t1690E/t1690E00.htm

Mirabito L, Galliot P, Souchet C, Dumont F and Thomeret F 2005a. Logement collectif des lapines reproductrices: conséquences zootechniques11èmes Journées de la Recherche Cunicole, Paris, France, November 29–30, pp. 53–56.

Mirabito L, Dumont F, Galliot P and Souchet C 2005b. Logement collectif des lapines reproductrices: conséquences sur le comportement11èmes Journées de la Recherche Cunicole, Paris, France, November 29–30, pp. 57–60.

Mugnai C, Dal Bosco A and Castellini C 2009. Effect of different rearing systems and pre-kindling handling on behaviour and performance of rabbit does. Applied Animal Behaviour Science 118, 91–100.

Mykytowycz R and Dudzinski ML 1972. Aggressive and protective behaviour of adult rabbits *Oryctolagus cuniculus (L.)* towards juveniles. Behaviour 43, 97–120.

Palme R, Robia C, Messmann S, Hofer J and Möstl E 1999. Measurement of featal cortisol metabolites in ruminants: non-invasive parameter of adrenocortical function Wiener tieraerztliche. Monatsschrift 86, 237–241.

Poujardieu B and Theau-Clèment M 1995. Productivitè de la lapine et ètat physiologique. Annales de Zootechnie 44, 29–39.

Rödel GH Starkloff A, Bautista A, Friderich A-C and von Holst D 2008. Infanticide and maternal offspring defence in European wild rabbits under natural breeding condition. Ethology 114, 22–31.

Rommers JM, Boiti C, De Jong I and Brecchia G 2006. Performance and behaviour of rabbit does in a group-housing system with natural mating or artificial insemination. Reproduction Nutrition Development 46, 677–687.

Ruis M 2006. Group housing of breeding does. In Recent advances in rabbit sciences (ed. L Maertens and P Coudert), pp. 99–205. ILVO, Melle, Belgium.

Ruis M and Coenen E 2004. A group-housing system for rabbit does in commercial production: a new approach. Proceedings of the 8th World Rabbit Congress, Puebla, Mexico, September 7–10, pp. 1501–1506.

Southern HN 1948. Sexual and aggressive behaviour of the wild rabbit. Behaviour 1, 173–194.

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

Szendrő Zs, Radnai I, ment M, Jovánczai Zs, meth E, Milisits G and Poigner J 1999. Some factors influencing the effectiveness of *post partum* artificial insemination. Proceedings of the 11th Hungarian Conference on Rabbit Production, Kaposvár, Hungary, May 26, pp. 113–118.

Xiccato G 1996. Nutrition of lactating does. Proceedings of the 6th World Rabbit Congress, Toulouse, France, July 9–12, vol 1, pp. 13–47.

5.2. EXPERIMENT 2

Location preference of rabbits does between common sized and double sized cages

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LOCATION PREFERENCE OF RABBIT DOES BETWEEN COMMON SIZED AND DOUBLE SIZED CAGES

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ABSTRACT

The aim of this study was to observe the location preference of non-pregnant (n = 44), pregnant and lactating rabbit does (n = 19) between cages of different sizes. In each cage block does were housed individually and could move freely between a small (57.5 × 38 × 30 cm) and a large cage (57.5 cm × 76 × 30 cm), through swing door. The cage-blocks were separated with non-transparent plate walls, excluding any visual contact. Using infrared cameras, 24-hour recordings were performed. The actual location of the does was registered at each half hour (48 times a day). The data of non-pregnant does were evaluated according the different day parts (23:00–05:00, 05:00–11:00, 11:00–17:00, and 17:00–23:00). Location preference was first evaluated independently of the place of kindling (in the small or large cage), and its influence on the does' location preference was also analyzed. Non-pregnant (65%) and pregnant rabbit does (73.1%) spent significantly ($P < 0.001$) more time in the large cage than in the small cage. Cage preference seemed to be proportional to the cage sizes (1/3 and 2/3) thus cage choice may be considered as random. The difference of location preference was tested between the observed and expected frequencies (33.3% and 66.6% for the smaller and larger cages, respectively). The small and large cage blocks were chosen with a frequency of 23 and 77% and 29.2 and 70.8% when kindling took place in the small and large cages, respectively. Based on the results the rabbit does show higher preference for large cages but this preference was lower when the kindling took place there.

Key words: rabbits / rabbit does / ethology / animal behaviour / animal welfare / housing / cage size

1 INTRODUCTION

Under intensive production in most cases rabbit does are housed individually. There is a generalization that the cage size of rabbit does is too small, thus it is uncomfortable for the animals moreover rabbit does cannot adequately carry out locomotory behaviour. The effects of group size and stocking density on the production and behaviour of growing rabbits were analyzed by several authors (Maertens and De Groote, 1984; Aubret and Duperray, 1992; Eiben *et al.*, 2001; Matics *et al.*, 2002; Szendrő and Dalle Zotte, 2011). However, so far, only few authors evaluated the effect of cage size on production of rabbit does. Rommers and Meijerhof (1998) analyzed the production and behaviour of the does on cages of different size (50 × 60 × 30 cm and 100 × 60 × 30 cm) and height (50 × 60 × 50 cm). The cage size did not have a significant effect on fertility rate and behaviour of rabbit does. Mirabito *et al.* (2005) evaluated the rabbit does' production and behaviour using three different cage size (3420 cm², 4508 cm² and 5880 cm²) in combination with two kinds of enrichment (a platform in types 1 and 2 and a plastic tunnel in type 3). No differences were observed in production. Time budgets showed, there were no differences between the six treatments except in cages with platforms, where does spent 4 to 15% of their time stretched out, and 10 to 25% of their time in other cages. Selzer *et al.* (2004) analyzed the effect of cage size on nursing behaviour. Based on their results, in smaller

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cages the multiple nursing events (twice or three times per day) were more frequent.

By means of preference test the most favourable housing conditions can be determined. This method was applied in different studies using growing rabbits (Matics *et al.*, 2003; Orova *et al.*, 2004; Princz *et al.*, 2008; Dalle Zotte *et al.*, 2009) or rabbit does (Gerencsér *et al.*, 2011). The aim of the experiment was to observe the location preference of non-pregnant, pregnant and lactating rabbit does between cages of different size.

2 MATERIALS AND METHODS

2.1 ANIMALS AND EXPERIMENTAL DESIGN

The experiment was conducted at the experimental rabbit farm of Kaposvár University. The temperature ranged between 15 and 17 °C, and the lighting schedule was 16 hours light (06:00–22:00) and 8 hours dark (22:00–06:00). The animals consumed commercial pellet *ad libitum* (digestible energy: 11.1 MJ/kg, crude protein: 18.0%, crude fibre: 15.0%). Water was also available *ad libitum* from nipple drinkers.

Each cage-block consisted of two wire-net cages. The length, width and height of the smaller cage were 57.5, 38 and 30 cm, respectively. The basic area of the large cage was twice as large (57.5 × 76 × 30 cm) than that of the small cage. Each cage was equipped with a 20 cm wide feeder, nipple drinker and nest box (28.5 × 38 cm). The two cages were separated with a wire-net wall, while the cage-blocks were separated with non-transparent plate walls, to prevent any visual contact between the does which could influence their cage choice. At the beginning of the experiment half of the does were put into the small and the other half into the large cage. The does could move freely between the two cages through a swing door. Using infrared cameras (placed above the cages), 24-hour recordings were performed. A total of 44 non-pregnant and 19 pregnant and lactating multiparous does were observed. After one-day adaptation period, the preference of non-pregnant does was recorded for 5 days. The pregnant and lactating does were placed to the cages 7 days prior to the expected kindling date. The observed days of lactation were co-ordinated to the real kindling date. The nest boxes were opened 3 days prior to the estimated kindling. The location preferences of the pregnant and lactating does were continuously monitored until the kits reached the age of 3 weeks. The litter size was standardized to ten at birth.

By analyzing the video recordings, the actual location of the does was registered at each half hour (48 times a day). A total of observations were 10,560 for non-lactating does (44 does × 5 days × 48 per day) and 20,064 for lactating does (19 does × 22 days × 48 per day). The data of non-pregnant does was evaluated according to the different day parts (23:00–05:00, 05:00–11:00, 11:00–17:00, and 17:00–23:00). In the group of pregnant and lactating does, day of observation was started from parturition (before and after kindling). Location preference was first evaluated independently of the place of parturition (in the small or large cage), and its influence on the does' location preference was also analyzed.

2.2 STATISTICAL ANALYSIS

Based on the actual location of the does which was registered at each half hour, the observed frequencies were determined according to the days of observation and according to the different day parts. It was supposed that the does choose randomly between the two cage parts and also that the choice is proportional to the basic area of the different cage parts. Thus the expected frequencies were 33.3% and 66.6% respectively. Test of the difference between the observed and expected frequencies were carried out by chi-square test using SAS 9.1 software package.

3 RESULTS AND DISCUSSION

The average time spending of non-pregnant rabbit does was 35% and 65% in small and large cages, respectively. They spent significantly more time in the larger cage every day ($P < 0.05$). Cage preference seemed to be proportional to the cage sizes (1/3 and 2/3), thus cage choice may be considered as random. Therefore the difference of location preference was also tested between the observed and expected (33.3% and 66.6% for the smaller and larger cages, respectively) frequencies (Table 1). Considering the hypothetical location possibility, the does have spent more time in the small cage during only

Table 1: *Preference (%) of non-pregnant rabbit does (n = 44) between the cages with different size*

	Days of observation				
Cage types	1	2	3	4	5
Small	37.5^{b*}	33.9^{a}	34.2^{a}	33.7^{a}	35.9^{ab}
Large	62.5^{b*}	66.1^{a}	65.8^{a}	66.3^{a}	64.1^{ab}

^{a,b} Means with different letters on the same row differ significantly ($P < 0.05$); * Means are significantly differ from the hypothetical location possibility (33.3% in the small, 66.6% in the large cage) of the rabbit does at $P < 0.05$ level; Small cage 57.5 × 38 cm; Large cage: 57.5 × 76 cm

Table 2: *Location preference (%) of non-pregnant rabbit does (n = 44) in different parts of the day*

	Periods of the days			
Cage types	23:00–5:00	05:00–11:00	11:00–17:00	17:00–23:00
Small	31.8[a]	38.3[c*]	36.4[b*]	34.7[b]
Large	68.2[a]	61.7[c*]	63.6[b*]	65.3[b]

[a,b] and * means the same, as in Table 1. Small cage: 57.5 × 38 cm; Large cage: 57.5 × 76 cm

the first day compared to the remaining observed days. It can be explained by their exploring behaviour. Their cage choice was more balanced afterwards.

Part of the day had an effect on the location preference of rabbit does (Table 2). The cage choice showed the highest difference between the two cages between 23:00 and 5:00. It was the dark time period which was their active period. During the 05:00–11:00 period, the cage choice of rabbit does most differed from expected frequencies. During the resting period (11:00–17:00) and between 17:00 and 23:00 their location preferences were more balanced than the other parts of the day.

The pregnant and lactating rabbit does spent most of their time (73.1%) in the large cage ($P < 0.001$), analysed independently of the place of kindling. Difference between cage preferences was larger 1–4 days prior to kindling than immediately before parturition or after day 12–14 of lactation.

Kindling of 7 and 12 does was registered in the small and in the large cages, respectively. Location preference was affected by the cage (nest-box) where the kindling took place. When parturition took place in the nest box of the small or in the large cage, compared to the expected values (33.3% and 66.6%), the cage preferences were 23 and 77%, and 29.2 and 70.8%, respectively. Thus, the location preference of rabbit does was significantly different ($P < 0.001$) from the expected frequencies.

