

Survey of the Husbandry, Health, and Welfare of Norwegian Pet Rabbits

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Abstract

The domestic rabbit is a commonly kept pet in many countries, including Norway. This study aimed to survey the current health and welfare of pet rabbits in Norway based on recommendations for rabbit keeping put forth by the Norwegian Food Safety Authority and the Norwegian Veterinary Institute. An online questionnaire consisting of 65 questions was shared online. Data collection lasted from March to May of 2021 and yielded 513 responses from pet rabbit owners representing all Norwegian counties. Forty-five percent of the rabbits were female, 53.6% were male and most of the rabbits (76.0%) were neutered. Almost all rabbits (97.5%) had permanent access to hay. Complete pelleted feed was the most fed concentrate (n=492, 95.9%). Almost all rabbits (96.9%) were reported to be healthy at the current moment. Of the surveyed disease conditions, constipation (19.7%), diarrhoea (12.3%), and reduced appetite (17.9%) were the most common. Dental disease was reported in 29 rabbits (5.7%). The veterinarian was a source of information for 49.1% of rabbit owners. Most rabbits (86.2%) were kept in a living space above the recommended 200x300 cm. Although keeping conditions were reported to be of a high standard, pet rabbits were still suffering from preventable husbandry-related diseases. Education of rabbit owners is an important task of the veterinarian and should focus especially on feeding habits, and owner recognition of rabbit behaviour and diseases.

KEYWORDS

Nutrition, Disease, Prevention, Welfare, Survey, Rabbit

INTRODUCTION

The domestic rabbit is a commonly kept pet in many countries, including Norway. Yet, their biological and physiological requirements differ greatly from those of other common household pets, such as cats and dogs. This often leads to the intricate needs of the rabbit being underestimated, especially with regard to their nutrition and activity. Improper nutrition frequently leads to common diseases such as diarrhoea or dental disease (Oneill *et al.*, 2020).

On assignment from the Norwegian Food Safety Authority (NFSA) in 2017, the Norwegian Veterinary Institute (NVI) developed an information booklet named "Welfare needs of rabbits" to describe these biological and physiological needs intended as an information source on rabbit husbandry for the pet rabbit owners (NVI, 2017). This led to the development of a separate information booklet published by the NFSA in 2019 termed "Guide to rabbit keeping". This booklet was more directly aimed at pet rabbit owners and related its contents to the Norwegian Animal Welfare Act.

The purpose of this study was to investigate the current state of pet rabbit health and welfare in Norway, with special emphasis on their compliance with the keeping recommendations formulated by the NVI and the NFSA.

MATERIALS AND METHODS

An online questionnaire was published in the largest Norwegian pet rabbit interest group on Facebook called "Den store kaninboka" with approximately 14700 members. One private veterinary clinic called Grim Torv Veterinærhus, with around 1700 followers, two animal welfare organisations, Kaninhjelpen Sørlandet and Dyrebeskyttelsen Mandal, with approximately 2900 and 5000 followers respectively, as well as four private Facebook users chose to share the survey. Data collection lasted from March to May of 2021.

The questionnaire consisted of 65 questions that were both open and closed in nature, and were presented in both single-choice, multiple-choice and free text formats. The questionnaire included 65 questions divided into 9 sections:

Section 1. Respondents: gender, age, location, highest education, employment status, type of residence, details of any children, whether the rabbit is considered a family member.

Section 2. Rabbit: number of rabbits currently owned and having owned in total, sex, age, breed, neuter status and reason for neutering, main reason for acquiring a rabbit and from where the rabbit was acquired, main caretaker of the rabbit.

Section 3. Housing: size and details of primary living space, type of flooring, access to additional large areas (including frequency, timing and time spent there).

Section 4. Nutrition: type of given concentrates (including daily amount, feeding frequency and selective feeding behaviour of the rabbit) and other feedstuffs, access to hay, salt lick, fresh vegetables, treats.

Section 5. Health: current health status, disorders currently or in the past (27 common rabbit diseases were listed), reasons for visiting the veterinarian in the past, vaccination (Myxomatosis, Rabbit Haemorrhagic Disease 1 and 2; RHD-1, RHD-2).

Section 6. Behaviour: observed positive or stereotypical behaviours in the primary living space, and when lifted or being handled; possibilities to perform certain behaviours in the primary living space.

Section 7. Companionship: whether rabbit lives with another animal, the species and sex of the companion (including neutering status), behaviour of rabbit towards the companion.

Section 8. Husbandry: how much time is spent on feeding, cleaning, and playing with or training the rabbit per week, information sources on rabbit keeping.

Section 9. Finances: annual income, monthly spendings on food, bedding material, toys and veterinary service/medication, rabbit insurance.

Owners were told to answer the rabbit related questions with regards to their oldest owned rabbit in order to eliminate favouritism should they currently own more than one. Ethical approval was not required.

Statistical analyses

Correlation between health disorders, behaviours, and monetary variables was estimated using Kendall's tau rank correlation coefficient, following the transformation of ordinal variables into numerical ones. Brunner-Munzel test (BMT) was used for the relationship between annual gross income and pet insurance.

