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# INTENSIVE RABBIT BREEDING AND WELFARE: DEVELOPMENT OF RESEARCH , TRENDS AND APPLICATIONS (Main paper)

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# INTENSIVE RABBIT BREEDING AND WELFARE: DEVELOPMENT OF RESEARCH , TRENDS AND APPLICATIONS

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## ABSTRACT

Aim of this review is to outline some aspects of rabbit intensive husbandry systems and management, mainly looking at their potential effects on animals' welfare. Starting from the differences and analogies between wild and domestic rabbits, the possibility to evaluate welfare levels in these animals is considered in relation to the housing and management systems in fattening rabbits, does and pups. Moreover, some alternative systems of housing and management and some developing trends are outlined, together with their effects on welfare and production too.

## INTRODUCTION

Since many years rabbits are reared in intensive husbandry systems, mainly in cages both for does and fattening rabbit production. The intensive rabbit husbandry systems have to face two main problems: the first one is the time since rabbits have been domesticated, the second one is the adaptive capability and coping systems of these animals; both these aspects have some implications in the present and future husbandry and management of rabbits reared for different purposes, including meat and fur production, and laboratory too. Many issues in intensive rabbits husbandry may be related to welfare: for example the feeding regime, the breeding system of the does (intensive or semi-intensive), the genetic strain adaptability, the housing and management. In this review some aspects of these last two points will be considered, together with their potential effects on the welfare of the animals.

## WILD AND DOMESTIC RABBIT: FROM THE NATURE TO THE FARM

Compared to the other domestic species, rabbits have been domesticated rather recently (Sandford, 1992; Morisse, 1999). This doesn’t mean that these animals have not been able to adapt to the environment and to the management systems used by man (Verga, 1992; Loliger, 1992). In fact they can reproduce, grow and express their “fitness” both in natural environment (Clutton-Brock, 1989) and also in an environment totally controlled by humans, which includes many variables, such as feeding regime, photoperiod and reproduction schedules. However, in spite of the adaptability, the domestic rabbits retain certain traits which are peculiar of wild rabbits (Stodart & Myers, 1964). These are mainly some behavioural characteristics, such as the maternal behaviour features, the neonatal reactions, the social system and other traits of the ethogram (i.e. the behavioural repertoire) which are typical of this species. The main differences between wild and domestic rabbit are related to the daily rhythms, determined by the light and dark hours, the habitat (colony burrows), and the social contacts (groups).

Looking more deeply at the main rabbits' traits, these animals, due to their evolution process, developed as social animals living in groups. In their living area or 'home range' all the

members of the colony find the possibility to survive (Denenberg et al., 1969). In fact, the evolution has developed a defence strategy from both predators and other colonies, which implies the complex building of colony burrows, from where rabbits exit to find feed according to the daily light and dark periods with higher activity at sunrise and sunset (Nelissen, 1973). They show a typical defence pattern in the case of predators' presence, which is the 'freezing' behaviour. This may be considered a kind of adaptive behavioural and physiological defensive reaction, which has the aim to hide the animal from the danger of being identified and caught by the predator. In the colony system, a certain level of fights aiming at determining and maintaining the social hierarchy is shown (Camps, 1984), although agonistic encounters seldom appear before 10-12 weeks of age (Mykytowicz & Dudzinski, 1972; Lehman, 1987). The natural selection mechanisms allow the survival of the subjects whose fitness is greatest compared to the other ones (Lehman, 1991). This selection strategy implies that, once reached the sexual maturity, the males have to fight in order to remain in the original colony. The does also may be very aggressive towards younger rabbits, mainly at the end of the breeding season, which in nature is rather well defined (Denenberg et al., 1969).

Another typical trait of wild rabbits is related to the parental strategy and pups survival: in fact it is well known that does are "nesting" animals, preparing a suitable environment for their pups just a few days before delivering time using the available nesting material which they may find in the environment. Just immediately before parturition, the doe lines the nest with her fur, in order to prepare a more comfortable environment for the pups, who are "altricial" animals and need a warm and soft nest to survive. The doe's maternal strategy includes also another typical feature: the very short daily time devoted to the parental care and nursing of the pups. In fact it is limited to a few minutes once a day in the first two days, and then it implies just two very brief visits of the mother to the pups in order to nurse them. In spite of this fact, the young pups develop and grow very well. Hudson et al. (1996) have deeply studied the basis of the relationships between the doe and the pups, mainly considering the efficacy of the olfactory stimuli or pheromones, which allow the pups to learn the mother's odour and to attach to her in a kind of 'imprinting' process.

