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ALTERNATIVE AND ENRICHED HOUSING SYSTEMS FOR BREEDING DOES: A REVIEW

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Abstract: The main results and observations on group and individually housed rabbit does were reviewed by Szendrő and McNitt in 2012, but in recent years several new papers in this field have been published. This provides a new opportunity to summarise the current knowledge on alternative housing systems for breeding does. In Switzerland, rabbit does are generally housed in group systems. The recently legislated Belgian and Dutch housing systems will be converted step by step into group housing systems. Recent research demonstrated that with semi-group housing systems much better performance levels are possible than with the Swiss group housing system. However, solutions to eliminate aggression, stress and injuries which are common among rabbit does in group housing systems have yet to be found. Some authors are of the opinion that individual cages are too small and allow limited possibilities for movement and social contact. Positive results were seen when platforms were inserted into the cages and the possibility for movement increased. The does and their kits could jump up and down using the platforms. Using footrests, the incidence of sore hocks declined. Several environmental enrichments which increase the well-being of rabbit does can also be used. These enriched cages (equipped with platforms, footrests, gnawing sticks, etc.) are fully in line with animal welfare requirements. Increasing the size of cages and enriching them increases the production cost and the meat will be more expensive.

Key Words: rabbit does, group housing, individual housing, enrichment, welfare.

INTRODUCTION

Domestic rabbits originated from the European wild rabbit (*Oryctolagus cuniculus*), which generally lives in groups numbering between a single pair and up to 30 individuals, inside burrow systems (Leach, 1989). The Romans dispersed the rabbit as a wild animal in the majority of territories of their empire for hunting and supplies of fresh meat. At that time rabbits lived in large enclosed spaces called "leporaria" (Lebas *et al.,* 2010). Initially, rabbits (adults and young) were kept in groups, often together with other animals. The beginning of housing rabbit does in hutches occurred in the 15th and 16th centuries, mainly to supply replacements for the *leporaria* where the kindling rates and production of young were very low. At the beginning of the 17th century, rabbit does were also kept in individual boxes (Lebas *et al.,* 2010). Due to several problems, housing rabbit does in groups was phased out in France in the late 1970s (Mirabito *et al.,* 2005a). In the first part of the 20th century, the size of a breeding doe cage was 0.48-0.56 m^2, which is barely larger than currently practiced for the majority of breeding does in Europe (EFSA, 2005). It seems that the small farmer's experience and the modern wire-mesh cages for large farms are close to each other. Nevertheless, in recent years there has been increasing interest in alternative and enriched housing systems. This ranges widely from group housing to cages with environmental enrichment, and has been investigated, developed and used in some farms.

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The main results and observations on group and individually housed rabbit does were reviewed by Szendrő and McNitt (2012), but in recent years several new results have been published in this field. This provides a new opportunity to summarise the current knowledge on alternative housing systems for breeding does.

GROUP HOUSING SYSTEMS

Does are continuously together

The first alternative accommodation system, housing the rabbit does in groups in near-to-nature surroundings, was published by Stauffacher (1992). He summarised the main problems of individual housing: limited freedom of movement, stereotypies (e.g. wire-gnawing), restlessness, and disturbed sexual, nesting and nursing behaviours. The main goal of group-housing of rabbit does was to provide near-to-nature environmental conditions, similar to those of the European wild rabbits. Because rabbits are social animals that exhibit several social behaviour forms, mating is natural, maternal (nursing) behaviour is not restricted, and they live in groups with a large area for moving, group housing seemed to be a good alternative to individual housing.

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 and for kits, as well as a nest box for each doe with a tunnel-like entrance (Stauffacher, 1992). Pens were enriched with raised platforms, hiding places, hay racks, gnawing sticks, and similar. The fertility rate was satisfactory (89%), the litter size was 8.4 and the suckling mortality was 16%. One remarkable observation was 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.

Over the past 20 yr, several modified Stauffacher systems have been investigated; mostly in Switzerland. In more recent years, 3 methods of group housing have been used on several farms (Andrist *et al.,* 2013): 1) does are mated naturally, the buck is usually introduced for 10 d, and a 33-d reproduction rhythm is used; 2) breeders apply artificial insemination (AI) with a 33-d reproduction rhythm, or 3) a 42-d reproduction rhythm, in which does are held in individual housing from the 30th d of pregnancy until 12 d after birth when they are inseminated, and from day 12 of lactation till day 30 of pregnancy they are housed in groups. According to Andrist *et al.* (2013) the sizes of the farms examined were small (35-138 does/farm). Most of the farms used hybrids. The size of groups was 5-9 does and the average kindling rate was low (61% overall; 64% naturally mated; 60% AI). The average litter size was 9.6 (between 8 and 12). The suckling mortality was sometimes high and ranged from 4 to 25%. Aggressiveness was the basic problem: lesions occurred on all farms; 33% of animals had at least one lesion and the occurrence of more severe injuries was 9%.