Relationships between disorders and housing conditions were examined using binary logistic regressions. First, a model was built with a set of candidate explanatory variables which were either assumed to affect the occurrence of the disorder based on preliminary veterinary knowledge or visual examination of the association between the disorder and the explanatory variable suggested a possible effect. Then, model selection was performed by manual backward-forward selection: insignificant interaction terms and variables were individually eliminated and then re-entered to test if the order of removal affected their significance, a method also aided by likelihood ratio tests of nested models. Age was always included in the models due to the assumption that with passing time, the probability that the rabbit had developed a disorder at least once in its life, increases. For this purpose, age was converted from a categorical variable into a numerical one by assigning the mean age as the value to each category (i.e., 1.5 to the category '1-2 years'). Since a mean age for the category '13 years or older' could not be calculated, rabbits falling into this category were excluded from these analyses. Relationships between the frequency of different behaviours and housing conditions were examined with BMT and logistic regressions in the case of ordinal and binary behavioural variables, respectively. Analyses were performed in R v.4.0.3 (R Core Team 2021). Records with missing values or with answers of "Don't know" and "Prefer not to answer" were excluded from a given analysis. Logistic regressions were conducted using base R function `glm`, Kendall's tau correlation coefficients were estimated with `cor.test`, and BMT were performed with the Brunner-Munzel test function from package `lawstat` (Gastwirth *et al.*, 2020). Likelihood ratio tests were executed with base R function `ANOVA`. Throughout the analysis, p-values less than 0.05 were

considered significant. Where multiple comparisons took place p-values were adjusted using the Bonferroni method. Goodness of fit of models were assessed by examining influential points and comparing the distribution of observed values with the distribution of expected values generated from the model. Post-hoc pairwise comparisons of factor levels were performed with the Dunnett method (each level compared to the reference) using function `glht` from package `multcomp` (Hothorn *et al.*, 2008).

RESULTS

Owner demographics

The survey had been completed by 513 pet rabbit owners. Most of the respondents were female (n=492, 95.9%) and 3.7% (n=19) were male. Participants from all Norwegian countries had been recruited, where most (n=304, 59.3%) were between 25 and 44 years of age, 20.3% were under 24 and 20.5% were above 44 years of age. The participants' educational and employment status as well as the type of residence are listed in Tables 1, 2 and 3.

Table 1. The highest level of completed education.

Highest level of completed education	Number	Percentage
Bachelor's degree	189	36.80%
Upper secondary school	127	24.80%
Master's degree	75	14.60%
Vocational subjects	57	11.10%
Lower secondary school	43	8.40%
Prefer not to answer	9	1.80%
Professional studies	3	0.60%
Ph.D. or higher	3	0.60%
Less than lower secondary school	2	0.40%
Professional degree in vocational subjects	2	0.40%
Scandinavian university college	1	0.20%
Bachelor's degree with specialisation	1	0.20%
Apprentice	1	0.20%
Total	513	

Table 2. Current employment status.

Employment status	Number	Percentage
Full-time employee	249	48.50%
Student	81	15.80%
Part-time employee	69	13.50%
Disabled	49	9.60%
Self-employed	24	4.70%
Homemaker	13	2.50%
Prefer not to answer	13	2.50%
Unemployed, jobseeking	11	2.10%
Unemployed, not jobseeking	3	0.60%
Retired	1	0.20%
Total	513	

Rabbit information

Most rabbits were between one and four years of age (n=266, 51.9%). Fifty-nine rabbits were under 1 year of age, eighty-nine animals were between 5-6 and seventy-six between 7-10 years of age. Twelve rabbits were older than 11 years. Fig. 1 shows the

rabbit breeds. Forty-five per cent (n=231) of rabbits were female and 53.6% (n=275) were male. Neutering was common, with 390 rabbits (76.0%) already being neutered and 43 (8.4%) owners planning to neuter their rabbit in the future. Male rabbits were 1.5 times more likely than female rabbits to be neutered. Reasons for neutering included reducing the risk of uterine- or testicular cancer (n=292, 67.4%), controlling behavioural problems related to inappropriate urination or defecation (n=267, 61.7%), controlling behavioural problems towards companion animal (n=259, 59.8%), and preventing unwanted pregnancy (n=211, 48.7%).

Rabbit acquisition

The most common reasons owners had for obtaining a rabbit (Table 4) were personal companionship (n=184, 36.0%). When asked whether the rabbit was considered a family member, 466 (90.8%) answered yes and fifteen (2.9%) were unsure. Rabbits were most commonly adopted (n=258, 50.3%), followed by being bought from a breeder (n=135, 26.3%) or from a pet shop (n=75, 14.6%). Other sources included purchasing from a previous owner, own rabbit litter, or online marketplace. Currently, most of the respondents owned 2 rabbits (n=267, 52%), followed by 1 rabbit (n=132, 25.7%), 3 rabbits (n=49, 9.6%), 4 rabbits (n=33, 6.4%), and more than 4 rabbits (n=31, 6.0 %).

Table 4. Owners' reasons for acquiring a rabbit.