The last main point of the adaptive strategies of wild rabbits concerns their fitness: it is well known how many problems followed their spreading in some particular Countries. This possibility to reproduce and invade territories digging burrows is related to the physiological traits of rabbits' reproduction and to the many pups delivered and able to survive when the habitat is suitable to their needs and the predators are not so efficient. These traits, together with the colony living and protecting system, explain why these animals may really become a 'pest' (Clutton-Brock, 1989). This may be due to their very high adaptability to the habitat, also when it is changing or when it is controlled by man through the farming system.

## INTENSIVE RABBIT HUSBANDRY AND PRODUCTION: 'UP TO DATE' SITUATION AND PROBLEMS FOR WELFARE

In spite of rabbits' adaptability, the typical reactions outlined in the previous paragraph may explain some fundamental reasons why, in intensive rabbit systems, any problems might arise. Due to this fact, the farmers should take into account the possibility to improve rabbits' husbandry and management, in order to avoid both undue stress for the animals, and eventually negative consequences for their welfare and production. In fact, the absence mainly of chronic stress and of the behavioural, physiological and health related factors, which may lower not only the animals' welfare, but also their productive and reproductive

efficiency, is needed. Table 1 shows the main issues which are raised by the actual intensive husbandry systems for rabbits.

**Table 1 - Main problems in intensive husbandry systems for rabbits**
(after Stauffacher, 1992, modified)

- Lack of space in order to perform movements (i.e. 'hopping' or 'jumping')
- Lack of separate areas where to hide or to rest
- Lack of objects to gnaw (i.e. sticks, straw, grass)
- Lack of social contacts or too high density of animals
- Lack of possibility to close the nest after nursing

The main problems, in this respect, are related to the aspects listed in Table 2, mainly related to the type of housing, in particular the quantity and quality of the available space, the handling and management by the stockman, the type of reproduction and the reproductive rhythms for the doe, the environment given the does and the pups, the type of feeding regime. In this review the housing for the fattening rabbits and for the doe and pups, the handling and the problems related to these aspects will be considered, together with the trends on the improvement of the conventional cages, using for example some kinds of environmental enrichment, or the possibility to develop alternative systems.

**Table 2 - Welfare problems for rabbits in intensive husbandry systems**
(after Stauffacher, 1992, modified)

- Changes in locomotion and in locomotion apparatus
- Presence of 'abnormal behaviours', such as stereotypies (i.e. wire-gnawing)
- Restlessness and space-time organization disorders
- Disturbed sexual behaviour and low conception rate
- Disturbed maternal behaviour and parental care (i.e. disturbed nursing)

The quantity and quality of the space available have special importance for the welfare of rabbits. Generally fattening rabbits are reared for the most part in cages, individually or two per cage. Also the does are reared in individual cages containing the nest for the pups. Colony cages are rarely used, although alternative husbandry systems are actually developing. In fact, although there are no common European rules on rabbits welfare up to now, apart for laboratory animals (EC Directive 86/609, 1986), in many European Countries there are local guidelines on rabbit husbandry systems. Codes of Welfare for the husbandry systems and management of many species, including rabbits, have been stated since 1987 for example in U.K. These Codes include indications on the space requirements for the animals, reared both in cages and on ground floor (Table 3).
The German section of the W.R.S.A. (World Rabbit Science Association) also has stated, since 1992, some indications on the minimum space required for the rabbits in intensive husbandry systems (Table 4). Moreover, guidelines have been stated also in Switzerland (Swiss Order on Animal Protection, 1991, Bigler & Oester, 1996). At the European level, however, rabbits' husbandry has recently deserved attention too: in fact a working group has been constituted by some Countries, such as The Netherlands, Italy, Switzerland and France, with the aim to study some Recommendations taking into account rabbits' welfare.

Both the housing system and the management of rabbits may negatively affect their welfare; however, besides the housing system, which may potentially be stressful for the animals, other environmental factors may constitute stressors, and the major ones are listed in Table 5.

| **Table 3 - Recommendations for Rabbits in U.K.**<br>(Codes of Recommendations for the welfare of livestock, 1987) | |
|---|---|
| Housing system | Minimum space |
| Cage | |
| Does and pups (till 5 weeks of age) | 0.56 $m^2$ total area |
| Does and pups (till 8 weeks of age) | 0.74 $m^2$ total area |
| Rabbits from 5 to 12 weeks of age | 0.07 $m^2$/subject |
| Rabbits after 12 weeks of age (multiple cages) | 0.18 $m^2$/subject |
| Breeders | 0.56 $m^2$/subject |
| Group rearing | |
| Does and pups (till 5 weeks of age) | 0.75 $m^2$ total area |
| Does and pups (till 8 weeks of age) | 0.93 $m^2$ total area |
| Rabbits from 5 to 12 weeks of age | 0.09 $m^2$/subject |
| Breeders | 0.75 $m^2$/subject |

