

EFFECT OF HOUSING ON THE HEALTH OF PET RABBITS

Word count: "< 13.382 >"

Emilie Winnepenninckx

Student number: 01300062

Supervisor: Prof. dr. Katleen Hermans

Supervisor: Prof. dr. Christel Moons

A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of
Master of Veterinary Medicine

Academic year: 2019 - 2020

Ghent University, its employees and/or students, give no warranty that the information provided in this thesis is accurate or exhaustive, nor that the content of this thesis will not constitute or result in any infringement of third-party rights.

Ghent University, its employees and/or students do not accept any liability or responsibility for any use which may be made of the content or information given in the thesis, nor for any reliance which may be placed on any advice or information provided in this thesis.

Acknowledgements

I would like to express my deepest appreciation to my promotors Prof. Dr. Katleen Hermans and Prof. Dr. Christel Moons for their guidance and advice throughout these last two years, when working on my thesis subject.

Additionally, I would like to thank my parents for their unconditional support and allowing me to chase my childhood dream of becoming a veterinarian.

And last but not least, I would like to thank my partner for being my rock throughout my master's degree and especially during my hectic last year.

Table of Contents

Abstract	5
Samenvatting	5
1. Introduction	6
2. Literature study	8
2.1. Wild rabbit habitat	8
2.2. Housing	8
2.2.1. Cage size.....	8
2.2.3. Environmental conditions	9
2.2.4. Bedding	10
2.2.5. Exercise.....	11
2.2.6. Enrichment.....	11
2.2.7. Companionship as social enrichment	12
2.3. Impact of housing on health	13
2.3.1. Infectious diseases.....	14
2.3.2. Dental disease	14
2.3.3. Ocular problems.....	15
2.3.5. Digestive problems.....	15
2.3.6. Pododermatitis	17
2.3.7. Musculoskeletal pathology	18
2.3.8. Overweight and obesity.....	19
2.4. Owner knowledge and expectations	20
3. Material and methods	22
4. Results	23
4.1. Housing	23
4.2. Companionship	24
4.3. Medical conditions	24
4.4. Owner knowledge and expectations	26
4. Discussion	27
4.1. Housing	27
4.2. Companionship	29
4.3. Medical conditions	29
4.4. Owner knowledge and expectations	30
5. Conclusion	31
6. References	32
Appendix	40

Abstract - The rabbit is a popular pet in Europe and although it is a common pet, the general public's knowledge of their needs are often limited. These misunderstandings range from housing and social nature to feed. In Belgium and the Netherlands, there are no concrete legislation or guidelines on the housing of pet rabbits, which may lead to a scenario in which each owner creates their own interpretation of good housing. The aim of this study is to investigate how pet rabbits are kept in Flanders and the Netherlands and whether housing may influence their health. This was investigated through a literature study, followed by a survey directed to Flemish and Dutch rabbit owners. Compared to previous literature, there seems to be a favorable evolution in the way pet rabbits are kept. The majority is no longer acquired just for children and adults seem to discover more of the pleasures of keeping a rabbit. According to the questionnaire, a substantial number of rabbits are "free-roaming" (25.6%) and only a small number do not have access to a run (5.8%). Additionally, 57.7% of the rabbits are housed together with a conspecific, whilst 33.2% of the owners still keep their rabbits solitary. This number is also reflected in the number of rabbits per owner, as the most popular answers were two (49.8%) and one (30.2%) rabbit(s). Contrary to a previous study, the Internet seems to be the most popular information source regarding rabbit requirement. Looking at the response regarding rabbit health, the most common illnesses appear to be dental (8%), digestive (6.3%) and eye problems (5.8%), although most owners (46.7%) reported no health problems in one or more of their rabbits, which is in line with the results obtained with previous research. Generalised, there seems to be a positive evolution regarding certain key requirement to pet rabbit housing.

Samenvatting - Het konijn is een populair huisdier in Europa en hoewel het een vaak gehouden dier is, is de kennis over hun behoeften bij het algemene publiek vaak gelimiteerd. De misverstanden gaan uit van voeding tot huisvesting en sociale aard. Aangezien er in België en Nederland geen concrete wetgeving of richtlijnen bestaan over de huisvesting van konijnen gehouden als huisdier, zorgt dit ervoor dat iedere eigenaar een eigen interpretatie kan creëren van een adequate huisvesting. Het doel van deze studie is om te onderzoeken hoe konijnen in Vlaanderen en Nederland worden gehouden en of de huisvesting de gezondheid van de konijnen zou kunnen beïnvloeden. Dit werd onderzocht via een literatuurstudie, gevolgd door een enquête gericht naar Vlaamse en Nederlandse konijneneigenaars. Vergeleken met vroegere literatuur lijkt er een gunstige evolutie te zijn in de manier waarop konijnen worden gehouden als huisdier. De meerderheid wordt niet meer enkel voor de kinderen aangekocht en volwassenen lijken meer plezier te halen uit het houden van een konijn. Volgens de resultaten van de enquête kan een groot aantal van de konijnen dagelijks "free roamen" terwijl slechts een klein aantal geen toegang heeft tot een ren (5.8%). Verder is 57.7% van de konijnen samen met een soortgenoot gehuisvest, terwijl 33.2% van de eigenaars zijn of haar konijn(en) solitair houdt. Dit wordt ook weerspiegeld in het aantal konijnen per eigenaar, vermits de meest populaire antwoorden twee (49.8%) en één (30.2%) konijnen zijn. Tegengesteld aan een eerdere studie blijkt het internet de meest populaire informatiebron te zijn voor het houden van konijnen. In verband met de gezondheidstoestand van het konijnen lijken de meest voorkomende ziekten voornamelijk tand-, spijsverterings- en oogproblemen te zijn. De meeste eigenaars (46.7%) rapporteren echter geen gezondheidsproblemen bij een of meerdere van hun konijnen, wat in lijn is met eerdere studies. Veralgemeend lijkt er een positieve evolutie te zijn betreft de belangrijkste vereisten voor de huisvesting van konijnen als huisdier.

1. Introduction

In Belgium and many other countries in Europe, the rabbit is a common pet. Contrary to the dog and cat population, however, the exact number of pet rabbits held in European countries remains largely unclear. No mandatory registration of pet rabbits is required, which may be the reason why there is a lack of precise numbers. In the Netherlands, the pet rabbit population was estimated at 1.2 million¹ and they are, second to cats and dogs respectively, the most frequently held mammals². The Dutch human population count at this time was about 16.9 million³, which is about 1 rabbit for every 14 inhabitants. In 2019, the UK rabbit population was estimated at 900,000, according to the Animal Well-being (PAW) report⁴ of the People's Dispensary for Sick Animals (PDSA). With a population of 66.64 million³, 2% of UK adults owned a rabbit in at that time⁵.

Even though rabbits are popular pets, there still are numerous problems regarding feeding, husbandry and housing of these animals. In 2017, a substantial 35% of rabbits were kept in inadequate housing conditions (PAW report 2017⁵). The more recent PAW report of 2019⁴, however, describes that these conditions have been improved recently, with 25% of the rabbits estimated to still live in inadequate housing. For example, many rabbits are kept on their own, however they are a highly social species and prefer to live in stable social groups (Bays, 2006). In a study by Mullan and Main (2006) where owners of 102 rabbits in the UK were interviewed, 44% of the rabbits were housed singly. In other studies discussed below, the numbers varied between 49% and 67%. In addition, most of the rabbits from the interviewed owners were housed in a hutch smaller than the recommended minimal size by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) at that time. (Mullan and Main, 2006). It is also of importance to offer regular exercise outside of the cage since immobile rabbits are at risk for various diseases and poorer welfare. Richardson (2000) recommends at least 4 hours of exercise every day.

Aside from misunderstandings about how to keep pet rabbits, there are also certain veterinary misconceptions. For instance, knowledge cannot always be extrapolated from cats and dogs towards rabbits. There are, for example, certain antibiotics commonly used for cats and dogs that are toxic to rabbits, due to their unusual digestive system. It is in fact essential to know the specifics of rabbit anatomy, physiology and behaviour in order to successfully treat these animals (Bays, 2006).

The base of this knowledge lies in the education of veterinary students or veterinarians. Saunders (2018) states rabbit coverage in the curriculum should be in line with the high popularity of the animal, which is not always the case.

The purpose of this master thesis is to investigate how pet rabbits are held and which housing factors might have an impact on their health, using Flanders and the Netherlands as an example. First, a literature study will be conducted to determine relevant housing factors

¹ Feiten & Cijfers Gezelschapsdierensector 2015: <http://edepot.wur.nl/361828>. Last consulted on 12/05/2019.

² Gedeelde zorg Welzijn Gezelschapsdieren (feiten en cijfers) 2006: <https://www.rda.nl/publicaties/zienswijzen/2006/03/23/welzijn-gezelschapsdieren>. Last consulted on 12/05/2019

³ Eurostat: <https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en>. Last consulted on 30/12/2019

⁴ PAW Report PDSA 2019: https://www.pdsa.org.uk/media/7420/2019-paw-report_downloadable.pdf. Last consulted on 29/12/2019

⁵ PAW Report PDSA 2017: https://www.pdsa.org.uk/media/3291/pdsa-paw-report-2017_printable-1.pdf. Last consulted on 2/05/2020

and medical conditions to examine and to investigate what is described in the literature about the relationship between them. Information will be acquired through critically reviewed scientific papers, animal welfare reports, case reports and literature books that are related to this topic. Next, we describe research involving a survey that was administered to rabbit owners in Flanders, Belgium and the Netherlands.

This thesis seeks to answer three general research questions:

1. *Under which conditions are pet rabbits held in Flanders and the Netherlands?*
2. *Which health problems are common in Flanders and the Netherlands and could these be influenced by housing?*
3. *Are Flemish and Dutch pet rabbit owners aware of their rabbit's housing needs and did ownership turn out the way they expected before acquiring the animal(s)?*

2. Literature study

Pet rabbits are the domesticated form of the wild rabbit. To understand a pet rabbit's needs, we need to consider the wild rabbit's biology and way of life. To be able to evaluate the housing conditions and medical issues of the pet rabbits from our survey, we examine various housing aspects and findings in previous research, which is followed by a review of physical and behavioural health issues with possible reference to housing. The literature study ends with a segment regarding owner knowledge and expectations, as this has considerable impact on how pet rabbits are housed and cared for.

2.1. Wild rabbit habitat

The European rabbit, *Oryctolagus cuniculus*, lives in large colonies that each consist of several social groups from two to eight adults plus juveniles (McBride, 1988, as cited in Varga, 2013). They spend most of the day in their warrens and burrows, typically dug in sandy and hilly terrain, that they leave at dusk to forage (Grzimek 1975 as cited in Nowak, 1999; Bays, 2006). They usually return around dawn, although they can also be seen above ground during daytime (Nowak, 1999). Being a prey animal, constant vigilance to detect potential danger is essential to survive in the wild. According to Nowak (1999), rabbits use their keen senses of hearing and smell as detection devices. Additionally, they have laterally implanted eyes that provide a large field of view, which they can use to scan the surroundings (Jenkins, 2001). When danger is detected, they thump their hind legs to warn their group members (Nowak, 1999, Crowell-Davis, 2007).

Domestication of the rabbit led to tame and social animals that are easy to handle, while wild rabbits seldom become tame in captivity. It has even been found that egg transfer from a wild rabbit to a domesticated rabbit led to more fearful kits (Adams, 1987, as cited in Harcourt-Brown, 2002). Despite their differences, pet rabbits have retained most of the behavioural repertoire of wild rabbits, according to Stauffacher (1992), even if their housing conditions today can differ greatly from the original environment.

2.2. Housing

There is substantial variation in housing types, cage sizes, environmental conditions, bedding and runs for rabbits. Rabbits can be kept in- or outdoors, in cages, garden sheds, hutches, free roaming in the garden or in the house. Regardless of the type of housing an owner may choose, it has to comply with several key requirements.

2.2.1. Cage size

In a study by Edgar and Mullan (2011), where rabbit owners at the point of sale were questioned about their knowledge and attitude towards their new pet, it was found that 88% of owners plan to keep their rabbit(s) in a hutch. Even though the size was cited as the most important factor when choosing a hutch, 60% of the respondents were planning to buy a hutch smaller than the recommended minimal size. Cages found at, and therefore promoted by pet and garden stores are often small and limited in structural complexity, according to

Mullan and Main (2006).

In 2003, The Royal Society for the Prevention of Cruelty to Animals (RSPCA) guidelines recommended a minimum hutch size of 1.5 x 0.6 x 0.75 m for two medium sized rabbits (Mullan and Main, 2006). The minimum height is based on the requirement for the rabbit to be able to rear up, which is a natural and innate behaviour that allows scanning for predators and improves the musculoskeletal fitness (Rooney et al., 2014). The longest side of the hutch must accommodate performing at least three consecutive hops and give the rabbit the opportunity of laying down completely stretched⁶. In a study by Mullan and Main (2006) 82% of the examined rabbits were kept in shorter hutches, 46% in narrower and 84% in lower hutches. The same study also mentions home-made hutches having a bigger area, compared to store-bought hutches, who have the smallest area. At this time for two medium sized rabbits, the RSPCA recommends a housing condition of at least 3 x 2 x 1 m that consist of a run and a shelter⁷. The bigger their enclosure, the better, as stated by the RSPCA.

According to Dixon et al. (2010), rabbits were more active and interacted more with the environment in larger pens compared to smaller pens. In addition, when moving rabbits from a smaller to a larger pen, a rebound effect was described as a reaction to the period of deprivation, as the animals demonstrated an increase in activity and rearing. This suggests that rearing is a behavioural pattern that has a high motivation in rabbits. Depriving them from this behaviour could decrease their welfare. It has also been suggested that permanent restriction of natural movement of the young rabbit can cause permanent abnormalities of the skeleton, like bone injuries, deformities (Drescher, 1993, as cited in Varga, 2013) and various metabolic diseases, which will be discussed in chapter 2.3.

2.2.2. Accommodation structure

Not only size, but also the design of the accommodation is of importance for safe and adequate housing. The enclosure should be free of sharp edges and must be easy to clean and disinfect in order to prevent harm and reduce the risk of health complications (Harkness et al., 2010). Fully enclosed cages, such as aquaria, should strictly be avoided as these often have a poor air circulation (Bradley, 2004). This may result in high levels of ammonia and carbon dioxide, which predisposes for respiratory tract infection and conjunctivitis (Varga, 2013). Also, rabbits kept in enclosed cages which are exposed to direct sunlight are more prone to hyperthermia (Harkness et al., 2010).

