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NEW PERSPECTIVES OF HOUSING REPRODUCTING AND GROWING RABBITS

Zsolt SZENDRŐ

Faculty of Animal Science, Kaposvár University, 40, Guba S. str, Kaposvár, H-7400, Hungary
*Corresponding author: szendro.zsolt@ke.hu

ABSTRACT

An increasing proportion of consumers recognize animal welfare aspects, they prefer to buy meat of animals kept in an environment with adequate housing conditions. But the situation is more complicated. Researchers and farmers have to take into consideration consumer demands, animal welfare, production costs, profitability, competitiveness, food safety, traceability, etc. The aim of this review was to compare individual and group-housing system of rabbit does, focusing on the production and welfare aspects. Some information about the benefits and costs of group-living European wild rabbits are also provided. The advantages and disadvantages of different alternative systems of growing rabbits are synthesized as well. The main conclusions of the experiments are summarized. Some of the housing systems (group-housing of does, rearing rabbits on deep litter and in large group) are against the welfare (chronic stress, aggressiveness and injuries, higher risk of diseases and mortality...), reproductive and productive performances are lower, and the cost and the price of rabbit and meat are higher. These housing systems do not respect the demand of animal, they are against the well-being, how ever consumers are given to believe that these are the best housing conditions, and they pay higher price for the meat originating from these animals. The human idea of the optimal housing conditions of a certain animal may not coincide with those animals' real demands. People do not have the rabbits' mind to think. Therefore, it would be very important to give a correct picture, and provide up-to-date information about the real needs of rabbits. Some alternative housing systems (plastic mesh floor, elevated platform, larger cage and footrest for the does, dual-purpose cage, and gnawing stick as environmental enrichment) increase the production cost, but improve the welfare of animals (more comfortable, larger area for activity, less boredom and incidence of behavioral stereotypes). The higher price of rabbit meat originated from these housing systems covers the higher cost of production. At the same time we have to consider the financial opportunities of the poorer who can afford to buy rabbit meat only originated from intensive production system. There are several countries of mostly price-sensitive buyers, whose decisions are primarily determined by the price of products. We should help them to be able to purchase cheaper rabbit meat as well. We had better not forget that the rabbit meat has one of the highest biological values, it is healthy and has some functional aspects, on the other hand, many people cannot buy expensive food. Seven billion people live in the world, and one and a half billion people are starving. The population is increasing, but the field used for agricultural purposes is decreasing. The ecological footprint is a question of not only the future, but present, as today humanity uses the equivalent of 1.5 planets to provide the resources we use and absorb our waste. The increasing needs of human population can be met only with intensive production, but at the same time, we have to produce rabbit meat to demanding customers who are able to pay higher price for rabbit meat originating from different alternative systems.

Key words: Rabbit, housing systems, group-housing, alternative methods

INTRODUCTION

Domesticated rabbits are originating from European wild rabbit which lives in territorial breeding groups, consisting of an average of 2-9 does, 2-3 bucks and their progenies (Surridge *et al.,* 1999). Rabbits are social animals, however during the establishment of a hierarchy, does may attack, bite and chase each other or engage in brief fights, but once the hierarchy is established, aggression is markedly reduced (EFSA, 2005).

The *leporaria* were the origin of the warrens or game parks that subsequently developed in the Middle Ages (Lebas *et al.,* 1997). When rabbits were first domesticated, they 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.,* 2005). 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). Nowadays, rabbits kept for meat production are generally reared in intensive husbandry system in several European countries; does are housed individually, and fatteners in small groups (2-6 rabbits/pen) (EFSA, 2005). Thus far, the development of housing of rabbits was more and more intensive. However, there is an increasing demand for products originating from rabbits reared in nature-like environment. There are recommendations suggesting group-housing of rabbit does and rearing growing rabbits in large groups or even regulations exist making these systems compulsory (*e.g.* Bioswiss, Naturland).

The aim of this review is to compare the individual and group-housing system of rabbit does, focusing on the production and welfare aspects. Some information about benefits and costs of group-living European wild rabbits are also provided. The advantages and disadvantages of different alternative systems of growing rabbits are synthesized as well. At the end of the review the main conclusions of the experiments are summarized.

Effect of housing conditions on rabbit does

Group-housing of rabbit does

The main principles of group-housing rabbit does is to provide them similar conditions to that of the European wild rabbits. In that regard, rabbits are social animals, exhibiting several social behaviour forms, mating is natural, and maternal (nursing) behaviour is not restricted (EFSA, 2005). In rabbit farms, some does are housed together with a buck and they can freely choose their place of kindling (there is at least one nest box for each doe) and can freely nurse their kits.

Various group-housing systems have been developed. In the following sections the key features of these systems are summarized and their effect on reproductive performance and welfare separately, because in most cases the housing, reproductive or nursing systems were different, and the results may be related to such factors. The main results of the experiments are summarized in Table 1.

In one of the **first experiments**, 1 buck and 4-5 does were housed in a pen with a basic area of 9 m^2 which was split into various areas: central area (isolating floor and structures for withdrawing), feeding (metal grating floor, feeders, drinkers, hay rack and gnawing materials), breeding (deep litter floor and 4 nest boxes with tunnel-like entrances), and kit area (straw bedded, feeders), and 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 the comparison. In another study (Baumann *et al.,* 2003), 1 buck was kept with 8-10 does in a structured multilevel pen, with areas for withdrawal, feeding, nesting, and placefor the kits.

Table 1: Comparison of production and welfare of group and individually housed does.

Authors	Stauffacher, 1992	Bauman *et al.*, 2003	Mirabito *et al.*, 2005a	Rommers *et al.*, 2006	Mugnai *et al.*, 2009		Andrist *et al.*, 2011	Szendrő *et al.*, 2012	
					TC	UC		S-33	S-42
Kindling rate, %	Good	-	NS	-29	-14	-35	Low	-32	-40
Pseudopregnant,%	-	-	-	+23.9	-	-	-	-	-
Litter size									
total	-	-	NS	NS	-	-	Good	NS	NS
alive	-	-		NS	NS	-1.7	-	NS	NS
at weaning	-	-		NS	NS	-1.6	-	-	-
Suckling mortality, %	-	-	+8.8	NS	NS	NS	-	+24.5	+23.3
Kit' weight, g									
at 14 d	-	-	-	NS			-	-	-
at weaning	-	-	-	-121	NS	NS	-	-	-
Survival of does, %	-	-	-	-	-	-	-	-26	
Annual replacement of does, %	-	-	-	+11	+12.5	+20.8	-	-	-
Multiple birth/nest box	9	-	37	-	-	-	-	7.7	
Injured does, %	-	18.1	-	18.9	3.8	8.3	33.0	-	-
Corticosteron, nmol/g	-	-	-	-	-	-	-	+114	+121
Rabbits/193d/doe	-	-	-	-	-	-	-	-17.5	-22.3
Rabbits sold/yr/doe	-	-	-	-	-5.9	-13.1	-	-	
Rabbits/193d/m^2	-	-	-	-	-	-	-	-4486	-5174