| **Table 4 - Indications for rabbits' housing from W.R.S.A. - German Section (1991)** | | |
|---|---|---|
| | Minimum space ($m^2$) | Height |
| Breeders | | |
| Till 4 Kg live weight | 0.20 | 35 |
| Till 5.5 Kg live weight | 0.30 | 40 |
| More than 5.5 Kg live weight | 0.40 | 40 |
| Fattening rabbits | | |
| From weaning till 6 weeks | 0.04 | 35 |
| Till 3.3 Kg live weight | 0.08 | 35 |
| Pens | 0.12 | |
| Nest | 0.10 | 30 |

| **Table 5 - Environmental possible stressors for rabbits in intensive husbandry systems**<br>(after Verga, 1997, modified) |
|---|
| - Inadequate housing system (i.e. building, ventilation, microclimate, hygiene) |
| - Not appropriate feed (quality and quantity) |
| - Health problems |
| - Inappropriate handling methods |
| - Presence of stressors such as noises, animals |
| - Inconsistent daily routine |
| - High stocking density; too many animals in a group |
| - Presence of aggressive behaviours (i.e. competition) |
| - Not appropriate means and practice for the transport of the animals |

## WELFARE EVALUATION OF RABBITS ACCORDING TO HOUSING AND MANAGEMENT

The meaning of 'welfare' has been defined by many authors (see for example: Moberg, 1985; Verga, 1993; Broom & Johnson, 1993; Fraser & Broom, 1994), as well as many definitions of welfare have been given (i.e. Hughes, 1976; Broom, 1986; A.V.M.A., 1987; Dawkins, 1990). According to these ones, welfare includes the ease or difficulty of coping and its effects on behaviour, physiology and health status of the organism, which may have also consequences on the quantity and quality of production performances. In farm animals, guidelines for welfare should take into account the 'five freedoms" (FAWC, 1991), i.e. freedom from hungry and thirst, from an inadequate environment, from pain, injuries and distress, from 'fear' and from the impossibility to express the 'normal' behavioural repertoire. Also the possibility to scientifically evaluate and objectively quantify welfare levels of rabbits has been studied in some researches, although the references on this species are rather few, due to the fact that it has been studied mainly from the physiological and neuro-physiological side. According to the current literature, the same welfare indicators used for the other farm animals may be used on rabbits too (Morisse & Maurice, 1994), and these indicators belong to the four categories listed in Table 6 together with some examples.

| **Table 6 - Main welfare indicators** (after Verga, 1997) | |
|---|---|
| - Behaviour | Behavioural repertoire (i.e. 'ethogram') |
| | Reaction to behavioural tests ('open-field; tonic immobility; preference tests) |
| - Health status | Pathologies<br>Injuries |
| - Physiology | Hormone levels |
| | Heart rate variations |
| | Immune reactions |
| - Production | Growth rate |
| | Mortality |
| | Fertility rate |

Welfare evaluation of rabbits has to consider both behaviour and other variables, such as the physiological ones. As far as the former are concerned, mainly the presence of 'abnormal behaviours', called 'stereotypies' (Lawrence & Rushen, 1993), may indicate some problems for the animals (Podbercheck et al., 1991), although pawing on the cage floor or gnawing may also be considered 'normal' behaviours in an inadequate environmental context (Morisse & Maurice, 1997). Other significant indicators of acute stress, due for example to transportation or handling practices, may be evaluated looking at other behaviours, such as feeding activity (Finzi et al., 1986b), social and maternal behaviour (Verga et al., 1978; Lehman, 1987; 1991; Verga, 1997; Morisse, 1999). Some physiological indicators, such as leucocyte evaluation, adrenal weight, ascorbic acid and corticosterone levels, have been used in relation to the housing and welfare of rabbits. The effect of handling or of placement in a new environment, as well as of an ACTH challenge, on the endocrine system has been evaluated by Fenske et al. (1982), who found that both the management practices may be stressful, although less than the pharmacological challenge. Verde & Piquer (1986) found that rabbits aged 42-43 days react to heat stress (32-34°) and to noise stress (90 +/-5 dB, 200 c/sec) showing higher corticosterone and lower ascorbic acid levels. In rabbits interesting results have been obtained evaluating the reaction to behavioural tests such as "open-field" ( Mejisser et al., 1989; Ferrante et al., 1992; Verga et al. 1994; Xiccato et al., 1999) and "tonic immobility (T.I.)"