Last but not least, the availability of a dark shelter within their accommodation, like a tunnel or box, is considered to be beneficial as it allows the animal to retreat to a safe spot in stress situations (Richardson, 2000; Jenkins, 2001; Bays 2006). Since it is open in the front and closed on top, bottom and sides, it mimics the safety of a burrow (Jenkins, 2001).

2.2.3. Environmental conditions

The environmental requirements for rabbit housing are largely based on the natural preferences of these animals. The thermoneutral zone of the rabbit lies between 16°C and 22°C, according to the Institute for Laboratory Animal Research (ILAR) and the Canadian

⁶ Animal Welfare act, 2006 via <https://rabbitwelfare.co.uk/rabbit-care-advice/rabbit-housing/why-hutch-not-enough/>. Last consulted on 23/05/2020

⁷ <https://www.rspca.org.uk/adviceandwelfare/pets/rabbits/environment> Last visited on 31/12/2019

Council on Animal Care (CCAC) guidelines. The lower critical temperature is -7°C and the higher critical temperature is 28-30°C (Spector 1956). Humidity recommendations may vary between 30 and 70% (ILAR) or 40 and 70% (CCAC) (Harkness et al., 2010).

Rabbits are highly susceptible to heat stroke, since they do not possess many methods to cool down. They have a low ability to sweat and pant, although the ears of the rabbit are large and highly vascularised and can serve as a cooling device (Lidfors et al., 2004). In order to reduce the risk of heat stroke, access to shadow should be available at all times. Rabbits can tolerate cold conditions when having a good body condition score and being provided with adequate shelter and bedding. In case of low body fat or illness, rabbits need additional support in cold circumstances (Varga, 2013).

It is also of interest paying attention to the occurrence of predators in the environment. Animals perceived as dangerous, such as dogs, cats, foxes, ferrets or raptors, are big stressors for rabbits (Jenkins, 2001). To lower the stress of a prey animal, such as rabbits, it is of best interest to minimize contact with predator species. In order for a rabbit to feel secure, it is also important that it can rear up and scan for potential predators in the environment. In addition, for the safety of the outdoor rabbit, it is best to ensure the housing is predator-proof, for example by using strong materials, providing a roof or preventing digging under the fence.

2.2.4. Bedding

Bedding types that are commonly advised for housing rabbits are hay, non-sharp straw like oat straw, newspaper, paper towels, pelleted products and commercial beddings made from recycled paper (Bradley, 2004; Varga, 2013). Hay and straw have the benefit of being part of the diet (Varga, 2013). Garden peat has been shown to have the additional benefit of neutralization of ammonia build-up. In turn, this reduces the risk of eye and respiratory tract irritation (Malley, 1995, as cited in Varga, 2013). On the other hand, it is best to avoid clumping, indigestible or toxic litter types as rabbits are known to occasionally eat their litter (Bradley, 2004; Crowell-Davis, 2007). The preferential litter type is also influenced by the environmental conditions. For example, in colder climates, it is important not to overlook the use of litter that has a good insulation capacity (Varga, 2013).

Certain wood products such as soft wood shavings are suggested to cause hepatotoxicity due to inhalation of phenols, especially in poorly ventilated housing systems^{8,9} (Bradley, 2004; Varga, 2013). Additionally, dusty and contaminated bedding may cause respiratory problems and conjunctivitis (Bradley, 2004; Davies, 2010). According to several sources (Bradley, 2004; Varga, 2013) contact dermatitis can occur when being repeatedly exposed to chemicals, newsprint or wood shavings. Abrasive substrate or a wire floor has been associated with pododermatitis due to an alteration in weight bearing with avascular necrosis as a result (Richardson, 2000).

Furthermore, adequate hygienic measures should be accounted for. It is essential to replace the bedding at least 1-3 times per week, as the accumulation of excretions may attract flies, which are potential disease vectors and cause of myiasis or fly strike. Secondary, wet bedding and faecal contamination can increase the risk of a bacterial infection (Varga, 2013). When given the choice, rabbits prefer no bedding to soiled bedding material (Morisse et al., 1999). These authors have the hypothesis that rabbits usually prefer bedding, but only if it is sufficiently clean.

⁸ <https://rabbit.org/the-dangers-of-softwood-shavings/> Last consulted on 14/04/2020

⁹ <https://rabbit.org/liver-hepatic-disease-in-rabbits/> Last consulted on 14/04/2020

For an indoor rabbit that is allowed to roam outside the cage, it has been recommended to use carpet on slippery flooring such as tiles, since sliding can cause injuries. Unless there is no alternative, rabbits tend to not set foot on flooring where they have no grip on (McBride, 2017).

2.2.5. Exercise

Access to a piece of land with grass provides ideal nutrition and environmental enrichment. According to the survey by Mullan and Main (2006), 12.7% of the rabbits never go outside. Those who did go outside were mainly put in a run with a mean size of 1.5 x 0.88 m, which was smaller than the RSPCA guidelines (3 x 2 x 1 m) at this time and thereby inadequate for exercise. In addition, the run frequently had a mesh floor that prevented digging, which is an innate exploratory activity (Trocino and Xiccato, 2006). A recipient with digging substrate could solve this problem (McBride, 2017).

It was stated by Richardson (2000) that at least 4 hours of exercise is required daily. Previous RSPCA guidelines recommended that the rabbits have unlimited access to the run, or, if not possible, have at least 2 hours of exercise every day. For many rabbit owners, it is not always feasible to comply with these guidelines. For example in Australia, 30% of the rabbits were permitted outside of their hutch less than 1 hour per week, and 47% was permitted to go outside less than once per week (Howell et al., 2015). In the UK, only 16% of rabbit owners planned to provide permanent access to a run (Edgar and Mullan, 2011), whilst the PAW report in 2011 states that this number is 21%. The most recent RSPCA guidelines, however, only consider a housing condition with permanent access to the run as adequate. The 2019 PAW report mentions that approximately 10% of the rabbits do not have access to a run and only live in a hutch. On the other hand, 28% of the rabbits in the UK are free roaming, which is an encouraging number according to the RSPCA (PAW report 2019).

2.2.6. Enrichment

Enrichment is used to give rabbits the ability to perform natural behaviour and keeping them mentally and physically occupied. Newberry (1995) defined environmental enrichment as "an improvement in the biological functioning of captive animals resulting from modifications to their environment". It would increase the animal's physical and mental health by creating a habitat similar to the original wild conditions, which allows interaction with the environment and performing species-specific behaviour. This has mostly been examined in fattening and laboratory rabbits, contrary to pet rabbits. It was found that fattening rabbits that were living in enriched cages were less likely to perform stereotypies (Luzi et al., 2003). According to Verga et al. (2004), fattening rabbits in cages enriched with gnawing sticks were more active, spent more time with investigatory behaviour and less time resting, whilst also showing lower levels of aggressiveness. This was confirmed by Princz et al. (2008), who observed that growing rabbits spent less time eating, were more active and that comfort behaviour increased. In turn, this may also reduce the occurrence of overweight and obesity, which will be discussed later on.

2.2.7. Companionship as social enrichment

Unlike hares, cottontails and other lagomorphs that are solitary, European wild rabbits are very social animals. As rabbits are prey animals, living in a colony gives them, among other things, an advantage in protection against predators. This is due to efficient predator detection (Buseth and Saunders, 2015) and the lower likelihood of a certain rabbit being caught by a predator in proximity of other prey (colony companions). In a study by Schepers et al. (2009), it was observed that during the open field test, solitary-housed rabbits sat up more than socially housed rabbits, suggesting increased fearfulness.

The rabbit is a highly social species and housing them in a pair or group will positively influence their behavioural health (Harkness et al., 2010). Laboratory rabbits were found to be highly motivated to seek social contact (Seaman et al., 2008) and when having the choice, they will be more likely to stay in company of a conspecific rather than being alone (Huls, 1991). In contrast to the social nature of the rabbit, Schepers et al. (2009) demonstrated that close to half (48%) of the survey respondents in the Netherlands housed their pet rabbit solitary and the majority in relatively small cages (< 5,000 cm²). An Australian study found that 63% of the rabbits were housed solitary (Howell et al., 2015). In the UK, however, survey results are slightly different whereas 44% of rabbits were not housed with a companion (Mullan and Main, 2006) and when future rabbit owners were asked, 40% of them planned to keep their rabbit on its own (Edgar and Mullan, 2011). In contrast, the PDSA Animal Well-being (PAW) report in 2011 states that 67% of the rabbits live alone and a more recent study by Rooney et al. (2014) demonstrated that 58.1% of the owners kept their rabbits without a conspecific. The 2019 PAW report shows a gradual reduction to 49%, which is still a high percentage for such a social animal. It is important to note that some owners only have one rabbit, namely 25.3% according to a study by Oxley et al. (2015). In a survey conducted by Welch et al. (2017), 50.5% of the owners declared having a companion for their rabbit and 48.6% did not. Although 73.1% agreed strongly with the statement "I would do almost anything to take care of my rabbit" and 21.7% agreed somewhat. This might indicate that owners are not always aware of their rabbit's needs.

In the study by Schepers et al. (2009), it was found that socially housed rabbits had a higher maximum lifespan than solitary held rabbits, 5.1 years and 3.3 years respectively. Restrictions in living space and exercise, sub-optimal feeding and a lack of protection against diseases were also identified as potential causes of premature death. In a survey conducted in the Netherlands the average lifespan of the pet rabbit was found to be 4.2 years (Schepers et al., 2009), whilst having a potential lifespan of 13 years, according to Altman & Dittmer (1972), as cited in Schepers et al. (2009).

Next to increasing the life span of the rabbit, there are some other medical benefits of keeping a rabbit with a conspecific. Allogrooming or social grooming can help to clean less reachable places and reduce the occurrence of fur parasites (Varga, 2013). Paired rabbits also seem to exhibit more locomotion than individually housed rabbits, which may counteract the emergence of osteoporosis and other musculoskeletal conditions that are negatively influenced by restriction of movement (Chu et al., 2004).

During hospitalisation, it is important to house the rabbit with his companion and to keep them far from predator species to reduce stress (Bays, 2006). Boers (2002) also recommends keeping the composition of a group stable. If a rabbit needs to be separated due to an illness, it is best to house it in a way it can maintain visual contact with the group. In this way, it will be recognised and accepted when returning.

On the other end of the spectrum, overcrowding may also lower the rabbits' welfare and modify behaviour and physiology (Verga, 2007). Rabbits kept at high stocking density had a significantly higher serum cortisol, which is associated with stress. In addition, the concentration of neurotransmitters like dopamine, serotonin and GABA in brain tissue was significantly decreased (El-Tarabany et al., 2019). Plasma serotonin is found to be an important messenger in the brain-gut axis and is related to gastrointestinal motility (Hansen et al., 2008; Delesalle et al., 2008). Thus, it is possible that a low serotonin level could contribute to the origin of ileus in rabbits.

A common argument for housing rabbits solitary, especially in laboratory or farming conditions, is aggression between rabbits. Male rabbits at the age of puberty can indeed become aggressive towards other males, even littermates. Neutering bucks can help decreasing aggressive behaviour. Aggression can also occur between does at an older age. The safest situation would be to partner up neutered rabbits of the opposite sex and approximately the same age. It should be kept in mind that introducing a rabbit takes time and should only be done under supervision (Harcourt-Brow, 2002; Bays, 2006). Of all the pet rabbits housed with a conspecific in the study of Rooney et al. (2014), over a quarter were reported to fight occasionally. This demonstrates that not all cohabiting pairs are compatible and thus it would be interesting to provide education about compatible pairs and professional help for owners to find an appropriate companion for their rabbit. According to Mullan and Main (2006), however, there were no reports of aggression as the relationship was described to be very friendly in 84% and quite friendly in 16% of the cases. Based on these 2 contradictory articles, it can be suggested that there is a knowledge gap regarding the prevalence of aggression towards conspecifics in pet rabbits.

Sometimes, guinea pigs are kept as companions for the rabbit, although this is not as ideal as another rabbit. There are some problems that can be encountered when keeping a rabbit and guinea pig together. Interspecies differences in behaviour and communication can lead to bullying of the guinea pig by the rabbit in some cases. It can help to provide the guinea pig with a shelter that the rabbit can not access and sexual harassment can be resolved by neutering. In case of consistent bullying it is best to separate the pair, considering the welfare of both animals (Varga, 2013). All previous findings do not alter that in some cases a rabbit and another animal, like a guinea pig, can form a strong bond and become inseparable (Varga, 2013).

2.3. Impact of housing on health

Both physical and mental health can be affected by housing, however this thesis will mainly focus on the physical health. The most common health issues in pet rabbits are dental problems, digestive problems, ocular problems, respiratory problems, parasites, overweight and pododermatitis (Mullan and Main, 2006; Normando and Gelli, 2011; Rooney et al., 2014).

It should be kept in mind that it is not always easy for owners to notice that their rabbit is in discomfort or has a medical issue, generally due to the fact that rabbits are prey animals and will try to hide illness and injury (Crowell-Davis, 2007). For example, when examining recruited pet rabbits, only 6 out of 30 owners were aware of their rabbits' dental issues, although most of these issues were still in a subclinical phase (Mullan and Main, 2006). An approach to this problem could be to advise regular check-ups by a veterinarian and to

inform the owner on rabbit needs and the signs of illness, such as a reduced appetite or lethargy.

The relationship between housing and health of companion rabbits has not always been well described within the literature. Therefore, the upcoming subsections will sometimes focus on rabbits held for food production or research purposed due to the fact that for those rabbit types, more studies are available on the subject.

2.3.1. Infectious diseases

First of all, prolonged stress, such as chronic pain and a poor environment, can induce a long lasting stress leukogram with lymphopenia and leucocytosis due to high cortisol levels (Melillo, 2007). This can interfere with the immune system of the rabbit and make it more susceptible to infections.