There were not control (individually housed) group: Stuuffacher (1992), Bauman *et al*. (2003), Andrist*etal.* (2011).
TC: trained and UC: not trained to recognize their own nest box
S-33 and S-42: the single housed does were inseminated *post partum* or 11 d after parturition, respectively (33 and 42 d reproduction. rhythms)
NS: the differnces were not significant
-: no results were published

The reproduction performance in the Stauffacher (1988, 1992) system was good; kindling rate: 89%, number of kits born alive and weaned 8.4 and 7.1, respectively, suckling mortality: 16%. Does were able to close the nest entrance with straw (69% of cases they blocked), but 9% of the cases dominant does gave birth in the nest where another doe had been kindled. The male moderated the aggressive interactions among females. However, this is the base of some group-housing systems, but according to Stauffacher (1992), further steps towards optimization are required. Some recent results show that some deficiencies have not been solved. According to Baumann *et al.* (2003) the system is good, but they observed that 1.8 and 16.6% of the animals had mild or severe injuries, and too long claws, cutaneous mycoses, hair eating and tail biting.

Andrist *et al.* (2011) published some information about group-housing of does (Hycole and Zika) **in Switzerland**. In a group an average of 8 (5-9) does were housed. Three reproductive methods were used: 1. Does were mated naturally, but the buck was usually introduced for 10 days, following a 33-d reproduction rhythm (*post partum*mating). Nowadays, breeders start to apply artificial insemination (AI) with 33-d or 42-d reproduction system (AI 11 d after parturition). In the 42-d system does were held single from day 30 of pregnancy until 12 d after birth. During the isolation, does were kept in a separated compartment with a nest within their group to avoid the pseudopregnancy. Average kindling rate was 61% (50-74% in the different farms, 64 and 60% if they were mated naturally and AI, respectively). Litter size at birth was 9.6 (8-12), and the suckling mortality was 15% (4-25%). Lesions occurred on all farms; 33% of the animals had at least one lesion, including 9% more severe injuries. The ratio was higher in case of using isolation. These results show that about 20 years after Stauffacher's experiment, the problems of group-housing have not been solved.

In France, Mirabito's team carried out some experiments analysing the effect of group-housing of does. It is noteworthy that natural mating was replaced by AI in several studies. Mirabito *et al.* (2005a,b) reared together 4 young females from weaning until first kindling at 24 wk of age, then these rabbits were split in one of the two 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 4 nest boxes with tunnels in front of them. The size of individual cages was 61x46 cm. 42-d reproduction rhythm and free nursing was applied. Rearing future does together was not successful, because it induced a high number of fighting and injuries, and one-third of the rabbits were culled for these reasons. They found no significant differences between the kindling rates and litter sizes of group-housed and single-caged does. The suckling mortality doubled in case of group-housing (17.2 *vs* 8.4%). The main reason of this could be the multiple kindlings to the same nest box: the frequencies of double and triple kindlings were 31.3 and 6.3%, respectively. Regardless of the provided straw, no attempts to seal up the nests were observed. Does housed on groups of 4 interacted with their nest boxes twice as often as those housed individually. When they tried to divide the kits (of multiple births) into different nest boxes, does would have not left their original nest (Mirabito, 2003).

In Italy, the Perugia team published some results. Mugnai *et al.* (2009) placed 4 does in a cage of 1.14 m^2, or they were housed individually (S) in standard cage of 38x60cm. Two subgroups were formed: trained (TC) and not trained (UC) to recognize their own nest box. In TC group, during the first 2 days after grouping, the does were put into the same (own) nest for 10 min. The pregnant does were housed in groups 5 days prior to kindling, then after weaning (at 30 d) they were artificially inseminated in individual cages. Before kindling the nest boxes were opened, but control nursing was performed until 16 d. Mugnai *et al.* (2009) reported very low sexual receptivity and a lower fertility rate for group-housed does (41, 61 and 76% in groups of UC, TC and S, respectively) and a decreased litter size (by 1.3 kits/litter), but the suckling mortality was not different among groups. The annual replacement was 21 and 13% higher in groups UC and TC, respectively, than that of in S group. Rabbits sold/year/doe were significantly lower in group-housed does (17.7, 24.9 and 30.8 kits in groups UC, TC and S, respectively). The does in groups showed fewer social behaviours, however, the interactions between animals were sometimes aggressive, particularly in the UC group (attack: 27 *vs* 14%, dominance: 13 *vs* 9 %) in comparison to TC does. The ratio of severely injured does was 8.3 and 3.8% in groups of UC and TC, respectively, and they also reported high corticosterone concentrations in group-housed does.

In Hungary, a group-housing system, recommended by an animal protection group, was tested (Szendrő*et al.*, 2012). The S does were housed in commercial rabbit cages (0.32 m^2). In group G, four does and one buck (during the whole experiment) were housed in each of four pens with 7.7 m^2 (half of the floor was deep litter and the other half was plastic slat) with 4 nest boxes, feeder, hay rack, nipple drinkers and a plank tube for hiding in each pen. In group S, half of the does were inseminated 2 d after kindling (S-33), whereas in the remaining, AI was done 11 d after kindling (S-42). A single-batch system was used in both S groups. The does could freely nurse in each group. Kindling rates were 77.6, 85.2 and 45.6% in groups S-33, S-42 and G, respectively. During the experiment, the percent of does that kindled 0, 1, 2, 3, 4, and 5-times were: 0, 0, 0, 8, 69, 23% (group S-33); 0, 0, 17, 58, and 25% (group S-42); and 17, 25, 17, 25, 17, and 0% (group G). There were no significant differences among groups for litter size. The frequency of two does kindled in the same nest box was 8% for the does housed in groups. In groups S-33, S-42 and G, suckling mortality was 14.0, 15.2 and 38.5%, respectively, survival of does was 71, 81, and 50%, and faecal corticosterone concentrations were 61, 54, and 175 nmol/g. In the G group, 49 young rabbits (< 14 d 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. During the entire experiment (193 d), the number of weaned rabbits per doe (calculated based on the number of does at the outset) in the S-33, S-42 and G groups was 36.2, 41.0 and 18.7, respectively, whereas the number of weaned rabbits per 100 m^2 basic area was 5222, 5908 and 734. The cost of production is much higher in group-housing system than in case of individual-housing.