(Hansen et al., 1993), which respectively might indicate the 'fear' reaction to a new environment and towards humans. Heart rate variations (Carli, 1974), as well as increased ACTH, corticosterone and testosterone levels (Carli et al., 1979; Farabollini et al., 1978; 1990) , have been shown in rabbits during the phases of T.I. reaction.
As it has been already shown in Table 5, many factors may be potentially stressful for the rabbits, eventually leading to an impaired health status (Galassi, 1985).

## EFFECTS OF HOUSING AND MANAGEMENT ON FATTENING RABBITS

As far as housing is concerned, although intensive husbandry systems may take into account some rabbits' needs, such as an adequate feeding regime, a suitable microclimate and the lack of risk from natural predators, in many cases they do not allow to satisfy other animals' needs, such as the ones listed in Table 7 according to Stauffacher (1992). Thus the animals may show some adverse effects at behavioural and physical level, as well as on productive and reproductive performances.

**Table 7 - Rabbits' needs according to welfare**

- Sufficient space to perform correct movement
- Objects to gnaw or 'to play' with
- Social contacts
- Nest box; nest material; possibility to close the nest; hiding places

The effects of cage size and of the cage vs. floor rearing have been studied and different aspects of rabbits' welfare, including bone structure, body functions, behaviour, physiology and production parameters have been considered.
Recently Van Der Host et al. (1999) found lower growth rate in pen reared rabbits (64 subjects, 8/ $m^2$) compared to the animals reared in the classical fattening cage, 7 subjects per cage ( 16/$m^2$), with a live weight reduction of about 14% at 86 days, and worse dressing percentage (56,7 vs. 58%), but higher perirenal fat (2,8 vs. 1,8%), and no effects on mortality rate.
As far as behaviour is concerned, different activity and resting times have been recorded in group pens vs. cages by Podberscek et al. (1991): in fact the total activity percentage is respectively 75 and 66%. Lehman (1987) reports that rabbits in cages show more displacement activities than those kept in pens. Better adaptive behaviour reactions in 'open-field' test have been shown by Ferrante et al. (1992) in group pen reared rabbits compared to the caged ones, although production did not differ. Stereotypies have been found only in individually caged rabbits (Podberscek et al., 1991).
Group size in cages affects behaviour too. 6-group rabbits show more active behaviours (locomotion, exploration and eating behaviours) than rabbits reared at 2 per cage, at 64 days of age (Mirabito et al., 1999a). This could be due to the more restricted possibility of movement in the double cage compared to the collective one.
Xiccato et al. (1999) found that individual caged rabbits grow faster than 3-group caged rabbits. On the contrary, they did not observe any effect of the density in the cages, comparing 12 vs. 16 subjects/$m^2$. Higher transport losses and lower dressing out percentage ($P<0.01$), as well as stronger bones ($P<0.01$), were found in both individual cages and rabbits reared at higher density. In the same study, the behaviour in open-field test doesn't seem to be different comparing individual vs. 3-group rearing in cages during the fattening period, while the animals seem to be able to adapt to the test environment according to the age.

No influence of the group size has been observed on growth, feed intake and mortality rate in rabbits reared in 6, 12, 18, 30, 42 and 54 per cage, at a density of 17 animals/$m^2$ (Rommers & Meijherof, 1998); uniformity and bone strength also were not affected. However, increased injuries according with age are reported by the same authors, who support the recommendation "to finish the fattening period before 80 days of age". Bigler & Oester (1996) report higher levels of aggressive behaviour in groups of 16-30 till 40 vs. groups of 10-15 rabbits, between 60 and 80 days of age.
Mirabito et al. (1999b) found that the group size of the rabbits reared in cages may affect growth rate during the fattening period: comparing 2 vs. 6 animals/cage with the same density, better results were found in the latter ones.
The effects of the density in group pens have also been studied: Ferrante et al. (1997) found higher final live weights and carcass dressing percentage in rabbits reared at 850 vs. 600 $cm^2$/head. Gallazzi (1985) reports worse growth rates in rabbits reared in pens at 800 $cm^2$/head. Crimella et al. (1987) also found a negative correlation between density and growth rate, as well as Aubret & Duperray (1992), who found a negative correlation between stocking density and growth rate till 68 days of age in 6 to 10 rabbits per cage at densities of 16.9, 19.8, 22.6, 25.4 and 28.2 rabbits/$m^2$. Maertens & De Groote (1984) showed that rabbits reared at densities of 19.3 and 23.2 $m^2$/head have higher average daily gain ($P<0.05$) compared to densities of 11.6 and 15.4 $m^2$/head; on the contrary, other authors found contrasting results (Abadie et al., 1983).
The effects of stocking density on behaviour have been also studied in rabbits. Morisse & Maurice (1996) compared caged rabbits in groups of six, seven, eight and nine, at a density respectively of 15.3, 17.8, 20.4 and 23 subjects/$m^2$, at 6 and 10 weeks of age. The results show that at 10 weeks of age, the rabbits at higher densities (>6 per cage) showed increased self-directed activities (78 vs. 68%) and fewer social interactions and locomotor activities. The authors conclude that 40 Kg/ $m^2$ is the "acceptable threshold in terms of animal welfare" for intensively reared rabbits.
Besides the cage size, also the floor material may affect animal welfare. Comparing fattening rabbits reared on wire netting vs. half wire netted and half covered with straw bedding floors, Morisse et al. (1999) found that 88.8% and 76.9% of rabbits strongly preferred the wired part of the area, at 7 and 10 weeks of age ($P<0.01$) respectively. Such a result is quite unexpected according to the considerations on the effect of the type of floor on foot lesions in breeding rabbits reported by other researches (Morisse, 1999).