During the later days of lactation the lactating does preferred more frequently the t cage without nest box (Fig. 1). When the kits activity was increasing (leaving the nest box first), the does tried to avoid the contact with them. This behaviour of does is valid in both cages s. The preference of does for large cage, which gave birth to the small cage increased after day 4 of lactation. The does which kindled into the nest box of large cage preferred to stay in the larger cage less frequently after day 7 of lactation, thus their large cage preference was lowest. The preference during days before parturition can be associated with the nest making behaviour and their might have been trying to find the optional place for giving birth. In addition based on preference of large area before parturition the does which chose the small cage' nest box for kindling spent in average less time (76.7%) in large cage before parturition compared the does, which chose the nest box of large cage for kindling place (87.9%).

4 CONCLUSIONS

The cage preference of non-pregnant rabbit does was proportional to the basic area of the two cages. Although, parturition and lactation influenced the does' location preference, the effect of place (cage) of kindling was the largest on the cage choice. In this case the cage preference was different from the expected frequencies (33.3% and 66.6%) and the does preferred more frequently the other cage than that of the place of kindling. The location preference showed large individual variation, that requires further analysis.

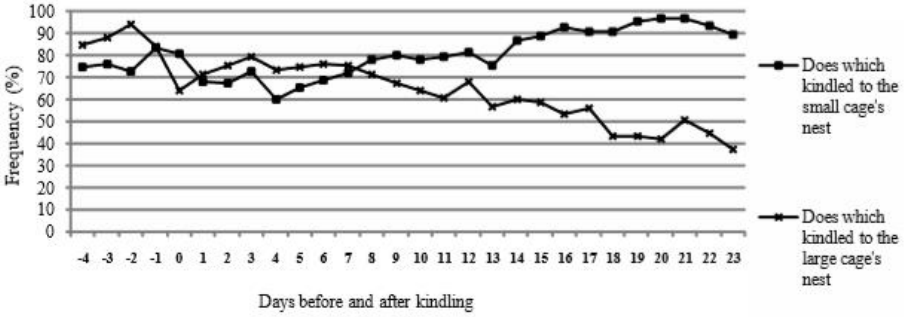

Figure 1: *The does large cage preference which kindled to the nest box of small cage (n = 7) or which kindled to the nest box of large cage (n = 12); 0 = the day of parturition*

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6 REFERENCES

Aubret J., Duperray J. 1992. Effect of cage density on the performance and health of the growing rabbit. Journal of Applied Rabbit Research, 15: 656–660

Dalle Zotte A., Princz Z., Matics Zs., Gerencsér Zs., Metzger Sz., Szendrő Zs. 2009. Rabbit preference for cages and pens with or without mirrors. Applied Animal Behaviour Science, 116: 273–278

Eiben Cs., Szendrő Zs., Radnai I., Biró-Németh E. 2001. Effect of weaning age, cage size and stocking density on the performance of fattening rabbits (in Hung.) In: Proceedings, 13th Hungarian Conference on Rabbit Production, Kaposvár. 75–79

Gerencsér Zs., Matics Zs., Odermatt M., Radnai I., Nagy I., Szendrő Zs. 2011. Light colour preference of rabbit does (preliminary results). In: Proceedings, 17. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere. Celle, Germany, 2011. 251–258

Maertens L., De Groote G. 1984. Influence of the number of fryer rabbits per cage on their performance. Journal of Applied Rabbit Research, 7, 4:

Matics Zs., Szendrő Zs., Radnai I., Biró-Németh E., Gyovai M. 2002. Free choice of rabbit kits among cages with different size (Preliminary results) (in Hung.). In: Proceedings, 14th Hungarian Conference on Rabbit Production, Kaposvár. 43–48

Matics Zs., Szendrő Zs., Radnai I., Biró-Németh E., Gyovai M. 2003. Examination of free choice of rabbits among different cage-floors. Agric Consectus Science, 68: 265–268

Mirabito L., Galliot P., Souchet C. 2005. Effet de la surface disponible et de l'aménagement des cages sur les performances zootechniques et le comportement des lapines. In: 11émes Journées de la Recherche Cunicole, Paris. 61–64

Orova Z., Szendrő Zs., Matics Zs., Radnai I., Biró-Németh E. 2004. Free choice of growing rabbits between deep litter and wire net floor in pens. In: Proceedings, 8th World Rabbit Congress, Puebla City. 1263–1265

Princz Z., Dalle Zotte A., Radnai I., Biró-Németh E., Matics Zs., Gerencsér Zs., Nagy I., Szendrő Zs. 2008. Behaviour of growing rabbits under various housing conditions. Applied Animal Behaviour Science, 111: 342–356

Rommers J., Meijerhof R. 1998. La dimension de la cage influence t'elle la productivite et le bien-entre des lapins? Cuniculture, 140: 67–72

Selzer D., Lange K., Hoy St. 2004. Frequency of nursing in domestic rabbits under different housing conditions. Applied Animal Behaviour Science, 87, 314: 317–324

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

5.3. EXPERIMENT 3

Performance and welfare of rabbit does in various caging systems

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Performance and welfare of rabbit does in various caging systems

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The objective of the study was to compare production and welfare of rabbit does and their kits housed in various types of cages. Female rabbits were randomly allocated to four groups with the following cage types: CN: common wire-mesh flat-deck cage, without footrest; CF: cage similar to the CN but with plastic footrest; ECWP: enlarged cage with wire-mesh platform; and ECPP: extra enlarged cage with plastic-mesh platform. All does were inseminated on the same day, 11 days after kindlings. Reproductive performance was evaluated during the first five consecutive kindlings. Severity of sore hocks was scored at each insemination. Location preference of the does and the platform usage of their kits were evaluated. Kindling rate, litter size (total born, born alive, alive at 21 and 35 days) and kit mortality were not significantly influenced by the cage types. The litter weight at 21 days was higher in ECWP and ECPP cages than in the CF group (3516, 3576 and 3291 g, respectively; P < 0.001), and at 35 days the difference was only significant between the groups ECPP and CF (8712 and 8060 g, respectively, P < 0.05). At 21 and 35 days of age, the kits were heavier in large (ECWP and ECPP) than in conventional cages (CF and CN) (P < 0.001). At the fifth insemination, the percentage of rabbits with sore hocks' score of 1 to 2 (0 = intact foot pads; 1 = no hairs, callus formed, <2.5 cm; 2 = no hairs, callus formed, >2.5 cm) and 3 to 4 (3 = callus opened, cracks present; 4 = wounds) were 58%, 60%, 78% and 48%, and 0%, 5%, 0% and 48% in groups ECPP, ECWP, CF and CN, respectively. Higher number of daily nest visits was observed for CF does than for ECWP does (12.5 v. 5.9; P < 0.05). The frequency of multiple nursing events (>2/day) was higher in the CF group than in the ECWP group (12.1 v. 3.2%; P < 0.01). Within large cages, the does were observed on the platform more frequently in the ECPP cages compared with the ECWP cages (56.9% v. 31.7%; P < 0.001). Similarly, 2.7% and 0.2% of kits at 21 days of age, and 33.2% and 5.2% of kits at 28 days of age, were found on the platforms of ECPP and ECWP cages, respectively. In conclusion, cages larger than the conventional ones improved kits' weaning weight, plastic footrests and plastic-mesh platforms in conventional and/or large cages reduced sore hocks' problems, plastic-mesh platforms were more used by both does and kits compared with the wire-mesh platforms.

Keywords: rabbit does, cage types, reproduction, sore hocks, preference

Implications

According to several animal rights movements (Bio Suisse, Naturland), the conventional cages in the commercial rabbit farms are too small, and the rabbit does' movement possibilities are limited. The objective of the present study was to compare production and animal welfare of rabbit does housed in conventional and alternative (large) cages equipped or not with plastic footrests, wire or plastic-mesh platform. We concluded that housing the does in cages larger than commercial ones slightly improved kit weaning weight, but increased production costs (as these cages are larger and require more space). However, these cages gave more opportunity for animal movement and reduced prevalence of sore hocks when provided with plastic footrests and/or plastic-mesh platforms.

Introduction

Research aiming to optimize housing conditions for rabbits is gaining importance (Szendrő and Dalle Zotte, 2011; Szendrő and McNitt, 2012; Trocino *et al.*, 2013; Xiccato *et al.*, 2013). Although there are no EU-based directives for rabbit housing, there are some national recommendations (Germany: Hoy, 2012; Switzerland: WBF, 2013). Determining the optimal housing requirements of rabbits, without anthropomorphic and emotional influences, is of great importance and requires detailed knowledge of the behaviour of European wild rabbits and of domesticated rabbits under various housing conditions (Szendrő and Dalle Zotte, 2011; Szendrő and McNitt, 2012).

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Important factors that affect the well-being of rabbit does include their ability to move, cage size, floor type and environmental enrichment. The cages of does could be too small, uncomfortable and excessively limit movement. Therefore, solutions are either an increase in cage size or environmental enrichment, for example, equipping cages with platforms (Rommers and Meijerhof, 1998; Mirabito, 2007), although platforms may enable the rabbit does to avoid nursing attempts of the kits. Furthermore, there is no definitive proof that larger cages or those equipped with platforms provide the expected benefits. For example, the productivity of rabbit does did not improve in cages that were larger or higher (Rommers and Meijerhof, 1998; Mirabito, 2007). Furthermore, in most cases, equipping cages with platforms had no effect on kindling rate, litter size, suckling mortality and weight gain of kits (Mirabito, 2007). The platform in the cage should provide a place for the rabbit does to escape from the nursing attempts of their kits (Szendrő and McNitt, 2012). However, once the kits leave the nest box, they can also visit the platform (Mirabito, 2007).

From the animal welfare perspective, the type of the cage floor is critical (Szendrő and McNitt, 2012). The percentage of does in Spanish commercial farms with sore hocks ranged from 12% to 70% (Rosell and De la Fuente, 2009). In that regard, footrests reduced the development of sore hocks (Rosell and De la Fuente, 2009; Rommers and De Jong, 2011).

The aim of the experiment was to compare four commercial cages: conventional cages with footrests; conventional cages without footrests; alternative (large) cages equipped with wire-mesh platforms and footrests; and alternative (large) cages with plastic-mesh platforms and without footrests. In addition to reproductive performance, nursing behaviour, the occurrence of sore hocks and, in cages with platforms, the location preference of rabbit does and platform utilization of the kits were also monitored.

Material and methods

Animals, feeding and experimental conditions

Crossbred rabbit does ($n = 108$) were used in this experiment, which was conducted at the rabbit farm of Kaposvár University. The temperature of the rabbitry ranged from 15°C to 28°C, depending on the season; the lighting schedule was 16 h light (0600 to 2200 h) and 8 h dark. Each cage was equipped with a feeder and a nipple drinker. Rabbits (does and their kits) were fed *ad libitum* a commercial pellet (11.1 MJ/kg DE, 18% CP and 15% crude fibre), and water was available *ad libitum*.