Aggressive behaviour has been well known for a long time in European wild rabbits (Southern, 1948). At the start of the reproductive season, the fights are very intense (von Holst *et al.,* 1999). Dominance order is established and maintained through chase rituals and aggressive interactions (Mykytowycz, 1958).

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, but smaller (4.5 m^2). They wanted to build the groups at a young age, but rearing future does together was not successful, as it resulted in a high incidence of fighting and injuries (wounds and abscesses). One-third of the rabbits were culled for these reasons. AI, a 42-d reproduction rhythm and free nursing was applied. No differences were found in kindling rate and litter size. However, the suckling mortality was twice as high in grouped does compared to those housed individually (8.4 *vs.* 17.4%). One of the reasons for this could be the kindling of 2 or 3 does in the same nest box. The authors reported that 1, 2 or 3 litters per box occurred 62.4, 31.3 and 6.3% of the time, respectively. These rates of suckling mortality were very high compared to other experiments. Separating these litters was not successful. 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.

Rödel *et al.* (2008) also observed double kindling among European wild rabbits in the same nest, which caused higher mortality after parturition. In 68% of the infanticide cases, the kits were found dead with the typical wounds caused by rabbit incisors. In 17% of the infanticides, another female built a new nest and gave birth inside the chamber

within the day after the first doe kindled. In another 36% of cases, another female of the group kindled in an adjacent breeding chamber (30-50 cm apart) within the same burrow.

Szendrő *et al.* (2013) tested the recommendation of the Four Paws' (Vier Pfoten) animal protection organisation for group housing of does (G). The size of pens was 7.7 m^2 for 4 does and 1 buck with 4 nest boxes in a pen. The control does were individually housed (I); half of them were inseminated 2 d after kindling and the other half 11 d after parturition (33-d and 42-d reproductive rhythms, respectively). The kindling rate was significantly lower in G than in the I groups (46% for the G group *vs.* 78 and 85% for the 42 d and 33 d reproductive rhythms, respectively). The concentration of cortisol metabolites in faecal samples was 3 times higher in the grouped does (175 *vs.* 54 and 61 nmol/g, respectively). Housing did not affect the litter sizes, although the rate of suckling mortality was more than twofold in group housed does (38 *vs.* 14 and 15% for the 42 d and 33 d reproductive rhythms, respectively). One of the reasons was that in 18% of the parturitions 2 does kindled in the same nest box. A few day-old kits were scraped out of the nest boxes onto the floor and some of them had injuries attributed to biting or chewing. Survival of rabbit does was significantly lower in groups than in individually housed does. The number of weaned rabbits per doe per year was significantly lower in grouped does.

Similar results were seen in European wild rabbits, as pointed out by Szendrő *et al.* (2013). Von Holst *et al.* (2002) measured lower levels of corticosterone and lower heart rates of males and females in dominant positions than in animals with lower rank position. Fertility and reproductive success of the females depended on their social ranks. The number of litters per year was 3.7 and 2.1, and number of kits born per year was 18 and 9 in first and fifth rank position does, respectively). Social rank is established by intensive fights (Rödel *et al.,* 2004).

In the group housing experiment when the Four Paws' recommendation was tested, Mikó *et al.* (2013a) observed the number of fighting episodes in the first month after establishing the group. Aggressive behaviour was high throughout this period. One older doe was in the group, and she attacked the other rabbits 59, 30 and 3 times in a month, depending on their position in the social ranking order, with the lower ranked does receiving more attacks. The other rabbit does initiated attacks 16 times in total. Mikó *et al.* (2013b) also evaluated the sexual activity of the buck and does. The number of sexual attempts among the buck and does was 56, and a similar number (52) of mounting attempts were observed among does, which could cause pseudopregnancy.