## EFFECTS OF HOUSING AND MANAGEMENT ON DOES AND PUPS

Some concern exists also for the welfare of does and pups, regarding mainly the cage size and shape, the possibility to rear the does in group, the nest features and material given the doe prior to parturition, besides the reproductive rhythms, which however will not be considered in this review. Other interesting issues of research, in relation to welfare, regard the adequacy of closing the access to the nest for the does, thus imitating what happens in nature, and also the opportunity to adopt some management practices, mainly the handling of the pups.
As far as the cage size is concerned, Drescher (1996) has shown, by radiological examinations in caged does (but not in male rabbits) that the shape and size of the cage may induce deformations of the vertebral column. According to the same author, the deformations may be due to the following four main factors: "1. Long-termed 'flat sitting' because of the poor cage height; 2. Systemic hypoplasia of the bone tissue because of deficiency in locomotion; 3. Caudale dislocation of the body's centre of gravity as well as a change in the static-dynamic

forces of the trunk construction caused by the weight of the gravid uterus; 4. High calcium need caused by gravidity and lactation at the same time".
More adequate postures may be shown by the does in cages with a height of 50 instead of 30 cm (Rommers & Meijheroff, 1997). However, the welfare of the does is also affected by the reproductive regime (Maertens & Okerman, 1988).
As far as the space quality is concerned, Rommers & Meijherof (1996) tested seven different floor types, compared to the traditional wire floor, studying their effects on footpad injuries of does. The authors found that these injuries "mainly developed after the second litter was weaned", and that "on the wire floor the incidence of does with severe injuries of footpads was higher than on the alternative floors" (80% vs. 30%).
Another important feature in the housing for does is the quality of the nest, i.e. the position in the cage and the material given the doe prior to parturition in order to prepare the nest itself. As it has already been said before, the maternal strategy of the domestic does is peculiar of the species and it has not been so much modified by domestication process. In fact the doe, whichever may be the environment where give birth to the pups, needs a nest box and some material in order to show the first phase of the nest building behaviour ("straw nest"), that is the lining of the nest. Afterwards, the second phase ("maternal nest") is shown, when the doe picks up the hair from her body in order to complete nest building (Denenberg et al., 1969; Verga et al., 1978; Vastrade, 1984). The nest quality, as well as the individual characteristics of the doe, are of fundamental importance for pups' survival and growth (Lebas, 1974; Verga et al. 1983; Battaglini et al., 1986; Verga et al., 1987; Mohamed & Szendro, 1992). The main traits of maternal care are also similar in wild and domestic does: in fact it is sufficient "just three minutes a day" (Hudson et al., 1996) for the pups to suck and perfectly grow. The behaviour of the pups and their interactions with the doe are based on an 'imprinting-like process', in which odour, i.e. the pheromones of the mother, attract the newborn rabbits towards the mother. To allow the doe a limited access to the nest in the intensive rabbit husbandry systems may be more closely resembling what happens in nature: this practice has been proven to be useful by some studies (Verga et al., 1986; Arveux, 1994; Hudson et al., 1996; Verga, 1997).
Also the maternal behaviour may be disturbed by many stressful factors in the environment (Verga et al., 1978).