Does were first inseminated at 16.5 weeks of age. All does were inseminated on the same day, 11 days after kindling (42 days reproductive rhythm, single-batch system). The does did not receive hormonal treatments or biostimulation to induce *oestrus*. Litter size of the first and subsequent parities was standardized to 8 and 10 kits, respectively. Cross-fostering was practiced within groups. The entrance hole of the nest box was opened and the does could nurse their kits freely. Rabbits were weaned at 35 days of age. Rabbit does with bad body conditions (health problem or poor body condition) or remaining non-pregnant after two successive inseminations were culled and not replaced. The percentage of discarded does was similar in the groups: it ranged from 25% to 29%. Reproductive performance of up to five consecutive kindlings was evaluated. The performance of rabbit does that were culled or died was also evaluated. The initial BW and BW at first artificial insemination (AI) were similar in the groups.

Rabbit does were randomly allocated to four groups with the following cage types:

CN: conventional wire-mesh flat-deck cage (86 × 38 × 30 cm, including the 25 × 38 cm floor sized nest box, total surface for the does and their kits: 0.33 m^2; wire diameter of the cage floor was 2 mm and the hole size of wires was 48 × 10.5 mm), without footrest ($n = 30$);

CF: as CN cage, with plastic footrest (40 × 25 cm, width of the plastic-mesh: 17 mm; hole size: 64 × 12 mm; $n = 30$);

ECWP: enlarged cage (102.5 × 38 × 61 cm, including the 25 × 38 cm floor sized nest box) with wire-mesh platform, the cage floor was wire-mesh (wire diameter 2.5 mm, hole size of wires: 60 × 12.5 mm), the platform (28.5 × 38 cm) was 26.5 cm above the cage floor, a plastic footrest (40 × 25 cm, width of the plastic-mesh: 17 mm, hole size: 64 × 12 mm) was on the lower level, 2/3 part of the footrest was below the platform; the total surface (floor and platform) for the does and their kits was 0.50 m^2 ($n = 24$);

ECPP: extra enlarged cage (102.5 × 52.5 × 97 cm, including the 21.5 × 52.5 cm floor sized nest box) with plastic-mesh platform, the cage floor was wire-mesh (wire diameter: 3 mm, hole size of wires: 73 × 12 mm), the platform (41.5 × 52.5 cm) was 25 cm above the cage floor; the total surface (floor and platform) for the does and their kits was 0.76 m^2 (width of the plastic-mesh: 16 mm; hole size: 60 × 13 mm) ($n = 24$).

Reproductive performance

The BW of rabbit does at kindling, kindling rate, total number of kits born, number of kits born alive and stillborn, litter size at 21 and 35 days, litter and individual weight at 21 and 35 days of age, and the mortality of kits were recorded.

Nursing behaviour

Video recordings were continuously carried out from kindling till day 20 of the third lactation using IR cameras (12 pieces of KPC-S50 NV, B/W CCD IR cameras, fixed on the ceiling above the cages, GeoVision GV-800 System, Multicam Surveillance System 6.1 software) (CF = 10, ECWP = 10, ECPP = 10 randomly selected does). The events above were recorded and evaluated:

- the number of daily nest visits when the doe enters into the nest box without nursing;
- the number of daily nursing events;
- the length of nursing events starting from the moment when the doe is staying in a special hunchbacked body posture above the kits to the moment when it jumps out of the nest box.

Altogether the total length of the video recordings was 14 400 h, and during this period 846 nursing events were observed.

Sore hocks

At each insemination, severity of sore hocks was scored according to Rommers and De Jong (2011): 0 = intact foot pads; 1 = no hairs, callus formed (<2.5 cm); 2 = no hairs, callus formed (>2.5 cm); 3 = callus opened, cracks present; and 4 = wounds. Foot pads of rabbit does showing scores 3 or 4 were treated with Cyclo Spray (p.a. chlorotetracycline 200 mg/ml; Bimeda, Ireland).

Location preference

At the third and fifth kindling, location of does ($n = 31$) within the cages and number of kits on the platform were evaluated in enlarged cages. IR cameras were placed above the cages, and 24 h videos of 16 rabbit does in the enlarged cages (ECWP) and 15 individuals in the extra enlarged cages (ECPP) were recorded. The location preference of the rabbit does was observed twice weekly on the same days (every Tuesday and Friday) from kindling to 31 days *postpartum* (nine times per lactation). The location of the rabbits was given according to time of day (0500 to 1100 h; 1100 to 1700 h; 1700 to 2300 h; and 2300 to 0500 h). The periods 1100 to 1700 h and 2300 to 0500 h were called resting and active periods, respectively, because wild and domestic rabbits are more active during the dark and they rest during the light period, mainly during the middle of the day (Stodart and Meyers, 1964; Podberscek *et al.*,1991; Selzer and Hoy, 2003). The location of the rabbit does on the platform, below the platform or in front of the platform was recorded every 30 min (48 times a day, 432 times/lactation). Concurrently, from the time of leaving the nest box, the number of kits located on the platform was also determined. Location of the does was expressed in percentage of frequency they were observed on the different parts of the cages (total = 100%), and the platform usage of kits was expressed as percentage of the number of kits present in the cages.

Statistical analyses

Performance measurements (weight of does at kindling, litter size, litter weight and individual BW) were considered as repeated measures and analysed using a mixed model (PROC MIXED). The model contained type of cage and insemination order as fixed effects, and the rabbit does as random effect (preliminary analyses showed that interaction between the fixed effects was not significant). The length of the nursing events and the number of nest visits were evaluated with the same procedure (PROC MIXED). The model contained type of cage and day of lactation as fixed effects, and the rabbit does as random effect (preliminary analyses showed that interaction between the fixed effects was not significant). Sore hocks score was evaluated with a multinomial logistic regression (PROC GLINMIX). The model contained as fixed effects type of cage (flat-deck cages without footrest was used as the reference) and insemination order (insemination 5 was used as the reference) and rabbit does as random effect (preliminary analyses showed that interaction between the fixed effects was not significant). Daily number of nursing events in the different cage types, kindling rate and mortality of kits in the different groups, and location of rabbit does and kits in enlarged cages were compared by χ^2 test (PROC FREQ). Besides, location of the rabbit does was also evaluated by separate χ^2 tests for the different day parts (2300 to 0500 h; 0500 to 1100 h; 1100 to 1700 h; 1700 to 2300 h). All statistical analyses were performed using SAS 9.3 software (SAS Institute Inc., 2011).

Results

Reproductive performance

Kindling rate, litter size (born total, born alive and stillborn, at 21 and 35 days) (Table 1) and kit mortality (Table 2) were not significantly influenced by the cage types, although BW of does at kindling (Table 1) differed between the groups CN and CF ($P < 0.05$). There were no significant differences between the two conventional cages (CN and CF), and between the two enlarged cages with platforms (ECWP and ECPP) in litter and individual weight at 21 and 35 days; however, comparing the conventional cages (CN and CF) with enlarged cages (ECWP and ECPP), these characteristics were higher in the enlarged cages ($P < 0.001$ and $P < 0.01$).

Sore hocks

Because there were no sore hocks at the first insemination of the study, only the subsequent insemination orders were analysed. Both the effects of cage type and insemination order were significant, as the estimated logistic regression coefficients were all significant (Table 3). The logistic regression coefficients can be converted to odds ratios by exponentiating them (Table 3). The severity of this phenomenon increased significantly with advancing insemination order (Tables 3 and 4). Compared with the fifth insemination, at the second insemination, the rabbit does had the highest odds to have a sore hocks score of 0. Taking the cages without footrest (CN) as a reference, the odd ratios showed that the most favourable cage type was the enlarged cage with plastic-mesh platform followed by enlarged cage with wire-mesh platform and footrest on the bottom level; however, even flat-deck cage with footrest was much better for the rabbits than the CN cages.

At the last period of examination (fifth AI), the most severe sore hocks were observed in CN cages (no footrest) (Figure 1). The most favourable results were observed in the ECPP group (platform made of plastic mesh) where 84% of the rabbits had sore hocks score 0 and 1, and 16% had no severe injuries (score 2).

In cages with footrest (CF), problems of sore hocks were not serious. The occurrence rate of sore hocks was intermediate in the ECWP cages. The proportion of rabbits with no or only slight injuries (score 0 and 1) was high (75%), but score 2 to 3 was also frequently detected (25%) (Table 4).

Table 1 *Effect of cage type and insemination order (AI) on rabbit doe performance (least squares means ± s.e.)*

Traits	Cage types				*P*-values	
	CN	CF	ECWP	ECPP	Cage type	AI order
No. kindlings	103	110	93	85	–	–
Weight of does at kindling (g)	$4340^{c} \pm 32$	$4101^{a} \pm 31$	$4183^{ab} \pm 34$	$4258^{abc} \pm 36$	<0.001	<0.001
Litter size						
Total born	11.0 ± 0.30	11.5 ± 0.29	11.5 ± 0.32	11.2 ± 0.33	0.545	<0.001
Stillborn	0.59 ± 0.12	0.50 ± 0.11	0.48 ± 0.12	0.68 ± 0.13	0.672	
Born alive	10.4 ± 0.30	10.9 ± 0.29	11.0 ± 0.32	10.5 ± 0.33	0.373	<0.001
At 21 days	8.96 ± 0.11	8.93 ± 0.11	8.78 ± 0.12	8.95 ± 0.12	0.657	<0.001
At 35 days	8.77 ± 0.14	8.57 ± 0.13	8.57 ± 0.14	8.79 ± 0.15	0.538	<0.001
Litter weight (g)						
At 21 days	$3399^{ab} \pm 53$	$3291^{a} \pm 51$	$3515^{bc} \pm 55$	$3576^{c} \pm 58$	<0.001	<0.001
At 35 days	$8309^{ab} \pm 147$	$8060^{a} \pm 140$	$8463^{ab} \pm 152$	$8712^{b} \pm 161$	0.020	<0.001
Individual BW (g)						
At 21 days	$382^{a} \pm 5.20$	$372^{a} \pm 4.98$	$402^{b} \pm 5.43$	$401^{b} \pm 5.68$	<0.001	<0.001
At 35 days	$947^{a} \pm 9.06$	$942^{a} \pm 8.69$	$987^{b} \pm 9.51$	$986^{b} \pm 9.90$	<0.001	<0.001

AI = artificial insemination; CN = flat-deck cages without footrest; CF = flat-deck cages with footrest; ECWP = pens with wire-mesh platform and footrest on the bottom level; ECPP = pens with plastic-mesh platform.
[a,b,c]Means within the same row with different superscripts differ significantly ($P<0.05$).

Table 2 *Effect of cage type on rabbit does' kindling rate and on the mortality of kits (%)*

Traits	Cage types				
	CN	CF	ECWP	ECPP	*P*-value
No. kindlings	103	110	93	85	–
Kindling rate (%)	80.2	82.9	81.7	76.4	0.634
Mortality of kits (%)					
0 to 21 days	6.5	6.0	6.8	5.2	0.584
0 to 35 days	7.8	9.9	9.0	7.2	0.172

CN = flat-deck cages without footrest; CF = flat-deck cages with footrest; ECWP = pens with wire-mesh platform and footrest on the bottom level; ECPP = pens with plastic-mesh platform.

Nursing behaviour

Does in conventional cages (CF) entered the nests twice as frequently than the animals in enlarged cages (12.5 and 7.0 nest visits per day in conventional cages and enlarged cages with platform, respectively, $P<0.05$). The difference between the CF and ECWP groups was significant (Table 5). The frequency of multiple nursing events (>2) was also significantly higher in the CF group than in the ECWP group.

Location preference

The percentage of platform preference in the 24 h period was 25.2% greater in the ECPP cages than in the ECWP cages ($P<0.001$; Table 6). However, rabbits in the ECWP cages were found more often below and in front of the platform than in the ECPP group.