Reason	Number	Percentage
Personal companionship	184	35.90%
Adopted (either directly from another home or via an organisation)	125	24.40%
Companion for another rabbit	50	9.70%
Gift for a family member in the household	49	9.60%
Pressure from others (e.g., kids or spouse)	26	5.10%
Family decision	18	3.50%
For use in breeding, shows and competitions	18	3.50%
Found as a stray	12	2.30%
Other ^a	29	5.60%

^aReceived as a gift (n=8), rescue (n=8), fostering (n=4), allergies to other pets within the family (n=2), unwanted by previous owner (n=3), non-response (n=2), yarn or meat production (n=1), spontaneous purchase (n=1)

Table 5. Size of the primary and secondary living space.

Size of the primary living space	Number	%	Hight of the primary living space	Number	%	Size of the secondary living space	Number.	%
100x50 cm	7	1.40%	45 cm	2	0.40%	100x50 cm	4	0.80%
120x60 cm	13	2.50%	50 – 60 cm	20	3.90%	120x60 cm	3	0.60%
150x60 cm	7	1.40%	70 - 80 cm	19	3.70%	150x60 cm	2	0.40%
200x100 cm	22	4.30%	90 – 100 cm	24	4.70%	200x100 cm	14	2.90%
200x60 cm	12	2.30%	More than 100 cm	444	86.50%	200x60 cm	8	1.60%
300x200 cm	81	15.80%	Don't know/ no reply	4	0.80%	300x200 cm	44	9.10%
400x300 cm	71	13.80%				400x300 cm	58	11.90%
500x400 cm	46	9.00%				500x400 cm	44	9.10%
70x60 cm	3	0.60%				Less than 70x60 cm	1	0.20%
Less than 70x60 cm	4	0.80%				More than 500x400 cm	308	63.40%
More than 500x400 cm	244	47.60%						
No reply	3	0.60%						
Total	513			513			308	

Table 3. The type of residence.

Type of residence	Number	Percentage
Bedsit	1	0.20%
Semi-detached house	2	0.40%
Semi-detached house	6	1.20%
Farm	22	4.30%
Terraced house	54	10.50%
Apartment	126	24.60%
Detached house	300	58.50%
Prefer not to answer	2	0.40%
Total	513	

Housing

The primary living space was defined as the space where the rabbit spends the most amount of time daily. The most common were free ranging within the house (n=219, 42.7%) or in an enclosed area within the house (n=110, 21.4%), followed by rabbit hutch with access to a run (n=88, 17.1%), shed/garage with access to a run (n=48, 9.3%), barn stall (n=22, 4.3%) and other housing conditions (n=22, 4.3%). Although the size of the primary living area varied, 442 rabbits (86.2%) were given access to more than the recommended 200x300 cm (Table 5). Most rabbits

Table 6. Information about the additional living area.

Approximately how often does the rabbit have access to this area?	Number	%	What are the conditions for allowing the rabbit access to this area?	Number	%	Approximately how much time is the rabbit allowed to spend in this area on each occasion?	Number	%	At what time of day is it most likely that the rabbit is given access to this area?	Number	%
Less than once a month	23	4.70%	Time of day	61	8.40%	Less than 30 min.	3	0.60%	Morning	17	3.50%
Once or twice a month	15	3.10%	The season	124	17.00%	30 min. – 1 hour	50	10.30%	Midday	89	18.30%
Once or twice a week	56	11.50%	The weather	130	17.80%	2 – 3 hours	84	17.40%	Afternoon	100	20.60%
Once a day	103	13.20%	Supervising possibility	196	26.80%	4 – 5 hours	53	11.00%	Evening	33	6.80%
More than once a day	224	21.20%	Unconditional	203	27.80%	6 – 7 hours	37	7.60%	Night	3	0.60%
Free/ permanent access	224	46.20%	Presence of other animals	4	0.50%	8 hours or more	255	52.70%	Free access	244	50.20%
			Able to use a suitable area	12	1.60%						
Total	485			730			482			486	

(n=487, 94.9%) regularly had access to a separate area for exercise or larger movements (Table 6). The most common bedding in the primary enclosure was carpet (n=285, 48.8%) and wood shavings (n=100, 17.1%), followed by hay (n=52, 8.9%), and wood pellets (n=40, 6.8%) (Table 7). The time spent on essential activities such as feeding and cleaning and on playing or training is shown in Figure 2.

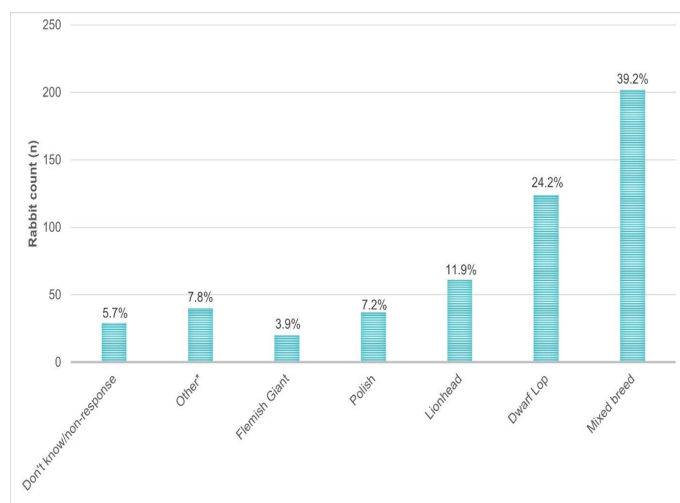


Fig. 1. The most commonly kept rabbit breeds. *Dwarf lion lop (n=15), French lop (n=8), angora (n=4), trønder (n=3), New Zealand red (n=2), rex (n=2), giant papillon (n=2), little Havana (n=2), hollender (n=1), sallander (n=1).

