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Partner in livestock innovations

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Brief of Requirements of the rabbit

Rabbits on Course (Konijnen op Koers)

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Publisher
Wageningen UR Livestock Research
P.O. Box 65, 8200 AB Lelystad
Telephone +31 320 - 238238
Fax +31 320 - 238050
E-mail info.livestockresearch@wur.nl
Internet http://www.livestockresearch.wur.nl

Editing
Communication Services

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Single numbers can be obtained from the website.

ISO 9001 certification by DNV emphasizes our quality level. All our research projects are subject to the General Conditions of the Animal Sciences Group, which have been filed with the District Court Zwolle.

Abstract
The Brief of Requirements of the rabbit maps the needs of the rabbit and translates this to the requirements the design of the animal husbandry system.

Keywords
Brief of Requirements, needs, rabbit, rabbit husbandry, designs for system innovation, sustainable animal husbandry

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Author(s)
J.M.R. Cornelissen
F. Schepers
H. J. E. van Weeghel
J. M. Rommers
O. N. M. van Eijk

Title
Brief of Requirements of the rabbit

Preface

Entirely sustainable livestock production by 2023 – this is the aim of the Dutch Government and livestock organisations that signed the Policy Agenda for Sustainable Livestock Production. Is it possible to produce entirely sustainable rabbit meat? The Rabbit on Course project focuses on this issue and takes a broad view of sustainability. The aim is to create designs that improve conditions for the animals, their keepers, and the environment, which consumers and neighbouring residents not only tolerate, but also appreciate.

The project provides a forum for all parties involved in the production or consumption of rabbit meat to work towards a truly sustainable sector. The output functions as a long-term vision answering questions such as How do we want the industry to evolve in 20 to 25 years? How can we ensure it will have a valued place in our society? And what do those involved in the sector need to start doing today in order to attain these goals for the future?

Turbulent times

Today, rabbit farming is in an unsettled state, with new developments rapidly succeeding one another. A Dutch rabbit farmer must now comply with animal welfare regulations, while still responding to market demands for free-range rabbits, for example. How can farmers best invest in their businesses? And how long will these investments remain tenable? These are the issues currently facing rabbit farmers. One of the dangers of an unsettled sector is that we arrive at solutions too soon. That gives a sense of relief, but our experience with these sorts of developments is that solutions chosen too quickly may ultimately not prove to be the best ones. However, rabbit farmers can only spend each euro they have once, so opting for bad solutions can lead to a dead end. The project aims to prevent this situation from occurring. The time for this seems right; all those involved feel that something has to change.

Unifying needs

In addition to examining in greater depth the motives of various parties involved in the sector, the project will survey the needs of the animals, farmers, citizens, and the environment. This Brief of Requirement of the rabbit is one of the project milestones in this roadmap. Together with the needs of the other actors, these requirements will serve as the conditions which an entirely sustainable system must satisfy.

Pooling visions and daring to innovate

The methods used in the Rabbit on Course project have been successful in earlier projects such as Hen Husbandry (Houden van Hennen), Cow Power (Kracht van Koeien), and Pig Opportunities (Varkansen)[1]. These projects have shown the value of devising an integral solution to a series of challenges rather than addressing them individually. Some solutions strengthen each other, increasing their net effects. It is crucial to work together, pool visions, and dare to innovate. An essential mindset is that one is prepared to critically assess the current situation and take the leap towards a sustainable sector.

[1] See www.duurzameveehouderij.wur.nl

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1 Introduction

In this report we present the Brief of Requirements (BoR) of the rabbit. The Brief of Requirements (BoR) of the rabbit is based on the ethological needs of the rabbit and specifies the requirements of the rabbit regarding its environment, which is made up of technological, natural and social components. Together with the needs of the rabbit farmer, the citizen-consumer and the environment, these requirements will serve as input in a re-design process following the reflexive interactive design approach (or RIO approach), developed by Wageningen UR Livestock Research (Bos et al., 2009). In the re-design process, researchers from various disciplines work together with stakeholders of the rabbit production sector on designs of the rabbit husbandry system which contain the promise of an integral sustainable future. These will be based on the basic needs of the main actors in the system: rabbit, rabbit farmer, environment and society (using their Briefs of Requirements). The re-designs function as stepping stones towards system innovation. The RIO approach has been applied in several other animal husbandry sectors (e.g. laying hens, dairy cows and fattening pigs) and proved to function successfully as drivers for change.

1.1 Animal welfare

Over the past decades animal welfare has become increasingly important and developed into an established science. Many definitions of animal welfare have been proposed by scientists and were brought together in the EFSA report (EFSA, 2005):

- 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”.
- 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 Sandøe, 1997).

1.2 From needs to requirements

The needs of animals can be used to assess their overall welfare (Bracke et al., 1999). One way to determine these needs and assess welfare is to base needs on motivational systems and decompose them to requirements. Bracke et al. (2001) used an Animal Needs Index or a Decision Support System, which uses attributes of the husbandry system and its management. This means that the environmental design (e.g. space allowance, floor type, management) affects the animal (e.g. behaviour, physiology, health).

The EFSA working group (EFSA, 2005) agreed that it can be expected that there are no genetic differences that cause farmed rabbits to have different needs from laboratory rabbits or pet rabbits. Furthermore, they expect there will be few differences from wild rabbits. In light of this, literature on all types of rabbits (wild, pet, breeding and laboratory) was consulted.

2 Methods

For the BoR the list of needs by Bracke et al. (1999) for pigs was used and adapted for rabbits. For the rabbit we distinguish seventeen different needs in seven categories (see Table 1).