In the ECPP cages, at the beginning (1700 to 2300 h) and during the active period (2300 to 0500 h), does were found more often on the platform than during the light (resting) period (0500 to 1700 h) (Table 6). On the contrary, percentage of time when the rabbits were observed under the

Table 3 *Effect of insemination order and cage type on the rabbits' sore hocks[1] scores ($b^{2} \pm$ s.e.)*

Independent variable	Level	*b*	*P*-value	Exp(*b*)
Insemination order	2	5.92 ± 0.48	<0.001	372
	3	4.80 ± 0.42	<0.001	121
	4	1.88 ± 0.33	<0.001	6.55
	5	0	<0.001	
Cage type	ECPP	3.75 ± 0.75	<0.001	42.5
	ECWP	3.43 ± 0.74	<0.001	30.8
	CF	3.00 ± 0.70	<0.001	20.1
	CN	0		

ECPP = pens with plastic-mesh platform; ECWP = pens with wire-mesh platform and footrest on the bottom level; CF = flat-deck cages with footrest; CN = flat-deck cages without footrest.
[1]Sore hocks scores: 0 = intact foot pads; 1 = no hairs, callus formed (<2.5 cm); 2 = no hairs, callus formed (>2.5 cm); 3 callus opened, cracks present; 4 = wounds.
[2]Logistic regression coefficients.

Table 4 *Average sore hocks[1] scores of does in different cage types at different inseminations*

AI order	Cage types			
	CN	CF	ECWP	ECPP
1	0.00	0.00	0.00	0.00
2	0.71	0.24	0.09	0.08
3	1.00	0.32	0.26	0.33
4	1.80	1.09	0.95	0.81
5	3.00	1.45	1.33	1.00

CN = flat-deck cages without footrest; CF = flat-deck cages with footrest; ECWP = pens with wire-mesh platform and footrest on the bottom level; ECPP = pens with plastic-mesh platform.
[1]Sore hocks scores: 0 = intact foot pads; 1 = no hairs, callus formed (<2.5 cm); 2 = no hairs, callus formed (>2.5 cm); 3 = callus opened, cracks present; 4 = wounds.

platform was 2.5 to 3.5 times higher between 0500 and 1700 h than during the dark period (2300 to 0500 h). The effect of the periods of the day was smaller in the ECWP cages. The rabbit does were also found more often on the platform between 1700 and 0500 h than between 0500 and 1700 h.

The platform usage of does and their kits in the enlarged cages, between days 3 and 31 of lactation, are shown on Figure 2. In the ECPP cages, the percentage of observations that the does were observed on the platform ranged between 55.9% and 64.4% during the first 17 days of lactation. However, once the kits left the nest boxes, utilization of the platform by does increased substantially and reached a peak on day 21 (67.1%). Thereafter, the increased use of platform by the kits was associated with decreased usage of platform by the does. Lesser use of the platform by the does (25% to 38%) occurred in the ECWP group compared with the ECPP group between kindling and weaning, but the changes in platform usage were similar in both cage types. When the kits left the nest boxes, the does used the platform more often, and then after day 21, when the kits started to visit the platform, the platform usage by the does decreased.

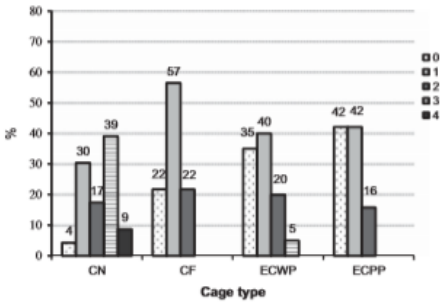

Figure 1 The percentage of rabbit does in each type of cage with different scores for sore hocks at the fifth artificial insemination. 0 = intact foot pads, 1 = no hairs, callus formed (<2.5 cm), 2 = no hairs, callus formed (>2.5 cm), 3 = callus opened, cracks present, 4 = wounds, CN = flat-deck cages without footrest, CF = flat-deck cages with footrest, ECWP = pens with wire-mesh platform and footrest on the bottom level, ECPP = pens with plastic-mesh platform.

The kits started to visit the platform at the age of 17 days, and the platform usage of the kits increased until weaning (Figure 2). The use of the wire-mesh platform by kits was lower than that of the plastic platform ($P < 0.001$).

Discussion

Theoretically, in larger cages, rabbit does can move more, which may influence their performance. In fact, we observed an improved trend (higher weaning weight of kits) in larger cages. However, previous studies did not find different reproductive performance in does housed in larger or higher cages compared with conventional cages (Rommers and Meijerhof, 1998; Mirabito *et al.*, 2005b), or in cages with platform compared with cages without platform (Mirabito *et al.*, 1999, 2005a; Mirabito, 2007). According to Mirabito *et al.* (1999, 2005a) and Mirabito (2002, 2007), a platform did not appear to be a means for does to escape from their kits and remain undisturbed, and did not affect the kits' nursing attempts. Doe escapes (i.e. visiting the platform) and the kits' usage of the platform did not influence the difference for the 21-day litter and individual weights as the kits had left the nest box only few days earlier. The lower weight of kits in conventional cages may depend on the higher disturbance to sleeping kits because of the higher number of visits to the nest boxes and the higher frequency of more than two nursing events per day of rabbit does compared with those of enlarged cages with platforms. Similarly, Hoy *et al.* (2000) observed higher number of nursing events per day and percentage of days with >2 nursing events in larger than in conventional-sized get-away cages.

Although the size of cages and platform preference of does and kits were substantially different between the ECWP and ECPP groups, there were no significant differences in reproductive performances. It seems, in this case, that the reproductive performances of does were independent of the size of cages and the material of the platform.

The incidence and severity of sore hocks was the highest in conventional cages without footrest. The impact of footpad or plastic-mesh platform on reproductive performance has not been demonstrated. When the callus was opened and

Table 5 *Characteristics of nursing behaviour of does in various cage types*

				P-values	
Characteristics	CF	ECWP	ECPP	Cage type	Day of lactation
Daily number of visits into the nest box (least squares means ± s.e.)	$12.5^{b} \pm 1.8$	$5.9^{a} \pm 1.8$	$8.2^{ab} \pm 1.8$	0.047	<0.001
Percentages of days with the following number of nursing events per day (%)					
0	1.6	3.7	1.1	0.174	
1	55.8	63.3	62.3	0.858	
2	30.5	29.8	26.1	0.825	
>2	12.1^{a}	3.2^{b}	10.6^{a}	0.006	
Duration of nursing events (least squares means ± s.e.) (s)	207 ± 7.8	208 ± 7.8	204 ± 7.7	0.932	<0.001

CF = flat-deck cages with footrest; ECWP = pens with wire-mesh platform and footrest on the bottom level; ECPP = pens with plastic-mesh platform.
[a,b]Values within a row with superscripts differ significantly at $P < 0.05$.

Table 6 *Location preference of rabbit does in enlarged cages with platform, depending on the periods of the day*

		Period of day			
% of time spent in each location	24 h	2300 to 0500 h	0500 to 1100 h	1100 to 1700 h	1700 to 2300 h
Pens with wire-net platform (ECWP)					
On the platform	31.7	36.5^{a}	28.0^{b}	26.3^{b}	36.1^{a}
Under the platform	30.4	23.8^{d}	32.0^{b}	38.5^{a}	27.4^{c}
In front of the platform	37.9	39.7^{a}	40.0^{a}	35.2^{b}	36.5^{a}
Pens with plastic platform (ECPP)					
On the platform	56.9	65.1^{a}	51.7^{c}	51.0^{c}	59.9^{b}
Under the platform	22.6	9.7^{d}	26.4^{b}	34.0^{a}	20.4^{c}
In front of the platform	20.5	25.2^{a}	21.9^{b}	15.0^{c}	19.7^{b}
P-value[1]	<0.001	<0.001	<0.001	<0.001	<0.001

^{a,b,c,d}Values within a row with different superscripts differ significantly at $P<0.05$.
[1]*P*-value shows difference between the locations of does in the different cage types within each time period.

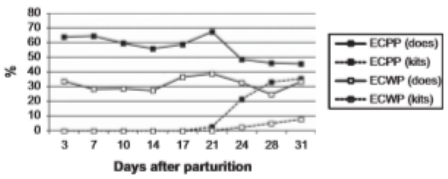

Figure 2 Platform usage of does and their kits in different types of platform cages. ECWP = wire-mesh platform, ECPP = plastic-mesh platform. The presence of rabbit does on the platform is expressed as the percentage of observations. The presence of kits on the platform is expressed as the percentage of number of kits in the cage. The platform usage of the does during the whole observed period and the platform usage of their kits after day 21 of lactation differed significantly ($P < 0.05$) in the groups ECPP and ECWP.

cracks had been formed, foot pads were treated by Cyclo Spray to prevent pain and suffering, and also to avoid decreasing of the performance. It should be noted that the diameter of the wire was appropriate because comparing the 2 and 3 mm thick wire, the 3 mm thick wire floor did not reduce sore hocks (Rommers and De Jong, 2011). The present study proved that both plastic-mesh platforms and/or plastic footrests in enlarged and conventional cages have the potential to improve animal welfare. Similarly, Rosell and De la Fuente (2009) and Rommers and De Jong (2011) reported that plastic footrests reduced sore hocks.

Examining the platform utilization of rabbit does, we confirmed previous results that state the influence of the presence of kits (Mirabito, 2002, 2007): in the presence of kits, the does stayed more frequently on the platform (Mirabito *et al*., 1999, Mirabito, 2007). In fact, non-lactating does visited the platform less frequently than those nursing their kits (Mirabito *et al*., 1999). Besides, based on our results, we can state that platform preference was highly dependent on its type (plastic *v.* wire) and on the level of provided comfort: does were found more often on platforms when it was made of plastic mesh compared with wire mesh (56.9% *v.* 31.7%). The presence of comfortable plastic footrests below wire-mesh platform could have contributed to reduce the preference of does towards the platform in the ECWP cages we used.

In the experiment by Mirabito *et al.* (1999), at 5 weeks of lactation, 16% of the kits were located on the platform. In our study, the difference in platform preference of the kits was mainly attributed to platform type (wire-mesh or plastic-mesh) because the plastic-mesh was probably more comfortable for the kits as well. The size of the platform also has to be taken into account, as it was double size in the ECPP cages compared with the ECWP cages.

In the ECWP group, when the doe stayed on the platform, there was space for only a few kits. As the does spent 68.3% of their time on the lower level, the platform usage of the does only partially restricted opportunities for kits to visit the platform.

As Mirabito *et al.* (1999) restricted their observations to time with visible light they could not report outcomes throughout the entire day. In our study, platform preference of does was greater during the active period, whereas during the resting period does preferred to stay under the platform. These findings may be explained by behaviour characteristics of the European wild rabbit. They prefer living in the shelter of dense scrub, and during the light (resting) period they stay in their warrens for safety (Pérez *et al*., 2008).

In conclusion, plastic-mesh platforms or footrests have the potential to improve doe welfare because of the reduced incidence of sore hocks. Housing rabbit does in enlarged cages with platform is advantageous because kit weaning weight increased, but the number of rabbits per rabbit house is reduced, and thus production costs are also higher.

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References

Hoy St 2012. German regulations and guidelines on rabbit housing. In Proceedings of the 10th World Rabbit Congress (ed. A Daader and G Xiccato), pp. 999–1003. Sharm El- Sheikh, Egypt.

Hoy St, Seitz K, Selzer D and Schüddemage M 2000. Nursing behaviour of domesticated and wild rabbit does under different keeping conditions. World Rabbit Science 8 (suppl. 1), 537–543.