To overcome previous problems and deficiencies, a new group-housing system was developed **in TheNetherlands** (Ruis, 2006; Rommers*et al.*, 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 (coded transporter) 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). Eight does were housed in each pen. Firstly natural mating was applied, but later it was changed to artificial insemination at 11 d after parturition allowing a cycle reproduction system (Rommers*et al*., 2006). Using this method, they reported a lower kindling rate for group-housed does (55.6 *vs.* 84.2%). High corticosterone concentrations were measured for group-housed rabbits, and the ratio of pseudopregnant does was 23%, which could contribute to the unfavourable kindling rate. (A close correlation was found between progesterone concentration and 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 group-housing system (841 *vs.* 720 g), which may have occurred due to the fact that after leaving the nest box, kits had reduced chance to suck. The percentage of does with injuries was between 17 and 21%.

According to Ruis (2006), aggression may occur when previously unfamiliar does are put together, and when new does are introduced to a group. Three form of aggression may arise when group of breeding females are newly formed: dominance aggression, territorial aggression and resource-related aggression (Graf *et al.*, 2011). These forms of aggressions are also well known among European wild rabbits. Regrouping of does can induce agonistic interactions, resulting injuries and chronic stress. Graf *et al.* (2011) compared two methods and established that regrouping does in a novel pen was associated with a higher incidence of injuries and higher stress than regrouping them in a pen that was familiar to the majority of the group.

Ruis and Coenen (2004) summarized the **main problems of group-housing of rabbit does**: 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, leading to high aggression; 3) the system is labour-intensive, due to monitoring and cleaning; 4) a high hygienic standard is required; 5) the lack of animal recognition of young rabbits makes selection of breeding does more difficult; and 6) higher production costs in group-housing versus individual-housing systems.

The published results are summarized as follows. The basic idea of applying group-housing of does in rabbit farms was to imitate the habitat of European wild rabbits. The only good results were published by Stauffacher (1988, 1992) in a complicated (enriched) housing system. After some modifications, the main problems of this system have not been solved. Production was low, due to the aggressive behaviour some rabbits were injured, etc. A new special group-housing system was developed in The Netherlands based on the principles proposed by Stauffacher (1992). After the first results of the experiments, natural mating was changed to AI, but as a result of the aggressive behaviour, stress and pseudopregnancy, the kindling rate was low and the percentage of injured rabbits was high, in addition, the weight of kits at weaning decreased (Rommers *et al.,* 1996). One of the worst results was obtained when a system recommended by an animal protection group was used (Szendrő*et al.,* 2012). Rearing the future does in group was not successful, because of the high rate of injury (Mirabito*et al.* (2005a). Training the does to recognize their own nest box led to better results than the non-trained group, but their production was significantly lower than in the group of individually-housed does (Mugnai *et al.*, 2009). When does were housed individually from some days before of kindling until insemination to decrease the percentage of pseudopregnancy was not successful, because after replacing them back into the group, the level of aggressiveness became higher with some negative effects (Mugnai *et al.*, 2009; Andrist *et al.*, 2011). Problems are similar when a new group is established or the dead and culled does are replaced. According to Cornelissen *et al.* (2011) one of the needs of rabbits is “no injury”. This could be achieved only in individual-housing.

Because of the complications, housing rabbit does in groups was finished in France in the late 1970’s (Mirabito*et al.,* 2005). The evaluation of rabbit husbandry goes back about 100 years when using group-housing systems. In the survey by Andrist*et al.* (2011) on average 132 does, in a range between 35 and 383 females, were kept per farms. This farm size is good to produce rabbit meat for a special market. In France, the number of rabbit does per farm are 582 (up to several thousand females), with very good production level

(Coulet, 2011). Similar sized rabbit farms can be found in Italy, in Spain or in Hungary. They produce rabbit meat much lower price (1.66 €/kg in France; Coulet, 2011) than that of in Switzerland.

In animal breeding, one of the most important aspects are the so-called „**five freedoms**" (freedom from: 1, hunger and thirst; 2, an inadequate environment; 3, pain, injuries and distress; 4, fear and 5, the impossibility to express to normal behaviour; Farm Animal Welfare Council, FAWC, 1992) should not be violated. Main **welfare indicators** for rabbits are: no or low mortality, low or unavoidable morbidity, physiological parameters in the species-specific standard, species-specific behaviour, productive and reproductive performance on a good level (Hoy and Verga, 2006). Group-housing of does is against some point of "five freedoms" (FAWC, 1992): e.g. freedom from pain, injuries, distress, fear; and the rabbit welfare recommendation (Hoy and Verga, 2006): e.g. low morbidity, mortality, and stress hormone level, good level of reproductive performance. No. 5 point of freedoms is questionable, because aggressiveness is one of the normal behaviour patterns of European wild rabbit, but it is against the welfare. Examining the five freedoms or welfare indicators, the group-housing system of rabbit does violate the animals' well-being several times.

European wild rabbits as a group-living animal

The question is; if there are so many problems with the group-housed domesticated rabbits,thenwhat is the situation with the European wild rabbits?

Aggressive behaviour is well known in different wild animal species (Kutsukade, 2009), mainly in group-living species, such as the European wild rabbits (Southern, 1948). A **dominance hierarchy** exists among the females and separately, between the males in European wild rabbit (von Holst *et al.*, 1999, 2002). When the dominance hierarchy is established, especially in 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 to their burrows and are intolerant against other rabbit does (Southern, 1948). Despite of the large pen-size, the domesticated rabbit does could not always withdraw when attacked, therefore the occurrence of stress and lesions are probably higher than that of the European wild rabbits. The average distance between two wild rabbit does in a large semi-natural enclosure is 20.7 m (Cornelissen *et al.,* 2011). Compared to this, in a large, well-furnished pen the fight distance and possibility to withdraw is limited.

According to Mykytowycz and Dudzinski (1972) does tolerated own kits, but attacked other young. The adult buck is tolerant towards all kits. In some studies it was also observed that does bite and injured the kits of other does (Szendrő*et al.,* 2012). Infanticide, the killing of conspecific young, has been observed in many different animal species. For the European wild rabbits a doe-doe competition for a limited number of breeding burrows may have been resulted in infanticide (Künkele, 1992). According to Rödel *et al.* (2008) the occurrence rate of infanticide of the whole litter was 5-6%. Signs of biting were detectable on 68% of died 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 similarly to the results with domestic rabbits (Mitabito *et al.*, 2005a; Szendrő *et al.,* 2012) scrapping out the previous litter, kindling two does into the same nest, injuring the kits can be observed also in the European wild rabbits. The occurrence of infanticide was more frequent by 7% where same-age females lived together, compared to a group having heterogeneous age structure. Social instability could be the reason for the increased infanticide. When farmed rabbit does are housed together, the age of the does placed to the same pen is similar, the homogenous age structure could be the cause of further increases in aggressiveness and killing the young 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 45.7% kindling rate for the European wild rabbits which was very similar to the results of Rommers *et al.* (2006), Mugnai *et al.* (2009) and Szendrő *et al.* (2012). The reduced fecundity was probably due to uterine loss of the whole litter. 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%, which was equal to the results of Szendrő *et al.* (2012). One of the most important factors of reproductive success of females was the social rank. The higher reproductive success of the dominant does was probably caused by their better physical condition. They had higher body weight, lower corticosterone level and lower heart rate 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). In studies with domestic rabbits in group-housing system, the level of stress hormone was also high (Rommers *et al.,* 2006; Szendrő *et al.,* 2012), and lower survival rate was recorded for group-housing, besides died and culled does showed unfavourable condition (Mugnai *et al*., 2009; Szendrő *et al.,* 2012).