Table 1 Needs of the rabbit

Category	Need
Physical comfort	Rest
	Locomotion
	Body care
Reproduction	Sexual behaviour
	Nest building
	Maternal behaviour
Physiological comfort	Excretion
	Thermoregulation
	Respiration
Nutrition	Food
	Water
Other behaviours	Social interaction
	Play
Health	No illness
	No injury
Safety	No danger
	Minimal aggression

2.1 Database search

The basis of a BoR is the current scientific (both fundamental and applied) knowledge. The databases Scopus and OvidSP were consulted for relevant literature. In order to make a selection of references from these databases that encompasses as much relevant literature as possible, without including a lot of irrelevant literature, a search string was developed.

The keywords in the search string included the word 'rabbit' combined with the following words: needs; welfare; wellbeing; well-being; well being; quality of life; behavior; behaviour; housing; husbandry; health. This means that if one of these words were found together with the word rabbit in the title, abstract or keywords of a reference it was selected. The timespan for inclusion was 1910 onwards. Furthermore, for searching Scopus only those references that were categorized in the following subject areas were included: Agricultural and Biological Sciences; Biochemistry, Earth and Planetary Sciences, Environmental Science; Genetics and Molecular Biology; Multidisciplinary; Veterinary; Undefined. This means that references from the following subject areas were excluded: Arts and Humanities; Business, Management and Accounting; Chemical Engineering; Chemistry; Computer Science; Decision Sciences; Dentistry; Economics, Econometrics and Finance; Energy; Engineering; Health Professions; Immunology and Microbiology; Materials Science; Mathematics; Medicine; Neuroscience; Nursing; Pharmacology, Toxicology and Pharmaceutics; Physics and Astronomy; Psychology; Social Sciences.

This yielded over 9000 references. All 9000 references went through a quick skimming procedure, where title, keywords and affiliation were judged for relevance. Only those references that dealt with the animal rabbit (all types of rabbits: wild, pet, breeding and laboratory) and that reviewed or researched a topic related to the rabbit's needs, welfare, behaviour, housing or health were included. After this step, about 1000 references were included for the next step. Next, the remaining references were scanned again for relevance (using the same criteria), based on the information in the abstract. Eventually, over 80 references were used to develop the BoR.

2.2 Reviewing process

Several experts on rabbit husbandry were consulted during the development of this BoR. The experts have contributed to the development of this BoR by discussing certain controversial points; issues on which there was very little or contradicting literature, or by reviewing the concept version of the BoR. The expert panel is displayed in Table 2.

Table 2 Expert panel

Name	Institute
Claude Andrist (PhD-student)	Centre for proper housing of poultry and rabbits (ZTHZ), Federal veterinary office FVO (Zollikofen, Switzerland)
Lotti Bigler	Centre for proper housing of poultry and rabbits (ZTHZ), Federal veterinary office FVO (Zollikofen, Switzerland)
Stephanie Buijs	Institute for Agricultural and Fisheries Research (ILVO) (Merelbeke, Belgium)
Steffen Hoy	Department of Animal Breeding and Genetics, Justus Liebig University Gießen (Gießen, Germany)
Ingrid de Jong	Livestock Research, Wageningen UR (Lelystad, The Netherlands)
Luc Maertens	Institute for Agricultural and Fisheries Research (ILVO) (Merelbeke, Belgium)
Knut Niebuhr	Institute of Animal Husbandry and Animal Welfare, University of Veterinary Medicine Vienna (Vienne, Austria)
Jorine Rommers	Livestock Research, Wageningen UR (Lelystad, The Netherlands)
Zsolt Szendro	Faculty of Animal Science University of Kaposvar (Kaposvar, Hungary)

2.3 Lay-out of the BoR

The BoR is divided into seven categories (Physical comfort; Reproduction; Physiological comfort; Nutrition; Other behaviours; Health; Safety) and contains seventeen different needs (Rest; Locomotion; Body care; Sexual behaviour; Nest building; Maternal behaviour; Excretion; Thermoregulation; Respiration; Food; Water; Social interaction; Play; No illness; No injury; No danger; Minimal aggression).

The results of the BoR are displayed in a four-column table. The needs are indicated in bold and placed in grey cells. Each specification has at least one requirement. The requirements represent the preferred level of the rabbit. Fulfilment of the requirements will enable rabbits to practice their behaviour undisturbed and without unnecessary stress, aggression and other negative behavioural or physiological discomfort. In addition, it enables natural behaviour and gives the best possible chances for good welfare. The requirements are stated in a solution-free manner. A description of the requirement is given in the first column. Where possible, quantification is given in the second column. The third column gives remarks and explanations on the requirement. The fourth column states the sources that were used to develop the requirement. Sources used varied from peer-reviewed scientific papers, to conferences proceedings, handbooks and even expert views.

3 Brief of Requirements

3.1 Physical comfort

3.1.1 Rest

Rabbits attempt to divide their living space into separate areas for feeding, resting and excretion. An area specifically suited for resting is important since rabbits spend most of their time resting. Rabbits also tend to rest where other rabbits are already resting. For about half of the time when they rest, rabbit are in body-contact with another rabbit. 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. The lie out straight position takes the most space.The resting area should have a floor that is attractive for resting and should cater for all rabbits simultaneously. It should be located in a competition free area (i.e. not near or on route to a food or nesting area).

Table 3 Requirements for the need 'Rest'

Description	Value	Remark	Source
Spatial arrangement of resting area			
All rabbits should be able to reside simultaneously in the resting area	Surface area available per rabbit ≥ surface area that a lying rabbit occupies		(EFSA, 2005)
Constructed so that it provides visual cover from above and behind the animal		Rabbits want cover from above and behind to protect them from air and ground predators. E.g. a limited height in the resting area.	(Love, 1994; Coenen et al., 2004; Princz et al., 2008)
Area where does can withdraw from the kits, where comfortable resting is possible	Surface area available per rabbit ≥ surface area that a lying rabbit occupies	Currently, a platform offers the doe the opportunity to withdraw from her kits. However, this does not seem to suffice in sufficiently reducing suckling attempts	(Love, 1994; Hansen and Berthelsen, 2000; Seaman et al., 2008)
	Not accessible for kits		Expert view
Disturbance free (from other rabbits that are not resting)	E.g. no walking line through resting area, not near or on the route towards food or nesting area	So that the resting rabbits are not disturbed by active rabbits	(Stauffacher, 1992), expert view
Protection from wind, rain, sun, etc.			Expert view
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)

