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Scientific Opinion of the Scientific Panel on Animal Health and Welfare on

"The Impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits"

EFSA-Q-2004-023

Adopted on 13th and 14th September 2005

SUMMARY

Executive Summary – Farmed Rabbit Health and Welfare

Rabbit farming is a small-scale industry that does not have a major national or international representative organisation in most of the EU countries. Over 76% of the total production in the EU is in Italy, Spain and France, and home production is still widespread. The production of jointed and processed products is increasing rapidly compared with whole carcase sales and rabbit meat consumption, although less than other meats, is still significant in some countries. In the Report are chapters on the behaviour and biology of rabbits (3), statistics of rabbit production (4), and current farming systems (5). There follow chapters on aspects of farming that may affect their health and welfare: the housing and husbandry of rabbits and space allowances and quality of that space (6); nutritional aspects (7); reproductive (8) and weaning practices (9); genetic issues (10); and finally health issues and biosecurity (11). An attempt was made to carry out risk assessments which we have called risk profiles. Even though this is a relatively new approach for animal welfare issues, we believe the method is helpful to understanding some of the critical hazards that impact on rabbit health and welfare, in each of the above areas.

In this Opinion, based on the scientific data as well as the experience of the Working Group's Report we draw some conclusions and make recommendations as well as giving pointers for future research. Overall there is a serious lack of information and scientific studies on the farming of this species compared with other farmed species, particularly on welfare. While there are few data on the types of rabbit farming systems it can be generally considered to be intensive with rabbits being reared in cages rather than being kept in large areas equivalent to a free-range style as with some other farmed species. The Panel recommends that such data be collected.

Farmed rabbits are genetically not far removed from other rabbits used in laboratories or those in the wild and so their needs, the causes of poor welfare, and their susceptibility to disease is very similar. In particular, the Panel notes with some concern, that the mortality and morbidity of farmed rabbits seems considerably higher than in other farmed animal species due to enteric and respiratory infections, and reproductive problems. The breeding life of does is very short with more than 100% often being replaced each year.

The Panel makes some recommendations relating to biosecurity, disease prevention, and therapeutic interventions including the use of additives, to reduce disease in growers and adult breeders. Breeding does may benefit from an easing of reproductive pressures caused by intensive breeding practices leading to a decrease in disease mortality as well as the need for earlier culling. All of these may help to improve this situation that would be in the best interests of both animals and farmers.

In addition to improvements in health there is also a need to improve rabbit welfare by modifying both housing and husbandry practices. The panel has recommended increases in cage size and lower maximum stocking densities for growing animals, bearing in mind that slaughter weights vary greatly between countries according to local customs. The panel is also mindful that aggression between rabbits at certain times in the farming situation precludes them having social contact that they may choose to have. "Enrichment" of the rather barren normal cage environment for rabbits may sometimes carry the disadvantage of causing poor hygiene, but the Panel is convinced that more could be done to overcome some of these problems. In fact, disease status may actually be improved as a result of improving the environment particularly in

addition to more research being carried out into some of the common diseases. A better understanding of their aetiology would lead to improved hygienic and husbandry measures as well as therapies aimed at prevention and optimised early treatment. The use of floor mats and platforms (as is happening in some countries) may well reduce the incidence of sore hocks, another serious cause for culling animals, although hygiene has to be well controlled.

The main problems holding back development and improvements in rabbit health and welfare is the lack of research and of a cohesive structure in the industry by which improvement strategies can be implemented at farm level.

Specific risk profiles for disease and husbandry practices are included in the report and some of the associated conclusions and recommendations have been included in the Opinion.

Key words: Rabbit, health and welfare, handling, housing, space allowance, behaviour, husbandry, nutritional, reproductive, weaning, genetics.

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1. TERMS OF REFERENCE

1.1. Background

The Council of Europe[1] is an inter-governmental body which comprises 45 countries including all EU member countries and several acceding states. Its activities in the field of animal welfare are particularly noteworthy and comprise the elaboration of various Conventions and Recommendations for the protection of animals[2]. With regard to the specific European Convention for the protection of animals kept for farming purposes, a Standing Committee composed of representative of the parties to the Convention is currently preparing a draft recommendation concerning the welfare of farmed domestic rabbits (*Oryctolagus cuniculus*).

During the ongoing discussion, the Standing Committee members identified that the availability of an independent assessment of available scientific data and literature in this field could facilitate the drafting of their recommendation. The Commission supported by all Member States, proposed that this work could be assisted by an independent EFSA scientific opinion on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. This EFSA opinion should take into account the latest available scientific data and should consider *inter alia* the impact of housing environment and infrastructure, space allowances for rabbits kept for breeding and growing purposes, enrichment structures, types of cage flooring and access to feed and water.

The EFSA Scientific Panel on Animal Health and Welfare (AHAW) was asked by the Commission services to report on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits.

The mandate was accepted by the AHAW Panel at the 5th Plenary Meeting on 30th and 31st March 2004. It was decided to establish a Working Group of AHAW experts chaired by one Panel member and supported by another member of the Panel. Therefore the Plenary entrusted a Scientific Report to a working group under the Chairmanship of Prof David Morton co-chaired by Prof. Marina Verga.

This Scientific Opinion has been adopted by the Plenary Meeting of the AHAW Panel at the XVth AHAW Plernary Meeting on 13th and 14th September 2005 and the relevant conclusions and recommendations are based on the Scientific Report separately published on the EFSA web site[3], which was drafted by the Working Group.

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[1] http://www.coe.int/DefaultEN.asp

[2] http://www.coe.int/T/E/Legal_affairs/Legal_co-operation/Biological_safety,_use_of_animals

[3] http://www.efsa.eu.int

1.2. Terms of reference

The Commission asks EFSA to issue an independent scientific opinion on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits.

This EFSA opinion should take into account the latest available scientific data and should consider *inter alia* the impact of housing environment and infrastructure, space allowances for rabbits kept for breeding and fattening purposes, enrichment structures, types of cage flooring and access to feed and water.

2. ASSESSMENT

This Scientific opinion is a scientific assessment on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits adopted by the EFSA AHAW Panel based on the data of the Scientific Report. In drafting this Scientific Opinion, the panel did not consider ethical, socio-economic, cultural or religious aspects of this topic.

A full assessment can be found in the Scientific Report and the Risk Profiles (RP), published in the EFSA web site, which were drafted by a Working Group, set up by the AHAW Panel. The Risk Profiles included in the report tries to make a Risk Assessment (RA) for each farming practice that has been identified as posing a hazard. These RPs provide a summary of the cardinal points and, where there is little quantitative data (as is generally the case), members of the Working Group recommend from their experience and knowledge "good farming practices", that should mitigate the hazard and either prevent poor welfare or promote good welfare for the animals. The lack of good quantitative data has lead to several recommendations for future research in each chapter.

The Scientific Report is considered as the basis for the discussion to establish the conclusions and recommendations by the AHAW Panel, as expressed in this opinion.

2.1. Terminology

The terminology in this Opinion is explained in the Report but, in summary, all rabbit farming could be described as intensive (caged animals kept mainly indoors or in open sheds) and the terms intensive and extensive refer specifically to the interval between parturition and mating.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1. Biology and behaviour of rabbits

Conclusions

1. Rabbits have been domesticated relatively recently, compared with other domestic animals. However, they show high productivity in intensive rearing systems.

2. The rabbits' behaviour has not been qualitatively changed by domestication and breeding and domestic rabbits show behaviours typical of wild rabbits, such as post-partum mating, maternal behaviour, nest building, neonatal reactions, and the social system. Both adult bucks and does exhibit independent linear rank orders and once set up, the rank order stays stable over several months. Their olfactory sense is especially important in social and sexual contexts. Distance-increasing behaviours such as threats and bites occurs either in actual competition for a preferred partner or for food, resting and nesting sites, but in stable groups, serious fights are rare.

3. Rabbits reproduce and express high fitness levels (reproductive success) in controlled environments; they give birth to altricial kit in a nest built by the doe. The maternal strategy is similar in wild and domestic does and it is sufficient for the doe to nurse the kits for just a few minutes a day for them to suck and grow.

3.2. Handling

Conclusions

1. Animal handling at an early age may habituate the animal and so, cause less stress resulting from human contact at an older age, and may improve welfare and productivity.

2. Poor animal handling can cause serious injuries.

Recommendations

1. Before de-populating enclosures or houses, potentially injurious fixtures and fittings should be removed.

2. Particular care shall be taken when moving rabbits within or from an enclosure or house to ensure that no animal is injured by the equipment or handling procedures.

3. Rabbits should be lifted and carried by firmly grasping the skin over the shoulders at the same time slipping the other hand under the body to bear its weight. Young rabbits may be lifted by grasping them gently around the loins with one hand.

4. Rabbits should not be lifted by their ears or limbs.

5. Rabbits should be carried by hand individually and placed in containers or trolleys one at a time.

6. The distance rabbits are carried by hand should be minimised.

3.3. Rabbit production statistics in the EU

Conclusions

1. At the present, EU meat production is estimated to be around 520,000 TEC and is concentrated in Mediterranean Countries such as Italy, Spain and France which together account for 76.4% of total production.

2. Major changes have occurred in the way rabbit meat is marketed. In the past, rabbit meat was mainly sold as whole carcasses, while in recent years the proportion of jointed and further processed products has increased more than tenfold as previously observed in the poultry sector. However, the production of traditional rural rabbit meat related to the differences in culinary and cultural consumption habits among different EU regions still appears to be significant. In some areas home-consumption is still widespread.

3.4. General overview of current housing and management systems on commercial farms

Conclusions

1. There are no data on the extent to which the various husbandry systems are used in the member states. Therefore any quantitative risk profile based on husbandry systems is limited by this lack of data.

Recommendations

1. There should be a more comprehensive collection of statistical data on the extent to which the various husbandry systems are used.

3.5. Effects of husbandry and management related to cage and, group

Conclusions

3.5.1. Cage Flooring

3.5.1.1. Breeding rabbits

1 For breeding females and males kept for long periods on wire mesh floors footpad lesions are commonly observed, and the use of floor mats (floor rests) reduces such lesions. The incidence of sore hocks increases with age. Under commercial conditions the prevalence of such lesions increases from 5 to 15% from <3 to >6 litters respectively. The incidence of sore hocks may be quite high, as it is the 3rd commonest cause of culling.

3.5.1.2. Growing rabbits

1 For growing rabbits sore hocks are not commonly observed.

2. Litter materials such as hay and straw may cause hygiene problems as they prevent faeces falling through mesh floors, and so they are enabling factors for animals to develop disease, on the other hand rabbits play with the litter.

3. Wire mesh floors lead to better hygiene, as the faeces are separated from the animals, and there is less chance of disease for growing rabbits.

4. Farmed rabbits choose to spend time on either wire mesh or straw floors depending on the ambient temperature and humidity.

3.5.1.3. Adult rabbits

1. Straw, hay or wood supplements have been shown to be a way of reducing stereotypies such as 'cage gnawing' especially for laboratory rabbits. In farmed rabbits there is evidence that behaviour and productivity were variably affected (behaviour was unaffected sometimes, and productivity increased and decreased depending on the study). However, the presence of such objects could put the health of the animals at risk.

2. For adult rabbits, insufficient data are available to decide whether platforms promote better welfare and whether productivity is affected. However, although there was no effect on health, hygiene is often poorer with platforms, depending on their construction suggesting that this effect on hygiene was not critical to the health of the animals. When platforms are available, females with kits will spend 30-50% of their time on top of the platform. Females, with or without kits, use the platform independently of space available, although the motivation of females is not well understood it may still be important to the rabbits that use it.

3. Growing rabbits will use a platform but insufficient data are available to decide if platforms promote better welfare.

3.5.1.4. Impact of flooring on health and welfare

Conclusion

1. For breeding females and males kept for long periods on wire mesh floors footpad lesions are commonly observed, and the use of floor mats (floor rests) reduces such lesions. For growing rabbits, wire mesh floors are an appropriate type of flooring based on the prevalence of enteric diseases, because of better hygiene.

Recommendations

1. Foot mats avoid some of the adverse effects from the viewpoint of hygiene and rigidity while appearing to achieve the aim of reducing the frequency of paw injuries.

2. The application of direct prophylaxis measures such as well designed and maintained cages, regular cleaning and disinfection aim to reduce foot injuries as well as to reduce floor contamination with faeces.

3.5.2. Group housing and Space allowances

Conclusions

3.5.2.1. Females

1. Breeding females are kept in a single cage for several months (average 9 months), before they are replaced, but during that time they spend only a few weeks on their own i.e. when they do not have kits. Even when they do have young they may be normally separated from them according to the farming system.

2. Keeping <u>lactating</u> does in pairs, rather than singly, did not abolish stereotyped behaviours but may have reduced it, however aggression between pairs can be a serious problem.

3. Keeping <u>non-lactating</u> does in pairs, rather than singly, did not abolish stereotypies but may reduce them.

4. Group housing allows breeding females to develop social interactions, which can be both positive (allo-grooming) and negative (aggression). Does that give birth in the same nest seems to promote aggression to alien kits by the does, particularly when they born at different times. Neonatal mortality is higher when does are kept in groups than when they are singly caged. Female aggression also leads to higher adult culling. At the present time, knowledge of this system of group housing breeding females is not sufficiently developed to recommend for implementation on farms.

3.5.2.2. Growing rabbits

1. Young rabbits are gregarious animals and need enough space to hop. For animals raised in groups, like growing rabbits, the space available depends on the age and on the area available for each animal, the number of individuals per group and also the total area. However, studies have only been conducted on the two first factors in recent years.

2. Using a retrospective analysis space allowance depends on the final bodyweight of rabbits and growth rate was reduced when rabbits are kept at more than 40kg/m². For a given size of cage the more animals it contains the more likely is behaviour to be restricted.

3. Based on behavioural studies, lower space allowances over 16 animals/m² or 19 animals/m² (depending on the final slaughter weight) carry the risk of poor welfare. Because of the reduced functional space, the risk of overcrowding and inability to carry out certain behaviours is larger in small cages than in large cages even at the same space allowance.

Note: Space allowances have been calculated on the basis of 1, Space required to carry out certain behaviours, 2, Productivity measures, 3, Theoretical calculations of space based on metabolic weight, space allowance (40kg/m²), and group size, and 4, practical considerations

4. Comparisons of the welfare of farmed rabbits at different space allowances are lacking, with the exception of studies of production and limited information on behaviour. Data on effects of space allowance on mortality rates, disease prevalence, physiological and immunological functioning and injuries were very limited.

3.5.2.3. Space for breeding animals

Conclusion

1. Breeding males are kept for about one year and weigh about 5-6kg depending on the breed. They should be given adequate space to lie out and to move e.g. hop, around.

Recommendation

1. Based on productivity and their behaviour it is recommended that housing density should be not higher than 40 kg/m² at the end of the growing period (in hot conditions it may have to be less).

3.5.2.4. impact of the available surface area of growers' cages on health and welfare

Conclusions

1. Actual cage dimensions and surface area per rabbit restrict the normal locomotory behavior of growers especially when reaching the heavier slaughter weights.

2. Small cages (although they can provide the same surface area per rabbit), holds higher risks for poor welfare than larger cages because of the difference in functional space.

Recommendations

1. Cage dimensions have to allow normal hopping of rabbit, which includes that minimal dimension of total surface, has to be respected. Minimum dimensions should be 75-80cm length and 35-40cm wide.

2. Recommendations for minimal surface area per rabbit have to make distinction between small groups (cages) and larger group sizes.

3.5.3. Cage shape and size

Conclusions

1. There is little scientific data by how much space restricts behaviour for farmed rabbits. However, as rabbits get heavier and bigger so they are less able to carry out certain behaviours due to obvious space restriction.

2. When animals are young they need space to play and so larger areas than for heavier rabbits may have to be given.

3. Cages can be square or rectangular and this may influence what behaviours rabbits are able to perform. The minimum width should be such that the doe should be able to turn round comfortably and the minimum length so it can lie out and a rectangular cage will enable more behaviour. At present cage dimensions are between 34 – 48cm width, and 60 to 65cm length without the nest box, depending on the husbandry system being used. The experience of the working group suggests that a minimum length of 65-75cm might be a more appropriate length to enable does to lie out.

4. If the cage was rectangular rather than square it would permit rabbits to carry out certain behaviours such as stretching and hopping. The need for rabbits to be able to turn round comfortably and for other rabbits to pass by a resting rabbit would seem reasonable parameters on which to determine cage size. A rabbit towards the end of the growing period e.g. 2-3kg, in order to perform a hop and to lie out needs 75-80cm length, to turn round a width of 25cm. So for 2 or more rabbits, increasing width (e.g. to 35-40cm) will be required as each animal should be able to lie stretched out at the same time.

5. As rabbits cool by lying out, more space is needed to permit that behaviour when the ventilation system does not maintain suitable ambient conditions. Consequently, space allowance at certain times may be increased e.g. by 10%, according to the climatic conditions and the ventilation system (cooling particularly) being used.

3.5.3.1. Cage height

Conclusions

1. In the absence of scientific evidence concerning the needs of rabbits, it was considered that it may be important for growing rabbits to be able to sit and stand with their ears erect, and occasionally to rear up, as these are conserved behaviours to increase the rabbits' field of vision on arousal, and to thermoregulate (erect ears but this can also take place when animals are sitting or lying down). However, some preference tests have shown that rabbits spent much of their time in cages with heights of between 20cm and 40cm. On other occasions they chose to be in higher cages or in open tops. This choice may be important for rabbits. There is little data at intermediate heights.

2. In the absence of scientific evidence concerning the needs of breeding male and female rabbits, it was considered that it may be important for these rabbits to be able to sit and stand with their ears erect, and occasionally to rear up, as these are conserved behaviours to increase the rabbits' field of vision on arousal, and to thermoregulate. There is some evidence that rabbits will utilise taller cages given the opportunity e.g. 50cm; the current height is between 30 and 35cm and in a cage 50cm high they show "standing" behaviour. There is little data at intermediate heights.

Recommendations

1. In order for rabbits to be able to choose a suitable height according to their current needs, cages should be provided with an area where they can retreat (a minimum height of 20-25cm), and where they can sit up with their ears erect that has a minimum height of 38-40cm.

3.5.3.2. Impact of the height of growers' cages on health and welfare

Conclusions

1. Cage heights limit some behaviors of growing rabbits especially with increasing age (weight). However, the possible effects of limited cage height on rabbit welfare have not been published.

Recommendations

1. Although cage height does not seem to provoke abnormal behaviour or health problems, it is recommended to use cages with an area of increased height to allow standing up.

3.5.3.3. Cage width and length

Recommendations

1. To allow young rabbits to carry out some of their natural behaviours then a minimum length of 75-80cm should be provided for the growing period, and a minimum width of 35-40cm is required. The space allowance will vary according to final slaughter weight.

2. A breeding female rabbit towards the end of pregnancy e.g. 4-5kg, in order to lie stretched out needs 65-75cm, to turn round and lying on their sternum a minimum width of 38cm. When she is lactating and towards the time of weaning with her litter they will need increasing area so that each animal will be able to lie stretched out at the same time. The minimum total surface area should be $3500cm^2$ based on the few studies available but, it is obvious that, during the fifth week of nursing (depending on the age at weaning and the number of young), some behaviour will be limited.

3.5.3.4. Group size

Conclusions

1. Grouping growing rabbits is important as they are social animals. There are good data that growing rabbits kept in groups show a variety of responses e.g. diversity of behaviour, also a risk of aggression and increased levels of wounds (particularly after 10 weeks), and there is also a risk of disease spread. Group sizes of 2, 6, and up to 100 have been tried and the optimum seemed to be between 6 and 24 rabbits. Practical experience suggests that a group of 7-9 rabbits is practically advantageous based on growth rate and behaviour (this happens to be an average litter size that would have the added advantage of avoiding mixing litters).

Recommendation

1. Based on available studies and practical experience, it seems that a group size of 7-9, preferably retaining litter groups, would be advantageous.

3.5.3.5. Cage area

Conclusion

1. Between 3000 and 6000cm² no differences were seen in productivity or behaviour. However, very little research has been carried out on the requirements of singly housed adult females.

Recommendation

1. In order for breeding male and female rabbits to be able to choose a suitable height according to their current needs, cages should be provided with an area where they can retreat (a minimum height of 20-25cm), and where they can sit up with their ears erect that has a minimum height of 45 to 50cm. The correct height will depend on the genetic type (e.g. lop eared vs pricked ears) as well as the age and weight of the rabbit.

3.5.3.6. Impact of restricted space and social isolation on health and welfare

Conclusion

1. Keeping animals in overly confined conditions will cause suffering.

Recommendation

1. Singly housed adult rabbits should be kept in cages with a minimum length of 65 to 75, a minimum width of 38cm, and a minimum height of 38-40cm, depending on the size of the rabbit. However, the Working Group in the absence of good scientific data, for both practical purposes and for welfare reasons considers it may be better to have a standard cage size of 75-80cm to accommodate both growing and adult animals.

3.5.3.7. Nest boxes

Conclusion

1. The provision of a nest box for pregnant does is essential for them to build a nest. The position of the nest box can be inside or outside of the cage, however, no clear advantages have been reported for either position. The nest may be closed and so the doe does not always have access to it. The current nest box size appears to be adequate.

Recommendation

1. The nest box should not be taken into consideration when calculating the minimum area for a breeding doe when it is not accessible to the female.

3.5.4. General Recommendations on husbandry and management

1. Depending on the farming system many does may be kept singly e.g. empty (barren), isolated for disease control, future breeding stock. Nevertheless, it still has behavioural needs to lie stretched out thermoregulate and to move around. There should be a minimum length of 75cm, and a minimum width for them to be able to turn round, groom comfortably, and to carry out locomotory behaviours possibly with a platform, to be in visual contact with other animals, and other enrichment to compensate for the social isolation.

2. To facilitate normal locomotory abilities and physiological development, young growing rabbits should be allowed adequate space to perform their natural behaviours e.g. play, sequences of hopping steps.

3. Rabbits should be able to rest, withdraw and hide from sources of potential danger.

4. Rabbits should be able to groom themselves and other con-specifics.

5. The husbandry of rabbits should take into account the following specific traits: sociality, time budget and maternal behaviour.

6. Young rabbits before puberty should be group housed and housing systems should enable rabbits to interact with each other but avoid aggressive behaviours due to competition.

7. Rabbits should be able to carry out normal behaviour and physiological activities, including caecotrophy according to the diurnal rhythms.

8. Special care should be paid to does and kits to allow specific expression of maternal and neonatal survival strategies.

9. For young rabbits after weaning, minimum space allowances should normally refer to the final weight that rabbits will reach.

10. Feed restricted animals should have access to objects they can gnaw.

11. During breeding, the mother should be allowed to build a nest, and to be apart from the litter and other stimuli, either by her own activity or by management measures.

12. When group housing rabbits, the environment should be subdivided by partitions in such a way that each animal is able to initiate or to avoid social contact.

3.5.5. Future Research on husbandy and management

3.5.5.1. General recommendations

1. It is important to carry out motivational tests on rabbits' needs for space in order to show certain behaviours.

2. The use of enrichment techniques such as small wooden sticks hanging from the ceiling of the cage or rolls of compacted straw or toys (e.g. beverage cans), or blocks of food supplement need to be evaluated with the objective of solving hygiene and practical problems of their use.

3. The use of platforms in furnished cages is still unsolved and further investigation will be necessary

4. Is required analysing the amount of space required for hopping and playing behaviours, and the amount of time spent carrying out this behaviour.

5. Is needed to establish the importance of whether two separate areas should be provided within a cage in order to improve the welfare of the animals concerned.

6. Is needed an optimal group size, and the interaction between space allowance and group size.

7. Studies are needed to reduce the frequency of behavioural problems when keeping does in groups, particularly between does and aggression to alien kits.

8. Maintaining does in family groups for long periods may be an alternative rearing method.

9. Individual nest box recognition systems on farms should be further developed.

10. The position of the nest box can be inside or outside of the cage, and further research is needed to identify the most appropriate position and design.

11. Information on the impact of temporary space restriction in relation to physiological status and behavioural needs of breeding animals is required

12. Is required to develop an alternative cage for these sorts of animals than the ones that are currently being used.

3.5.5.2. Future research on the impact of restricted space and social isolation on health and welfare

1. Ways to enrich a cage that avoid mental suffering should be sought.

2. Research concerning the required height is missing and has to be combined with studies with raised areas as rabbits seem to prefer housing conditions with differing heights.

3.5.5.3. Future research on the impact of flooring on health and welfare

1. Further research is needed to study the impact of alternative floor types on the welfare of rabbits

3.5.5.4. Future research on the impact of the available surface area of growers' cages on health and welfare

1. Research making distinction between group size, space allowance and the available functional space is necessary in order to define sustainable recommendations

3.6. Conclusions and recommedations on nutritional aspects

3.6.1. The impact of poor nutrition on health and welfare

Conclusion
1. Under current commercial conditions inadequate nutrition appears to be a low risk in commercial rabbitries.

Recommendation
1. Rabbit diets should contain enough fibre for digestive trouble prevention.

2. Rabbits that are restricted in their diet should be given enrichment and/or a low energy diet.

Future Research.
1. The quantitative relationship between nutritional factors and enteric losses is not fully known, but it is certain that there is a cause and effect. It is not known if diet restricted does are hungry and this could be researched through motivational tests.

3.6.2. The impact of dietary toxins on health and welfare

Conclusion
1. Rabbits are known to be a sensitive species for mycotoxins. What is the probability of risk and this occurs due to the different husbandry systems indecently of the food industry as this is outside our remit. However, there exists few specific knowledge concerning the toxic dosages of the different mycotoxins.

Recommendation
1. The farmer should regularly check animals for signs of ill health that might be due to toxins

2. Storage conditions for feed at farm level should be dry.

Future Research
1. Study of the toxicity levels of different mycotoxins in rabbits.

3.6.3. The impact of feed additives on health and welfare

Conclusion
1. The widespread use of anti-coccidials is well known and may be due to the husbandry system itself..

Recommendation
1. If there is a widespread use of anticoccidials and anti-microbials to support animals in a particular farming system, then the housing, management and hygiene strategies should be carefully scrutinised and modified appropriately.

Future Research
1. Rabbits are sensitive to gut disorders and a better knowledge of the various infections, the additives other than antibiotics to enhance the gut microbiota and gut flora balance is desirable.

3.7. Conclusions and recommendations on reproductive strategies

3.7.1. Is welfare jeopardised by intensive breeding systems?

Conclusion
1. Some of the biostimulation methods (lighting and feeding programmes, dam-litter separation) could be an alternative to hormonal treatment. These methods are easy to apply, inexpensive, easy to adapt to cyclic production systems, and unlikely to affect animal welfare. Some of them are used in practice but more experiments have to be done to improve our theoretical and practical knowledge.

2. The breeding system has to be balanced with the genetic ability of the breed (hybrid), the nutritional level, the housing and environmental conditions, and the breeding intensity with regard to animal welfare.

Recommendation
1. Intensive or semi-intensive breeding systems should preferably be used with healthy rabbit stock, high nutritional level and appropriate husbandry and care.

Future Research
1. Examination of less extensive breeding (which could fit to batch system) on reproductive traits, longevity and animal welfare.

1. Examination of strategies to reduce the nulli-and primiparous does' body energy deficit under intensive or semi-intensive breeding systems.

3.7.2. Is welfare and health affected by hormone treatments?

Conclusion
1. The hormonal treatments have to be limited and substituted if possible for alternative methods that do not involve animal welfare consequences.

Recommendation
1. To use hormone treatments as infrequently as possible.

Future Research
1. Determine the optimal/minimal doses and frequency of hormonal treatment.

2. Search for alternative methods instead of using hormones.

3.7.3. Is poor welfare associated with artificial insemination?

Conclusion
1. AI is a method that has potential to cause adverse effects on animals e.g. perforation of the vagina, infection.

Recommendation
2. Personnel should be adequate trained and competent in the technique of artificial insemination.

3.7.4. Is poor welfare caused by biostimulation?

Conclusion
1. A limited (in duration) DLS is an alternative for hormonal oestrus synchronisation in commercial rabbit breeding.

Recommendation
1. Spreading the knowledge about alternative methods for breeders using one of the effective biostimulation methods instead of hormonal (PMSG) treatment for oestrus synchronization

Future Research
1. More experiments are needed to make detailed proposal for lighting (light/day before and after AI, intensity, colour, etc.) for breeders. Some research is needed to examine the effect of flushing does.

3.8. Conclusions and recommendations on weaning practices

3.8.1. What is the impact of poor nursing and inadequate milk supply on the welfare?

Conclusions
1. *Kits:* All factors that negatively affect milk production or milk supply per kit (e.g. large litter size, small kits, and poor health) are likely to increase mortality or to decrease bodyweight gain of kits, and to affect their wellbeing. Before kits die from hunger and thirst their welfare will be affected as physiological needs are not being met.

2. *Does*: Large litters as well as high milk production negatively affect the energy balance of the doe and can be connected with lower productivity, higher culling rate and shorter productive life of the does.

3. *Kits and does:* Under higher temperature or when the does are fed an unbalanced diet the milk production of does as well as the milk supply of kits will be limited.

4. In conclusion, double nursing using the same doe is not effective, while using two does increase productivity by overcoming the effect of the limited milk production of the doe. However, no measures of the welfare impact of this approach on the does or kits were made other than mortality. According to the latest experimental results, the survival of kits nursed by two does is higher.

5. Milk production and the nursing ability of does are key aspects for rearing young rabbits. Nursing of kits can be free or controlled and the differences between the two methods need further research, although controlled nursing seems to be better for the welfare of the kits

Recommendations : Good agricultural practices
1. Equalization of litters according to the number and weight of kits.

2. Avoid fostering from unhealthy does.

3. Limitation of litter size to 8 for primiparous and to 9 to10 for multiparous does.

4. Cull weak and unhealthy does.

5. Cooling and heating systems to maintain appropriate environmental temperatures and relative humidities during hot and cold seasons.

6. A negative energy balance for the does can be avoided by early weaning.

7. To avoid the problem of nervous does (jump into the nest box) controlled nursing can be used.

8. The milk intake of kits can be increased by better nutritional status of does (higher energy and protein content, fat supplementation etc.).

Future Research
1. To look at methods that increase the nutrient supply of kits (artificial milk, eating solid feed in younger age, nursing by two does, etc.).

2. To research methods of avoiding the negative energy balance of does.

3.8.2. What is the impact of weaning on the welfare of the kits?

Conclusions on the consequences for animal welfare and productivity
1. If weaning is carried out too early then losses may be greater and the growth of kits could be reduced.

2. If weaning is carried out too late then while the kits may be stronger, and mortality may be less, the welfare of the doe may be compromised and ultimately reduce her productivity. Thus it is a balance that can potentially increase farm output, and management of weaning is a crucial factor.

Recommendations : Good agricultural practices
1. Harmonization of the reproductive rhythm and the weaning age.

2. Delay weaning for the underweight kits.

3. Special starter diet for kits

4. Higher (20-22C) room temperature for early-weaned rabbits.

5. Don't wean rabbits later than 35 days of age.

Future Research: It is necessary to know more about:
1. The environmental and rearing condition for weaned rabbits

2. The nutritional requirement of early weaned kits

3. Replacement of medication (e.g. antibiotic treatment) to redcue kit losses at weaning

3.8.3. What contribution does abnormal maternal behaviour make to poor welfare of kits and does?

Conclusions
1. Kits can die of starvation when maternal behaviour is disturbed

2. High losses lead to financial losse

Recommendations
1. The doe should have the chance to build the nest in an optimal way by giving her a large enough nest and optimal materials. The doe should be able to close the nest entrance as well as a management measure.

2. Does should be provided with an adequately sized nest box and suitable materials for nest building, and does and farmers should be able to control the access.

Future Research
1. To improve the knowledge of both genetics and environmental factors that affect maternal behaviour and that cause abnormal maternal behaviours. To find out the most suitable type of nest in terms of structure and material in order that the doe may prepare a well-built nest that increases kit survival.

3.9. Conclusions and recommendations on genetic selection

General Conclusion
1. Genetic selection at present is concentrated on litter size and growth rate. There is little emphasis on factors such as disease resistance, body composition or stress resistance.

General Recommendation
1. More research into the genetics of disease resistance and stress resistance is required.

3.9.1. What are the welfare and health consequences in the selection of future breeders?

Conclusions
1. Risks for poor welfare derived from genetic selection programmes appear in sire lines derived from the higher adult weight of the males.

2. Selection will have the same risks for the females.

3. In the short and medium term, cage enrichment by using floor mats creates resting areas in the cages avoiding leg injuries.

4. In the longer term, new design of cages for males might be needed to avoid this problem.

5 Other risks derived from selection are related with a higher mortality of large litter sizes, but cross fostering reduces this risk at farm level.

Recommendations: Good Agricultural Practices
1. Enrichment of the cage by adding a floor mat (made by plastic or other synthetic material), creating a resting area in the cage.

2. In the future, males used in the industry coming from sire lines may require special cages. If that is not possible then selection of such breeding stock should not be done.

3. Cross fostering reduce the risks derived from large litters.

Future Research

1. No research has been done on the genetics of stress and very little has been done on the genetics of disease resistance. Reducing stress by selection has been showed to be feasible in poultry, and disease resistance is currently being investigated in several species.

2. Disease resistance has often been related to single genes or to nearby loci (QTL) and this is a promising area that deserves more attention.

3.10. Conclusions an recommendations on health issues: general measures to control disease

3.10.1. Conclusions

1. Compared with most other animal species used for food production in the EU, the mortality in rabbit production, mainly due to the occurrence of different types of infectious diseases as well as non-infectious conditions, is high:

a. On the most successful intensive closed cycle farms, parturition-to-sale losses are around 10-15% and mortality levels can be as high as 25-30%. Occasionally, severe outbreaks of disease with mortalities of more than 50% of animals can occur.

b. In one large scale study of culling and other mortality in doe rabbits showed the annual culling was 68%, largely because of production related disease and reproductive disorders, and the number of does found dead was 38%. Footnote to explain why more than 100%

c. More than 55% of breeding does are replaced before their fifth litter (often less than one year old and yet they can live for far longer) mainly as a result of different kinds of disease. Mortality constitutes approximately 25-45 % of the replacement and culling the remaining part.

2. The replacement of does has many causes particularly respiratory and enteric diseases. However, a significant number of does are culled due to reproductive failure (infertility, mastitis) often linked to lesions of the genito-urinary system (such as salpingitis, metritis, prolapse, torsion of the uterus), and interstitial (often caused by E. cuniculi) and purulent nephritis. In addition sore hocks are often an indirect cause of doe replacement.

3. There is a direct correlation between losses or culling of does and their age and number of births, as after the first pregnancy only a few die or are culled.

4. Data indicate that gastroenteric diseases have increased significantly over the last 15 years becoming the most common cause of mortality. They cause more than 50% of losses during the whole production cycle, occur mainly in 35-50 day old rabbits, and usually have multiple aetiology.

5. Respiratory diseases are the second commonest cause of mortality and are prevalent in adult animals (breeding does) and during the second part of the fattening period (50-80 days). The relative importance of respiratory problems has diminished in last ten years. Environmental conditions and improved hygiene schedules have contributed to the reduction in respiratory problems.

6. The prevention and control of infectious diseases in rabbit production is a challenge when considering its substantial biological dynamic. For example, on a 500 doe farm apart from the does themselves, there will be 4,000- 5,000 suckling rabbits and 3500-4000 weaned rabbits, i.e. a total of around 10,000 rabbits forming the "population at risk". In addition a continuous production policy is usually applied as "all in - all out" strategies or other breaks in the production chain that might break infection cycles are rarely applied.

3.10.2. Recommendations

1. The identification and implementation of optimal housing, management, and disease prevention procedures should be an urgent priority (see Appendix on Risk Profiles). In particular, efforts should be made to reduce the incidence of infectious disease in rabbit production. Because of very high morbidity and mortality rates reported, Rabbit housing, management and hygiene systems should be reviewed urgently so as to significantly reduce them. These high losses do not seem to relate to any one farming system.

2. Existing and future data from different types of health surveillance, e g. from autopsies, abattoir surveys, should be analysed to increase knowledge on farming systems and disease occurrence as a basis for measuring improvements as a result of implementing health and welfare strategies.

3. Special attention should be paid to increasing the health status of does e.g. by culling animals as soon as a disorder appears (e.g. sore hocks) which could reduce animal suffering.

4. Efforts should be made to reduce the culling rate e.g. expanding the interval between insemination or mating and the last litter might give the does more time to "recover" between pregnancies, resulting in lower cull rates.

5. In view of the EU ban from 2006 of growth promoters, alternatives to the continuous use of antibiotics and anticoccidial drugs as feed additives for disease prevention should urgently be sought.

6. We recommend that a comparison of farm losses for the various species should be prepared.

3.10.3. General conclusions and recommendations based on the disease risk profiles

Conclusions

1. Quarantining animals enables health checks to be carried out to allow clinically and sub-clinically affected animals to be detected e.g. colibacillosis, *Staphylococcus* spp. and dermatomycosis.

2. All in, all out systems have clear advantages in terms of disease control and they are becoming more commonly used in rabbit farming. However they have a downside in that it requires oestrus synchronisation that may jeopardise animal welfare.

Recommendations

1. Continual health surveillance should be carried out in all farming systems

2. Quarantine facilities should be provided in all farming systems

3. More data should be collected on all in - all out systems as such systems appear to have significant advantages in terms of disease control and should be seriously considered by rabbit farmers.

4 Culling must be done without causing undue pain, agitation or other forms of distress and without delay by a person skilled in the techniques of killing.

5. The current use of antibiotics, vaccines and hormones in the rabbit industry should be reviewed.

3.10.4. Specific conclusions and recommendations based on the disease risk profiles

3.10.4.1. Myxomatosis

Conclusions

1 Myxomatosis is still a relatively common disease in farmed rabbits and it can be only partially controlled with appropriate hygiene and vaccination schedules.

2 Rabbits kept under plein air or semi-plein air systems are particularly at risk as they expose animals to the wild reservoir.

Recommendations

1. Attention should be paid to prevent the introduction of the virus onto rabbit premises. If it is introduced onto an industrial unit, the only effective policy is eradication through slaughter of all rabbits on the farm.

2. Farmers keeping animals in plein air systems where animals are particularly at risk should be strongly encouraged to vaccinate their animals, and take measures to control the vectors.

Future Research

1. Improved vaccination (vaccines need to be developed to contain a marker to detect vaccinated as opposed to naturally infected animals).

2. Increased knowledge of immune response in the rabbit.

3. Identification of the factors that determine virulence in the different viral strains.

4. Definition of criteria for differentiating pathotypes.

5. Mechanisms of genetic resistance.

3.10.4.2. Rabbit Haemorrhagic Disease

Conclusion

1. RHD is a quite “new” disease that is important because of its high economic impact and for the tendency of the virus to mutate. See also those conclusions under myxomatosis.

Recommendations

1. Steps should be taken to avoid the introduction of the virus onto the premises. Continuous epidemiological monitoring (e.g. through the use of sentinels) would help detect new variant strains that are potentially dangerous even for vaccinated populations.