Mirabito L 2002. Le bien-être des lapines: impact de nouveaux systémes de logement. Journée nationale, ITAVI, Elevage du lapin de chair, Nantes, France, p. 13.

Mirabito L 2007. Logement et bien-être du lapin: plus de question que réponses? Inra Productions Animales 20, 59–64.

Mirabito L, Galliot P and Souchet C 2005a. Effet de la surface disponible et de l'aménagement des cages sur les performances zootechniques et le comportement des lapines. 11émes Journées de la Recherche Cunicole, Paris, France, pp. 61–64.

Mirabito L, Galliot P, Souchet C, Dumont F and Thomeret F 2005b. Logement collectif des lapines reproductrices: Conséquences zootechniques. 11émes Journées de la Recherche Cunicole, Paris, France, pp. 53–56.

Mirabito L, Buthon L, Cialdi G, Galliot P and Souchet C 1999. Effet du logement des lapines en cages rehaussées avec plate-forme: Premiers résultats. 8émes Journées de la Recherche Cunicole, Paris, France, pp. 67–70.

Pérez SS, Jacksic D, Meriggi A and Rosin VA 2008. Density and habitat use by the European wild rabbit (Oryctolagus cuniculus) in an agricultural area of Northern Italy. Hystrix: the Italian Journal of Mammalogy 19, 143–156.

Podberscek AL, Blackshaw JK and Beattle AW 1991. The behaviour of group penned and individually caged laboratory rabbits. Applied Animal Behaviour Science 28, 353–363.

Rommers JM and Meijerhof R 1998. La dimension de la cage influence-t'elle la productivité et le bien-être des lapins? Cuniculture 140, 67–72.

Rommers JM and De Jong IC 2011. Technical note: plastic mats prevent footpad injuries in rabbit does. World Rabbit Science 19, 233–237.

Rosell J and De la Fuente L 2009. Effect of footrests on the incidence of ulcerative pododermatitis in domestic rabbit does. Animal Welfare 18, 199–204.

SAS Institute Inc. 2011. SAS/STAT 9.3 User's Guide. SAS Institute Inc., Cary, NC, USA.

Selzer D and Hoy St 2003. Comparative investigations on behaviour of wild and domestic rabbits in the nest. World Rabbit Science 11, 13–21.

Stodart E and Meyers K 1964. A comparison of behaviour, reproduction, and mortality of wild and domestic rabbits in confined population. CIRO Wildlife Research 9, 144–159.

Szendrõ Zs and Dalle Zotte A 2011. Effect of housing condition on production and behaviour of growing meat rabbits: a review. Livestock Science 137, 296–303.

Szendrõ Zs and McNitt IJ 2012. Housing of rabbit does: group and individual systems: a review. Livestock Science 150, 1–10.

Trocino A, Majolini D, Tazzoli M, Filiou E and Xiccato G 2013. Housing of growing rabbits in individual, bicellular and collective cages: fear level and behavioural patterns. Animal 7, 633–639.

WBF 2013. Verordnung des EVD über Ethoprogramme (Ethoprogrammverordnung) vom 25. Juni 2008 (Stand am 1. Januar 2010) 910.132.4. Retrieved 1 September 2013 from http://www.admin.ch/ch/d/sr/9/910.132.4.de.pdf

Xiccato G, Trocino A, Majolini D, Tazzoli M and Zuffellato A 2013. Housing of growing rabbits in individual, bicellular and collective cages: growth performance, carcass traits and meat quality. Animal 7, 627–632.

6. GENERAL DISCUSSION

For improving animal welfare new housing methods and systems are suggested by animal rights organizations from time to time and in connection with these expectations new technologies are offered by companies for farm animal housing. Prior to practical application these forms of housing should be thoroughly scientifically investigated from the viewpoints of animal welfare, production and profitability. Main conclusions and recommendations can be made after evaluating the results of several experiments carried out by research teams. My aim was to contribute to this joint work with some new results.

During my studies a group housing system for rabbit does (offered by an animal protection foundation) and different individual cages for does (different sizes, floor types, elevated platforms) were examined with the goal to analyse the advantages and disadvantages of these housing conditions.

In the first study, group housing of rabbit does (four does and one buck) and commonly used individual cage housing in two different reproduction rhythms (33d and 42d) were compared. It was clearly revealed that group housed does had worse reproductive performances (lower kindling rate, high kit' mortality, lower number of weaned kits, shorten lifespan of does) than that of individually housed ones. Moreover, in group housing less does can be housed in a building and it needs more labour which further increases the cost and decreases the profitability. Later on video recordings (made during the first month of the study) were evaluated to search for the reasons of the lower production level. Sexual behaviour between does (they mounted each

other) was observed frequently which may cause pseudopregnancy and the low kindling rate (Gerencsér *et al.*, 2016). The nests with some day old kits were often destroyed by another doe and this also resulted higher suckling mortality and smaller number of weaned kits. The does were often aggressive against the other ones (Szendrő *et al.*, 2016a) and because of the continuous stress increased corticosterone hormone level was measured. These findings show that continuous group housing has lots of disadvantages for the farmers and for the rabbits too, it was contrary to animal welfare. Our results and the published reviews (Szendrő and McNitt, 2012; Szendrő *et al.*, 2016b; Hoy and Matics, 2016) have contributed that the continuous group housing of does should be discontinued.

Since group housing of does in so called "park systems" is legal regulation in Belgium and The Netherlands lots of researchers work on decreasing the problems of group housing. Plenty of different systems were tested (huge parks, identification chip in the ear, cat-flap for the usage of own nest-boxes; Hoy and Matics, 2016), but most of these technologies were expensive and the production level was low. Using semi-group housing system (does are housed individually for 3 weeks and in groups for the next 3 weeks) the does had comparable reproductive performances to individual housing system, however until now the problems of aggressive behaviour and high percentage of injured rabbits after regrouping of does has not been solved. In a recent survey, the majority of Belgian farmers had a negative opinion concerning park housing (Maertens, 2017), so it is contrary to animal and farmer welfare.

Due to the inefficiency and disadvantages of group housing, alternative individual cages for does were also tested. Free choice of individually housed rabbit does between different sized cages was examined in the second study. Offering larger space for rabbits has the goal to fulfil the request of the green movements. Based on video observations it was revealed that the location of does was more or less comparable to the floor size of the cages. Moreover, large individual variations were observed in the location. The cage choice may be considered as random and it can not be stated that the larger cages are more preferred by rabbit does.

Regardless of the results above it can be accepted that rabbit does can move more in larger cages. In observation of Rommers and Meijerhof (1998) rabbit does spent more time resting with extended body position in wider cages than in smaller ones. Experimental results (Rommers and Meijerhof, 1998; Mirabito *et al.*, 1999) also show that performance of does is not affected by the cage size. In our second experiment the rabbit does could move freely between two different sized cages. However, the location preference showed large individual variation, lactating does stayed more frequently in the other cage than in the place of kindling.

The other possibility for increasing the space for the rabbits is the installation of elevated platform into individual cages. This also means environmental enrichment as rabbits can move in third dimension, they can jump up and down or lay on or under the platform. In the third study commercially available individual cage types (flat-deck wire-mesh

cages with and without footrest, cages with wire-mesh or plastic-mesh elevated platform) were compared from different viewpoints. The results showed that when footrests were fixed on the wire-mesh floor, or the platforms were made of plastic-mesh the occurrence and severity of food pad injuries (sore hocks) of rabbit does significantly decreased. Since than it has been legally required (32/1999. (III. 31.) FVM rendelet a mezőgazdasági haszonállatok tartásának állatvédelmi szabályairól) to equip the wire mesh cages of breeding rabbits with a minimum 25 x 40 cm plastic footrest to avoid footpad injuries.

Installing elevated platforms into the breeding cages has double goals: increasing of the space and escaping possibility for the doe against the suckling attempts of kits after they leave the nest box. Similarly to the data in the literature (Mirabito *et al.*, 1999; Mirabito, 2002) in our observations the does spent time on the platforms. The platforms made of plastic mesh were used by the rabbits more frequently than that of wire mesh. As for escaping against the suckling attempts, the platform is just a temporary solution for the does because after the kits leave the nest box some days later they are able to jump up the platform.

Most of the examined reproductive traits were similar in the different cages; however the body weight of kits at 21d and 35d was higher in cages with then without platforms. As for the profitability the disadvantage of the cages equipped with platforms is that it is not possible placing a second level of cages over the others, worse is the occupancy of the building. From the viewpoint of animal welfare and production level, individual housing of rabbit does in enlarged cages

equipped with plastic elevated platforms can be a suitable compromise in case price of rabbit and meat increases.

7. CONCLUSIONS

During my studies several housing systems were compared from the viewpoint of production level and animal welfare. Based on the findings the following conclusions have been made.

1. Rabbit does housed continuously in group according to the recommendations of an animal protection group had substantially lower production than that of the individually housed ones. Group housing had several disadvantages from animal welfare aspect: frequent aggressive behaviour, severe injuries, high stress, shorter life span and high suckling mortality. This group housing system of rabbit does can not be offered for the practice.

2. In case of free choice between different sized cages it was observed at the 3rd week of lactation, that does spent more time in cage which was farther away from the nest than in the cage to which the nest belonged. Because of the large individual variations in the location of the does and the random choice between different sized cages, further investigations are required to define the appropriate cage size for rabbit does.

3. Housing rabbit does in enlarged cages equipped with plastic-mesh platform is advantageous, because there was higher body weight (better milk supply) of kits compared to conventional cages. It also improves the welfare of does because the higher possibility for moving, possible

choice of the most convenient part of cage and reduced incidence of sore hocks.

8. NEW SCIENTIFIC RESULTS

1. It was stated, that the continuously group housed rabbit does have substantially lower production and higher stress level than that of the individually housed ones (kindling rate: 45.6% vs. 77.6-85.2%, $P<0.05$; suckling mortality: 38.5% vs. 14.0-15.2%, $P<0.001$; faecal corticosterone metabolite concentration: 175 nmol/g vs. 54-61 nmol/g; $P<0.001$; in group housed and individually housed rabbit does in 33 d and 42 d reproduction rhythm, respectively), therefore the group housing of does is contrary to animal welfare.

2. It was stated, that in case of free choice between two different sized cages, rabbit does stayed with increasing frequency in cage farther from the nest during the 3rd week of lactation, independently of the cage size.

3. It was stated, that rabbit does spent more time on elevated platform made of plastic mesh than that of wire mesh (56.9 % vs. 31.7%, respectively; $P<0.001$). However, does can not escape from the suckling attempts of the kits, because the platforms were also used by kits after 17 days of age. When kits are able to jump up the platform does stay less frequent on it.

4. It was stated, that individual weight of kits at 21 days of age was significantly higher in does housed in enlarged cages with elevated platform compared to flat-deck housing (401-402 g vs. 372-382 g, respectively; $P<0.001$) which is related to the better milk supply of kits.

9. MAGYAR NYELVŰ ÖSSZEFOGLALÓ

Az utóbbi évtizedekben a nyúltenyésztés intenzív árutermelő ágazattá vált, ahol a nyulakat többnyire drótrácsból készült ketrecekben tartják. Világszerte egyre nagyobb elvárás azonban az állatok jóllétének biztosítása. Az állattenyésztésben nagy hangsúlyt kell fektetni az állatok jóllétére, azonban nem szabad figyelmen kívül hagyni a kutatások eredményeit és egyéb szempontokat sem, mint például a higiénia, állategészségügy vagy a gazdaságos termelés kérdése. Mielőtt törvényileg előírják egy új tartási mód alkalmazását, feltétlenül szükséges az egyes rendszerek fejlesztése, tesztelése, hogy azok valóban az állatok speciális igényeit szolgálják és lehetőség szerint minden fontos szempontot vegyenek figyelembe.