Floor			
Attractive for resting	Requirements regarding materials, design or friction unknown	The preference for different floor types seems to depend on several factors, such as insulating capacity, cleanliness or dryness of the floor	(Morisse et al., 1999; Matics et al., 2003; Orova et al., 2005), Expert view
	Clean and dry	No moist, water, urine or dropping should accumulate on the floor	(Garibaldi et al., 1990; Morisse et al., 1999; Matics et al., 2003)
Rabbit should have a free choice between different floor types		This enables the rabbit to choose their own comfort temperature. Combined floors (wire net and straw litter) lead to more social behaviour and less stereotypes	(Jekkel and Milisits, 2009), Expert view
Presence of conspecifics			
Physical contact with another rabbit should be possible during resting		For about 50% of resting time rabbits are in body-contact with at least one other animal	(Stauffacher, 1992; Love, 1994; EFSA, 2005)
Circadian rhythm			
Light intensity which follows a natural light-dark rhythm	~ 16h light/24h; during dark period no light should be present; duration of dusk and dawn unknown	Rabbits display a two-peak circadian rhythm crepuscular with active periods (incl. eating) around dawn and dusk. Over 60% of the solid feed is consumed in the dark period	(EFSA, 2005; Fortun-Lamothe and Gidenne, 2006), expert view

3.1.2 Locomotion

Rabbits should be able to perform locomotive behaviour, this includes hops[2], jumps, frisky hops, running[3] and turning. It has been shown that if they are unable to perform these behaviours they suffer injury to their locomotor system. The floor and the spatial arrangement (design of the rabbits' living environment) are pivotal for this need.

[2] Commonest mode of locomotion. Events: body rests on hind legs; forelegs reach forward; forelegs are placed on the ground one after the other; both hind legs are pushed away and swung forward underneath a bent body; front legs are lifted (floating phase); hind legs are moved forward rapidly on the outside of the forelegs; hind legs are placed on the ground; front legs reach forward

[3] Fasted mode of locomotion. Events: body rests on hind legs; forelegs reach forward; hind legs are pushed away and body is stretched fully (first floating phase); front legs are placed on the ground; both hind legs are swung forward underneath a bent body, front legs are lifted (second floating phase); hind legs are moved forward rapidly on the outside of the forelegs; hind legs are placed on the ground; front legs reach forward

Table 4 Requirements for the need 'Locomotion'

Description	Value	Remarks	Source
Spatial arrangement of activity area			
Space to run and perform at least 3 consecutive hops, jumps and frisky hops	Length of area ≥ 210 cm length, height ≥ 100 cm	This space should not be occupied with other animals resting for instance. If they cannot perform locomotory behaviour, they lose their ability to perform this behaviour and they suffer from injury to their locomotor system	(Stauffacher, 1992; Love, 1994; EFSA, 2005)
An area in which rabbits can sit up normally with ears erect	Height (up to 1,5 kg BW) ≥ 30 cm height, (from 1,5 kg BW up to slaughter weight (2,5 kg)) ≥ 45 cm height	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 (EFSA, 2005)	(EFSA, 2005)
	Length, width or surface area unknown		Expert view
A raised area	Height of raised area unknown	Females, with or without kits, use the platform independently of space available. It is argued that a raised area gives the animal the opportunity to explore/map their environment and that it promotes locomotory behaviour thereby strengthening the rabbit's locomotory system	(Drescher, 1990), Expert view
Constructed so that it encourages locomotion			Expert view
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)
Living environment that is and remains challenging and stimulating.		To stimulate the rabbit (reducing abnormal and stereotypic behaviours, boredom and stress). This can be done by a set of heterogeneous methods of improving animal welfare, including everything from social companionship to toys. Materials added for social enrichment should be edible. More than one means to stimulate the rabbit should be used	(Johnson et al., 2003; Baumans, 2005)
Appropriate	Allowing species specific locomotion	Appropriate flooring will cause no discomfort, distress or injury, and form a rigid, even and stable, but not slippery, surface.	(EFSA, 2005)
	Clean and dry	No moist, water, urine or dropping should accumulate on the floor	(Garibaldi et al., 1990; Morisse et al., 1999; Matics et al., 2003)

Sufficient level of light during active period	≥ 50 Lux	To allow the rabbits to have visual contact, to investigate their surroundings visually and to show normal levels of activity The value depends on the measurement method	(EFSA, 2005)
Light intensity which follows a natural light-dark rhythm	~ 16h light/24h; during dark period no light should be present; duration of dusk and dawn unknown	Rabbits display a two-peak circadian rhythm crepuscular with active periods (incl. eating) around dawn and dusk. Over 60% of the solid feed is consumed in the dark period	(EFSA, 2005; Fortun-Lamothe and Gidenne, 2006), expert view

3.1.3 Body care

Rabbits show many kinds of comfort behaviours such as, scratching, stretching, yawning, sneezing and grooming. They prefer to groom and allogroom during resting. Presence of other rabbit and enough space to perform the behaviour is important.

Table 5 Requirements for the need 'Body care'

Description	Value	Remarks	Source
Spatial arrangement			
Enough space for grooming behaviour		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 hind paw, and nibble dirty spots with the teeth or scratch them with the claws of a hind leg	Expert view
Floor			
Not slippery			Expert view
Mutual grooming			
Physical contact with another rabbit should be possible during resting		Mutual (allo-) grooming is important in rabbits and increases group cohesion	(EFSA, 2005)

3.2 Reproduction

3.2.1 Sexual behaviour

In the wild, rabbits are mated directly after parturition (post-partum) during the mating season. However, during wintertime they are in anoestrus and can restore body reserves. In the current reproduction system, such seasonality is not present. Rabbits are not mated post-partum but during the lactation period. Rabbit does are artificially inseminated on most of the farms. It is important to do this when does are physically ready. They should e.g. have a good body condition score (not too thin or fat) and be sexual receptive. There is no scientific consensus on the best time for mating.