Based on these findings it can be concluded that the disadvantages of group-housing also exist for the European wild rabbits. It can be asked, why the European wild rabbits live in groups despite of the mentioned disadvantages? The advantages and disadvantages of living in groups were generally summarized by König (1997) and Kunsukade (2009), and for the European wild rabbits by Cowan (1987). **The most importantbenefits** for the European wild rabbits are: predation risk decreases, cooperative construction of warren, territory for group (food). **The most important costs**: increased competition-aggressiveness among group members, sub-dominant female live under stress and their productivity is lower, probability of infection and visibility of predator in group are higher, and rabbits use energy for defence of territory (Table 2).

Table 2: Benefits and costs of group-living of European wild rabbits (Adapted after König /1997/ and Cowan /1987/).

Benefits	**Costs**
Reduced predation risk - many eyes - dilution effect - alarm calls **Cooperative construction of warrens** - safe from predators - protection against climatic variability - nest sites - thermoregulatory huddling **Territory for the group (food)**	**Increased competition** among group members (aggressiveness) - for food - for nest sites (females compete to gain access to nest sites) - for mates (males compete to gain access to females) **Sub-dominant females (higher stress)** - bred less frequently - lower kindling rate - smaller litters - higher kits' mortality - shorter lifespan **Defence of territory** by dominant male Increased **probability of infection** with parasites and diseases **Visibility of predators** **Vigilance**

Animals and also **European wild rabbits form groups when the benefits of group-living exceed its costs.** For the domesticated rabbits there are no predators, there is no need to dig a warren and the feed is available *ad libitum*, which are the most important benefits of living in groups, thus the remaining benefits are: larger place for activity, wider behavioural repertoire and the possibility of social interactions. On the contrary, all costs of living in groups remain (Table 3).

Table 3: Benefits and costs of group-housing of does and growing rabbit.

Benefits	Costs
- larger place for movement - wider behavioural repertoire - social contact	**for does** - higher rate of aggressiveness (stress and injuries) - competition for nest sites (infanticide) - lower productivity shorter lifespan **for fattening rabbits** - higher rate of aggressiveness (injuries) - lower productivity - higher probability of infection (diseases, mortality)

In a review, Morgan and Tromborg (2007) established that housing animals in social groups that are not species-typical may also be stressful. Crowding too many animals into an enclosure, or remix groups has higher risk of diseases which is against animal well-being. The effect of social instability is often used as research paradigms to induce stress. In nature, animals can retreat from agonistic encounters or avoid dominant conspecies in potential conflict situation. In captivity, such conflict avoidance strategies may be impossible to employ. All these statements are true for group-housing of does or rearing growing rabbits in large group.

Based on the relevant literature, Lombardini *et al.* (2003) concluded that the 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 habit and behaviour depending on the risk of predation or the environmental conditions. At the same time, in the nature, the European wild rabbits have the possibility for choosing a new habitat. In most cases, young and sub-dominant rabbits loose the competition, and so, they should be forced to leave the natal site (Künkele and von Holst, 1996). The dispersal at the age of 5 months was 89 and 44% for male and female rabbits, respectively. High dispersal rates were also published by Webb *et al.* (1995) and Richardson *et al.* (2002). Farmed rabbits do not have this opportunity, they have to live under a condition provided, and therefore, using our best knowledge we have to provide them the best possible keeping environment. According to the EFSA report (EFSA, 2005) at the present time, knowledge of the **system of group-housing breeding females is not sufficiently developed to recommend for implementation on farms.**

Individual-housing of rabbit does

On the other hand, in case of individual-housing, rabbit does have limited space for moving and it may cause mental distress such as boredom, frustration, and social isolation. The good agricultural practice is keeping such animals in larger cages, which will help to avoid some of these sufferings (EFSA, 2005).

When the choice was given to females between pens (group *vs.* singly housed), they tended to prefer a solitary pen regardless of their social rank (Held *et al.*, 1995). Finzi *et al.* (2010) proved 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 statement could be important in case of individually housed rabbit does. Solid walls may cause lower production: the kindling rate declined (Gacek, 2002), or the total litter loss increased (Szendrő, unpublished data) without visual contact of the surrounding. Visual and olfactory connection among does can be provided by **wire net walls** of their cages.

One of the most important points, independently from the type of individual cage, is the floor. Rabbits live (rest and move) on it, therefore if it has no good quality, footpad injuries are commonly observed on does (EFSA, 2005). Rommers and Meijerh of (1996) reported that in Dutch farms 25% of replaced does was due to **sore hock**. Mirabito and Delbreil (1997) carried out a survey on French farms, and on average 12% (range 5-40%) of does had sore hock. Rossel and de la Fuente (2009) observed sore hock on 70% of does housed on wire mesh floor, compared to 15% of does in cages equipped with plastic **footrest**. If the footpad injury is serious, rabbits show signs of discomfort. There was a gradual increase in the number of affected animals with age (kindling order) (Rosell and de la Fuente, 2009; Rommers and de Jong, 2011; Matics *et al.,* 2011; Mikó *etal.,* 2012). The same authors showed that when footrests were fixed to the wire mesh, they reduced the frequency and severity of footpad injuries. So, inserting footrest on the floor of breeding cages can be recommended from the viewpoint of welfare.

Increasing the **size of breeding cages,** horizontally or vertically (using of 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 or higher cages thereproductive performances of the does did not improve (Rommers and Meijerh of, 1998; Mirabito*et al.,* 2005).The non-pregnant rabbit does spent 37% and 63% of their time in smaller and double-larger cages, respectively (Mikó*et al.,* 2012). Their preference between cages was similar to the difference in size of cages (1/3 and 2/3), which is the same as the random choice. The preference was different in pregnant and lactating does. In case of kindling in a nest box belonging to the small cage, the preferences of smaller and larger cages were 14.3 and 85.7%, respectively, but when they kindled in the large cage, does stayed in the smaller cages more frequently (29.7 and 70.3%).