For *Encephalitozoön cuniculi*, a protozoan parasite, and other parasites like *Psoroptes cuniculi* it is best to avoid contact between pet rabbits and wild rabbits. Also, it would be a good idea to avoid contact between non-vaccinated pet rabbits and wild rabbits, since they can transfer infectious diseases like rabbit haemorrhagic disease (RHD). The 2019 PAW report⁴ states that only 49% of the owners reported that their rabbit had received a primary vaccination course when being young and 49% reported that their rabbit did not receive regular booster vaccinations against myxomatosis and RHD. Myxomatosis is a poxvirus that is transmitted through fleas, mosquitoes, midges and mites (Sayers, 2010). For this disease it would also be a good idea to prevent contact with wild animals, but in combination with insect control not being evident, vaccination would be the safest option.

2.3.2. Dental disease

Dental disease is a common problem in rabbits, although frequently underestimated by the owners as mentioned earlier. The aetiology of dental disease can lie in congenital factors such as mandibular prognathism and hypodontia, but it can also have an iatrogenic component such as improper clipping of the teeth or inappropriate feeding (Jekl and Redrobe, 2013). A problem at the level of the teeth can be characterised by chewing problems, which may lead to change of food preference, hypersalivation, poor coat maintenance, perineal soiling, anorexia and a poor body condition score (Sayers, 2010; Jekl and Redrobe, 2013).

Through evolution, rabbit teeth were adapted for the uptake of a high fibre diet. Since the rabbit has an elodont dentition, meaning the teeth grow continuously, they have to wear against each other to maintain their shape and occlusion (Varga, 2013). In a study by Mullan and Main (2006) it was found that feeding a concentrate mix, or muesli, was significantly associated with a higher prevalence of dental disease, which was confirmed by Meredith et al. (2015). Additionally, the combination of inappropriate feed with indoor housing may lead to metabolic bone disease, due to hypocalcaemia and hypovitaminosis D. This condition causes bone demineralisation, which makes the teeth more prone to displacement (Ashcraft, 1992), leading to malocclusion and abnormal wearing, causing (pre)molar spurs and overgrowth of the incisors. Further in the pathogenesis, dental roots will elongate into the maxilla and/or mandibula, causing rhinitis, epiphora, dacrocystitis and abscesses (Harcourt-Brown, 2002). Additionally, if rabbits are not provided with appropriate material to chew on,

like grass, hay or wood, they might chew on hard cage components such as metal and plastic, which may damage their incisors (Legendre, 2003; Poggiagliolmi et al., 2011). This damage can again lead to malocclusion with overgrowth and spur-formation (Harcourt-Brown, 2002).

2.3.3. Ocular problems

Conjunctivitis is a frequently encountered problem in rabbits and can be caused by both infectious and non-infectious (husbandry related, neoplastic, eyelid abnormalities or immune mediated) agents (Varga, 2013; Bedard, 2018). Primary conjunctivitis has been described in rabbits, although it is quite uncommon (Wagner and Fehr, 2007; Varga, 2013).

Mechanical irritation, for example due to hay dust is a frequently cited cause in the literature (Buckley and Lowman, 1979; Varga, 2013; Bedard, 2018). Buckley and Lowman (1979) have found that altering the way in which hay is given could reduce the release of dust and therefore improve the conjunctivitis score. It is therefore advised to put hay in hoppers or on the floor instead of using overhead hayracks.

Chemical irritation caused by ammonia build-up, due to insufficient ventilation or saturated bedding, also is a predisposing factor for mucosal irritation and conjunctivitis (Coon et al., 1970; Varga, 2013).

2.3.4. Respiratory problems

For the respiratory system, hygienic measures and ventilation are of importance. High ammonia levels and (cleaning) chemicals can inactivate the cilia on the epithelium of the respiratory tract, which predisposes for secondary infection (Harcourt-Brown, 2002; Lidfors et al., 2004). Another factor that can irritate the respiratory tract is dust, for example originating from hay (Harcourt-Brown, 2002).

Exposure to tobacco smoke during one month was found to cause several histological pathologies in rabbit lungs like epithelial proliferation, alveolar destruction and intraparenchymal haemorrhages (Fidan et al., 2006). It would therefore be of best interest not to smoke in proximity of the rabbit.

2.3.5. Digestive problems

Gastrointestinal disorders are common in rabbits and are often considered to be related to an inappropriate diet rather than infectious pathogens (Meredith and Prebble, 2017). A schematic overview of potential causes for gastrointestinal disorders is showed in Figure 1. The digestive tract system of rabbits is adapted for processing high fibre levels in the feed. They rely on microbial fermentation in the gut to obtain sufficient nutrients. Indigestible fibre will be eliminated as hard, dry faecal pellets, while the rest fermentates in the caecum and will be eliminated as caecotrophs. These soft faecal pellets are re-ingested directly from the anus to gain additional nutrients, such as amino acids, vitamins and minerals (Varga, 2013). When available in abundance, the fibre and protein level of the feed influence the amount of caecotrophs that will be consumed. A high level of fibre will increase intake, whereas high

protein levels will decrease the intake of caecotrophs (R. Rees Davies and J.A.E. Rees Davies, 2003; Sayers, 2010, Varga, 2013). This was confirmed by Meredith and Prebble (2017) who frequently saw uneaten caecotrophs in all groups fed concentrates, but infrequently in the group that was only receiving hay.

Additional to an inappropriate diet, there are numerous conditions that can affect the uptake of caecotrophs. Due to oral discomfort, such as dental issues, rabbits can be reluctant or even unable to ingest caecotrophs (Harcourt-Brown, 2002). In a study by Mullan and Main (2006), rabbits with a dental score of 2 or more were significantly more likely to have impacted caecotrophs. Furthermore, musculoskeletal problems, obesity and pododermatitis can prevent the rabbit from adapting a position to reach their anus. In addition, it was found that fattening rabbits housed in enriched cages showed higher feeding and caecotrophy compared to rabbits with no access to enrichment (Luzi et al., 2003). The authors suggest that environmental enrichment may improve the biological functioning of the rabbit. Reflecting back on pet rabbit owners, in a study by Rooney et al. (2014) 53.6% of the owners indicated seeing caecotrophs occasionally and 9.4% saw it often.

Uneaten caecotrophs can become entangled in the fur under the tail, which can lead to bacterial dermatitis and attract brown flies with myiasis as a result (Sayers, 2010; Varga, 2013). The occurrence of myiasis is also promoted by high temperatures and high humidity, although it is sometimes seen in winter (Sayers, 2010).

Stress can also have an impact on the gastrointestinal tract. An increased level of glucocorticoids increases coliform counts and lowers the aerobic/anaerobic bacteria ratio in the intestines (Straw, 1988, as cited in Varga, 2013). Pain and stress also cause an adrenergic stimulation and therefore inhibit gut motility and lead to impaction and gastric tympany (DeCubellis and Graham, 2013; Varga, 2013). In a study by Jackson (1991, as cited in Varga, 2013) the incidence of trichobezoars fell dramatically in rabbits that were exposed to a lower amount of stress, suggesting an increase in gastrointestinal motility.

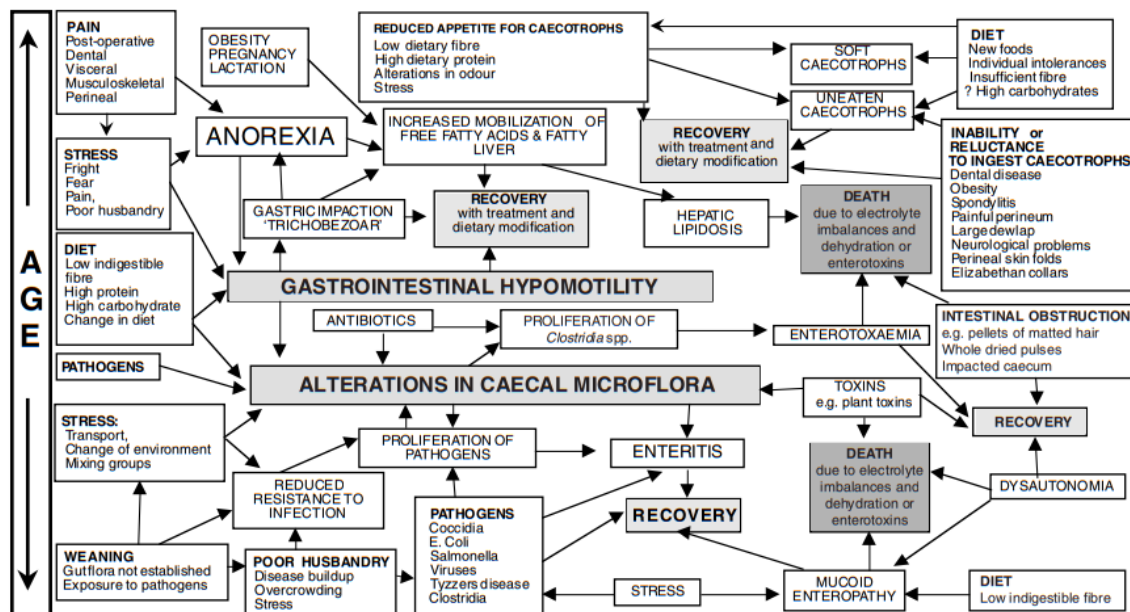


Figure 1: An illustration of potential causes for gastrointestinal disease in the rabbit (Harcourt-Brown, 2002).

2.3.6. Pododermatitis

One of the most occurring illnesses in rabbits held for food production and research is pododermatitis, also called sore hocks. According to Richardson (2000), pododermatitis is caused due to an interference with the rabbit's locomotion and weight bearing, which is commonly a result of obesity, spinal pain, conformational defects, lack of exercise or housing on hard or wire flooring. Consequently, the housing of the rabbit has an impact on the development of pododermatitis. Mainly the type of substrate they are housed on and the lack of motility are of importance. Normally, the weight of the rabbit is supported by the claws during locomotion. When in rest, the weight is distributed between the claws and plantar aspect of the metatarsi. When the claws are not allowed to sink in the substrate or support a part of the weight, which is the case in wire or hard flooring, it may cause avascular necrosis of the plantar aspect of the feet. This condition compromises the rabbit's welfare by causing chronic pain (Harcourt-Brown, 2002). For a visualisation of the pathogenesis, see Figure 2. A secondary bacterial infection can occur, mostly when in contact with wet bedding and excretions. The infection can spread to underlying structures and cause sepsis, osteomyelitis and synovitis. The two latter may lead to a displacement of the superficial flexor tendon, which in turn forces the rabbit to continue shifting their weight onto their hocks, worsening the condition and prognosis (Harcourt-Brown, 2002; Quesenberry and Carpenter, 2012).

Close confinement and a lack of exercise also have an impact on the distribution of weight (Harcourt-Brown, 2002). Exercise improves blood circulation and prevents pressure sores (Varga, 2013). A link has been established between small cage size and painful conditions, such as skeletal disorders or ulcerative pododermatitis, in intensively reared rabbits (Drescher, 1992, as cited in Dixon et al., 2010).

Furthermore, it has been seen that not only intensively reared, but also pet rabbits exhibit this condition. In a study by Mancinelli et al. (2014) it was shown that 93.8% of the 179 examined pet rabbits presented at the clinic of the University of Edinburgh had pododermatitis. Whereas, in a UK study, only two rabbits out of 102 were found to have pododermatitis (Mullan and Main, 2006).

A study by Courcier et al. (2012) has shown a higher risk of developing pododermatitis when being female, being neutered and with increased age. This might be related with less movement and becoming overweight, as overweight occurs more in female and neutered rabbits. Certain breeds, such as Angora and Rex, have less protective thick fur at the level of the metatarsi and are predisposed for sore hocks (Richardson, 2000; Harcourt-Brown, 2002; Harkness et al., 2010). Large breeds, such as the Flemish giant, and overweight rabbits are also more susceptible (Harcourt-Brown, 2002).

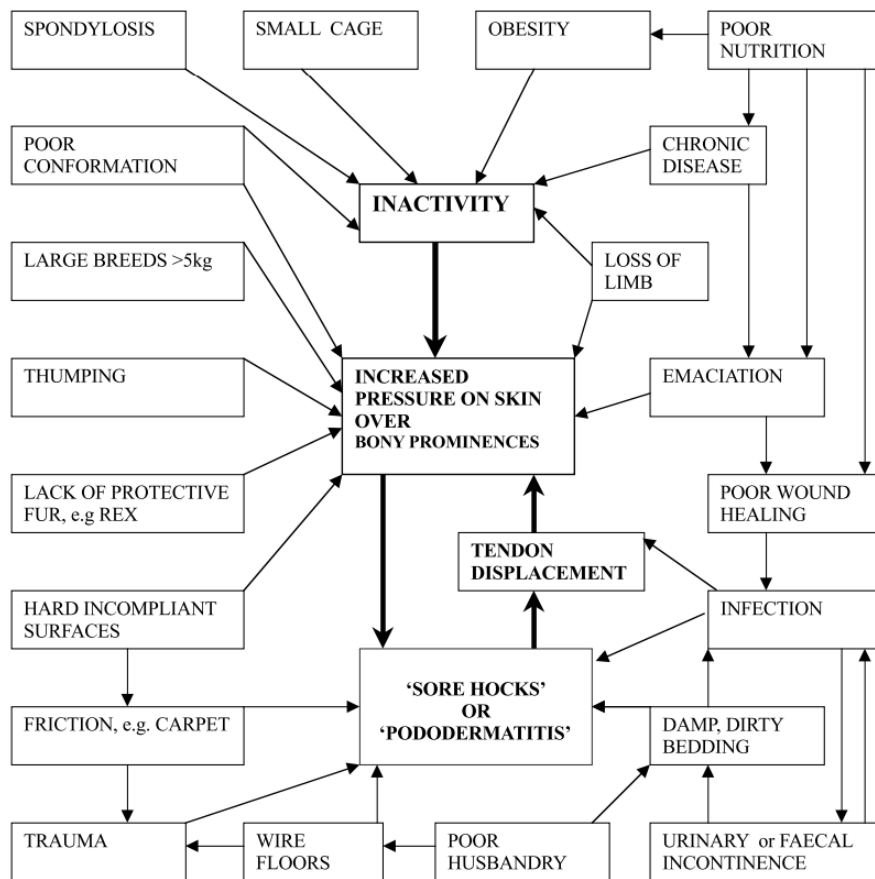


Figure 2: Pathogenesis of pododermatitis in rabbits (Harcourt-Brown, 2002).