2. In areas at risk or after a major outbreak growing animals should be vaccinated for 1-2 cycles.

3.10.16: Some animals should be left unvaccinated to act as sentinels.

Future Research

1. To chararacterise the molecular and antigenic epidemiology of new strains.

2. To develop new strategies for vaccination as well as new vaccines.

3. To carry out studies on the pathogenesis and mechanisms of resistance e.g. age, genetics.

4. To carry out epidemiological surveillance of wild *Oryctolagus* sp. populations and related species (*Lepus* spp. and *Sylvilagus* spp.) for emerging new viruses.

3.10.4.3. Rotavirus

Conclusions

1. Rabbit rotavirus is considered only mildly pathogenic but it can cause important losses and high mortality when viral infections are complicated and aggravated by secondary pathogens like enteropathogenic *E. coli*. Based on sero-epidemiological investigation rotavirus seems to be widespread and could be considered endemic in commercial rabbit populations.

2. Farming system is irrelevant for this disease.

Recommendation

1. Attention should be paid to avoid the introduction of virus onto the premises and to limit its spread e.g. through controlling environmental contamination on the farm.

Future Research

1. Precise evaluation of antigenic and molecular diversity among domestic animal herd populations is of critical importance to understand better the global ecology of rotaviruses and the mechanisms of rotavirus evolution.

2. An understanding of the prevalence of the exact genotypes and phenotypes in the different animal species, including rabbit, is essential to develop effective vaccines for the control of rotavirus-associated disease in humans and animals.

3.10.4.4. Pasteurellosis

Conclusions

1. Pasteurellosis in rabbits still remain one of the major sanitary problems in industrial rabbit production, specifically in closed buildings, since the agent is widely present in a latent status. The disease most often occurs in its acute form when environmental factors become deleterious.

2. A precise identification of the strain is important for effective vaccination.

Recommendation
1. In closed buildings, the quality of the air is important and so high levels of hygiene and good environmental conditions should be practised in order to limit the presence and spread of Pasteurellosis.

Future Research
1. Development of better vaccine strategies.

2. Defining the virulence factors of pathogenic strains

3.10.4.5. Mucoid Enteropathy

Conclusions
1. Digestive disorders are the main cause of morbidity and mortality in growing rabbiteries and are responsible for important economic losses.

2. "All in, all out" systems may have lower incidence of disease.

Recommendation
1. Research is urgently needed to promote animal welfare, minimise economic losses and to avoid the use of therapeutic agents such as antibiotics.

Future Research
1 Efforts should be continued to improve diagnosis of rabbit enteropathies, and to identify the etiological agent(s) and their epidemiology.

2. Data are needed on the incidence of this disease by farming system, and all in - all out practices.

3.10.4.6. Colibacilosis

Conclusion
1. EPEC are considered to be the most important cause of diarrhoea and enteritis in suckling and post-weaning growing rabbits. They are frequently associated with other agents causing mucoid enteropathy.

Recommendation
1. High levels of hygiene and biosecurity in association should be adopted. When quarantining animals, checks on the colibacillosis status of animals should be done.

Future Research
1. Development of new vaccine strategies and attenuated vaccines and penside diagnostics.

3.10.4.7. Clostridiosis

Conclusions

1. Despite improvements in technological tools, management and hygiene, enteric diseases (including clostridiosis) still represent the main sanitary problem of rabbit breeding. In the past *Clostridium perfringens* was mostly involved in rabbit clostridiosis but recently *Clostridium spiroforme* has been increasing.

2. Clostridial enteropathies are increasing as a consequence of the misuse of antibiotics, which, by changing the intestinal flora, promote outbreaks of clostridiosis.

Recommendations
1. In order to avoid misuse of antimicrobials, farmers should consult their veterinarian before using them. To control infection, laboratory support should be obtained to diagnose clostridiosis and to target therapy.

2. The production of safe feed should be ensured through good agricultural practices including biochemical and microbiological controls.

Future Research
1. Definition of virulence and characterization of toxins

2. Development of new strategies for control. and vaccination

3. Improvement of diagnostic tools (e.g. selective media for isolation of *C. spiroforme*)

3.10.4.8. Salmonellosis

Conclusions
1. Rabbit salmonellosis is not frequently observed in closed buildings but is more frequently observed in plein air and semi-plein air systems.

2. Salmonellosis is a zoonosis, and can assume a high economic and social importance.

3. There are no commercial vaccines against rabbit salmonellosis although it is possible to prepare inactivated autovaccines.

Recommendations
1. Attention should be given to avoid the introduction of the bacteria onto the farm by applying biosecurity programmes and checking the sanitary status of newly introduced rabbits.

2. In a disease outbreak inactivated autovaccines could be prepared but only after the disease has been diagnosed.

Future Research
1. Application of serological methods for routine monitoring of farms and development of vaccines and development of a vaccination strategy

3.10.4.9. Staphylococcosis and Staphylococcal infections leading to Sore hocks and Mastitis

Conclusions
1. Farms contaminated by virulent and pathogenic strains can suffer severe damage in terms of economic losses as well as serious poor welfare for the animals.

2. Rabbit farms are contaminated by bringing in future breeding stock, so control of this infection by the breeders is important.

3. Poor maintenance of farm equipment can predispose rabbits to injury and infection.

Recommendation
1. An effective and planned maintenance programme for farm equipment, and for screening incoming stock, should help prevent injury and infection.

Future Research
1. Basic researches on immunological and diagnostic tools are needed to decrease and prevent the spread of staphylococcal infections.

3.10.4.10. Dermatomycoses

Conclusions
1. Endemic or epidemic outbreaks of skin mycoses are commonly observed. In common with parasites, dermatomycoses tend to persist in the buildings potentially causing disease in almost all animals.

2. New breeders are likely to bring infection onto a farm.

Recommendations
1. The occurrence of dermatomycoses should be prevented by attending to the overall hygienic situation and on the environmental conditions (macro- and micro-climate) including temperature and humidity that can favour the development, spread and survival of fungi.

2. Breeding animals coming on to a farm should be quarantined and screened for infection.

Future Research
1 Development of vaccine and new strategy of treatments

3.10.4.11. Coccidiosis

Conclusion
1. Coccidia of the genus *Eimeria* are common parasites in the digestive tract of rabbits. They represent a major cause of intestinal disorders and complications of parasitic origin in rabbit breeding units.

Recommendations
1. Due to the negative effect on production and the frequent association with other pathogens to induce clinical disease, coccidiosis should be always kept under control.

2. Pre-weaning rabbits should be kept on anticoccidial substances during the risk period i.e. up to 30do.

Future research
1. Development of vaccines and definition of a better strategy of control, which include either prevention or therapy.

2. In the long term, the elimination of this disease should be aimed for, by breeding animals free from this infection as then it may be possible to enrich the environment to meet the behavioural needs of rabbits without fear of this disease occurring.

3.10.4.12. Encephalitozoonosis

Conclusion
1. E. *cuniculi i*nfection is a widespread organism that lies dormant but can seriously affect animal health, welfare and productivity.

Recommendation
1. Farmers should take steps to control and eradicate this disease.

Future Research
1. To investigate substances that can be used for therapeutic treatment or for vaccination.

3.10.4.13. Sore Hocks

Conclusions
1. The condition of sore hocks is likely to cause chronic poor welfare due to tissue damage.

2. Many breeding rabbits develop sore hocks over time and is one of the main reasons for culling (16.5%).

Recommendations
1. Breeders should consider genetic selection of rabbits according to foot health.

2. The use of foot mats is recommended.

3. An appropriate thickness of the wire should be used (unpublished industry data suggests it should not be less than 2.5mm).

Future Research
1. The development of strains of rabbits those are more resistant to sore hocks.

2. The development of cages (design and materials) that do not prdispose to sore hocks.

3.10.4.14. Metabolic disease

Future Research
1. This seems to be a future welfare and economic risk, and is an increasing problem that needs to be researched more.

4. DOCUMENTATION PROVIDED TO EFSA

No data was provided by the Commission.

5. REFERENCES

All references are available in the scientific report on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits.

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Annex to the *EFSA Journal (2005) 267, 1-31*; The Impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits

SCIENTIFIC REPORT

"The Impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits"

EFSA-Q-2004-023

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TABLE OF CONTENTS

GLOSSARY

ACTH: Adenocorticotrophic Hormone
AI: Artificial Insemination
Altricial: being hatched or born or having young that are hatched or born in a very immature and helpless condition so as to require care for some time.
ADLR: Acid Detergent Lignin Recommendations

BWt: Body Weight
Batch: number of animals considered as a production group
Barren doe: empty doe
Buck: adult male rabbit

Cal: California rabbit breed
Caecotrophy is the process by which rabbits will reingest part of their faeces directly from the anus to gain extra nutrients. This should not be confused with the term coprophagy (eating fecal material) since rabbits only ingest the soft "night" feces or **caecotrophs.**
CF: Crude Fibre
CIA: Competitive Inhibition Assay
Circadian: being, having, characterised by, or occurring in approximately 24h periods or cycles (as of biological activity or function).
cM: centiMorgan, unit of distance between sequences of DNA.
CP: Crude Protein

DFI: Daily Food Intake
DGR: Daily Growth Rate
Digesta: Diet that is being digested in the gastrointestinal tract
DLS: Dam Litter Separation
DM: Dry matter
do: Day Old
Doe: adult female rabbit
Dyadic: two individuals maintaining a sociologically significant relationship.
DWG: Daily Weight Gain

ELISA: Enzyme-Linked Immuno-Sorbent Assay
EPEC: Entero-Pathogenic *E. coli*
ERE: Epizootic Rabbit Enteropathy
EU: European Union

FCR: Food Conversion Ratio
Fertility: the ability of animals to produce healthy offspring in accordance with the norm for that species or strain.
Fertility rate: Total number of animals born per year as a percentage of the number of mature females or the proportion of mature females giving birth.
FSH: Follicle Stimulating Hormone

GnRH: Gonadotrophin Realeasing Hormone

hCG: Human Chorionic Gonadotropin
HRD: High Roughage Diet – diet containing much indigestible material acting as fiber.

Homeostasis: Is the property of a living organism, to regulate its internal environment so as to maintain a stable condition, by means of multiple dynamic equilibrium adjustements controlled by interrelated regulation mechanisms.

Imprinting: A learning process which takes place during sensitive periods very early in life that ensures young animals follow their parents and will later mate with members of their own species.
IU/Kg: International Units/ Kilogramme

Kit: young rabbit, also called pup.
KHz: KiloHertz

LD_{50}: Lethal Dose 50%: the amount of a toxic agent (as a poison, virus, or radiation) that is sufficient to kill 50% of a population of animals usually within a certain time.
Longevity: the maximum age a member of a certain population can reach. This is also sometimes called the maximum life expectancy.
Lumen/m²: a unit of luminous flux equal to the light emitted in a unit solid angle by a uniform point source of one candle intensity.
Lx: The lux (symbolized lx) is the unit of illuminance in the International System of Units. It is defined in terms of lumens per square metre (lm/m²).
LxWxH: Length by Width by Height

Macrosmatic: Having the sense or organs of smell highly developed.
ME: Mucoid Enteropathy
Methaphylaxis: is defined as the timely mass medication of an entire group of animals to eliminate or minimize an expectedoutbreak of disease.
Microbiota: Micro-organisms present in or characteristic of a special location

NWZ: New Zealand rabbit breed

OIE: Organisation Internationale des Epizootics i.e. the World Organisation for Animal Health
ODC: Ornithine Decarboxylase
OWA: Overall Welfare Assessment

PCR: Polymerase Chain Reaction
$PGF_{2\alpha}$: Prostaglandin F2-alpha
PMSG: Pregnant Mare Serum Gonadotropin
Pre-biotic: fermentable substrates that increase proliferation of beneficial gut bacteria of the host
Pro-biotic: micro-organisms that enhance the gut microflora of the host
Prophylaxis: measures designed to preserve health and prevent the spread of disease
Prolificacy: relating to the number of young produced in unit time.
ppm: parts per million (0.0001%)

QTL: Quantitative Trait Loci is a region of DNA that is associated with a particular trait (e.g., body weight). Though not necessarily genes themselves, QTLs are stretches of DNA that are closely linked to the genes that underlie the trait in question.

RCV: Rabbit Calicivirus
RHDV: Rabbit Haemorragic Disease Virus
RHDVa: Rabbit Haemorragic Disease Virus subtype “a”

Space allowance: expressed in numbers of rabbits/m² or total rabbit bodyweight/m²

TEC: Tonnes Equivalent Carcasses
Thermal efficiency: the ability to conserve heat through behaviour

vs: versus

WHO: World Health Organisation
wo: Week Old

TABLES

FIGURES

1. TERMS OF REFERENCE

1.1. Background

The Council of Europe[1] is an inter-governmental body which comprises 45 countries including all EU member countries and several acceding states. Its activities in the field of animal welfare are particularly noteworthy and comprise the elaboration of various Conventions and Recommendations for the protection of animals[2]. With regard to the specific European Convention for the protection of animals kept for farming purposes, a Standing Committee composed of representative of the parties to the Convention is currently preparing a draft recommendation concerning the welfare of farmed domestic rabbits (Oryctolagus cuniculus).

During the ongoing discussion, the Standing Committee members identified that the availability of an independent assessment of available scientific data and literature in this field could facilitate the drafting of their recommendation. The Commission supported by all Member States, proposed that this work could be assisted by an independent EFSA scientific opinion on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. This EFSA opinion should take into account the latest available scientific data and should consider *inter alia* the impact of housing environment and infrastructure, space allowances for rabbits kept for breeding and growing purposes, enrichment structures, types of cage flooring and access to feed and water.

1.2. Mandate

The Commission asks EFSA to issue an independent scientific opinion on the impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits.

This EFSA opinion should take into account the latest available scientific data and should consider *inter alia* the impact of housing environment and infrastructure, space allowances for rabbits kept for breeding and fattening purposes, enrichment structures, types of cage flooring and access to feed and water.

1.3. Approach

The approach of members of the Working Group (WG) has been to consider what general information exists on the recognition and assessment of good and poor welfare in rabbits (Chapter 2), to then look at the scale of the potential problem (Chapter 4), and the biology and behaviour of rabbits that may enable or disable them to respond and to adapt to their environmental circumstances (Chapter 3). Current methods of husbandry and housing are detailed in Chapter 5 and that is used as the basis for assessing the risk for causing poor rabbit welfare under specific farming practices in the following chapters. Chapter 6 deals with the impact of housing and husbandry, Chapter 7 nutritional aspects, Chapter 8 and Chapter 9 reproductive and weaning practices, Chapter 10 looks at the opportunities for the use of genetic selection that may make

[1] http://www.coe.int/DefaultEN.asp

[2] http://www.coe.int/T/E/Legal_affairs/Legal_co-operation/Biological_safety,_use_of_animals

strains more susceptible or might improve welfare and, finally, Chapter 11 deals with the impact of poor health on welfare.

Terminology

The rabbit industry uses conventional farming terms sometimes in a different way to other intensive farming practices. Thus intensive, semi-intensive and extensive refer to the interval between parturition and mating: at birth being intensive, at weaning extensive and during lactation as semi-intensive. As the rabbit has a post-partum oestrus it is possible to increase productivity by mating her at that time as would most likely happen in the wild. However, in captivity that period can be delayed to some intermediate period between birth and weaning, and farms vary in their practices (see Chapter 8).

The use of the word "fattener" has been replaced by "grower", as animals do not simply get fat, but rather grow and put on weight due to the growth of muscle protein.

2. INTRODUCTION

One of the earliest reports on the welfare of animals, as a separate field from animal health, was the Brambell Report in 1965 (Brambell, 1965). Over the past 10-20 years animal welfare has become an established science (see for example: Fraser and Broom, 1990; Broom and Johnson, 1993; Lawrence and Rushen 1993; Moberg, 1985; Moberg and Mench, 2000) and it is now recognised as a basic topic in order both to deepen the knowledge of domestic animals and to define Community rules on animal management. The improvement of animals' welfare gives animals a better quality of life, which means also better health status by avoiding chronic stress reactions that lower the organism's coping ability. Such stress reactions may induce the development of pathologies due to e.g. the impairment of the immune system.

Many definitions of animal welfare have been proposed by scientists:

Brambell Report (Brambell, 1965): "Welfare is a wide term that embraces both the physical and mental well-being of the animal. Any attempt to evaluate welfare, therefore, must take into account the scientific evidence available concerning the feelings of animals that can be derived from their structure and function and also from their behaviour".

Hughes (1976): "Welfare is a state of complete mental and physical health, where the animal is in harmony with its environment".

Broom (1986): "The welfare of an individual is its state as regards its attempts to cope with its environment".

Others have noted that:

Dawkins (1990): "Animal Welfare involves the subjective feelings of animals"

Welfare has to be assessed according to scientific criteria taking into account:

- the species' evolution in the natural environment;
- the species' evolution following the domestication process; and

- the species' "coping" systems towards the stressors challenging the homeostasis both from inside and outside the organism itself. (Mendl, 1991; Jensen and Sandoe, 1997).

Environment and management may affect coping success, according to an individual's genetics and experience (i.e. the effects of learning).

Domestication is "that process by which a population of animals becomes adapted to humans and to captivity by some combination of genetic changes occurring over generations and environmentally induced developmental events recurring during each generation" (Price, 1984, 2002). The effects of this process on domestic animals, compared with the animals in their natural environment, include some modifications, for example increased reproductive index and growth rate, as well as some behavioural traits, such as reduced flight distance towards humans. Rabbits have been domesticated relatively recently, compared with other domestic animals (Sandford, 1992; Clutton-Brock, 1989). They reproduce and express high fitness levels (reproductive success) both in nature (Clutton-Brock, 1989) and in controlled environments, i.e. they have adapted to the environment and management systems in terms of their productivity, but this does not mean that their welfare has not been affected (Verga, 1992; Loliger, 1992) and this is the subject of this report.

Welfare has to be scientifically assessed, according to criteria aimed at identifying the effects of environment and management on the organism's reactions. The OWA (Overall Welfare Assessment) for example (Bracke *et al*., 1999) may be based on the effects of environmental design on consequences for the animal. This means that the former (i.e. the environment in terms of space allowance, floor type) affect the latter (e.g. animal's reaction, such as behaviour, physiology, health and productivity).

Although a clear and unique definition of "stress" has not yet been stated, due to the complexity of the possible aetiology and to the different types of stress that an organism may experience (e.g. "'acute stress" or "chronic stress"), according to Moberg (2000), stress may be defined as: "the biological response elicited when an individual perceives a threat to its homeostasis. The threat is the "stressor". When the stress response truly threatens the animal's well-being, then the animal experiences 'distress'".

The evaluation of welfare includes making measurements of the extent of any distress which will mean there might be poor welfare, and also indicators of good welfare. Poor welfare may result in poor health due to the relationship between the nervous and the immune systems (Moberg, 1985; 2000; Broom and Johnson, 1993).

Although rabbits may cope with different artificial environments fairly well, intensive rabbit husbandry and management systems may raise some problems for their welfare.

The Working group discussed what the potential welfare problems were for farmed animals (their mandate) compared with laboratory animals where other guidelines had been produced (CoE ETS 123 Appendix A). It was generally agreed that there are no genetic differences that cause farmed rabbits to have different needs from laboratory rabbits or pet rabbits, and there will be few differences from wild rabbits.

There are clearly differences in practices between farms and laboratories and yet the animals are the same species, but are there inherent differences that can justify differing husbandry practices such as space requirements, group housing, environmental control, provision of enrichment. Part of this could be answered empirically in that the different management practices raise different hazards and risks. However, in most cases little data was available for farm rabbits on which to make a judgement.

The satisfacton of needs for food and water are essential for life and these resources are normally provided for both farmed and laboratory rabbits, but where do we place behaviours such as space in which to leap, jump, play, lie out, reach up, and to rear up on hind legs with ears erect, and to have social contact?. The key questions are how strong the preferences of rabbits are, and what are the negative affects on rabbit health and welfare if needs are not met. There are few data from studies of this kind on rabbits and what data is available is often difficult to interpret or conflicting. In some respects these questionable points lead to what humans consider to be basic or exaggerated welfare requirements for the animals. It is the interpretation of the available biological data that determines what husbandry practices are adopted on farms and elsewhere in regard to maintaining good rabbit welfare. Clearly also the weighing of welfare aspects against other relevant aspects (e.g. investments, economic return) will determine what husbandry practices are adopted (are affordable) under different conditions.

With regard to space, when farmed animals are very young and are used for growing, they can, of course, carry out most of those activities listed above, and are always kept in groups until slaughtered (breeding animals are dealt with later). But as growing animals get older and bigger they may not be able to carry out some of these behaviours due to the restricted space in a cage. This change in space becomes progressively more restrictive after weaning. Moreover, the quality (i.e. what is in it e.g. manipulanda) of space is also important.

Another factor to consider is the length of time an animal is kept under those restricted conditions. For growing rabbits it may be between 3 and 10 weeks after weaning (depending on the country animals are weaned at 4-5 weeks, and slaughtered at 8 to 13 weeks old - 1.9 to 3.2kg Body Weight - BWt. For breeding rabbits however, they may be held in cages for 6 months or more after their first litter.

For laboratory animals the view is sometimes taken that they should be treated better than farmed animals of the same species as they are being cause harm, in ways that other animals are not, in the name of science. Moreover, laboratory animals need to be healthy and relatively stress free to provide good scientific data.

For farmed animals the need to satisfy the ‘five freedoms’ (Brambell Report, 1965) has been expressed, and among these is “the freedom from pain, injury and disease”. A major cause of poor welfare on rabbit farms at the present time is poor health caused by infectious and non-infectious diseases, and the risk assessments reflect this aspect of welfare (see Chapter 11).

Welfare has to be measured using objective measurable indicators, such as behaviour, physiology, health status and productivity, and studying the relationship among the measured variables. However, in rabbits, there is little literature on such measures and so behavioural and physiological indicators identified in other farm animals may have be applied (Morisse and Maurice, 1994).

Some of the indicators that have been used in evaluating rabbits’ welfare level are stereotypies that are regularly observed and may be due to a lack of environmental stimuli and a lack of control over their environment (see Chapter 3 and Chapter 6). In laboratory rabbits other behaviours in addition to those above have been used including nosing (sliding nose up and down the bars), head in corner, head swaying, partial rearing, and chewing and licking activities that are seen in caged animals to a greater extent than in penned animals with no roof (Morton *et al*., 1993, Gunn and Morton, 1994, 1995). In addition, behaviour in an open-field test and the reaction of rabbits to a tonic immobility test have been studied in order to assess the "fear" reactions to a new environment and towards humans (Carli, 1974; Meijsser *et al*., 1989; Ferrante *et al*., 1992; Hansen *et al*., 2000; Verga *et al*., 1994; Xiccato *et al*., 1999). Physiological indicators such as leucocyte numbers, adrenal weight, ascorbic acid, corticosterone and testosterone levels have also been studied in rabbits (Carli *et al*., 1979; Farabollini *et al*., 1978; 1990). Fenske *et al*. (1982) found that handling and placing rabbits in a new environment were stressful, and Verde and Piquer (1986) found higher corticosterone and ascorbic acid levels in rabbits reacting to heat stress (32-34C) and noise stress (90±5 dB, 200 c/sec) in rabbits caged at 42-43 days.

The following chapters detail the evidence that is available when addressing specific areas of husbandry.

2.1. Effects of handling by humans in rabbits

Handling by humans may affect rabbits' welfare from when they are kits until the end of life, when they have to be transported, stunned and slaughtered. Any handling has to avoid undue stress and the possible transmission of disease. Although little research has been carried on this issue, some studies have shown that rabbit behaviour and welfare may be positively affected by repeated handling carried out by familiar people. Rabbits handled when kits show reduced "fear of humans later in their lives compared with unhandled controls" (Pongracz and Altbacker, 2003; Marai and Rashwan, 2004). Handling is effective when it is performed during a sensitive period, around the 1st week post-partum, and near the time of nursing. Other researchers have shown that handling at an early age by humans may affect rabbits' welfare decreasing their stress 'fear' reaction towards them. Metz (1983) showed that handling kits from birth until three weeks of age reduces fear and increases exploratory behaviour. Kersten *et al.* (1989) found a positive effect of early handling in reducing kits' emotionality if applied after the 10^{th} day of age, placing the kits in a separate compartment of a closed box and returning them to the nest after 3 minutes. Podberceck *et al*. (1991) found reduced fearfulness in post-weaned rabbits following repeated approaching and handling by humans. The individual handling of rabbits from 17 to 20 days of life may also reduce the mortality rate (Duperray, 1996). Jiezierski and Konecka (1996) too found that handling rabbits for 10min from 10 days to 10 weeks of age have higher growth rate (3.01 vs. 2.85 kg) and lower mortality rate (17.5% vs. 31.9%). Such effects seems to be long-lasting, because handled does have successively higher breeding performance (Bilkò and Altbacker, 2000) and Verga *et al*. (2004a) found there was a trend towards better reproductive performance in terms of nest quality and number of weaned kits.

Verga *et al*. (2004a) found that handled compared with control kits showed more movements such as escape attempts and digging in open-field tests during the growing period, and showed a lower tonic immobility duration in the tonic immobility test. No freezing behaviour was shown by any of the kits in the study.

However, the effect of handling may negatively affect welfare when it is performed as a management practice during the rearing period, if the handling procedures don't take into account some points, as stated in the Scientific Report: "The welfare of animals during transport" (30^{th} March 2004, Question N.° EFSA-Q-2003-094). These points mainly stress that "rabbits commonly suffer fatal back injuries from incorrect handling or falling". Moreover, another important issue is the operators' safety, as "the rabbit has very powerful legs and long sharp claws which can inflict bad scratches "thus the operator has to use the maximum care to handle this animal.

Fenske *et al*. (1982) found that handling and placing rabbits in a new environment may be stressful as it leads to a release of corticosteroids, although less than a pharmacological challenge with ACTH.

Very few data are available on the handling of rabbits at the end of the growing period, however the attitudes and handling procedures used by farmers, hauliers and abattoir personnel, as well as the transport logistics may significantly affect the welfare of rabbits. In a survey carried out by Buil *et al*. (2004) in Spain, data were collected on the methods for loading, unloading, transporting, holding and slaughter. Handling procedures differ widely among farms, especially regarding cage size (ranging from 1430 cm^2 to 10000 cm^2). According to the UK Codes of Recommendations for the welfare of livestock: Rabbits (DEFRA 1987 and CRWL, 1988), "the proper handling of rabbits requires skill, and it should be undertaken only by competent persons". Rabbits should be lifted by grasping the loose skin at the back of the neck and supported by placing the hand under the hindquarters. Handling should be carried out quietly and confidently exercising care to avoid unnecessary struggling which could bruise or otherwise injure an animal.

Also according to the Animal Welfare Institute (AWI) it is important to keep in mind the following points:

a) Quietness and avoiding sudden movements are essential to minimizing stress during handling and catching.

b) Rabbits must never be picked up or held by the ears.

c) Rabbits should be caught with a minimum of chasing.

The rabbit should be handled in such a way that they are protected and feel secure. This can be done by grasping the skin at the back of the neck and supporting the weight of the body with the other hand under the hindquarters or the stomach area. Procedures carried out with the rabbits should be as free from stress as possible. Carefully wrapping a rabbit in a blanket and gently covering his or her eyes with a towel usually has a "calming" effect, even on a very agitated animal (but no studies have investigated whether this is simply a freezing or a tonic immobility effect).

3. BIOLOGY AND BEHAVIOUR OF RABBITS

The ancestor of the domestic rabbit *(Oryctolagus cuniculus)* is the wild rabbit, a cosmopolitan mammal of the order Lagomorpha with a high capacity to adapt to different habitats in a variety of climatic regions (semi-arid, temperate, sub-arctic Domestic rabbits are bred in a large number of different rabbit breeds, strains and varieties (see Chapter 10). Although the proportions, size, colour and reproductive performance are highly variable and considerably different from the wild ancestor, the rabbits' behavioural repertoire has not been changed much by domestication and breeding i.e. it is still the same as in the wild rabbit no behaviour patterns have been lost, and no new ones created (Bell, 1980; Kraft, 1979, Mykytowycz and Hestermann, 1975) but the similarities in the behaviour of wild and domestic rabbits only become obvious under environmental conditions that allow rabbits to choose from a variety of stimuli and features, such as in a near-to-nature environment (Stodart and Myers, 1964; Lehmann, 1987, 1991). Domestic rabbits show many of the behaviours of wild rabbits, e.g. maintenance behaviours, maternal behaviour and nest building, the neonatal reactions, and the social system (Verga *et al*., 1978; Kraft, 1979; However, the frequency, intensity and duration of behaviour are strain-specific, as well as the threshold of physiological and environmental cues eliciting behaviour.

3.1. Environmental perception and senses

Rabbits are macrosmatic mammals with about 100 million olfactory cells (humans have 30 million) and their olfactory sense is especially important in social and sexual contexts. Many pheromones produced by different glands have a signalling function. Pheromones of the anal glands are excreted during defecation as well as when a rabbit sits. These scent marks comprise information providing some "security" and "reconnaissance" for group members and warnings for outsiders). Faeces (and to a lesser extent urine) are deposited at prominent places within the territory as well as on its boundaries. Mainly during aggressive encounters and reproduction periods, males mark con-specifics by spraying urine on them, and female urine pheromones influence growth and maturation of the males (Bell and Mitchell, 1984). Secretions of mandibular glands are deposited at burrow entrances and landmarks for territorial marking (Myers and Poole, 1963), and over the backs of does and kits for social marking ("chinning" behaviour; Bell, 1980);. The size of the chinning glands and the chinning activity depend on the dominance status (dominants >> subdominants) and on the sex (bucks >> does).Furthermore, rabbit mothers release a mammary pheromone that triggers immediate suckling behaviour by their kits (Hudson and Distel, 1983), whereas kit odours from the nest triggers the does' nest closing behaviour (Baumann *et al*., 2005).

The large and independently movable ears allow the detection of sound sources without any movement of the head. The auditory sense (up to 50kHz; humans <20kHz) is especially important for detecting predators. Rabbits are normally silent animals but if in severe pain or distress they may squeal loudly. Non-receptive does signal their refusal to an approaching buck by making a repeated growling sound. Thumping produced by a hind paw stamping repeatedly on the ground serves an alarm signal for others.

Their visual sense is good but at close distance the lens has a reduced ability to accommodate, and colour vision is poor, if it exists at all. Colour vision of rabbits adapted to twilight is similar to that of humans and it is the most sensitive at 511 nm (Brown, 1936). The rabbit's visual field is large with 170o per eye, but the lateral position of the eyes allows binocular vision at an angle of only 10°.

Most important is their tactile sense as the long muzzle *vibrissae* help rabbits orientate in the dark burrows.

3.2. Maintenance behaviour

3.2.1. Feeding and drinking

To avoid predation especially from the air, rabbits feed mainly during dusk and dawn and at intervals during the night. They feed selectively on a variety of herbs particularly grass. Lush leaves, fresh bark (rich in minerals!), roots and tubers are preferred over lignified stems and branches. The kits learn the smell of edible grass and other plants originating from the nest material or faeces of does (dropped in the nest after nursing).

Their incisors grow some 1-2mm a week that facilitates their gnawing and if the incisors are not worn down serious tooth overgrowth may develop (mandibular prognathismus is an inherited abnormality). The daily food intake is high and only possible with an enlarged large intestine. Depending on food quality, a rabbit can consume about 5 to 10% (in dry matter) of its body weight a day. The enzyme cellulase, produced by bacteria in the large caecum, aids the conversion of cellulose into glucose leading to soft faeces (caecotrophs) that are rich in bacteria and are a source of essential amino acids as well as vitamins of the B-complex and vitamin K. Rabbits take these soft faeces from their anus and ingest them, and caecotrophy is an essential behaviour with the consequence that more nutrients are obtained from the food (see Chapter 7). While rabbits take these faeces (caecotrophs) directly from the anus they need to be able to adopt the necessary position to do so.

Free ranging rabbits usually extract most of their water requirements from fresh and dew-covered grass and herbs but when fed with dry materials (hay, straw, food pellets) in captivity, fresh water is essential.

3.2.2. Locomotion and digging

Hopping is a typical locomotory action of rabbits and a medium sized rabbit in good condition moves about 70cm per hop, but during grazing rabbits move slowly (walking). Young rabbits engaged in locomotory play (play gambolling: Morton *et al.*, 1993), and adults during social encounters and escape may run at a speed up to 30km/h, jump higher than one metre and suddenly change direction by zigzagging (Kraft, 1979; Lehmann, 1987). When rabbits dig burrows, they alternately scratch the ground with the forepaws and then throw the earth under and behind the body. From time to time, the rabbit turns and pushes the earth with both fore paws out of the way.

3.2.3. Resting and hiding

Depending on the degree of relaxation, rabbits rest in a crouched position (lying alert), or with their hind legs stretched out laterally or behind the body, or lying on their side with all legs extended. Rabbits rest for 12-18h a day but that is subdivided into several periods that follow a relatively strict time schedule (Kraft, 1979). When resting above ground, rabbits prefer the company of conspecifics and lie against protecting structures such as stems of trees and shrubs, stones and walls. For instance, a solitary bush in a meadow displays the following features essential for rabbits: Light gradient (→ shadow), humidity gradient (→ dry substrate), top cover (→ protection from air predators and rain) and cover from behind (→ control of the environment, protection from ground predators). In an artificial housing environment some of these features can be achieved by a shelf (Stauffacher, 1992). For hiding, rabbits use their burrows, or, in the context of social interactions, any structure providing visual cover.

3.2.4. Grooming

For grooming, rabbits use their teeth, tongue and paws. They lick their coat with sweeping movements of the head, wash their face and ears with licked forepaws, clean their ears with a hindpaw, and nibble dirty spots with the teeth or scratch them with the claws of a hindleg. Following resting rabbits may perform body stretching. Mutual (allo-) grooming is very important in rabbits and increases group cohesion (Stauffacher, 1988)..

Mutual grooming is directed to sensitive body parts, mainly the head and ears, and is triggered by a specific crouching gesture of the recipient (see Section 3.3).

3.2.5. Elimination

Defecation occurs passively during feeding or actively at specific places within or at the boundary of the home range (See section on “Senses”). For urination rabbits may visit specific places (for the social function of urination, see Section 3.1).

3.2.6. Alertness and Exploration

Exploration includes sniffing at objects on which they feed. Due to the high predator pressure rabbits are very alert animals and they interrupt activities regularly to check the environment, by sitting or rearing up on their hind legs, either standing free or against objects, with ears upright and turned towards the stimulus. If there is no way to escape, they show a typical stress defensive reaction, which is *freezing*, i.e. immobilisation to avoid to be discovered by a predator.

3.3. Social behaviour

The social behaviour of rabbits starts at the beginning of life with the benefits that sibling presence gives newborn kits, allowing their survival in terms of ”increased thermal efficiency” (Bautista *et al*., 2003). Adult rabbits live in stable social groups (2-10 adults and a variable number of rabbits under 3 months old) with a linear dominance hierarchy that governs interactions among does (Vastrade, 1984; 1986). In free-ranging rabbit colonies the male hierarchy seems to be correlated with area whereas females share their smaller “home range” with other females (Vastrade, 1987). 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. In general, does and bucks are extremely tolerant of young rabbits, but depending on the population density, does may be aggressive towards younger rabbits, mainly at the end of the breeding season. Held *et al*. (1994) found that, although aggressiveness was rare in groups of domesticated does, it can become relevant when living space and flight distance are limited, particularly for low-ranking animals which cannot withdraw when attacked. However, rabbits tend to fight with the same sex, particularly males, both for sexual and territorial possession (Xu, 1996). In this regard, scent marking the environment by chemical secretions (pheromones) plays an important role (Xu, 1996). In semi-natural conditions, this behaviour seems to be strictly related to sexual maturity, since males generally do not display sexual behaviour before 70 days of age (Mykytowicz and Dudzinski, 1972; Lehmann, 1991). Aggression is not confined to males: in group housed female laboratory rabbits aggression can occur during and after the establishment of dominance hierarchies, when hierarchies are disrupted, and also in association with sexual, nesting and maternal behaviour (Held *et al*., 1994; Stauffacher, , 2000). Aggressiveness can vary considerably between seasons and days, as well as between groups and individuals, but low-ranking animals tend to receive more attacks than other rabbits (Held *et al*., 1995).

3.3.1. Group size and social structure

Rabbits are social animals and this also applies to domesticated rabbits if they are familiar with each other and as long as the environment allows an individual to initiate contact as well as to avoid it. Wild rabbits in their natural habitats, and domestic rabbits kept in a large near-to-nature enclosures, live in stable matrilinear family groups of 2-9 does, 1-3 adult bucks, their offspring and, eventually, some sub-adult satellite males (Stodart and Myers, 1964; Bell, 1984; Lehmann, 1991). Living in groups is thought to have evolved in response to high predation risks and to the distribution of resources such as food and favourable burrowing and nesting sites. Rabbits share a “home range” and live in burrows, which they may defend against predators as well against intruding rabbits. Over time, a colony of rabbis will dig large and complex burrow systems (warrens) used for resting and shelter from predators as well as for rearing their progeny. Their behaviour is rather synchronised and follows a two-peak circadian rhythm crepuscular with active periods around dawn and dusk (Kraft, 1979).

Under good feed conditions or at high population densities, groups of wild rabbits may gather in large colonies of up to hundreds of animals covering a range of several hectares (Myers and Poole, 1963). The optimal group size is determined by various factors, and some of the benefits include better predator detection, increased protection in the large burrow system, thermoregulatory effects of group-huddling during cold periods, as well as an increase in the nutrient value of the feed due to changes in the composition of the vegetation as a consequence of grazing and fertilizing. However, these benefits are balanced by costs such as increased disease and parasite transmission, increased competition for resources and, potentially, a predator realising that such sites have a high density of prey, especially young rabbits.

Rabbit groups are territorial and have a polygynous mating system (Bell, 1984). The tight social groups may be a result of enforced underground cohabitation, but interestingly, the partnership system studied indicated a tendency towards monogamy (Roberts, 1987). Both males and females exhibit linear dominance hierarchies. Within groups, dominant individuals have higher reproduction success than subordinates of the same sex (van Der Horst *et al*., 1999). Dispersal is male-biased with almost 100% of young males leaving the group before reaching sexual maturity compared with only 50% of females (van Der Horst, 1999).

3.3.2. Types of social contacts

Contact-making (neutral) behaviours such as sniffing the nose, body or anogenital region of another may occur at any time. The dominant buck regularly patrols the entire territory or enclosure and approaches all individuals. But also adult does and younger animals approach others for olfactory information, probably leading to some form of social constraints;(Lehmann, 1991).

Contact-promoting (tolerant) behaviours such as lying against each other and mutual grooming are restricted to resting times. For about 50% of resting time rabbits are in body-contact with at least one other animal. But there is a high variability depending on the individual and its reproductive cycle. Does with small kits tend to be separate from others adults (Stauffacher, 1988).