Environmental and social enrichment

More than 70% of the surveyed rabbits were able to perform all of the activities surveyed (chew on a suitable toy, create a separate area for eating, sleeping and defecation, climb, hide, and dig). A place for hiding and the possibility to create a separate area for eating, sleeping, and defecation were the most commonly provided, only lacking for six (1.2%) and ten (1.9%) rabbits respectively.

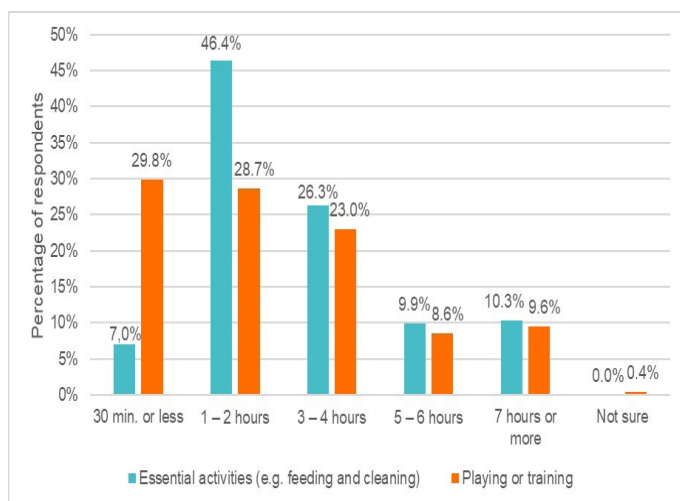


Fig. 2. Comparison of time spent on essential activities such as feeding and cleaning versus on playing or training.

Living with a companion animal is considered social enrichment, and 377 rabbits (73.5%) were reported to do so. The most common companion animal was the rabbit (n=341), followed by cat (n=21), dog (n=19), and other species (n=19) (Table 8). When two rabbits were housed together, both were neutered in 250 cases (74.9%). A comparison between the behaviour of the surveyed rabbit towards its companion can be seen in Fig. 3.

Table 7. Type of substrate/bedding in the primary and secondary living area.

Bedding in the primary living area	Number	%	Bedding in the secondary living area	Number	%
Cat litter	1	0.17%	Plastic	1	0.20%
Hemp	1	0.17%	Tiles	1	0.20%
Tiles	1	0.17%	Rubber	1	0.20%
Wool	2	0.34%	Asphalt	1	0.20%
Soil	5	0.86%	Wooden pellets	1	0.20%
Grass	8	1.37%	Linoleum flooring	2	0.40%
Paper	11	1.90%	Laminate flooring	2	0.40%
Bark	19	3.30%	Hay	3	0.60%
None/ no reply	29	5.00%	Stone	5	0.90%
Straw	30	5.10%	Wood shavings	7	1.30%
Wooden pellets	40	6.80%	Concrete	9	1.70%
Hay	52	8.90%	Soil	10	1.90%
Wood shavings	100	17.10%	Bark	11	2.10%
Carpet	285	48.80%	Sand	21	4.00%
			Wood	38	7.20%
			Parquet	65	12.30%
			Carpet	134	25.30%
			Grass	218	41.10%
Total	584		Total	530	

Table 8. Companion animal species housed together with the surveyed pet rabbits.

Species	Number	%
Duck	1	0.20%
Guinea Pig	1	0.20%
Bird	1	0.20%
Goat	2	0.40%
Hamster	3	0.60%
Horse	3	0.60%
Hen	4	0.80%
Chinchilla	4	0.80%
Dog	19	3.70%
Cat	21	4.10%
Rabbit	341	66.50%
Total	400	

Table 9. Most frequently fed vegetables and treats.

Vegetable	Number	%
Peas	5	0.50%
Corn	10	0.90%
Tomatoes	23	2.10%
Celery	47	4.30%
Spinach leaves	88	8.00%
Bell pepper	140	12.70%
Cucumber	142	12.90%
Iceberg lettuce	195	17.70%
Carrots	353	32.10%
None of these	98	8.90%
Total	1101	

Positive interactions were expressed more often towards rabbit companion than non-rabbit companion. When both the rabbit in question and its companion were neutered, the BMT found self-grooming ($p=0.0250$) and companion grooming ($p=0.0421$) to be more common. The rabbit was also more relaxed ($p=0.0245$) when both were neutered. The BMT also found mounting of the companion to be more frequent if both were intact ($p=0.0093$). Avoidance was seen in almost equal amount towards the rabbit and non-rabbit companion.