2.3.7. Musculoskeletal pathology

Another possible effect of limited movement is osteoporosis (Lehmann, 1987, as cited in Marai and Rashwan, 2004). Immobilisation was found to cause an increase of bone remodelling, combined with a decrease of osteoblast activity and resulted to a decrease in bone mass (Minaire, 1989). In several studies, it was found that a decreased cage size leads to decrease in leg bone diameter (Gordon, 1989; Martrenchar et al., 2001; Buijs et al., 2012). Studies on different species have shown that exercise may increase the thickness of the limb bone cortices and therefore possibly increase bone strength (Gordon, 1989). In a more recent study, the thinner cortex in rabbits housed more restrictively was confirmed, however the breaking strength of these bones did not decrease significantly (Martrenchar et al., 2001; Buijs et al., 2012; Buijs et al., 2014). In rabbits kept for meat production, it was found that the prevalence of spinal deformities in does was not influenced by the housing, according to Buijs et al. (2014). Perhaps these deformities occur in growing rabbits or when being confined for a longer period. More research is needed to gain a better view on this pathology. Osteoporosis can also be caused by glucocorticoid administration (Ashcraft, 1992; Castañeda et al., 2008) and a review by Jekl and Redrobe (2013) suggested that research is required to know if stress with its endogenous glucocorticoids could also contribute to the development of osteoporosis.

Osteomalacia and a poor degree of calcification, which also predisposes for dental disease (Harcourt-Brown, 1996), may be due to a decreased intestinal resorption of calcium, magnesium and phosphate following a vitamin D deficiency (Mellanby and Killick, 1926). Generally, vitamin D is produced in the body under influence of UVB in sunlight and it has

been found that rabbits kept in hutches had a lower vitamin D level, compared to free roaming rabbits, especially in the spring period (Fairham and Harcourt-Brown, 1999). Dietary uptake, for example through hay, is also a possibility. However, the level of vitamin D will be variable depending on the amount of sunlight the hay was exposed to during production (Harcourt-Brown, 1996).

Next to bone abnormalities, the articular cartilage can also be affected. It has also been found that immobilization can cause disturbances in the articular cartilage and lead to osteoarthritis (Langenskiöld, 1979; Videman, 1982).

2.3.8. Overweight and obesity

Although less important for rabbits held for food industry and research, it has been described that obesity is an emerging disease in companion rabbits. In a study by Courcier et al. (2012) where medical records of 157 rabbits were gathered, 7.6% of the rabbits were overweight, none were obese (Body condition score (BCS) 5/5) and 15.9 % was underweight. This is very similar to the findings of a study by Mullan and Main (2006) of 102 UK pet rabbits, who found that 74% had a BCS between 2.5 and 3.5. However, based on veterinary notions within the 2018 PAW report¹⁰ it was estimated that 30% of the patient rabbits were either overweight or had obesity. The incidence of being overweight seems higher in female rabbits than male and more in neutered animals (Courcier et al., 2012; Meredith, 2012).

Common factors that lead to the development of obesity are reduced activity levels and a high calorific diet (Stapleton, 2014). It has also been suggested that boredom results in extra food intake as a pastime and can therefore be considered a predisposing factor as well (Varga, 2013). Controlling rabbit weight is important as obesity may be a predisposing factor for the development of other diseases, such as myiasis, pododermatitis, arthritic conditions, cystitis, urine scalding, pregnancy toxemia, hepatic lipidosis, hyperthermia and gastrointestinal stasis (Harcourt-Brown, 2002; Meredith, 2012; Stapleton 2014).

A first result of being overweight is the fact that rabbits tend to have more difficulties grooming themselves and consume caecotrophs, which can lead to cheyletiellosis, pyoderma or myiasis.

Next are mobility problems, for example caused by obesity or pododermatitis, which may prevent the rabbit to take an adequate position for urinating, potentially leading to urine retention. This retention in the urinary bladder can cause urinary sludge with secondary cystitis and urine leakage, eventually resulting in urine scalding of the skin. Another related issue due to obesity is the development of a fat skirt in does that may complicate the ability of urinating without soiling the skin (Varga, 2013). Furthermore, as it increases the weight burden upon different joints and/or results into inadequate positioning, obesity may also cause arthritic conditions (Varga, 2013; Stapleton, 2014).

Additionally, according to a study by Carroll et al. (1996), obese rabbits tend to be tachycardic and can develop hypertension and cardiac hypertrophy. Even a short period of obesity with hypertension was shown to lead to an increased ventricular weight.

It has also been found that obese rabbits have a higher occurrence of hyperinsulinaemia, hyperglycaemia and an increase of plasma triglyceride level by 111% (Carroll et al., 1996). The latter abnormality makes that obese rabbits are prone to developing hepatic lipidosis when becoming anorectic, especially when being stressed. This makes obese rabbits poor surgical candidates (Meredith, 2012; Varga, 2013). Another reason that makes spaying surgery more risky is the fact that the intra-abdominal fat is stored in the broad ligament of

¹⁰ <https://www.pdsa.org.uk/media/4371/paw-2018-full-web-ready.pdf> Last consulted on 23/05/2020

the uterus, which makes the visualisation of the uterine vessels more difficult. Hyperlipaemia can also cause atherosclerosis in rabbits. Plaques consisting of inflammatory cells, cholesterol, triglycerides and calcium accumulate on the wall of arteries, reducing their distensibility. This can affect the blood pressure and blood flow in severe cases (Orlandi et al., 2004; Reusch, 2005; Stapleton, 2014).

Finally, being overweight has been linked with disturbances of the endocrine pathway. A study by Yamamoto et al. (1999) found a decreased fertility success in male rabbits with hypercholesterolaemia, due to a significant reduction in sperm concentration and motility and modifications in the spermatogenesis, which was confirmed by Marco-Jimenez and Vicente (2017).

On the other hand, being underweight can be a sign of inadequate husbandry, discomfort or illness, very often dental disease. Approximately 15.9% of rabbits presented at veterinary clinics were underweight according to Courcier et al. (2012). The fact that more rabbits were found to be underweight than being overweight (7.6%) should not be overlooked, since this may reflect a great welfare concern, especially if low body condition is due to medical conditions, such as dental disease (Meredith, 2012).

2.4. Owner knowledge and expectations

Like with any other pet, acquiring rabbits must be preceded by preparation and education rather than acquiring on impulse. Rabbits and other small mammals are often sold in garden centres, pet shops (Schepers et al., 2009) and via advertisement websites (Ulfsdotter et al., 2016). They typically have a high reproduction rate, which often results in a relatively low purchase cost¹¹. The combination of the low initial cost with the purchase being an easy and quick action could stimulate impulse purchases, which leave the owners no time for research regarding rabbit needs, welfare and cost (Edgar and Mullan, 2011). Additionally, the study by Edgar and Mullan (2011) demonstrated that 18% of the respondents who purchased their rabbit in a pet store did so after deciding on the same day. The supposition of impulse purchases can be reinforced by the fact that a noteworthy 99% of the owners had underestimated the lifetime cost of keeping a rabbit and 30% found that the ownership is harder work than they initially thought, according to the 2011 PAW report¹². Similar results were obtained in an Australian study by Howell et al. (2015) where 24% of the respondents agreed that husbandry of their rabbit proved to be more difficult than expected.

The owners' underestimations regarding cost and time investment and limited knowledge about rabbit care and needs can contribute to increased risk of relinquishment. A survey, in which shelters were asked for reasons given by owners when relinquishing rabbits, described that lack of time was the most common reason (Cook and McCobb, 2012). These findings are in accordance with results by Ulfsdotter et al. (2016) and Neville et al. (2019). The study by Ulfsdotter et al. (2016) also mentioned that rabbits sold on advertisement sites have a mean age of 17.6 months. According to the authors, these two findings combined suggest that rabbit owners often fail to estimate the time and effort required to take proper care of their rabbit. Another reason for the young age of rabbits being relinquished could be unplanned litters. Sexing of rabbits, neutering and informing owners about sexual maturity in rabbits could be of great importance.

¹¹ Rabbits: revisited, by M.E. Cotter: <http://www.rabbitcare.org/aspca.pdf> Last consulted on 09/09/2019

¹² PAW report 2011: https://www.pdsa.org.uk/media/2584/pdsa_animal_wellbeing_report_2011.pdf Last consulted on 30/12/2019

Rabbits were traditionally acquired as a pet for children, which could lead to another common reason for relinquishment as the child may lose interest. According to the PAW report in 2011⁶ where reasons for acquiring a pet were investigated, most rabbits (40%) were obtained for a child, which is remarkably different for other popular animals. In cats and dogs the top four most cited reasons for acquirement were "makes me happy", "had one before", "companionship" and "completes the family". In a study by Rooney et al. (2014) it was confirmed that a large portion of rabbits were obtained for a child (27.6%), but in this survey most rabbits were obtained for the respondents themselves (49%). A potential problem with buying a pet for a child is that the interest from the child may wear off and result in lesser care and attention⁶ for the animal, which is then more likely to end up in a shelter or rehomed. In a UK survey, more than half of the rabbits were bought for children, although 49% of the owners said that their rabbits were not easy to handle for children. This could lead to unfulfilled expectations and a weak pet-owner bond" (Mullan and Main, 2006).

For the welfare of these pets, it is essential that pet shop owners and other people selling animals are concerned with the (future) care of these animals and they should, most of all, be able to give correct information. This is of great importance since these people are often the first point of contact for new owners (Edgar and Mullan, 2011). Ideally, every new owner gets information from a person with qualifications, like a veterinarian. Based on a questionnaire presented to rabbit owners in the UK, 90% of the respondents planned to take their newly bought rabbit to the veterinarian for an initial check-up (Edgar and Mullan, 2011). This is a great opportunity for veterinarians to play an active role in increasing the awareness of the importance of welfare and health, specifically related to housing and nutrition. On the contrary, a more recent study conducted by Welch et al. (2017) observed that most rabbit owners think that shelter or rescue staff provides the best information on rabbit care. Veterinarians were only the fourth preferred source of information, after shelter or rescue staff, other rabbit owners and the internet, respectively. This may suggest that veterinarians lack knowledge and experience regarding rabbit care or that they are less approachable for pet rabbit owners. Martin (2014) suggested to include animal welfare in veterinarians' newsletters, putting the focus on more than just vaccinations and common diseases. It is also of importance to encourage owners to discuss housing, husbandry and feeding, possibly by organising informative sessions or personal pre-ownership counselling, which is also mentioned by other studies (Marder and Duxbury, 2008 and Ellis et al., 2017).

For a veterinarian to be able to provide information regarding rabbit care it is essential that rabbit owners initiate contact. Although 90% of the owners planned to take their new rabbit to the veterinarian (Edgar and Mullan, 2011), only 56% of the rabbits in the UK are registered in a veterinary practice according to the 2011 PAW report. In addition, this report also stated that 54% of the rabbits have never been vaccinated and 63% is not neutered. A possible explanation for this may be that veterinarians with good rabbit knowledge and experience might not be very common. In a survey of Howell et al. (2015) 29% of their respondents stated that their rabbit had never visited a veterinarian for a health check and 32% had never been vaccinated against common diseases. There seems to be a positive evolution regarding veterinary involvement, as the 2019 PAW report shows an increase of registered rabbits to 71%.

3. Material and methods

The target audience for the survey consisted of Flemish or Dutch speaking pet rabbit owners. The survey was mainly distributed through social media and forums in Flanders, the Flemish speaking part of Belgium and the Netherlands. To evaluate the regional distribution of respondents, the survey contained a question regarding the place of residence. To counter the occurrence of biasing, the questionnaire was not only advertised in rabbit-specific forums or groups, but also in more general groups to reach respondents who are not as active in this domain.

The questionnaire was compiled in the online survey tool SurveyMonkey and was available between 30 March and 15 April 2020. It consisted of 19 multiple-choice questions regarding the acquisition of the rabbit(s), information sources, housing type, social enrichment, health problems and owner expectations. The survey required approximately 5 minutes to complete since it was our purpose to keep the survey as short and simple as possible to gain a maximal response. An open option where the respondent could explain their answer or add an answer option was provided in some questions. These answers were also taken into account for the interpretation of the results and new answer categories were created if required for the analysis. To further illustrate certain answer options or the question itself, pictures were occasionally implemented.

A cut-off parameter, as to which respondents would be included in the survey, was determined beforehand. Thereby, all participants who had answered the question about their rabbit(s) having any medical issues (question seven) were selected for further analysis. This parameter was selected due to the fact that this question is considered to be the most important for answering one of the research questions regarding the relationship between housing and rabbit health. Additionally, a respondent who answered "I do not know" on every question was not included in the analysis. By using these criteria, data from 1372 respondents were obtained and used for the interpretation of the results.

An important note is that answering a question was not mandatory to continue the questionnaire and sometimes multiple answer options were available. These two factors resulted in the fact that the total entry numbers varied per question. The results were always presented in exact numbers and in percentages, which are calculated based on the total number of entries on that specific question, including the "I do not know" answer option.

The survey results were first transferred into Microsoft Excel for initial screening and the creation of clear and comprehensible tables. Further visualisation of the data in stacked bar graphs was conducted through the use of GraphPad Prism 8. The interpretation of the results was mostly based on descriptive statistics and, for certain parameters, the determination of the odds ratio was conducted. The Fisher's exact test was implemented in the analysis of contingency tables

4. Results

As mentioned above, interpretation of the results is mostly based on descriptive statistics. Due to the number of questions and answer options, the results section will only contain the most important and informative results. A full demonstration of the results for each question is presented in the appendix (section 8).

Based on the set cut-off value, a total 1372 out of 1442 pet rabbit owners filled in survey. Of these respondents, 50.6% lives in the Netherlands, 45.7% in Flanders, 0.4% in Wallonia and 0.2% in Brussels Capital Region (Appendix table 19).