One of the aims of building an **elevated platform** in a cage is to increase the floor surface. The other function of the platform is to escape of does from their kits when they leave the nest-box and want to suck at any time of the day (Szendrő, 2006). Equipping the cages with platform generally had no effect on production (Mirabito *et al.,*1999; Mirabito, 2002). According to Barge *et al.* (2008), litter size, body weight of the does, litter- and individual weight of the kits increased significantly in cages with platform, however the pregnancy rate substantially decreased, and the number of kits at 19 d per AI was larger in the cages without platform. Mikó *et al.* (2012) compared cages with elevated platform (wire net or plastic slat) with flat-deck cages. Most of the reproductive performances were similar in all cages. Differences were observed in litter- and individual weights, with better results in cage with platform. Plastic platform and footrest had an effect on the prevention of footpad injuries. The incidence and severity of sore hock were the lowest in does housed in cage with plastic slat platform, and the highest in flat-deck cages without footrest.

Mirabito *et al.* (1999) observed that after kits leaved the nest-box does spent more time on the platform than at the 2nd week of lactation or the non-lactating females. When after nursing, the kits were moved to another cage, the does spent less time on the platform compared to those staying in the same cage as their kits (12-16 *vs.* 32-42%) between the weeks of 3 and 5 of lactation (Mirabito *et al.,* 2002). In another experiment, Mirabito *et al.* (2004) found that does in the smaller cages spent less time on the platform than that of in the larger cages. In these experiments the presence of platform did not affect the nursing attempts, because kits also learned to use the platform, and when does left the platform their kits had a chance to suck. In the experiment of Mikó *et al.* (2012b), the does spent more time on the plastic net platform by 25% compared to the wire net platform. After the kits left the nest-boxes the does chose the platform more frequently, but after day 21, when the kits started to use the platform, the does' platform preference decreased. Usage of the wire net platform by kits was lower than that of the plastic platform.

From the animal welfare viewpoint, cages/pens enriched with platform can be considered as advantageous, especially when the platform is made from plastic slat. On the other hand, cages with platform may cause hygiene problems. If it is solid, manure can accumulate on it, though, if it is made of wire net, droppings and urine fall onto kits, and into feeders and drinkers (Szendrő, 2006).

Recently, there is an increasing trend observed in commercial rabbitries in Europe where **dual-purpose cages** are used, suitable for both rearing the kits with the does and for growing rabbits until slaughter. The size of a dual-purpose cage is larger (0.45-0.65m2) than that of a traditional cage for a doe (0.24-0.31 m^2, without nest-box) (EFSA, 2005). Cages with elevated platform are appropriate for this purpose. At weaning the female may be transferred to another cage or even another building, while the weaned young remain in the cage. The clean, disinfected cages which the does arrive into 3-4 days before kindling, was previously held for growing rabbits from the cycle before the last, which were slaughtered at approximately 70 days of age. The abattoir sets the pick-up day for the rabbits, so weaning is adjusted around this day to ensure that cages are vacated when required. Thus, the slaughtered rabbits were born in the same cages from which they were sold. This method fits to the „all-in all-out" system. For a variety of reasons (reduction of labour, delivery of large numbers of broiler rabbits, all-in all-out approach) and traceability of meat products, batch management is generally used and so does are inseminated in large groups on the same day that leads to animals being taken to the slaughterhouse on a limited but scheduled number of days in the year (EFSA, 2005). The reproduction rhythm in the single batch system is generally 42 days (e.g. in France), but in those countries where rabbits are sold on larger weight, and at older age (e.g. in Italy), the 49-day reproduction rhythm is better fit to single-batch system.

As it was shown, there are several developments in the individual-housing systems which **improve the welfare of does**; they can move more, the cages are more comfortable, the hygienic conditions and health status are better, no stress, rabbits do not suffer from injury. However, the improvements increase the production costs.

Effect of housing conditions on growing rabbits

Various researchers have studied the effect of group size on productive and carcass traits, meat quality and behaviour of growing rabbits (Trocino and Xiccato, 2006; Verga *et al.,* 2007; Szendrő and DalleZotte, 2011).

The highest weight gain and body weight may be reached with **individual-housing** of growing rabbits. Daily weight gain, final body weight and daily feed intake decreased significantly in groups of 3 or 4 animals/cage (Maertens and De Groote, 1984; Xiccato *et al*., 1999). But the rabbit is a social animal, thus living in social isolation can display physiological symptoms of stress (Held *et al*., 1995; Chu *et al*., 2004). When growing rabbits had the possibility to choose between two cages (their walls were covered with mirrors or plastic panels), 72% of the rabbits showed a preference for the cage with mirrors (DalleZotte *et al*., 2009a), because the mirror images may make the cage a more pleasant environment. Thus, individual-housing of growing rabbits could be against their welfare.

Group size

Comparing 2 kits/cage to **larger groups** of rabbits, in the large group animals **consumed less feed**, and in some cases the differences (5-25 g/d) were significant (Maertens and Van Herck, 2000; Dal Bosco *et al*., 2000; Maertens and Van Oeckel, 2001; Lambertini *et al*., 2001; Figure 1). Theoretically, when animals are housed in larger group, their energy requirements increase due to the increased movements, and they consume more feed. The reason for the lower feed consumption could be the chronic social stress in larger groups which leads to depression of immune function, reduced digestive efficiency and increased risk of diseases. The consequence of the lower feed intake is decreasing in weight gain (1.0-9.3 g/d), final weight (33-445 g). The slower growth rate can also be related to higher locomotory activity, because part of the ingested energy is used for this purpose (Szendrő and DalleZotte, 2011). In most cases, mortality has been observed to be independent of group size. The main reason for this lack of correlation between group size and mortality could be attributed to the common practice of providing medication in the feed.

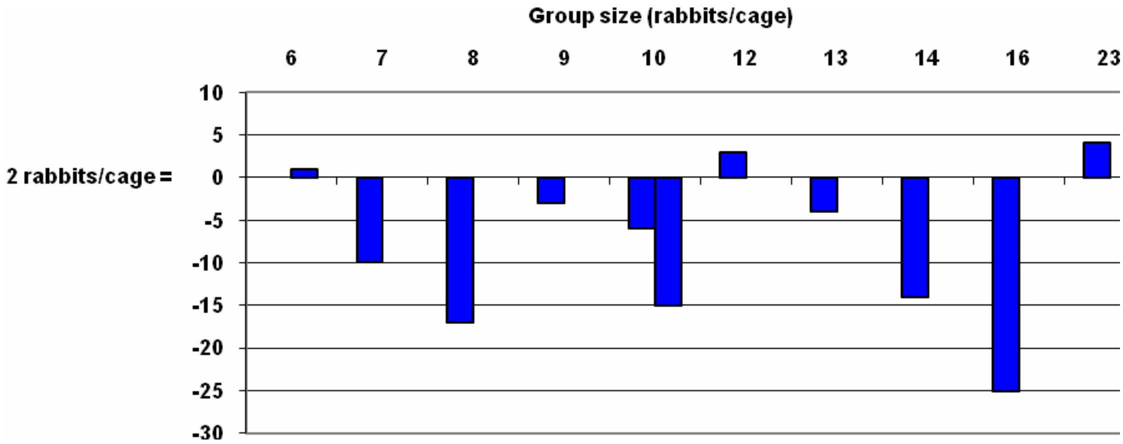

Figure 1: Effect of group size on daily feed consumption of growing rabbits
(The horizontalline (with value of 0) showsthe daily feed consumption ofthegroups of 2 rabbits/cage. The differences in consumption of the other groups are shown by the blue columns.)