One of the problems in continuous group-housing is that more does kindle in the same nest box (double littering), which may be the reason for higher suckling mortality. To prevent this problem, a modified Stauffacher housing system (4.5 m^2) was developed in The Netherlands (Ruis, 2006). The main difference was that the nest boxes opened from an elevated platform and does had clips in their ears to open their own nest box (individual electronic nest box recognition system) to avoid the double littering. Initially, natural mating was used (8 does and 1 buck) but in a second trial it was changed to AI. In the latter case, does were inseminated 11 d after kindling (42-d reproductive rhythm). According to Rommers *et al.* (2006) the kindling rate was lower in group (G) than in individually (I) housed does (55.6 *vs.* 84.2%), which was connected with pseudopregnancy because a number of sexual attempts were observed among the does between kindling and insemination. No significant differences were found in litter size, suckling mortality and weight of kits at 14 d of age, although the weight difference was substantial ($P<0.001$) at weaning (weaning weight of G: 720 g *vs.* I: 841 g). It seems that after leaving the nest box, kits were not able to go back and they thus missed suckling events. The percentage of injured does was 21 and 17% in experiments 1 and 2, respectively. Rommers *et al.* (2012) observed the nursing behaviour of does. The average duration of nursing events (nest box visits) was shorter (113 *vs.* 158 s, respectively) and the frequency of nursing was lower (1.9 and 2.6 per day, respectively) in group housing than in individual cages in the first 2 wk of lactation. According to the authors, in G group the nest boxes were used as a resting place or does escaped there from the aggressive animals. In I group all does nursed their kits at least once a day, but in G group sometimes the nursing event was missed. In weeks 4 and 5, some G does (32 and 62%, respectively) did not nurse their kits, which might cause negative effects on the kits' weight, while in I group all does visited the nest box.

Table 1 summarises the benefits and costs of group-living of European wild rabbits. The main benefit is that rabbits have a greater chance of surviving the risk of predation. As there are no predators on farms, in group housing systems when does are continuously together almost all of the drawbacks remain, but most of the benefits are lost.

Table 1: Benefits and costs of group-living European wild rabbits [Adapted from König (1997) and Cowan (1987)].

Benefits	Costs
Living in group	Increased competition among group members (aggressiveness)
Social behaviour	For food
Reduced predation risk	For mating (males compete to gain access to females)
Many eyes (predator avoidance)	For nest sites (females compete to gain access to nest sites)
Alarm calls (with their hind legs)	Sub-dominant females (higher stress)
Dilution effect (running zigzags into the warren)	Breed less frequently
Cooperative construction of warrens	Lower kindling rate
Safe from predators	Smaller litters
Protection against climatic variability	Higher kit mortality
Nest sites (thermoregulatory huddling of kits)	Shorter lifespan
Territory for the group (food)	Defence of territory by dominant male
	Greater visibility to predators

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

Due to the absence of predators, most of the benefits of continuous group living disappeared but the costs remained (Table 2). In addition, some new points arise: there is more manual work and production costs are higher than in individual housing systems.

Attention has recently shifted to semi-group housing systems (Andrist *et al.,* 2012). In these systems rabbit does are housed in groups for some weeks and then individually.

Semi-group 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 and new groups are established. In case of semi-group housing systems, in most experiments pregnant does before kindling are grouped, so in each reproductive cycle new does are in a group.

Mugnai *et al.* (2009) housed four pregnant does for 5 d prior to kindling in a 1.52 m^2 pen with 4 nest boxes. After weaning, the does were artificially inseminated and placed in individual cages. During the first 2 d in the group, half the does were trained to go into their own nest box by putting each doe into its assigned nest box and holding it inside for 10 min (TC), or they were untrained (UC). The performance of group-housed does was compared with individually

Table 2: Benefits and costs of group housing systems when domestic rabbit does are continuously together.

Benefits	Costs
Living in group	Increased competition among group members (aggressiveness)
Social behaviour	For mating (males compete to gain access to females, only in case of natural mating)
Larger pens	For nest sites (females compete to gain access to nest sites)
Larger possibility for moving	Several litters in a nest box (double littering)
	Sub-dominant females (higher stress)
	Bred less frequently (in case of natural mating)
	Lower kindling rate (high rate of pseudopregnancy)
	Smaller litters
	Higher kit mortality
	Shorter lifespan
	Work and income
	Labour-intensive
	Production costs are higher than in regular individual housing system

Table 3: Comparison of the performance of individually and group housed rabbit does (Mugnai *et al.,* 2009).