Distance-increasing behaviours such as threats and bites occur either in actual competition for a preferred partner (see below) or for food, resting and nesting sites. In stable groups, serious fights including leaping at one another and gripping the opponent with the teeth in the neck and raking with the hind claws, are as rare as an aggressive chase (Lehmann, 1991).

3.3.3. Rank order and relationships

Both adult bucks and does exhibit independent linear rank orders (van Der Horst *et al*., 1999). Once set up, the rank order stays stable over several months and is maintained by threats, and submission or avoidance. Submission is displayed by a freeze- crouching position with the head withdrawn, the ears flattened, and the head and shoulders pressed down. Dominant does display their rank position often at resting places, by threatening and nudging with their backsides making the recipient move away. This sequence is either followed by the dominant doe lying down, or the doe repeating these actions with other animals (Stauffacher, 1988).

In domesticated rabbits the frequency and intensity of agonistic interactions is much lower than in wild rabbits. This also applies to the threshold eliciting aggression (Stodart and Myers, 1964; Kraft, 1979).

The dominant buck is tolerant of young rabbits and does, but can be very aggressive against sub-adult males (Lehmann, 1991). When a rabbit is chasing another or driving a female and the dominant buck appears, the aggressor turns towards the buck and crouches or retreats, and so the aggressive or sexual encounter ends (Stauffacher, 1988; Lehmann, 1991).

There are very strong dyadic relationships between specific animals reflected in staying close together and resting together. The most preferred partner is the dominant buck, followed by does of a much higher or much lower rank position (Stauffacher, 1988).

3.3.4. Mother-kit relationships and nest bulding

Under natural conditions reproduction normally occurs in the period when the environment (climate, feed) is most favourable, however moulting may adversely affect reproduction, both in the wild and in the captive rabbits (Verga *et al*., 1978). Lefévre *et* *al*. (1976) showed that a sudden environmental change may facilitate the onset of oestrus in nulliparous rabbits. The hypothesis is that sudden environmental changes act simply as a stressor, resulting in raised blood hormone levels, as shown in rats for corticosteroids and prolactin (Seggie and Brown, 1975).

The presence of the male may explain the gradual increase in the rate of acceptance from day-to-day. Pheromones are active in the female rabbit, since ablation of olfactory bulb causes an atrophy of the genital tract (Frank, 1966).

After delivering and cleaning the offspring, the doe leaves the kits and returns to the group, after plugging (covering or closing a nest) the access to the burrow so as to mask it (Angermann and Thenius, 1973). This is done not only to protect the litter from predators and other hazards, but also to shelter it from sudden temperature changes (Verga *et al*., 1978). This maternal strategy is similar in both wild and domestic rabbit does. It is sufficient for the doe to nurse her kits for just three minutes a day for them to suck and grow (Hudson *et al*., 1996). The nest building behaviour is controlled by specific hormones, i.e. a combination of oestradiol, progesterone, testosterone and prolactin. Moreover, specific regions in the forebrain (the pre-optic area and septum) control nest building and maternal behaviour. This is stimulated by the perception of the stimuli from the kits (Baumann *et al*., 2005), during mother/kit contact at parturition and during early lactation (Gonzalez-Mariscal *et al*., 1998; Gonzalez-Mariscal, 2004).

The behaviour of the kits and their interactions with the doe may be based on an "imprinting-like process", in which the pheromones of the mother attract the kits to her (Verga, 2000). On the other hand, in groups of breeding does there is no evidence that mothers recognize their own progeny or *vice versa*. When kits have left the nest at the age of 12-15 days they will try to suckle from alien lactating does, and does regularly nurse alien kits (Stauffacher, 1988). From an evolutionary standpoint there was no need for does to develop strategies to recognize their own progeny as long as they stay in the nest burrow or nearby. Furthermore, collective nesting and nursing may be observed in groups of breeding does (Stauffacher, 1988).

A survey was carried out among rabbits' farmers in order to gather their observations on does' sexual and maternal behaviour (Verga *et al*., 1978). The results indicate that the particular attention has to be paid to the management in these rearing phases. Sometimes, anomalous maternal behaviours may be shown, such as: failure to build the nest or delivery outside the nest or cannibalism of the kits. These behaviours may be affected by some environmental variables, such as: hygiene, space, prevention, immediate identification treatment of disease, cage flooring, human-animal relationships, feeding, temperature, humidity, lighting, quietness, animals or "strange persons" being present in the environment.

A typical rabbit behaviour, retained from nature, is the doe's maternal strategy which implies the need of a nest place and some material in order to build the nest to give birth. Nest building is carried out in two phases: the first phase is building the "straw nest", i.e. lining the nest with the material given to the doe or collected by her; and the second phase is the "maternal nest", when the doe plucks hair from her body in order to complete nest building (Denenberg *et al*., 1969; Verga *et al*., 1978; Vastrade, 1984). The type of nest material and nest box given to the does before parturition may affect maternal behaviour and the kits' survival, due to the microclimate conditions inside the nest (Verga *et al*., 1987, Baumann *et al*., 2005a,b). Nest quality is an important factor for the survival and growing of kits, as well as the individual traits of the doe (Zarrow *et al*. 1963; Lebas, 1974; Verga *et al*., 1983; Battaglini *et al*., 1986; Verga *et al*., 1987;

Mohamed and Szendrő, 1992), and it improves over the first three litters (Ross *et al.*, 1956; Canali *et al.*, 1991).

4. RABBIT PRODUCTION STATISTICS IN THE EU

4.1. Global and European rabbit production

4.1.1. Global meat production

Global meat rabbit production is currently estimated at 1,107,025 Tonnes Equivalent Carcases (TEC) corresponding to 856,797,000 slaughtered animals (Table 4.1). Rabbit production is concentrated in two major areas (Europe and Asia). In Europe, 552 thousand TEC were produced, in Italy 222, Spain 115, France 85, Czech Republic 39, Germany 34, Ukraine 15 and Hungary 11. In Asia, 448 thousand TEC were produced: the biggest producer is China which accounts for 99% of Asian production. Production areas are also found in some regions of Africa (86 thousand TEC) and America (21 thousand TEC). Rabbit meat is not produced in most countries of the Near East and Oceania.

Table 4-1. World rabbit meat production in 2003.

Continent	Rabbit Meat Production		Number of Rabbits
	(TEC)	(%)	(000s)
Europe	552,137	49.9	375,561
Asia	447,942	40.5	390,785
Africa	85,591	7.7	72,236
America	21,356	1.9	18,215
Oceania	0	0.0	0
World	1,107,025	100.0	856,797

(FAOSTAT data, 2004)

4.1.2. European meat production

Rabbit meat production is only 1.2% of total meat produced in the EU which is more than 42 millions TEC (Table 4.2). EU Countries make up about 95% of European rabbit meat production (520 thousand TEC). The production is concentrated in the Mediterranean Region. Italy is by far European's leading producer of rabbit meat, with Spain second, and France third (Table 4.3). However, in the FAO statistics, some countries with a significant commercial rabbit production as The Netherlands and Belgium are lacking. Among non-EU Countries, the main producers are Ukraine, the Russian Federation, Bulgaria and Romania.

Table 4-2. Meat production in the EU in 2003.

Type of meat	Meat production	
	(TEC)	(%)
Pig	21,644,533	51.1
Poultry	10,593,075	25.0
Beef, Veal and Buffalo	8,072,528	19.0
Mutton, Lamb and Goat	1,075,596	2.5
Rabbit	520,367	1.2
Others	478,657	1.1
Total	42,384,756	100.0

(FAOSTAT data, 2004).

Table 4-3. Rabbit meat production in Europe in 2003.

Country	Rabbit Meat Production	
	(TEC)	(%)
EU Countries		
Italy	222,000	40.2
Spain	114,732	20.8
France	85,200	15.4
Czech Republic	38,500	7.0
Germany	33,800	6.1
Hungary	10,800	2.0
Greece	5,000	0.9
Poland	3,600	0.7
Slovakia	3,500	0.6
Malta	1,350	0.2
Austria	850	0.2
Lithuania	185	0.0
Estonia	20	0.0
EU (25)	520,367	100.0
Non-EU Countries		
Ukraine	15,000	2.7
Russian Federation	6,000	1.1
Bulgaria	5,000	0.9
Romania	4,000	0.7
Moldova, Republic of	1,500	0.3
Switzerland	1,100	0.2
Total Europe	552,137	100.0

(FAOSTAT data, 2004).

In the early 1970s, rabbit production in Italy was still traditional. However, due to a strong demand for this product in the north as well as in the south, production units grew rapidly between 1975 and 2000 and rabbit meat production rose from roughly 120,000 TEC in 1975 to 222,000 TEC in 2003 (Table 4.4). At present Italy is nearly self-sufficient and imports are very low. The greatest concentration and the largest rabbitries are found in northern Italy (Veneto, Lombardia, Emilia-Romagna and Piemonte regions), but production is also substantial throughout the country. Rabbit production in northern Italy is characterised by large intensive farms (500-1,000 does), while in central and southern Italy there are a large number of medium and small sized farms (100-500 does).

Table 4-4. Evolution of rabbit meat production in EU Countries from 1961 to 2003.

	Rabbit Meat Production (TEC)					
	2003	1998	1993	1983	1973	1961
Austria	850	860	890	400	500	700
Czech Republic*	38,500	38,350	34,305	44,172	34,935	9,800
Estonia	20	41	100	n.d.	n.d	n.d
France	85,200	84,756	99,522	140,000	180,000	190,000
Germany	33,800	33,920	33,920	32,505	44,700	16,300
Greece	5,000	5,000	5,000	7,500	7,107	1,500
Hungary	10,800	9,274	16,000	21,800	15,000	4,000
Italy	222,000	217,000	202,700	177,000	109,260	48,870
Lithuania	185	200	150	n.d.	n.d	n.d
Malta	1,350	1,350	330	315	0	0
Poland	3,600	4,000	5,100	13,500	14,600	9,900
Slovakia	3,500	3,680	9,760	n.d.	n.d	n.d
Spain	114,732	128,864	98,072	75,197	29,200	20,560
EU (25)	520,367	527,295	505,849	512,389	435,302	301,630
Non-EU Countries	32,600	30,224	53,037	7,176	6,237	9,783
Total	552,137	557,519	558,886	519,565	441,539	311,413

* total production of Czechoslovakia. (FAOSTAT data, 2004).

The situation in **France** is somewhat different. Output stabilised at about 200,000 TEC a year between 1965 and 1972, then suddenly dropped and now stands at roughly 85,000 TEC (Table 4.4). This situation is in line with the rapid decrease in the number of very small producers who consumed much of their own production but supplied an appreciable part of their production to local markets (Lebas *et al*., 1997). It is estimated that two thirds of rabbit meat is produced on commercial farms, and the remaining production comes from in-house farms (Magdeleine, 2003).

Spain produced little during the 1960s but then many rabbitries were opened from 1970 onwards which led to a substantial increase in output and in the marketing of rabbit meat. The present total is 114,000 TEC (Tab. 4.4). The highest production region is Catalunya, where one-third of Spanish rabbit meat is produced. Other important producer regions are Aragón (14.5%), Galicia (13.8%) and Valencia (9.2%) but small local production is still present in Castilla-León, Castilla-La Mancha and Andalucia. Five percent of Spanish production is exported to Portugal and France (Rafel, 2002; Corrent, 2002).

At present, rabbit production in **Hungary** is less than half of what it was in the peak years of 1982 and 1991. In 2003, the total quantity of Hungarian rabbit production was about 10,000 TEC (Table 4.4) with 2-3% going into the national market, and the remainder being exported to Italy (44%), Switzerland (28%) and Germany (18%). Shipments included 61% whole carcass and 39% cut products. Before 2003, 95-98% of the rabbits were produced on small farms, but now about 75% of the total production originates from large farms of up to a thousand does (Szendrő, 2004).

Rabbit meat production and consumption in other Western European countries is still low. However, in The Netherlands and Belgium there is a significant commercial rabbit production which together amounts to around 30 thousand TEC (Colin and Lebas, 1995). Due to restrictions related to the protection of the environment and disease problems (enteropathy), there is a downturn in production in Belgium. There seems to be a slight increase in Germany, where breeders are being encouraged to increase their output. There are a large number of exhibitor breeders in Germany who raise a few pedigree animals as a hobby but also consume a small proportion. Production and consumption in Sweden and Norway is very low. Rabbit breeding is still a tradition in Denmark, although the national output, once mostly exported to Germany, has now dropped (Lebas *et al*., 1997). The Czech Republic, together with Hungary, stands out among Eastern European countries with a predominant small family-scale rabbit production with 5 to 20 does. At the same time, large production rabbitries with 10,000 to 15,000 breeding females established in the 1970s and 1980s have been abandoned because of management problems (Colin and Lebas, 1995).

4.1.3. Export/Import rabbit meat market

Europe is 99% self-sufficient and net import is very low (6,000 TEC). The major exporting country in the world is China with 9,000 TEC. In Europe exports reached more than 24,000 TEC, whereas imports are 30,000 TEC. In the EU, Hungary, Spain and France are the main net exporters, while Germany, Portugal and Belgium are the main net importers. Among non-EU Countries, only Switzerland accounts for significant rabbit meat imports (Table 4.5).

Table 4-5. European rabbit meat trade in 2002.

Country	Rabbit Meat		
	Exports (TEC)	Imports (TEC)	Balance (TEC)
EU Countries			
Austria	196	410	-214
Belgium	1,684	2,765	-1,081
Czech Republic	917	678	239
Denmark	1	28	-27
Estonia	0	1	-1
Finland	0	1	-1
France	5,073	3,544	1,529
Germany	354	7,589	-7,235
Greece	2	1,309	-1,307
Hungary	5,460	0	5,460
Ireland	0	6	-6
Italy	2,670	3,475	-805
Luxembourg	12	274	-262
Netherlands	3,991	4,442	-451
Poland	179	43	136
Portugal	4	1,980	-1,976
Slovakia	58	28	30
Spain	3496	543	2,953
Sweden	1	21	-20
United Kingdom	138	266	-128
EU (25)	24,236	27,403	-3,167
No EU Countries			
Albania	0	3	-3
Croatia	0	7	-7
Norway	0	7	-7
Russian Federation	0	152	-152
Switzerland	0	2,718	-2,718
Ukraine	0	24	-24
Europe	24,236	30,314	-6,078

(FAOSTAT data, 2004).

4.2. The Industry in the Member States

The processing industry in Europe is gradually improving the availability of rabbit meat as a variety of processed ready-meals which make it easier to prepare, thus meeting the demands of consumers. As with poultry, the proportion of jointed and further processed products is likely to increase over the next few years. However the prolonged effect of a stagnant economy in some EU Countries had a negative impact on the further development of processed products in 2004.

4.2.1. Rabbit meat consumption

Rabbit meat consumption varies around the globe, where various factors affect consumers' demand. Among these factors are consumer preference, tradition and price. Table 4.6 shows rabbit meat consumption in selected countries. At the top are Malta, Cyprus and Italy, followed by Belgium, Portugal, Spain, The Czech Republic and France. In other EU countries such as Great Britain and Scandinavian Countries, where rabbits are often kept as pets, rabbit meat consumption is very low.

Table 4-6. Estimated consumption in some EU countries (kg per inhabitant per year).

Country	Rabbit meat consumption (kg per inhabitant)
Malta	8.9
Cyprus	4.4
Italy	4.0
Belgium	2.7*
Portugal	1.9
Spain	1.8
Czech Republic	1.7
France	1.5
Slovenia	0.8
Greece	0.7
Netherlands	0.6
Poland	0.5
Germany	0.4
Hungary	0.1

(Lebas *et al*., 1997; Corrent, 2002; Rafel, 2002).

4.2.2. Trends rabbit meat marketing

Table 4.7 shows the rabbit meat retail market in the three main EU producer countries. It can be assumed that in France most rabbit meat is sold in supermarkets, whereas in Spain and Italy traditional retailers are more common. This reflects the different distribution in retail markets among these countries. Production for self-consumption still appears to be significant.

Table 4-7. Rabbit meat retail market in the larger producing EU countries.

Country	Traditional point-of-sale	Supermarket	Home-consumption	Others
Italy	40%	39%	7%	14%
Spain	45%	30%	20%	5%
France	24%	51%	13%	13%

(Corrent, 2002; Magdelaine, 2003).

Table 4-8. Body weight at slaughter and carcass weight in different countries.

Country	BWt (kg)	Carcass wt (kg)
China	2.0 - 2.2	1.0 - 1.1
Cyprus	2.4 - 2.5	1.3 - 1.5
Czech Republic	2.6 - 2.8	1.4 - 1.6
Egypt (rational)	2.0 - 2.5	1.1 - 1.4
Egypt (traditional)	1.5 - 2.0	0.7 - 1.1
France	2.3 - 2.4	1.3 - 1.4
Germany	2.8 - 3.0	1.6 - 1.8
Greece	3.0 - 3.2	1.8 - 2.0
Hungary	2.6 - 2.7	1.4 - 1.5
Italy (Campania)	1.8 - 2.0	1.0 - 1.2
Italy (Central)	2.4 - 2.5	1.4 - 1.5
Italy (Lombardia, Veneto, Emilia-Romagna)	2.5 - 2.6	1.4 - 1.5
Italy (Piemonte)	2.8 - 3.0	1.6 - 1.8
Mexico	2.0 - 2.2	1.0 - 1.2
Morocco	2.0 - 2.7	1.0 - 1.5
Philippines	1.8 - 2.0	0.9 - 1.1
Portugal	2.0 - 2.2	1.1 - 1.2
Slovak	2.6 - 2.8	1.4 - 1.6
Spain	1.8 - 2.0	1.0 - 1.2
Switzerland	2.2 - 3.1	1.2 - 1.8
Tunisia	2.9 - 3.0	1.6 - 1.7
USA	2.1 - 2.3	1.1 - 1.2

(Lebas *et al*., 1997 adapted).

Table 4.8 shows the different live weight at slaughter and carcass weight in different countries (Lebas *et al*., 1997). These differences are due both to production reasons (slow-growth breed, rearing systems, etc) and to consumers' preferences. It can be assumed that this shift towards further processed products in Europe will soon underline the necessity for heavier animals in order to increase process yield and improve technological properties of rabbit meat during processing (Maertens, 2000).

5. GENERAL OVERVIEW OF CURRENT HOUSING AND MANAGEMENT SYSTEMS ON COMMERCIAL FARMS

5.1. Introduction

Objective: this chapter describes briefly the current housing and management systems used on most commercial rabbit farms (>95%) that are mainly concentrated in the Mediterranean region (see Chapter 4). The data have been provided by members of the workgroup and give an overview (summary) of the current commercial rabbit production systems (see other chapters for details and references). The tables summarise the farming situation in the main rabbit producing countries.

Definitions: there are many definitions leading to confusion because of different languages, because terminology taken from other species and the Working Group will use the following terms throughout their report (see Table 5.1).

Table 5-1. Terminology used in rabbit housing.

Housing types	Number of animal	Categories
Floor	Individual	Growers
Cage	Pairs	Breeding Males and Females
Pen	Group	Future breeders

Commercial cages for rabbits are nearly exclusively made of wire and always have a roof. A description of the different cage sizes and arrangements is given in Section 5.4. A pen (or park) can be made of different materials but has no roof and in general the number of rabbits housed in a pen is greater than in a cage. When the rabbits are housed on the ground, then the term "floor" housing is used. If rabbits are housed with more than 2 together, then the term group is used. In Italy "colony" rearing is used for a small group of growers housed in a cage but this term will not be used.

Commercial rabbit production is almost exclusively intensive in the usual farming sense i.e. when considering technological inputs, concentrated diets and husbandry systems. Only the niche production of organic farming and small-scale production can be considered as extensive. However, in rabbit farming, the terms "intensive", "semi-intensive" and "extensive" refer to the breeding system being defined by the interval between parturition and re-mating (or artificial insemination). When rebreeding occurs immediately after the parturition it is referred to as "intensive", rebreeding during the lactation period as "semi-intensive", and rebreeding after weaning as "extensive".

5.2. Type of farms

Commercial rabbit farms are mainly still "family farms" with the number of does varying from several hundred up to thousands. In this latter case, workers are employed and they may be referred to as "industrial" farms.

The majority of farms are of a **closed-cycle type** with breeding and growing units on the same place. However, farms with only breeding or only growing rabbits also exist, and are called “open-cycle” farms.

The rabbits are mainly housed in closed buildings (breeding stock) but in Southern Europe growers are sometimes housed in half-open buildings with open sides called - “semi-plein-air – or in outside placed cages, called – plein-air”. Closed buildings have ventilation and heating systems and many are also equipped with a water-cooling system. The temperature within buildings is normally maintained between 15C and 20C.

There is an increasing trend to having only reproduction stock in the same reproduction phase or growers of the same age within a building in order to facilitate an all-in all-out system.

5.3. Housing

Females are **individually** caged but group housing may be found in experimental units or in small scale “alternative” systems. Males, if present on the farm, are housed individually. **Future breeding stock** is housed (see Figure 5.1 in the Annex), after the normal growing period, **individually or in pairs**. Growers are housed in groups of different numbers according to cages available. Growing in pairs is widespread in Italy (see Figure 5.2 in the Annex). When dual-purpose (suitable for rearing young and growing) cages are used, growers are housed per 5-8 in a cage, but when specific grower cages are used, groups can be larger e.g. 10-12. Pen housing (on the floor or on wire) is only used for niche production such as organic or farm assurance labels.

In the breeding unit shown in Figure 5.1, there are two tiers: the breeding stock on the lower tier and on the upper level are kits and breeding stock or females without litter.

5.4. Cages and equipment

The cages are mainly constructed of wire and sometimes the walls are solid metal sheets. The zinc-coated wire of the cage-bottom has a diameter of 2 to 2.5 or 3 mm with rectangular slats (70-75 x 13-15 mm) while for the sides and top a smaller diameter is sometimes used. In a minority of the farms the bottom consists of slatted plastic floor and, in breeder cages, there is an increasing trend to use plastic footrests or floor-mats that cover part of the wire flooring (see Figure 5.3 in the Annex).

In Picture 5.4 is a dual purpose cage (see Annex) occupied with 6wo weaned kits and with cage top removed at the time the picture was taken.

There is an increasing trend observed in commercial rabbitries that new cage equipment is dual purpose i.e. suitable for both rearing the young with the doe and during growing (see Figure 5.4 in the Annex), and facilitates the all-in, all-out approach. At weaning the female may be transferred to another cage or even another building while the young growers remain in the cage. When the nest box is taken out of the cage (when the kits are 21-25 do) the available floor area is increased by approximately 800-1000 cm^2.

However, as the slaughter weight of growers differs (2.0-2.8 kg) between and even within countries, and so space allowance will vary as well as the floor area per animal during that growing period.

Table 5-2. An overview of the different cage sizes is presented.

	Length (cm)	Width (cm)	Height (cm)	Floor area/ animal (cm²)
Female, without a nest box	60-65	40-48	30-35	2400-3120
Growers (4-10 weeks of age)				
In Pairs	40-42	25-28	28-30	500-585
In Dual purpose cage*	60-65	40-48	30-35	480-520
In Dual purpose cage + nest place#	85-90	40-48	30-35	485-540
In Grower cage϶	80-100	50-60	30-35	450-600
Future breeding stock	40-42	25-28	28-30	1000-1175

* 5-6 rabbits in a cage; # 7-8 in a cage; ϶ 9-10 in a cage.

Cages are normally equipped with a feeder and nipple drinker but no other structural objects are provided.

Breeding cages are nearly always at one level (flat-deck) while for growers, especially when kept in pairs, they may be in tiers of 2 or 3 levels.

5.5. Reproduction and husbandry

Artificial Insemination (AI) (see Chapter 8) is used on most commercial farms and is carried out by the farmer or specialised insemination teams (see Figure 5.5 in the Annex). Semen comes from males kept on specialised farms, centres or selection units, but a number of farms still provide their own. Females are inseminated in large groups (batches) on the same day using a 42 day interval, which means that AI is carried out 11 days after parturition and young rabbits are weaned at 28 to37 days. Strategies of early weaning (23-27do) are seldom practised but are under evaluation (see Chapter 9). In a minority of farms, other reproduction strategies are also used such as the intensive breeding system (mating or insemination after weaning), or extensive breeding intervals.

Two to four days before the expected parturition, females are given access to a nest box that has been filled with nest building material (wood shavings, straw, hay, hemp or synthetic fibre). After parturition, cross-fostering of kits to equalise litter size is a common practice, and some farms apply controlled lactation where females are allowed to nurse their kits daily for only a few minutes each day (see Chapter 9).

5.5.1. Size of nest box.

Nest-boxes are made from various materials in combination i.e. metal sides with a plastic floor (see Figure 5.6 in the Annex). The minimum width is commonly 34-45cm, length 24-27cm, and height 30-38cm (same height as the cage). The box is normally built from metal with plastic (floors), or in wood, or in plastic. Concrete boxes are being used occasionally, the width is 26cm, length is 74cm, and height is 48cm. The box may be outside or inside the doe's cage, and this makes the area available for the doe different in each case.

Depending on the breeding strategy, weaning is performed at 28-42 days of age and rabbits are marketed from 9 weeks of age in Spain (1.9-2.1 kg body weight (BWt), 10 weeks in France and Portugal (2.3-2.4 kg BWt), to 11-12 weeks for the Italian and Greek markets (2.6-2.8 kg BWt). In some Italian regions even 14 weeks old (3.3 kg BWt) rabbits are produced to be sold as meat portions.

The average reproductive lifespan of a female is 5-6 litters in commercial units and a restocking rate of rabbit does in farms is often 100-120% yearly.

5.6. Feeding

In commercial units rabbits are fed mainly ad libitum with an all-mash pellet using automated systems (see Chapter 7).

5.7. Management as batch

For a variety of reasons (reduction of labour, delivery of large numbers of broiler rabbits, all-in all-out systems) and traceability of meat products, batch management is generally used and so females 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.

5.8. Animals

Nowadays rabbits reared for commercial purposes are New Zealand White and Californian, crosses or hybrids developed by several research institutes and breeding companies in Europe. With the exception of heavy male lines all belong to medium sized types (see Chapter 10) and have an adult weight between 4 and 5 kg. They are often characterised by their white fur.

5.9. Production statistics

Rabbits are fertile animals with an average of over 60 kits born/female/year but rabbit production is also accompanied by high losses with an average parturition to sale loss on closed cycle farms of 15-30% (Table 5.3). For details see Chapter 11.

Table 5-3. Average production data and losses in French rabbitries in 2003.

No of farms considered	1 125
Average number of females/farm	449
Fertility (kindlings/inseminations), %	78
Interval between 2 litters (days)	56.9
No of litters/female/year	6.4
Litter size at parturition	9.9
Age of sold rabbits (days)	73.7
Growers produced/female/year	45.1
Kg produced/year/female	107.8
Yearly replacement level of females (%)	100

(Source: ITAVI, 2005)

The main causes of losses are in growers due to enteric and respiratory diseases. In adult breeders respiratory and enteric diseases frequently cause mortality but a significant number of does are culled due to reproductive failures. The diseases associated with the above losses are specifically and in more detail covered in Chapter 11.

5.10. Ventilation and conditioning

When rabbits are kept indoors the ambient temperature, the air velocity, the relative humidity, the dust level and other atmospheric conditions are controlled. Appropriate measures, such as cooling of buildings are taken where the weather is hot, as in Southern Europe. The ventilation system and the facilities for storing and handling litter and manure are designed and managed to prevent the exposure of rabbits to adverse concentration of gases (ammonia, hydrogen sulphide, carbon dioxide) that can cause discomfort to the animals and sometimes a health problem. Indeed even when rabbits are kept outdoors in cages, they are protected as far as possible from thermal discomfort. The tables below show different spaces allowances depending on the production system and ventilation used.

Table 5-4. Recommended air volume for phase and type of ventilation.

Phase	Natural Ventilation (m^3/animal)	Dynamic Ventilation (m^3/animal)
Lactating females	**3,50**	**3,00**
Breeding females	**3,00**	**2,75**
Males	**2,75**	**2,50**
Future breeders	**2,25**	**2,00**
Growers	**0,35**	**0,30**

(Source Ferré and Rosell, 2000)

Table 5-5. Densities rabbit/m² depending on the ventilation system

Natural Ventilation							Dynamic Ventilation (4)			
Season		Summer (>30ºC)		Winter		Rest	Summer		Rest	
Female		0,35 m^2		0,30 m^2			0,25 m^2		>0,25 m^2	
GROWING	Single batch (1)	20 kg (3)	10 kits (3)	22 kg (3)	11 kits (3)	24 kg (3)	28 kg (3)	14 kits (3)	30 kg (3)	15 kits (3)
	6 batches (2)	20 kg (3)	14 kits (3)	22 kg (3)	16 kits (3)	24 kg (3)	28 kg (3)	20 kits (3)	30 kg (3)	22 kits (3)
Future breeders	0,20 m^2 /animal						> 0,15 / animal			

Source: Ferré and Rosell, 2000). (1) Up to 2 kg BWt whole batch; (2) Average 1,375 kg BWt; (3) m^2 useful cage; (4) Dynamic ventilation, cooling and support heating.

5.11. Lighting

In buildings a sufficient level of light (at least, 50 lumen/m^2 or 50 Lux) is provided to allow the rabbits to have visual contact, to investigate their surroundings visually and to show normal levels of activity. The lighting regime follows a 24h rhythm and includes an uninterrupted dark period usually corresponding to a third of a day (8h).

6. EFFECTS OF HUSBANDRY AND MANAGEMENT RELATED TO CAGE SIZE

6.1. Introduction

It is important that buildings, equipment and husbandry practices should enable animals to live in good conditions of hygiene and welfare and not cause any physical injuries. In this chapter the effects of housing systems on growing rabbits, on stud males, and breeding does and kits will be considered.

Little research seems to have been carried out on farm rabbit welfare compared with many of the other farmed species, and so much of this report will deal with productivity traits, as well as welfare measurements when they are available. Because cage size and shape are inextricably linked with the number and age/size of rabbits, stocking densities (rabbits/m2 and kg/m2) and other factors, details have been provided where they are relevant. The experience of the working group has had to be key in providing guidance as to good agricultural practice in many areas, as the hazards associated with, and leading to, poor welfare have not been well characterised. This chapter deals with cage flooring, enrichment, group housing and layout of space for breeding does and for growing rabbits. With the latter group it has to be borne in mind that the available space to carry out certain behaviours will change with age, as cage size cannot easily changed in a commercial setting.

6.2. Cage Floor

6.2.1. Breeding does

Certain authors have criticised the widespread use of wire-mesh flooring in cages as the cause of paw lesions with varying degrees of tissue damage (Drescher and Schlender-Bobbis, 1996) and Mirabito and Delbreil (1997) carried out a survey on 69 farms forming a representative cross-section of French rabbit farms. On each farm, 50 females were observed and injuries were graded according to the classification scale of Drescher and Schlender-Bobbis, (1996). On average, 12% (range 5-40%) of female rabbits had paw injuries that were sufficiently serious for them to show signs of discomfort. However, the situation was extremely variable as the frequencies recorded varied between 5% and 40% according to the farm. On 50% of the farms, more than 10% of the rabbits were injured. There was a gradual increase in the number of affected animals with age, but the main source of variation seemed to be the parity (not to be confused with age) of females. The incidence of injury was over 16% in those rabbits that had had more than six litters, but only 5% of those that had had less than three litters. The age of the cages also affected injury rates but to a lesser extent, whereas building type and cage-type were not linked to the frequency of injuries. Recently, Rosell and De la Fuente (2004) examined physically 13,941 does on 115 farms for the prevalence of sore hocks and found an average of 9.19% (range 8.3% to 15.3%) does affected, with the origin of the doe showing a significant difference.

For some years, alternatives to wire-mesh flooring have been sought and this has led to the use of synthetic flooring with a rectangular mesh, and to perforated metal floors. Rommers and Meijerhof (1996) compared 6 types of flooring in which female rabbits that had not yet had a litter were monitored for a year in two experiments (n=15 and n=10). Overall, 80% of females housed in cages with wire-mesh floors developed paw lesions (from minor skin hardening to raw lesions) after the fourth litter compared with only 30% of those given alternative flooring, although the latter type of flooring did not always produce consistent results. Furthermore, one type of alternative flooring (synthetic with oval meshform) caused paw fractures, two other types were found not to be hard-wearing enough (slat and synthetic), and two others were considered by the authors to cause hygiene problems due to the retention of faeces on the floor (synthetic with diamond meshform and steel with round meshform). Consequently, despite their advantages when it comes to preventing injuries, problems unrelated to the animal health posed by these alternative surfaces, as well as their high price, have precluded their widespread use.

The importance of the design of alternative flooring (slatted floor) was also mentioned by Petersen *et al*. (2000) who showed, on the basis of observations of 32 female rabbits and their offspring, that the gap (10 to 16 mm) between 10 mm-wide boards had an influence on female rabbits' orientation and the locomotor behaviour of kits when they begin to go out of the nest. They concluded that a 14 mm gap was the optimum distance for this kind of floor. Even if there is not any published study, experience and practice have lead to a similar value for wire mesh and it could probably be assumed that this is an optimun between hygiene and comfort properties of floor.

More recently, various manufacturers of husbandry equipment have proposed a system of paw-rests (foot mats) fixed to the wire mesh, which have the merit of covering only a part of the floor surface. This arrangement avoids poor hygiene whilst at the same time reducing the frequency of paw injuries. Tudela (reported by Ruis, 2004) showed that this system significantly decreased the number of culled does, and these results seem to be being confirmed through their widespread in several countries (e.g. Rosell and De la Fuente (2004) found a significant ($P<0.001$) reduction of the prevalence sore hocks in farms when such a foot mat was used).

In some cases, particularly with heavy breeds, some authors (Anonymous, 1988) recommend that rabbits are kept on floors covered with litter, however, this is normally considered to be at odds with maintaining good animal health.

6.2.2. Growing rabbits

Due to the early slaughter age of growing rabbits, there are no reported problems with footpad lesions on wire-mesh floors. However, some researchers still propose using litter to enable animals to adopt more varied postures and activities, leading in turn to an enrichment in their surroundings (e.g. Morton *et al*., 1993, Morisse (personal communication) compared young rabbits kept on wire-mesh flooring with rabbits kept on litter-covered flooring (6 animals per cage), and showed that there was a significantly higher incidence of coccidiosis in the animals on the littered floor. Similar observations in littered-pens have been found by Lambertini *et al*. (2001) and Dal Bosco (2002) who linked the higher level of mortality with coccidiosis. The straw and hay block the holes in the wire mesh floor and stop faeces passing through leading to animals being in direct ciontact with their faeces leading to a build up of organisms like coccidia. In addition, there is a risk that such materials could carry mycotoxins and even transfer infections from wild rabbits (e.g. myxomatosis, RHD). Based on practical experience, these risks were considered to be high by the WG although no quantitative data are available to make a risk assessment. On the other hand it was noted that hay and straw are given to increase the Crude Fibre level of the animals' diet and that in laboratory facilities, caged and group-housed adult rabbits are regularly given sterilised hay and straw with no detrimental effects. It can therefore be concluded that under current farming conditions a higher incidence of enteric diseases (see Chapter 11) seems to be facilitated through the use of litter.

Perhaps not surprisingly, preference tests conducted by Morisse *et al*. (1999) showed that young rabbits were not attracted by wet and dirty litter. A study of the time budgets of 24 subjects (12 males and 12 females) housed in 8 enclosures (with half of the floor covered in wire mesh and the other half in litter) at a density of 15 rabbits/m² and a temperature ranging from 15C to 20C showed that they spent 89% of their time on the wire-mesh floor after seven weeks, and 77% after ten weeks. The percentages were even higher when the animals were lying down i.e. they preferred to lie out on wire mesh floors. The authors believe that the main explanation for this behaviour is the fact that the litter was wet and dirty and the animals only really frequented the litter after a fresh supply had been added. At that time they also played with pieces of straw and used them as material for oral activity. Orova *et al*. (2004), using a similar experimental design (16-18C), recently confirmed this result and found that the growing rabbits spent over 80% of their time on the wire mesh floor.

The preference for wire mesh was independent of age (e.g. after weaning on dry and clean litter) and space allowance (12 or 16 rabbits/m²). In a two part cage design, at 16 rabbits/m² preference tests, led to 27-28 rabbits/m² on the mesh compared with only 4-5 animals/m² on deep litter (Orova *et al.,* 2004)

Using free choice system weaned rabbits preferred staying in cage with plastic mesh and rejects the solid floor. However, at the end of the growing period (10 weeks of age) no difference was found in the preference for the plastic mesh, plastic slat and wire net floor (Matics et al, 2004a).

Alternative floors to wire-mesh have also been evaluated for growing rabbits. Trocino *et al*. (2004) compared slatted floor (galvanised steel bars of 2x2cm section and 1.5cm span) with wire-mesh floors. In cages of 8 growing rabbits, at two space allowances (12.1 and 16.0 rabbits/m²), they did not observe any effect of floor type on the zootechnical traits (daily growth rate and feed intake), their behaviour (time-budget video recorded during 24h at 57 and 68 do) and bone integrity (tibia and femur dimensions and resistance to fracture).

Princz *et al*. (2005) compared cages and pens (0.12 vs 0.83 m²) with a plastic or wire mesh floor did not find any significant difference in productivity (weight gain, feed intake, feed consumption) and carcass traits. However, mortality (4.4 vs 7%) and ear lesions (6.9 vs 13%) were higher in rabbits housed on the plastic rather than the wire mesh floor.

6.3. Environmental Enrichment

Many studies have focused on the possibility of enrichment in laboratory conditions where rabbits are often singly housed, feed restricted, are subjected to stressful manipulations, and kept for long periods. This is not typical for farmed rabbits apart from the breeding males.

These enrichment studies can be summarised according to three objectives:

- oral enrichment with the goal of reducing “abnormal” behaviour;
- environmental enrichment like development of furnished cages in order to increase the possibilities for rabbits to express various behaviours, and to improve the “development” of the animals; and
- social enrichment following similar objectives

In the following parts, we do not report all the available literature but try to focus on those references that are potentially useful when considering modern farmed rabbits.

6.3.1. Adult rabbits in laboratory conditions

The use of straw or other materials such as wood, hay or food pellets for oral activities has been evaluated in numerous studies with older adult rabbits (e.g. Huls *et al*., 1991). They provided 8 rabbits (7 months old and singly caged) with a piece of wood and various types of wooden and metal toys, after which the animals were observed for 25 minutes. During a 25 min observation period, rabbits spent 77% of their time with metal toys and 94% of their time with wood, interacting with these new objects – for the most part by gnawing. Furthermore, these authors reported that the animals did not lose interest in the objects, even after they had been in the cage for 40 days. Lidfors (1997) compared the behaviour of rabbits provided with four different sources of enrichment (hay, grass cubes, two sticks and a black box with an entrance, placed in the middle of the cage) with a group of control subjects with no enrichment. Twelve 12-week-old rabbits per batch were observed for one hour a day during daylight for a period of 40 days. There were 10 times more instances of some interaction between the rabbits with the hay than with the sticks or the box, while the grass cubes occupied an intermediate position. At the same time, "abnormal" behaviour (licking, gnawing or nibbling at cages, etc.) were halved when animals were provided with hay or grass compared with animals provided with other items of enrichment, and compared with the controls. However, this result must be treated with caution as the animals were rationed to 100g of feed pellets per day (each rabbit weighing 2.5 kg) and so the interaction could have been carried out to satisfy their appetites. Berthelsen and Hansen (1999) tested the effect of providing hay for rabbits (16 to 31 months old) housed individually in conventional cages and converted cages (with a raised rear section on top of a wooden box). The animals were given 120g of food per day, and comparisons were made with the period preceding the distribution of the hay. Access to hay caused a significant reduction in grooming and cage gnawing and an increase in scent marking, and such a change could be considered an improvement in welfare, although this may have been linked to the hay being distributed on the top of the cage and the time taken for the animals to drag it into the cage.