Table 6 Requirements for the need 'Sexual behaviour'

Description	Value	Remarks	Source
Time of mating or AI			
When the doe is physically ready		E.g. good body condition score and sexual receptivity	(Castellini et al., 2006; 2007)
No breeding of primiparous females immediately after parturition			(EFSA, 2005)
First mating of nulliparous does	Age of doe ≥ 17 weeks		(Rommers et al., 2004)
Circadian rhythm			
Sufficient amount (in time and intensity) of light	~ 16h light/24h	Increasing the day length has a positive effect on the reproduction performance while a decreasing length has an opposite effect	(

3.2.2 Nest building

Rabbit does start to build a nest 8 to 6 days before parturition whereas the real nest building behaviour is limited to a few days before kindling. In order to perform this behaviour they need a proper nesting place. It should be constructed so that the kits stay in the nest and that the doe can fill it with nesting material and hair so that it offers the needed insulation for the kits. Nesting material should be available as well as a substrate that the doe can manipulate to build her own nest by digging and scraping into it. Digging is a natural behaviour for rabbit does, and when the substrate does not change when doing so, the doe's emotions are frustrated and the digging is considered abnormal.

Table 7 Requirements for the need 'Nest building'

Description	Value	Remarks	Source
Nesting place availability			
Available for pregnant does	From 5 to 3 days before parturition		(EFSA, 2005; Hoy, 2009)
Spatial arrangement of nesting place			
Constructed so that kits cannot leave the nest too early		If kits leave the nest too soon (<15 days of age) they can die because they cannot remain their body temperature	Expert views

Large enough for the doe to turn around	Length of sides ≥ 25 cm		(Anonymous, 1988)
Contain substrate suitable for digging/ scraping	Substrate should be flexible and manipulable		(Stauffacher, 1992)
Solid sides/walls			Expert view
Narrow access			Expert view
Separate from the common area			Expert view
Doe should be able to close the nest with manipulable substrate		Odours from the nest triggers the does' nest closing behaviour. Closing and keeping distance to the nest protects the litter from predators and other hazards, and insulates it. It is evolutionary highly adaptive and still present in domesticated does	(Stauffacher, 1992; Coureaud et al., 2000; Baumann et al., 2005a; 2005b; 2005c; Verga et al., 2009)
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)
Nesting material			
Available before parturition	From 3 days to parturition		(Canali et al., 1991; González-Mariscal et al., 1994)
Loose and manipulable			(Canali et al., 1991; González-Mariscal et al., 1994)

3.2.3 Maternal behaviour

Under natural circumstances does suckle their kits once a day for a few minutes (although some individual suckle their kits more often), usually at dusk and/or dawn. During the rest of the period they close the nest and leave it. This is an evolutionary adaptive behaviour and serves as predator avoidance, but also to keep the climatic conditions for the kits optimal. If a doe will fail to achieve the feedback of a successful removal of nest stimuli, in spite of conducting the appropriate behavioural patterns, this leads to repeated nest contacts, nest visits and nest closing attempts and can increase kit mortality due to the crushing of kits and the disturbance of their energy-saving strategy of resting between nursing visits. Furthermore the doe and kits should not be disturbed during suckling. Startling of

the doe might lead to abrupt suckling termination or even trampling of kits. Weaning of the kits should occur at an appropriate age. In the wild, when does are mated post-partum, kits are usually weaned at age 23 to 25 days. Weaning too early is detrimental for the kits and too late compromises the body condition of the doe. However, there is still debate about the optimal weaning age

Table 8 Requirements for the need 'Maternal behaviour'

Description	Value	Remarks	Source
Nest visits			
Does should have unlimited and free access to the kits for suckling		Naturally does suckle their kits once a day for a few minutes, after dawn and/or dusk. The doe should initiate nursing not the kits	(Zarrow et al., 1965; Schulte and Hoy, 1997; Seitz et al., 1998; Selzer et al., 2004)
Kits should not be disturbed by nest visits by the doe too often	Approx. 1 or 2 nest visit a day	Naturally does nurse once a day. If the doe visits the nest more often, kit mortality can increase due to the crushing of kits and the disturbance of their energy-saving strategy of resting deep inside the insulating nest material between nursing visits	Expert view
Nest closure and withdrawal from nest			
Doe should be able to get out of reach of sight and smell of the kits		If a doe receives continuous stimuli from the nest (sounds, sight, smell) she performs maternal behaviour (attempting to close the nest entrance, accessing the nest and suckle kits) outside normal suckling episodes. A pen of 2 x 2 meters was not enough to avert these stimuli. As a result of excessive suckling and nest visits, kit mortality can increase due to the crushing of kits and the disturbance of their energy-saving strategy	(Coureaud et al., 2000; Selzer et al., 2004; Baumann et al., 2005a; 2005b; 2005c), expert view
Doe should be able to close the nest with manipulable substrate		Odours from the nest triggers the does' nest closing behaviour. Closing and keeping distance to the nest protects the litter from predators and other hazards, and insulates it. It is evolutionary highly adaptive and still present in domesticated does	(Stauffacher, 1992; Coureaud et al., 2000; Baumann et al., 2005a; 2005b; 2005c; Verga et al., 2009)
Litter size			
Milk demand from the litter should not cause a negative energy balance of the doe	Litter size proportionally with milk production of the doe (in primiparous does litter size ≤ 8 kits)	Too large litters are detrimental for the doe (require high milk production which negatively affects her energy balance) as well as for the kits (competition between kits is strong during nursing). In current husbandry systems, litters are homogenised at parturition to avoid excessive competition for milk	(Rommers et al., 2001; EFSA, 2005), expert view