4.1. Housing

In order to obtain a perspective on the living conditions of pet rabbits, owners were asked what their rabbit accommodation looks like (Appendix table 17) and what type of bedding was implemented within these housing systems (Appendix table 15). First and foremost, the most popular housing types mentioned were outdoor shelter with low run (15.5%), free roaming indoor (14.8%) and indoor shelter with run (14.6%). Free roaming outdoor was the specific housing type mentioned in 10.8% of the responses. Regarding these housing types, a substantial 94.8% of the owners claim that their pet rabbit(s) have the possibility rear up on a daily basis without the ears touching the ceiling of their enclosure (Appendix table 16). The owners were also asked if their outdoor pet rabbits could protect themselves from sunlight, wind and rain (Appendix table 14). The response indicates that the vast majority is able to protect themselves from either sunlight (99.1%), wind (96.6%) and rain (97.3%).

Owners were also questioned about the location of their rabbits' cage / shelter and run. The answers of the respondents are demonstrated in Table 1 for each combination, whilst also providing the separate responses for either cage or roaming spot alone under the "total" header. The most common location that owners provide for their rabbits is either completely indoor (25.3%) or outdoor (35.8%). Regardless of their free roaming location, 34.9% of the rabbit cages are located indoor and 44.7% outdoor. The other way around, 29.9% of the owners provide a roaming location indoor, whilst 40% provides one outdoor. Expanding on these numbers, 10.4% of the rabbits have access to both an indoor and outdoor shelter and roaming spot. Only a minor portion (5.8%) of the respondents indicated that there is no location provided for their rabbits to roam in a run or free roam, whilst 0.7% mentions that there is no cage or shelter available.

More on roaming (Appendix table 13), most owners (44.2%) stated that their rabbits are always able to roam, without any exceptions. This is followed by a 23.2% of the owners that only allow roaming when they are home themselves, whilst 11.8% only allow roaming during daytime. A total of 14.3% of the rabbits is not able to perform roaming on a daily basis and 4.8% is never able to roam.

Table 1: The living conditions of pet rabbits regarding indoor and outdoor access

Living conditions	Run / free roaming						Total
	Indoor	Outdoor	Both indoor and outdoor	Not present	Unknown	No answer	
Indoor	347 (25.3%)	17 (1.2%)	93 (6.8%)	18 (1.3%)	1 (0.1%)	3 (0.2%)	479 (34.9%)
Outdoor	14 (1.0%)	491 (35.8%)	51 (3.7%)	49 (3.6%)	1 (0.1%)	7 (0.5%)	613 (44.7%)
Both indoor and outdoor	26 (1.9%)	35 (2.6%)	143 (10.4%)	13 (0.9%)	1 (0.1%)	3 (0.2%)	221 (16.1%)
Not present	5 (0.4%)	1 (0.1%)	4 (0.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (0.7%)
Unknown	1 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
No answer	17 (1.2%)	5 (0.4%)	10 (0.7%)	0 (0.0%)	0 (0.0%)	16 (1.2%)	48 (3.5%)
Total	410 (29.9%)	549 (40.0%)	301 (21.9%)	80 (5.8%)	3 (0.2%)	29 (2.1%)	1372.00 (100%)

At last, when asking about the use of bedding material, the housing systems mostly contained straw (22.1%), beech snips (16.4%), sawdust (14.4%) or hay (12.7%) as bedding material. The implementation of wood or straw pellets (7.9%), hemp (7.8%) and paper based bedding (5.4%) composes the majority of the remaining responses. On the other hand, 7.8% of the owners reportedly do not make use of any ground cover, litter or bedding material (Appendix table 15).

4.2. Companionship

Most of the respondents (57.7%) mentioned that all of their rabbits were co-housed with a conspecific, whilst co-housing for only some of the owned rabbits was answered in 7.1% of the responses (Appendix table 9). In addition, a cumulative total of 33.5% of the respondents indicates that all of their rabbit(s) are housed in solitude, either due to having only one rabbit (27%), a required temporary solitude (1.3%) or effectively not providing co-housing whilst having more than one rabbit (5.3%). A small portion (0.7%) of the owners have their rabbit co-housed with other species, such as guinea pigs, chicken, dogs and cats. The three most cited reasons why rabbits are kept in solitude are to prevent aggressive behaviour (41.1%), reproduction (19.9%) and due to a deceased partner (10.6%) (Appendix table 10). This is followed by solitary housing due to practical reasons (7.6%), the presence of a disease (6.8%) or whilst waiting for a new partner (5.9%). Only 1.3% of the owners' motivation for solitary housing is due to the fact that he/she is satisfied with having one rabbit.

4.3. Medical conditions

Three questions were asked to get further insight in the medical condition of the pet rabbits. In addition, the odds of certain medical conditions due to the presence of particular risk factors has been analysed and will be discussed below.

First, the owners were asked if they have visited a veterinarian in the past twelve months. This was the case for at least 84.8% of the respondents, of which 55.0% consulted a veterinarian for preventive treatment and 29.7% for curative treatment. 15.0% of the owners did not consult a veterinarian in the past year and 0.2% did not know whether or not this was the case (Appendix table 6).

The second question in this category clears up that 69.3% of the owners have at least one neutered rabbit, 29.7% only owns intact rabbits and for 1% the presence of gonads is unknown (Appendix table 8).

With the third question, the owners were asked for the presence of any known medical conditions in their rabbits. The results are demonstrated in Table 2 and only consider the owner's input, regardless of any confirmation by a veterinary expert. Table 3 reports the odds ratio determined for certain important parameters. The significance of these tests was evaluated through a Fisher's exact test. First and foremost, a substantial 58.2% of the owners reported no health problems in at least one of their rabbits, whilst 2.2% is not aware of any health related issues. Based on the complete owner's response, the most common medical conditions are dental problems (8.0%), gastrointestinal problems (6.3%), eye problems (5.8%), overweight (4.7%) and respiratory problems (4.1%).

Table 2: reported health problems in pet rabbits.

Health problems	N	Percentage of total response	Percentage of total respondents
No health problems	798	46.7%	58.2%
Reduced activity	25	1.5%	1.8%
Overweight	81	4.7%	5.9%
Underweight	20	1.2%	1.5%
Dental problems	137	8.0%	10.0%
Eye problems	100	5.8%	7.3%
Ear problems	34	2.0%	2.5%
Respiratory problems	70	4.1%	5.1%
Neurological problems	44	2.6%	3.2%
Defecation problems	107	6.3%	7.8%
Urinary problems	35	2.0%	2.6%
Mobility problems	36	2.1%	2.6%
Fur problems	33	1.9%	2.4%
Wounds on foot soles	45	2.6%	3.3%
Skin wounds (foot soles excluded)	25	1.5%	1.8%
Abscesses	48	2.8%	3.5%
Reproduction problems	3	0.2%	0.2%
Neoplasia	13	0.8%	0.9%
Unknown	30	1.8%	2.2%
Other	26	1.5%	1.9%
Total	1710	100%	124.6%

Note: Representation of the answered health problems with N = number of responses and the corresponding percentages for total response (multiple answer options were possible) and total respondents that filled in the questionnaire.

Table 3: Odds ratio and Fisher's exact test for major medical conditions.

Association	Odds ratio	Confidence interval	Fisher's exact test
Hay on eye problems	1.287	0.8423 to 2.003	0.1525
Indoor housing	1.729	0.7840 to 3.780	0.1375
Solitary housing	0.6523	0.06241 to 3.942	0.5538
Neutering	1.160	0.6955 to 1.900	0.3297
Solitary housing	2.067	0.9808 to 4.332	0.0605
Overweight	0.9643	0.2239 to 3.773	0.6578
Overweight	3.119	1.292 to 7.006	0.0140*
Absence of daily roaming	0.9483	0.5388 to 1.642	0.4731
Absence of daily roaming	1.211	0.7066 to 2.072	0.2884
Absence of daily roaming	1.462	0.6043 to 3.500	0.2948

4.4. Owner knowledge and expectations

As presented in Appendix table 1, the majority of the owners reported to have one (30.2%) or two (49.8%) rabbits. A total of 6.7% of the owners currently have three rabbits, whilst only 7.7% of the owners reported to have more than four rabbits. When the respondents were asked about how many rabbits they have owned before the one(s) they have at this moment, the majority answered zero (34.6%), two (17.2%) and one rabbit (14.4%). Owners that previously had three (8.5%), four (7.6%), five (2.5%), six (3.4%), seven (1.4%), eight (1.7%), nine (0.7%), ten (0.8%), or more than 10 (5.8%) rabbits make up for a total of 32.4% of the respondents (Appendix table 2).

Regardless of the current or previous number of held rabbits, respondents were asked who the rabbit(s) were acquired for. This data is presented in Appendix table 3 and demonstrates that 66.8% of the acquired rabbits were only acquired for the respondent, 8.2% only for the respondent's child(ren) and 1.2% only for the respondent's partner. Furthermore, 8.8% of the rabbits were meant for both the respondent and the partner, whilst 7.6% were meant for both the owner and his/her child(ren).

The survey respondents were further asked where they have acquired their rabbit(s). As some owners have more than one rabbit, multiple answers were possible. The (pet) shop (23.3%), animal shelters (20.6%), breeder (15.6%), family or acquaintance (13.2%) and advertisement websites (12.9%), such as www.2dehands.be and www.marktplaats.nl, are considered to be the most popular answers in this survey. The full response, including less mentioned options, is demonstrated in Appendix table 4.

In terms of the information sources that are preferably consulted by pet rabbit owners, the internet has been selected most often (65.5%) as the most used information source (Figure 3). Second in place comes the veterinarian, selected by 28.0% of the respondents as most used. The response shows that books, acquaintances and animal shelters are rarely used (58.9%, 54.4% and 60.7%, respectively) to obtain information.

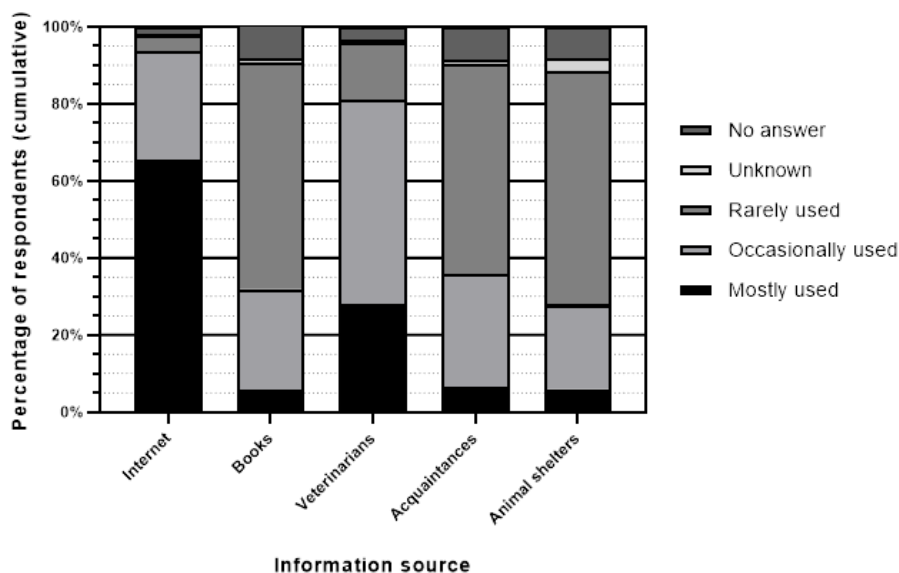


Figure 3: A stacked bar representation of the preferred information sources, specifically internet, books, veterinarians, acquaintances and animal shelters, according to the question answer options: mostly used, occasionally used or rarely used. For a complete overview with response number and percentages, see Appendix table 5.

For the final question within this section, the respondents were asked to reflect on time investment, expenses and joy fulfilment relating with owning a pet rabbit (Figure 4). Regarding time investment, most owners (69.0%) mentioned that this turned out as expected, whilst 22.7% finds it more and 4.9% less than expected. The expenses are higher than expected for 22.6%, as expected for 67.1% and lower than expected for 6.6% of the owners, whereas the fulfilment of joy was considered to be more than expected for 50.7%, as expected for 41.3% and less than expected for 4.8% of the owners.

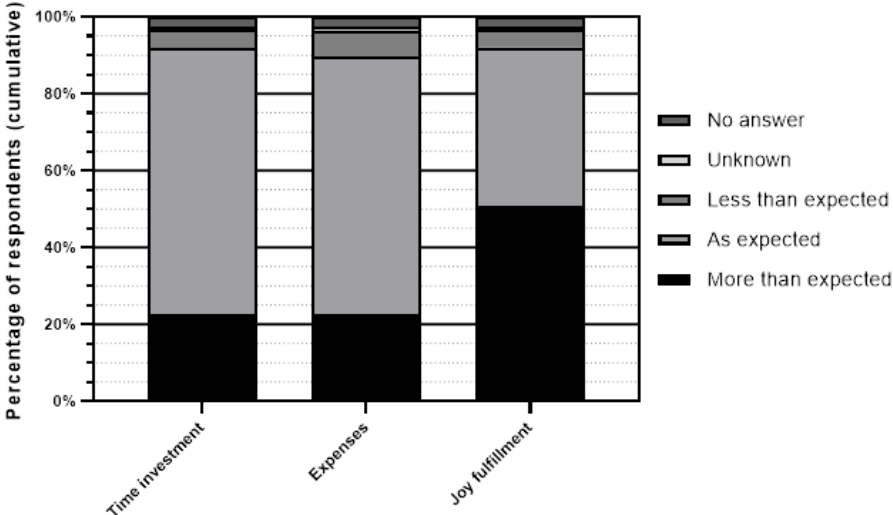


Figure 4: A stacked bar representation of the owner's expectation regarding time investment, expenses and joy fulfilment. For each of these options, owners were able to answer with more than expected, as expected, less than expected or unknown. A table format of the generated information is presented in Appendix table 18.

4. Discussion

Since participation in the survey was voluntary, the results of the survey could be biased towards keen owners. Therefore, the obtained results of this survey are most likely to be more positive than the actual situation in the whole population.

4.1. Housing

Evaluating the response regarding certain housing parameters, it first becomes clear that a substantial percentage of the owners provides either solely indoor (25.3%) or outdoor (35.8%) housing. This first percentage varies from the results obtained by Mullan and Main (2006), as they reported that 3.9% of the rabbits did never go outside. A possible explanation for these differences might be due to the questionnaire being filled in in a different season, regional differences, a smaller population or it could have evolved over time.