All the above results seem to show that providing animals with forage or wood improve their welfare, however, a few reservations have to be made when extrapolating this data to farmed animals even though rabbit behaviour does not seem to have been qualitatively changed by domestication and breeding (see Chapter 3). First, this improvement is mainly based on an interpretation of a reduction in the frequency of forms of behaviour that are regarded as abnormal, such as cage gnawing/nibbling and over-grooming and the nature of these behaviours could be questioned. Another criticism relates to the conditions in which these tests were carried out. In every case, the animals involved were reared individually and their food was rationed but under normal farming conditions, rationing is used only for non-nursing females or future breeding rabbits and these animals account for only a small proportion of the animals. Therefore, in diet restricted rabbits, it is likely that making a foodstuff such as hay available would lead to them to using the hay as a food supplement rather than as an enrichment. Furthermore, Krohn *et al*. (1999) have shown that in diet restricted 3 month old rabbits, the time the animals were given the pellets (08:00h vs 14:00h) could have a significant effect on the frequency of abnormal behaviours during the dark period (decreased in the "14:00h" group) whereas these behaviours were very rare in all treatments during the light period. As they also compared rabbits housed in wire-mesh cages and in littered pens, they noticed that this reduction was of the same level as that observed in littered-pens compared with wire-mesh cages. Even if there were strong methodological limits of this study because of the time and duration of the behavioural observations, this study suggests that other strategies to reduce the frequency of "abnormal" behaviour need to be investigated.

6.3.2. Rabbits kept under farm conditions

6.3.2.1. Welfare measurements

Overall there is a lack of data for farmed animals and their conditions as few studies have been carried out looking specifically at welfare aspects such as behaviour and enrichment.

Luzi *et al*. (2003) carried out a study in cages of 8 growing rabbits with and without wooden sticks as enrichment and reported that gnawing the bars of the cage decreased significantly with enrichment, while feeding behaviour and caecotrophy increased. Verga *et al*. (2004b) studied the behaviour of growing rabbits housed in cages with space allowances varying from 9.5 to 19 rabbits/m² (2, 3 and 4 rabbits per cage) and half of the rabbits were given a wooden stick. They observed that during the growing period (beginning, middle and before slaughtering) the enriched caged rabbits performed many more behaviours - jumping, allo-grooming, smelling the other rabbit and the environment, as well as activity towards the wooden stick. On the other hand, control animals showed mainly alert and aggression behaviours, and gnawed the bars of their cages. In contrast to these results, Jordan *et al*. (2004) studied the behaviour of singly caged growing rabbits fed *ad libitum* in which 3 groups of 12 rabbits were given different kinds of wooden sticks and compared them with a control group without any enrichment. The behaviour of rabbits was video-recorded from weaning until they were 101do but no effect of enrichment on behaviours such as cage gnawing was reported, and that the main effect of the wooden stick was a decrease in the duration of eating behaviour with one kind of wood (Norwegian Spruce or "Christmas Tree", *Picea abies*) which appeared to be the more attractive for the rabbits ("wood gnawing" for 0.21% of the time). Postollec *et al*. (2002) compared pens of 52-60 growing rabbits (space allowance at 15-17 rabbits/m²) with a tunnel (withdrawal area for the kits) and straw in pens without any other enrichment and found that the main effect of the straw was a decrease in time spent by rabbits feeding and moving, whereas drinking, grooming and other activities were unaffected.

The contradictory results obtained with growing rabbits may be due to the different housing systems and types of environmental enrichment given the animals, so it is difficult to draw conclusions. Nevertheless, these studies seem to show that these kinds of enrichment mainly affect feeding behaviours, as well as behaviours such as exploration, activity level and social behaviour.

6.3.2.2. Productivity traits

Luzi *et al*. (2003) reported higher daily weight gain and slaughter weight in cages with wooden sticks in healthy rabbits. In another study (Mirabito *et al*., 2000) looking at the impact of enrichment (wood attached to the cage wall and hay) on productivity, rabbits developed a concurrent enterocolitis and the death rate increased from 16 to 23%, it is not clear whether any studies were carried out using hay or wood separately. One theory to explain the different mortalities is that the pieces of wood could have acted as an extra source of infection between animals in the same cage. Daily growth rate and feed intake were not greatly affected, although providing hay tended to decrease the consumption of pellets in the post-weaning period (36 to 54 days). Maertens and van Oeckel (2001) did not confirm this result. Postollec *et al*. (2002) reported that they only observed a negative significant effect on the daily growth rate in enriched pens in 1 out of 4 trials. Verga et *al*. (2004b) did not observe any effect of enrichment with a wooden stick on mortality or on growth rate. Some other strategies for enrichment have been suggested, for example, using small wooden sticks hanging from the ceiling of the cage or inserted on the wall of the cage or rolls of compacted straw or toys (e.g. beverage cans), or blocks of food supplement, but all these need further evaluation.

6.3.3. Furnished cages for adult rabbits

Stauffacher (1992) has suggested that it may be necessary to consider the layout of cages to provide female rabbits with a retreat or resting area where they can get away from their kits. He proposed installing an elevated area (a platform) within the cage for this purpose but it would also be possible for other systems, such as a separate compartment or a tunnel to play this role. These sorts of cages are not in common use in commercial farming at the present time.

Finzi *et al*. (1996) pointed out that installing a raised platform in a cage has the advantage of increasing the space available for the animals without altering the area a cage occupies on the ground (cage footprint). They designed a cage with a 22cm-high platform and found that over a 15 day period, 6 females (18wo) spent 53% of time on the platform and 47% in the lower part of the cage. In contrast, covered areas such as tunnels were used very little (2% of the time) in keeping with observations by Lidfors (1997). Hansen and Berthelsen (2000) also tested the impact of the presence of a wooden box (44Lx25Wx19H cm) that could be used either as a shelter or as a raised surface. The box was positioned at the back of the cage, where the total headroom was 80cm as opposed to 40cm in the rest of the cage. Male and female rabbits were tested but the results were contradictory. However, it was clear that the box was used primarily as a platform (for more than 13h a day) rather than a shelter (around 12 minutes). Stauffacher (2000) compared females (18-22wo) housed in conventional individual cages with those housed in furnished cages (with a 30cm high platform at the back of the cage). During the period on either side of lights going out, females in furnished cages spent 38% of their resting time on the platform (range 13 and 58%). These tests, involving adult females with no kits, clearly showed that they used the raised area.

6.3.3.1. Effect of a raised area on the behaviour of farmed female rabbits

Under farm conditions, over a conventional 42-day breeding cycle, Mirabito *et al*. (1999a) tested the impact of a platform on animals' occupation of the space provided. Sixty females were housed in furnished cages (61x46x58cm, with a platform 46x39x29cm) and the animals observed twice a week over two breeding cycles during the light period. When females were nursing, the time spent on the platform increased (from 20% to 35%) between the second and fourth week after parturition, that is the time corresponding to the emergence of the kits and the removal of the nest boxes (18 days after birth). From the fourth week onwards, the young rabbits began to occupy the platform, and by the 5th week were spending about 10% of their time on it. These results suggested that the platform was used by the females to get away from their kits but could also have been due to the power of attraction for a nest around the parturition but not at other times, or an effect linked to the space available. For these reasons, Mirabito (2002) carried out a second set of experiments, in which they tested whether the presence of young rabbits affected the time spent by mothers on the platform. Two groups of 20 females were established and housed in converted cages. In the test group, kits were left with their mothers only for the time necessary for suckling, and were then moved to a separate cage. In the control group females had free access to the nest box. Between the third and the fifth week, females in the control group spent 32-42% of their time on the platform whereas those in the test group spent only 12-16%. Therefore, it is very likely that the presence of young rabbits causes the female to spend more time on the platform. The question is whether this is because of the overall lack of space or a desire on the part of the mother to get away from her young rabbits, bearing in mind that this period of relief would last only a few days anyway. Therefore, a third set of experiments was carried out, looking for a potential "rebound" effect. Three groups of 8 lactating does were formed and an automatic recording system was installed to record the presence of rabbits on the platform on a continuous basis. From the 17th day following parturition, the mothers in one test group were prevented from having access to the platform for 2 days and in another test group for 5 days. Compared with the control group which were given continuous access to the platform, no "rebound" in the time spent on the platform following the lifting of the restriction was observed. This would suggest that the female rabbits have little "motivation" to get away from their kits, although major differences in the behaviour of the 3 groups during the pre-experimental phase compelled the author to regard these results with some caution (Mirabito, 2002). Mirabito *et al*. (2004) then carried out another set of experiments. Six groups of around 20 does were housed in three kinds of cages which differed in the space available (38x65cm, 46x73cm, and 60x73cm). Half of each was equipped with platform (type 1 and 2) or a tunnel (type 3). The time spent by the does on the platform during the fourth week of lactation was significantly lower in the smallest cage compared with the largest. This result would suggest that the lack of space was not a factor that could explain the behaviour of the female.

While the layout of cages has a significant effect on the occupation of cage space by farmed female rabbits, what impact did it have on other types of behaviour? The behaviour of 16 female rabbits housed in furnished cages was compared with that of 16 females housed in conventional cages during the second, fourth and fifth weeks following parturition (Mirabito, 2002). In furnished cages, during the light period, resting activities remained unaltered, "gentle wire-gnawing" tended to decrease in week two and the frequency and time devoted to grooming the kits diminished significantly in week four. The presence of a platform did not reduce the frequency of the kits' attempts to suckle (Mirabito, 2002). However, Hoy *et al*. (2000) measured the frequency of daily nursing in conventional cages and in furnished cages (50x70x45 or70cm) with a raised area (50x20x20cm) which were a standard size or enlarged by a factor of 1.5, 2 or 3. These authors found that an increase in the available surface area tended to reduce the frequency of daily nursing. They also found that the addition of enrichments (tunnels, hay or wood) lead to a similar result.

Finally, Mirabito *et al*. (2004) studied the interactions between the doe and her kits (suckling attempts and response of the does) in 3 sizes of cage (38x65cm, 46x73cm, and 60x73cm) and observed the behaviour pattern of females when the kits tried to suckle: running, turning and finally lying on the floor. In the smallest cages females were not observed jumping on the platform to escape, in the middle size cages they often jumped on the platform when the kits tried to suckle (more than 60% of the cases), and in the largest cages which were equipped with a plastic tunnel instead of a platform, the does used the tunnel to escape and rest in more than 60% of the cases, but they were often pushed out of the tunnel by the kits. This study confirmed the use of the raised area by the does to escape but it raised several question about the welfare of the kits and does with regard to nursing. First, at 3 weeks after delivery, the number of suckling attempts by the kits during a 48h period ranged from 31 to 35 per doe in the furnished cages and from 13 to 25 per doe in the control cages. The platform did not appear to be a good system to reduce the frequency of suckling attempts even if it was used by the females to escape. At 4/5 weeks, there was no difference but the average level was lower (4 to 13 per doe). Second, at 4/5 weeks after delivery, the suckling attempts seemed to be synchronised with the lactating rhythm of the does (one per day between) as 80% of the attempts were observed in the hour before lactation (mainly half an hour before until the doe decided to nurse). At 3 weeks after delivery, the observations were slight different with no obvious synchronisation between suckling attempts and the nursing event, and between the does themselves. One of the conclusions of the authors was that if the synchronisation of suckling and lactation is the normal behaviour (observed in the first days of life of the kits), in order to improve welfare, more knowledge about the behaviour of rabbits during the third week after delivery is needed (as at this time, there are many changes in the kits' life as they begin to leave the nest to eat and drink).

6.3.3.2. Effect of a raised platform area on performance traits for farmed female breeders

From the zootechnical viewpoint, platforms did not seem to have any effect on fertility, prolificacy or longevity of females or on the mortality of nursing kits (Mirabito *et al.*, 1999a; Mirabito, 2002). They examined the effect of housing type during the rearing stage (up to 18 weeks) and the breeding stage (beyond 18 wo) using 2x2 factor analysis. During the rearing stage, females were housed in control cage (77x23x26cm) or experimental furnished cage (77x23x58cm with a platform of 46 cm). During the breeding stage, the converted cages were the same as those described in Mirabito (1999a) and the test was carried out over the productive lives of 234 females. The housing system during the breeding stage had no effect but from the second breeding cycle onwards, the weight of females housed in cages with platforms was significantly higher (4%) than those housed in conventional cages. Moreover, housing in furnished cages during the rearing stage led to a lower mortality rate among females over this period (6.8% vs 14.1%), a slower decline in the breeding stock, and a trend (not significant) towards a lower mortality rate among kits during the breeding period. From a zootechnical viewpoint, it would seem that housing in cages with platforms during the breeding stage has several advantages, especially its effect during the rearing stage on female longevity.

Despite these promising results, there may be hygiene problems. First, faeces accumulate on the platform and, secondly, droppings and urine fall onto any equipment or animals located underneath. Notwithstanding some experimental studies (Finzi *et al.*, 1996; Mirabito *et al.*, 2004) no solution was found. Finzi *et al.* (1996) put forward the theory that by barring an animal's access to the platform during the first few days it could be trained to deposit its faeces in the lower part of the cage, thus solving the problem. However this was not reproducible by other workers and in spite of further modifications no solution was found to the problem of droppings and urine falling on the animals in the lower compartments (Mirabito *et al.*, 2004). Tests carried out with collecting trays proved impractical because the trays filled up so quickly and caused handling problems for the staff.

6.3.4. Furnished cages for growing rabbits

Very few studies have been carried out in growing rabbits although in the common "all in, all out" farm system (see chapter 5), it is obvious that the use of the same cages for does and growing rabbits require a coordinated approach in the whole farm (Mirabito, 2002).

Growing rabbits reared in pens with tunnels used the tunnels for 1 or 2 weeks after weaning (Postollec *et al*., 2002). Maertens *et al*. (2004) compared pens of 34 rabbits at a space allowance of 17 rabbits/m² without enrichment with pens of 17 rabbits (8.95 rabbits/m²) with straw, a hiding box and raised platform. They noted that the box was mainly used shortly after weaning whereas the platform was visited more frequently in the second part of the growing period.

Preliminary results on the effects of a raised wire-mesh platform in cage used by Mirabito *et al*. (1999a) have been reported by Jehl *et al*. (2003) and Postollec *et al*., (2003). These two studies lead to contradictory zootechnical results: in the first study, daily growth rate (GR) in furnished cages of 10 rabbits was equivalent to the GR in a conventional cage of 6 rabbits, whereas GR was significantly reduced in furnished cages in the second study. The use of the platform also varied perhaps due to small differences in cage design e.g. height of the platform, and the way of housing the kits before weaning (conventional or furnished cages).

6.4. Group Housing

6.4.1. Non-lactating females

Several references have dealt with the possibility of group housing adult female rabbits (Love, 1994; Huls *et al*., 1991; Bigler and Oester, 1993; Chu *et al*., 2003 for example) but group-housing males seems to be impossible. For non-lactating pair housed females, it was found that the animals usually spend around 20-30% in contact with each other and showed less "abnormal" behaviour, but it was not abolished. Most authors reported that aggression can occur between females and, in several studies, some pairs have had to be separated. Furthermore, when the choice was given to females between pens (group vs singly housed), they tended to prefer a solitary pen whatever their social rank (Held *et al*., 1995). In the experience of one Working Group member, non-lactating does housing in pairs leads to few scars and aggression, and reduced stereotyped behaviour (exerience with some thousand lab rabbit pairs, so far, in several countries).

6.4.2. Breeding does

Under farm conditions females are rarely not lactating (less than 1 week in 6) and so it is difficult to extrapolate from the results obtained in non-lactating laboratory does. However, group-housing of breeding does was investigated at the beginning of the modern rabbit husbandry methods as it was less time consuming than single housing, but, at the end of the 1970s this practice ceased because of behavioural problems and poor productivity (Lecerf, 1982). Aggressiveness of males against kits and unproductive females due to mating preference of males were mentioned as main problems for this group housing system.

Group housing breeding rabbits can permit the expression of natural reproductive and maternal behaviour, and several studies have recently been carried out to investigate the potential benefit for rabbit welfare. Stauffacher (1988, 1992) proposed a system of housing in 2m by 4.5m enclosures designed to accommodate 1 male and 4 to 5 females. Generally speaking, these enclosures comprised two areas, one for feeding (containing food and drinking troughs and straw racks) and one for breeding (with litter on the floor and nest boxes), and the enclosures also contained various enrichment structures (shelters, platforms, etc). To assess social behaviour, 6 groups were observed for eight 24h periods. The animals spent 50% of their time close together and, among the does, there was a linear hierarchy as the male appeared to have a moderating effect on the aggressive interactions between females. Interaction between adults and kits were instigated for the most part by the latter and where attempts at suckling were observed, the does' reaction was to move away from the kits. Maternal behaviour was examined in 6 groups over fifteen 24h periods. Stauffacher (1988, 1992) reported that does seemed to have a clear preference for certain nesting sites and that competition could arise if two does were at the same stage of lactation. In 4 cases out of 44, dominant females gave birth in nests that were already occupied, and in 69% of cases the rabbits blocked the entrance to the nest with any straw that was available. Subsequently, females spent 99% of their time away from the nest. No aggressive behaviour by adults towards kits was observed. After emerging from the nest, interaction was initiated for the most part by the kits and in 63% of cases suckling resulted from repeated attempts by kits. In the 9 groups studied, the fertility rate was 89%, and there were 795 live births from 94 litters with an average number of weaned rabbits of 7.1 per litter.

This housing system has also been used by others (Drescher and Reichel 1996) proposed a modification so that female rabbits could be reared in pairs, in two cages fitted with a platform and joined at the back. Mirabito (2003; *et al.,* 2005a) recently assessed these two housing arrangements under normal farming conditions (42-day rhythm and artificial insemination) and compared them with animals housed in individual cages (61x46x29cm). All females were provided with straw at all times. Six series of females were monitored throughout their first 4 breeding cycles in an experiment involving 29 pairs, 19 enclosures-groups and 27 single cages. While fertility and prolificacy were unaffected by housing arrangements, the mortality of nursing kits was considerably higher in the group enclosures containing 4 individuals (ranging from 13 to 23% depending on the cycle) than that recorded in individual cages (3 to 16%) or pair-housing (6 to 17%). These deaths, which mainly occurred before 18 days, could be put down for the most part to the large number of multiple births in the same nest (32.5% of births took place in a box where a doe had already given birth and, in more than 6% of cases 3 does gave birth in the same box). Prior to the tests Mirabito 2003; *et al.,* 2005a) tried to divide the kits into a number of different boxes but this strategy was unsuccessful because does would not leave their original nesting site. Furthermore, despite the fact that tunnels in front of each box and straw were provided, no attempts to seal up the nests were observed. Lastly, it seems that one criticism about this system was rearing future breeding rabbits as in order to form social groups as early as possible, young female rabbits were reared together. Unfortunately, this resulted in a high number of fighting injuries leading to abscesses, and one-third of rabbits had to be culled. Enlarging the rearing cages, installing raised platforms, using straw as oral enrichment, and providing rabbits with toys had no remedial effect on this aggression.

Mirabito (2003; *et al*. 2005b in prep) assessed behaviour (7 sequences of 20 minutes spread over a 24h period) every week during the first breeding cycle in 9 four-rabbit enclosures, 9 pair-cages and 18 single-cages. The type of housing had an influence on posture and females housed in pairs lay on their sides more often, a posture commonly seen on platforms. Similarly, the height of the cage used for groups enabled rabbits to sit up on their hind legs for 1.4 to 1.8% of the time. Lastly, in enclosures, does spent 2.7% of their time moving about compared with 1.2% in paired cages and 0.6% in single cages. Females housed in groups of 4 interacted more frequently with their nest boxes (around twice as often) than those housed in other types of enclosure. On the other hand, suckling attemps of kits were less frequent among females housed in pairs (0.1% of the time) than in other types of housing (0.3 to 0.4%). In the 4-rabbit enclosures, does spend 30% of their time together whereas in paired cages, this was only 0.8% of the time. Furthermore, in 2 out of 9 pairs, there was a situation of mutual exclusion, in which each female remained in its own cage. Only 1 in 9 pairs of does shared the space, spending equal amounts of time in each compartment. In the 6 other pairs, there were varying degrees of dominance by one animal over the other and, in one extreme case, the subordinate rabbit was confined to the lower part of its cage – a situation which prompted the investigators to cull some of the pairs over the course of the experiment.

There was a degree of distortion between the results of the two studies described above, which may be due to the type of housing tested (different enrichment structures), the nature of the social groups examined (presence or not of a male) and the test conditions. Nevertheless, the high level of mortality of kits in the enclosure mentioned by Mirabito (2003; *et al.,* 2005a) confirmed previous impressions of farmers. These experiments show that number of animals/m² independently of their age (weight) does not give a good guide. Expressing density as kg/m² is an improvement to indicate maximum load before welfare problems occur.

Recently, in the Netherlands the "Stauffacher group housing system" has been adapted with an individual electronic nest box recognition system to solve the problem of multiple litters in one nest (Ruis and Coenen, 2004). The hygiene of the first prototype did not reach the desired standards. The second prototype could solve this problem with comparable productivity to individual housed females (Rommers et al., 2005a). However, the prevalence of moderate and more severe skin lesions in some groups revealed that aggression had become a problem (Ruis et al., 2005; Rommers et al., 2005b). Apart from the high technological input and risks of aggressiveness, the authors also mentioned that the system has to be adapted to current management techniques (batch production, AI) before it can be considered as a real alternative to the regular individual housing.

6.5. The layout of space

6.5.1. General considerations for young rabbits

The main questions raised relate to the notion of available space and the possibility for rabbits to show "normal" locomotive behaviour (Lehmann, 1989; Stauffacher, 1992) and development (Drescher, 1992).

Only a few studies have been conducted on the rabbits' 'needs'. Lehmann (1989) compared the locomotor behaviour of rabbits aged from 38do to 92do housed in cages (45x40X28cm) and kept in pairs with the behaviour of rabbits in semi-natural conditions (enclosure of 600m²). He concluded that locomotion was less frequent in cage, 'hopping' behaviour was interrupted and the ability to perform this behaviour after 92do is reduced and, furthermore, bone integrity was altered. Bessei (1997), using operant conditioning, concluded that rabbits preferred space was between 545cm² and

3150cm². Matics *et al*. (2004a), using a free choice design with four cages of either same area (first trial: 500x750 mm) or different sizes (second trial: 500 x 300 – 600 - 900 - 1200 mm) with swing doors between them, recorded the choices of different groups of rabbits varying in number (18 to 30 and 8 to 24) and space allowance (12 to 20 rabbits/m² and 5.3 to 16 rabbits/m²) between 3 weeks (at weaning) and at 10wo. In the first trial, rabbits huddled together in just one of the cages. In the second experiment they preferred one of the smallest cages reaching a space allowance of 60-70 rabbits/m² and only a few of them chose the largest cage. After 5-6wo they began to spread into all of the cages, however, the preference for the smallest cage was significant until the end of the experiment.

6.5.2. Growing rabbits

6.5.2.1. Space allowance and productivity

The effects of density during the growing period have generally been assessed in groups of varying size (between 6 and 10 animals) with densities ranging from 12 to 28 animals per m². From the zootechnical viewpoint, Maertens and De Groote (1984), compared groups of between 3 and 6 rabbits (space allowance of between 11.6 to 23.2 in cages of 60x43 cm), and showed a reduction in daily weight gain and feed intake at 19.3 and 23.2 rabbits/m² versus 11.6 and 15.4 rabbits/m². This reduction was only significant in the last weeks of the growing period and therefore these authors calculated the space allowance in terms of weight per m². Once the weight was over 40kg/m², feed intake dropped and, as a consequence, so did weight gain. In another experiment (Maertens and De Groote, 1985), used larger cages (76x60 cm) and compared groups of between 7 and 9 (space allowance ranging from 15.4 to 19.7 rabbits/m²) and did not observe any effect on daily weight gain or feed intake. They explained the absence of any effect by the difference in total available area (functional area) indicating that in larger cages (pens) higher densities can be housed before overcrowding led to reduced productivity.

Aubret and Duperray (1992), using cages of 46x77cm with between 6 and 10 rabbits per cage (i.e. space allowance ranging from 16.9 to 28.2 rabbits/m²) observed a reduction in the growth rate when densities were greatest (more than 19.8 rabbits/m²) and in the daily feed intake when they were more than 22.6 rabbits/m². More recently, Trocino *et al*. (2004) compared two space allowances (12.1 and 16 rabbits/m²) in groups of 8 rabbits (110x60 and 100x50cm) and did not observe any effect of space allowance on the growth rate (GR) or daily feed intake (DFI), nor on bone integrity (tibia and femur dimension and resistance to fracture). Verga *et al*. (2004a) compared groups of between 2 and 4 rabbits (9.5-14.3-19.1 rabbits/m²) and also did not observe any effect of the three space allowances studied.

Since young rabbits like to huddle together, the higher space allowance in younger age groups had no significant effect on growth traits. If the number of rabbits per cage was doubled from normal (6 vs 3 or 4 vs 2 in cages of 40x30 vs 40x25 cm) in the first part of growing (between 3 and 6 weeks), and then the larger groups were halved afterwards, the weight gain, feed intake, feed conversion and mortality did not differ from rabbits reared the usual way (as a 3 or 2) during the whole growing period (Rashwan *et al*., 2003; Matics *et al*., 2004a).

All the previous studies have been made with small or medium groups of rabbits and there are few studies looking at the effect of space allowance in larger groups. Lambertini *et al*. (2001) compared the production traits of rabbits housed in two cages

(42x30cm) with those of rabbits housed in littered-pens of $1m^2$ at two space allowances (combined with group sizes of 8 and 16). These two experiments differing in their use of an antibiotic treatment during the second experiment. During the first experiment, they observed significant decreases in daily weight gain and feed intake of the rabbits housed in littered pens but they also showed a three times higher mortality in the pens with the higher space allowance compared with pens at the lower space allowance. Conversely, during the second experiment, they observed a significant decrease in growth rate in the pens with lower space allowance compared with the pens with higher space allowance.

6.5.2.2. Space allowance and behaviour

Morisse and Maurice (1996) analysed the effect on animals' behaviour of four densities (15.3, 17.8, 20.4 and 23 rabbits/m^2, corresponding to 6, 7, 8 and 9 animals per cage). Observations were made in 3 cages per trial over 24h periods when the rabbits were 6 to 10 weeks old. At 6 weeks of age, the space allowance had no effect, but at 10 weeks, animals housed in enclosures with lower densities (<17.8) exhibited more social behaviour, whereas in cages with higher densities, "comfort" (body care) and "exploration" (related to cages) activities tended to increase while locomotor activity tended to decrease. However, Trocino *et al*. (2004) analysed the behavioural time-budget in 57 and 68 day old rabbits (24h video recording of 16 cages) and did not observe any difference between the two space allowances evaluated (12 and 16 rabbits/m^2). In smaller groups, Verga *et al*. (2004a) reported that rabbits housed two per cage at 9.5 rabbits/m^2 exhibit less resting behaviour than those housed at 3 or 4 per cage at space allowances of 14.3 and 19.1 rabbits/m^2.

6.5.2.3. Group size and productivity

The experiments described above varied usually in both space allowance and group size and few studies have been designed to investigate these two factors simultaneously. Xiccato *et al*. (1999) compared productivity in rabbits raised in individual cages and in groups (3 rabbits per cage) at two densities (12 and 16 rabbits/m^2). In the 2 group cages, they recorded a reduction of 3% in final live weight, and in food consumption compared with individual cages. In cages with two (3 commercial models) and six rabbits (space allowance of 18.4-19.5 in pair cages and 17.4 in cages with 6 animals), Mirabito *et al*. (1999b) obtained an overall significant decrease in growth rate and daily feed intake in the smallest groups but, as they observed different results with the three models tested, they linked this result with the design of the cages and the feeding method. Luzi *et al*. (2000), comparing rabbits housed in pair cages (40x30 cm) and in six rabbit cages (40x90 cm) at the same space allowance (16.7 rabbits/m^2), did not observe any difference in daily weight gain between weaning and 90 days. However, when the rabbits were 120 do, they noticed a significant decrease of growth rate in the group of six rabbits.

Rommers and Meijerhof (1998) reported that variations in larger group sizes from 6 to 54 animals (at a density of 17 rabbits/m^2) had no effect on growth rate or food consumption, or on the frequency of injuries at 10 weeks. However, the proportion of injured animals was twice as high at 80do compared with 70do. The latter result differed from that of Bigler and Oester (1996), who had recorded a significant rise in the number and severity of injuries as group size increased.

Martrenchar *et al*. (2001) compared rabbits housed in groups of 6 or 24 at the same density (cages of 77x51x30 cm and pens of 160x100cm with 15 rabbits/m²) and found that 65% of the animals in groups of 6 had no ear injuries compared with 93% in the groups of 24. However, these authors link this result with problems of overcrowding in cages rather than problems of fighting between animals. They also noted a reduction of 2% in the final weight and an increase of femur diameter of the rabbits housed in groups of 24 while breaking strength was not affected. In a comparison of animals housed in groups of 4 and 30 (at the same density of 15.5 rabbits/m²). Maertens and Van Herck (2000) noted a 4% reduction in final weight and also in daily food consumption in groups of 30 compared with groups of 4. In another experiment using the same housing type, Maertens and Van Oeckel (2001) recorded a 5% reduction in the final weight of the larger groups. Jehl *et al*. (2003) compared groups of 6 rabbits, 10 rabbits (cage with platform) and 45 rabbits in pen at the same space allowance (17 rabbits/m²). They noted a significant reduction of 8% in the final body weight in pens. These authors also noted a significantly higher level of mortality in pens (18% vs 4% in a cage) and linked this observation to a greater and faster spread of disease inside the pen. In a similar experience with three groups of rabbits (cage of 6, cage with platform of 10, pen of 60 rabbits, all treatments at 15 rabbits/m²), Postollec *et al*. (2003) observed a significant reduction of 8% in the final body weight of rabbits housed in pens compared with cages of 10 rabbits, but they did not observe any difference in the mortality rate.

Princz *et al*. (2005) compared the performance of rabbits housed in pens (13 rabbits/0.83 m²) with those in cages (2 rabbits/0.12 m²). The body weight at 11wo was 3% lower, the weight gain and feed intake were a little lower, and the feed conversion was significantly higher in the pens. The mortality and dressing out percentage were similar. The frequency of ear lesions was higher in pens than in cages (11.9 vs 5.6%) but by inserting a wooden stick onto the wall the ear lesions could be reduced significantly.

Some other studies have tested the effect of group size of rabbits during growing with conflicting outcomes. Van der Horst *et al*. (1999) obtained a significant decrease in body weight at slaughter age in rabbits housed in a wire-mesh pen of 64 rabbits at a space allowance of 8 rabbits/m² (half of the pen indoors and half outdoors) compared with rabbits housed in wire-mesh cages of 7 rabbits at a space allowance of 16 rabbits/m². Dal Bosco *et al*. (2000, 2002) reported a significant decrease in daily weight gain and feed intake and increase in mortality in littered-pens at a space allowance of 10.1 compared with pair wire mesh cages with a space allowance of 17 rabbits/m². However, in a second experiment, they used a wire-mesh pen that also lead to a decrease in productivity compared with the cages (Dal Bosco *et al*., 2002). Metzger *et al*. (2003) compared groups of 3 rabbits in wire-mesh cages at a space allowance of 18.7 rabbits/m² with groups of 80 rabbits in littered-pens at a space allowance of 8 rabbits/m², and showed a decreased body weight and increased mortality at slaughter age in the pens.

6.5.2.4. Group size and behaviour

Xiccato *et al*. (1999) compared productivity in rabbits raised in individual cages and in groups (3 rabbits per cage) at two densities (12 and 16 rabbits/m²). However, such small variations in group size did not result in major changes in locomotive behaviour (probably as the animals had too little space in which to express their normal locomotory behaviours). When comparing groups of 2 and 6 rabbits, Mirabito *et al*. (1999b) recorded the time-budget of rabbits by direct observation during the light period. They reported that, in groups of two rabbits, the resting time was increased only during the last week of the growing period while the other activities (locomotor, exploration, social) were more frequent in groups of six rabbits during the first and last week of the growing period. To assess the behavioural consequences of increasing group size (6 vs 24), Martrenchar *et al*. (2001) carried out observations of 6 and 9 week-old rabbits for two 24h periods. At 9 weeks of age, the time devoted to rest decreased in the groups of six rabbits while the time spent eating and interacting socially increased. The time spent on locomotory activities did not vary according to the type of housing. However, at 6 weeks, the number of "multiple hops" was higher in pens than in cages whereas, at 9 weeks of age, the number of single hops was higher in the cage. The frequency of abnormal behaviour was unaffected by the housing system.

Dal Bosco *et al*. (2002) carried out direct observations of the behaviour of rabbits at 6 and 10 weeks of age during the light period in cages of two rabbits and pens of 100 rabbits. They reported that, in pens, rabbits exhibited more comfort, social and locomotor behaviours, and less rest and feeding activities. Postollec *et al*. (2003) carried out observations on groups of 6, 10 (with platform) and 60 rabbits but did not report any variation in the average time-budget during the whole growing period in their three housing systems. However, they noticed that in 51% of "focal 10min samples observations" on penned rabbits, the animals expressed behaviours such as running and hopping. In cages with six and ten animals, they expressed this behaviour in 30% of the sequences and this difference was significant from the groups of 60 rabbits. It should be noted, however, that in half of the enriched cage of ten rabbits, the platforms were probably too high (38cm vs 30cm) to permit rabbits to express their behaviour as some other results have lead to different conclusions (Jehl, personal communication).

6.5.2.5. Cage height, productivity and behaviour

There have been no studies on the effect of cage height for growing rabbits. In open pens (without a top), Martrenchar *et al*. (2001) reported that rabbits showed "standing up" behaviour for <0.7% (and less than 0.4% in a cage) of their time and that, in cages, the full posture was never observed. Time budgets do not always reflect what animals find important as a behaviour that may occupy only a few seconds per day, may still be important to the animal.

Recently, Princz *et al*. (2005) have tested the preference of young growing rabbits in a similar design as described for Matics *et al*. (2004a). The rabbits were housed in cage-blocks (2m²) divided into 4 cages varying in heights of 20, 30, 40 cm and an open-top. They reported that, during the whole experiment, the fewest rabbits were observed in the open top (less than 17%) and the choice of the other cages seemed to depend on the activity so that when the animals were active they chose the higher cages but the lower heights at rest. The preference of higher (open-top) or lower cages was independent of space allowance (16 or 12 rabbits/m²).

6.5.2.6. Cage shape, productivity and behaviour

Cages can be square or rectangular and this may influence what behaviours rabbits are able to perform. Towards the end of the growing period as the rabbits get bigger if the cage was rectangular rather than square it would permit them to carry out certain behaviours such as stretching and hopping. This would require between 40 and 100cm depending on the husbandry system being used (see Chapter 5, Table 5.2). Lehmann (1989) found that in cages of 40x45cm with 2 rabbits, they had reduced locomotor behaviour (mainly "hopping") and showed some bone disorders. Martrenchar *et al*. (2001) found that, in cages of 77x51cm, rabbits at 9wo were able to hop but that when they were housed in pens of 160x100cm they could carry out a number of sequential hops (Martrenchar *et al*., 2001). Furthermore, there were slight differences in bone integrity between the two systems. Based on these two studies, we can assume that reduced length of cage has a negative effect on the welfare of rabbits and in growing rabbits a minimum of 75-80 cm is required for most of the growing period.

6.5.2.7. Cage size, productivity and behaviour

If a cage, say of 1m², is divided up then the functional space, that is the space that can be used by the rabbits, is decreased. Some experiments have been carried out looking at the effect of cage size, number of animals and space allowance in terms of kg/m² on diversity of behaviour, productivity and mortality. When similar work was carried out in pens (i.e. cages with no tops) the effects were different. The effect of the functional space is presented in Figure 6-1 and Table 6-1. When the same area is divided into small cages (e.g. 4), the maximum load/cage before overcrowding effects were observed was 4. When this same area is divided into 2 cages, up to 10 rabbits could be housed before overcrowding was observed. This means that the total functional space available is an important factor apart from stocking density (number of animals/m²).

Figure 6-1. 3 Model Cages in 1m² and maximum load

<table>
<tr><th colspan="2">A</th><th colspan="3">B</th><th>C</th></tr>
<tr><td>4 rabbits</td><td>4 rabbits</td><td rowspan="2">6 rabbits</td><td rowspan="2">6 rabbits</td><td rowspan="2">6 rabbits</td><td>10 rabbits</td></tr>
<tr><td>4 rabbits</td><td>4 rabbits</td><td>10 rabbits</td></tr>
</table>

(Source Maertens et al, 2004)

Table 6-1. Space allowances in 1m² according figure 6.1 and maximum load

Variable	A (4 cages 50x50cm)	B (3 cages 33,3x100cm)	C (2 cages 50x100cm)
Rabbits/cage	4	6	10
Rabbits/m²	16	18	20
Kg/m²	40	45	50

(Source Maertens et al, 2004)

Table 6-2. Comparing 3 model of cages in 1m²

Model	Cages in 1m²	Dimension	Rabbits/cage
A	4	50x50cm	4
B	3	33,3x100cm	6
C	2	50x100cm	10

(Source Maertens et al, 2004)

Because of the overall increased availability of space even though the space allowance is the same, it has the effect of increasing the space that can be used by each rabbit, and it is more likely that the animals are able to carry out their behaviours, with no loss of productivity. The original figures from Maertens et al (1984, 1985) and Morisse and Maurice (1996) may well have been related to the cage size in which these experiments were conducted. However, Morisse and Maurice (1996) also showed that in bigger cages not only was the functional space increased, but so too was behavioural diversity and productivity up to 40kg/m². This may well be important for young rabbits that need space to play. No research has been carried out on cages larger than 1m².

Normally litters of rabbits are partially kept together in groups in the same cage from weaning to slaughter and so after weaning they have sufficient space to carry out a range of natural behaviours. However, as the rabbits grow bigger towards the end of the growing period, so the space they require to carry out the same behaviours will increase in terms of height and area. This will also be influenced by the age at which rabbits are slaughtered.