Suckling			
Does should not be disturbed during suckling			(EFSA, 2005)
Competition during suckling should be minimized for the kits	Litter size proportionally with milk production of the doe (in primiparous does litter size ≤ 8 kits)	Too large litters are detrimental for the doe (require high milk production which negatively affects her energy balance) as well as for the kits (competition between kits is strong during nursing). In current husbandry systems, litters are homogenised at parturition to avoid excessive competition for milk	(Rommers et al., 2001; EFSA, 2005), expert view
	Homogenous litters (regarding weight of the kits)		(EFSA, 2005)
Weaning			
There should be an area where does can withdraw from the nest/kits and where they can rest comfortably	Surface area available per rabbit ≥ surface area that a lying rabbit occupies	If a doe can withdraw from the kits, she will have free choice of when to wean the kits. Currently, a platform offer the doe te opportunity to withdraw from her kits. However, this does not seem to suffice in sufficiently reducing suckling attempts. Currently, kits are weaned at 28-37 days. However, kits and doe may benefit from early weaning: energy output of doe and consequent body energy deficit might be reduced and kit nutritional requirements might be better covered with specific starter diets. Possibly, also pathogen transmission might be reduced by the shorter period of contact between litters and does	(Love, 1994; Hansen and Berthelsen, 2000; Pascual, 2001; Seaman et al., 2008), expert view
	Not accessible for kits		Expert view
Starter diets for kits available			Expert view

3.3 Physiological comfort

3.3.1 Excretion

There should be an excretion area distinct from a feeding and resting area. Rabbits make latrines, however, it is difficult to predict the area rabbits will use as a latrine. Usually it is in corners or near to walls. (Domestic) rabbits can be trained to use a certain area for excretion.

Table 9 Requirements for the need 'Excretion'

Description	Value	Remarks	Source
Hygiene			
Rabbits should not be in contact with faeces (hard pellets) and urine			(EFSA, 2005)
Spatial arrangement of excretion area			
Distinct from feeding and resting area		Defecation occurs passively during feeding and drinking or actively at specific places within or at the boundary of the home range (however, it is difficult to predict the area that rabbits will use as latrine). For urination rabbits may visit specific places	(Baumans, 2005; EFSA, 2005)
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)
Floor in feeding and drinking area			
Floor that separates faeces and urine from the animals		Since defecation occurs passively during feeding and drinking	Expert view

3.3.2 Thermoregulation

Rabbits are extremely susceptible to high temperatures and draft. Rabbit have several thermoregulation strategies, for instance they lie out straight to cool down and they huddle together to warm themselves. Flooring type and different temperature zones are important in thermoregulation.

Table 10 Requirements for the need 'Thermoregulation'

Description	Value	Remarks	Source
Environmental temperature			
Appropriate	13 °C ≤ T ≤ 20 °C (except for kits weaned at ≤ 27 days old); 20 °C ≤ T ≤ 22 °C (for kits weaned at ≤ 27 days old)		(Anonymous, 1988; Marai and Rashwan, 2004; EFSA, 2005)
Relative humidity			
Appropriate	55% ≤ RH ≤ 65%		(Marai and Rashwan, 2004; EFSA, 2005)

Air flow velocity			
No draft	0.15 m/s ≤ v_{air} ≤ 0.20 m/s		(EFSA, 2005)
Spatial arrangement			
Rabbits should be able to choose their own comfort temperature		Several methods of free choice in comfort temperature are possible, e.g. different floors, temperature gradient, ventilation, substrate, etc.	(EFSA, 2005)
All rabbits should be able to lie out straight at the same time	Surface area available per rabbit ≥ surface area that a lying rabbit occupies	Rabbits cool by lying out straight	(EFSA, 2005)
Kit thermal efficiency strategy			
Kits should be reared in a nest with nest material that provides enough insulation		Kits exert an energy-saving strategy by resting deep inside the insulating nest material between nursing visits. The thermal efficiency of kits increases when several kits rest in the nest	Expert view
Kits should be in the presence of other kits in the nest			(Bautista et al., 2003; EFSA, 2005)
The nest should be of such a size that the kits can huddle together			Expert view

3.3.3 Respiration

For respiration the air needs to be of a good quality (e.g. avoiding too high levels of NH_3, CO_2, NO), which requires adequate ventilation. Data on the maximum levels for rabbits is unknown.

Table 11 Requirements for the need 'Respiration'

Description	Value	Remarks	Source
Air quality			
Fresh air	0.17 m3/min air flow per rabbit		(Anonymous, 1988; Marai and Rashwan, 2004; EFSA, 2005)
Not too much dust in the air	Total dust ≤ 2,4 mg/m3; respirable dust ≤ 0,16 mg/m3	Dust can lead to respiratory and ocular distress. Total dust (PM100 and smaller) will enter nose and mouth during breathing. Respirable dust (PM5 and smaller) will penetrate into the gas exchange region of the lungs. No data for rabbit husbandry is available; re-	(Winkel et al., 2010)

		quirements are threshold limit exposure guidelines for people working in hen and pig husbandry. It is expected that skin, hair, feed, faeces and bedding are potential sources of dust	
Ammonia levels	≤ 10 ppm		(Hubrecht and Kirkwood, 2010)

3.4 Nutrition

3.4.1 Food

Rabbits eat many times per day and should be able to eat whenever they feel the need. Food should be provided in a feeding area, which is distinct from a resting and excretion area. The diet of rabbits should be fitted to their digestive system. Therefore, a correct dietary composition is important. Rabbit diets should contain enough fibre for prevention of digestive problems.