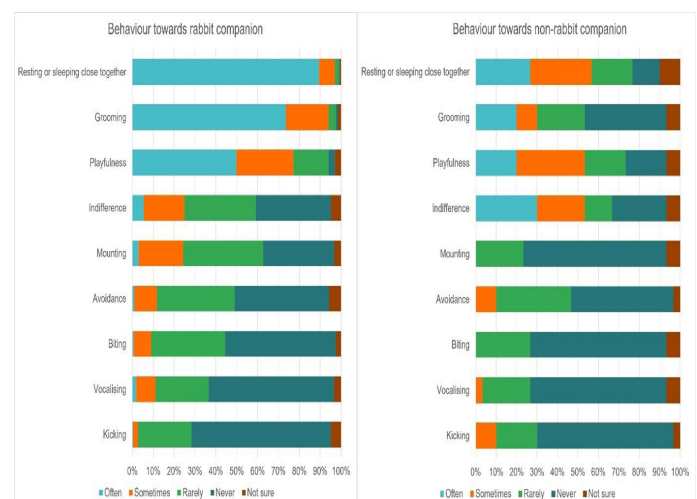


Fig. 3. Comparison of the behaviour expressed by rabbits towards their companion when housed with a rabbit versus non-rabbit companion.

Rabbit behaviour

Fig. 4 displays rabbit behaviours exhibited in their primary enclosure. In families without children, rabbits were more often observed to be calm and relaxed than in families with 2-4 children ($p=0.0039$). In families with 2-4 children, the odds of the rabbit biting when picked up was 2.3 times higher ($p=0.0015$)

Table 10. Most frequently fed treats.

Treat	Number	%
Dairy products	1	0.10%
Breakfast cereal	2	0.10%
Pellets of the same brand as the primary feed	3	0.20%
Pellets of another brand than the primary feed	3	0.20%
Nuts and seeds	4	0.30%
Homemade	7	0.50%
Vegetables	12	0.90%
Bread or biscuits	24	1.70%
Store bought	143	10.20%
Berries	261	18.60%
Herbs	272	19.40%
Bark or twigs	311	22.20%
Fruits	359	25.60%
Total	1402	

Table 11. The respondents' annual household income in Norwegian kroner.

Household annual gross income (NOK)	Number	%
1 000 000 or more	115	22.40%
900 000 – 999 000	39	7.60%
800 000 – 899 000	50	9.70%
700 000 – 799 000	33	6.40%
600 000 – 699 000	36	7.00%
500 000 – 599 000	40	7.80%
400 000 – 499 000	49	9.60%
300 000 – 399 000	32	6.20%
200.000 – 299 000	23	4.50%
100 000 – 199 000	20	3.90%
61 000 – 99 000	5	1.00%
60 000 or less	6	1.20%
Prefer not to answer	65	12.70%
Total	513	

than in families without children. Also in these families, vocalising when picked up and while being handled was more common (OR=1.771, $p=0.0237$; OR=1.790, $p=0.0309$). Approximately 60%

Table 12. Monthly spendings in Norwegian kroner.

Monthly spending in Norwegian kroner					
on veterinary services and/ or medications			on food, bedding material and toys		
	n	%		n	%
Under 500	457	89.10%	Under 100	46	9.00%
500 – 999	33	6.40%	100-399	262	51.10%
1000 – 1999	11	2.10%	400-699	152	29.60%
2000 – 2999	5	1.00%	700-999	30	5.80%
3000 – 3999	1	0.20%	1000 or more	22	4.30%
4000 - 4999	0	0.00%	Not sure	1	0.20%
5000 or more	2	0.40%			
Not sure	4	0.80%			
Total	513			513	

of the rabbits often or sometimes behave calmly and relaxed both when picked up and when handled. Rabbits with a larger enclosure were less likely to bite when lifted ($p=0.0113$). The odds of vocalising and biting were 1.5 times higher in rabbits without companion ($p=0.0309$ and $p=0.0100$).

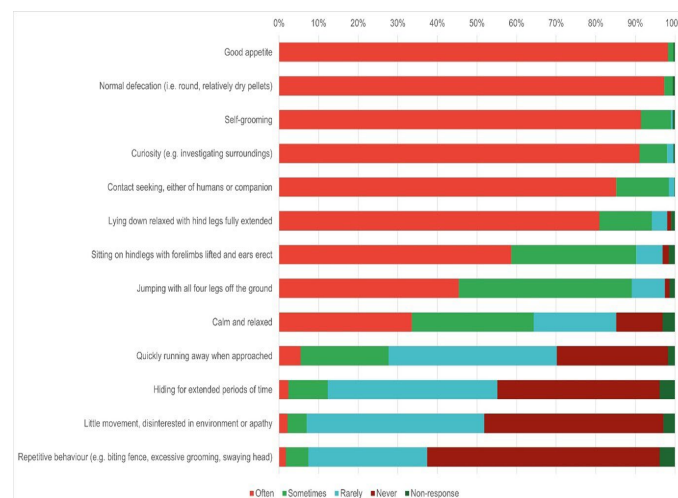


Fig. 4. The most commonly observed rabbit behaviours in the primary living space.

Nutrition

Complete feed was the most prevalent type of concentrate, with 95.9% ($n=492$) choosing this type of feed over a mixed muesli-type ($n=15$, 2.9%), although six (1.2%) respondents said they never feed their rabbit concentrates. Among those who did ($n=506$), 493 (97.4%) gave it daily, 10 (2.0%) gave it weekly, one (0.2%) monthly, and two (0.4%) less than monthly. Only two owners (0.4%) never gave fresh vegetables while two owners (0.4%) gave unlimited treats (Tables 9 and 10). Almost all rabbits (97.5%) had permanent access to hay.