6.5.2.8. Space allowance based on metabolic weight

Taylor (1985) has stressed that many biological characteristics of mammals, mainly the ones related to growth and feed efficiency, were similar when animals were compared at the same state of maturity. To do this he used a metabolic time scale proportional to the metabolic weight of the animal rather than to body weight. Moreover, maintenance needs of mammals and consequently heat losses also depend on metabolic weight. As an additional source of information to determine space allowance, it seems reasonable to calculate the surface needed for growing animals as a function of their metabolic weight. Behavioural needs, however, may lead to different space allowances.

Based on the recommended density of 40kg/m² coming from the experiments detailed in Section 6.5.2, we calculated a constant based in the metabolic weight of the rabbits:

$$K = \frac{W^{0.75} \times N}{L \times Wi} = 33 \quad \text{(kg of metabolic weight / m}^2\text{)}$$

Where ***W*** is weight of each rabbit at slaughter time, ***N*** number of animals per cage, ***L*** length and ***Wi*** width of the cage. Then, taking a fixed length of 0.80m, which is within the interval of the minimum length recommended, and taking the number of animals per cage, and the commercial weights of the animals (see Table 4.8), we can calculate the width of the cage as follows.

$$Wi = \frac{W^{0.75} \times N}{L \times K}$$

and then the surface of the cage recommended for each different case. This allows us to present some examples of cages in Table 6.3, showing examples of different cages for different body weights of rabbits at slaughter time and number of rabbits per cage. Width and surface were calculated according to a minimum recommended length and metabolic weight density (kg/m²) (see text).

Table 6-3. Examples of different cages for different Body Weight.

Body Weight Kg	Number Rabbits	Length m	Width m	Surface cm^2
2	7	0,80	0,44	3520
2,5	7	0,80	0,52	4160
3	7	0,80	0,60	4800
2	8	0,80	0,50	4000
2,5	8	0,80	0,60	4800
3	8	0,80	0,69	5520
2	9	0,80	0,57	4560
2,5	9	0,80	0,67	5360
3	9	0,80	0,77	6160

(Source Taylor, 1985)

6.5.3. Breeding animals

Breeding males

There is no information available that specifically applies to breeding males. However, due to the increased use of AI (see Section 8.2) perhaps 80% of farms, keeping males on farms is less common than a few years ago. Nevertheless, there is still cause for concern for those breeding males at the semen collection centres as well as the farms that still use natural mating.

Breeding females

There is little information on the effects of cage area for breeding females but it has been suggested that by Drescher (1992, 1996) that cramped conditions (in terms of surface area and height) could lead to deformations of the vertebral column and osteoporosis. However, this work has been criticised (Lebas, 2000b) and these conclusions may be flawed due to an inadequate diet and also no controls were run at the same time. Moreover, culled breeding females on farms today do not show osteoporosis, broken bones or deformations of the vertebral column and so in practice it is not seen as a relevant practical problem. Nor is it seen in breeding males.

6.5.3.1. Breeding does. Effect of the cage size and height on behaviour and productivity

Krohn *et al*. (1999) recorded the behaviour of 3 month old non-lactating rabbits housed singly in cages of 2800 cm^2, 5600 cm^2 and a littered-pen of 3.5 m^2. There were differences in behaviour between pen and cage (higher frequency of exploratory and lower frequency of abnormal behaviour in pens), but they did not report differences between the two cages except that abnormal behaviour was less frequent in the smallest one.

Rommers and Meijerhof (1997) looked at the effect of cage area (6000cm^2 and 3000cm^2), cage height (50cm and 30cm) and cage floor type (wire and alternative) on the performance of does during four cycles of reproduction. Standing on the hind legs was 5 times less in the standard cages with a height of 30cm compared with cages of 50cm, most probably due to the lack of space. They observed few effects on productivity but, on average, there was an increase in the number of kits born in the larger cage and in the taller cages, but the differences were only significant during the third and fourth cycle of reproduction. Furthermore, the number of kits born alive only increased in the higher cage during the fourth cycle, due to high levels of mortality at birth in the other cases. Finally, they observed a positive effect of increased area and height on the number of kits weaned during the first cycle, and of increased height on the weight of the kits weaned during the first and second cycles.

Mirabito *et al*. (2004) carried out a similar experiment by testing the impact of three cage areas (included the nest box) (3420 cm^2, 4508 cm^2, 5880 cm^2) in combination with two kinds of enrichment (a platform in types 1 and 2 and a plastic tunnel in type 3 – see above); all cages were 60cm high. They measured the performance of the does during 5 theoretical cycles and did not observe any difference between the six treatments in term of fertility, prolificacy, mortality and growth rate of the kits. Time-budgets showed there were no differences between the six treatments except in cages with platforms, where does spent 4 to 15% of their time stretched out, and 10 to 25% of their time in the other cages. Conversely, in the furnished cages they adopted a posture on the platform in a sternal position with legs partly under the body. The authors related this choice to the space available on the platform. However, the cage area did not seem to have any impact on the posture of the females.

There has been little work on the length and width that a cage should provide for animals, but the experience of the working group would suggest providing a minimum of 65-80cm in order for adult rabbits to lie out and 38cm for them to turn round and to groom comfortably. However, adult animals would not be able to carry out other behaviours such as hopping.

6.6. Risk questions related to housing

6.6.1. The impact of flooring on welfare

Background and definition

In rabbit farming, buildings and equipment e.g. cages must enable the animals to live in good conditions of hygiene and not cause any traumatic injuries. In particular, floors and platforms (when present) shall be of an appropriate design and material suitable for the breed as well as for the size, age and weight of the animals. In current rabbit farm practices, wire mesh flooring is usually adopted (see Section 5.4). Alternatives to wire flooring have been sought and tested.

Recognition of poor welfare: diagnosis and incidence.

The presence of inadequate flooring in adult rabbits is mainly revealed by the occurrence of sore hocks and bacterial lesions (e.g. mastitis) caused by *S. aureus* (see Chapter 11).

In suckling rabbits lesions (mainly bone fractures) can be observed when the design of wire mesh floor is inappropriate (see Section 6.2.1).

In growing rabbits inapproriate flooring is reflected by an increase in enteric disease with clinical signs of diarrhea and mortality (see Section 6.2.2).

Exposure factors

Faulty mesh floors can lead to serious injury so it must be closely inspected and maintained to ensure that there are no loose or sharp projections, or loss of zinc-coating.

The presence of residual of droppings due to insufficient cleaning could be source of transmission of pathogens (virus, bacteria and parasites).

Consequences for animal welfare
The disadvantages of wire flooring are many; e.g. they are uncomfortable for resting and locomotion and they may lead to paw lesions, which can be painful and become infected (see Chapter 11 Sore Hocks).

Other floor types (e.g. litter) have been shown to cause hygiene problems and to be enabling factors for animals to develop enteric disease. In particular eating unsterilised materials (es. straw and hay) may pose a health risk due to easier transmission of pathogens. Productivity can be adversely affected.

Good agricultural practices
Appropriate floors that do not cause harm to the paws, and that allow species specific locomotion of the does and pups, as well as fatteners, and that do not get too dirty.

Appropriate flooring will cause no discomfort, distress or injury, and form a rigid, even and stable, but not slippery, surface.

Floor should be well drained in order to remove urine, droppings and spills of water, without health hazards to other animals.

6.6.2. The impact of restricted space and social isolation on welfare

Background and definition
Cages by their very nature will restrict the space in which rabbits are able to carry out their natural behaviours. A requirement under the Convention on Farmed Animals (see Articles 3 and 4: European Convention for the Protection of Animals Kept for Farming Purposes. Strasbourg, 10.III.1976) is to limit any restriction that may cause unnecessary suffering, in accordance with established experience and scientific knowledge.

Recognition of poor welfare: diagnosis and incidence.
Animals kept in restricted and unenriched conditions are more likely to show stereotypic behaviours. They may be unable to groom, turn round, perform some hopping steps, lie out flat with legs extended, and sit up with ears erect.

Exposure factors:
Barren does, future breedering stock, and male rabbits are frequently kept in small cages on their own.

Consequences for animal welfare
Not meeting the behavioural needs of rabbits and restricting their behaviour may cause mental distress (suffering) involving feelings such as boredom, frustration, and social isolation.

Good agricultural practices
Keeping such animals in large cages will help avoid some of this suffering.

6.6.3. The height of growers' cages

Background and definition

Growers are normally housed in cages with a height between 28 and 35 cm (See Chapter 5). Such cages have one level floor and no raised area. There are no published data available about the minimum height to allow the growers to sit, or to move or to stand with ears erect. The WG assumed that below a weight of 1.5 kg, 30 cm allows these behaviors but above 1.5 kg this height becomes limiting. Rabbits rear up, if possible, for only a limited time (0.4 –0.7% of their time budget: (Martranchar *et al*., 2001). No published data are available about the minimum height but the WG assumed after visual observation that up to a weight of 1.5 kg a minimum height of 30 cm would be acceptable, and up to 2.5 kg a height of 40 cm is necessary for this behaviour. Growers show preference for cages with limited height during the resting period and increased height during the active period (Princz *et al*., 2005).

Recognition, diagnosis, incidence

Growers are not able to sit up with their ears erect, nor "stand up", nor to jump

Exposure factors

The hazard increases with increasing weight (age) of the growers

Consequences for animal welfare and productivity

Growers are limited in their ability to express natural behaviors
Growers like to have an area with low height during their resting time
Deformations of vertebral column are not mentioned in the literature
Productivity is not affected by the height of the cages

Good Agricultural Practices

Height of cages to permit the expression of natural locomotory behavior
Cages or housing facilities with different utilisable heights.

6.6.4. The available surface area of growers' cages

Background and definition

Growers are normally housed in cages with a surface area per animal of between 450 and 600cm² (see Chapter 5). When housed in small groups the total area available (functional space) does not allow rabbits to express normal behaviours such as hopping - a single hop for a 2.0kg rabbit requires at least 70cm. Other locomotory behaviors and gamboling (multiple hops) are also very restricted. In small cages with limited surface area per rabbit, less comfort behaviours, as well as fewer social and locomotory activities are seen, but increased rest and feed behaviours have been observed. However, when rabbits are housed in large groups the available space for each rabbit increases and so a broader range of space occupying behaviours is permitted. There are also effects of stocking density on productivity.

Recognition, diagnosis, incidence

Reduced locomotory behaviour
Rabbits are unable to lie 'all-together' at rest
Overcrowding expressed as increased aggression (fur plucking, skin lesions, e.g. scrotal injuries in males)

Exposure factors:
The hazard (small surface area) increases with increasing weight (age) of the growers.
Because of the limited functional space and lack of retreat areas, the hazard higher in small than in large cages

Consequences for animal welfare and productivity
Growers are limited in their behavioural repertoire e.g. locomotory behaviour
With only a limited surface area, rabbits show more apathy and aggression
Clear stereotypies due to a limited available space are not observed
Productivity is lower when the surface area is low compared with a large functional space with a greater surface area per rabbit is available. In small cages, densities above 16 rabbits/m² or under 625cm² surface area per animal, show a reduced daily weight gain once the total weight exceeded 40kg/m². In larger cages (and in pens), only above a density of around 19 rabbits/m² or when the weight exceeds 45kg/m², such negative effects have been observed.

Good Agricultural Practices
Rabbits are social animals and when housed in groups the functional space increases and allows more space to express their locomotory behavior at the same surface area per rabbit.
Because growers are housed in the same group size from weaning until slaughter, the minimal surface area has to reflect the needs of growers at the end of the fattening period.
At least one side of the cage should have a dimension of 75 - 80cm.

7. NUTRITIONAL ASPECTS

This chapter deals with the rabbit's digestive system, nutritional requirements, and their diet and management. The relevant question for this risk assessment is whether there is an impact of feeding practices according to the various housing and husbandry systems on the health and welfare of the animals.

7.1. Digestive system

Rabbits are strict herbivores and consequently well adapted to high-roughage diets. Their digestive strategy is uniquely different from ruminants because they eliminate fibre from the gut rapidly, which allows the digestive processes to breakdown the non-fibre constituents (see later). Once the rabbit has reached the age of 4-5 weeks, there is a rapid increase in the functional capacity of the caecum and colon. The digestive system is almost fully developed by 8-9 weeks of age (Carabaño and Piquer, 1998). The average retention time of a balanced rabbit diet in the digestive tract is between 18 and 20h (Gidenne, 1992), but the stomach of a rabbit is never completely empty, and even after a fast of 24h, it is still half full of digesta.

7.2. Digestive process

After digestion in the small intestine the undigested fraction enters the caecum, where the microbial population aids digestion and releases additional energy, amino acids and vitamins. However, because of selective separation in the proximal colon, fibre is rapidly eliminated, and fermentation processes breakdown the non-fibrous constituents in the caecum. Apart from the carbohydrate fraction, the nitrogenous material entering the caecum is catabolised by proteolytic bacteria and the main end product is ammonia, which is used for microbial synthesis and has a good biological value. Microbial protein represents about 20% of the total daily protein intake in rabbits. Finally, microbial activity is also responsible for the synthesis of Vitamin K and B-complex vitamins.

Without these processes, the end products of caecal fermentation would be lost with the excretion of the faeces. The continuous distal contractions in the colon lead to the accumulation of large particles (>0.3 mm) in the lumen, while small particles and fluids accumulate in the haustra of the proximal colon. These larger fibre-rich particles are excreted in the normal faeces of the rabbits and due to an anti-peristaltic action in the haustrae, the finer particles and fluids move continuously back to the caecum (Ruckebush and Hörnicke, 1977). This mechanical separation depends on the feeding pattern. In *ad libitum* fed rabbits, the anti-peristaltic movements disappear during the morning until 14.00-15.00h and so caecal contents now enter the proximal colon and covered by a mucous envelope. This excretion is soft and is called 'soft faeces' or 'caecotrophs'; their content of electrolytes and nitrogen is much higher than in hard faeces while their fibre content is lower.

These soft faeces consist of small pellets and are excreted as a cluster that rabbits recognize. They take the caecotrophs directly from the anus (caecotrophy) and swallow them without mastication, where they reside intact in the stomach until the mucus is degraded. They then mix with other digesta and follow the normal digestive processes. Rabbits will not normally eat hard faeces or soft faeces that have dropped on the bottom of the cage, consequently, keeping rabbits in wire cages has no effect on caecotrophy (Carabaño and Merino, 1996).

7.3. Feeding behaviour

During the first 20 days of life, does nurse their kits only once or twice daily. With increasing age, the mother's milk does not cover the requirements for growth and the kits start to eat solid food changing from one to several feedings a day. This transition period in rabbits is short and depends on the weaning age. By 28d of age, milk represents only 20% of the total dry matter (DM) intake, while at 5 weeks milk intake is minimal and the kits are virtually weaned (Fortun-Lamothe and Gidenne, 2003).

Adult and growing rabbits fed *ad libitum* consume feed in 20-30 meals (feed and water), usually utilizing 3 to 4h/day for feeding. The number of meals is somewhat larger in young animals near to weaning time, than in adults. The intake pattern depends on light cycle and is concentrated in the late afternoon and night. The large number of meals reduces competition among animals at feeders and drinkers, and so under *ad libitum* feeding conditions, a ratio of growers to feeding places 3:1 is sufficient (Maertens, 2001).

7.4. Nutrient requirements

Rabbits fed a dry feed have a water requirement that exceeds their dry matter (DM) intake and the ratio of feed to water consumption is approximately 1:1.7. In young rabbits this ratio is somewhat lower while in adults this ratio is near to 1:2 under moderate temperature conditions. If water is not available, feed intake drops quickly and will stop within 24h. Restricted drinking water or limited drinking time leads to a reduced feed intake that is directly proportional to the amount of water consumed (Szendrő, 1997).

When fed exclusively on green forage, drinking water may not be required, however, rabbits should always have free access to drinking water because they regulate their water intake according to the feed and the environmental temperature.

Dietary recommendations have been recently summarised by Lebas (2004), and dietary fibre requirements to prevent digestive troubles have also become available (Gidenne, 2003). Besides low-digestible fibre, necessary to maintain gut motility, a sufficient quantity of digestible fibre is required for optimal fermentation and reduced health risk (Gidenne, 2003). The Vitamin A requirement is largely met if the diet contains 10,000IU per kg or 30ppm of ß-carotene. The dietary recommended Vitamin D level is 800 to 1000IU/kg (Lebas, 2000). The water-soluble vitamins (B-complex and C) are normally synthesised by the rabbits' digestive flora. In cases where there is a high risk of digestive disorders, dietary supplementation may be advisable (Lebas, 2000).

7.5. Feedstuffs for Rabbits

Rabbit diets usually contain a wider range of feedstuffs than other animal diets. The greater complexity is the result of the combination of energy sources, protein concentrates, and fibre sources to ensure optimum performance and, in addition, to minimize digestive disorders. Feed grains are widely used as a source of energy: barley and wheat are the most used but also oats, corn, sorghum, and triticale (wheat and rye cross). The higher resistance of cornstarch to intestinal digestion has been linked with a carbohydrate overload in the caecum and large amounts in the diets for young rabbits are not desirable. Grain milling by-products can be used to up to one third of the diet and they provide some fibre and an important part of the dietary protein.

Cassava meal and sweet potatoes can be substituted for grains, but they have a high-starch content. Beet and citrus pulp are also energy sources as they have high digestibility of their fibre fraction. Both by-products can be incorporated in rabbit diets up to 20% but their fibre content should be disregarded when calculating the low digestible dietary fibre requirement.

Protein supplements used in rabbit diets are nearly exclusively of plant origin. The most common are sunflower meal (fibre-rich), soybean meal and rapeseed meal (canola meal). Caution should be taken when feeding cottonseed meal because it contains high levels of gossypol, making the diet unpalatable and toxic. Problems related to rapeseed meal are minimum with the decreasing levels of erucic acid in the new varieties. Peanut meal, and sesame meal are known sometimes to contain high levels of aflatoxins, which are highly toxic to rabbits. Full fat soybeans and lupine beans are used but some raw beans have been reported to affect animal performance due to their high content of anti-trypsin and other growth-depressant compounds; appropriate heat treatment inactivates these compounds.

Forage is used in rabbit diets mainly to provide dietary fibre. It can be directly incorporated into a completely pelleted feed or be used as a complement to pellets. It is more convenient from the point of handling and monitoring of animal intake to include forage in the pellets. However, in some situations, direct use could be more convenient, as in case of small enterprises. When given separately from pellets, it is better to offer fresh forage in the form of hay to avoid feeding of mouldy batches.

The most widely used fibre source in rabbit feeding is alfalfa and this legume also provides an important part of the protein and calcium (Ca) in the ration. Caution should be taken with when using very young alfalfa as it is rich in protein (>20%) but quite low in lignocellulose. Clovers and dehydrated grass meal can substitute alfalfa meal.

Alternative fibre sources are sometimes used to fulfil the Acid Detergent Lignin recommendation. Hulls from sunflower seeds, oats, rice and soybean or flax chaff, straw and grape seed meal can be used for this purpose but they will markedly dilute the energy content of the diet.

7.5.1. Additives

Additives are currently used in rabbit diets especially for disease control. The authorisation and use of additives for use in animal nutrition is regulated by Regulation (EC) 1831/2003 which establishes several categories of additives (i.e., technological, sensory, nutritional, zootechnical and coccidiostats and histomonostats) according to its main function. Antibiotics for use as growth promoters will be forbidden as of January 2006. The category “zootechnical additives” includes, amongst others, the functional groups digestibility enhancers and gut flora stabilisers.

Young rabbits are very susceptible to coccidiosis and so it is common to include an anti-coccidial substance in their diet, but its use should be clearly stated in the specific labelling. Attention has to be drawn to the sensitivity of rabbits for ionoforous coccidiostats and contamination with even small amounts reduces feed intake and can cause death.

Rabbits are very sensitive to enteritis and preventive therapies more acceptable to the consumer (i.e. not antibiotics), are on the market to combat sub-clinical enteric diseases. Probiotics, supplements that contain beneficial live or reviable (organisms that are added in spore form and becomes "alive"under favourable environmental conditions, e.g. the gut) microorganism or contribute to the maintenance of the flora equilibrium (gut flora stabilisers), are not always beneficial and they cannot be used to treat highly pathogenic agents, but they may well be useful complementary treatments.

7.6. Diet Presentation

In intensive rabbit production dried and ground raw materials are used to prepare balanced compound diets. These concentrated diets are generally pelleted because rabbits show a strong preference for pellets over the same diet in meal or mash form. Significantly lower amounts are consumed on meal diets, resulting in lower weight gains, inferior feed efficiency and also lower slaughter yield. When offered a choice between meal and pellet form, 97% of total feed intake was taken as pellets (Harris *et al*., 1984). Other benefits of pelleting are comparable with those for other animals: separation of parts of the diet or selection between the different raw materials by animals is impossible thus ensuring a balanced dietary intake. Furthermore, higher amounts of by-products can be fed, feed wastage is minimal, dust problems in the rabbitry are reduced, and automatic or semi-automatic rabbit feeders work more easily with pellets than with meal or mash. In intensive rabbit meat production, a pelleted balanced diet is the basis for meeting nutrient requirements for maximizing biological performance. All "alternative" methods e.g. meal, mash, roughages, mixture of raw materials etc., decrease the daily dry matter intake. Most of these methods are labour consuming because they have to be fed daily, are difficult to distribute automatically and, therefore, are not suitable for large-scale production.

7.7. Grinding and Pelleting

The raw materials used in rabbit diets come in very different preparations; some of them are available in pellet form (e.g. dehydrated alfalfa) others as a fine meal (e.g. cassava meal) or as grain. In order to have a homogenous mixture and to facilitate the pelleting process, grinding the raw materials is necessary.

The technique of grinding of raw materials for rabbit diets has been the topic of much discussion. The presence of a large amount of very finely ground particles is not desirable in terms of dietary safety and fibre sources have to ground with caution. However, when commercial screens (3mm - 7mm) are used in a mill, differences in particle size are small and no effect on retention time or health disturbance was detected (Lebas *et al*., 1986). The preferred length of pellets is between 8 and 10mm. If longer, there is a higher risk of breaking during handling and so losses of single pellet and their fragments are more frequent through the mesh floor. Optimal pellet diameter is in the range of 3-4mm, and above 5mm, the risk of pellet wastage increases. Small size (diameter < 2.5mm) tends to decrease the feed intake probably due to increased feeding time.

Pellet durability and hardness are the major quality characteristics of rabbit pellets as rabbits do not eat the fines from broken pellets. Several types of device for measuring pellet quality have been used by the industry. Generally these devices can be classified into those testing the resistance of pellets to crushing (hardness), or fragmentation when rubbed or shaken (durability). The pneumatic-powered hardness testers determine the power (in kg) for crushing pellets. Although this method is quick, sufficient pellets (> 10) have to be tested in order to have a good repeatability. Testers using a motor drive instead of manual handling are preferable because they exclude effects due to the operator. Under correct processing and handling conditions, less than 2% of "fines" may be produced in quality pellets during transport, in silos or bags and in tubes and rabbit feeders.

Molasses is known as a good pellet binder and is commonly used at a dietary level of 4-6%.

7.8. Feed Storage

With increasing size of rabbit breeding units, feeds are mainly delivered in bulk. Packaging in bags is still used for small units or for special feeds (e.g. weaning diet). Storage time should be limited to 3 - 4 weeks, particularly with outdoor silos. If stored in a dry location, rabbit feed with a DM content of at least 89% can be stored for several months, which leads to fewer dietary changes during an animal's growing cycle. Cages should have feeders of a sufficient size to contain at least the quantity consumed daily. When using automatic feeding, tubes supplying a number of cages rather than individual feeders are used. In such a system, feed is distributed several times per day. Although it is claimed that rabbits eat more when fresh feed is served, no experiments have demonstrated this (Maertens and Villamide, 1998).

7.9. Diets distribution

With increasing knowledge of the specific requirements of the different categories of rabbits, a series of diets could be proposed. However, because of practical considerations and the relatively small differences in nutrient concentrations between different diets, the number of diets is generally limited. In practice, 2 or 3 silos (diets) are economically optimum for a middle-sized rabbitry, otherwise the quantities involved are too small to operate with a bulk feeding system. Furthermore, automatic or semi-automatic feeding systems are increasingly being used in large units and this does not easily allow for the distribution of different diets to different categories of animals. However, rabbit management is changing from individual handling to a batch system and in this way animal in the same reproductive phase or at the same age are grouped together in one building or battery and such a management system would permit the use of phase feeding programmes.

7.10. Risk Questions related to Nutrition

7.10.1. Impact of poor nutrition on welfare and health

Background and definition

The nutritional requirements of rabbits are quite well known and can be fulfilled if a balanced diet is fed (De Blas and Wiseman, 1998). Under commercial rabbit breeding conditions, rabbits are exclusively fed with a pelleted diet. Rabbits are strict herbivores and consequently well adapted to high-roughage diets. They produce two types of faeces: hard and soft, and the soft faeces (caecotrophs with caecal content) are systematically taken directly from the anus and ingested to obtain the nutrients that have been produced in the large intestine (caecotrophy).

Rabbits are mainly fed a fibrous diet (15-18% crude fibre) *ad libitum* because they regulate their intake according to the energy content of the diet in order to achieve to a constant daily energy intake. Rabbits consume feed in 20-30 daily meals (feed and water), usually utilizing 3 to 4h/day for feeding. Rabbits fed a dry feed have a water requirement that exceeds their dry matter intake and the ratio of feed to water consumption is approximately 1:1.7.

Recognition of poor welfare: its diagnosis and incidence.
Poor body condition due to an unbalanced diet or insufficient quantity of feed
High morbidity or mortality due to poor nutrition causing enteric disease and animal losses

Exposure and predisposing factors:
Group: Reproducing and lactating females and kits after weaning are particularly susceptible

Husbandry (poor management):

- Too rapid a change of diet or in food composition
- Ad libitum feeding may overload the gut
- Unbalanced diet in terms of fibre provision
- Inefficient watering system e.g. blockages
- Insufficient number of feeding places leading to excessive competition at the feeder
- Bad presentation of diet with meal or fine accumulation in the feeder leading to reduced feed intake

Housing:

- Poor design of cage feeders and watering equipment

Consequences for animal welfare
Animals may end up in poor body condition
Animals may suffer from enteric disease
Reduced productivity (e.g. milk production with an effect on kit nutrition) is likely to result, poor fertility.
Empty does may suffer hunger when diet restriction is used as a therapy

Good agricultural practices
Complete diets should be formulated and prepared according to scientific recommendations.
The presentation of the diet should be in pellets of 3-4mm diameter that contain only a small amount (<2%) of fines. The accumulation of fines in the feeders will block the feeder thus depriving rabbits' food.
Lactating females and growing rabbits should be fed ad libitum
Ratio of rabbits: feeding places should be at least 3-4:1 for group housed animals
Water should be continuously available *ad libitum*.
Diet should be in accordance with the diseases prevalent on the farm e.g. additives, composition.

7.10.2. Impact of dietary toxins on health and welfare

Background and definition

Mycotoxins are metabolites produced by certain fungi on standing or from harvested crops. They can also occur on stored grains, forages and on other raw materials and feeds because of non-hygienic storage conditions. Feeding rabbits on mouldy diets is responsible for many problems such as decreased feed intake, functional alteration of liver, kidneys and genital tract, causing adverse changes in blood constituents (Abdelhamid, 1990).

Rabbits are very sensitive to aflatoxins and the acute oral single-dose LD50 (0.3mg.kg-1 body weight) is among the lowest of any animal species (Lebas *et al.*, 1998).
Fusarium species produce different toxins as Zearalenone (F-2 toxin), T-2 toxins and vomitoxin. Vomitoxin above 1mg/kg causes a slight decrease in feed intake (Verdelhan *et al.*, 2001).

Recognition of poor welfare: its diagnosis and incidence.

The clinical signs can be acute, subacute or chronic depending of the toxin, dose, age of animal,
Clinical signs after introducing of a “new” feed
Decreased feed intake, bad growth or even weight loss
Diarrhoea and mortality
Hypertrophic development of the genital tract of the female
Renal damage with tubular dysfunction and necrosis

Exposure factors:

The use of mouldy diets
Harvesting or storing raw materials in poor conditions
Storing of diets under bad conditions
Poor hygiene on the farm

Consequences for animal welfare

Reduced productivity
Animals suffering recognised as enteric disease and various pathologies

Good agricultural practices

Use only high quality raw materials
Mouldy raw materials or diets have to be destroyed
Feeds have to be stored under good (dry) conditions
Special attention for moulds if forages are fed; it is better to offer fresh forage in the form of hay and so avoid feeding mouldy batches.

7.10.3. Impact of feed additives on health and welfare

Background and definition

Several additives are used in rabbit diets to improve certain characteristics, to enhance animal performance and to reduce the incidence of disease (coccidiosis), such as preservatives, acidifiers, pellet binders, flavours, oligosaccharides, enzymes, pre- and probiotics and coccidiostats.

The use of coccidiostats as feed additives is widespread in rabbit production (robenide and salinomycin are used and are the authorised). However, some ionophores are toxic for rabbits (Maduramicine, Narasin) and contamination with feed from other species can cause toxicity (Peeters *et al*., 1993). As stated above (Section 7.5.1) antibiotoics used as "growth promoters" will be banned by the EU legislation after 31/12/2005. (EC 1831/2003). The use of enzymes is of particular interest as they may enhance dietary digestibility and health of young rabbits (Gutiérrez *et al*, 2002a,b). Oligosaccharides, pre- and pro-biotics are used to improve gut health, however, results are not always consistent (Mateos and De Blas, 1998).

Recognition, diagnosis, incidence of poor welfare

Intestinal coccidiosis is one of the most important diseases affecting young rabbits particularly and the dietary use of coccidiostat substances for growers is widespread.
Cross-contamination with ionophores can cause mortality and morbidity
Excessive coccidiostats dosing can cause a reduction in feed intake
Problems with the use of oligosaccharides, pre- and pro-biotics are not commonly acknowledged.

Consequences for animal welfare

Anticoccidials can improve health and performance in affected farms
For some additives a withdrawal period has to be observed
Ionophores can seriously impair the animal welfare by a reduction in feed intake and toxicity

Good agricultural practices

Avoid cross contamination with feed from other species
Only use recommended dosages
Observe the withdrawal period

8. REPRODUCTIVE STRATEGIES

This chapter deals with the rabbit reproduction. The relevant question for this risk assessment is whether there is an effect of reproduction practices according to how the various housing and husbandry systems impact on the health and welfare of the animals.

Young does of intensive breeds and hybrids are first inseminated at the age of 4-5 months, when they reach about 75-80% of their adult weight (Lebas *et al.*, 1997).

8.1. Natural mating

Natural mating is only used on a minority of farms because it is time consuming, otherwise artificial insemination is used.

8.2. Artificial insemination

Artificial insemination (AI) has become a routine practice in industrial rabbit production (Carluccio *et al.*, 2004). The technique offers significant benefits, including genetic selection, prolonged fertility even during unfavourable times of the year, cycled production, more efficient breeding programmes, and improved health monitoring (Bergonzoni *et al.*, 1994).

AI in rabbits is generally performed with 0.5ml of extended (diluted) semen. While, theoretically, it is possible to obtain 30-40 doses per ejaculate, in everyday practice it is preferable to have a dilution rate from 1:5 to 1:15 that equates to 10-15 doses/ejaculate, containing at least 10 million viable spermatozoa (Castellini and Lattaiolli, 1999). Semen must be used within 36 to 48 hours after collection and dilution (with the media currently employed), and it is kept at 18C (15-20C) until use (Boussit, 1989, Egea *et al.*, 2000). Using fresh semen taken from bucks of different hybrids has laid the foundation for the establishment of AI centres, so rabbit breeders buy and use the semen to suit their female stock and their production goals.

The use of AI in industrial rabbit production has created the need for pharmacological induction of ovulation, which is easily achieved by an intramuscular injection of around 1.6µg GnRH synthetic analogue (Mollo *et al.*, 2003). Artificial insemination and GnRH treatment have no adverse effects on the biology and welfare of the rabbit does other than in its administration.

Using single batch management all does on the farm are inseminated on the same day and AI is repeated on 11, 18 or 25 days after birth using a 42, 49 or 56day interval between births. On some farms, females are divided into two groups and in this case does are inseminated every 3 weeks. On large farms with e.g. more than 15,000 does, a group of does will be inseminated every week.

Theau-Clément and Roustan (1992) showed that there was a particularly strong inverse relationship between lactation and reproductive function. During lactation there are high prolactin levels (Fuchs *et al.*, 1984) that exert a hormonal antagonism on gonadotrophin release (Fortun-Lamothe and Bolet, 1995) thus inhibiting ovarian follicle development (Hamada *et al.*, 1980).

8.2.1. Oestrous synchronization

To solve the hormonal antagonism between prolactin and gonadotrophin and to increase the receptivity of does, the use of a PMSG (Pregnant Mare Serum Gonadotrophin) 2-3 days before AI, usually at dosage of 20 to 40 IU/animal (Stradaioli *et al*., 1997), became widespread (Maertens and Luzi, 1995). PMSG stimulation shows a positive response on receptivity (Maertens *et al*, 1983), and on conception rate (Khalifa *et al*., 1990), as well as on litter size (Bourdillon *et al*., 1992). However, some authors have stressed some disadvantages. Boiti *et al*. (1995) found an increase in anti-PMSG antibodies in does repeatedly treated with PMSG and with an increasing number of PMSG treatments, its efficacy is reduced (Bonanno *et al*., 1993). However, this effect is affected by parity (age) that can also reduce conception rate (Castellini, 1996).

PMSG treatment may be connected with:

- An abnormal ovarian response - a higher number of cystic and haemorrhagic follicles (Boiti *et al*., 1995);
- Lower numbers of embryos;
- A reduced conception rate (Garcia-Ximenes and Vicente (1992);
- Abnormal distribution of litter size with higher percentages of too small and too large litters with a high mortality at birth (Maertens and Luzi, 1995); and
- A reduction in milk production (Bonanno *et al*., 1995).

These disadvantages are recognised (as well as EC policy regarding meat residuals and animal welfare) and the need to maintain a "natural" image of rabbit meat. All these factors will probably lead to a reduction in the use of PMSG and it is for these reasons that alternative methods are being developed such as biostimulation.

8.2.2. Biostimulation

Several approaches have been tried such as animal manipulation, controlled lactation, feeding programmes, shearing of does during the hot season, feeding programmes, and buck effect. The results of biostimulation are summarised below according to the reviews of Castellini (1996), Boiti (1998) and Theau-Clément (2000).

8.2.2.1. Animal manipulation

A change of cage of nulliparous does before AI can improve fertility and increase litter size. In contrast, transferring does and their litters into another cage produced no improvement. Gathering does (3 or 8/cage) immediately before AI gave contrasting results: in one experiment fertility increased, while in the other performance did not improve (Castellini, 1996). Overall, the efficiency of animal manipulation has not been clearly demonstrated and in any event these biostimulation methods are time consuming and difficult to manage on large farms.

8.2.2.2. Dam-litter separation

It is well known that shortly after weaning, a high percentage of does come into oestrus. However, during lactation, a short period of dam-litter separation (DLS) has potentially been shown to induce oestrus. Since rabbit farms generally use a 42-day rhythm (batch management), most of the studies have been based on this cycle. In some cases a 24h DLS just before insemination improved the sexual receptivity and fertility of lactating does but other studies showed no improvement in fertility. Litter size, however, was not affected in these experiments. Using longer separation (36-48h) fertility improved significantly, but litter size increased in only one case (Boiti, 1998). A single dam-litter separation at insemination can improve further productivity of lactating does. When free nursing and a 42-day reproduction rhythm are used, the DLS could be a real alternative to hormonal (PMSG) treatment for inducing oestrus synchronisation and improving productivity (fertility). Nevertheless, the positive effect of such a biostimulation is not clear when controlled nursing is applied (Theau-Clément, 2000).

Although the 36-48h single DLS (applied before an 11-day post partum AI) increases the fertility rate of free-nursing does, it reduces the growth rate of litters (kits). That is why a splitting of DLS was applied by Bonanno *et al*. (2004), Eiben *et al*. (2004) and Matics *et al*. (2004b). In the group with split DLS, free nursing (the door of the nest box is opened for 24 hours) was changed to controlled nursing (the door of the nest box is opened for 10-20 minutes a day in the morning) 2 or 3 days before AI. Fertility appeared to be improved (Bonanno *et al*., 2004; Eiben *et al*., 2004) and litter size was increased (Eiben *et al*., 2004; Matics *et al*., 2004b).

There is general agreement that neither the incidence of mastitis nor the young rabbit mortality is affected by a short DLS. However, weaning weight was decreased because of one nursing omission. One nursing omission is not necessarily against the welfare as litters isolated from their mother and deprived of one nursing show the normal pattern of behaviour (sleeping kits covered by hair in the nest), and 2 days after last being nursed they were able to nurse normally (Hudson *et al*., 1996). It seems that the effect of a biological clock on active and resting periods is more important than the hunger that might be caused. Moreover, the short interruption in the DLS (from free nursing to controlled nursing) might be considered a valid alternative strategy for improving the reproductive performance of does without any serious negative effect on growth of kits and their welfare.

8.2.2.3. Short term feeding programmes

Stimulation with an increase in pre-mating energy intake has a positive effect on receptivity and fertility on many farm animals, however, food restriction has a detrimental effect on sexual receptivity and litter weight. In one experiment, a 4-day ‘flushing’ with a high energy diet just before AI on lactating does failed to improve sexual receptivity, fertility or litter size (Maertens, 1998). These results were explained by the low palatability of the experimental diet. In another study, ”flushing” using propylene glycol increased fertility but did not have any effect on litter size (Luzi *et al*., 2000).

Feeding programmes are well adapted to a cycled production and are easy to apply but, at the present time, the experimental results are not compelling enough to adopt them in practice.

8.2.2.4. Lighting

Wild rabbits have a well-defined seasonal cycle of reproduction and fertility improves with increasing day length. By modifying the lighting programme from 8h light/day to 16h light/day, 8 days before AI, an improvement in sexual receptivity and fertility was found (Theau-Clément, 2000). In contrast, no modification in reproductive performance was observed if the lighting was changed from 10h light/day to 16h light/day 4 days before AI (Maertens and Luzi, 1995). In all these light experiments, litter weight was lower in the treated group suggesting that the lighting programme can adversely affect the milk production of does. Overall, these results show the need for studying the effect of photoperiod on the performance of rabbit does, as lighting programmes are easy to apply, do not need increased labour costs, and are well suited to cycled production systems.

8.2.2.5. Other methods

According to some experimental results there is a buck effect (putting males in a cage in a row of does' cages some days before AI) but it was not significant on reproductive performance (Kustos *et al*., 2000; Eiben *et al*., 2001). The same results were found if rabbit does were sheared 2 days before AI in the hot season (Szendrő *et al*., 2004).