It is clear that higher locomotory activity and lower feed consumption generate a poorer **dressing out percentage**, lower fat deposition and a decrease in the meat-to-bone ratio. A tendency towards a decrease in the ratio of fore part to the reference carcass (0.2-0.6%) was observed. There was no defined change in the intermediate part of carcass, while the hind part of animals housed in larger groups increased by 0.1-1.7%, because of the higher activity. Meat pH_u values tended to decrease with increasing group size. In the larger groups the meat was lighter (L*), but the effects of group size on redness (a*) and yellowness (b*) values were unclear. The meat of rabbits kept in large groups was leaner and contained more water, while neither protein content nor ash content was affected by the group size. The total amounts of saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA), n-6 and n-3 and n-6/n-3 ratio increased in pen-housed rabbits ,while monounsaturated fatty acids (MUFA) decreased compared to rabbits in cages (Dal Bosco *et al*., 2002; DalleZotte *et al*., 2009b; Szendrő*et al*., 2009a,b; Combes*et al*., 2010).

In larger groups, rabbits rested less and were **more active**. They spent more time with moving around and investigatory, social and aggressive behaviour forms, whereas the frequency of ingestion was lower in most cases (Dal Bosco*et al*., 2002; Lambertini*et al*., 2005; Princz*et al*., 2008a). Aggressive behaviour is one of the main problems of housing rabbits in large groups. Upon reaching sexual maturity, the number of aggressive conflicts increases and causes more or less serious injuries to different parts of the body. Body injury frequency and severity were related to group size (Bigler and Oester, 1996; Rommers and Meijerh, 1998). Szendrő*et al*. (2009) also observed a close correlation between group size and frequency of injury on rabbits (Figure 2). The percentage of aggressive animals may be unrelated to group size. The reason for increasing frequency of injuries with increasing group size is that in a larger group an aggressive animal can injure more group-mates than in a smaller one. This phenomenon is obviously against animal welfare. Among European wild rabbits, aggression is common mainly at the time of sexual maturity as well as at the start of breeding season (von Holst *et al*., 1999 & 2002). In nature, of course, sub-dominant animals can run away, but this is impossible on farms, even in large pens.

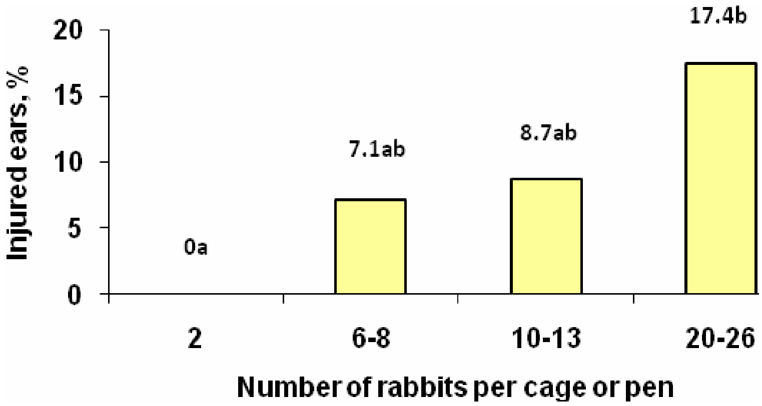

Figure 2: Effect of group size on ear lesions (aggressiveness) (Szendrő*et al*., 2009b)

According to von Holst *et al.*(2002), in the European wild rabbits separate rank orders are formed for the females and males. On the contrary, among the domesticated growing rabbits Mykytowycz *et al.* (1974) and Vervaecke *et al*. (2010) reported that aggression was also present between males and females. Szendrő *et al*. (2012a) placed full-sibs, only females, only males, or mixed sexes in the pens. The **groupsex-composition** had no effect on the production and on the behavioural patterns. Lesions on the body caused by the aggressive animals were more frequent for the female group between the ages of 7-9 weeks, but at the age of 11 weeks the occurrence of the lesions was 40.5% in the male group, which was higher than that of the other groups (23.8-28.6%). Based on the results it could be concluded that housing the growing rabbits segregated by sex is disadvantageous. Although, no differences were found between the mix-sex and litter-mate groups, but the risk of contamination by any disease is lower when the whole litter is reared together.

The most critical element of rabbit housing is the **floor type,** because the animals have a direct and continuous contact with the floor (resting, locomotory behaviour). In large scale rabbit farms keeping the animals on wire mesh floor became a widespread method about 40-50 years ago. This method avoids the animals contact with their faeces thus hinders coccidia infection. In most of the experiments the effect of group size or the stocking density were evaluated in cages or pens with wire net flooring.

Only a few experiments were carried out in pens with other floor-materials, e.g. deep litter. The general belief is that **deep litter** is an optimal floor type for rabbits; however, rabbits can consume the spoiled litter material (Lambertini*et al.,* 2001; Dal Bosco*et al.,* 2002; Jekkel and Milisits, 2009), which increases the risk of digestive diseases (primarily coccidiosis) and mortality (Dal Bosco*et al.,* 2002). Because of the litter consumption (containing low level of nutrients) the rabbits consume less pellet, and show a lowered weight gain, body weight and dressing out percentage (Lambertini*et al*., 2001; Dal Bosco*et al.,* 2002; Metzger *et al.,* 2003; Trocino *et al.*, 2008). If provided with a free choice of the locations, above the temperatures of 15-16 °C the rabbits generally show a preference towards wire mesh floor as opposed to deep litter (Morisse*etal.,* 1999; Orova*et al.,* 2004), because digestive heat dissipation is easier on that surface (Bessei*et al.,* 2001). Recently, Gerencsér*et al.* (2012) examined the free choice of growing rabbits between floors of deep litter, wire net and **plastic mesh**, at the temperature of about 10°C. Most of the growing rabbits preferred staying on plastic slat, while the least rabbits were found on deep litter. The preference of plastic mesh decreased from 70 to 52% between ages of 5 and 11 wk, and it increased on wire net and deep litter from 23 and 8% to 33 and 14%, respectively. It can be concluded that the most preferred floor-type is the plastic net at 10°C.When growing rabbits could choose between wire net and plastic mesh floor, most of the rabbits preferred staying on plastic mesh floor (62.5 and 76.5%, depending on the stocking densities of 16 or 12 rabbits/m^2, respectively (Princz*et al.,* 2008a). When deciding between

different floor types, we should realize that wire net is the most hygienic option, while in case of plastic mash the manure can accumulate on it more frequently.
There is a great difference between consumer expectations and the real welfare demands of animals with regard to optimal floor type for rabbits. A **compromise** could be achieved through the use of cages provided with both **wire mesh and deep litter floors**, but the negative phenomenon of litter consumption and its consequences were yet exist as described for deep litter floor (Morisse*et al.,* 1999; Jekkel *etal.,* 2008a). A better solution could be if rabbits were kept on wire net floor after weaning, and the litter material would be placed into the pens only a few weeks after weaning (Kustos*et al.,* 2003; Jekkel*et al.,* 2008b; Princz*et al.,* 2008a). Consequently, from the aspect of coccidia infection during the most critical period, rabbits are kept on wire mesh floor. The other possibility is housing rabbits in wire net floor pen, enriched with a deep litter elevated platform. The results are presented later in this paper.