Moreover, 10.4% of the rabbits in this survey have both shelter and run indoor and outdoor. These rabbits are most likely permitted outdoor access only if weather conditions are suitable and will be kept mostly indoors during unfit weather conditions. An important note for the questions related to the housing conditions is that owners were not able to answer the question for multiple rabbits that are kept in different housing. This may have been a limiting factor for certain owners. Additionally, it would have been interesting to know the surface of

the housing, but on the other hand it is often not easy for respondents to estimate a surface accurately.

Only 0.8% of the owners did not provide a shelter for their rabbit(s), which means most of the rabbits are able to retreat. Only few outdoor rabbits (0.9%) were not able to escape direct sunlight, which is important since the rabbit is susceptible to heath stroke. Rabbits can tolerate bad weather if provided with adequate shelter. The vast majority is able to escape rain or wind (97.3% and 96.6% respectively), according to the owner.

As demonstrated in Appendix table 12, a total of 5.8% of the owners mentioned that roaming possibilities in the form of a run or free roaming are not provided for their rabbits, whereas the PAW report of 2019 mentioned that 10% of their respondents did not provide access to a run. When the owners were asked for the frequency of free roaming (Appendix table 13), a lower 4.8% of the owners answered this with “never”. This slight inconsistency may be due to differences in question formulation. Nonetheless, 44.2% of the owners reported that their rabbit(s) have continuous access to a run or free roam, whilst a study by Edgar and Mullan (2011) reported that this was only the case for 16% of the rabbits. A possibility is that the respondents of this study more often provide access to a run, in which unsupervised roaming is more feasible. Expanding towards the results on the frequency of free roaming, a previous study by Howell et al. (2015) reported that 47% of the rabbits could go outside of their hutch less than weekly. In this study, the numbers are remarkably lower as only 9.5% of the owners allow their rabbit(s) to roam less than weekly. This substantial difference may indicate that the respondents in this questionnaire are more motivated in providing adequate levels of free roaming for their rabbits. It may, however, deviate from the actual average if some level of biasing plays an underlying role.

Although the size of the accommodation provided by the questionnaire’s respondents is unknown, most rabbits (94.8%) have the possibility rear up on a daily basis without the ears touching the ceiling. This is a positive outcome as rearing is a natural behaviour for the rabbit with a high motivation (Dixon et al., 2010). This is in line with the results on housing type (Appendix table 17), which indicate that at least 83% of the rabbit are kept in housing types that would facilitate this type of rearing behaviour. Rabbits kept in a small indoor one story cage (Appendix table 17: Picture 3), outdoor one story cage (Appendix table 17: Picture 9) or outdoor triangle cage (Appendix table 17: Picture 10) are less likely to be able to rear up, but may be provided with access to a run or free roam. It is also important to take into account that the respondents had to select the best fitting picture of accommodation, thus may differ from the actual accommodation.

For bedding option or litter type, straw and beech snips were the most popular answers, although these substrates are not very absorbent and relatively harsh. It has been reported that straw may increase the prevalence of eye problems (Buckley and Lowman, 1979; Varga, 2013; Bedard, 2018). However, based on a Fisher’s exact test, no significant impact of straw or hay on the prevalence of eye problems was found in this study. Saw dust is also a popular choice even though it may cause dust formation and is suggested to potentially be hepatotoxic, as mentioned above in the literature study. A relatively low price point may explain the popularity of these beddings, but a good alternative could be hemp or bedding based on recycled paper, although this last option is more expensive.

4.2. Companionship

According to the results displayed in Appendix table 9, co-housing of rabbits with a conspecific was the most popular answer at 57.7%. On the other hand, 33.5% of the owners reported keeping their rabbit(s) solitary, largely due to the fact that they only have one rabbit (27%). As mentioned above, previous studies demonstrated a solitary housing rate between 44% and 67%. This may indicate that owners are now more aware of the companionship requirements for their rabbits compared to the PAW report of 2019 that mentions that 49% of the rabbits are still housed in solitude. These variations may be due to geographical or cultural differences between the countries in which the survey took place. Furthermore, 7.1% of the owners declared that some of their rabbits are housed with a conspecific, whilst some are housed in solitary. When owners were asked why their rabbit(s) were housed without other companions, 41.1% of the owners answered that it was to prevent fighting amongst their pets. This reinforces the statement that not all pairs are compatible and that this is one of the major concerns to consider when providing co-housing. To prevent this from occurring, it is important to educate future rabbit owners and provide professional help for those that are experiencing problems. At 19.9%, the second reason for solitary housing is to prevent reproduction, which could be solved by neutering.

4.3. Medical conditions

Many diseases described in rabbits have a multifactorial aetiology, which may complicate the investigation of certain relations and risk factors. As mentioned in the results section, the questions related to medical conditions is purely based on the owner's findings and thus do not guarantee that the information provided is correct. Although not conducted due to practical reasons, more accurate results could have been obtained through performing clinical examination by a veterinarian. Nonetheless, at least 84.8% of the responders indicates that they have visited the veterinarian in the past year, either for preventive or curative treatment. Due to this high percentage, it is likely that the medical conditions provided in Table 2 have actually been diagnosed by a veterinarian. On the other hand, 15% of the owners did not take their rabbit to a veterinarian in the past twelve months, to which this group may be more likely to miss certain medical conditions.

The most common health issues are dental, digestive, ocular and respiratory problems and overweight, which is in line with findings in previous research (Mullan and Main, 2006; Normando and Gelli, 2011; Rooney et al., 2014). For the most common medical conditions, the relation to certain risk factors were evaluated. However, due to the fact that the prevalence of these diseases is very low if related to potential risk factors, most associations were found to be not significant. It remains a possibility that the survey is filled in by more motivated rabbit owners that take more care for their pet rabbits than the average rabbit owner. This may explain why certain associations, for example between neutering and the prevalence of overweight, were not found significant, although they are supposed to be related according to Courcier et al. (2012) and Meredith (2012). As mentioned in the results, only the impact of obesity on the chance of developing pododermatitis was tested significant through the Fisher's exact test. Also, there were no questions incorporated regarding the feeding regiment and water provision, which both have a considerable impact on the physical health (Varga, 2013). As this master thesis is focused on health in relation to housing, food and water are not strictly considered.

4.4. Owner knowledge and expectations

When asked about the quantity of rabbits owned at this moment, most owners answered two (49.8%) and one (30.2%) rabbit(s). In a study by Oxley et al. (2015), where a similar amount of respondents were obtained, it was found that 44.9% owned two rabbits and 25.3% owned one rabbit. Also, the majority of the owners in this questionnaire (34.6%) mentions that they did not have any rabbit(s) before the current one(s).

When the owners were asked for whom they have acquired the rabbit(s), 66.8% answered strictly for themselves and 8.2% for their child(ren). This evolution from children to adult pet has already been seen by Rooney et al. (2014), where 49% of the owners declared acquiring a rabbit for themselves and 27.6% for their child(ren). The high number of respondents answering “myself” in this question may also be impacted by the fact that the respondents are most likely rather motivated rabbit owners. People that, for example, acquired a rabbit purely for their child, may not take the effort filling in this survey.

Stores and shelters appear to be the most popular rabbit acquisition sites amongst owners, although it is unclear how many rabbits were acquired through each option. In the study by Schepers et al. (2009), most rabbits have been acquired at a pet shop (33%), breeders (15%), shelters (14%), family (11%) or born in the household (7%). Compared to the current study, the number have shifted slightly. Regardless of the way that the pets are acquired, it remains essential that future owners are sufficiently informed about taking care of pet rabbits and maintaining a high standard of animal welfare. It is therefore an important factor that the seller is and remains educated in this field and is also able to transfer the correct information to the new owners. The response on this question also indicates that 72 out of 1372 owners received a rabbit as present, a group of owners that may be more likely to have lesser knowledge regarding rabbit care than owners that actively sought out the acquisition of a pet rabbit. Based on this survey, however, it is impossible to determine whether or not these owners knew of the present beforehand and were able to properly educate themselves.

The preferred method for obtaining information regarding rabbit care is the Internet with 65.5% of the owners mentioning this option as mostly used. Although the Internet contains a lot of information and is very accessible to consult, it may also be risky due to the fact that not all the provided information is reliable. If the Internet is used as information source, it may be important for owners to consult various different Internet resources and to assess them critically. The veterinarian as information source was only selected second after the Internet as mostly used by 28% of the respondents. Most likely due to a higher cost, being less accessible or approachable and/or perhaps due to a bad experience. The results of previous research (Welch et al., 2017) are quite different, whereas most of the rabbit owners think shelter staff provide best information, followed by other rabbit owners, internet and veterinarians. These differences suggest a positive evolution regarding the role of the veterinarian in providing correct and applicable information regarding caretaking of rabbits.

The cost and time investment related to having a pet rabbit appeared to be as expected for the majority of the respondents, namely at 67.1% and 69.0% respectively. For 22.6% of the respondents, the cost was higher than expected, which is different compared to the PAW report from 2011, where 99% of the owners underestimated the lifetime cost of a rabbit. This might also be due to more expensive veterinary care in the UK. Furthermore, the time investment was higher than expected for 22.7% of the owners, whilst in the 2011 PAW report¹² it was stated that 30% of the owners found that taking care of their rabbit was harder work than expected. According to Cook and McCobb (2012) and Ulfsdotter et al. (2016), this is an important factor as a lack of time is the most common reason for relinquishment. The

comparison with previous studies for both cost and time investment suggests that the respondents to this survey were better informed regarding these topics, which may say something about their motivation as rabbit owners. This is also reflected in the response towards the joy fulfilment, as 50.7% of the respondents agree that they have experience more joy from keeping a rabbit as pet than expected beforehand.

5. Conclusion

The information generated in the survey attached to this study gives an indication regarding the current status of the housing conditions, companionship, prevalence of medical conditions, and owner knowledge and expectation regarding rabbit care in Flanders and the Netherlands. A positive evolution was seen for certain key elements, such as shelter from environmental conditions, providing roaming possibilities and housing with a conspecific. Although there seems to be an increase in the awareness of the importance for companionship, a considerable amount of owners still owns one rabbit. The most common health issues remain dental, digestive, ocular and respiratory problems, and overweight. Generalised, it becomes clear that the effect of housing on pet rabbit health is a very broad topic which is influenced by many factors that make it a complex subject to analyse. In order to get a better understanding on the potential risk factors related to housing and health, it is important that each aspect is thoroughly evaluated in future studies.

6. References

Ashcraft, M.B., Southard, K.A., Tolley, E.A., 1992. The effect of corticosteroid-induced osteoporosis on orthodontic tooth movement. *American Journal of Orthodontics and Dentofacial Orthopedics* 102, 310 - 319.

Bays, T.B., 2006. Rabbit Behaviour. In: *Exotic Pet Behaviour*, First Edn. Saunders, St. Louis, MO, USA, pp. 1- 49.

Bedard, K.M., 2018. Ocular Surface Disease of Rabbits. In: S.L.C., *Medical and Surgical Management of Ocular Surface Disease in Exotic Animals, An Issue of Veterinary Clinics of North America: Exotic Animal Practice*, Volume 22-1, First Edn. Elsevier, Amsterdam, the Netherlands, pp. 1 - 14.

Boers, K., McCormick, S., Turcotte, N., 2002. Comfortable Quarters for Rabbits in Research Institutions. *Journal unknown*.

Bradley, T., 2004. Rabbit care and husbandry. *Veterinary clinics: exotic animal practice* 7, 299 - 313.

Buckley, P., Lowman, D.M.R., 1979. Chronic non-infective conjunctivitis in rabbits. *Laboratory Animals* 13, 69 - 73.

Buijs, S., Van Poucke, E., Van Dongen, S., Lens, L., Tuytens, 2012. Cage size and enrichment effects on the bone quality and fluctuating asymmetry of fattening rabbits. *Journal of Animal Science* 90, 3568 - 3573.

Buijs, S., Hermans, K., Maertens, L., Van Caelenberg, A., Tuytens, F.A.M., 2014. Effects of semi-group housing and floor type on pododermatitis, spinal deformation and bone quality in rabbit does. *Animal* 8, 1728 - 1734.

Buseth, M.E., Saunders, R., 2015. The Origins and Development of Rabbits. In: *Rabbit Behaviour, Health and Care*, First Edn. CABI, Wallingford, United Kingdom, pp. 72 - 73.

Carroll J.F., Dwyer, T.M., Grady, A.W., Reinhart, G.A., Montani, J.-P., Cockrell, K., Meydrech, E.F., Mizelle, H.L., 1996. Hypertension, cardiac hypertrophy, and neurohumoral activity in a new animal model of obesity. *The American Physiological Society* 271, 373 - 378.

Castañeda, S., Calvo, E., González-González, R.L.R., Díaz-Curiel, P.M., Herrero-Beaumont, G., 2008. Characterization of a new experimental model of osteoporosis in rabbits. *Journal of Bone and Mineral Metabolism* 26, 53 - 59.

Chu. L., Garner, J.P., Mench, J.A., 2004. A behavioral comparison of New Zealand White rabbits (*Oryctolagus cuniculus*) housed individually or in pairs in conventional laboratory cages. *Applied Animal Behaviour Science* 85, 121 - 139.

Cook, A.J., McCobb, E., 2012. Quantifying the Shelter Rabbit Population: An Analysis of Massachusetts and Rhode Island Animal Shelters. *Journal of Applied Animal Welfare Science* 15, 297 - 312.

Coon, R.A., Jones, R.A., Jenkins, L.J. Jr., Siegel J., 1970. Animal Inhalation Studies on Ammonia, Ethylene, Glycol, Formaldehyde, Dimethylamine, and Ethanol. *Toxicology and applied pharmacology* 16, 646 - 655.

Courcier, E.A., Mellor, D.J., Pendlebury, E., Evans, C., Yam, P.S., 2012. Preliminary investigation to establish prevalence and risk factors for being overweight in pet rabbits in Great Britain. *Veterinary Record* 171, 197.

Crowell-Davis, S., 2007. Behaviour problems in pet rabbits. *Journal of Exotic Pet Medicine* 16, 38-44.

Davies, M., 2010. Preventive medicine for pet rabbits. *Veterinary Nursing Journal* 25, 55 - 58.

DeCubellis, J., Graham, J., 2013. Gastrointestinal Disease in Guinea Pigs and Rabbits. *Veterinary Clinics: Exotic Animal Practice* 16, 421 - 435.