Az értekezés általános célkitűzése a különböző tartási rendszerekben elhelyezett anyanyulak termelésének és viselkedésének a vizsgálata annak érdekében, hogy a termelők számára is hasznosítható ismeretek száma bővüljön, és az eredményekkel hozzájáruljon a nagyüzemi nyúltartás számára megalapozottabb ajánlások kidolgozásához.

Az első kísérletben egy állatvédő szervezet által ajánlott csoportos anyanyúl-tartási rendszert (4 anyanyúl, 1 bak) hasonlítottunk össze a nagyüzemekben elterjedt egyedi, ketreces elhelyezéssel, kétféle szaporítási ritmus (33 napos, 42 napos) mellett. Csoportos tartásban rosszabb volt a fialási arány (egyedi: 77,6-85,2 %; csoportos: 45,6 %; $P<0,05$). Bár a fialási alomlétszám nem különbözött, a szopóskori elhullás viszont több mint kétszer olyan magas volt csoportos tartásban, mint az egyedi ketrecekben (egyedi: 10,4-15,2 %; csoportos: 38,5 %; $P<0,001$). A csoportos tartás esetében 7,7 %-ban előfordult, hogy két

anyanyúl ugyanabba a fiaztató ládába fialt. A csoportos elhelyezésben 49 (14 naposnál fiatalabb) szopósnyulat találtunk a fiaztató ládán kívül, a mélyalomban vagy a műanyag rácson, esetenként sérülten vagy elpusztulva.. A kísérlet végén, az anyanyulak túlélési aránya az egyedi tartásban 71% és 81%, a csoportosban csupán 50% volt (P=0,084). A teljes kísérleti időszakra (193 nap), egy anyanyúlra számított választott nyulak számában jelentős különbség mutatkozott (egyedi: 29,3-24,9; csoportos: 13,6). A bélsár mintákból kimutatott kortikoszteron metabolit koncentáció a csoportosan tartott anyanyulaknál háromszor magasabb volt, mint az egyedileg tartott anyanyulak esetében (egyedi: 53,6-61,0 nmol/g; csoportos: 174,6 nmol/g; P<0,001). A csoportosan tartott anyanyulak teljesítménye tehát lényegesen rosszabb volt, mint az egyedileg tartott anyanyulaké. Állatjólléti szempontból az anyanyulak csoportos tartásnak számos hátránya volt megfigyelhető, úgy, mint agresszív viselkedésből eredő sérülések, stressz, nagy arányú szopóskori elhullás és az anyanyulak rövid élettartama.

A második kísérletben üresen álló, illetve vemhes és szoptató anyanyulak szabad helyválasztását vizsgáltuk egy nagyüzemekben elterjedten használt (57,5 x 38 x 30 cm) és egy kétszeres méretű (57,5 x 76 x 30 cm), drótrácsból készült ketrec között. A nem vemhes anyanyulak átlagosan idejük 35%-át a kisebb, 65%-át a nagyobb ketrecben töltötték, amely arányos volt a ketrecek méretével (1/3 és 2/3). A vemhes és szoptató anyanyulak idejük nagyobb részét (73,1%) a nagyobb ketrecben töltötték (P <0,001). Az anyanyulak ketrecválasztására hatással volt az, hogy az anyanyúl melyik ketrecbe fialt, a laktáció második felében az anyanyulak nagyobb arányban tartózkodtak a fészküktől távolabbi ketrecben. Mivel a

ketrecválasztásban nagy egyedi eltérést tapasztaltunk, ezért megalapozottabb következtetés levonásához még további vizsgálatokra van szükség.

A harmadik kísérletben négy különböző típusú ketrecben (pihenőrács nélküli nagyüzemi ketrec; nagyüzemi ketrec pihenőráccsal; ketrec drótrács polccal és pihenőráccsal; nagyméretű ketrec műanyagrács polccal, pihenőrács nélkül) az anyanyulak termelésének és viselkedésének (jóllétének) összehasonlítása volt. A fialási arányt, az alomlétszámot (összes-, élve- és halva született, 21 és 35 napos) és a szopósnyulak elhullását nem befolyásolta a ketrec típusa. Nem volt különbség a két hagyományos, kisebb méretű ketrec között, és a két polccal felszerelt ketrec között sem a 21 és 35 napos korban mért alomsúlyban és az egyedi súlyban, ugyanakkor nagyobb alom és egyedi súlyt mértünk a polccal felszerelt ketrecekben ($P < 0{,}001$ és $P < 0{,}01$). A talpfekély előfordulási aránya és súlyossága legkedvezőbben a műanyag polccal felszerelt ketrecben alakult, ezt követte a drótrács polccal és pihenőlappal felszerelt ketrec. A pihenőlap nélküli hagyományos ketrecben volt leggyakoribb és legsúlyosabb a talpfekély előfordulása. A fémrács polcos ketrecben az anyanyulak ritkábban (25-38%) voltak a polcon, mint műanyag rács polc esetén (55,9-64,4%). A polchasználat tendenciáját tekintve a két ketrecben hasonlóan alakult. Amikor a kisnyulak elhagyták a fiaztató ládákat, megnőtt az anyanyulak polclátogatása, a laktáció 21. napját követően, amikor a kisnyulak is fel tudtak menni a polcra, az anyanyulak polcon töltött ideje csökkent.

10. SUMMARY

In recent decades, rabbits have been kept mainly in intensive husbandry systems in wire-mesh cages. There is a growing interest worldwide about the animal welfare and well-being of farmed animals. In animal husbandry emphasis has to be put on the aspect of animal welfare but it is also important not to ignore the scientific results and aspects of hygiene, health and economy. Before a new housing system is prescribed by the law the development and testing of new housing conditions for does with kits and for growing rabbits has an important role to take the specific needs of animals and all other possible aspects into account.

The general aim of the PhD research was to examine the production and behaviour of rabbit does under different housing conditions to expend the range of knowledge useful for farmers and to contribute to the development of well-founded recommendations for housing of rabbits. In the first experiment, the generally used individual-housing system (single-caged, with two different reproduction rhythm: 33d and 42d) with the group-housing system of rabbit does (4 does and 1 buck) recommended by an animal protection group. The continuously group housed does had lower kindling rate (individual: 77.6-85.2 %; group: 45.6 %; $P<0.05$). There was not significant difference between the litter weights at kindling but the suckling mortality was more than two times higher in case of group housing comparing to individual ones (individual: 10.4-15.2 %; group: 38.5 %; $P<0.001$). The frequency of multiple kindling in the same nest box was 7.7% and 49 young rabbits (<14 days old) were found outside the nest box, either on the plastic

slats or in deep litter in case of group housed does. Many of these kits had injuries attributed to biting or chewing by the doe. At the end of the experiment, the survival rates of does were 71% and 81% in individual housing and 50% in groups (P=0.084). During the entire experiment (193 days), large difference was observed in the number of weaned rabbits per doe (individual: 24.9-29.3; group: 13.6). Faecal corticosterone metabolite concentration of does housed in groups was approximately 3 times higher than for does caged individually (individual: 53.6-61.0 nmol/g; group: 174.6 nmol/g; $P<0.001$). The production of group housed rabbit does was substantially lower than that of the individually housed does. From the aspect of animal welfare, group housing of rabbit does had several disadvantages: stress related to aggressive behaviour, frequent and harmful injuries, high suckling mortality and short lifespan.

In the second experiment the location preference of non-pregnant, pregnant and lactating rabbit does was observed between wire mesh cages of different size (commercial cage for individual housing of does: 57.5 x 38 x 30 cm and a large cage with two times bigger floor space: 57.5 x 76 x 30 cm). The average time spending of non-pregnant rabbit does was 35% and 65% in small and large cages, respectively, which seemed to be proportional to the cage sizes (1/3 and 2/3). The pregnant and lactating rabbit does spent most of their time (73.1%) in the large cage ($P < 0.001$). Location preference was affected by the cage where the kindling took place, in the second half of lactation period the does preferred to stay more frequently in the cage without nest box. The location preference showed large individual variation, that requires further analysis.

In the third experiment four commercial cages were compared: conventional cages with footrests; conventional cages without footrests; alternative (large) cages equipped with wire-mesh platforms and footrests; and alternative (large) cages with plastic-mesh platforms and without footrests. Reproductive performance, nursing behaviour, the occurrence of sore hocks and, in cages with platforms, the location preference of rabbit does and platform utilization of the kits were monitored. Kindling rate, litter size (born total, born alive and stillborn, at 21 and 35 days), and kit mortality were not influenced by the cage types. There were no significant differences between the two smaller, conventional cages, and between the two enlarged cages with platforms in litter and individual weight at 21 and 35 days; however, comparing the conventional cages with enlarged cages, these characteristics were higher in the enlarged cages ($P < 0.001$ and $P < 0.01$). Concerning the occurrence and severity of sore hocks (pododermatitis), the most favourable cage type was the enlarged cage with plastic-mesh platform followed by enlarged cage with wire-mesh platform and footrest on the bottom level; however, even flat-deck cage with footrest was much better for the rabbits than the commercial cages without footrest. Rabbit does spent less time on the platform when it was made of wire mesh (25-38%) than on platform made of plastic mesh (55.9-64.4%). The time spent by does on the platform showed similar tendency in both types of cages equipped with platform. When the kits left the nest boxes, the does used the platform more often, and then after day 21, when the kits started to visit the platform, the platform usage by the does decreased.

11. REFERENCES

32/1999. (III. 31.) FVM rendelet a mezőgazdasági haszonállatok tartásának állatvédelmi szabályairól

Alfonso-Carrillo, C., Martin, E., De Blas, C., Ibanez, M.A., Garcia-Rebollar P., Garcia-Ruiz, A.I. 2014. Effect of cage type on the behaviour pattern of rabbit does at different physiological stages. World Rabbit Sci., 22. 59-69.

Andrist C.A., Bigler L.M., Würbel H., Roth B.A. 2012. Effects of group stability on aggression, stress and injuries in breeding rabbits. Appl. Anim. Behav. Sci., 142: 182-188.

Andrist C.A., Bigler L.M., Würbel H., Roth B.A. 2014. Masking odour when regrouping rabbit does: Effect on aggression, stress and lesions. Livest. Sci., 170: 150-157.

Andrist C.A., van den Borne B.H.P., Bigler L.M., Buchwalder T., Roth B.A. 2013. Epidemiologic survey in Swiss group-housed breeding rabbits: Extent of lesions and potential risk factors. Prev. Vet. Med., 108: 218-224.

Barge P., Masoero G., Chicco R. 2008. Raising rabbit does in platform cages. In: 9th World Rabbit Congress, Verona, Italy, pp. 1153-1157.

Bignon L., Bouchier M., Coutelet G., Galliot P., Souchet C., Fortun-Lamothe L. 2012. Individual housing of young does in different sized cages: Impact on welfare, economic costs and productive data. In: 10th World Rabbit Congress, September 3-6, Sharm El-Sheikh, Egypt, pp. 1045-1049.

Bohus, B., Koolhaas, J.M., De Ruiter, A.J.H., Heijnen, C.J., 1991. Stress and differential alterations in immune system functions: conclusions from social stress studies in animals. Neth. J. Med., 39: 306-315.