## TRENDS TO ALTERNATIVE HOUSING AND MANAGEMENT SYSTEMS FOR RABBITS

Many authors have proposed alternative housing systems for rabbits. The solutions may vary from the modification of the conventional cages and the environmental enrichment in cages to group rearing in pens, or to other housing and management systems such as the ‘open-air’ or ‘*plein air’*.
The conventional cages may be modified as far as the area/subject and the type of floor are concerned, as well as adding some facilities to enrich the environment. Wire floors may cause footpad injuries, mainly in rabbits breeders, for whom litter could be used. On the contrary, this option doesn't seem to be suitable for fattening rabbits, to whom it may cause worse health conditions (Mirabito, 1998). However, alternatives to the wire floors deserve further studies in order to improve rabbits' welfare (Rommers & Meijherof, 1996), and this trend is also in agreement with the observations of the natural features of the rabbits' living habitat, which might help in improving the housing systems modifying and enriching them. According to Stauffacher (1992), these features for the rabbit are the following ones: "light intensity (bright to dark), cover from above (potential air predator), view across the ground

(potential ground predator or interaction partner), less ground humidity and ledges the rabbit can snuggle against". Moreover, the same author proposes the provision of a resting area for does, far enough from feeding place and from the nests to avoid competitions and disturbance of subordinate subjects by the threats of the dominant ones. With the same aim he studied a possible housing system (inner measurements 2.0 x 4.5 m) for groups of 3 to 5 does, one buck and their offspring till weaning, divided into five functional areas: 1) central area; 2) feeding area; 3) nesting area; 4) pup area; 5) isolation cage. The results show no disorders in reproductive behaviour, and successful mating *post partum* in 77% of the 44 observed parturitions. Pups from different litters mixed together after leaving the nest; cross suckling was observed too, but apparently without disadvantages for the does. Good results were obtained also from the production viewpoint. However, special attention has to be paid to hygiene in breeding group housing, mainly to avoid the spread of infectious diseases, and because the production costs may be higher. In cages it may also be added a raised resting place, using a solid horizontal bar at a height of 20-30 cm with a cage height of at least 60 cm (Stauffacher, 1992). An alternative to the conventional cage has been proposed also by Finzi et al. (1997) which is characterised by an increased area using the vertical space with a two-floor cage system. The cage dimensions are 40x75x52 cm; the second floor is at 22 cm of height and includes a covered surface 16x40x16 cm. The rabbits use all the cage area, although they spend very short time in the covered area; a restriction of the access to the higher part of the cage is needed for the first two days, to train the animals to defecate elsewhere.

Enriched (double height) cages for does, with a platform inside, have been recently tested (Mirabito et al., 1999c). The time spent on the platform was 20% during the first two weeks of lactation, 35% after the nest box was removed ($18^{th}$ day), and 16% during the last week of lactation (weaning at 36 days). The non-lactating does spent 27% of time on the platform. The authors conclude that this kind of environmental enrichment is not enough in order to allow the female to rest more quietly and escape from the pups, and raises some hygienic problems too. However, they considered only the daylight hours, thus further observations taken on the whole daytime might add information on the does' time budget and use of space.

Environmental enrichment means also to increase the complexity of the environment in which animals live, adding stimuli, not only 'dividing enclosures into different functional areas', but also for example 'presenting food in ways that stimulate foraging behaviour' (Newberry, 1995). Berthelsen & Hansen (1999) found that rabbits kept in cages where hay was available showed less stereotypies compared to controls without access to hay, which may suggest that in the latter situation the animals were more stressed, and that this kind of environmental enrichment could improve the welfare of cages rabbits.

As far as the density is considered, some studies have been carried out on behaviour and performances of rabbits reared in cages with higher surface/head. Rommers & Meijerhof (1998) compared 60 x 100 x 50 cm in height cages to standard 60 x 50 x 30 in height cages, provided with the same nests (30x25x30 cm in height). Different floors were used too (conventional wire mesh vs. 'alternative' metal floor with round spaces 15 mm in diameter). The larger cage seems to give better production results (number of pups and weaned rabbits and higher growth rate in those cages with 'alternative' floor). No differences in resting and comfort, as well as in abnormal behaviours, have been observed, while in larger cages higher frequencies of 'righting up' behaviour occurred

To meet the rabbits' requirements, mainly from the ethological viewpoint, group_rearing in pens with straw has been considered a possible alternative, although some problems may arise due to aggressive behaviours; infestations ( i.e. coccidiosis) that have to be of course very strictly controlled. In the previously quoted study made by Bigler & Oester (1996), 55 groups of fattening rabbits of different group sizes: male, female and mixed-sex groups, reared in