Table 12 Requirements for the need 'Food'

Description	Value	Remarks	Source
Food quality / composition			
Correct dietary composition (energy, fibre, vitamins, etc.)	Specific requirements depend on several factors	For specific data on feed requirements several studies can be consulted	(Adamson and Fisher, 1973; Xiccato, 1996; Lebas, 2000; Debray et al., 2002; Feugier et al., 2006; Volek et al., 2006; Carabaño et al., 2008; Mateos et al., 2010)
Free from toxins		To prevent physiological problems. It should e.g. not contain mould	(EFSA, 2005)
Clean (free from faeces, urine, pathogens, etc.)			(EFSA, 2005)
Roughage	Ad libitum	Roughage promotes times spent on foraging, reduces abnormal and stereotypic behaviour and reduces trichobezoars and teeth problems	(Lehmann, 1990; Mulder et al., 1992; Love, 1994)
Food availability			
Sufficient amount of feeding places	Feeding place of a width of ≥ 3 cm (weaning age) to ≥ 4 cm (max 4 kg bodyweight) available per rabbit, for adult bucks ≥ 10 cm per animal	There is minimal competition among rabbits because they feed 30-40 times a day	(Hoy, 2009)
Use a feeder type suitable for rabbits that is easily accessible		It is unclear whether rabbits prefer group feeders over individual feeders. Kits prefer to	(EFSA, 2005)

		eat out of the does' feeder and do not need separate kit-feeders.	
Unlimited access	Ad libitum; 24 hrs /day	Rabbits feed 30 - 40 times a day	(EFSA, 2005)
Spatial arrangement of the feeding area			
Constructed so that feeding area is separate from resting and excretion area		There are several ways to do this. E.g. making the floor in the feeding area unattractive for resting	(Stauffacher, 1992; Baumans, 2005)
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)
Foraging			
Substrate available that is suitable for scraping[4]	flexible and manipulable substrate	Rabbit forage by scraping in a in order to uncover roots and tubers. It gives animals information about their environment and is a medium of occupation	(Dean, 1999), expert view
Gnawing			
Gnawing material present that is flexible, manipulable, non-toxic, free of pathogens, mould, faeces and urine		Soft wood or natural branches can be used. Gnawing is connected with the animals' digestive process	(Huls et al., 1992; Lidfors, 1997; Baumans, 2005; Rommers and Jong, 2010)
Gnawing material that is easy to clean/disinfect or that is used once			(Huls et al., 1992; Baumans, 2005; Rommers and Jong, 2010)
Circadian rhythm			
Light intensity which follows a natural light-dark rhythm	~ 16h light/24h; during dark period no light should be present; duration of dusk and dawn unknown	Rabbits display a two-peak circadian rhythm crepuscular with active periods (incl. eating) around dawn and dusk. Over 60% of the solid feed is consumed in the dark period	(EFSA, 2005; Fortun-Lamothe and Gidenne, 2006), expert view

[4] Rabbits move their front legs to the back alternately. Scraping is seen in wild rabbits in a range of situations (when constructing living or nesting tubes; to surface roots and tubers in the superficial layer of the soil; in hay or grass while also using the hind legs in order to collect the substrate under their belly; in conflict situations as displacement activity.

3.4.2 Water

Rabbits should have ad libitum access to water. Therefore there need to be enough and suitable drinking points. The drinking points need to be hygienic and the water itself has to be clean and safe for drinking.

Table 13 Requirements for the need 'Water'

Description	Value	Remarks	Source
Water quality			
Clean and safe for drinking			(Anonymous, 1988)
Drinkers should be clean		E.g. Free from urine, droppings, hairs, algae	Expert view
Sufficient amount of drinking points	≥ 2 drinkers per group and ≥ 1 drinker per 10 rabbits		(Verga et al., 2009)
Water availability			
Use a drinker type suitable for rabbits that is easily accessible		E.g. a nipple drinker or bowl	(Drescher and Hanisch, 1995)
Rabbits should always have access to water	Ad libitum	Under normal temperature conditions, the feed water ratio is between 1.7 and 2.0. Only under heat stress conditions, this ratio is >2.0	(Anonymous, 1988; Wolf et al., 2008; De Blas and Wiseman, 2010)

3.5 Other behaviours

3.5.1 Social contact

Rabbits are gregarious animals and need the presence of conspecifics. They have a high motivation for social contact. It has been shown that group housing reduces abnormal and stereotypic behaviour. The optimal group size and density is unknown at this moment, despite numerous studies performed. Because of dominance hierarchies the environment should be constructed so that each rabbit is able to initiate or avoid social contact and/or physical contact.

Table 14 Requirements for the need 'Social contact'

Description	Value	Remarks	Source
Spatial arrangement			
Physical contact with another rabbit should be possible		Rabbits have a high motivation for social contact just as much as the need for food	(Huls et al., 1992; Reiter, 1994; Drescher and Reiter, 1996; Dean, 1999; Seaman et al., 2008)
The living environment should be constructed so that each rabbit is able to initiate or avoid social contact and/or physical contact with conspecifics at its own will		This means that it should provide enough space and the right structuring (e.g. visual barriers or hiding possibilities)	(Baumans, 2005)
Group composition			
Groups of growing rabbits should consist of littermates			(Baumans, 2005)
Groups of does should remain stable; i.e. no introduction of new does in an already stable group		Does establish a hierarchy. 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 managements where the does are isolated around parturition, this might not be relevant, because after being apart for some time the does need to re-establish the hierarchy and thus tend to fight regardless of their group composition before and after isolation	(Mykytowycz and Dudziński, 1972; Vastrade, 1986; 1987; Lehmann, 1991)
Buck present in a group of does	1 buck per group of does	Bucks have a territory which they defend against other bucks. In the wild and under semi-natural conditions, bucks intervene in aggressive encounters between does	(Mykytowycz and Dudziński, 1972)
Male growing rabbits should be removed from the group when there is too much restlessness or too many injuries		This is likely linked to the sexual maturity of male rabbits, at this time they start to display aggressiveness amongst each other. Furthermore, also the buck (when present) starts to display aggressiveness towards the young rabbit when they reach sexual maturity	Expert view
Bucks should not be housed in the same group with other bucks			Expert view
Group size			
Optimal	Unknown		Expert view

Light			
Sufficient level of light during active period	≥ 50 Lux	To allow the rabbits to have visual contact, to investigate their surroundings visually and to show normal levels of activity. The value depends on the measurement method	(EFSA, 2005)

3.5.2 Play

Play behaviour is mostly in the form of gambolling, zigzagging and jumping. During gambolling speeds of 30 km/hour are reached, zigzagging and jumps up to 1 meter in the air take place.