By using **environmental enrichments** in group-housing system, the aggressiveness, and the frequency and severity of injuries could be reduced. Several enrichments (hay or grass cubes, hanged or fixed gnawing sticks, wire chain, toys) have been tested. The addition of gnawing stick as an environmental enrichment had only a slight, in most cases not significant effect on productive and carcass traits (Jordan *et al.,* 2006). Buijs *et al.* (2011),by using ”U” shaped wooden structure in cages, found a favourable effect on welfare by preventing a redirection of gnawing towards the cage and conspecifics. In practice, most of the farmers use different types of **gnawing sticks.** If they are wide or hanging down from the top of the cages, rabbits use them as toys, because they are not able to gnaw them. If they are made of hard wood, rabbits can hardly chew them. Their suitability for environmental enrichment is correlated to the type of wood (tree species). Rabbits prefer soft wood types and reject hard ones. Princz*et al.* (2008a) compared three groups: with no gnawing sticks, with hard White Locust (*Robiniapseudoacacia*) sticks and with soft Little-leaf Linden (*Tiliacordata*) sticks. The rate of injured rabbits at 11 weeks of age was 17% in the cages without gnawing sticks, White locust sticks reduced the incidence of ear lesions to 8%,while soft gnawing sticks (Little-leaf linden) decreased aggressive behavior even more, to 2%, and turned out to be the most suitable for group-housing. Gnawing sticks were also found to be more beneficial in larger than in smaller groups. Gnawing sticks of soft wood with 3 cm diameter, fixed on cage walls are one of the most efficient enrichments in reducing bodily injury caused by aggressiveness (Szendrő and DalleZotte, 2011).

Based on the numerous experiments conducted with domesticated rabbits, it can be concluded that higher group size results in higher stress, lower feed intake and weight gain, decreased slaughter performance, increased infection and mortality rate and higher occurrence of lesions on the body due to aggression paler meat (Trocino and Xiccato, 2007; Szendrő and DalleZotte, 2011). Housing growing rabbits in large groups has more disadvantages than advantages (social behaviour, larger moving area, increased PUFA content in the meat). The best solution could be 4-5 rabbits, maximum **a litter per cage or pen** which is enriched with soft gnawing stick (Szendrő and DalleZotte, 2011). Housing rabbits in dual-purpose cages meets these requirements.

Stocking density

Several researchers have examined the effect of **stocking densityonproductive performance** (Trocino and Xiccato, 2006; Verga*et al.,* 2007; Szendrő and DalleZotte, 2011). When stocking density was higher than 15-17 rabbits/m^2, daily weight gain, final body weight and feed intake declined. When stocking density was lower than 15-17 rabbits/m^2, only a random fluctuation was observed. Maertens and De Groote (1985) and Aubret and Duperray (1992) demonstrated that it is not the number of animals/m^2, but rather the total weight of the animals/m^2 that induces lower feed intake and weight gain if density is higher than optimal. When the total weight of rabbits per m^2 was higher than 45 kg, daily weight gain declined.

The connection between **stocking density and carcass traits** were summarized by Szendrő and DalleZotte (2011). A slight increase in dressing out percentage was observed when the stocking density was higher than 15-17 rabbits/m^2. The ratio of carcass parts, fat deposits and meat-to-bone ratio was not significantly affected by stocking density. The effect of **stocking density on meat quality traits** was examined only by a few researchers. The pH_u values of muscles increased slightly as stocking density decreased. Changes in meat colour observed in the meat of rabbits reared at lower stocking density can be attributed to the enhancement of locomotory behaviour that increases oxidative muscle energy metabolism. The effect of stocking density on rabbit meat proximate composition (water, protein, lipid, ash content) is unclear. At a lower stocking density than 16 rabbits/m^2 a general decrease in SFA and MUFA was observed, while an increase in PUFA could be seen.

Morisse and Maurice (1996) compared the effects of **stocking density on behaviour** of growing rabbits. They stated that 40 kg/m^2 could be considered an acceptable threshold in terms of animal welfare. Stocking densities with less than 16 rabbits/m^2 do not provide any positive effect on the behaviour. Comparing densities of 12 and 16 rabbits/m^2,Trocino*et al.* (2004) did not observe any significant differences in the behaviour forms (resting, moving, eating, self-grooming) of growing rabbits.

Experimental data and accountancy data based on 15 Belgian farms were combined to calculate the financial impact of different stocking densities on farm profitability (Verspecht*et al.,* 2011). Reducing stocking density implies a negative impact on **farm profitability**. Reducing stocking density from the standard situation of 15 rabbits per m² to 10 rabbits per m² reduced added value by €22 per doe. Below a density of 9 rabbits/m², a negative farm income was calculated.

Reducing the socking density to a lower level than 16 rabbits/m^2 (40-45 kg rabbits/m^2) have no any positive effect on production and welfare of growing rabbits, but the production costs increase and the profit decreases. Therefore, we have to realize that the **optimal stocking density is about 16 rabbits/m^2**, and at the end of growing period it ~~do~~should not be higher than **40-45 kg rabbits/m^2** (Szendrő and DalleZotte, 2011). This statement is true only for cages with wire net floor.

Other factors

Contrary to the opinion of some experts, rabbits prefer tostay in the **cagewith top** on it than in an **open top cage**.In the experiment of Princz*et al.* (2008b) weaned rabbits were housed in cage blocks. The cage block consisted of four equal floor-space cages and the rabbits could move freely among the cages through swing doors. The cages differed only in their height (20, 30, 40 cm or open top). The rabbits had a low preference for open top cages, the least number of rabbits chose this option. There was no difference in preference among the closed cages, but most of the rabbits stayed in the 40 cm and 20 cm high cage during the active and resting period, respectively. European wild rabbits prefer areas covered with vegetation (e.g. bushes),as they are safer from birds of prey (Virgós*et al*., 2003; Beja*et al*., 2007). The area under the platform is similar to the burrow that European wild rabbits dig for protection from predators (Palomares, 2003; Lombardini*et al*., 2003, 2007).The cage height had no effect on the rabbits' production. The frequency of the ear lesions connected with aggressive behaviours was the smallest and the greatest in the 30 cm and 20 cm high cages, respectively. Examining the rabbits' preference, ear lesions connected to aggressive behaviour and production (indicators of well-being) it can be concluded that the commonly used **30–35 cm high cages are satisfactory for the growing rabbits.**

A new housing system is rearing the growing rabbits in cages equipped with **elevated platform**. In this housing system growing rabbits can use a larger area, they move more and may jump on the platform or sit under it during the resting period, which could have a positive effect on welfare.