pens without or with partial bedding were considered. Other groups were observed in fattening cages, in floor pens or in wooden cages with bedding. The number of animals/group was <10, 10-15, 16-30 and > or = 40 subjects, while the density was between 3.4 and 6.0, 2.1 and 6.1, 2.1 and 7.3, 7.2 and 8.1 animals /$m^2$. Both the number and severity of injuries, and the aggressive behaviours recorded from 60 to 80 days are higher in larger groups, with 16-30 and >or = 40 subjects. According to the same authors, the levels of injuries and aggressions recorded in their study (from 18% to 56% and 64% in the largest groups) are too high. However, they consider that other causes of aggressive behaviours may be related to "individuality, stocking density, housing systems with different shelters and possibilities for avoiding each other, lighting, etc." Moreover, in larger groups the hierarchy may be disturbed because of the low control of the environment in a very stressful situation from the spatial and social viewpoint. A solution to these problems of aggression has to be studied, for example "the slaughtering at an earlier age (11 weeks), or the optimum enrichment of the pen or the delay of sexual maturity" Other researches found problems in male fattening rabbits, due to the conflicts at the beginning of sexual maturity (Bigler & Oester, 1996). On the contrary, Gallazzi (1985) did not observe fights among the rabbits before 70 days of age. Similar results have bee obtained by Ferrante et al., (1992), on rabbits kept in pens at 850 $cm^2$/head.

Finally, the 'open air' or *'plein air'* system has been studied too, both in cages and on the ground. Many types of cages for does have been proposed by Finzi (1985) and Finzi et al. (1986a), to be used outside, thus also reducing the production costs. Finzi & Ciorba (1995) used movable cages, similar to the one proposed many years ago. These cages allow to avoid infestations and to reduce the risk of *Pasteurellosis* due to the free air environment. In this system, coccidiosis may also be controlled without pharmacological aids. The cages have not to be placed on the same area before six months, although shorter time intervals may be adequate too. Each cage is approximately 1 $m^2$ and may contain up to six rabbits. The floor is a wire mesh 5.0 x 2.5 cm, which allows the animals to graze avoiding foot injuries. Another advantage may be the fertilisation of the ground.

Sinkovics & Gabor (1993) used an 'open air' system for does, with ‘tunnels’ closed only during winter. They found high levels of mortality (probably due to the development of coccidiosis on litter); moreover, the does wasted the litter material while building the nest, and the growth rate of pups was rather low. During winter, heating the nest gives better results, thus indicating that this practice is needed when temperature is below 0°; the material given the doe to build the nest has to be adequate. Higher levels of fertility (+4%), as well as less weaned pups, but heavier, have been found by Finzi et al. (1986a) in does reared in cages outside vs. inside.

The *'plein air'* system however may be suitable for the health status of the animals, mainly avoiding *Pasteurellosis*, and may be considered a practicable option when management standards are sufficiently accurate. This is true mainly for fattening rabbits (Crimella & Luzi, 1995. Breeding does and pups, as well as the stockman, may have problems due to climatic conditions, although in *'plein air'* nests temperature and R.H. levels similar to the ones inside have been recorded (Crimella et al., 1996).

Another possibility is the 'semi-*plein air'* system for fattening rabbits, housed in groups of 5 to 7 subjects, in partially closed buildings. This system, which has been very often used for example in France, allows rather good performances, although the environmental variables, such as temperature, R.H. and ventilation have to be very accurately controlled. Other important aspects to take into account are the density of animals, the building materials, the water distribution system, the manure disposal and, last but not least, the whole hygiene (Guadagno, 1987). According to Crimella et al. (1996), the 'semi-*plein air'* system may improve both rabbits' welfare and the quality of the whole husbandry process; it may give economic advantages to the farmer too, in fact the improvement of the quality of life of

animals meets the consumers' demand and attitudes. In Table 8 the main features, advantages and disadvantages of the *'plein air'* and 'semi-*plein air'* systems are reported. Some results in *'plein-air'* compared to the inside housing system are shown in Table 9 (Crimella et al., 1996; Colin, 1994).

| **Table 8 - Alternative housing systems for fattening rabbits** (after Crimella et al., 1996) | | |
|---|---|---|
| - Semi *plein air* | | |
| Main features | Advantages | Disadvantages |
| Wire or wooden closed cages closed to protect the rabbits from air flow<br>Sometimes the cages are covered in order to insulate the environment | Low cost<br>Better environment (low gas)<br>Better health<br>Better use of the space | High hygienic control<br>High control of the health status of the rabbits (i.e. vaccinations)<br>Climate may be a problem |
| - *Plein air* | | |
| Wire or wooden cages. Other materials may be used too.<br>Insulated covering of the cages<br>The housing is totally outside<br>Sometimes the cages are put on a concrete surface<br>Different types of shadowing | The same advantages than in the semi *plein air* system<br>Better control of the climate, using movable roofs on the cages, manually or automatically | The same advantages than in the semi *plein air* system<br>Higher initial costs |