Table 15 Requirements for the need 'Play'

Description	Value	Remarks	Source
Spatial arrangement			
Enough space for play gambolling	Height ≥ 100 cm		(EFSA, 2005)
	Length, height or surface area unknown	This needs considerable space since during gambolling speeds of 30 km/hour are reached	(EFSA, 2005)
Living environment that is and remains challeng-ing and stimulating		To stimulate the rabbit (reducing abnormal and stereotypic behaviours, boredom and stress). This can be done by a set of heterogeneous methods of improving animal welfare, including everything from social companionship to toys. Materials added for social enrichment should be edible. More than one means to stimulate the rabbit should be used	(Johnson et al., 2003; Baumans, 2005)

3.6 Health

3.6.1 No illness

Illness is closely related to hygiene. It is therefore necessary to provide an optimal hygiene level, which requires regular cleaning and disinfecting. Rabbits should not be in contact with their faeces and/or urine and liquids should not be able to accumulate on the floor, because those are ideal environments for bacteria, fungi and other germs to multiply. Furthermore, the bedding that is used should not be toxic for rabbits, high amounts of dust should be prevented, because they can cause respiratory and ocular distress and contact with insect, wild rabbit, rodents and birds should be prevented.

Table 16 Requirements for the need 'No illness'

Description	Value	Remarks	Source
Hygiene			
Rabbits should not be in contact with faeces (hard pellets) and urine			(EFSA, 2005)
Floors/bedding should be dry		No moist or water should be able to accumulate on the floor	(Garibaldi et al., 1990)
Environment should be low in pathogens and sources of infection		No specific data available for rabbit	(EFSA, 2005)
Environment should be low in insects		So as to reduce the risk of infections and diseases	(EFSA, 2005)
No exposure to wild rabbits, rodents and birds		So as to reduce the risk of infections and diseases	(EFSA, 2005)
Bedding			
Non-toxic		e.g. sawdust from conifers contains toxic components such as abietic acid and phenols	(Klaver, 2008)
Feed			
Roughage	Ad libitum	Roughage (such as hay or straw) promotes times spend on foraging, reduces abnormal and stereotypic behaviour and reduces trichobezoars as well as teeth problems	(Lehmann, 1990; Mulder et al., 1992; Love, 1994)
Gnawing			
Gnawing material present that is flexible, manipulable, non-toxic, free of pathogens, mould, faeces and urine		Soft wood or natural branches can be used. Rabbits need to gnaw due to continuous growth of their incisor teeth. Gnawing is connected with the animals' digestive process	(Huls et al., 1992; Baumans, 2005; Rommers and Jong, 2010)
Gnawing material that is easy to clean/disinfect or that is used once			(Huls et al., 1992; Baumans, 2005; Rommers and Jong, 2010)
Spatial arrangement			
Rabbits should be able to take the posture needed for caecotrophy		Rabbits take soft faeces (caecotrophs) directly from their anus and ingest them. Caecotrophy is an essential behaviour with the consequence that more nutrients are obtained from the food. Caecotrophy follow approximately 8 hours after feeding and is not dependent on circadian rhythm	(Hornicke et al., 1984; EFSA, 2005)

Light			
Exposure to daylight	Light spectrum resembling day-light	Under the influence of ultraviolet light vitamin D precursors are synthesised in the skin. Vitamin D is a fat soluble vitamin which plays an important role in the homeostasis of calcium and phosphorus	(Fairham and Harcourt-Brown, 1999)

3.6.2 No injury

Rabbits should not be injured form their environment, e.g. there should be no sharp objects. Special attention needs to be paid to the floor. Sore hocks are the third commonest cause of culling of breeding does. Therefore, the floor should not cause foot injuries. Appropriate flooring will cause no discomfort, distress or injury, and form a rigid, flat and stable, but not slippery, surface. Slippery flooring can cause hip dysplasia and other musculoskeletal changes in growing rabbits.

Rabbits are easily injured during handling by humans. Proper handling prevents this. 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. Rabbits should be carried by hand individually and placed in containers or trolleys one at a time. The distance rabbits are carried by hand should be minimised.

Table 17 Requirements for the need 'No injury'

Description	Value	Remarks	Source
Spatial arrangement			
The living environment should be constructed so that rabbits cannot injure themselves		E.g. no sharp objects in the environment	(EFSA, 2005)
Floor			
Floor type should not cause foot injuries		Adult rabbits experience problems with wire mesh (even if the diameter is higher than 3 mm). The installation of a plastic platform or slatted footrest on a wire mesh can prevent or even cure sore hocks	(Rosell and Fuente, 2009), Expert view
Gaps in the floor of optimal size	14 mm (10 mm ≤ width ≤ 16 mm)	Gaps should not be too small (faeces can't fall through) or too large (feet of does or kit can get stuck, kits fall through with their legs)	(Hoy, 2009)
The floor should provide enough grip	Friction coefficient unknown	Rearing on slippery floor from the early postnatal period caused hip dysplasia and other musculoskeletal changes in growing rabbits	(Owiny et al., 2001)
Human handling and contact			
Proper handling of animals		Rabbits should be carried by hand individually and placed in containers or trolleys one at a time. The distance rabbits are carried should be minimised	(Anonymous, 1988; EFSA, 2005)

3.7 Safety

3.7.1 No danger

Due to the high predator pressure (from the air and the ground) 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. Rabbits are easily startled and therefore, there should be no sudden noises in their environment. They also need to be able to withdraw and hide from sources of potential danger. They prefer places where they are visually covered from above. Handling by humans can cause a lot of stress for rabbits. To minimise stress, daily handling of kits is proposed. Possibly, also older rabbits can also be habituated to human handling.