In the experiment of Szendrő*et al.* (2012) three types of flooring of the **elevated platforms** were used: **deep litter and wire net without or with a manure-tray bellow it**. When the platform was deep litter, more rabbits used the area under the platform (54%) than stayed on the platform (12%).When there was no manure-tray fixed below the platform with wire net floor, more rabbits used the platforms than did so when a manure tray was below the platform. The rabbits' avoidance of the area under the platform without a manure tray can be explained by the fact that the rabbits on the platform may urinate on the rabbits underneath the platform. Therefore, the rabbits stayed on the platforms with an increased frequency. The greatest number of rabbits stayed in the area under the platform when the platform floor type was deep litter or when a manure tray was fixed below the wire net platform, because the area under the platform may have provided safety for the rabbits, which would explain their high use of it. The effect of different periods of the day on preference was significant. In the active period, the preference of platform was higher. The wire net platform with the manure-tray provides the optimal environment as the rabbits are spreadmore evenly in the pen (i.e. the platform expands available floor area) without risk of soiling from above, without adverse effects on heat dissipation, and with the possibility to seek cover when desired. Lang and Hoy (2011) compared pens **without or with plastic slatted platform**. After weaning, the percentage of rabbits staying on the platform was higher (48%) than at the end of the fattening period (41%). More rabbits stayed on the platform during the night (70%) than during daytime (40%). Opposite tendency was observed under the platform. The usage of the platform appears to depend upon the amount of space available; in a large pen (60 rabbits/pen, 15 rabbits/m^2), an elevated platform can be utilized as an exercise structure, while in a small pen (10 rabbits/pen, 15 rabbits/m^2) it was used more as a simple extra space to occupy (Postollec*et al.*, 2008).

Summarising the above stated results of the experiments, a **preference order** of using elevated platform can be established:

plastic slatted > wire net > deep litter.

Similar results were obtained when preference of growing rabbits rearing on floors of wire net, plastic mesh and deep litter were examined (Matics *et al.*, 2012).

Lang and Hoy (2011) found no difference between cages **without or with plastic slatted platform** concerning morbidity, mortality and the frequency of skin lesions, but rabbits in cage with platform showed higher weight gain and body weight in two replications. Contradictory results regarding daily growth rate in enriched cages were reported by Jehl*et al.* (2003) and Postollec *et al.* (2003). Whereas,Jehl *et al.* (2003) showed an equivalent daily growth rate in cages with and without an elevated platform, Postollec*et al.* (2003) showed a significantly reduced daily growth rate in enriched cages with an elevated platform.

Combes *et al.* (2011) compared conventional cages (6 rabbits/cage) and pens with platform (small pens of 10 rabbits, and large pens of 60 rabbits). Daily weight gain was reduced for rabbits housed in small (-3%) or in large pens (-8%) compared to those caged. Dressing out percentage and meat-to-bone ratio were not influenced by the housing system, but hind part proportion was higher (+1%) in rabbits reared in large pens compared to caged rabbits. Percentage of fat deposit was the highest in caged rabbits. The redness (a* value) and yellowness (b* value) of meat, cooking loss were higher in rabbits reared in large pens than in the other two groups. While moisture in meat was the highest for the small pen group, but neither lipids content nor Warner-Bratzler shear were affected by housing conditions. Only small modifications to chemical traits were measured. The study demonstrated that large pens with a platform affected carcass and meat characteristics moderately compared to conventional housing. These observations might be related to the locomotory behaviour in rabbits reared in large pens.

Matics*et al.* (2012) examined the **productive, carcass and meat quality traits** of rabbits housed in cage or in pen (11 or 16 rabbits/m^2without platform, and with wire net or deep litter platforms). Weight gain and body weight at 11 wk were lower in pens with deep litter platform comparing to the other groups. Feed conversion ratio and mortality were not affected by the housing conditions. Dressing out percentage of the groups showed small differences. Rabbits housed in cage had the smallest hind part of reference carcass and the largest percentage of perirenal and scapular fat. Pen-housed rabbits had heavier, thicker and stronger hind leg bones compared to those of rabbits kept in cages, whereas the meat-to-bone ratio was the largest in cage. Among the meat quality traits, significant differences were only recorded for a* value and lipid content of m. *Longissimusdorsi*. Although, the difference between rabbits housed in cage and those housed in pens was significant, but not substantial. Therefore, **a platform covered by straw litter could be** suggested as **analternative housing method,** since it meets consumer demands.

CONCLUSIONS

Several papers start with a sentence similar to:"An increasing proportion of consumers recognize animal welfare aspects, they prefer to buy meat of animals kept in an environment with adequate housing conditions". But the situation is more complicated. Researcher and farmers have to take into consideration consumer demands, animal welfare, production costs, profitability, competitiveness, food safety, traceability…On the other hand, we should not forget that the rabbit meat has one of the highest biological values, yet many people cannot buy expensive food. Sevenbillion peoplelivein the world, and one and a halfbillion peopleare starving. The population is increasing, but the field used for agricultural purposes is decreasing. The ecological footprint is a question of not only the future, but present, as today humanity uses the equivalent of 1.5 planets to provide the resources we use and absorb our waste.

Some of the housing systems (group-housing of does, rearing rabbits on deep litter and in large group) are against the animal welfare (chronic stress, aggressiveness and injuries, higher risk of diseases and mortality...), while reproductive and productive performances are lower, the cost and the price of rabbit and the meat are higher. These housing systems do not respect the demand of animal, however consumers are given to believe that these are the best housing conditions, and they pay higher price for the meat originating from these animals. However, the human idea of the optimal housing conditions of a certain animal may not coincide with those animals' real demands. People do nothave the rabbits' mind to think.

Some alternative housing systems (plastic mesh floor, elevated platform, larger cage and footrest for the does, dual-purpose cage, gnawing stick as environmental enrichment) increase the production cost, even so improve the welfare of animals (more comfortable, larger area for activity, less boredom and incidence of behavioural stereotypes). The higher price of rabbit meat originated from these housing systems covers the higher cost of production.

At the same time we have to consider the financial opportunities of the poorer who can afford to buy rabbit meat only originated from intensive production system. There are several countries of mostly price-sensitive buyers, whose decisions are primarily determined by the price of products. We should help them to be able to purchase cheaper rabbit meat as well.

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