Rabbit health

Four hundred forty-five rabbits (86.7%) had visited the veterinarian in the past for various reasons (Fig. 5). Nearly all ($n=497$, 96.9%) rabbit owners considered their rabbit healthy at the current moment. Constipation ($n=101$, 19.7%), reduced appetite ($n=92$, 17.9%) and diarrhoea ($n=63$, 12.3%) were the most common diseases where constipation being positively correlat-

ed with reduced appetite ($\tau = 0.545$, $p < 0.0001$). Movement difficulties were reported in 28 (5.5%) cases and were found to be positively correlated with both limping ($\tau = 0.371$, $p < 0.0001$) and neurologic conditions ($\tau = 0.382$, $p < 0.0001$). Excessive itching ($n=9$, 1.8%) was found to be positively correlated with the presence of fleas, lice, or mites ($\tau = 0.410$, $p < 0.0001$). The odds of the rabbit having developed constipation or diarrhoea at least once increased with its age in a quadratic manner, being the highest for rabbits around the age of 7-8 years and decreasing for older rabbits. Neutered rabbits had 3.6 times higher odds of having constipation than those not neutered ($p=0.0015$). Daily feeding of fresh vegetables significantly increased the risk of constipation in comparison with weekly feeding ($OR=2.003$, $p=0.0315$). On the other hand, the odds of diarrhoea were 9.1 times higher if rabbits had ad libitum access to concentrates in comparison with limited access, although the small sample size ($n=7$) of rabbits with ad libitum access to concentrates makes the reliability of this result questionable ($p=0.0054$).

In total, 24 rabbits (4.7%) were vaccinated. Twenty-three were vaccinated against myxomatosis, thirteen against RHDV-1, and fourteen against RHDV-2. Eleven rabbits (2.1%) were vaccinated against all three diseases.

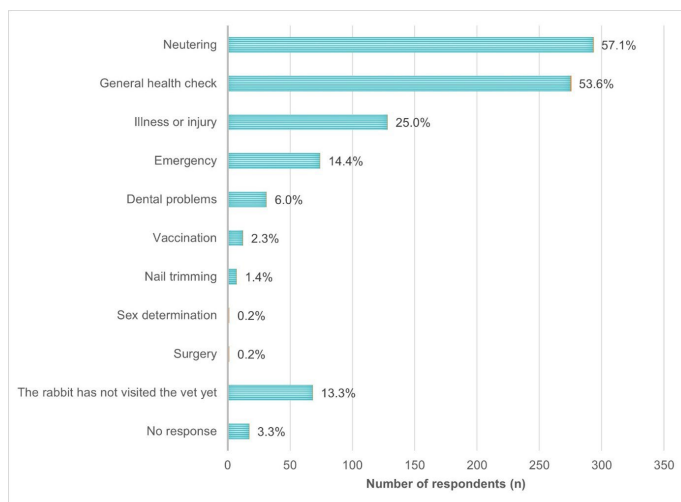


Fig. 5. Reasons for visiting the veterinarian in the past.

Owner experience and information sources

Owner experience with rabbit keeping ranged from less than one year ($n=56$, 10.9%) to 10 or more ($n=142$, 27.3%). Most of the owners had 1-3 ($n=124$, 24.2%) or 4-6 ($n=120$, 23.4%) years of experience. Seventy (13.6%) owners had been keeping rabbits for 7-9 years.

The most important information source was the internet (90.8%) followed by books (58.1%) and veterinarians (49.1%). Other sources of information can be seen in Fig. 6. The income and costs related to rabbit keeping are shown in Tables 11 and 12. No correlation was found between the amount spent on rabbit food, bedding material, and toys and the participant's income. Income was also not related to the amount they were currently spending on veterinary services or medications, nor the amount they were willing to spend in the future. However, a weak positive correlation was found between the amount currently spent and the amount participants were willing to spend ($\tau = 0.176$, $p < 0.0001$). Only 34.1% ($n=175$) of rabbits were insured, and among those not currently insured, 11.5% ($n=59$) were planning to insure in the future. A weak negative correlation was found between participants' income and their rabbit's insurance status ($\tau = -0.101$, $p=0.0112$). The BMT showed a significant difference

between the income of those owners whose rabbit is currently not insured but they are planning to insure, and of those not planning to insure at all, with income being higher in the latter group ($p=0.0260$).