8.2.3. Risk questions related to reproduction strategies

8.2.3.1. Is welfare jeopardised by intensive breeding systems?

Background and Definition

The interval between parturition and re-mating (or insemination) defines the description of the farming system as intensive, semi-intensive and extensive. Rabbit females are ready to accept a mating immediately after parturition, and mating at this time is termed "intensive". When a female is re-bred (or inseminated) during lactation, the breeding system is called "semi-intensive". If the female is re-bred after weaning of the kits, then this is an "extensive" breeding system. The period between birth and insemination is critical for the doe and if misused can exhaust females if they are not given time to recuperate and this is the hazard that can result in poor welfare.

In commercial rabbitries, 80-90% of breeders follow a 6 week reproduction cycle with re-breeding of the females 11 days after parturition (Castellini, 1996). In the wild during the breeding season does would normally be re-bred immediately after kindling so it can be argued that rabbits have evolved to survive in this way and intensive breeding is not against the biology of the female rabbit.

Recognition, diagnosis, incidence of poor welfare

Poor condition of females
Weak maternal behaviour (e.g. nest building)
High mortality in females
Short reproduction life
Poor milk production
High kit mortality

Exposure Factors:

Unadapted strain under sub-optimal housing and feeding conditions
Short interval between weaning and next parturition
Young females used in intensive systems
Too early breeding of young females
Unit infected with pasteurellosis

Consequences for animal welfare

Females in poor body condition
High culling out percentage of females
High mortality rate of females
Reduced productivity (e.g. reduced number of weanlings per female per year).

However, an adapted strain under good housing and feeding conditions can support a short remating interval (Nicodemus *et al*., 2002).

Good agricultural practices

Increasing the breeding interval between parturition and next insemination when females are in poor condition

Do not breed primiparous females immediately after parturition

Reduce litter size (and as a consequence the burden of milk production) of primiparous females by fostering kits onto multiparous does.

Do not breed young females before they reach 80% of expected adult weight

Maintain breeding does on a high energy and protein diet when used in intensive or semi-intensive breeding systems.

8.2.3.2. Is welfare affected by hormone treatments?

Definition and background

Several hormone treatments are applied to rabbits under commercial farming conditions:

a) As rabbits are reflex ovulators (ovulate in response to natural mating) they require a hormonal induction (LH analogue by injection or hCG or GnRH) of the ovulation (Castellini, 1996) when artificial insemination is used. LH analogue induces the ovulation comparable with the mating effect.
b) As females in commercial rabbitries are inseminated groups at fixed intervals, an oestrus synchronisation programme is necessary, that can consist of an injection of PMSG (FSH) hormone 2 days before the insemination followed by a further treatment with LH at AI (Maertens *et al*., 1995; Alfonso and Pages-Mante, 2002; Mollo *et al*., 2003). PMSG treatment induces oestrus.
c) $PGF_{2\alpha}$ has a luteolytic effect and induces oestrus, simultaneous injection will lead to oestrus synchronisation (Facchin *et al*., 1992; Castellini, 1996; Boiti, 1999; Mollo *et al*., 2003). This treatment has to be used for pseudopregnant does, for mated but empty females >18 days after parturition.
d) Oxytocin and $PGF_{2\alpha}$: are sometimes used together to induce parturition with a subsequent post-partum oestrus.

Recognition, diagnosis, incidence of poor welfare

Lameness may be seen after intramuscular injection.

Poor body condition of does if used inappropriately

Exposure factors:

Artificial inseminated herds use these procedures

Low fertility in the herd.

Consequences for animal welfare:

Treatment with LH analogue replaces the natural ovulatory stimulation by the male and the impact on the hormonal balance is limited.

Females treated with PMSG are forced to cycle although they can be physiological in anoestrus.

PMSG treatment increases the variability in litter size. It can increase litter size but also the number of still-born.

Oxytocin treatment of females that have not yet littered 24h after the expected parturition increases the survival chances of kits and does.

Intramuscular injections should be done skilfully (e.g. avoiding nerves, maintaining good hygiene) and done with the advice of a veterinary surgeon. Poorly administered injections are painful and, if badly positioned, can cause lameness.

Good agricultural practices

Females in good body condition have a higher incidence of oestrus during lactation and so there is less need for oestrus induction etc.

Alternative methods (see biostimulation) instead of PMSG treatment may be used to synchronise oestrus.

Re-inseminate non-pregnant females 2-3 days after weaning when natural oestrus occurs.

8.2.3.3. Is poor welfare associated with artificial insemination?

Definition and Background

From the late eighties, artificial insemination (AI) has been commonly used in European commercial rabbit production (Castellini, 1996; Theau-Clément, 2000). Insemination with single-use disposable pipettes or with multi-use glass tubes is deep vaginal and easy for trained persons. The inseminations are mainly carried out by the breeders or by insemination teams. Simultaneously with the AI, ovulation is induced hormonally (see Section 8.2.3.2). All females in a batch are inseminated, independently of whether they are in oestrus or not. The insemination is done with the female held in the lordosis position and takes only a few seconds.

In order to minimise the work and to manage the farm in an efficient and economic way, a so called cycled production is applied: all does in the same batch are inseminated on the same day whatever their sexual receptivity.

Recognition, Diagnosis, Incidence of poor welfare

Vaginal perforation

Blood at the vulva after AI

Frightened females

Genital diseases, sometimes due to *P. multocida* or *Staphylococcus* or other opportunistic bacteria, could be a consequebce of poor AI technique (e.g. contaminated instruments, poor hygiene).

Exposure factors:

Using AI in stock with poor health status, in poor body condition, and under bad environmental conditions (feeding, housing).

Poor hygiene conditions when using AI

AI not carried out by a skilled person.

Consequences for Animal Welfare

When competent and trained personnel carry out the AI, the incidence of injury is low.

Insemination is carried out with females restrained in a lordosis position. It is quick but the welfare aspects have not been investigated, however, stress is likely to be less if done by skilled persons.

Numerous reports have indicated that comparable productivity is obtained with AI as with natural mating.

Good agricultural practices and Recommendations

AI is a skilled procedure and should be carried out with the advice of a veterinary surgeon and only by competent, trained personnel maintaining a high standard of hygiene and taking care to avoid injury and unnecessary disturbance of the females.

Single use pipettes or sterilised glass tubes should be used in order to avoid the transmission of infections.

8.2.3.4. Is poor welfare caused by biostimulation

Definition and Background

Rabbit females do not always have a clear and regular oestrous cycle. Moreover with the 'batch' management oestrous synchronisation is required for successful reproduction efficiency. As an alternative for hormone treatments (see Section 8.2.3.2) different biostimulation methods such as feeding programmes, lighting programmes and doe-litter separation can be applied (Theau-Clément, 2000). However for lactating does, the only practical and successful method is a temporary separation of mother from her kits. Numerous experiments have been carried out to study the impact of a 24 to 48h separation on the receptivity and fertility of females, and on the condition of the kits (Theau-Clément, 2000; Bonanno *et al*., 2004). Doe-litter separation is nearly always carried out before the intended insemination on day 11 post-partum. An increasing number of farms use the doe-litter separation (DLS) as an alternative method to PMSG oestrus synchronisation

Recognition, diagnosis, incidence of poor welfare

In case of doe-litter separation, the nest box is closed for at least one day and a female may repeatedly try to enter the nest box to nurse her kits.

Kits are active in the nest because they expect their mother and are probably hungry.

Exposure factors:

Females and kits are separated during 24 till 48 hours during the lactation.

Consequences for animal welfare

Rabbit does have limited contact with their kits and visit them briefly (only about 3-4 minutes) just once or twice a day in order to nurse (Hudson *et al*., 1996; Hoy and Selzer, 2002).

The doe may experience some frustration and discomfort through full mammary glands

A 24h separation does not appear to invoke stress or to have any impact on the kits.

When a longer separation is applied, females are stressed (they want to nurse their kits) and a 5-6% lower weaning weight of kits is observed (Maertens, 1998). Increased kit mortality due to dam-litter separation is not reported if carried out in the second week of lactation.

Recently, it has been shown that a split dam-litter separation of 48h just interrupted for a controlled lactation after 24h leads to comparable fertility results as a continuously split of 48h but without negative impact on kit weight. Using split DLS (the free nursing was changed to controlled nursing 2 or 3 days before AI) the fertility was improved and the litter size was increased as well (Bonanno *et al*. 2004; Eiben *et al*., 2004; Matics *et al*., 2004b).

Dam-litter separation has been shown to be a good alternative to PMSG treatment.

Good agricultural practices

For increasing receptivity, fertility and litter size a 36h single or 3-day split dam-litter separation or longer daily light (from 8 hours to 16 hours for one week) before insemination is suggested.

9. WEANING PRACTICES

This chapter deals with the rabbit weaning practices. The relevant question for this risk assessment is whether there is an impact of weaning practices according to the various housing and husbandry systems impact on the health and welfare of the animals.

9.1. Pregnancy

Pregnancy can be detected by palpation by an experienced person at the earliest 10-12 days after insemination. Other methods such as ultrasonography can detect pregnancy by day 7 after insemination (Gutiérrez et al, 2002) but are not used in commercial rabbit production.

9.2. Kindling

Rabbit does normally kindle 31-33 days after the mating or artificial insemination. Birth (kindling) occurs mainly during the night (Rashwan *et al*., 2003) and better monitoring and control could reduce kit mortality (e.g. kindling outside the nest box, poor quality of the nest etc). After kindling, the kits are counted, and dead kits and bloody nest material are removed.

9.3. Litter size

The average litter size is about 8-9 for a breed suitable for intensive farming, and 10-11 for a high prolific hybrid (Table 9.1).

Table 9-1. Reproductive performance of some hybrids and two breeds.

Traits	Hybrids and breeds		
	NWZ	Cal	Hybrids
Conception Rate, %	70-80	70-80	70-85
Litter size			
total	7-9	8-10	8.5-10.5
alive	7-8.5	7-8	8-10
at weaning	6-8	6-7	7.5-8.5

(Literature data)

An increase in litter size is accompanied by a decrease in average individual birth weight (Seitz *et al*., 1998; Poigner *et al*., 2000) as the degree of nutrient supply per foetus during the gestation period is more favourable in does carrying fewer kits. Increased mortality was observed in both very small and very large litters (Maertens and Luzi, 1995). In small litters the total litter loss is cause of mortality due to the bad condition of does or to poor kindling, whereas in large litters weak viability arising from low birth weight is responsible for the increased mortality (Szendrő and Barna, 1984).

During the lactation period, milk production of rabbit does is higher when the litter size is larger (McNitt and Lukefahr, 1990), but despite this young rabbits reared in larger litters have access to less milk, which leads to reduced weight gain (Polastre *et al*., 1992; Ferguson *et al*., 1997b). In a study involving high production does, Maertens and De Groote (1991) observed that from the 9th day of lactation the milk production of the doe could no longer meet the requirements of the nursing rabbits for maximal growth.

9.4. Fostering

Since the teat (nipple) number of does (8, 9 or 10) (Fleischhaner *et al*., 1985) and the milk production are limited, fostering (litter homogenization) is recommended (Poigner *et al*., 2000). Fostering kits from large litters onto small litters is a recognised procedure that has been used for a long time. Does accept without problems fostered kits. The application of this method serves the purposes of reducing mortality and balancing the weight differences between kits.

9.5. Nursing

The only food for young rabbits until they begin to consume solid feed (16-18 days after parturition) is dam's milk. At the beginning of lactation the daily milk production is 50-60g and at the peak 260-280g/day is reached on the 16^{th} – 20^{th} day of lactation (McNitt and Lukefahr, 1990). After peak lactation, the milk output of does that become pregnant immediately after kindling declines rapidly. Before 18 days of age, kits' feed is exclusively on the dam's milk and so their survival and growth depend on milk production and nursing ability of the does.

According to several authors (Hudson *et al*., 1996) rabbit does nurse their kits only once a day, whereas, some more recent results show 20-30% of does nurse twice or more a day (Hoy *et al*., 2000; Matics *et al*., 2004b). Nursing duration decreases from 4-6min to 2.5-3min at the same time as milk production increases from birth till the peak of lactation. This indicates that kits are increasing their rate of milk intake (Mohamed *et al*., 1992).

9.5.1. Nursing methods

Under normal environmental conditions, the doe visits her kits for only a few minutes to nurse her kits. However, a frightened doe (hearing a sudden noise or a human entering into the rabbitry at an unusual time) jumping into the nest may scatter and even trample her offspring, causing them considerable harm. To avoid this problem, it has been suggested (Szendrő *et al*., 1999, Baumann *et al*., 2005a,b) that entry to the nest box should be controlled and limited to only once a day for 20-30 min in the morning and then closed for the remainder of the day. Another way is to place the nest box away from the cage to reduce the repeated and unsuccessful nesting behaviour of the doe due to the permanent kit odour ( ). This is in contrast to the traditional, free nursing method. Nowadays it is possible to limit access to the nest box in the breeding cages and many breeders use it in the practice, even though the advantages of this method have not been confirmed in all cases. For example, Pizzi and Crimella (1985) showed no difference in mortality or in weight of kits between free and controlled nursing, whereas Costantini *et al*. (1986) found higher mortality in groups nursed only once a day. Coureaud *et al*. (1998) found controlled nursing more favourable during the first day after parturition, while free nursing was an advantage later on. In contrast, Szendrő *et al*. (1999) showed that free nursing was better in the first week after kindling but once-a-day nursing gave lower mortality until the kits were weaned. Furthermore, some observations show that free nursing is advantageous with primiparous does and controlled nursing was better with multiparous does.

9.5.2. Double nursing

An entirely new nursing strategy was presented by Spencer *et al*. (1985) when they reared young rabbits with two does in order to model overfeeding in human infants. McNitt and Moody (1988) and Szendrő *et al*. (2002) have conducted similar experiments. From these findings it was found that young suckling kits were indeed willing to suckle from two does, from one in the morning and from the other in the afternoon (or evening). This has been achieved by using a doe weaned at 21 days for a second nursing (Szendrő *et al.*, 2000) and in this way the kits had access to substantially greater quantities of milk; their weight gain in the first weeks of life increased and they reached the slaughter weight of 2.5kg, 5 to 6 days sooner.

An alternative was to try to increase kit milk intake by placing the mother of the litter into the nest box twice a day: once in the morning and again in the afternoon. Does adapted themselves easily to double nursing, but this method did not increase kit growth rate (Tudela *et al.*, 2002) and the same mortality was observed in the experimental as in the control groups.

9.6. Weaning

Weaning implies several different things. First, mother and kits are separated. Secondly, after nursing the kits start to consume only solid feed which eventually replaces nursing. Thirdly, the mother or the kits or both are moved to a new cage (environment).

9.6.1. Weaning age

Wild does may completely wean their kits at 23-25 days of age because they often mate soon after birth and give birth again in a few days (Hudson *et al.*, 2000). Therefore, early weaning would be more in accordance with wild rabbit behaviour than late weaning. Under field conditions, kits are usually separated from their mothers at 28-35 days of age. The weaning age depends on the re-mating interval (Lebas, 2000b). When does are pregnant immediately after parturition (intensive reproductive system), the kits have to be weaned at the age of 28 days because their mothers give birth some days later. If does are inseminated 11 days post partum (semi-intensive rhythm), the kits could be weaned at the age of 35 days, but the weaning age depends on the management of the farm as well. Using an all-in all-out method, the rabbitries are emptied on a regular basis.

Previous research showed a negative correlation between weaning weight and post-weaning mortality (Morisse, 1987; Lebas, 1993) and encouraged technicians and breeders to increase kit weight by delaying weaning age. Other studies conducted to increase the weight of kits for a given age, or by stimulating milk intake (Gyarmati *et al.*, 2000), or by increasing the intake of solid feed (Maertens and De Groote, 1990) have not proved practical on farms.

On the other hand, later experiments have proposed an earlier weaning age (Pascual, 2001), summarised by Xiccato and Trocino (2005).

9.6.1.1. Early weaning

Both kits and does may benefit from earlier weaning: the energy output for milk production for the doe and consequent body energy deficit might be reduced, and kit nutritional requirements might be better provided for through their solid intake of e.g. specific starter diets. It has also been hypothesised that pathogen transmission might be reduced by the shorter period of contact between litters and does. Genetic selection has been aimed at maximising doe productivity by improving prolificacy and milk production, without considering feed intake capability for the increased nutritional needs of pregnancy and lactation. At the same time, maximum doe exploitation was pursued by adopting intensive and semi-intensive reproductive rhythms. Under these conditions, rabbit does are usually found to be in a negative body energy balance at the end of the first lactation, as well as with higher parity. The most evident consequences of body energy deficit in the doe are reduced fertility and increased culling rate.

Different nutritional strategies aimed at stimulating dietary energy intake in reproducing females and therefore improving body condition have not produced positive results. Early weaning has been proposed as a means of reducing doe body energy deficit through the decrease of body energy demand for milk production by shortening the lactation period (phase of energy deficit) and the increase of body energy restoration by prolonging the dry period (phase of energy surplus).

As regards any effect on animal health, some authors have not observed significant correlation between weaning age or bodyweight and mortality in the post-weaning and growing periods, but no studies have actually looked at any welfare aspects of these procedures.

Before the age of 18 days, weaning requires special techniques such as the provision of artificial milk to be successful (Ferguson *et al*., 1997a). Weaning at 20-23 days is much easier to perform because kits are already eating solid food spontaneously. At this age however, milk still represents the main dietary energy source and kits begin to ingest increasing quantities of water and solid food only 24 hours after the last nursing. Xiccato *et al*. (2003) reported successful weaning at 21 days without any increase in mortality. When delaying the weaning age to 25-28 days, the stress caused by the change in feeding regime is further reduced. Feed intake was sufficiently high to permit the weaning at this age without any apparent problems for either kits or does in terms of their behaviour or health.

Weaning the rabbits at an even younger age is questionable. Artificial feeding of kits weaned at 14 days of age is technically possible (Ferguson *et al*., 1997a), although this method may not be economically feasible. In addition, a decrease in growth and survival is observed, and the high costs of artificial milk are further limitations of this method.

Weaning at a young age has advantages including less of a drain on the energy balance for the does and so the body condition of the doe is improved. There have been no specific welfare investigations. Moreover, the nutritional requirements of the kits are better met and kit mortality and digestive problems, often regardless of the weaning diet adopted, are reduced. Although current knowledge on protein, fat, fibre and starch supply appears sufficient for the formulation of starter diets adapted to early weaning, further research is needed for a better understanding of digestive physiology, and to define the nutritional requirements of young rabbits in order to reduce dietary disease and to improve growth performance (Gidenne and Fortun-Lamothe, 2002).

9.6.2. Weaning methods

After weaning, the kits are usually moved to grower cages but they can also stay in the breeding cages and the does are moved into other ones.

McNitt (2000) compared abrupt weaning at 28 days with the kits being moved to a different clean cage in another area of the rabbitry as opposed to phased weaning when the kits are reared in the doe's cage. The kits that had been weaned abruptly were heavier than those subjected to phased weaning. This may indicate that there is more stress involved in being in the doe's cage without the doe, than being separated from the doe and moved different cage. Similar results were published by Patton *et al*. (1986) who did not find any difference in weight gain between weanlings that were moved and those that remained in their birth cage. These results indicate that phased weaning of rabbits is counter-productive and that all changes (doe removal, cage change etc.) for the weanlings should take place at one time. It also seems that the most common practical method to move weaned rabbits to cleaned grower cages does not affect their productivity, mortality and morbidity. No specific welfare studies have been carried out.

9.7. Maternal behaviour

The limited access to the nest for the doe in rabbits farming may more closely resemble what happens in nature and limiting the does access to her kits has been proven to be useful in practice (Verga *et al*., 1986; Arveux, 1994; Hudson *et al*., 1996; Verga, 1997).

Maternal behaviour is affected by many internal and external variables, and some abnormal maternal behaviours have been observed in does such as excessive nest controls and stereotyped nest plugging behaviour when the nest entrance cannot be closed (Baumann *et al*., 2005a).

Cannibalism occurs when the mother, after swallowing the placenta also devours part of the kits. It may be related, for example, to mother's feed intake and body conditions (Hafez *et al*., 1966).

9.8. Risk questions related to weaning practices

9.8.1. What is the impact of poor nursing and inadequate milk supply on the welfare?

Definition and Background

Dam's milk is the only food for nursing until the age of 16-18 days. On the first day the milk production of does is about 50-60g and lactation reaches its peak at 18-20 days after parturition (McNitt and Lukefahr, 1990; Szendrő *et al*., 1999). This is the time when kits begin to consume solid feed. Rabbit does nurse their kits once a day (Hudson *et al*., 2000) or sometimes (20-30% of the does) twice or more times a day (Hoy *et al*., 2002, Matics *et al*., 2004b). The duration of one nursing event is about 2.5-3 min. Does' milk does not cover the milk requirement of their kits at the third week of life (Maertens and De Groote, 1991), thus, kits are starving because they are able to suck more milk every day (Szendrő *et al*., 2002). The growth and survival of kits are closely correlated with mother's milk production and maternal behaviour.

Recognition of poor and good welfare may be associated with nursing and with the milk supply of kits:

Poor welfare occurs when:

- litter size is higher than the teat number of the doe, as competition between kits is strong during nursing;
- smaller kits in a litter are in unfavourable position during nursing to reach a teat;
- does are nervous as maternal behaviour is weak;
- does are primiparous as milk production is lower than with older does;
- does are in poor conditions or have poor health as milk production and maternal behaviour are low;
- animals are under heat stress (e.g. hot climate and poor environmental control) as milk production is low;
- does carry or are suffering from a disease as they can infect their kits; and
- the energy balance of lactating does nursing a large litter is negative.

Good welfare occurs when:

- more milk is produced as with high productive breeds;
- large litters are nursed by multiparous does;
- does accept fostered kits;
- kits can be nursed by two does; and
- a comfortable nest box is available

Exposure factors

- Litter size is higher than 8 for primiparous – and 9 to10 for multiparous does.
- Unbalanced intra-litter homogenization.
- Birth weight is lower than 45g.
- Litter size is 2 kits larger than the number of teats. The most common teat numbers are 8, 9 or 10, but the average litter size of a high prolific hybrid doe is 10 or 11. So it could be 20-30%, but fostering solves this problem.
- The ambient temperature in the house is higher than 25C.
- Does have poor body condition or poor health status.

Consequences for animal welfare and productivity

Kits

All factors that negatively affect milk production or milk supply per kit (e.g. large litter size, small kits, and poor health) are likely to increase mortality or to decrease bodyweight gain of kits, and to affect their wellbeing. Before kits die from hunger and thirst their welfare will be affected as physiological needs are not being met.

Does

Large litters as well as high milk production negatively affect the energy balance of the doe and can be connected with lower productivity, higher culling rate and shorter productive life of the does.

Kits and does

Under higher temperature or when the does are fed an unbalanced diet the milk production of does as well as the milk supply of kits will be limited.

Good agricultural practices

- Equalization of litters according to the number and weight of kits.
- Avoid fostering from unhealthy does.
- Limitation of litter size to 8 for primiparous and to 9 to10 for multiparous does.
- Cull weak and unhealthy does.
- Cooling and heating systems to maintain appropriate environmental temperatures and relative humidities during hot and cold seasons.
- A negative energy balance for the does can be avoided by early weaning.
- To avoid the problem of nervous does (jump into the nest box) controlled nursing can be used.
- The milk intake of kits can be increased by better nutritional status of does (higher energy and protein content, fat supplementation etc.).
- Nursing kits by two does can be tested.

9.8.2. What is the impact of weaning on the welfare of the kits?

Definition and Background

Weaning is the act of permanently separating the kits from the mother and unlike other species used in farming, the young rabbits are separated from their dams at about the same time or later as in the wild. Wild rabbit does may completely wean their kits at 23-25 days of age (Hudson *et al*., 2000) but on farms the kits are usually separated from their mothers at 28-35 days of age for management reasons. When does are pregnant immediately after parturition kits have to be weaned at 28 days, whereas if does are inseminated 11 days post partum, the age of weaning can be nearer to 35 days.

Both kits and does may benefit from earlier weaning: energy output for milk production of doe and consequent body energy deficit might be reduced (Xiccato *et al*., 2004a,b), and kit nutritional requirements might be provided with better coverage through the administration of specific starter diets (Gidenne and Fortun-Lamothe, 2002). It has also been hypothesised that pathogen transmission might be reduced by the shorter period of contact between litters and does (Schlolaut, 1988). Sudden interruption in milk ingestion and a rapid increase in solid food intake stimulate digestive apparatus development and caecal fermentation activity (Kovács *et al*., 2004).

The reasons for weaning are:

1. doe kindles her next litter;
2. to promote the growth rate of the growing rabbits and to provide a suitable diet for both dam and kits;
3. to allow more room for the all the rabbits;
4. to avoid the stress of continual suckling attempts by kits on the pregnant doe;
5. to allow enough time for the doe to rebuild her body reserves lost after pregnancy and lactation;
6. sometimes when a doe attacks her kits it may be necessary to separate them; and
7. with early weaning the body energy losses of does can be reduced and the risk of diseases from doe to her kits is limited.

Recognition of signs of poor and good welfare that may be associated with the act of weaning:

Poor welfare:

- They eat or drink less than necessary because of the wrong position of feeder or drinker.
- They are inactive.
- They may be more prone to disease at weaning

Good welfare:

- They gain bodyweight.
- Low kit mortality.

Exposure Factors

- There is a higher risk of poor welfare when the animals are weaned below 4 weeks of age as at 3 weeks of age they are only just starting to eat solid food.
- When the kits are very small for a given age (smaller than the average weight – 2SD) there is also a higher risk of poor welfare.

- Late weaning (>35 days) is also a risk factor due to the restricted access to the feeding area, type of feed, and competition between the doe and young animals for feed.
- The doe's welfare may be compromised due to prolonged sucking by the kits.
- Late weaning may be a problem of space as the cages become too small for all the animals.

Consequences for animal welfare and productivity

If weaning is carried out too early then losses may be greater and the growth of kits could be reduced.

If weaning is carried out too late then while the kits may be stronger, and mortality may be less, the welfare of the doe may be compromised and ultimately reduce her productivity. Thus it is a balance that can potentially increase farm output, and management of weaning is a crucial factor.

Good agricultural practices

Harmonization of the reproductive rhythm and the weaning age.
Delay weaning for the underweight kits.
Special starter diet for kits
Higher (20-22C) room temperature for early-weaned rabbits.
Don't wean rabbits later than 35 days of age.

9.8.3. What contribution does abnormal maternal behaviour make to poor welfare of kits and does?.

Definition and Background

When does do not carry out, or are not able to carry out, normal maternal strategies such as nest building. The nest is normally built in two parts: a "straw nest" using material that she may find in the environment, and a "maternal nest", lining the straw nest with fur plucked from her body. A doe may then deliver her kits out of the nest, scattering them and even cannibalising them. Even more important is that the nest entrance can be closed by the doe's own activity or by management measures.

Consequences for animal welfare, human welfare and productivity

Kits may die as for the first few days they need to live in an adequate environment i.e. a well-built nest in a separate section of the mother's living environment. Poor care leading to hypothermia, starvation, dehydration and cannibalism are all serious welfare issues. The welfare of the doe may also be lowered as she may not be able to meet her natural instincts leading to distress (she is losing her fitness from a biological perspective). For the farmer the consequences are losing animals (units of production) and eventually the need to substitute the breeding females.

Recognition of signs of poor and good welfare that may be associated with the act of weaning:

Poor welfare:

- High kit mortality
- Cannibalism of kits

Good welfare:

- Kits gain bodyweight.
- Low kit mortality.

Exposure Factors
Inadequate nest box
Shortage of material to build a nest
Disturbance of the doe

Consequences for animal welfare and productivity
Kits die of starvation
High losses lead to financial losses

Good agricultural practices
To provide an adequate sized nest box and suitable material for next building.

10. GENETICS SELECTION

This chapter deals with the rabbit genetics. The relevant question for this risk assessment is whether there is an impact of genetic selection practices in the various housing and husbandry systems that affect the health and welfare of the animals.

10.1. Genetic variability

The rabbit presents a remarkable genetic variability considering that its domestication is rather recent and that its breeding conditions have not differed dramatically between countries and systems of production during that time, in comparison with cattle or sheep. Three main industries deal with rabbit production using different rabbit breeds: meat, fur and wool. The wool industry nowadays is mainly concentrated in China and uses different breeds of Angora rabbit. Fur represents a small industry, and is commercially more widespread, particularly in France, although it represents a very small part of the rabbit business. Meat production occurs all over the world, and intensive production is particularly important in Europe, mainly in Italy, Spain and France. This section focuses on breeds reared for meat.

Meat breeds are classified in three types: light, medium and heavy. Light breeds are nowadays rarely used, as industrial production uses medium breeds for dams, usually crossed dams, and heavy breeds for terminal sires. Most of the breeds used in the intensive industry are artificial. New Zealand White and California breeds are typical components of the dam lines, and several breeds, many of them heavy ones, are components of the sire lines. A recent review of the maternal lines used in modern intensive production can be found in Garreau *et al*. (2004a). Sire lines have been reviewed by Baselga (2004).

10.2. Selection programmes in the industry

Selection objectives in maternal lines are litter size at birth or at weaning. Some trait related to milking ability is also a criterion e.g. the weight of the litter at weaning or individual weaning weights (Garreau *et al*., 2004a). New objectives such as longevity or reduction of litter variance in birth weight or litter size, might be introduced in the future. Selection objectives in sire lines are food conversion rate and carcass quality, but as both traits are difficult to measure, selection is performed on growth rate (weight at slaughter or difference between weaning and slaughter weight). At an experimental level, selection of sire lines has been performed on carcass composition (Szendrő *et al*., 2004) or on food efficiency for lean meat (Larzul *et al*., 2004). In countries in which rabbit production is not industrialised as in Europe, sometimes a single line is selected for both growth rate and litter size or milking ability measured weighing the litter (Baselga, 2004).

New criteria for selection have been proposed in order to obtain a higher uniformity of the individual litter weight (Garreau *et al*., 2004b) but it has yet to be proven useful at farm level. Another new objective was ovulation rate. Although selection for ovulation rate has been performed in pigs and mice without success for improving litter size, no experiments have been performed in rabbit. The first results show that indirect selection for litter size is possible, but it is less efficient than expected Ibáñez *et al*., 2004).

One of the most important problems of rabbit production nowadays is the Epizootic Rabbit Enteropathy (ERE), which is affecting most of the commercial farms.

Rochambeau *et al*, (2004) showed the existence of genetic variability for resistance to ERE, thus it may be considered also as an objective for selection.

Molecular genetics is not used yet in rabbit breeding programmes and one reason is that the small size of the business does not allow for large investments (Armero and Blasco, 1992). The other reason is that the sequencing of the rabbit genome is relatively recent (Chantry-Darmon *et al*., 2004). Most domestic species have a genetic map dense enough to permit genetics studies to search Quantitative Trait Loci (QTL).

This has not been the case of rabbits until 2004. The rabbit genome has around 300 centMorgan (cM) and this year a genetic map has been constructed, mapping every 10 to 20 cM. The authors expected to have the first genetic map of the rabbit with 150 to 200 informative genetic markers by the end of 2004 (Chantry-Darmon *et al*., 2004).
This is a promising area, and it is known that several experiments have kept genetic material ready to be analysed for searching QTL when markers will be available.
Transgenic rabbits have been examined at an experimental level without successful application for farming purposes (Rafay *et al*., 2004).

10.3. Impact of selection on welfare

As mentioned before, the rabbit industry is based on medium-weight crossbred dams selected for litter size or milking ability, whereas terminal sires are selected for growth rate.

10.3.1. Selection for growth rate

Selection for growth rate has a correlated phenotypic response in adult body weight. Blasco *et al*. (2003) clearly showed that selection acts along the whole growth curve, and adult weight is augmented as a result of scale. As selection for growth rate is successful, and generation intervals are about six months for sire lines, this means that sire rabbit lines will increase their adult weight much more than dam lines. As a consequence, the current materials and sizes for cages might be inappropriate for heavy lines. A classical injury in rabbits, lameness, is seen more frequently in heavy lines. Some types of resting areas (i.e. floor coverings made of plastic or other synthetic material) have been added to a cage and can be recommended. This is a frequent practice that will be more important in the future, however, if sire lines become very heavy, special cages might be needed for them.

10.3.2. Selection for litter size

An increase in litter size is accompanied by a reduction in individual birth weight, an increase in the variability of individual birth weight, and an increase in mortality. However, these correlations are low (Argente *et al*., 1999a). It is known in pigs that as selection for litter size increases, so neonatal mortality is also increased to a greater degree than simply the effect of scaling up (Blasco *et al*., 1995). This may also happen in rabbits, but there is no data. Nevertheless, the current practice of cross fostering litters reduces this effect at farm level. New criteria for selection have been proposed in order to obtain a higher uniformity of individual litter weight (Garreau *et al*., 2004b) but it has yet to be proven useful at farm level. If selection is performed on litter size components (ovulation rate or prenatal survival), laparoscopies are needed to perform selection for ovulation rate. The female is anaesthetised for this operation, and an expert operator should perform laparoscopy to avoid risks derived from the operation (infection, damage to abdominal organs, as well as appropriate aftercare e.g. post-operative analgesia.

10.3.3. Disease resistance

One of the most important problems of rabbit production nowadays is Epizootic Rabbit Enteropathy (ERE), and it too may be considered as an objective for selection. Genetic variability has been detected by inoculating animals with ERE agents and this research might be a matter of concern, as survival is used as the way of selecting for resistance (Rochambeau *et al.,* 2004).

10.4. Risk questions related to genetic selection

10.4.1. What are the welfare consequences in the selection of future breeders?

Background
Selection objectives in maternal lines are litter size at birth and number weaned. Selection in sire lines is performed on growth rate. Other potential risks derived from molecular genetics are not present because the scale of the business does not allow for large investments. Transgenic rabbits have been examined at an experimental level, but without without successful application for farming purposes.

Exposure factors
Selection for growth rate has a correlated response in adult body weight (Blasco *et al*., 2003) and adult weight augments as a result of a scale effect. As selection for growth rate is successful, and generation intervals are short for sire lines, rabbit lines are expected to increase their adult weight much more than dam lines.

Selection for litter size increases litter size, and an increase in litter size is accompanied by a reduction in individual birth weight, an increase in the variability of individual birth weight and an increase in kits mortality.

Consequences for animal welfare
Current designs and materials for cages might be inappropriate for heavy lines. A classic injury in rabbits, leg pathology, is likely to become more frequent in heavy lines. In addition, it is known that selection for large litter sizes is accompanied by a higher mortality than the mortality simply expected by a scale effect (e.g. if the mortality is 1 in 10, then an increase of one dead kit together with an increased litter size could lead to an increase in mortality to 2 in 15 (Blasco *et al*., 1995, 2005).

Good Agricultural Practices and Recommendations
Enrichment of the cage by adding a floor mat (made by plastic or other synthetic material), creating a resting area in the cage. In the future, males used in the industry coming from sire lines may require special cages.

Cross fostering reduce the risks derived from large litters.

11. HEALTH ISSUES: GENERAL MEASURES TO EXCLUDE DISEASE

This chapter deals with the commonest rabbit diseases, and how the various housing and husbandry systems may affect the health and welfare of rabbits.

11.1. General aspects of rabbit diseases

Rabbit disease is important as it not only affects the welfare and productivity of the rabbits and the financial status of the farmers, but also the food produced (quantity and quality of rabbit meat) and human health (zoonoses). A relevant aspect is the method of production as, for example, on a 500 doe farm apart from the does themselves, there will be 4,000-5,000 nursing rabbits and weaned rabbits, that is around 10,000 rabbits forming the "population at risk". For this reason, the study of rabbit disease often involves an epizootiological perspective and in practice, it is necessary to understand the causative agents as well as predisposing and enabling risk factors (Thrusfield, 1995).

In the opinion of Lebas (2000b) rabbits as a species, are no more vulnerable to disease than pigs. In Table 11.2 the figures show that, excluding stillbirths and culls at birth that losses from day 1 to 35 days (pre-weaning) ranged from 8.5 to 15.7% with a mean of 14.1%, and from day 36 to 75 or 90 days (post-weaning) ranged from 3.6 to 20.2% with a mean of 9.5%. The total losses, excluding stillbirths and culls is, therefore, on average, 23.6% (range 12.9% to 30.4%). The total including stillbirths and culls is 23.6% + 9.2% = 32.8%.

On occasions, severe outbreaks can occur, with mortalities of over 25-50% in adult rabbits, nursing and weaned animals, due to both infectious and non-infectious conditions.

Several disorders can cause poor welfare rabbits. Chronic diseases such as sore hocks, mastitis, mange, ringworm, and abscesses are paradigms of long term low-moderate suffering in breeding and growing rabbits. Some disorders of the respiratory system and especially of the alimentary tract, such as Epizootic Rabbit Enteropathy (ERE, or Mucoid Enteropathy), cause acute pain; in fact, in the experience of ther Working Group, grinding the teeth (a clinical sign of acute pain) can often be observed in ERE.

This chapter deals briefly with epidemiological perspectives with respect: morbidity, mortality, prevalence and incidence of the most common rabbit disorders, besides enabling predisposing risk factors such as: housing and management, and the causative agents, as well as their clinical manifestations.

11.2. OIE list of notifiable diseases of rabbits

This chapter deals briefly with epidemiological perspectives with respect to morbidity, mortality, prevalence and incidence of the most common rabbit disorders, including enabling and predisposing risk factors, and the causative agents, as well as their clinical manifestations.

There are three OIE notifiable diseases of rabbits all of which were included in the previous List B. They are Myxomatosis, Rabbit Haemorrhagic Disease (RHD) and Tularemia. The last one is a zoonosis, and is of low incidence on farms, but it is a typical disease of wild lagomorphs: rabbits and hares, and of rodents. Some other diseases that can also affect rabbits are included in the OIE lists are, toxoplasmosis, cysticercosis, salmonellosis, porcine brucellosis, and cryptosporidiosis. Other zoonotic diseases: chlamydiosis, ringworm, encephalitozoonosis, and sarcoptic mange, must also be taken into account, in spite of their low incidence or prevalence in rabbitries and, especially, at abattoirs (Cerrone *et al*., 2004).

11.3. Average mortality and restocking levels in rabbits

The rate of annual restocking of does depends on the reproduction rhythm: it is usually low (70-80%) with an extensive rhythm (insemination at weaning) but it can be as high as 130% when adopting a semi-intensive extensive reproduction rhythm (insemination 11 days after parturition). There could be some differences between groups, for instance, mean number of females in production per farm, type of insemination, yearly mortality rates of females etc., but the restocking rate of rabbit does on an industrial farm is often 100% per year (see Table 11.1).

Table 11-1. Doe replacement on commercial rabbitries during 2003.