		Group housed	
Traits	Individually housed	Trained	Untrained
Kindling rate, %	86.5	61.2	40.8
No. of kits born alive	7.5	6.6	5.8
Replacement of does, %	62.5	75.0	83.3
Injured does, %	0	3.8	8.3

housed does (l). Some significant differences were found among the groups in kindling rate, in liveborn litter size, replacement of does and injured rabbits (Table 3). Performance and welfare levels in groups were lower than in individual housing. Training the does to use their own nest boxes reduced the difference between the treatments but did not eliminate it.

In Switzerland, rabbit does are housed in modified Stauffacher systems (Andrist *et al.,* 2013). Using AI and a 42-d reproductive rhythm, does are held in individual cages from the 30th d of pregnancy until 12 d after birth. During the isolation period, does are kept in a separate cage within their group pen with a nesting box to avoid double littering and sexual contact among does which could cause pseudopregnancy, while visual, olfactory and acoustic contact is still possible. New group members are also put into separate cages. After AI, does are grouped in open top pens (5.7 m^2) furnished with elevated areas, hiding places, and eight nest boxes. The kit areas of the unit (1 per pen) 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. The sizes of semi-group pens are 1.0×1.5×0.6 m (length×width×height) which consist of 4 individual cages, and the 3 walls are taken out to create the group pen (Buijs *et al.,* 2014; with some photos). Individual cages are used from 3 d before to 18 d after kindling, and the semi-group pens are used from 18 d after kindling to 3 d before the next kindling. These semi-group pens have small openings into the nest boxes where the kits can escape from the does, similar to the kits' area in the Stauffacher system. Using AI and a 42-d 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 *et al.* (2011) reported the performance of does obtained in a trial in the Netherlands which were housed in a combi-park (later the name of this system changed to semi-group) system with AI 11, 15 or 18 d after parturition or individually with AI on the 11th d. The performance (kindling rate, litter size, mortality of suckling kits, weight of kits at weaning and injured kits) in the 2 systems were similar, regardless of the time of insemination in the combi-park system. In another experiment, Maertens and Buijs (2013) compared the performance of semi-group housed female rabbits with wire-mesh or plastic-mesh platforms to that of individually caged does. The performance of individually housed does was significantly better in litter size at 18 d and weaning, suckling mortality, individual weight of kits at 18 d and weaning, and body weight of does at weaning. No females were lost due to fighting, but according to the authors, a number of problems (e.g. fight frequency and intensity especially during the first days after regrouping) remained to be solved. In a recent experiment, Maertens and Buijs (2015) compared park systems with cages. Significant differences were found among groups: the performance in cages was 3.3% higher in weaned rabbits and 8% higher in weaning weight. The production level in parks was also high. These results show that the rabbit does in semi-group housing systems are able to achieve nearly comparable results (9.9 weaned kits/litter, kit's mortality below 6%) to caged rabbits.

The main problem with these systems is that after regrouping of does, a high incidence of aggressive interactions and injuries was observed. According to Andrist *et al.* (2013) on farms with an isolation phase, there were more agonistic interactions after the does were regrouped. Percentages of does with lesions were 28 and 40% in farms without and with regrouping. Some methods of reducing the occurrence of aggression and related injuries and stress were tested. Rommers *et al.* (2014a) investigated environmental enrichments such as hiding places, straw and territory in semi-group pens. On average, 52% of the does had injuries on the body and ears, and the percentages of severe injuries were 13-39%. The hiding places (platform and 20 cm diameter and 50 cm long PVC pipe) only slightly reduced the aggression, the number of injured animals and culling rate.

Rommers *et al.* (2011) opened doors of eight cages 12 d after kindling to create a group of 8 does. The number of offensive, defensive and social behaviours on days 1 and 3 in the group were 148 and 51, respectively. On both days, 45% of the behavioural patterns were offensive and consisted of attacks and fights. Due to the high incidence of fighting, in later experiments only four cages were opened. In another experiment (Rommers *et al.,* 2013), group pens 1.5 m long were formed by taking out three side walls of the four individual cages equipped with platforms. Four possibilities for escaping and hiding in pens with different installations were compared: does could jump on and off the 50 cm wide platform from both sides, 2 PVC pipes were placed underneath the platform, three wooden panels were installed underneath the platform and a hidden dark corridor was established at the front side of compartment with one hole at each end. The average scores for injuries, percentage of injured does and frequency of aggressive behaviours were observed. The authors' main conclusions were that wooden panels and PVC pipes seemed to be the best opportunities for escape if aggression occurred. The dark corridor was unsuitable for this purpose.