Buijs S., Vangeyte J., Tuyttens F.A.M. 2016. Effects of communal rearing and group size on breeding rabbits' post-grouping behaviour and its relation to ano-genital distance. Appl. Anim. Behav. Sci. 182, 53–60.

Buijs, B., Hermans, K., Maertens, L., Van Caelenberg, A., Tuyttens, F.A.M. 2014. Effects of semi-group housing and floor type on pododermatitis, spinal deformation and bone quality in rabbit does. Anim., 8, 1728–1734.

Cornelissen, J.M.R., Scheper, F., van Weeghel, H.J.E., Rommers, J.M., van Eijk, O.N.M., 2011. Brief of Requirements of the Rabbit. Rabbit on Course. Report 524, Wageningen UR Livest. Res., pp. 1–27.

Cowan, D.P. 1987. Groupliving in the European rabbit (Oryctolagus cuniculus): mutual benefit or resource localization? J. Anim. Ecol., 5: 779-795.

de Jong I.C., Reimert H., Rommers J.M.. 2008. Effect of floor type on footpad injuries in does: a pilot study. In: 9th World Rabbit Congress, 10-13 June, 2008. Verona, Italy, 1171-1175.

EFSA, 2005. The impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. The EFSA Journal, 267: 1-140.

Farm Animal Welfare Council (FAWC) 1992. FAWC updates the five freedoms. Vet. Rec., 131: 357

Finzi, A., Negretti, P., Macchino, P., Gonzalez-Renodo, P., 2010. Cage rearing and ethological requirements of the rabbit. In: Proceedings of the XXXIV Symposium de Cuniculture de ASESCU, Sevilla, Spain. World Rabbit Sci. 18, 51.

Gerencsér Zs., Kustos K., Szabó R. T., Mikó A., Odermatt M., Radnai I., Matics Zs., Szendrő Zs., 2016. Mating behaviour of rabbit does and bucks in groups (preliminary results). In: 11th World Rabbit Congress. 15-18. June 2016, Qingdao, China, pp. 675-678.

Graf S., Bigler L.M., Failing K., Würbel H., Buchwalder T. 2011. Regrouping rabbit does in a familiar or novel pen: Effects on agonistic behaviour, injuries and core body temperature. Appl. Anim. Behav. Sci., 135: 121-127.

Held S.D.E., Turner R.J., Wootton R.J. 1995. Choice of laboratory rabbits for individual or group-housing. Appl. Anim. Behav. Sci., 46: 81-91.

Holst D. von 1998. The concept of stress and its relevance for animal behaviour. Advances in the Study of Behavior 27, 1–131.

Holst D. von, Hutzelmeyer H., Kaetze P., Khashei M., Schönheiter R. 1999. Social rank, stress, and life expectancy in wild rabbits. Naturwissenschaften 86: 388-393.

Holst D. von, Hutzelmeyer H., Kaetze, P., Khashei M., Rödel H.G., Schrutka H. 2002. Social rank, fecundity and life time reproductive success in wild European rabbits (Oryctolagus cuniculus). Behav. Ecol. Sociobiol., 51: 245-254.

Hoy St., Matics Zs. 2016. Alternative housing systems for rabbit does. In: 11th World Rabbit Congress. 15-18. June 2016, Qingdao, China, pp. 637-651.

König, B. 1997. Cooperative care of young in mammals. Naturwissenschaften 84: 95-104.

Künkele J. 1992. Infanticide in wild rabbits (Oryctolagus cuniculus). J. Mammal. 73, 317–320.

Kutsukake N. 2009. Complexity, dynamics and diversity of sociality in groupliving mammals. Ecol. Res. 24, 521–531.

Lebas F., Coudert P., de Rochambeau H., Thébault R.G. 1997. The Rabbit. Husbandry, health and production. FAO Animal Production and Health. Rome, Series No 21.

Lombardini L., Fernández N., Moreno S., Villafuert R. 2003. Habitat-related differences in rabbit (Orictolagus cuniculus) abundence, distribution, and activity. J. Mammal., 84: 26-36.

Maertens L., 2017. Farmers experiences with park housing of rabbits. In: 20th International Symposium on housing and diseases of rabbits, furproviding animals and pet animals. 17-18. May 2017, Celle, Germany, pp. 37-41.

Maertens L., Buijs S., 2013. Performances de femelles logées temporairement en groupe dans des parcs polyvalents et en système tout plein tout vide. In: Proc. Journées de la Recherche Cunicole en France, Le Mans 19-20 novembre: 35-38.

Maertens L., Buijs S. 2015. Production performances of semi-group housed rabbit does. In: 19th International Symposium on Housing and Diseases of Rabbits, Furproviding Animals and Pet Animals, 27 May - 28 May 2013, Celle, Germany, pp. 22-31.

Maertens L., Buijs S. 2016a. Comparison of fattening performances housed in parks or enriched cages. In: 11th World Rabbit Congress. Qingdao, China, 703–706.

Maertens L., Buijs S. 2016b. Production performances of rabbit does in a part-time group housing system. In: 11th World Rabbit Congress. Qingdao, China, 711–714.

Maertens L., Buijs S. 2016c. Impact of housing system (cage vs. part-time housing) and floor type on rabbit doe welfare. In: 11th World Rabbit Congress. Qingdao, China, 707–710.

Maertens L., Rommers J., Jacquet M. 2011. Le logement des lapins en parcs, une alternative pour les cages classiques dans un système "duo"? In: 14èmes Journ. Rech. Cunicole, 22-23 November 2011, Le Mans, France, pp. 85-88.

Masthoff T., Lang C., Hoy St., 2017. Einfluss der Fußbodengestaltung auf das Auftreten von Verschmutzungen und Fußläsionen bei Mastkaninchen. In: 20th International Symposium on housing and diseases of rabbits, furproviding animals and pet animals. 17-18. May 2017, Celle, Germany, pp. 53-61.

Matics Zs., Szendrő Zs., Radnai I., Farkas T.P., Kasza R., Kacsala L., Nagy I., Szabó R.T., Terhes K., Gerencséz Zs. 2017. ANIHWA – Experimental results at Kaposvár University. In: 20th International Symposium on housing and diseases of rabbits, furproviding animals and pet animals, Celle, Germany, 27-36.

Mirabito L., 2002. Le bien-être des lapines: impact de nouveaux systèmes de logement. Journée Nationale ITAVI, Elevage du lapin de chair, Nantes, France, 13.

Mirabito, L., 2003. Logement et bien-ętre du lapin: les nouveaux enjeux. In: 10èmes Journ. Rech. Cunicole, Paris, France, pp. 163-172.

Mirabito L., Buthon L., Cialdi G., Galliot P., Souchet C., 1999. Effet du logement des lapines en cages rehaussées avec platforme: Premiers résultats. In: 8émes Journées de la Recherche Cunicole, June 9-10, 1999, Paris, France, pp. 67-70.

Mirabito L., Galliot P., Souchet C., Dumont F., Thomeret F. 2005a. Logement collectif des lapines reproductrices: Conséquences zootechniques. In: 11émes Journ. Rech. Cunicole, November 29-30, 2005, Paris, France, pp. 53-56.

Mirabito, L., Dumont, F., Galliot, P., Souchet, C. 2005b. Logement collectif des lapines reproductrices : Conséquences sur le comportement. In: 11émes Journ. Rech. Cunicole, Paris, France, 57-60.

Mugnai, C., Dal Bosco, A., Castellini, C., 2009. Effect of different rearing systems and pre-kindling handling on behaviour and performance of rabbit does. Appl. Anim. Behav. Sci. 118, 91-100.

Mykytowycz R., Dudzinski M.L. 1972. Aggressive and protective behaviour of adult rabbits Oryctolagus cuniculus (L.) towards juveniles. Behav. 43, 97–120.

Negretti P., Bianconi G., Finzi A. 2010. Rabbit posture and behaviour to determine cage height in relationship with animal welfare. In: XXXV Symposium de cunicultura ASESCU, 2010 May, Segovia (Spain), pp 54-58

Prola L., Cornale P., Renna M., Macchi E., Perona G., Mimosi A. 2013. Effect of breed, cage type, and reproductive phase on fecal corticosterone levels in doe rabbits. J. Appl. Anim. Welfare Sci., 16: 140-149.

Rödel G.H., Starkloff A., Bautista A., Friderich A.C., von Holst D. 2008. Infanticide and maternal offspring defence in European wild rabbits under natural breeding condition. Ethol., 114: 22-31.

Rommers J., Meijerhof R. 1998. Effect of group size on performance, bone strength and skin lesions of meat rabbits housed under commercial conditions. World Rabbit Sci., 6: 299-302.

Rommers, J.M., Jong de, I.C. 2011. Technical note: Plastic mats prevent footpad injuries in rabbit doe. World Rabbit Sci., 19, 233-237.

Rommers J.M., Gunnink H., de Jong I.C. 2013. Effect of different types of places on aggression among does in a group-housing system: A pilot study. In: 18th International Symposium on Housing and Diseases of Rabbits, Fur Providing Animals and Pet Animals, May 22-23, 2013, Celle, Germany, pp. 59-68.

Rommers J.M., Boiti C., de Jong I., Brecchia G. 2006. Performance and behaviour of rabbit does in a group-housing system with natural mating or artificial insemination. Reprod. Nutr. Dev., 46: 677-687.

Rommers J.M., Gunnink H., Klop A., de Jong I.C. 2011. Dynamics in aggressive behaviour of rabbit does in a group-housing system: a

descriptive study. In: 17th International Symposium on Housing and Diseases of Rabbits, Fur Providing Animals and Pet Animals, May 11-12, 2011, Celle, Germany, pp. 75-85.

Rommers J.M., Reuvekamp B.J.F., Gunnink H., de Jong I.C. 2014. Effect of hiding places, straw and territory on aggression in group-housed rabbit does. Appl. Anim. Behav. Sci. 157, 117–126.

Rosell J.M., de la Fuente L.F. 2004. Health status of domestic rabbits in the Iberian peninsula. Influence of their origin. In: 8th World Rabbit Congress, 7-10 September, 2004. Puebla, Mexico.614-619.

Rosell J.M., de la Fuente L.F. 2009. Effect of footrests on the incidence of ulcerative pododermatitis in domestic rabbit does. Anim. Welfare, 18: 199-204.

Rosell J.M., de la Fuente L.F. 2013. Assessing ulcerative pododermatitis of breeding rabbits. Animals, 3: 318-326.

Ruis, M. 2006. Group housing of breeding does. In: Maertens, L. and Coudert, P. (Eds.): Recent Advances in Rabbit Science. ILVO, Belgium, 99-105.

Seaman S.C., Waran N.K., Mason G., D'Eatch R. 2008. Animal economics: assessing the motivation of female laboratory rabbits to reach a platform, social contact or food. Anim. Behav. 75, 31-42

Selzer D. 2000. Vergleichende Untersuchungen zum Verhalten von Wild- und Hauskaninchen unter verschiedenen Haltungsbedingungen. Thesis Univ. Gießen.

Selzer D., Lange K., Hoy St. 2004. Frequency of nursing in domestic rabbits under different housing conditions. Appl. Anim. Behav. Sci., 87: 317-324.

Southern H.N. 1948. Sexual and aggressive behaviour of the wild rabbit. Behav., 1: 173-194.

Stauffacher M. 1992. Group housing and enrichment cages for breeding, fattening and laboratory rabbits. Anim. Welfare, 1, 105-125.

Surridge, A.K., Bell, D.J., Hewitt, G.M. 1999. From population structure to individual behaviour: genetic analysis of social structure in the European wild rabbits (*Oryctolagus cuniculus*). Biol. J. Linn. Soc. 68: 57–71.