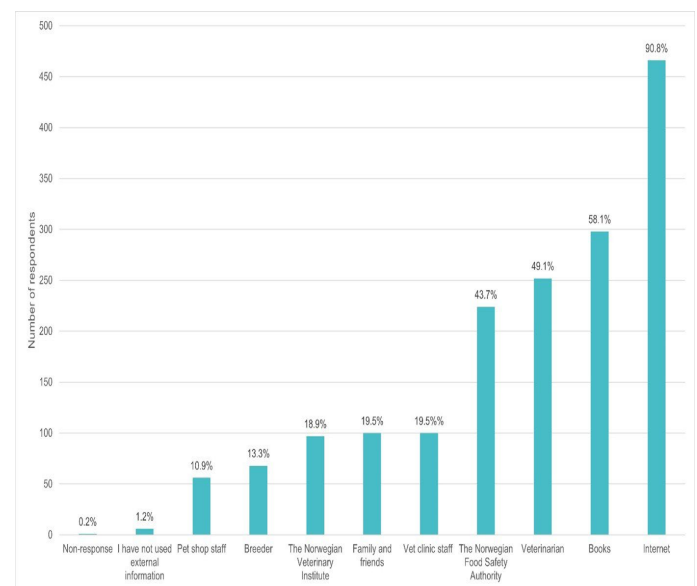


Fig. 6. Information sources used by owners to acquire knowledge on pet rabbit keeping.

DISCUSSION

Similar to other studies most of the respondents were females in the age range 25-43 (Rooney *et al.*, 2014; Welch *et al.*, 2017). Connections between rabbit acquisition and urban living have also been suggested by Mayer *et al.* (2017), possibly due to the common belief that rabbits require less space and maintenance than other common pets.

As in other studies among the purebred rabbits, the dwarf lop was the most common (65%, 28.1%, 37.2%, and 31.2%; Edgar and Mullan, 2011; Mäkitaipale *et al.*, 2015; Mullan and Main, 2006; Hetényi and Sátorhelyi, 2021). The female-to-male ratio was close to 50-50 in previous surveys as well (Mullan and Main, 2006; Mäkitaipale *et al.*, 2015; Hetényi and Sátorhelyi, 2021). The mean group age (3.9) was consistent with the result of Hetényi and Sátorhelyi (2021) of 3.7 years, and slightly higher than that was found by others (Rooney *et al.*, 2014; Mullan and Main, 2006; Mäkitaipale *et al.*, 2015). A higher proportion of rabbits were neutered (76.0%) than in other studies (42.1%, 59.1%, 28.1%, 68.2%, and 49.5%; Mullan and Main, 2006; Rooney *et al.*, 2014; Mäkitaipale *et al.*, 2015; Welch *et al.*, 2017; Hetényi and Sátorhelyi, 2021). Edgar and Mullan (2011) identified that 56% of rabbit owners were planning to neuter their rabbits to prevent behavioural problems. Mullan *et al.* (2006) found the proportion to be 20.6%. In terms of behavioural problems, the current study differentiated between those related to the environment such as inappropriate urination or defecation (61.7%), and those related to companion animal keeping (59.8%). Both were common reasons to neuter, although the most important reason stated by owners was reducing the risk of disease, in particular uterine- or testicular cancer, which was chosen by 67.4%. This far exceeds numbers seen in previous studies, where reducing the risk of disease was an important cause for neutering for only 11% 18.6% (Edgar and Mullan, 2011; Mullan and Main, 2006). Neutering is commonly recommended to prevent diseases, reduce aggression and other undesirable behaviours associated with sexual hormones (Meredith and Lord, 2014; Künzel *et al.*, 2015).

The proportion (50.3%) adopting via an organisation was consistent with the findings of Welch *et al.* (2017) (49.1%). Purchasing the rabbit from a breeder (26.3%) was less common in

other studies (15.8%, 10.7% and 12.4%, Rooney *et al.*, 2014; Welch *et al.*, 2017; Mayer *et al.*, 2017). Welch *et al.* (2017) and Oxley *et al.* (2015) found that a similar proportion of rabbits (14.0% and 12.9%) as in the current study were bought from a pet shop, while Mayer *et al.* (2017), Hetényi and Sátorhelyi (2021), and Rooney *et al.* (2014) saw higher proportions of 19.6%, 28.0%, and 39.1%. Concerning the number of currently owned rabbits, the results of this study was similar to that of Rooney *et al.* (2014) (44.4%) where most of the participants owned 2 rabbits. The insurance rate of rabbits was higher (34.1%) than in other studies (11.7%, 21.5%, Rooney *et al.*, 2014; Oxley *et al.*, 2015).

Rabbits should be able to perform all natural activities within their primary enclosure. Space recommendations by the NFSA (NVI, 2017), are based on the Rabbit Welfare Association and Fund (RWAf, 2016), who set minimum enclosure measurements of 3 m by 2 m with a 1 m ceiling height. Dixon *et al.* (2010) compared rabbits housed in enclosure sizes of 0.88 m², 1.68 m², and 3.35 m², and found that larger enclosure sizes led to increased prevalence of natural behaviours. In the present study, only 13.3% of rabbits lived in an area under the recommendations. An additional area for exercise was available in two other studies in 85% and 97.5% of cases (Edgar and Mullan, 2011; Rooney *et al.*, 2014). In the present study, such an area was available to 94.9% of rabbits. Contrary to other studies in which shavings (74.7%, Mullan and Main, 2006) or wooden pellets (75.2%, Hetényi and Sátorhelyi, 2021) were used in this study carpet was the most common indoor substrate (48.8%).

Based on the statistics, it seems that living with more than 2 children under the age of 16 in the household increases the stress level of rabbits. Rabbit companion was the most common as in other studies (Mullan and Main, 2006; Edgar and Mullan, 2011; Rooney *et al.*, 2014). Generally, a higher proportion of positive behaviours were expressed towards the rabbit companion than the non-rabbit companion.