Rabbit does were regrouped into home pen H, which was a home pen of 3-5 does or a new pen (N) freshly cleaned and disinfected (Graf *et al.,* 2011). Two unfamiliar rabbits were allocated to each group. The number and duration of agonistic interactions were not affected by the treatments. However, fewer H does were injured on the first day after regrouping than does in the N group. These results show that regrouping in the home pen may slightly reduce the risk of severe injuries and social stress.

Andrist *et al.* (2012) examined the effect of group stability on aggression, stress and injuries. The group composition before and after the 12 d isolation period remained the same (S: stable) or 2 or 3 does were replaced by unfamiliar does after the isolation phase (M: mixed). The incidence of new lesions was 46% during the first 6 d after regrouping. There were more lesions and higher stress levels in M groups than in S rabbits. It was interesting that more new lesions were found on new does compared to those that stayed in the same group. After regrouping, the faecal corticosterone metabolite levels were also increased in M groups, but not in S does. These authors recommend maintaining the group composition (group stability) 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.

Alcohol and vinegar as odours were sprayed onto rabbits to reduce aggressive behaviour, lesions and stress when unfamiliar does were placed in the group after isolation (Andrist *et al.,* 2014). They found 60% of the does with new lesions and 32% with severe lesions during the first 5 d after regrouping. According to the results, masking the group odours had little effect on lesions, stress and agonistic interactions.

Buijs *et al.* (2014) investigated spinal deformation and bone quality in rabbit does in relation to the housing system. Occurrence of spinal deformation was independent of the housing condition; however, the tibia cortex was thicker in semi-group housing than in individual cages. The reason for this could be greater opportunities for movement in larger pens and/or escape from the aggressive rabbits.

Compared to the group housing system when does are continuously together, some problems (e.g. pseudopregnancy, double littering) are solved in the semi-group housing system (Table 4). These systems fit with the actual good practices of large farms such as AI, batch and all-in all-out production systems. In some recent experiments the performance of does was acceptable (Maertens *et al.,* 2011; Maertens and Buijs, 2015). At the same time, aggressive behaviour

Table 4: Benefits and costs of semi-group housing of rabbit does.

Benefits	Costs
Living in group	Increased competition among group members (aggressiveness)
Social behaviour	After each regrouping, the frequencies of aggressiveness, fighting and injured rabbits are increased
Larger pens	
Greater possibility for moving	Sub-dominant females (higher stress)
	Lower productivity
	Shorter lifespan
	Work and income
	Labour-intensive
	Production costs are higher than in regular individual housing system

Table 5: 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.,* 2005
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

became a more serious problem (Table 5). After the end of individual housing when rabbit does were grouped again, the frequency of aggressive behaviour and injuries significantly increased, which goes against animal welfare and is contrary to two points of the five freedoms described by the Farm Animal Welfare Council (1992).

In summary, disadvantages of group-housing can be reduced by:

- introducing a buck into the group for a short time (in case of natural mating),
- changing from natural mating to artificial insemination,
- using clips in the ears of does to open their own nest boxes,
- using a semi-group housing system (housing the does in individual cages or isolating them in a separate compartment within their group pen from 3 d before to 18 d after kindling),
- housing the does in enriched pens,
- training the does to use their own nest box,
- using an effective odour on rabbits to reduce the aggressive behaviour, and
- maintaining the group composition (group stability) for as long as possible.

The goal of group housing of does was to develop an animal-friendly system. When housing does continuously together, the production and welfare levels of rabbits were lower than in individual cages. In semi-group housing systems the production level could be high, although the welfare level decreases. The main problems (aggressiveness, injuries, stress) of group-housing of does have not been solved.

According to our knowledge, individual housing is the only one which does not provide the opportunity for aggressive behaviour which can lead to stress and injuries (serious wounding). These are fundamentally contrary to animal welfare principles. Nevertheless, it is important to improve the comfort in this housing system.

INDIVIDUAL HOUSING

Cage walls

Most European wild rabbits live in groups; they are social animals (Jenkins, 2001). There is also some evidence that domestic rabbits like to have contact with other rabbits. Individually caged rabbits showed a preference for cages enriched with mirrors (Dalle Zotte *et al.,* 2009). Mirrors were able to mimic the presence of another rabbit and to improve the welfare of rabbits (Jones and Phillips, 2005; Dalle Zotte *et al.,* 2009; Edgar and Seaman, 2010). Negretti *et al.* (2004, 2008) observed that rabbits looked towards the neighbouring rabbits more frequently than toward empty cages.