Table 18 Requirements for the need 'No danger'

Description	Value	Remarks	Source
Human handling and contact			
Timely handling of kits and young rabbits	From 1st week postpartum, within 30 min after nursing	Handling is effective when it is performed during this sensitive period. Early handling leads to habituation of the rabbits and causes less stress from human contact at an older age	(Anderson et al., 1972; Wyly et al., 1975; Jezierski and Konecka, 1996; Pongrácz and Altbäcker, 1999; Bilkó and Altbäcker, 2000; Pongrácz et al., 2001; Csatádi et al., 2005; Dúcs et al., 2009; Verwer et al., 2009)
Proper handling of kits and young rabbits		Rabbits should be carried by hand individually and placed in containers or trolleys one at a time. The distance rabbits are carried should be minimised	(Anonymous, 1988; EFSA, 2005)
Procedures should be predictable and consistent			Expert view
Spatial arrangement			
The living environment should be constructed so that rabbits can withdraw and hide from sources of potential danger	Structures providing visual cover	As a prey species, rabbits are easily startled and as a response want to hide	(Love, 1994; EFSA, 2005)
Rabbits should be able to examine their surroundings	Height ≥ 60 cm	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 with ears upright and turned towards the stimulus	(Love, 1994; Hansen and Berthelsen, 2000; Hoy, 2009)

Substrate available for digging[5] that should make it possible for the rabbit to make burrow-like structures (i.e. a hole or tunnel) is suitable		Rabbit tend to hide in holes or tunnel. Besides this, digging can also be exercised as part of territorial display behaviour in (young) bucks	(Dean, 1999), expert view
Structured living environment (functional areas)		Rabbits attempt to divide their living space into separate areas for separate activities. This allows the animals to control their environment. Such divisions may be facilitated by structures in the cage	(Baumans, 2005)
Living environment that is and remains challenging and stimulating		To stimulate the rabbit (reducing abnormal and stereotypic behaviours, boredom and stress). This can be done by a set of heterogeneous methods of improving animal welfare, including everything from social companionship to toys. Materials added for social enrichment should be edible. More than one means to stimulate the rabbit should be used	(Johnson et al., 2003; Baumans, 2005)
Sound			
No sudden sounds			(Marai and Rashwan, 2004)
Not too much noise	Threshold level in dB unknown		Expert view
Light			
Sufficient level of light during active period	≥ 50 Lux	To allow the rabbits to have visual contact, to investigate their surroundings visually and to show normal levels of activity The value depends on the measurement method	(EFSA, 2005)
Circadian rhythm			
Light intensity which follows a natural light-dark rhythm	~ 16h light/24h; during dark period no light should be present; duration of dusk and dawn unknown	Rabbits display a two-peak circadian rhythm crepuscular with active periods (incl. eating) around dawn and dusk. Over 60% of the solid feed is consumed in the dark period	(EFSA, 2005; Fortun-Lamothe and Gidenne, 2006), expert view

[5] Rabbits swing their hind legs to the back simultaneously and thereby removing the substrate (that has been loosened by scraping in case of earth) from under their body and through their hind legs.

3.7.2 Minimal aggression

Aggression occurs in unstable groups but serious fights are rare in stable groups. However, the optimal group size and composition is unknown. Many studies have shown that there is very little aggression in family groups, consisting of one buck, several does and their young. In the wild female young usually stay with their group. Male young leave their group, because the adults will drive them out. Bucks seem to play an appeasing role, and intervene in fights between does and young. There should be no more than one buck in a group, because two adult bucks may seriously fight. When a group is stable, no new members should be introduced, because hierarchy fights can start again.

The living space and flight distance is also relevant. When these are limited, particularly low-ranking rabbits cannot not withdraw when attacked. Therefore there should be enough space and possibilities for rabbits to retreat from sight of each other.

Table 19 Requirements for the need 'Minimal aggression'

Description	Value	Remarks	Source
Group composition			
No new does should be introduced in an already stable group		Does establish a hierarchy. 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	(Mykytowycz and Dudziński, 1972; Vastrade, 1986; 1987; Lehmann, 1991)
One buck in a group of does		Bucks have a territory which they defend against other bucks. In the wild and under semi-natural conditions, bucks intervene in aggressive encounters.	(Mykytowycz and Dudziński, 1972; Vastrade, 1986; 1987; Lehmann, 1991)
No rabbits that are older than 11 weeks in a group with an adult buck (except for does)		When the young are reaching sexual maturity the bucks start to display aggressiveness towards them	Expert view
Spatial arrangement			
The living environment should be constructed so that rabbits can withdraw from sight of each other		Distance-increasing behaviours such as threats and bites occur in competition (for a preferred partner or for food, resting and nesting sites). Aggressiveness can occur when living space and flight distance are limited, particularly when rabbits cannot withdraw when attacked. The average distance between animals in a large semi-natural enclosure is 25 m for bucks, 20,7 for does and 23,9 between bucks and does	(Vastrade, 1987; Morton et al., 1993; Love, 1994; Held et al., 2001; Baumans, 2005)
Living environment that is and remains challenging and stimulating.		To stimulate the rabbit (reducing abnormal and stereotypic behaviours, boredom and stress). This can be done by a set of heterogeneous methods of improving animal welfare, including everything from social companionship to toys. Materials added for social enrichment should be edible. More than one means to stimulate the rabbit should be used	(Johnson et al., 2003; Baumans, 2005)

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Wageningen UR Livestock Research

Edelhertweg 15, 8219 PH Lelystad T 0320 238238 F 0320 238050

E info.livestockresearch@wur.nl I www.livestockresearch.wur.nl