Hay or grass was a regular part of the diet of all rabbits. Other studies also found that fibre-rich feed was given in high proportions of 83.5-98.3% (Mullan and Main, 2006; Rooney *et al.*, 2014; Mayer *et al.*, 2017; Hetényi and Sátorhelyi, 2021). Concentrates were available to almost all rabbits (98.8%) similar to two other surveys (>96%) (Mullan and Main, 2006; Mayer *et al.*, 2017). Interestingly, only 74.1% of the owners surveyed by Rooney *et al.* (2014) but 100% of those surveyed by Hetényi and Sátorhelyi (2021) were given concentrates. Edgar and Mullan (2011) suggests that anthropomorphism plays a role in the feeding of mixed type of concentrates and found that 45% were given this kind of feeds, as opposed to 2.9% in the present study. Perhaps owner awareness of the health risks associated with this kind of feed has contributed to this lower prevalence, since participants generally were quite academically educated, and most had conducted prior research into rabbit keeping. Selective feeding as a potential disadvantage of mix-based diets was also seen in this study (Harcourt-Brown 1996; Prebble and Meredith, 2014).

Green leafy forages were a common part of the diet (99.6%) similar to other surveys 72.3%, 83.3%, and 98.4% (Hetényi and Sátorhelyi, 2021; Mullan and Main, 2006; Mayer *et al.*, 2017). Fruits on the other hand, were reportedly given to 25.6%, compared with 20.2%, 70.6% and 91.3% (Hetényi and Sátorhelyi, 2021; Mullan and Main, 2006; Mayer *et al.*, 2017). Fruit consumption should be limited as it may lead to gastrointestinal problems and obesity (Meredith and Lord, 2014; Lowe, 2020).

Rabbits were mostly presented to the veterinarian for reasons other than clinical disease, namely neutering (57.1%) and general health checks (53.6%). Many gastrointestinal conditions arise from inappropriate feeds or feeding habits (Harcourt-Brown, 2007; Huynh and Pignon, 2013; Huynh *et al.* 2014). Gastrointestinal disease was a prevalent problem in this (32%) and other studies (40.1% and 47.7%, Hetényi and Sátorhelyi, 2021; Mayer *et al.*, 2017). The reason for the higher prevalence of constipation in elderly rabbits might be explained by the longer observation time available due to their age. Diarrhoea of rabbits having ad libitum access to concentrates could be explained by the probable lower

hay and consequently fibre intake. Dental diseases are common in pet rabbits (Harcourt-Brown, 2009ab; Jekl and Redrobe, 2013; Meredith and Lord, 2014). Interestingly the prevalence of dental disease was much lower (5.7%) than in other studies (21-22% and 35-40%, Mayer *et al.*, 2017; Rooney *et al.*, 2014; Mäkitaipale *et al.*, 2015; Hetényi and Sátorhelyi, 2021). Also, several other conditions including parasitic diseases, urinary track diseases, trauma, skin conditions, eye diseases and swellings anywhere on the body, or abscesses were less frequently seen than in other surveys (Mullan and Main, 2006; Rooney *et al.*, 2014; Mäkitaipale *et al.*, 2015; Mayer *et al.*, 2017; Hetényi and Sátorhelyi, 2021). On the other hand, pododermatitis (9.6%) was more common than in most of the other studies (1.8-4%, Mullan and Main, 2006; Rooney *et al.*, 2014; Mäkitaipale *et al.*, 2015; Mayer *et al.*, 2017; Hetényi and Sátorhelyi, 2021). The low prevalence of vaccinated individuals (4.7%) was expected, given that pet rabbit vaccination is not common practice in Norway compared with international literature, 89.9%, 62.7 and 70.8% (Hetényi and Sátorhelyi, 2021; Mullan and Main, 2006; Rooney *et al.*, 2014).

Respondents appear to be well researched since 98.6% of owners had used at least one external source of information on pet rabbit keeping. The internet was used by nearly all (90.8%), which was also reflected in the study by Welch *et al.* (2017) (92%). Books were also important resource in the present study (58.1%) and were used by 50.1% and 61% in two surveys (Edgar and Mullan, 2011; Welch *et al.*, 2017). Only the third most important resource in the present study was the veterinarian (49.1%) however, two studies found this to be the most important resource (66.7% and 75.2%, Mayer *et al.*, 2017; Hetényi and Sátorhelyi, 2021). Among the least used resource was the breeder in all studies.

CONCLUSION

Publishing the questionnaire on Facebook in a dedicated rabbit interest group was a deliberate choice to gain the widest geographical reach of participants across Norway. However, it is likely that the data gathered shows a bias towards notably committed rabbit owners that have actively joined the group in order to share information on responsible rabbit husbandry. The outreach is also limited to those owners able to participate in an online survey. Although keeping conditions were reported to be of a high standard, pet rabbits were still suffering from preventable husbandry-related diseases. Education of rabbit owners is an important task of the veterinarian and should focus especially on feeding habits, and owner recognition of rabbit behaviour and diseases.

CONFLICT OF INTEREST

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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