In the experiments of Seaman (2002), the rabbits had the opportunity to go through a weighted push-door from a central cage to reach other cages with minimal tactile contact through a mesh panel with an unfamiliar rabbit. In another experiment (Seaman *et al.,* 2009), the rabbit had four opportunities to go through weighted doors to different cages that were empty, equipped with an elevated platform, with food, or with limited social contact with another rabbit through wire-mesh. When an unfamiliar rabbit was at the end of a runway, rabbits pushed through the push-door (Seaman, 2002). This suggests that the olfactory and auditory cues from other rabbits stimulated the rabbits to get closer. In another experiment, rabbits were highly motivated to enter the cage where there was possibility for visual contact with another rabbit (Seaman *et al.,* 2009).

These results confirm the role of visual and olfactory contact in animal welfare. One of the opinions against individual housing is that social contact is limited among rabbit does. According to the scientific results, the individually housed rabbit does are not alone because visual, olfactory and acoustic contact is still possible among the rabbits in different cages and physical contact with their kits and with the adjacent doe by laying against the common wall in contact with each other through the wire.

Solid walls caused lower production, e.g. reduced kindling rate (Gacek, 2002), or increased total litter loss (Szendrő, unpublished data) due to the lack of visual contact with the surroundings. In the case of solid metal walls, rabbit does could easily be frightened, as they are only able to notice a person when she/he is very near (above) the cage, and does could jump into the nest boxes, tramping and killing some kits. In the case of wire-mesh walls, rabbits can see their surroundings, and the visual and olfactory contacts are not limited among the animals. Furthermore, the rabbit does are not alone for most of their lives, as they are together with their kits.

Cage sizes

Another controversial issue is the size of cages for rabbit does, because of the limited possibility for movement. Although the sizes of currently used cages differ only slightly from those that were used some centuries ago, we have to seek and develop more comfortable cage types for individually housed does.

The choices of does among cages with different sizes or among cages with different heights were investigated in preference tests.

When the rabbit does could choose between standard and double sized cages, the random ratio of choice between the 2 cages would be 1/3 and 2/3, respectively. The non-pregnant rabbit does spent 37 and 63% of their time in small and large cages, respectively (Mikó *et al.,* 2012), so they spent a little more time in smaller cages than expected. When does kindled in the nest box in the small or in the large cage, the cage preferences between the smaller and larger cages were 14 and 86%, and 30 and 70%, respectively. It seems lactating does prefer staying more frequently in the cages separated from the cages where their kits were in the nest boxes.

Selzer *et al.* (2004) observed the nursing behaviour of does in relation to the size of cages: standard size, or 2 or 3 times the standard size, and the presence of environmental enrichment (enrichment in standard cages: curtain, daily hay, piece of wood; enrichment in larger cages: tunnel at the entrance to the nest box, a curtain, daily hay, a piece of wood). Nursing activity of does tended to decrease with increasing cage size: the mean number of nursing events a day was 1.37, 1.26 and 1.25 in standard, and 2 and 3 times larger cages and 1.32, and 1.25 and 1.11 in standard, and 2 and 3 times larger enriched cages, respectively.

In another experiment, the preferences of adult does were observed among cages with differing heights (Matics, unpublished result). Compared to the random preference (25% per cage), the frequency of rabbits staying in cages with 30, 40, 50 cm heights or open tops was 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.

Rommers and Meijerhof (1998) compared the commercial sized cages (50×60 cm; length, width) to the double sized (100×60 cm) cages with the same height (30 cm) or to higher (50 cm) cages with similar floor size (50×60 cm). Some significant differences were found in litter sizes (total or alive) in the 3rd or 4th litter in favour of the enlarged or heightened cages; however the average number of weaned rabbits during the test period was similar. Mirabito *et al.* (2005a,b) examined 3 cages with different sizes: 0.34, 0.45 and 0.59 m^2. No significant differences were found in kindling rate, litter size, suckling mortality, weight gain of suckling rabbits or behavioural patterns. Bignon *et al.* (2012)

compared 2 different sized cages: standard (25×46×28.5 cm) and larger (33×68.5×40 cm). They did not find any difference in reproductive performance of young does, although the does in the larger cages were more active (sitting, standing, moving) and spent less time in lying position compared to the standard cage.

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

Cages with platforms

The size of cages can also be increased in the 3rd dimension, by inserting elevated platforms. Theoretical advantages of the platforms are the larger floor size (2 levels), greater possibility for movement and the fact that does can escape from their kits after leaving the nest box.