| **Table 9 - Comparison between *plein air* and conventional housing system for rabbits** (after Crimella et al., 1996) | | |
|---|---|---|
| **Italy** (beginning of the experiment: 36 days of age) | | |
| | *Plein air* | Inside |
| N. of animals | 328 | 300 |
| Weaning weigh (g)t | 834 | 896 |
| Average weight (g) | 2484 | 2421 |
| Mortality (%) | 6 | 6.5 |
| F.C.I. | 3.17 | 3.16 |
| F.C.I. (at 2.484 Kg) | 3.17 | 3.22 |
| Dressing percentage (%) | 57.2 | 56.0 |
| **France** | | |
| | *Plein air* | Inside |
| N. of animals | 553 | 576 |
| Weight at 28 days | 631 | 631 |
| Weight at 70 days | 2363 | 2305 |
| Mortality 28/70 (%) | 3.71 | 4.34 |
| F.C.I. | 3.21 | 3.32 |
| F.C.I. (at 2.363 Kg) | 3.21 | 3.38 |
| Average daily gain | 41.2 | 39.8 |

Controlled nursing and suitable nest material have been considered to reduce mortality rate in newborn pups till weaning, (Verga et al., 1987; Canali et al., 1991). According to Hudson et al. (1996), "limited contact between mother and young combined with a nursing time of only

three minutes" could give better conditions to artificially raise the pups. Controlled access to the nest box also may avoid some stress due to disturbance by the doe (Verga et al., 1986; Arveux, 1994).
Moreover, artificial feeding could be practised, providing the identification of the nipple-search pheromone, or otherwise giving the pups an odour to associate with sucking. This might avoid the death from starvation for many pups, enhancing their nipple-search reaction.
Another interesting possibility of reducing stress reactions of rabbits, towards both a new environment and humans, may be related to handling by humans. For example Kersten et al. (1989) found that 'early handling seems most effective in reducing emotionality if applied after the $10^{th}$ day of life, placing the pups in a separate compartment of a closed box and returning them to the nest after 3 minutes'. However the authors found also a genetic effect on the 'fear' response. A reduction in fearfulness towards humans has been shown also by Podbersceck et al. (1991) in post-weaned rabbits following repeated approaching and handling. Individually handled rabbits from 17 to 20 days of life may reduce the mortality rate (Duperray, 1996). According to Jiezierski & Konecka (1996), rabbits handled daily for 10 minutes, from 10 days to 10 weeks of age, show higher growth rate and higher activity levels. Although further research is needed on the effects of handling on behaviour, physiology and production of rabbits, it seems that a certain level of handling in the pups, is an effective suggestion to reduce the fear stress of the animals to new environments and humans. Of course the handling procedures have to be scheduled very accurately, in order to avoid undue stress for the rabbits, including the doe, and a waste of time for the farmer.

## CONCLUSION

The contrasting results shown sometimes by the literature, mainly on the effects of different types of housing considering both the quantity and quality of the available space, and the types of management and handling both for fattening rabbits and for does and pups, suggest the need to carry out further research on rabbits' welfare and on the underlying factors. This issue deserves major attention due to many factors, which are the same that are at the basis of the need to study welfare aspects on all the farm animals, mainly in intensive husbandry systems.
In fact, first of all we have to keep in mind the new trends of animal husbandry, which are directed towards a better quality of the whole productive process, including the improvement of the quality of life of the animals.
At the same time, it is compulsory to consider the consumers' demand, aimed at obtaining products from animals reared in more suitable environments, more adequate to animals' needs and welfare. This demand has already been considered by certain kinds of production, which have fixed requirements from the welfare viewpoint. These aspect might meet also the producers' interest, due to the fact that animals less stressed are generally more able to survive, grow and reproduce, thus allowing also better gains from the economic side. In spite of the eventually higher production costs, it might be possible that people will afford the need to pay some more money for products perceived and verified not only as healthier, but coming also from a more sustainable and welfare friendly type of production.
Moreover, rabbit husbandry systems might deserve attention from the legislation in the future, not only at regional or Country level, but also at a common European basis, as it has already been done for other farm animals, such as laying hens, pigs and calves. This constitutes another good reason to evaluate the rabbit rearing system, considering the impact of stressors which negatively affect welfare and production too.

Last, but not least, the previous considerations mean that it is the case to use a 'rule of thumbs' also in rabbit production, avoiding extreme positions concerning animal welfare or the production system. As it has already been said in this review, farm husbandry systems deserve a lot of attention in order to improve both animals' welfare and consumers' demand, as well as producers' economy. This can only be achieved by the collaboration among all the people involved in the process, including the farmers and the researchers coming from different sciences, such as ethology, physiology, pathology and zootechnics, working together with the aim to improve both animal welfare and its consequences on the results at the farming level.

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