Szendrő Zs., Matics Zs., Szabó R. T., Kustos K., Mikó A., Odermatt M., Gerencsér Zs., 2016. Aggressivity and its effect on lifespan of group housed rabbit does. Preliminary results. In: 11th World Rabbit Congress. 15-18. June 2016, Qingdao, China, pp. 719-722.

Szendrő Zs., McNitt I.J. 2012. Housing of rabbit does: Group and individual systems: A review. Livest. Sci., 150: 1-10.

Szendrő Zs., McNitt J. I., Matics Zs., Mikó A., Gerencsér Zs., 2016b. Alternative and enriched housing systems for breeding does: a review. World Rabbit Sci. 24:(1) pp. 1-14.

Trocino A., Zomeño C., Birolo M., Zuffellato A., Xiccato G. 2016. Characterization study of aggressive behaviours in group-housed

rabbit does. In: 11th World Rabbit Congress, Qingdao, China, 723-726.

Verga M., Luzi, F., Carenzi C. 2007. Effects of husbandry and management systems on physiology and behaviour of farmed and laboratory rabbits. Horm. Behav., 52: 122-129.

Zomeño C., Birolo M., Gratta F., Zuffellato A., Xiccato G., Trocino A. 2017a. Influence of group housing, lactation system and floor type on performance and injuries in rabbit does. It. J. Anim. Sci. 16 (s1), 80.

Zomeño C., Birolo M., Zuffellato A., Xiccato G., Trocino A. 2017b. Aggressiveness in group-housed rabbit does: Influence of group size and pen characteristics. Appl. Anim. Behav. Sci. doi:10.1016/j.applanim.2017.05.016

12. PUBLICATIONS

Peer-reviewed papers published in foreign scientific journals

Mikó A., Szendrő Zs., Matics Zs., Radnai I., Odermatt M. 2012. Location preference of rabbit does between common sized and double sized cages. Acta Agriculturae Slovenica 100:(Suppl.3) 299-302.

Szendrő Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Dezséry B., Garai É., Nagy I., Szendrő K., Matics Zs. 2013. Comparison of performance and welfare of single-caged and group-housed rabbit does. Animal 7:463-468.

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

Szendrő Zs., McNitt J.I., Matics, Zs., Mikó A., Gerencsér Zs. 2016. Alternative and enriched housing systems for breeding does: A review. World Rabbit Sci. 2016, 24: 1-14

Abstract in scientific journals

Matics Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Szendrő Zs. 2011. Effect of foot rest on sore hock of rabbit does. Ital, J. Anim. Sci., 10:(Suppl.1), 123.

Szendrő Zs., Mikó A., Odermatt M., Dezséry B., Garai É., Gerencsér Zs., Nagy I, Matics Zs. 2011. Group housing of rabbit does. Ital. J. Anim. Sci., 10:(Suppl.1), 124.

Conference proceedings published in foreign language

Szendrő Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Dezséry B., Garai É., Nagy I., Szendrő K., Matics Zs. 2011. Group housing of rabbit does. In Proc. 17. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere, Celle, Germany, 5-20.

Matics Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Szendrő Zs. 2011. Comparison of the production of rabbit does housed in cages with or without footrest. In: Proc. 17. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere, Celle, Germany, 21-27.

Mikó A., Matics Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Szendrő Zs. 2011. Location preference of rabbit does among cages of different size. In: Proc. 17. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere, Celle, Germany, 269-273.

Mikó A., Matics Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Szendrő Zs. 2011. Location preference of rabbit does and their kits in

cages with elevated platform. In: Proc. 17. Internationale Tagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere, Celle, Germany, 274-282.

Mikó A., Matics Zs., Gerencsér Zs., Radnai I., Odermatt M., Nagy I., Szendrő Zs. 2012. Location preference of lactating rabbit does and their kits in pens with elevated platform In: Proc. 10th World Rabbit Congress, Sharm El Sheikh, Egypt, 1029-1032.

Mikó A., Szendrő Zs., Matics Zs., Radnai I., Odermatt M., Nagy I., Gerencsér Zs. 2012. Free choice of rabbit does between cages of different sizes. In: Proc. 10th World Rabbit Congress, Sharm El Sheikh, Egypt, 1069-1073.

Mikó A., Szendrő Zs., Odermatt M., Gerencsér Zs., Radnai I., Matics Zs. 2013. Mating behaviour of group housed rabbits after establishing the group. In: Proc.18th International Symposium on Housing and Diseases of Rabbits, Furproviding Animals and Pet Animals, Giessen, Németország, Celle, Germany, 53-58.

Mikó A., Szendrő Zs., Odermatt M., Gerencsér Zs., Radnai I., Matics Zs. 2013. Aggressive behaviour of group-housed rabbit does after establishing the group. In: Proc. 18th International Symposium on Housing and Diseases of Rabbits, Furproviding Animals and Pet Animals, Celle, Germany, 69-75.

Gerencsér Zs., Kustos K., Szabó R.T., Mikó A., Odermatt M., Radnai I., Matics Zs., Szendrő Zs. 2016. Mating behaviour of rabbitdoes and bucks ingroups. In: Proc. 11th World Rabbit Congress, Qingdao, China, 675-678.

Szendrő Zs., Matics Zs., Szabó R.T., Kustos K., Mikó A., Odermatt M., Gerencsér Zs. 2016. Agressivity and its effect on lifespan of group housed rabbit does. In: Proc. 11th World Rabbit Congress, Qingdao, China, 719-722.

Conference proceedings published in Hungarian

Szendrő Zs., Dézsery B., Odermatt M., Gerencsér Zs., Nagy I., Molnár Sz., Mikó A., Radnai I., Matics Zs. 2010. Az egyedileg és csoportosan tartott anyanyulak termelésének vizsgálata. 22. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 77-82.

Mikó A., Matics Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Szendrő Zs. 2011. Anyanyulak termelésének összehasonlítása hagyományos egyszintes és polccal felszerelt ketrecekben. 23. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 55-58.

Mikó A., Matics Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Szendrő Zs. 2011. Anyanyulak és fiókáik szabad helyválasztása polccal felszerelt ketrecekben. 23. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 59-64.

Matics Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Szendrő Zs. 2011. Talpfekély előfordulása különböző módon tartott anyanyulakon. 23. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 65-68.

Mikó A., Matics Zs., Odermatt M. Gerencsér, Zs, Radnai I., Nagy I., Szendrő Zs. 2011. Anyanyulak helyválasztása különböző méretű ketrecek között. 23. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 69-72.

Szendrő Zs., Gerencsér Zs., Radnai I., Mikó A., Odermatt M., Dalle Zotte A., Matics Zs. 2013. Anyanyulak tartásával, viselkedésével és jóllétével kapcsolatos tudományos eredmények a Kaposvári Egyetemen (2008-2012). 25. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 25-36.

Gerencsér Zs., Matics Zs., Radnai I., Mikó A., Szendrő Zs. 2013. Az anyanyulak termelésével kapcsolatos kutatási eredmények a Kaposvári Egyetemen (2008-2012). 25. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 37-51.

Szendrő Zs., Mikó A., Odermatt M., Gerencsér Zs., Radnai I., Dezséry B., Garai É., Szendrő K., Nagy I., Matics Zs. 2013. Az anyanyulak csoportos tartása. 23. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 35-46.

Mikó A., Szendrő Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Matics Zs. 2014. A csoportosan tartott anyanyulak agresszív viselkedése a csoport kialakítását követő hónapban. 26. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 41-44.

Gerencsér Zs., Kustos K., Szabó R.T., Mikó A., Odermatt M., Radnai I., Matics Zs., Szendrő Zs. 2016. Szexuális viselkedés vizsgálata csoportosan tartott anyanyulaknál. 28. Nyúltenyésztési Tudományos Nap. Kaposvár, Magyarország, 103-107.

Szendrő Zs., Matics Zs., Szabó R.T., Kustos K., Mikó A., Odermatt M., Gerencsér Zs. 2016. Agresszív viselkedés vizsgálata csoportosan tartott anyanyulaknál. 28. Nyúltenyésztési Tudományos Nap. Kaposvár, Magyarország, 97-101.

Other publications not related to the topic of the dissertation

Peer-reviewed paper published in foreign scientific journal

Mikó A., Radnai I., Gerencsér Zs., Matics Zs., Nagy I., Szendrő K., Szendrő Zs. 2010. The profit of the slaughterhouses realized in the course of CT-aided selection of rabbits. Acta Agraria Kaposváriensis, 14:103-108.

Matics Zs., Gerencsér Zs., Radnai i., Dalle Zotte A., Palumbo M., Mikó A., Kasza R., Szendrő Zs. 2013. Effect of different lighting schedules (16L:8D or 12L:6D) on reproductive performance and nursing behaviour of rabbit does. Livestock Sci., 157:545-551.

Conference proceedings published in foreign language

Matics Zs., Gerencsér Zs., Radnai I., Mikó A., Hullár I., Szendrő Zs. 2013. Effect of fibre type and supplementation of probiotic and prebiotic on productive traits of growing rabbits. In: Proc. 18th International Symposium on Housing and Diseases of Rabbits, Furproviding Animals and Pet Animals, Celle, Germany, 92-98.

Conference proceedings published in Hungarian

Matics Zs., Gerencsér Zs., Radnai I., Mikó A., Nagy I., Szendrő Zs. 2012. Világítási program (16V:8S illetve 12V:6S) hatása az anyanyulak termelésére. 24. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 59-63.

Matics Zs., Gerencsér Zs., Mikó A., Radnai I., Odermatt M., Nagy I., Szendrő Zs. 2012. Világítási program (16V:8S illetve 12V:6S) hatása az anyanyulak szoptatási viselkedésére. 24. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 65-70.

Matics Zs., Gerencsér Zs., Radnai I., Mikó A., Kasza R., Szendrő Zs. 2014. Eltérő fényintenzitás hatása az anyanyulak termelésére. 26. Nyúltenyésztési Tudományos Nap, Kaposvár, Magyarország, 33-36.

Conference proceedings abstracts published in Hungarian

Mikó A., Szendrő Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Matics Zs. 2013. A csoportosan tartott nyulak párzási viselkedése a csoport kialakítását követő hónapban. Gödöllő, Szent István Egyetem, Magyarország, 55.

Mikó A., Szendrő Zs., Odermatt M., Gerencsér Zs., Radnai I., Nagy I., Matics Zs. 2013. A csoportosan tartott anyanyulak agresszív viselkedése a csoport kialakítását követő hónapban. Gödöllő, Szent István Egyetem, Magyarország, 56.

Mikó A. 2010. A CT szelekciós célú használata a nyúltenyésztésben és hasznosságának ökonómiai vizsgálata. Junior kutatók művészek tudományos és művészeti diákköri munkái a 2009/10 és a 2010/11-es tanévekben, Kaposvár, Kaposvári Egyetem, Magyarország, 17-18.

CURRICULUM VITAE

Annamária Mikó was born in Kaposvár, Hungary on 2nd of November in 1986.

In 2005 she finished her studies in Munkácsy Mihály Grammar School in Kaposvár.

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In 2010 she participated in Scientific Students' Associations Conference with a presentation with this topic.

After Graduate Studies she was a full-time student at the Doctoral School of Animal Science of Kaposvár University.

Since then she has been working in Banking Sector.

She obtained English (2004) language intermediate and German language (2017) basic level state exams.

She is a mother of a 2 and a 4 year-old girls.