Mirabito *et al.* (1999) 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. In another experiment, 3 different sized cages (38×65 cm and 46×73 cm with and without platforms, and 60×73 cm with and without tubes) were compared and no differences were found in reproductive performance (Mirabito *et al.,* 2005a). Barge *et al.* (2008) found significant differences in some traits: kindling rate (87.7 *vs.* 77.6%) and individual weight of kits at 19 d of age (747 *vs.* 647 g) were lower, while litter size (6.58 *vs.* 7.33) and litter weight at 19 d of age (2.07 *vs.* 2.31 kg) were higher in cages with platforms than in does housed in cages without platforms. The overall productivity (575 and 547 kits at 19 d/100 Al) was higher in cages without platforms. Alfonso-Carillo *et al.* (2014) observed 4.5% higher litter weights at 21 d of age and 5% better feed conversion ratio between 3 and 21 d in cages with elevated platforms. Mikó *et al.* (2014) also found higher litter and individual kit weights at 21 d of age (3.51 and 3.72 kg, 385 and 409 g, in cages equipped with or without platforms, respectively). According to most experiments, an elevated platform is beneficial to litter and individual weights. This may indicate an increased milk supply for the kits.

Mirabito *et al.* (1999) observed that rabbits preferred to use the platform during the light period. Non-lactating does (27%), and lactating does at the 2nd wk (20%) spent less time on the platform than after their kits left the nest boxes (35%), although kits between ages of 25-35 d 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 together (32-42%). Mikó *et al.* (2014) examined the preference for wire-mesh platforms (footrest on the floor), and plastic-mesh platforms (without footrest on the floor). The does used the plastic-mesh platforms twice as frequently (50-60%) as the wire-mesh platform (about 30%). Similar tendencies were observed on both platforms during the lactation period: the time spent on platforms increased when the kits left the nest boxes, and decreased when kits were able to go up onto the platforms. More kits moved to the plastic-mesh platforms. At 31 d of age the frequency of kits staying on the plastic-mesh and wire-mesh platforms were 66 and 8%, respectively (Figure 1).

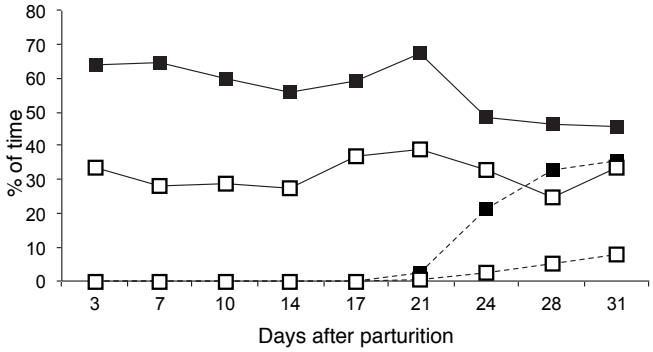

Figure 1: Platform use of does and their kits in different types of platform cages (Mikó *et al.,* 2014). —■—PP (does); ---■---PP (kits); —□—WP (does); ---□---WP (kits); PP=plastic-mesh platform. WP=wire-mesh platform.

Rabbit does prefer the part of the cage under the platform, but they choose the platform more frequently when their kits leave the nest box or when the platform material is more comfortable (e.g. plastic-mesh) than that of the floor. According to Mirabito *et al.* (1999) and Mirabito (2002), platforms do not appear to be means for does to escape from their kits and rest unmolested. Presence of platforms does not affect the nursing attempts, because when the does leave the platform kits want to nurse. However, there is a discrepancy between this statement and the higher litter weights of kits from cages without platforms. This is apparently related to the greater milk supply for the kits.

Floor type (in all types of cages and pens)

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

Rosell and de la Fuente (2009) investigated the effects of a footrest on sore hocks (pododermatitis) and plantar hyperkeratosis. The incidence rates of sore hocks were 71.5 and 15.1% and those of plantar hyperkeratosis were 100 and 64.5% in cages without and with footrests. One of the reasons for culling breeding animals was the sore hocks (Rosell and de la Fuente, 2008). 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 fell from 11.4% to 6.3% (Rosell and de la Fuente, 2013).

De Jong *et al.* (2008) established that the percentages of does with different footpad 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 presented by Rommers and Meijerhof (1996), the average sore hocks scores 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).