Delesalle, C., Van de Walle, G.R., Nolten, C., Ver Donck, L., Van Hemelrijck, A., Drinkenburg, W., De Bosschere, H., Claes, P., Lefere, L., Torfs, S. et al., 2008. Determination of the source of increased serotonin concentrations in blood and peritoneal fluid of colic horses with compromised bowel. *Equine veterinary journal* 40, 326 - 331.

Dixon, L.M., Hardiman, J.R., Cooper, J.J., 2010. The effects of spatial restriction on the behavior of rabbits (*Oryctolagus cuniculus*). *Journal of Veterinary Behavior* 5, 302 - 308.

Edgar, J.L., Mullan, S.M., 2011. Knowledge and attitudes of 52 UK pet rabbit owners at the point of sale. *Veterinary Record* 168, 353.

Ellis, C.F., McCormick, W., Tinarwo, A., 2017. Analysis of Factors Relating to Companion Rabbits Relinquished to Two United Kingdom Rehoming Centers. *Journal of Applied Animal Welfare Science* 20, 230 - 239.

El-Tarabany, M.S., Ahmed-Farid, O.A., El-Tarabany, A.A., 2019. Impact of space allowance on performance traits, brain neurotransmitters T and blood antioxidant activity of New Zealand White rabbits. *Preventive Veterinary Medicine* 163, 44 - 50.

Fairham, J., Harcourt-Brown, F.M., 1999. Preliminary investigation of the vitamin D status of pet rabbits. *Veterinary record* 145, 452 - 454.

Fidan, F., Unlu, M., Sezer, M., Sahin, O., Tokyol, C., Esme, H., 2006. Acute effects of environmental tobacco smoke and dried dung smoke on lung histopathology in rabbits. *Pathology* 38, 53 - 57.

Gordon, K.R., 1989. Adaptive Nature of Skeletal Design: *two-tiered plasticity allows changes in strength and locomotion*. *BioScience* 39, 784 - 790.

Hansen, B., Arif, F., Gregersen, H., Bruusgaard, H., Wallin, L., 2008. Effect of Serotonin on Small intestinal Contractility in Healthy Volunteers. *Physiological Research* 57, 63 - 71.

Harcourt-Brown, F.M., 1996. Calcium deficiency, diet and dental disease in pet rabbits. *Veterinary Record* 139, 567 - 571.

Harcourt-Brown, F.M., 2002. Biological characteristics of the domestic rabbit (*Oryctolagus cuniculi*), Diet and husbandry, Dental disease, Skin disease, Digestive disorders, cardiorespiratory disease. In: *Textbook of Rabbit Medicine, First Edn.* Butterworth–Heinemann, Oxford, UK, pp. 1-51, 165-205, 224-291, 324-334.

Harkness, J.E., 1987. Rabbit Husbandry and Medicine. *Veterinary Clinics of North America: Small Animal Practice* 17, 1019 - 1044.

Harkness, J.E, Turner, P.V., VandeWoude, S, Wheler, C.L., 2010. Introduction, General Husbandry, and Disease Prevention. In: *Harkness and Wagner's Biology and Medicine of Rabbits and*

Rodents, Fifth Edn. Wiley-Blackwell, Hoboken, NJ, USA, pp. 3 - 22.

Howell, T.J., Mornement, K., Bennett, P.C., 2015. Companion Rabbit and Companion Bird Management Practices Among a representative Sample of Guardians in Victoria, Australia. *Journal of Applied Animal Welfare Science* 18, 1 - 16.

Huls, W.L., Brooks, D.L., Bean-Knudsen D., 1991. Response of adult New Zealand white rabbits to enrichment objects and paired housing. *Laboratory Animal Science* 41, 609 - 612.

Jekl, V., Redrobe, S., 2013. Rabbit dental disease and calcium metabolism - the science behind divided opinions. *Journal of Small Animal Practice* 54, 481 - 490.

Jenkins, R., 2001. Rabbit behaviour. *Veterinary clinics of North America: exotic animal practice* 4, 669 - 679.

Langenskiöld, A., Michelsson, J.-E., Videman, T., 1979. Osteoarthritis of the Knee in the Rabbit Produced by Immobilization:: *Attempts to Achieve a Reproducible Model for Studies on Pathogenesis and Therapy*. *Acta Orthopaedica Scandinavica* 50, 1-14.

Legendre, L.F.J., 2003. Oral disorders of exotic rodents. *The veterinary clinics: exotic animal practice* 6, 601-628.

Lidfors, L., Edström, T., Lindberg, L., 2004. The welfare of laboratory rabbits, First Edn. In: *The welfare of laboratory animals: volume 2*. Springer, Dordrecht, The Netherlands, pp. 211 - 244.

Luzi, F., Ferrante, V., Heinzl, E., Verga, M., 2003. Effect of environmental enrichment on productive performance and welfare aspects in fattening rabbits. *Italian Journal of Animal Science* 2, 438-440 .

Mancinelli, E., Keeble, E., Richardson, J., Hedley, J., 2014. Husbandry risk factors associated with hock pododermatitis in UK pet rabbits (*Oryctolagus cuniculus*). *Veterinary Record* 174, 429.

Marco-Jiménez, F., Vicente, J.S., 2017. Overweight in young males reduce fertility in rabbit model. *PLoS ONE* 12, 1 - 11.

Marder, A., Duxbury, M.M., 2008. Obtaining a Pet: Realistic Expectations. *Veterinary Clinics of North America: Small Animal Practice* 38, 1145 - 1162.

Martin, N., 2012. The state of UK pet rabbit welfare: what we can do about it. *Veterinary Nursing Journal* 27, 66 - 68.

Martrenchar, A., Boilletot, E., Cotte, J.-P., Morisse, J.-P., 2001. Wire-floor pens as an alternative to metallic cages in fattening rabbits: influence on some welfare traits. *Animal Welfare* 10, 153 - 161.

McBride, E.A., 2017. Small prey species' behaviour and welfare: implications for veterinary professionals. *Journal of Small Animal Practice* 58, 423 - 436.

Melillo, A., 2007. Rabbit Clinical Pathology. *Journal of Exotic Pet Medicine* 16, 135 - 145.

Mellanby, M., Killick, E.M., 1926. A preliminary study of factors influencing calcification processes in the rabbit. *Biochemical journal* 20, 902 – 926.5.

Meredith, A., 2012. Is obesity a problem in pet rabbits? *Veterinary Record* 25, 192 - 193.

Meredith, A.L., Prebble, J.L., Shaw, D.J., 2015. Impact of diet on incisor growth and attrition and the development of dental disease in pet rabbits. *Journal of Small Animal Practice* 56, 377 - 382.

Meredith, A.L., Prebble, J.L., 2017. Impact of diet on faecal output and caecotroph consumption in rabbits. *Journal of Small Animal Practice* 58, 139 - 145.

Morisse, J.-P., Boilletot, E., Martrenchar, A., 1999. Preference testing in intensively kept meat production rabbits for straw on wire grid floor. *Applied Animal behaviour Science* 64, 71-80.

Mullan, S.M., Main, D.C.J., 2006. Survey of the husbandry, health and welfare of 102 pet rabbits. *Veterinary Record* 159, 103-109.

Neville, V., Hinde, K., Line, E., Todd, R., Saunders, R.A., 2019. Rabbit relinquishment through online classified advertisements in the United Kingdom when why and how many? *Journal of applied animal welfare* 22, 105 - 115.

Newberry, R.C., 1995. Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science* 44, 229-243.

Normando, S., Gelli, D., 2011. Behavioral complaints and owners' satisfaction in rabbits, mustelids, and rodents kept as pets. *Journal of Veterinary Behavior* 6, 337 - 342.

Nowak, R.M., 1999. Order Lagomorpha. In: *Walker's mammals of the world: Volume II*, sixth Edn. The Johns Hopkins University Press, Baltimore, MD, USA, pp. 1720-1730.

Orlandi, A., Francesconi, A., Marcellini, M., Ferlosio, A., Spagnoli, L.G., 2004. Role of ageing and coronary atherosclerosis in the development of cardiac fibrosis in the rabbit. *Cardiovascular Research* 64, 544 - 552.

Oxley, J. A., Previti, A., Alibrandi, A., Briefer, E. F., & Passantino, A., 2015. A preliminary Internet survey of pet rabbit owners' characteristics. *World Rabbit Science* 23, 289 - 293.

Poggiagliolmi, S., Crowell-Davis, S.L., Alworth L.C., Harvey, S.B., 2011. Environmental enrichment of New Zealand White rabbits living in laboratory cages. *Journal of Veterinary Behaviour* 6, 343 - 350.

Princz, Z., Zotte, A.D., Radnai, I., Bíró-Németh, E., Matics, Z., Gerencsér, Z., Nagy, I., Szendrő, Z., 2008. Behaviour of growing rabbits under various housing conditions. *Applied Animal Behaviour Science* 111, 342 - 356.

Quesenberry, K.E., Carpenter, J.W., 2012. Dermatologic diseases. In: *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*, Third Edn. Philadelphia, PA, USA, pp. 232 - 244.

Rees Davies, R., Rees Davies, J.A.E., 2003. Rabbit gastrointestinal physiology. *The veterinary clinics: exotic animal practices* 6, 139-153.

Reusch, B., 2005. Investigation and management of cardiovascular disease in rabbits. In *Practice* 27, 418-425.

Richardson, V.C.G., 2000. Husbandry, The skin. In *Rabbits: Health, Husbandry and Diseases*, First Edn. Wiley-Blackwell, Hoboken, NJ, USA, pp 1- 6, 29 - 43

Rooney, N.J., Blackwell, E.J., Mullan, S.M., Saunders, R., Baker, P.E., Hill, J.M., Sealey, C.E., Turner, M.J., Held, S.D.E., 2014. The current state of welfare, housing and husbandry of the English pet rabbit population. *BMC Research Notes* 7, 942.

Saunders, R., 2018. More attention should be given to rabbits. *Veterinary Record* 182, 639.

Sayers, I., 2010. Approach to preventive health care and welfare in rabbits. *In Practice* 32, 190 - 198.

Schepers, F., Koene, P., Beerda, B., 2009. Welfare assessment in pet rabbits. *Animal Welfare* 18, 477 - 485.

Seaman, S.C., Waran, N.K., Mason, G., D'Eath, R.B., 2008. Animal economics: assessing the motivation of female laboratory rabbits to reach a platform, social contact and food. *Animal behaviour* 75, 31 - 42.

Spector, W.S., 1956. Temperature characteristics: various homeothermic animals. In: *Handbook of biological data*, First Edn. W.B. Saunders company, Philadelphia, PA, USA, pp. 437.

Stapleton, N., 2014. The chubby bunny: a closer look at obesity in the pet rabbit. *The veterinary Nurse* 5, 360 - 365.

Stauffacher, M., 1992. Group housing and enrichment cages for breeding, fattening and laboratory rabbits. *Animal welfare* 1, 105-125.

Trocino, A., Xiccato, G., 2006. Animal welfare in reared rabbits: a review with emphasis on housing systems. *World Rabbit Science* 14, 77 - 93.

Ulfsdotter, L., Lundberg, A., Andersson, M., 2016. Rehoming of pet rabbits (*Oryctolagus cuniculus*) in Sweden: an investigation of national advertisement. *Animal Welfare* 25, 303-308.

Varga, M., 2013. Rabbit basic science, Dental disease, Skin diseases, Digestive disorders, Ophthalmic diseases, Cardiorespiratory diseases, Urogenital diseases. In: *Textbook of Rabbit Medicine*, Second Edn. Elsevier, Amsterdam, the Netherlands, pp. 3-108, 203-248, 271-366, 390-424.

Verga, M., Zingarelli, I., Heinzl, E., Ferrante, V., Martino, P.A., Luzi, F., 2004. Effect of housing and environmental enrichment on performance and behaviour in fattening rabbits. *World Rabbit Science* 13, 139 - 140.

Verga, M., Luzi, F., Carezzi, C., 2007. Effects of husbandry and management systems on physiology and behaviour of farmed and laboratory rabbits. *Hormones and Behaviour* 52, 122 - 129.

Videman, T., 1982. Experimental Osteoarthritis in the Rabbit: *Comparison of Different Periods of Repeated Immobilization*. *Acta Orthopaedica Scandinavica* 53, 339-347.

Wagner, F., Fehr, M., 2007. Common Ophthalmic Problems in Pet Rabbits. *Journal of Exotic Pet Medicine* 16, 158 - 167.

Welch, T., Coe, J.B., Niel, L., McCobb, E., 2017. A survey exploring factors associated with 2890 companion-rabbit owners' knowledge of rabbit care and the neuter status of their companion rabbit. *Preventive Veterinary Medicine* 137, 13 - 23.

Yamamoto, Y., Shimamoto, K., Sofikitis, N., Miyagawa, I., 1999. Effects of hypercholesterolaemia on Leydig and Sertoli cell secretory function and the overall sperm fertilizing capacity in the rabbit. *Human reproduction* 14, 1516-1521.

Appendix

Survey questions

1. How many rabbits do you own at this moment?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- more than 10
- I do not know

2. How many rabbits did you own before the rabbits you own at the moment?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- more than 10
- I do not know

3. For whom were/was the rabbit(s) mainly acquired? (multiple answers are possible)

- myself
- my partner
- my child(ren)
- another minor
- another major
- I do not know

4. Where you acquire your rabbit(s)? (multiple answers are possible)

- shelter or asylum
- shop
- family/acquaintance
- breeder
- gifted
- advertisement sites (such as 2dehands.be, marktplaats.nl, koopjeskrant.be...)