Criteria / Authors	Number of farms	Mean does per farm	% dead does	% culled does	% total renewed
Rosell and Perez, 2004*	106	813	38.4	64.8	103.2
Prieto *et al.,* 2004*	61	644	48	52	100
RENACEB. ITAVI 2004	1,125	449	23	77	100
RENALAP. ITAVI 2004	88	224	42	58	100

(RENALAP: all females were mated; RENACEB: all does were inseminated.) (*cited by Rosell, 2005)

Mortality in adult breeders is frequently caused by respiratory and enteric diseases but a significant number of does are culled due to reproductive failures (infertility) linked to lesions of the genito-urinary system (such as salpingitis, metritis, prolapse, torsion of the uterus), and interstitial (often caused by *E. cuniculi*) and purulent nephritis (Gusmaroli, 2000). In addition mastitis and sore hocks, both usually induced by *Staphylococcus aureus*, often cause losses. Mastitis is also an important cause of culling in does of all ages. Sore feet and hocks are common in does at all ages, and is an important cause of culling in older rabbits. Mortality of productive females is seen in the last 5 days of pregnancy and 3 first days after birth. Indeed, there is a direct correlation between losses or culling of females and age of does and number of cycles i.e. during the first pregnancy only a few nulliparous die or are culled, and more than 55% of does are culled before 5th cycle.

The rate and causes of mortality among growing rabbits can vary according to age: (Facchin *et al*., 1993).

At birth and during the perinatal period (1-6do) high mortality rates (5-8%) due to: 1) Environmental or equipment deficit or management mistakes that can cause crushing, chilling, cannibalism, starvation, etc., 2) staphylococcosis, when lactating does are suffering from mastitis, or paw lesions and podal dermatitis. In nursing rabbits staphylococcosis occurs as enteritis characterised by yellowish diarrhoea or diffuse dermatitis; and 3) colibacillosis is mostly detected in litters born from primiparous does.

During the nursing period (7-21do) losses are usually mild (2-4%) and caused by pathogens transmitted by the lactating does to their kits. Typical diseases found during this period are Colibacillosis, Staphylococcosis and Pasteurellosis.

During the pre-weaning period (22-35do) mortality is again low (1-2%), except in some rare cases. Rabbits are still in contact with does and this can determine the transmission of some infectious agents. Clinical signs found this period are related to 1) Enteric syndrome; 2) Respiratory diseases (mainly caused by *Pasteurella* spp.); and 3) Dermatomycosis as consequence of transmission of fungi by adult healthy carriers.

During the post-weaning (growing) period (36-55do) losses can vary and can also be particularly severe (6-8%) as consequence of the occurrence of viral infections (rota-, corona-, entero- parvo-virus) and of the "enteritis complex or post-weaning enteritis" that is a typical multifactorial and conditioned disease that comprises several cofactors, related to management, feeding regimes, housing and environment. It is often associated with a series of aetiological agents that are often of low virulence and are opportunistic infections.

During the Growing to slaughtering period (from 56 to 75-90do) the losses can vary and are more frequently related to respiratory disorders (*Pasteurella multocida, Bordetella bronchiseptica*).

11.4. Main health problems and incidence of diseases in various countries

Data from the literature and from personal observations are reported in the following tables. Table 11.2 shows different mortality rates in farmed growing rabbits from various countries in different years. It can be seen that mortality rates have not substantially decreased over 25 years despite modern rearing techniques, high hygiene levels, improved biosecurity and environmental improvements. However, it is not possible to relate mortality and morbidity to any particular farming system, as for the same farming system management practices are critically important when considering the incidence and prevalence of disease.

Table 11.3 shows the involvement of different organ systems in the mortality of rabbits of different ages. Table 11.4 shows apparent causes of death or disease in necropsied does on rabbitries during 2001-2004 in Spain. Table 11.5 shows the culling rates in does on 7 rabbit farms during 2003. These sources of information complement the perspective held by diagnostic laboratory experts as pointed later in the specific risk assessments, and in several papers (e.g. Grilli and Pisoni, 2002; Leone-Singer and Hoop, 2003).

Altogether these data indicate that gastroenteric diseases have significantly increased in the last 15 years becoming the most common cause of mortality. They cause more than 50% of losses during each production cycle, occur mainly in 35-50 day old rabbits, and usually have multiple aetiologies. Diseases of the alimentary tract, including epizootic rabbit enteropathy (ERE) (mucoid enteropathy) in rabbits of all ages, and enteritis-diarrhoea (colibacillosis, coccidiosis, clostridiosis) in the maternity section of a farm, in the growing section, or both, account for 53,1% of the emergency visits by veterinarians (Rosell, Pers. Comm.). Gastrointestinal diseases are mainly bacterial in origin: enterobacteria (*Escherichia coli,* also *Salmonella* spp., *Klebsiella* spp.), and several species of *Clostridium*. The most common viral agent of enteric diseases is rotavirus. Parasites are often concurrent agents in gut disorders, particularly *Eimeria* spp. (Coudert *et al*., 2000). Hepatic coccidiosis due to *E. stiedai* is rarely observed; *Passalurus ambiguus* is the most frequent caecal worm in domestic rabbits followed by the visceral form of *Cysticercus pisiformis.*

Respiratory disease is the second commonest cause of mortality and is prevalent in adult animals (breeders) and in the second growing period (50-80 days), often during the winter when the weather sudden changes, e.g. a drop in external temperature. *Pasteurella multocida* with and without *Bordetella bronchiseptica* are the most important bacteria. Most rabbits carry *Pasteurella* spp. in the upper respiratory tract and enabling factors such as microclimate, gases (ammonia, carbon dioxide) and dust can create suitable conditions for virulent strains to give rise to clinical signs of infection. Ten years ago respiratory problems were the most common, but now other diseases such as enteric disease are more common, although this may vary from year to year. Improved environmental conditions and improved hygiene schedules have also contributed to the reduction in respiratory problems.

<u>Diseases of reproduction</u> include infertility, lowered fecundity, and increased abortions and stillbirths. These disorders are probably underestimated by clinicians, who usually pay more attention to primary disorders such as gastrointestinal diseases and diet-related disorders. In Table 11.5 the main apparent causes of illness in culled does in 7 rabbitries during 2003 are given.

The two main viral diseases of rabbits, Myxomatosis and RHD, differ from secondary enteric and respiratory syndromes, as they are caused by primary agents and lead to epidemic infections characterised by high mortality rates. However, they can be easily prevented by vaccination

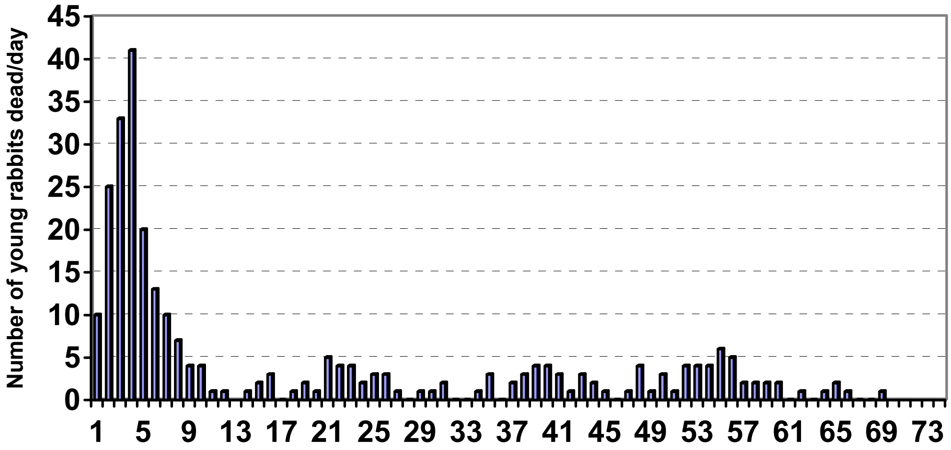
Table 11-2. Mortality in farmed rabbits.

<table>
<tr><th>Author</th><th colspan="2">Year</th><th>Period 1 and 2 (0-21 days) (%)</th><th>Period 3 (22 – 35 days) (%)</th><th>Period 4 and 5 (36 – 90 days) (%)</th><th>Total (%)</th><th>Weight (kg)</th></tr>
<tr><td>Roustan</td><td colspan="2">1980</td><td></td><td>17.0</td><td>8.5</td><td></td><td></td></tr>
<tr><td>Facchin</td><td colspan="2">1985</td><td>9.8</td><td>21.5</td><td>9.1</td><td>30.6</td><td></td></tr>
<tr><td rowspan="5">Costantini and Castellini</td><td colspan="2" rowspan="5">1990</td><td></td><td>5.6</td><td>5.5</td><td></td><td>2.43</td></tr>
<tr><td></td><td>21.1</td><td>10.5</td><td></td><td>2.45</td></tr>
<tr><td></td><td>11.6</td><td>11.5</td><td></td><td>2.20</td></tr>
<tr><td></td><td>29.1</td><td>6.7</td><td></td><td>2.39</td></tr>
<tr><td></td><td>11.2</td><td>7.8</td><td></td><td>2.50</td></tr>
<tr><td>Koehl et al.</td><td colspan="2">1994</td><td></td><td>15.0</td><td>9.0</td><td></td><td></td></tr>
<tr><td>Le Breton et al.</td><td colspan="2">1994</td><td></td><td>11.3</td><td></td><td></td><td></td></tr>
<tr><td>ITAVI</td><td colspan="2">1996</td><td>9.9</td><td>14.2</td><td>10.7</td><td>23.4</td><td>2.41</td></tr>
<tr><td rowspan="2">Rafel</td><td rowspan="2">1996</td><td>France</td><td rowspan="2"></td><td>17.0</td><td>10.0</td><td rowspan="2"></td><td>2.35</td></tr>
<tr><td>Spain</td><td>7.3</td><td>5.5</td><td>1.95</td></tr>
<tr><td>Torri</td><td colspan="2">2000</td><td colspan="2">15.7</td><td>8.9</td><td>24.6</td><td>2.73</td></tr>
<tr><td>Gusmaroli</td><td colspan="2">2000</td><td colspan="2">9.3</td><td>3.6</td><td>12.9</td><td>2.70</td></tr>
<tr><td rowspan="3">Brivio R. Pers. Comm.</td><td colspan="2">1999</td><td colspan="2">8.5</td><td>11.9</td><td>20.4</td><td>2.50</td></tr>
<tr><td colspan="2">2000</td><td colspan="2">9.2</td><td>12.5</td><td>21.7</td><td>2.50</td></tr>
<tr><td colspan="2">2001</td><td colspan="2">10.2</td><td>20.2</td><td>30.4</td><td>2.50</td></tr>
<tr><td>Prieto et al *</td><td colspan="2">2004**</td><td colspan="2">13.7</td><td>9.1</td><td>22.8</td><td></td></tr>
<tr><td>Rosell and Perez*</td><td colspan="2">2004**</td><td colspan="2">13</td><td>7.7</td><td>20.7</td><td></td></tr>
<tr><td>RENACEB. ITAVI *</td><td colspan="2">2004**</td><td colspan="2">15.1</td><td>10.4</td><td>25.5</td><td></td></tr>
<tr><td>RENALAP. ITAVI *</td><td colspan="2">2004**</td><td colspan="2">14.6</td><td>14.1</td><td>28.7</td><td></td></tr>
</table>

(* Papers included in: Rosell, 2005) (** Data referred to 2003, published in 2004)

Figure 11.1 summarises daily mortality of young rabbit in a farm without severe disorders.

Figure 11-1. Natural history of daily mortality in a batch with age (do).



Natural history of daily mortality in a batch of 178 births, 1,595 born alive and 1,308 marketed at 75 days with 2,442 kg BW. (Source: Rosell, 2005).

Table 11-3. Involvement of different organ systems in the mortality of farmed rabbits.

System	Farm "A"	Farm "B"			
		22 – 35 days	36 – 90 days	Breeders	Average
Digestive	51	71,3	66.8	55.8	67.2
Respiratory	55	39.1	45.3	51.2	43.4
Skin	7	14.8	13.9	34.1	17.2
Reproductive	3	0	0.3	29.4	4.3
Urinary	11	0.5	7.1	29.4	7.3
Trauma	7	1.5	3.4	5.4	2.8
Mammary	1	0	0	10.1	1.5
Others	8	2.7	2.6	3.9	2.8

(Value in %; Source: Gusmaroli, 2000).

Table 11-4. Necropsies performed on rabbitries.

Conditions	Suckling	Growing	Future breeders	Females	Males	Total
Enteritis - Diarrhoea	99	256	4	85	2	446
Mucoid enteropathy	72	140	5	23	-	240
Pneumonia	70	37	21	105	6	239
Haemorrhagic Septicaemia	-	-	3	13	4	20
Metritis, acute Mastitis, or both	-	-	-	36	-	36
Uterine Torsion	-	-	-	24	-	24
Pregnancy Toxaemia	-	-	-	25	-	25
Extra-uterine pregnancy	-	-	-	5	-	5
Mummified Fetuses	-	-	-	7	-	7
Viral Haemorrhagic Disease	-	9	5	4	-	18
Compatible with staphylococcosis	1	3	-	2	-	6
Inanition + hypothermia	179	-	-	-	-	179
Stillborn	210	-	-	-	-	210
Compatible with encephalitozoonosis	-	37	-	2	-	39
Miscellaneous or unknown conditions	55	25	2	50	1	133
Total:	686	507	40	381	13	1,627

Necropsies with apparent cause of death or illness. Spain, 2001-2004. (Source: Rosell, 2005).

As can be seen in Table 11.4, young rabbits die mainly from enteric diseases. Breeding rabbits die mainly from respiratory disease and then enteric disease.

Table 11-5. Culling rates in does.

Criteria	Number of does	%	Range
Low productivity	871	25.6	9.9 -42.9
Infertility	497	14.6	8.0 -27.7
Other causes	374	11.0	-
Mastitis	611	18.0	8.4 -37.8
Sore hocks	562	16.5	4.2 -28.6
Body condition	389	11.4	10.0 -31.6
Respiratory	227	6.7	1.0 -24.5
Uterine disorders	88	2.6	-
Abortions	88	2.6	-
Abscesses	70	2.0	-
Age	58	1.7	-
Vertebral fractures	49	1.4	-
Digestive disorders	46	1.3	-
Torticollis	40	1.2	-
Miscellaneous or unknown	305	9.0	-
Total Culled (excluded death)	3,404	100	
The average total annual culling rate of does per farm during 2003 was 68%			
The average total annual dead rate of females per rabbitry during 2003 was 38,5%			

Culling rates in does on 7 rabbit farms in Spain during 2003 (5,008 does in production). (Source: Rosell, 2005)

11.5. Diseases and environtmental factors

Some diseases are directly related with by some environtmental factors as high temperature and humidity, temperature changes, presence of vectors and the housing system as shows in table 11.6

Table 11-6. Examples of diseases enabled by rabbit housing.

Disease	Environmental factors involved	Agents involved
Contagious coryza	Draughts, changes and extremes	*P. multocida, B. bronchiseptica*
"Sore hocks"	Wire floors	*S. aureus* and other organisms
Ringworm	High heat and humidity	*T. mentagrophytes, M. canis*
Coccidiosis	Rabbits not separated from dejections	*Eimeria* spp.
Cutaneous pseudomonosis	Badly placed drinking troughs	*P. aeruginosa*
Mastitis	Cold, draughts and damp	*S. aureus*
Death of kits under 15 days of age outside the nest	Location and design of the nest	Inanition, hypothermia and traumatism (e.g., crushing)
Desertion of the litter, cannibalism	Brusque reduction in temperature	Neuroendocrine disorder
Subfertility in males	High ambient temperature	Neuroendocrine disorder
Low level acceptance of the male	Decreased photoperiod	Neuroendocrine disorder
Toxaemia/ketosis during gestation	Sudden increase in temperature	Neuroendocrine disorder
Viral haemorrhagic disease	Sudden changes in temperature	Calicivirus
Classic myxomatosis*	Abundant rain and mosquitoes	Myxomatosis virus

(Source: Rosell, adapted from Ferré and Rosell, 2000). (*)It can be pointed out here that the atypical form of myxomatosis that first appeared in Europe in 1979-1980 onwards, does not necessarily need mosquitoes for its diffusion, though logically it is facilitated by their presence.

11.6. Control of rabbit diseases

It is important to adopt programmes for the prevention and treatment of disease, as well as strict hygiene controls to prevent and combat subclinical and multifactorial/conditioned disorders (Grilli and Lavazza, 1998). A complete schedule would cover several aspects in rabbit production, such as hygiene, immunoprophylaxis, metaphylaxis and treatments (Schellenberg, 1979).

11.6.1. Zootechnical control

Zootechnical control addresses both genetic (predisposing) and technical (or enabling) risk factors for disease.

Genetic control should select for breeders that as heritable characters can reduce disease play a role in favouring the origin of conditioned syndromes (Bolet *et al*., 1996; Rochambeau *et al*, 2004). It isknown that there are some genetic lines that are more resistant to myxomatosis but the exact mechanisms have been not yet determined (Grilli personal observation), and the role of stress factors should be considered (Schellenberg, 1979; Galassi, 1985).

Technical controls are aimed at obtaining an overall improvement in the husbandry and environmental conditions (microclimate, equipment, cages, light regimes, feeding, amongst others).

11.6.2. Hygienic control

Hygienic control is complex but the main issues are direct (sanitary) prophylaxis, indirect (medical) prophylaxis and therapeutic prophylaxis (also called metaphylaxis) (see Figure 11.2).

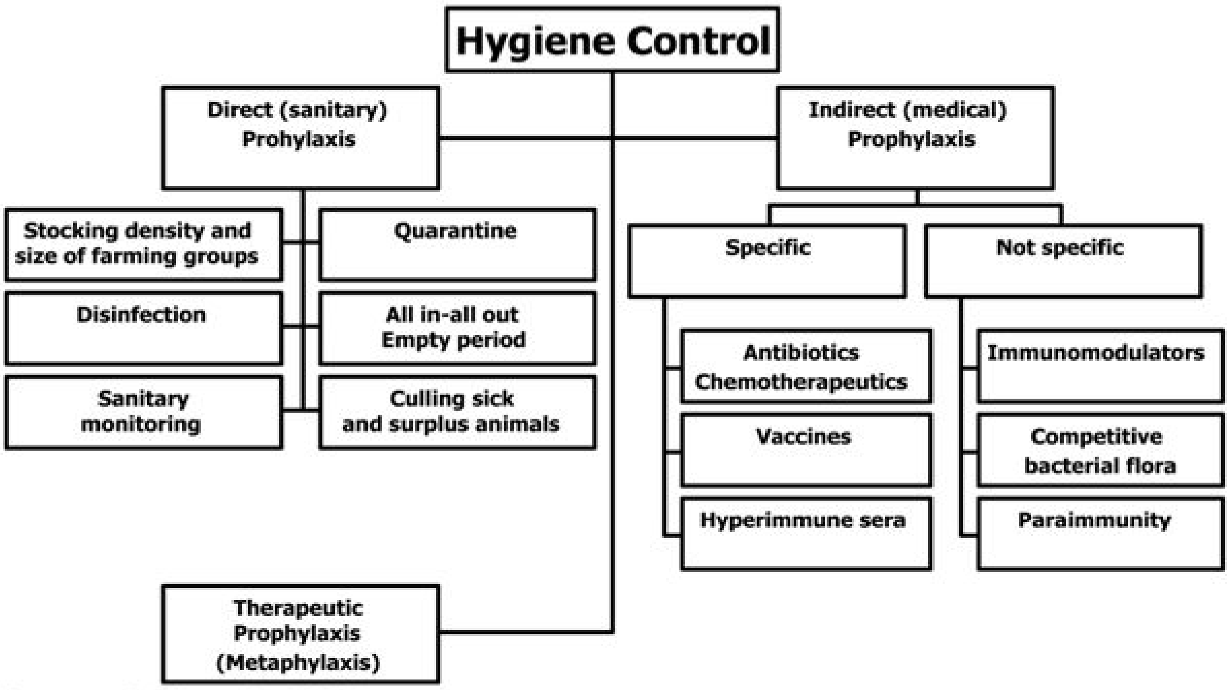
Direct. Direct (sanitary) prophylaxis is common to most farming systems.

11.6.3. Biosecurity

Biosecurity includes facilities and operational practices to exclude disease-causing organisms and includes the management, habitat and the environment. Its effective application depends on several factors: 1) all must believe in it from upper management to the stockpersons; 2) education in Biosecurity can be difficult because of the wide audience range; and 3) it can take a very long time and much repetition to influence a change in practice if it has not been adequately emphasised in the past.

Management of the facilities on the farm includes: 1) movement of rabbits to other operations (e.g. slaughterhouse); 2) type of farm and its location (industrial farms, rural units, wild rabbits); 3) design of buildings and materials used for construction and caging (ease of cleaning and disinfection, exclusion of wild mammals and birds); and 4) security of surrounding areas (fences, distance from other rabbits, animal access, carcass disposal). Unfortunately, many characteristics of the facilities cannot easily be changed making effective biosecurity difficult to achieve.

Figure 11-2 . Schematic representation of the control strategy in a rabbit farm.



(Source: Grilli *et al.*, 2002)

Elements comprising biosecurity programmes are numerous; the main features include: 1) Instructions and recommendations concerning: traffic control (visitors and employees); 2) sanitation (principles, chemicals, vehicles, buildings and equipment, waterlines, footbaths, carcass disposal); 3) pest control; and 4) communication. Other areas in need of consideration are routine as well as emergency situations such as vaccination, processing plants, catching for transport, transport for breeding or to the abattoir, catching for stunning and killing.

Biosecurity can be a very effective "first line of defense" but it cannot do it all. Other measures including vaccination may be an appropriate "second line of protection", depending on the situation. Indeed, continual disease surveillance is always important in order that early action is taken.

11.6.4. Disinfection

Disinfection should involve the chemical and physical treatment of equipment such as cages and the rabbit house, in order to clean and remove sources of infection. Such procedures should be compulsory. A good disinfectant should have the following characteristics: capacity to destroy all type of micro-organisms (virus, bacteria, fungi and parasites), to be innocuous for the user and the animals (in fact they are mostly used when rabbits are present), not to cause any damage (corrosion or oxidation) to the equipment, to have good penetration, not to be inactivated by dust and organic substances, not to induce resistance in a micro-organism, and be easy to handle. Price is also a relevant variable to consider. Since such a perfect disinfectant does not exist, combinations may have to be used together or in rotation (Quinn and Markey, 2001).

11.6.5. Health monitoring

Health monitoring, by applying a full programme of surveillance which includes routine examination of dead animals, verification of the causes of mortality, discrepancies, checking of contamination of equipments and of the environment etc) should be regularly performed and not just when an outbreak has occurred. It should screen for both primary and secondary pathogens. Bacterial isolation and sensitivity tests done at regular intervals provide important information on the prevalence of different bacteria circulating in the unit, and prepares farmers for a more targetted therapeutic treatment in the event of a disease outbreak, particularly when complicated by secondary infections. Where such a plan had been adopted, the number of treatments was reduced, the mortality rate decreased, and the losses decreased leading to an overall economic gain (Gusmaroli, 2000).

11.6.6. Quarantine

Quarantining newly introduced rabbits (mainly parent breeders) is useful and suitable accommodation should be available so that animals can be separated and confined for at least one month before being mixed with other rabbits on the farm. Where this is not practicable the origin of the parent breeders has to be carefully chosen, and preferably from a farm that carries out health monitoring, has good sanitation and a "clean" history of disease. Breeders can also be bought at a very young age (few days old) to minimise the chance of infection, as younger rabbits tend to be more healthy than older ones.

11.6.7. The "all in, all-out" approach,

The "all-in, all-out" approach incorporates a period in the rabbitry with no animals during which time the building can be disinfected and thoroughly cleaned. It is still not a common procedure due to the type of production cycles (based on reproductive cycles and the need for synchronisation). However, it is adopted or rather becomes an involuntary choice, after a disease outbreak with sharp increase in mortality rate (e.g. Myxomatosis) and serious adverse effect on production (Samoggia, 1987).

Potentially there are two systems: the first centred around the growing rabbit where buildings accommodate growers for a cycle of around 3 months. The second system is based around the breeding doe where accommodation is for one year, all does are then culled and a new influx of does is brought in and bred. For various reasons neither is in common use e.g. use of the home/birth cages for breeding and growing, the expense involved, the synchronisation of oestrus, continual doe replacement. In some farming systems, e.g. plein air, this system may be difficult to operate.

In any event, it would be better to plan an empty phase periodically, and to choose the most favourable time (e.g. diseases that require complete depopulation, adverse climatic conditions, low market prices). The optimal break is for 2-3 weeks (normally it is one week) during which time thorough cleaning and disinfection can be carried out between batches of animals.

11.6.8. Culling of sick and surplus rabbits

Culling of sick and surplus rabbits is important as if animals are ill or injured to such an extent that treatment is no longer feasible and transport would cause considerable additional suffering, they must be killed on the farm. The farmer should also always be alert to the first signs of a disease outbreak. The methods used should cause without delay by a person skilled in the techniques of killing.

11.6.9. Vaccination

After the diagnosis of a disease, vaccination is the most useful tool in the control of infectious diseases. Effective commercial vaccines are available for Rabbit Haemorrhagic Disease and myxomatosis, and for most important bacterial diseases (pasteurellosis, colibacillosis and staphylococcosis). It is also possible to produce bacterial autovaccines, using the same strain(s) isolated in each unit thus obtaining higher levels of efficacy and protection (Lavazza, 2003).

11.6.10. Non-specific indirect prophylaxis

Non-specific indirect prophylaxis includes the use of immunomodulators and paraimmunity factors, but their use is uncommon. There is little experience using competitive microbiota.

11.6.11. Treatment, future challenges and options in sanitary control

Therapeutic prophylaxis (metaphylaxis) is commonly used in industrial rabbit farming to limit gastroenteric and respiratory disease. The reasons for their success is that: 1) the age of rabbits at which these disorders occur (mainly enteric syndromes) is well defined; i.e., 35-50 do; 2) the pattern of the aetiological agent is quite restricted and defined; 3) it is difficult to control such diseases using commercial vaccines or autovaccines; 4) the ease of practical administration since the therapeutic substances are directly added to the feed or drinking water; and 5) the possible use of chemotherapeutics that are directly active in the gut and are not absorbed.

The use of antimicrobials requires strict veterinary control. Rabbit producers must be trained through contining education on their prudent use, including knowledge about adverse effects for rabbits, as well as the risks for consumers, handlers and the environment (Santi and Montesissa, 2000; Grilli *et al*., 2001). However, this type of prophylaxis is often used in excess and even misused (e.g. in some cases two or more antibiotics may be used at the same time) as the stockpersons are poorly trained in a rational hygienic-sanitary approach. The risks deriving from improper use of antibiotics, as in any farming system for any species, are numerous: 1) induction of bacterial resistance; 2) toxic damage to the animals (direct or indirect); 3) the risk of residues in the meat for human consumption; and 4) residual chemotherapeutics can find their way into the environment e.g. in the soil after spreading of litter and manure. There is also an added problem as there are so few antibiotics legally available for use on rabbit farming and they can only be used under the category of minor uses, minor species.

The general tendency in the EU and by way of national laws is to reduce the use of such medical products for controlling pathogens in farming, and this could be achieved in rabbit farming by a gradual application of new control strategies that could be applied over a period of time. Within the short to medium term (it could theoretically be done within a year but it largely depends on authorisation to the use of such products and their consequent commercial registration) one solution could be the use of medical products that are not enterically absorbed, such as avilamicin and zincobacitracin. In that way residues in meat products will be reduced. Moreover, medical products could be chosen that are not used for therapy in humans. Indeed, a better strategy for animal treatment would be using different products and changing them at regular intervals, in order to reduce the risk of inducing bacterial resistance. In the long term (2-10 years) it could be useful: 1) to have genetic lines of rabbits that are resistant to some pathogenic agents even if this would mean a huge effort by geneticists; 2) to develop and improve the use of antibacterial vaccines, using convenient ways of administration (e.g. anti-*E.coli* attenuated live vaccines administered orally); 3) to improve our knowledge on the use and effctiveness of bio-regulators (enzymes, probiotics, essential oils, vegetable proteins), providing an anti-microbial activity; and 4) to define the efficacy and ways of using so called "competitive microbiota", that are able to multiply in the gut and so reduce the multiplication and invasion of pathogenic bacteria.

11.7. Common diseases

This section deals with the most common diseases in current husbandry systems. The relevant question for this risk assessment is whether there is an impact of a disease that is affected by the various housing and husbandry systems on the health and welfare of the animals.

11.7.1. Myxomatosis

Definition: Myxomatosis is a highly contagious and fatal disease of wild and domestic European rabbits, firstly described one century ago in *Sylvilagus* spp., and then introduced into Europe in 1950s, where it rapidly became endemic.

Agent: Viral disease caused by a Leporipoxvirus with, at least, 5 degrees of virulence and pathogenicity.

Clinical signs and lesions: There are two clinical forms of the disease.
1) The classical form is observed mainly on rural farms and in wild rabbits (a reservoir of the virus) where insects can cause indirect transmission of the disease. It has a short incubation period, is easy to diagnose, and causes a high level of mortality.
2) The respiratory form (Brugère - Picoux, 1991) is observed in industrial units all year round, and is induced by milder attenuated strains of virus. It can be subclinical and is more difficult to diagnose.

Diagnosis: Clinical (presumptive) diagnosis is based on clinical and epizootiological data and depends on the virulence of the strain (Chantal and Bertagnoli, 2004). The classical form has nodular lesions on ear skin, conjunctiva, nose and genital mucosae. The respiratory form has a rapid onset and purulent nasal discharge. Pregnant females are more susceptible and both forms can be sub-clinical.

Laboratory diagnosis (using electron microscopy, immunofluorescence test, PCR, serological tests) is needed in the case of outbreaks on industrial farms, due to a wide pattern of clinical signs and lesions, including sub-clinical infections. Serologic tests could be useful to diagnose the disease (a high proportion of rabbits showing elevated titres), but these are purely indicative if used to gauge protection after vaccination. In myxomatosis protection is not based on humoral immunity but is mainly on cellular immunity and a wide range of individual immune responses is found.

Epizootiology: incidence of myxomatosis is moderate. 10-20% of the rabbitries are affected each year with variable percentages of sick adult or young rabbits (Marlier *et al*., 2001). Rabbitries can be affected throughout the year, with a high incidence in the summer and autumn, according to field observations (500 first visits with this diagnosis between 1986 and 2001: Rosell, 2003, cited in 2005).

Exposure factors.
Risk factors: animals at risk are rabbits older than 3 weeks of age. Pregnant females are particularly susceptible. There are no fully resistant strains but rabbits show different levels of susceptibility (see Chapter 10).

Enabling risk factors are areas with a high density of rabbit farms, high densities of rabbits on the farms, and proximity to areas with wild rabbits. People working with rabbits must pay attention to trucks collecting rabbits for abattoirs. Other factors include the introduction of semen and bringing new animals on to the farm. Abundant rain and vectors are risk factors (see Table 11.6)

Exposure and transmission: Mainly nasal, coital and respiratory routes, and contamination of wounds. Also, direct transmission (healthy rabbits in contact with clinically or sub-clinically infected animals), and indirect transmission by contaminated fomites humans, animals, birds, insects, ectoparasites. Iatrogenic transmission (vaccination, therapy administration) has been recorded (Titoli, 1980; Godard, 1987; Fioretti, 1985).

Consequences for animal welfare, human welfare, and productivity.
Major adverse effects on the animals in its severe form are due to blindness, sinusitis, dyspnoea often leading to death. There are no direct consequences on human welfare. Because it often kills the does, a killing out policy is adopted. Abortion and low fertility are often signs of subclinical infection. Reduced weight gain as animals have difficulties in feeding and drinking due to facial lesions.

Good agricultural practices
Strict measures of direct prophylaxis plus vaccination are the basis for controlling myxomatosis. Direct prophylaxis and biosecurity measures are aimed both to avoid introduction of virus in disease-free units and to limit its spread within the unit.

Sanitary arrangements: include:
Application of biosecurity programmes e.g. Visitor controls: restrict visits, and other animals such as dogs and cats.
Culling and removal of ill and dead animals, sick females and their litters.
Cleaning and disinfection of equipment, cages, instruments etc. using 1-2% formalin, or 0.5% sodium hypochlorite or 10% sodium hydroxide (Marlier and Bertagnoli, 2000) or even good commercial disnfectants that are usually a blend of an inorganic peroxide compound, inorganic salts, organic acid and anionic detergent, to minimize spread.
Disinfection of the air e.g. fogging.
Employ single use instruments for AI and therapies.

Environmental factors: Insect traps at the windows and ventilation intakes, improvement of environmental conditions within the rabbitry, and prevent wild rabbits entering the farm.

Vaccination (Godard, 1987) is effective in animals against all viral strains but there is a high variability in individual response, both in terms of level and duration of protection. Vaccination is usually given to breeders and restocking females and, in the case or farms at risk, to growing rabbits. It is possible to differentiate some vaccine strains from wild strains (Guerin *et al.*, 1998). There might be a need for repeated inoculation, possibly every 4 months in at-risk areas (high density of rabbitries, active outbreaks of disease, or both), and veterinary practitioners should use clincial judgement in each case. It is important, before vaccination, to assess the health status of rabbits and to exclude the presence of a low pathogenic infection as vaccination with live vaccines can promote an outbreak of disease.

11.7.2. Rabbit Haemorrhagic Disease

__Definition:__ Rabbit Haemorragic Desease (RHD) is a highly contagious and acute fatal disease of wild and domestic European rabbits (Capucci and Lavazza, 2004).
__Agent:__ RHD is caused by a non-cultivable calicivirus with one serotype and one major antigenic variant (RHDVa). In addition, at least one related non-pathogenic virus (Rabbit Calicivirus-RCV) has been identified, and the existence of other RHDV-like viruses has been indirectly demonstrated by serological evidence.

__Clinical signs and lesions:__ acute disease with few signs and sudden mortality (nervous signs and death within 48-96h). Typical lesions are: liver degeneration (hepatitis), spleen enlargement and diffuse haemorrhages. RHD is characterised by very high morbidity (90-100%) and a mortality rate between 40-90%. Infection occurs in rabbits of all ages but clinical disease is observed only in animals over 40-50 days of age. The mechanism of resistance in young animals is still unclear and is probably correlated to the pathogenesis of the infection.

__Diagnosis:__ Presumptive diagnosis is based on clinical signs and lesions; diagnosis of confirmation as well as strain characterization is made from laboratory tests (ELISAs and PCR).

__Epizootiology:__ Incidence in industrial units is low since the disease can be easily controlled by vaccination. Recently a new variant strain (RHDVa) has been determined by an increase in outbreaks after vaccination failures (Lavazza *et al,* 2004). RHDVa was firstly isolated in 1997 and the increase of outbreaks in recent years is the result of the spreading of RHDVa.

__Exposure factors.__
Currently RHD is endemic in East Asia, Europe and in Australia and New Zealand. Outbreaks have also been recorded in Central and South America (Mexico, Cuba and Uruguay), Saudi Arabia and West and North Africa. In 2000 and 2001 three independent outbreaks were recorded in the United States of America. The endemic persistence in a country is guaranteed by the spreading of the disease in rural units and in wild rabbits.

__Farming system__
Rabbits kept under plein air or semi-plein air systems are particularly at risk as they expose animals to the wild reservoir.

__Routes of exposure:__ RHD spreads very rapidly and infection can occur by nasal, conjunctival and oral routes. The disease can be transmitted directly and indirectly (e.g. equipment, cages, instruments, humans, birds, insects).

__Other risk factors of disease__: RHDV is very stable in the environment. There is a reservoir in wild rabbits. The introduction of breeders of unknown origin, without application of quarantine period. Transport of animals when trucks visit farms to pick up animals to go to an abattoir. There are no resistant commercial strains of rabbits. Rabbits older than 40 days are more susceptible to the disease. The disease is commonly observed during all year round.

Consequences for animal welfare, human welfare, and productivity
There is a major impact on welfare in acute form: nervous signs in terminal stages, dyspnoea and even death. None on human welfare as it is not a zoonosis. Because it often kills the adults, suckling rabbits can die due to inanition.

Good agricultural practices
Where RHD is endemic, an indirect control of the disease in industrial rabbitries is achieved by vaccination. The application of strict biosecurity measures is suggested to prevent the introduction of the infection on to farms.

Sanitary arrangements:
Application of biosecurity programmes e.g. Visitor controls: restrict visits, and other animals such as dogs and cats.
Culling and removal of ill and dead animals, sick females and their litters.
Cleaning and disinfection of equipment, cages, instruments etc. using 1-2% formalin, or 0.5% sodium hypochlorite or 10% sodium hydroxide (Marlier and Bertagnoli, 2000) or even good commercial disnfectants that are usually a blend of an inorganic peroxide compound, inorganic salts, organic acid and anionic detergent, to minimize spread.
Employ single use instruments for AI and therapies

Environmental factors: Protection against insect access at windows and ventilation intakes. Prevent wild rabbits entering the farm.

Vaccination: Vaccines are usually prepared by using clarified liver suspensions from experimentally infected rabbits, subsequently inactivated and mixed with adjuvant. Vaccinated breeders quickly produce a humoral immunity. Meat animals are usually not vaccinated, since their susceptible period is quite narrow (between 35-40do to slaughter at 60-80do) but in areas at risk, or after a major outbreak it may well be advisable to vaccinate them for 1-2 cycles. It is may be helpful to leave a small number of unvaccinated “sentinels” (~50-100) to determine the disease status of the farm.

11.7.3. Rotavirus

Definition: It is the most important pathogenic viral agent of enteritis in rabbits but is considered only mildly pathogenic (Thouless *et al*., 1988). It primarily causes enteric disease and is detected in 35-50 day old meat rabbits but it could also be involved in the aetiology of “enteritis complex” often associated with *E.coli*, clostridia and protozoa.

Agent: It is caused by a Group “A” rotavirus. Several strains with different antigenic and genomic properties have been described (Martella *et al*., 2004)

Clinical signs and lesions: The extension and the severity of the lesions are dose dependent i.e. the consequences of the infection (micro-villus degeneration, malabsorption and diarrhoea) are higher when the infectious dose is also high.

Diagnosis: Virological diagnosis can be achieved by testing faeces and intestinal contents by ELISA, electron microscopy and PCR.

Epizootiology. Incidence: It was detected in 16.4% of post-weaned rabbits with enteric signs (Nieddu *et al*., 2000). However, seroepidemiological surveys have shown that most adult rabbits are seropositive for rotavirus, thus indicating that there is normally a constant circulation of low amounts of rotavirus in industrial rabbit farming (Di Giacomo and Thouless, 1986).

Exposure factors.
Routes of exposure: Rabbits can become infected with rotavirus by the oro-fecal route. Farming system irrelevant for this disease.

Other risk factors: Introduction of breeders of unknown origin, without application of quarantine period, or both. The disease is dose-dependent i.e. the severity of clinical signs is directly linked to the infectious dose. Thus, a reduction in biosecurity and hygienic activities (cleaning, disinfection, removal of litter, within others) can lead to a huge increase of the environmental contamination with rotavirus.

Consequences for animal welfare, human welfare, and productivity
Even if rabbit rotavirus is considered only mildly pathogenic, meat rabbits suffering from enteritis can die due to dehydration and secondary bacterial infection. In those that recover, a decrease in productivity is commonly observed due to reduced absorption capacity (Thouless *et al*., 1988; Thouless *et al*., 1996; Schoeb *et al*., 1986). Genomic characterization of rabbit rotavirus indicates that the more common strains are different from those circulating in humans, but considering the high frequency of reassortment between viruses belonging to this genus, the theoretical possibility that such agent has a role in terms of human health cannot be excluded.