In the study by Mikó *et al.* (2014), four cage types were compared: flat deck cages with and without footrests, cages with wire-mesh platforms and footrests on the floor and cages with plastic-mesh platforms without footrests on the floor. The percentage of rabbit does with intact foot pads were 4, 22, 35 and 42%, respectively. The percentage of does with scores 3 or 4 were 48, 0, 5 and 0%, respectively. The scoring system was similar to that of Rommers and Meijerhof (1996).

Buijs *et al.* (2014) observed the incidence of sore hocks in three types of cages/pens with elevated platforms (individual cage with footrest, semi-group housing with footrest and 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).

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.

ENVIRONMENTAL ENRICHMENT

There is a wide range of environmental enrichments including footrests, elevated platforms or hiding places and straw which were used by Rommers *et al.* (2014a) in a semi-group pen. However, the most frequently used enrichment is the gnawing stick. Several experiments were done with growing rabbits using different enrichments (Princz *et al.,* 2007, 2008, 2009; Jordan *et al.,* 2008, 2011; Zucca *et al.,* 2012). One of the best and most easily used was the soft wooden stick attached to the cage wall.

Several experiments were also carried out with rabbit does. Some unusual materials were also tested: empty soft drinks cans (Carrilho *et al.,* 2005) and stainless-steel rabbit rattles on spring clips (Johnson *et al.,* 2003).

In the experiment of López *et al.* (2004), adult females received straw in 2 distribution systems: between the walls of 2 contiguous pens or in a metallic dish attached to the floor of the cage. The does were interested in the straw only for a short time as a novel item in their cages. The consumption was 2 g/doe per day. However, it modified some behavioural patterns such as resting, self-grooming, feeding, movement, gnawing the bars of the cage and playing, although the differences were not significant.

Maertens *et al.* (2013) examined 3 different wooden blocks with the same basal components and supplemented with wood mash, wood mash+chicory pulp or wood mash and inulin syrup, hanging from the roof of cages. Compared to the control group the blocks had no effect on litter size, kit mortality, litter and individual weights or feed consumption, but the weight of does was higher in the control than in the experimental groups. The block consumption was higher in the group supplemented with wood mash than in chicory pulp or inulin syrup groups.

According to Rommers *et al.* (2014b) it is best to provide edible materials as enrichments. They compared pens without additional enrichment with pens containing a pinewood stick, straw in a plastic bin, a compressed wooden block or a combination of straw and a pinewood stick. Differences were found among the treatments in the duration that does were occupied with the enrichments: the highest values were recorded in case of straw and the lowest with wooden blocks. There were no abnormal behaviours. The straw waste was eaten by the does or kits. Straw seemed to be the most preferred enrichment.

CONCLUSIONS

In Switzerland, rabbit does are generally housed in group systems. Maertens (2013) published a paper describing how the Belgian housing system will be converted step-by-step into a group housing system. As they work in very close connection in this field with Dutch researchers, the housing system for rabbits will be similar in both countries. To date, no researcher has been able to offer a solution to eliminate the aggression, stress and injuries common among rabbit does in group housing systems. Nevertheless, several common problems of group-living European wild rabbits have been solved.

Some authors are of the opinion that with individual housing of rabbit does the cages are barren, small and the possibilities for movement and social contact are limited. Positive results were obtained when platforms were inserted in the cages and the possibility for movement increased and the does and their kits could jump up and down. Using footrests, the incidence of sore hocks declined. Several environmental enrichments were used which increased the wellbeing of rabbit does. These enriched cages equipped with platforms, footrests, gnawing sticks, etc. are fully in line with animal welfare requirements.

In the semi-group and individual housing systems, rabbit does are alone from some days before kindling till their kits leave the nest box. During the following three weeks, after regrouping, more does and kits are together in a large pen. In the same period the individually housed rabbits are also not alone, as they are kept together with their kits in a cage. In the group housing system, in exchange for the direct social contact there is fighting, injuries and stress that may be frequent, especially after regrouping. In the case of individually housed rabbits, the direct social contact is limited to the case when 2 does are lying on opposite sides of the common wall of the cages, and at other periods there are visual and olfactory contacts with other rabbit does without any conflicts.

Welfare requirements cost money. Increasing the size of cages and enriching them raises the production cost and the meat becomes more expensive. This is particularly true for group housing systems. When rabbits are produced in conventional cages, the price of rabbit meat is higher than that of chicken meat or pork. Increasing the production cost will broaden the difference. Rabbit meat will not be competitive with other meat and rabbit meat from outside the EU. When developing housing systems, we have to take this aspect into consideration as well, as rabbit production in the EU could decline dramatically when only the rich can afford to buy rabbit meat.

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