- social media (such as Facebook, Twitter, Instagram...)
- I do not know
- other (please provide further explanation)

5. What are your information sources regarding rabbits? Please indicate for each source how often they are used.

	most used	used from time to time	rarely or never used	I do not know
Internet				
books				
veterinarian				
acquaintances				
shelter staff				
other (please provide further explanation)				

6. Have you been to the veterinarian with your rabbit(s) the past year? (multiple answers are possible)

- yes, for a preventive measure (vaccination, check-up, clipping nails, neutering, ...)
- yes, for a health problem
- no
- I do not know

7. Do your rabbits have health problems? If yes which one? (multiple answers are possible)

- yes, overweight
- yes, underweight
- yes, dental problems
- yes, eye problems
- yes, ear problems
- yes, respiratory problems
- yes, problems with defecation
- yes, problems with urinating
- yes, motility problems
- yes, fur problems
- yes, wounds on the foot soles
- yes, wounds on other parts of the skin
- yes, abscesses
- yes, being less active in general
- no, no health problems
- I do not know
- yes, others (please provide further explanation)

8. Do you own one or more neutered rabbits?

- yes
- no
- I do not know

9. Are your rabbits housed solitary or socially?

- I only have one rabbit
- all my rabbits are housed socially
- all my rabbits are housed solitary
- some rabbits are housed socially and some are housed solitary
- I do not know
- other (please provide further explanation)

10. If you have a solitary housed rabbit; what is the reason? (multiple answers are possible)

- I only have one rabbit
- to prevent reproduction
- to prevent aggression between the rabbits
- to have a better contact with my rabbit
- because of an illness
- for practical reasons
- all of my rabbits are housed socially
- I do not know
- other (please provide further explanation)

11. Has the housing of your rabbit(s) been changed the past twelve months?

- no
- I do not know
- yes (please provide further explanation)

12. How do(es) your rabbit(s) live? Please indicate what applies. (roaming is considered to be running free in the garden/house/room or running in a run)

	not present	indoor	outdoor	indoor and outdoor	I do not know
cage or shelter					
roaming					

13. When can your rabbit roam? (roaming is considered to be running free in the garden/house/room or running in a run)

- yes, my rabbit can roam at all times
- yes, my rabbit can roam during daytime
- yes, my rabbit can roam when I am at home
- yes, my rabbit can roam a few times per week
- yes, my rabbit can roam a few times per month
- yes, my rabbit can roam a few times per year
- no, my rabbit does not roam
- I do not know

14. If your rabbits go outdoors, can they:

	yes	no	I do not know	my rabbit does not go outdoors
put themselves completely in the shadow				
shelter from wind				
shelter from rain				

15. Which bedding do you use for your rabbit(s)? (multiple answers are possible)

- hay
- straw
- newspaper
- sawdust (illustrated with picture)
- beech chips (illustrated with picture)
- hemp (illustrated with picture)
- bedding based on paper (other than newspaper)
- I do not use any bedding
- I do not know
- Others (please provide further explanation)

16. Do(es) your rabbit(s) daily have the possibility to rear up, without the ears touching a ceiling? (illustrated with picture)

- yes
- no
- I do not know

17. What does the accommodation of your rabbit(s) look like? Choose the best fitting option

- two story cage (illustrated with picture)
- free roaming outdoor (illustrated with picture)
- small indoor one story cage (illustrated with picture)
- outdoor cage with small low run (illustrated with picture)
- indoor shelter with run (illustrated with picture)
- free roaming indoor (illustrated with picture)
- outdoor shelter with high run (illustrated with picture)
- outdoor one story cage (illustrated with picture)
- outdoor triangle cage (illustrated with picture)

18. Is keeping rabbits as you expected?

	less than expected	as expected	more than expected	I do not know
time investment				
cost				
joy				

19. Where do you live with your rabbit?

- Flemish region

- Brussels Capital region
- Walloon region
- The Netherlands
- other (please provide further explanation)

20. Do you have any comments about this survey or about keeping rabbits in general?

Survey results

Appendix table 1

Number of rabbits currently held	N	Percentage
0	0	0.0%
1	414	30.2%
2	683	49.8%
3	92	6.7%
4	77	5.6%
5	22	1.6%
6	26	1.9%
7	14	1.0%
8	11	0.8%
9	6	0.4%
10	6	0.4%
More than 10	20	1.5%
Unknown	1	0.1%
Total	1372	100%

Appendix table 2

Number of rabbits previously held	N	Percentage
0	475	34.6%
1	198	14.4%
2	236	17.2%
3	117	8.5%
4	104	7.6%
5	34	2.5%
6	47	3.4%
7	19	1.4%
8	23	1.7%
9	9	0.7%
10	11	0.8%
More than 10	79	5.8%
Unknown	20	1.5%
Total	1372	100%

Appendix table 3

	Bought a rabbit for	N	Percentage
Only for	Myself	917	66.8%
	My partner	17	1.2%
	My child(ren)	113	8.2%
	Other infant(s)	14	1.0%
	Other adult(s)	15	1.1%
A combination of	Myself and my partner	121	8.8%
	Myself, my partner and my child(ren)	23	1.7%
	Myself, my partner and other infant(s)	1	0.1%
	Myself and my child(ren)	104	7.6%
	Myself, other infant(s) and other adult(s)	4	0.3%
	Myself and other infant(s)	14	1.0%
	Myself and other adult(s)	16	1.2%
	My partner and my child(ren)	6	0.4%
	My child(ren) and other adult(s)	1	0.1%
	Myself and unknown	1	0.1%
	Unknown	5	0.4%
Total	1372	100%	

Appendix table 4

Where was the rabbit acquired	N	Percentage
Animal shelters	428	20.6%
(Pet) shop	484	23.3%
Family / acquaintance	274	13.2%
Breeder	324	15.6%
As present	72	3.5%
Consumer-to-consumer website	268	12.9%
Social media	73	3.5%
Market	20	1.0%
Found	41	2.0%
Own breeding	23	1.1%
Farm	18	0.9%
Veterinarian / Work / Education	21	1.0%
Other	27	1.3%
Unknown	2	0.1%
Total	2075	100%

Appendix table 5

Use of information sources	Internet	Books	Veterinarian	Acquaintances	Animal shelters
Mostly used	899 (65.5%)	78 (5.7%)	384 (28.0%)	91 (6.6%)	83 (6.0%)
Occasionally used	384 (28.0%)	359 (26.2%)	727 (53.0%)	400 (29.2%)	300 (21.9%)
Rarely used	61 (4.4%)	808 (58.9%)	205 (14.9%)	747 (54.4%)	833 (60.7%)
Unknown	3 (0.2%)	12 (0.9%)	9 (0.7%)	17 (1.2%)	42 (3.1%)
No answer	25 (1.8%)	115 (8.4%)	47 (3.4%)	117 (8.5%)	114 (8.3%)
Total	1372 (100%)	1372 (100%)	1372 (100%)	1372 (100%)	1372 (100%)

Appendix table 6

Veterinary consults in the last 12 months	N	Percentage
Yes. preventive treatment	952	55.1%
Yes. curative treatment	513	29.7%
No	260	15.0%
Unknown	4	0.2%
Total	1729	100%

Appendix table 7

Health problems	N	Percentage
No (known) health problems	798	46.7%
Reduced activity	25	1.5%
Overweight	81	4.7%
Underweight	20	1.2%
Dental problems	137	8.0%
Eye problems	100	5.8%
Ear problems	34	2.0%
Respiratory problems	70	4.1%
Neurological problems	44	2.6%
Defecation problems	107	6.3%
Urinary problems	35	2.0%
Mobility problems	36	2.1%
Fur problems	33	1.9%
Wounds foot soles	45	2.6%
Skin wounds (foot soles excl.)	25	1.5%
Abscesses	48	2.8%
Reproduction problems	3	0.2%
Neoplasia	13	0.8%
Unknown	30	1.8%
Other	26	1.5%
Total	1710	100%

Appendix table 8

one or more neutered rabbits?	N	Percentage
Yes	949	69.3%
No	407	29.7%
Unknown	14	1.0%
Total	1370	100%

Appendix table 9

Housing companion	N	Percentage
Co-housing for all rabbits (same species)	792	57.7%
Co-housing for some rabbits and not for others	97	7.1%
No co-housing	73	5.3%
I only have 1 rabbit	370	27.0%
Temporary solitude	18	1.3%
Co-housing (other species)	13	0.9%
No answer	9	0.7%
Total	1372	100%

Appendix table 10

Motivation for solitary housing	N	Percentage
To prevent reproduction	47	19.9%
To prevent infighting	97	41.1%
To stimulate contact with the owner	7	3.0%
Due to a disease	16	6.8%
Due to practical reasons	18	7.6%
Due to deceased partner	25	10.6%
Awaiting new partner	14	5.9%
Owner is satisfied with having 1 rabbit	3	1.3%
Unknown	5	2.1%
Other	4	1.7%
Total	236	100%

Appendix table 11

Changed housing the past year?	N	Percentage
Yes	647	47.5%
No	702	51.6%
Unknown	12	0.9%
Total	1361	100%

Appendix table 12

Living conditions	Free roaming						Total
	Indoor	Outdoor	Both indoor and outdoor	Not present	Unknown	No answer	
Indoor	347 (25.3%)	17 (1.2%)	93 (6.8%)	18 (1.3%)	1 (0.1%)	3 (0.2%)	479 (34.9%)
Outdoor	14 (1.0%)	491 (35.8%)	51 (3.7%)	49 (3.6%)	1 (0.1%)	7 (0.5%)	613 (44.7%)
Both indoor and outdoor	26 (1.9%)	35 (2.6%)	143 (10.4%)	13 (0.9%)	1 (0.1%)	3 (0.2%)	221 (16.1%)
Not present	5 (0.4%)	1 (0.1%)	4 (0.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (0.7%)
Unknown	1 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
No answer	17 (1.2%)	5 (0.4%)	10 (0.7%)	0 (0.0%)	0 (0.0%)	16 (1.2%)	48 (3.5%)
Total	410 (29.9%)	549 (40.0%)	301 (21.9%)	80 (5.8%)	3 (0.2%)	29 (2.1%)	1372.00 (100%)

Appendix table 13

Frequency of free roaming	N	Percentage
Always, no exceptions	606	44.2%
Always, but only during daytime	162	11.8%
Always, but only when the owner is home	318	23.2%
A few times per week	132	9.6%
A few times per month	40	2.9%
A few times per year	25	1.8%
Never	66	4.8%
Unknown	4	0.3%
No answer	19	1.4%
Total	1372	100%

Appendix table 14

Outdoor protection	Cover from sunlight	Cover from wind	Cover from rain
Yes	1051 76.6%	1021 74.4%	1014 73.9%
No	8 0.6%	21 1.5%	24 1.7%
Rabbit does not go outdoors	281 20.5%	283 20.6%	299 21.8%
Unknown	2 0.1%	15 1.1%	4 0.3%
No answer	30 2.2%	32 2.3%	31 2.3%
Total	1372 100%	1372 100%	1372 100%

Appendix table 15

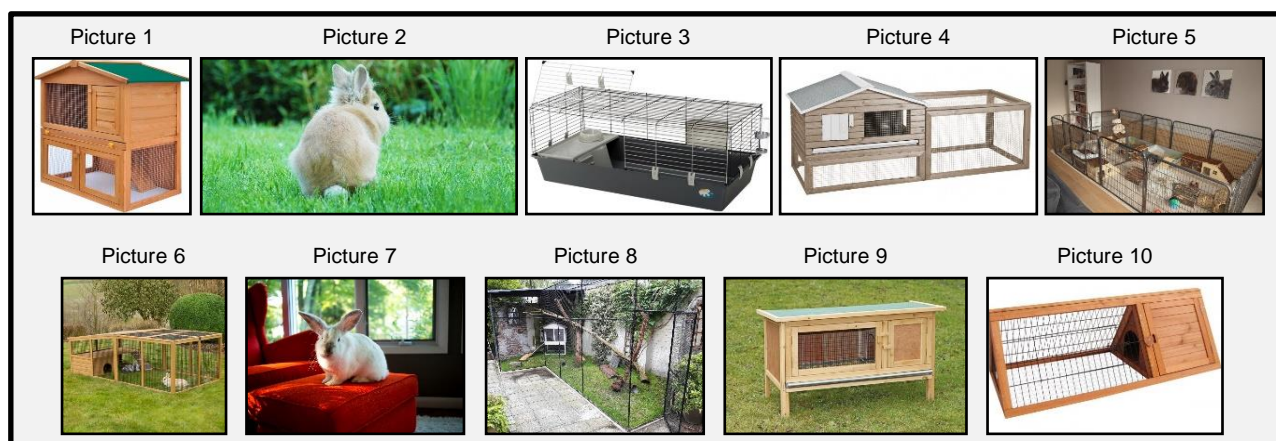
Ground cover / litter type	N	Percentage
Hay	385	12.7%
Straw	669	22.1%
Wood or straw pellets	238	7.9%
Newspapers	69	2.3%
Paper based (newspaper excl.)	163	5.4%
Sawdust	435	14.4%
Beech snips	496	16.4%
Hemp	236	7.8%
Flax	18	0.6%
Cat litter	11	0.4%
Textile	52	1.7%
None	235	7.8%
Unknown	1	0.0%
Other	17	0.6%
Total	3025	100%

Appendix table 16

Able to perform rearing? (illustrated with picture)	N	Percentage
Yes	1301	94.8%
No	31	2.3%
Unknown	11	0.8%
No answer	29	2.1%
Total	1372	100%

Appendix table 17

Housing type	Description	N	Percentage
Picture 1	Two story cage	170	12.4%
Picture 2	Free roaming outdoor	148	10.8%
Picture 3	Small indoor one story cage	143	10.4%
Picture 4	Outdoor cage with small run	95	6.9%
Picture 5	Indoor shelter with run	200	14.6%
Picture 6	Outdoor shelter with low run	212	15.5%
Picture 7	Free roaming indoor	203	14.8%
Picture 8	Outdoor shelter with high run	109	7.9%
Picture 9	Outdoor one story cage	29	2.1%
Picture 10	Outdoor triangle cage	2	0.1%
Unknown		25	1.8%
No answer		36	2.6%
Total		1372	100%



Appendix table 18

Expectations	Time investment	Expenses	Joy fulfilment
More than expected	312 22.7%	310 22.6%	696 50.7%
As expected	947 69.0%	921 67.1%	567 41.3%
Less than expected	67 4.9%	90 6.6%	66 4.8%
Unknown	11 0.8%	14 1.0%	7 0.5%
No answer	35 2.6%	37 2.7%	36 2.6%
Total	1372 100%	1372 100%	1372 100%

Appendix table 19

Region of residence	N	Percentage
Flemish region	627	45.7%
Walloon region	6	0.4%
Brussels Capital Region	3	0.2%
Netherlands	694	50.6%
Germany	2	0.1%
France	2	0.1%
Other	1	0.1%
Unknown	0	0.0%
No answer	37	2.7%
Total	1372	100%