Good agricultural practices
It is important to apply strict hygienic measures (e.g. biosecurity, cleaning and disinfection) in order to reduce the quantity of virus present in the environment, and to limit the possibility that young rabbits, when their passive immunity disappears, becoming infected by the oro-fecal route.

Sanitary arrangements. Application of biosecurity programmes. Culling and removal of ill and dead animals. Cleaning and disinfection of equipment, cages, instruments, and so on, with the same disinfectants used in myxomatosis. Visitor controls: restrict visits and other animals such as dogs and cats. No vaccines are available for rabbit rotavirosis.

11.7.4. Pasteurellosis

Definition: Pasteurellosis is one of the most common and severe bacterial diseases in the rabbit. It is characterised particularly by disease of the respiratory system, by pyogenic lesions affecting other organs, and even enteritis and septicaemia.

Aetiology: *Pasteurella multocida*, is a Gram negative bacillus. Strains are classified on the basis of capsular (A,B,D,E,F) and somatic (1-16) antigens. Rabbit strains of Pasteurella usually belong to Group A. However there is little or no relationship between serotype and pathogenic potency. The degree of virulence is linked to the presence of the enzyme ornithine decarboxylase (ODC) and the growth of the bacteria in large colonies.

<u>Clinical signs and lesions:</u> ***Pasteurella multocida*** **causes several disorders of the rabbit. Most relevant are those concerning a respiratory syndrome: rhinitis, coryza and snuffles, and pneumonia, but also otitis and genital troubles (e.g., orchitis, and metritis), and septicemia (Di Giacomo, 1992). So called "Pasteurellosis" is frequently related to respiratory diseases of the rabbit, but there are other pathogens as determinants of respiratory diseases; for instance, *Chlamydia* spp. (including *Chlamydophila psittaci*), *Mycoplasma* spp., and *Staphylococcus aureus*. The disease can be acute causing septicaemia but it can also develop into a chronic form.**

<u>Diagnosis</u>: **The presumptive diagnosis of Pasteurellosis is based on lesions at necropsy, especially when respiratory tract is involved, and by laboratory examination: isolation of *P. multocida* from infected organs, nasal and vaginal swabs.**

<u>Incidence</u>: **It is seen all year round but it usually causes peak mortality between summer and spring (Badiola *et al* 2000). Almost all industrial rabbit units should be considered as latently infected (Grilli *et al*., 1995b). It is seen in animals of all ages but more frequently in breeders and growing rabbits. The expected mean prevalence of clinical coryza in females is less than 20% in commercial rabbitries (Rosell, 2003, cited in 2005). Pneumonia is considered to be the principal cause of disease and death, with genital troubles second (Gallazzi *et al*., 1994) as well as otitis (Kpodékon *et al*., 1999).**

<u>Exposure factors.</u>

On breeding farms the main source of infection is the normal carrier status of the rabbits themselves. The does are constant reservoirs of Pasteurella both within the same breeding stock and between breeding stock via commercial operations (Coudert and Rideaud, 2002). Infection is promoted by triggering factors such as adverse microclimatic conditions (See Table 11.6), poor management, animal movements, pregnancy, and concurrent diseases. All these factors reduce the capacity of the host to resist infection.

<u>Routes of exposure</u>

P. multocida **is mainly directly transmitted by contact of ill animals with healthy ones by means of infected excreta. Indirect transmission can occur by contact with infected instruments and equipment, included those used for artificial insemination, and by fomites including humans (Rideaud and Coudert, 1994). *P. multocida* could replicate in the site of first localization (upper respiratory tract) or spread either by the bloodstream to other areas or spread locally to neighbouring organs (ear, conjunctiva, trachea and lungs).**

<u>Other risk factors</u>

The severity of the disease (septicaemic, acute or chronic) is related to the virulence of the strain.

Poor management and environmental conditions such as high air velocity, high humidity levels, presence of dust, high concentration of gases (ammonia, carbon dioxide), low standards of hygiene, and high animal densities all contribute to infection (e.g. Morisse 1981).

Other risk factors are season, type of rabbitry (closed building), age and sex (Badiola *et al*., 2000).

<u>Consequences for animal welfare, human welfare, and productivity</u>

Pasteurellosis is frequently linked with respiratory disease. It can cause severe welfare and health problems and economic losses. The clinical manifestations induced by *P.*

multocida are classified as "conditioned diseases", since its occurrence is closely related to triggering factors that reduce immunity and the natural resistance of the host.

Good agricultural practices
The control of pasteurellosis is based on direct and indirect measures.

Direct measures are aimed at eliminating all triggering factors through good management practices. In particular: cleaning and disinfection of equipment, cages, instruments etc; removal and culling of ill and carrier animals (their status should be checked by nasal swabs); control of environmental factors to ensure a good ventilation, an even temperature (optimal heat insulators) and low concentration of gases (NH_3, CO) and dust; optimal stocking densities and not over-reducing space allowance. Treatment with antibiotics is disappointing as recurrence is common.

Indirect control by vaccination is efficacious only when triggering factors have been eliminated. It is important to use only the vaccine strains that are antigenically involved in the outbreaks (Glass and Brasley, 1992).

11.7.5. Mucoid Enteropathy

Definition: Mucoid Enteropathy (ME) is a common disease in farmed rabbits with multi-factorial causes (viral, bacterial, protozoal). It is also known under different names (rabbit enteric syndrome, enteric complex, epizootic enterocolitis, rabbit epizootic enteropathy).

Agent: ME is recognised by its multiple aetiology, with a prevalence of enterobacteria (*Escherichia coli*) and Clostridia (mainly *Clostridium spiroforme, Clostridium perfrigens).*

Clinical signs and lesions: ME affects animals aged 3 to 4 weeks upwards i.e. mainly growing animals. Apart from the enteritis that causes diarrhoea that can either be mucoid or haemorrhagic, the clinical signs vary. Antimicrobials can alter the signs of the disease. In the case of Epizootic Rabbit Enteropathy (ERE) animals are bloated with a watery-diarrhoea presenting mainly as a distension of the whole intestinal tract including the stomach that is filled with gas and fluid. No inflammation or congestion of the intestine is seen. It is sometimes associated with caecal stasis and blockage, and the presence of mucus, especially in the colon.

Diagnosis: clinical and laboratory diagnosis often show a series of different pathogens. In the case of ERE, *C. perfringens* seems to have a major role, but the role of this bacteria as the primary pathogen is still questionable as reproduction of ERE has not been obtained after inoculation with strains of *C. perfringens* (Licois *et al*., 2003, Marlier *et al*., 2003). Moreover, this bacteria as well as its main toxins have been absent in numerous experimental samples when the disease was successfully reproduced (Marlier *et al*., 2003).

Incidence: it is seen in >95% of rabbit farms in most countries in the world and while enteritis can occur at all ages this particular syndrome is commonest around the time of weaning (35-50 day old rabbits). From the literature and from other observations (Grilli *et al*., 1996a; Gallazzi *et al*., 1999), it seems that gastroenteric diseases have significantly increased during the past 15 years and are now the commonest cause of death; losses can exceed 50% during a production cycle.

Exposure factors.

Farming systems: irrelevant, but all in, all out systems may have lower incidence of disease (but no data are available).

Unbalanced diets with regard to carbohydrates, indigestible and digestible fibre, and protein.

The lack of use and the misuse of antimicrobials can predispose to this disease.

Too rapid a change of diet.

Changes in the weather and environment and other stress factors, temperature change.

Poor hygiene on the farm.

Consequences for animal welfare, human welfare, and productivity

High mortality and high morbidity

Poor welfare due to poor health e.g. dehydration and diarrhoea, gut pain – colic,

Growth rate down, food conversion rate down.

Good agricultural practices

There is no recognised solution to this disease complex.

Good sanitation practices, and "All in, all out" policies may help.

The use of antimicrobials (bacitracin, tiamulin, tilmicosin) before an expected outbreak is not uncommon in some countries. It may be helpful to treat affected animals with antimicrobials.

Health monitoring on farms to identify the agent that may be causing the disease could be helpful.

Feed and water restriction of affected animals reduce the problem, but restricting water to dehydrated animals is in itself a welfare problem.

Economically there is a balance to be struck between animal losses and the costs of treatment with welfare consequences. This may predispose to poor welfare.

11.7.6. Colibacilosis

Definition: Colibacillosis constitutes one of the most important causes of diarrhoea, enteritis and mortality in suckling kits and post-weaning growing rabbits (Camguilhem *et al*., 1986).

Agent: All rabbit *E. coli* belong to the Entero Pathogenic *E. coli* (EPEC) group i.e. they do not produce toxins and do not invade the gut wall but just attach to the intestinal mucosa and cause a loss of microvilli, epithelial desquamation and villus atrophy.

Clinical signs and lesions: The most important sign is diarrhoea but the disease varies according to age of affected animals, the virulence of the strain and the infecting dose. In suckling rabbits mortality (up to 100%) occurs within 24-48h. At necropsy the stomach is full of milk and intestinal contents are fluid and often haemorrhagic. In post-weaned rabbits, mortality rates are lower and accompanied by lethargy, diarrhoea, and distension of the intestines due to presence of gas, and mucoid enteropathy.

Diagnosis: For the diagnosis of colibacillosis, suspected on the basis of clinical signs, it is necessary to run laboratory examinations (bacteriology and strain identification by biochemical, enzymatic and molecular methods).

Incidence: Experience (Grilli G, Gallazzi D and Lavazza A., personal observations, 1998) shows that *E. coli* is the most frequent pathogen isolated from rabbits with enteritis of all ages (57.6%; 29.3% EPEC). In particular, it has been isolated from 53.5% (23.8%

EPEC) of rabbits <28g; 52.0% (24.0% EPEC) of rabbits 29-40 do; 66.0% (44.5% EPEC) in rabbits 41-60 do, and 75% (16.7% EPEC) in adults.

Exposure factors.
Farming systems: irrelevant but quarantine is especially important for this disease.

Routes of exposure Transmission of EPEC occurs by the oro-fecal route by contact with faeces of ill or even sub-clinically infected rabbits rabbits e.g. with the introduction of new breeders. Infection can be direct or indirect by means of contaminated equipment and utensils.

Other risk factors *E. coli* is considered a normal component of the gut flora when present in low numbers, but it can grow rapidly and cause enteritis especially when its multiplication is favoured by predisposing factors (Morisse *et al.*, 1985; Grilli *et al.*, 1996a,b; Grilli, 1999). These factors include: 1) feed quality; 2) lower feed intake due to disease, stress, bad management, with 3) a consequent rise in pH (enterobacteria grow better at alkaline pH) and with a diminished activity of lactic flora; 4) concurrent diseases that induce immunosuppression; and 5) antibiotic administration that causes an imbalance of gut microbiota.

Consequences for animal welfare, human welfare, and productivity
High levels of mortality (100% of the litter can die in primiparous does) are observed in lactating rabbits 1-12 do. Lower mortality (20-50% in 1-2 weeks) after weaning in 35-55 do rabbits) is observed, but there is a general reduction in productivity.

Good agricultural practices
Antibiotic therapy to treat or prevent EPEC diarrrhoea is not the best solution for many reasons: the peculiarities of the digestive physiology and of the normal flora; the high susceptibility of the rabbit to some antibiotics (certain macrolides and lactames are toxic); the difficulties in solving such problems on farms; the high cost of treatment; the potential for acquired multi-resistance of *E. coli* strains and the potential spread of resistance to other bacteria in the gut; and the fact that even after a successful treatment a proportion of animals are always healthy carriers (Licois, 2004).

Sanitary arrangements and Environmental factors
The control of colibacillosis is mainly through sanitary measures to reduce the level of environmental contamination. This can be obtained by: frequent and correct cleaning and disinfections of enclosures or other arrangements, cages and equipment; efficacious ventilation (or better controlled ventilation); and disinfection of all equipment before the introduction of new animals (at weaning and restocking animals).

Vaccination Protecting rabbits against colibacillosis by vaccination has been proposed and experimentally tested with some success showing a reduction in incidence and mortality using multiple doses of an oral inactivated vaccine in growing rabbits (Milon and Camguilhem, 1989). In the case of neonatal colibacillosis it is possible to promote passive immunity (IgA milk) through vaccinating breeding does (Milon and Camguilhem, 1989; O'Hanley and Cantey, 1981).

11.7.7. Clostridiosis

Definition: *Clostridium* spp. are common pathogens in disease of the gastroenteric tract. Clostridia comprise only a small part of rabbit gut microbiota and their importance is highly correlated to the capacity to produce lethal toxins (Carman and Boriello, 1984; Grilli *et al*., 2003).

Agent: *C. spiroforme, C. perfringens, C. piliforme* and C. *sordelli* are the more relevant species involved in frequent cases of enteric troubles (Grilli *et al*., 1995a). Other organisms such as C. *septicum*, the cause of gas gangrene, are unusual in practice.

Clinical signs and lesions: lethargy and anorexia often associated with diarrhoea and more frequently the evolution is very acute with death occurring within 6-24h.

Diagnosis: To make a diagnosis of iota-enterotoxaemia the following are needed (Yonushonis *et al*,.1987: 1) Anatomo-histopathological examinations; 2) Bacterioscopic detection of *C. spiroforme* by Gram staining of faecal material taken from the caecum; 3) Isolation and identification of *C. spiroforme*; and 4) Demonstration of the production of iota toxin. In the case of other clostridia, isolation by anaerobiosis culture and further identification are needed.

Incidence: Clostridia can cause enteric diseases in animal of all ages, but it is mainly in growing rabbits 40-50 do, especially where there are predisposing factors

Exposure factors.
Farming system: irrelevant

Routes of exposures: *C. spiroforme* and other Clostridia are transmitted by the oro-fecal route by the ingestion of the spores. However, sporulation and multiplication of the bacteria occur only when the normal flora is imbalanced leading to an overgrowth of virulent bacteria (Grilli *et al*., 1995a). While diets may also be contaminated with *Clostridium*, this route appears to be uncommon cause in rabbits.

Other predisposing factors are: immunodepression of the host; imbalance of the gut microbiota; antimicrobial therapies especially using certain antibiotics (e.g. clindamicin); post-weaning stress; unbalanced diets especially if rich in starch and sugars (Cheeke and Patton, 1980; Merino and Carabaño, 1992; Peeters *et al*., 1993, 1995); and modification of the composition of the caecal flora and of the integrity of the intestinal mucosa as result of concurrent infections (*E.coli* EPEC, enteric viruses, intestinal protozoa (coccidian and flagellata).

Consequences for animal welfare, human welfare, and productivity
High levels of morbility and mortality
A general reduction in productivity

Good agricultural practices
Sanitary arrangements and Environmental factors: periodical cleaning and disinfection procedures; feeding with balanced diets; reduction of stress factors such as early weaning; not using antibiotics that destroy Gram positive microbiota and limiting predisposing and triggering factors.
Vaccination: some experimental results were obtained using vaccination with anatoxin at 28 days of age (Ellis *et al*., 1991) and the administration of caecal flora containing apathogenic strains of *C. spiroforme* (Carman and Evans, 1984)

11.7.8. Salmonellosis

Definition: Salmonellosis is a bacterial disease caused by several serotypes of Salmonella. Since it is a zoonosis it is of high economic and social importance.

Agent: Salmonellosis is usually caused by few species-specific serotypes: *S. typhimurium, S. enteritidis* and *S. pullorum*.

Clinical signs and lesions: Rabbit salmonellosis can induce enteritis in nursing and adult rabbits, septicaemia, abortions and perinatal mortality. Such clinical signs can be present separately or together, and the disease can be acute, chronic or even latent (Lebastard *et al*., 1995).

Diagnosis: Diagnosis is achieved by isolation of Salmonella from infected organs (liver, spleen, lung and uterus) or from blood in the case of septicaemia. Serotype identification is further obtained, using bacteriological and molecular methods.

Incidence: Its occurrence is quite rare in rabbit industrial farming (Grilli *et al*., 1996c). During 2000-2004, the species of Salmonella most frequently isolated from rabbits in Spain and Portugal were: *Salmonella enterica* ser Typhimurium, *Salmonella enterica* ser Albert, *Salmonella enterica* ser Enteritidis, and *Salmonella arizonae* IIIa 48:Z4C (Saco, personal communication 2004).

Exposure factors.
Routes of exposure and other predisposing factors: Salmonellosis was originally considered a disease typical of rural units, but it can also occur in industrial units when it rapidly spreads as a result of the numbers of animals in close proximity.

Infection is by the oro-fecal route, and different epidemiological pathways are recognised: contamination of feedstuffs or drinking water, presence of rodents (rat and mice) and birds (pigeons), and the introduction of latent infected animals (Gatti *et al*., 1988; Lebastard *et al*., 1995). It is more frequent in plein air and semi plein air systems than in closed buildings. Carriers and newly introduced breeders of unknown health status contribute to the dissemination of the disease.

Consequences for animal welfare, human welfare, and productivity
As with other enteric diseases it can cause reduced productivity, even death in more acute cases as well as causing infertility and abortion. It is an important zoonosis. There are occurrence data on Salmonellosis in humans and quarterly reports are published by Enter-net System. Some of the serovars affecting rabbits are in the list of the more frequently detected ones (e.g. *Salmonella enterica* serovar *Typhimurium, Salmonella enterica* serovar Enteritidis). However, there is no epidemiological evidence that the most human outbreaks are directly caused by consumption of rabbit meat or by contact with rabbits.

Good agricultural practices.
The control of Salmonellosis is exclusively obtained by application of direct prophylaxis measures and biosecurity programmes.

Sanitary arrangements include: control of quality of drinking water and of feedstuffs; application of biosecurity and of pest control (rats, mice, birds) programmes; culling and removal of ill and dead animals; cleaning and disinfection of equipment, cages, instruments etc. No particular disinfectants are to be recommended and “normal” procedures of cleaning and disinfection are sufficient to inactivate *Salmonella.*

Vaccination There are no commercial vaccines against rabbit salmonellosis although it is possible to prepare inactivated autovaccines after the disease has been diagnosed.

11.7.9. Staphylococcosis and Staphylococcal infections leading to Sore hocks and Mastitis

Definition and Agent Staphylococcal diseases are produced by *Staphylococcus* spp., with a special incidence of pathogenic *Staphylococcus aureus*, a common organism of rabbit skin and the upper respiratory tract.

Clinical signs and lesions There are two types of infections in rabbitries: mild and severe. Rabbits with a normal immune status, in good health and body condition can be infected by strains of *S. aureus* with low-moderate virulence, but not by the most pathogenic and virulent biotypes and phage types (Vancraeynest *et al*., 2004). Acute cases of "blue breasts" can be seen in primiparous does in rabbitries affected by high virulent and pathogenic strains of *Staphylococcus aureus*, however, other organisms can also be involved, e.g. *Pasteurella multocida* (Cerrone *et al.,* 2003). Acute mastitis can be lethal.

Chronic forms of mastitis affecting mammary gland represents a mean prevalence of 5% (Rosell, 2003, cited 2005). Other chronic forms are, pyoderma pustulosa in nursing rabbits and lactating females (which is the only pathognomonic pattern of *Staphylococcus aureus*, according to Anderson, 1986), multifocal abscesses (internal, external or both), and dermatitis: e.g., dermatitis digitalis, pododermatitis ulcerosa (or "sore hocks"), pneumonia and septicemia. These chronic forms are often observed at physical examination, for instance before the beginning of a new reproduction cycle, or at insemination. Chronic forms increase mortality of newborn and nursing rabbits, and survivors are thinner at weaning.

Diagnosis: The presumptive diagnosis of Staphylococcosis is based on lesions at necropsy, especially in mastitis and in dermal lesions in the kits. It may be possible to isolate *S. aureus* from infected organs and tissues.

Incidence: In an epidemiological survey carried out during 1989-1993, involving 2,539 visits to 334 rabbitries, 63% farms had pyoderma pustulosa in young rabbits; with 40% of affected litters, and a mean mortality rate in young rabbits of 64.2% (Rosell *et al*., 2000b, cited 2005).

Exposure factors.
S. aureus may spread between farms by bringing in breeding stock and also by semen (Rossi *et al.,* 1995). Poorly designed, poorly finished or badly maintained equipment can produce skin lesions (See Table 11.6). Infection can be a consequence of fighting. Good hygiene (disinfection) and therapeutics are useful in the control of these diseases but promoting the immune status of rabbits is also important (Grilli *et al*., 1997). The incidence of mastitis increases proportionally with the age of does.

The type of farming system is irrelevant but poorly designed floors, or dirty or rusty materials can enable to infection.

Consequences for animal welfare, human welfare, and productivity

The clinical conditions (mastitis, pyoderma, etc.) of Staphylococcosis are cause of acute and chronic suffering and poor welfare. Females affected by acute forms adopt postural signs of pain.

Staphylococcic infections produces a marked decrease in productivity and economical damage in affected rabbitries due to the mortality of nursing and weaned young rabbits. In adults there is decreased fertility and increased culling rates.

Good agricultural practices
Sanitary arrangements: Good sanitation, maintenance of equipment, cleaning and disinfection of the rabbitry. Animals affected severely should be culled.
Producers should given better information on heath status from the suppliers of future breeding stock, and farmers should insist on it.

A practical action that can be taken is with hygienic procedures and environmental controls in respect of temperature (16-18C) during the first week after birth, Relative Humidity (55-65%), and air speed (0,15-0,2 metres/second) (Ferré and Rosell, 2000).

Vaccination could be applied using either commercial vaccines, or autovaccines prepared using periodically isolated strains of *S. aureus*. They are all based on the use of bacteria inactivated with formalin and given with an adjuvant: There are commercially available vaccines prepared using both aluminium hydroxide and mineral oils as adjuvants (Lavazza, 2003).

11.7.10. Dermatomycoses

Definition and Agent Fungal diseases are a major cause of skin disorders (as well as P*seudomonas aeruginosa*, *Staphylococcus aureus*, sarcoptic mange) mainly due to dermatophytes such as *Trichophyton mentagrophytes* and *Microsporum canis* that can cause severe superficial infection or dermatophytosis (Cabañes, 2000). The aetiology depends on the country; for instance, in Spain, *T. mentagrophytes* is responsible over 90% of the infections on commercial farms (Torres-Rodríguez *et al*., 1992).

Dermatophytoses or ringworm must be differentially diagnosed from sarcoptic mange and disorders produced by other mites, as *Cheyletiella parasitovorax* and *Leporacus gibbus*.

Clinical signs and lesions: The lesions appear mainly on the head, ears and paws. There is alopecia (complete or partial) and the skin is dry and rough. Lesions can have secondary infections and become purulent.

Exposure factors.
The transmission occurs by direct contact e.g. from dam to kits, and is mainly favoured by low hygienic condition and poor management but also by other stress factors such as malnutrition, avitaminosis, poor environmental conditions (high humidity and high temperature) (See Table 11.6) and skin lesions (Moretti *et al.,* 1996).

Consequences for animal welfare, human welfare, and productivity
The economical impact is due to early slaughtering and culling, reduced productivity, increased cost for treatments etc.

Farming systems appear to be irrelevant but the incidence in closed buildings may be higher (there are no clear data).

Good agricultural practices.
Sanitary arrangements and Environmental factor: The treatment is done using both direct prophylaxis measures and medical treatment. Correct measures include: regularly removing wool and hair left hanging in the cages and in the building by burning with a gas-burner. Treatment of animals by spraying a solution of an appropriate antiseptic agent active against fungi (iodine solutions and sulphur powder) and anti-fungal substances (enilconazole topic). Disinfection of sheds, walls and ceilings.

11.7.11. Coccidiosis

Definition and aetiology: Enteric and hepatic coccidioses are the main parasitic infections (Peeters, 1987; Coudert *et al*., 1995). All eleven species that infect rabbits belong to the genus *Eimeria*, and they replicate in the intestinal epithelium or in the liver (*E. stiedai*) (Eckert *et al*., 1995).

Clinical signs and lesions: The replication of coccidia in the intestinal mucosa compromises gut function through a thinning of the mucosal layer and reduced absorption and secretion. Infection induces diarrhea of variable severity, and death in debilitated animals, even if the more frequent sign is just a reduction of production parameters.

Diagnosis: The diagnosis is quite easy to achieve either in live rabbits or at post mortem. It is important to count the number of oocyst in faeces, since it could be a good indicator of the environmental contamination as well as to identify the *Eimeria* species since they have different virulence and pathogenicity.

Incidence: Infection occurs mainly in 1-4 months old rabbits.

Exposure factors.
The farming system may predispose to infection when animals are in contact with their faeces.
The introduction of a new *Eimeria* species could be associated to the introduction of breeders as adult rabbits can act as healthy carriers since coccidia persist for the entire life of rabbits. Does transmit oocysts to their progeny.

The oocyst in its latent form is eliminated with faeces and can survive in the external environment for long times as it is highly resistant. For such reasons the persistence of contaminated fecal residual in the cages can favor infection of young rabbits. (See Table 11.6).

The use of the littered (straw and hay) floor as alternative to wire mesh flooring poses a real problem. Whilst litter enables animals to adopt more varied postures and activities, leading in turn to an enrichment in their surroundings, it also causes a significantly higher incidence of coccidiosis in the animals.

Direct prophylaxis is very important since it helps to reduce faecal contamination and to stop orofecal route of dissemination and transmission of Coccidia. In addition the periodical use (every 3-4 months) of chemical substances added to the feed is a common prophylactic practice since it help to reduce the number of coccidia globally present in the population. The authorised substances in the EU are: Robenidin, Metilclorpindol, Diclazuril and Salinomycin.

Consequences for animal welfare, human welfare, and productivity
They can cause relevant economic losses either due to mortality but mostly inducing reduced productivity. Indeed, by interfering with intestinal functions and inducing mild enteric lesions they can help some other bacteria to multiply and cause disease (e.g. *E. coli* and *Clostridium* spp).

Good agricultural practices.
In order to control the coccidiosis, measures of direct prophylaxis and cyclic methaphylaxis treatments using anticoccidial substances are often used.

It is important to maintain a good hygiene and avoid retention of faeces on the floor, (cleaning, disinfection, optimal microclimate, low stocking densities etc) in order to limit environmental contamination and to help animals to develop a solid immunity.

Vaccination: for several reasons (cost, chemoresistence, low number of therapeutic substances available) vaccination seems to be the only solution for the future. To date, only inoculation of live coccidia (precocious lines) has been found to provide adequate protection against coccidiosis (Grilli, 1998; Licois, 2004).

11.7.12. Encephalitozoonosis

Definition: Rabbit encephalitozoonosis causes a chronic disease.

Agent: Encephalitozoon cuniculi, a Gram-positive microsporidium and intracellular parasite, whose entire life cycle takes place within a single host.

Clinical signs and lesions: *E. cuniculi* can remain latent for long periods without causing disease but some epidemic outbreaks characterised by nervous signs such as torticollis can occur in stressed animals due to its reactivation.

Diagnosis: Diagnosis is made using laboratory tests particularly serology (CIA test and ELISA) and histology.

Incidence: Serological surveys in various countries have revealed an incidence of up to 90%. In Italy the parasite has been found histologically in 12.6% of slaughtered rabbits, and 20.4% of dead and sick rabbits. In one study (Lavazza *et al*., 1996) in Northern Italy, a seroprevalence of 32.5% and of 21.4% were found in industrial and rural rabbitries, respectively. In another seroepidemiological survey conducted in 12 industrial rabbitries, a prevalence from 6.7% to 96.7% (mean 47.5%) was detected (Saviotti *et al*., 2000).

Exposure factors

Farming system is not relevant

Routes of exposure: *E. cuniculi* multiplies in the kidneys and in the central nervous system and is excreted as a spore in the urine. The spore is infectious and is transmitted horizontally by ingestion of contaminated food or water, or more rarely by inhalation.

Other predisposing factors: Intensive rearing, poor hygiene, overcrowding, moving animals, and the introduction of (unchecked) animals from outside, are all factors that help spread infection.

Consequences for animal welfare, human welfare, and productivity.
In industrial animals and particularly rabbits reared for meat, infection can cause considerable financial losses due to culling of does, mortality (up to 15%), the rejection of carcasses for human consumption animals at the abattoir, and a reduced carcass weight (Greenstein, 1991; Lavazza *et al*., 1996; Saviotti *et al*., 2000; Vavra *et al.,* 1980). Lavazza *et al* (1996) have also shown the negative effect of infection have also shown the negative effect of infection on production parameters such as feed conversion index and killing out percentage. The importance of artificial insemination and good management to limit and prevent the spread of the parasite has been emphasised (Saviotti *et al*., 2000).

E. cuniculi is also a potential zoonotic agent that could infect immunodepressed humans.

Good agricultural practices.
Sanitary arrangements: Normal sanitary measures are insufficient to interrupt the life cycle of the parasite and no specific medical products are available for treatment, thus a specific plan of direct prophylaxis has to be adopted to reduce the seroprevalence or, better still, to eradicate the infection. The first step is to create groups of seronegative breeders in order to produce animals free from infection for the breeding units. Then, an eradication plan should be adopted and based on the following points. 1) Serological control and quarantine of all externally bought–in breeders. 2) To switch from natural to artificial insemination. 3) A gradual re-sanitation of sheds: they should first be emptied and after an adequate all-out sanitation period and a radical cleaning and disinfection, they should be re-populated with young seronegative does. 4) To select breeders by the elimination of seropositive rabbits. 5) Serological monitoring of samples from different aged rabbits and production categories to ensure that growing and future stock rabbits are negative.

11.7.13. Other endoparasitic diseases

Toxoplasmosis is reported in rabbits but is not frequent in industrial units. Infection can occur due to ingestion of feed and water contaminated by cats' faeces. In rabbits, two clinical forms are described (Di Sarno, 1995): the acute disease that causes abortion, fetal malformation, hydrocephalus and death of infected animals; and, secondly, a chronic disease characterised by a decrease in fertility and the presence of ocular lesions. The control is based on biosecurity programmes, and avoiding contact with cats.

Cryptosporidiosis is a rare parasitic disease caused by intracellular, extracytoplasmatic protozoa *Cryptosporidium parvum*. It has been described as occasional cause of severe diarrhoea and death in post-weaned rabbits, and may cause a mild enteritis in adults (Inman and Takeuchi, 1979). Its occurrence is favoured by concomitant disease that can depress the immune system of rabbits (e.g. *E.coli* or myxomatosis). Control is based on hygienic measures and disinfection of cages and equipment is recommended on infected farms.

Protozoa flagellata (*Chilomastix cuniculi, Monocercomonas cuniculi and Giardia duodenalis*) are becoming more important in rabbit farming even if their pathogenic role is not yet well defined. Their multiplication and occurrence is favoured by high rates of humidity. They are considered as important co-factors in the multiple etiology of the enteritis complex being able to determine an alteration of intestinal microbiota that can in turn trigger bacterial infections. In the case of outbreaks of enteritis, the correct diagnosis is made on animals necropsied immediately after death or suppression. Grilli *et al*. (1996a) found as many as 55% of animals positive during outbreaks of enteritis complex.

11.7.14. Helminths

Nemathelminths (round worms = Nematodes) and ***Platyhelminths*** (flat worms = Cestodes and Trematodes) are not frequently seen probably as rabbits are kept on wire-mesh floored cages and are fed with pelleted feeds that are rarely infested by nematodes. Secondly, the intermediate hosts of parasites that have their adult phase in rabbits are not present.

Nematodes
The most common nematode is the pinworm (4-11 mm) *Passalurus ambiguus* found in the caecum (4.2% of adult rabbits according to Grilli *et al*., 1996a). It has a direct cycle and rabbits are infested by ingestion of feed contaminated with parasite eggs that can persist on equipment and other structures. The parasite itself does not cause clinical signs but infested rabbits are nervous and appear excited and can show reduced growth.

Diagnosis is made by parasitological examination (egg counts) or at necropsy by looking for the worms that adhere to the caecal mucosa. Rabbit faeces contain eggs that persist in the environment. At 35-38C eggs develop rapidly and attain an infective stage in 7-8 days (Anderson, 1992) and rabbits are at risk of infestation from 15 days of age, especially older animals that are eating solid feed. Control is made by application of standard hygienic measures and by pharmacological treatment of infected adults

Cestodes
Hepatic cysticercosis is the most common infestation caused by *Cysticercus pisiformis* found in mainly in 4-7week old meat rabbits as a post mortem lesion. It is caused by the larval stage of the dog tapeworm *Taenia pisiformis* (and other carnivores). Water and feed can be contaminated by dogs' and cats' faeces living in the surroundings of the rabbit housing, and control is based on biosecurity programmes avoiding contact with those animals.

Trematodes
Fasciolosis. Domestic rabbits are at risk of infestation with *Fasciola hepatica* when they are feed with contaminated forages.

11.7.15. Ectoparasitic diseases

Psoroptic mange is a disease due to *Psoroptes cuniculi with a* low prevalence (3%) and moderate incidence: 29% of the rabbitries were found to be affected (Rosell, 2003, cited 2005). Hot summers (high temperatures and humidity) as well as poor hygiene and microclimatic conditions and lack of essential nutrients in feeding (e.g. vitamin A) are risk factors that lead to an increase of prevalence. In severe cases, reproduction failure is observed. The consequences for rabbit welfare are obvious as they scratch and develop proliferative and often ulcerated lesions on the internal sides of auricles and along the auditive meatus due to the irritiation and is a welfare issue. Infestation has an adverse impact on productivity, and is an economical disbenefit. Many farmers prevent this infestation by treatment with ointments containing sulphur and oil, or specific acaricides, at every new reproduction cycle. It is advisable to destroy the mites and their eggs from pits of droppings.

Sarcoptic infestation due to *Sarcoptes scabiei var cuniculi* is a rare disease in commercial rabbitries. Nevertheless, producers should pay attention because it affects rabbit welfare, productivity and is a zoonosis. Differential diagnose is necessary with ringworm.

11.8. Non Infectous disease

11.8.1. Sore Hocks

Definition: Sore hocks, or *pododermatitis ulcerosa*, is a common condition related to modern production system of rabbits on cages with wire mesh floors (Drescher and Schlender-Böbbis, 1996), but it is also seen on concrete floors. Wire mesh floors are necessary from a hygienic point of view as it is important to separate rabbits from their droppings. In fact, alternatives to wire-mesh flooring have been tested but despite their advantages to prevent injuries, other and more important hygienic and sanitary problems were posed by these alternative surfaces floor due to the retention of faeces on the floor.

Agent: Sore hocks is a multifactoral disease, but *S. aureus* is often involved.

Clinical signs and lesions: Sick rabbits adopt postures and adapt their behavior to alleviate pain, for instance, females stay in the nest. When they are physically examined lesions with different level of severity can be observed: from simply a thickening of the skin (not necessarily painful) to bloody ulcers (likely to be very painful) that can be observed on the plantar surface of the foot, and more frequently on the hind pad.

Incidence: Breeding does can become affected in the course of their production life. Injuries were found in over 16% of rabbits that have had more than six litters but only 5% of those that had had less than three litters. Thus, a mean prevalence of 10% in females is not unusual and aged does (more than 5 litters) become particularly predisposed, especially at birth (this could be due to their increased weight, their sedentary behavior, or to immunomodulation).

Exposure factors.

Farming system is irrelevant.

Enabling risk factors of disease are related with kind of floors (Rommers and Meijerhorf, 1996) and their degree of hygiene. Presence of residual of feaces on wire mesh can favour bacterial transmission. Quality and integrity of the wires of the cages (i.e. age of the cages used) are important: loss of zinc-coating and presence of abrasive surfaces can cause micro-lesions where *S. aureus* can easily multiply.

Consequences for animal welfare, human welfare, and productivity.
Sore hocks is a cause of chronic suffering. Economic interest in animals with sore hocks is based on decreased productivity in sick does, increasing sterility, newborn mortality, and increased culling rate amounting to between 4.2 and 28.6 % of the total yearly culled does (Table 11.5), but the proportion due to sore hocks is unknown.

Good agricultural practices.

A practical action that can be taken is to introduce a “softer” floor mat or footrest of some sort (e.g. plastic), on the wire mesh floor in the cages of adult rabbits, young future females and bucks. Foot mats are sometimes fixed to the wire mesh, and have the merit of covering only a part of the floor surface. They can easily be removed for cleaning and disinfection. This arrangement avoids some of the adverse effects from the viewpoint of hygiene and rigidity while appearing to achieve the aim of reducing the frequency of paw injuries (30% according to Rosell and De la Fuente, 2004). Wire thickness should be around 2.5 to 3mm (unpublished observations from trials within the industry).

11.8.2. Infertility

Definition: Infertility corresponds to the absence of gestation after natural or artificial insemination. Sub-fecundity is characterised by a reduced number of litters born over time including the reduced number of young per litter. Poor fertility is one of the main causes of culling of breeders in rabbit farms (see Table 11.5).

Agent: In both males and females sub-fertility could be an hereditary or an acquired deficit and it may also be the consequence of refusal of mating, or due to a failure in ovulation after mating. It can also result from infectious diseases that can primarily cause lesions of the reproductive tract (*Listeria monocytogenes*, *Salmonella* spp. Myxomatosis). Ovarian dysfunction and lesions can cause infertility or sub-fecundity.

Exposure factors.

Some predisposing factors are related to the intensive use and farming of does: the age of first insemination, the reproductive rhythm used on the farm, and the overlapping of lactation and reproductive phases (Renault, 1989; Gardi, 1992). When infertility lasts for a long time and its incidence is high among multiparous does, there is usually some neuroendocrine problem. This may be a consequence of environmental factors such as microclimatic conditions (for instance, high temperatures), bad lighting regimes, therapeutic treatments, poor management and insemination procedures, and poor quality of feed (e.g. energy/protein ratio and essential aminoacids).

However infertility could be also caused by infectious agents in the reproductive system (*Pasteurella multocida, Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli, Salmonella typhimurium* see Renault, 1989), or other general debilitating conditions (e.g. enteritis-diarrhoea).

Good agricultural practices.

Infertility could be preventing by application of good agricultural practices to insemination, management, environmental and microclimatic condition and feeding regimes.

11.8.3. Metabolic disease

The female rabbit has to support an intensive reproduction cycle with frequent renewals of plasma macro-nutrients and trace elements. Mineral exchanges and body condition decline is observed and sometimes is on the border between physiology and pathology (Lebas, 2000b). Within these disorders pregnancy toxaemia is a relevant disease with a clinical picture that can include death, but frequently does are affected by a subclinical forms.

Good agricultural practices.

Feeding and housing should be adequate in late pregnancy. Sometimes medical metaphylaxis with methionine or propylene glycol can be implemented to prevent this disorder. (Harcourt-Brown, 2002).

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Annex to the SCIENTIFIC REPORT

"The Impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits"

EFSA-Q-2004-023

Pictures

Picture 5.1. - Breeding unit.

Picture 5.2.- Growers in pairs with cage top removed.

Picture 5.3. - Cage with central placed foot rest with cage top removed.

Picture 5.4.- Dual-purpose cage.

Picture 5.5. Insemination of a doe.

Picture 5 6. Nest box with 14 day old kits