The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK

Animal Welfare 2004, 13: 57-62
ISSN 0962-7286

Preference of domestic rabbits for grass or coarse mix feeds

TK Leslie, L Dalton and CJC Phillips*

Department of Clinical Veterinary Medicine, University of Cambridge, Cambridge CB3 OES, UK
* Current address: School of Veterinary Science, University of Queensland, Gatton 4343, QLD, Australia
* Correspondence: c.phillips@uq.edu.au

Abstract

The motivation of juvenile rabbits to graze was tested by offering a choice of coarse mix or grass as rewards to rabbits fed a nutritionally adequate diet of carrots and hay. Before measuring the motivation of the 16 rabbits, eight were offered access to grass for 16 days and the remaining eight were kept in outdoor hutches. An initial preference test was then conducted using a Y-maze apparatus, in which the rabbits were offered a choice of grass or coarse mix for 3 min. The rabbits that had not previously been offered grass had a strong preference for the grass reward, whereas those that had chose coarse mix and grass equally. Measurement of rabbits' behaviour during the reward period revealed that rabbits spent longer eating if their reward was grass; this difference was particularly notable toward the end of the 3 min period. If they received a coarse mix reward, they spent more of the 3 min self-grooming, standing still and chewing the wire of the cage. Feeding rabbits with a coarse mix diet may therefore increase the likelihood of problem behaviours including inactivity and trichophagia. The rabbits were also trained in a novel operant test of motivation for the two rewards, in which they were required to circumnavigate an object several times before receiving a reward. The number of circumnavigations before a reward was offered was progressively increased, and rabbits were offered two opportunities to take the reward at each level. Although the rabbits were prepared to circumnavigate the object up to 11 times on average, there was little evidence that they would work harder for a grass reward than for a coarse mix reward. This may have been because they had previously had experience of grass during the preference tests. It is concluded that juvenile rabbits show a strong initial preference for a grass reward, compared with coarse mix, but that this preference disappears after brief exposure to grass. There was no strong evidence that rabbits will work harder to receive a grass reward than to receive a coarse mix reward.

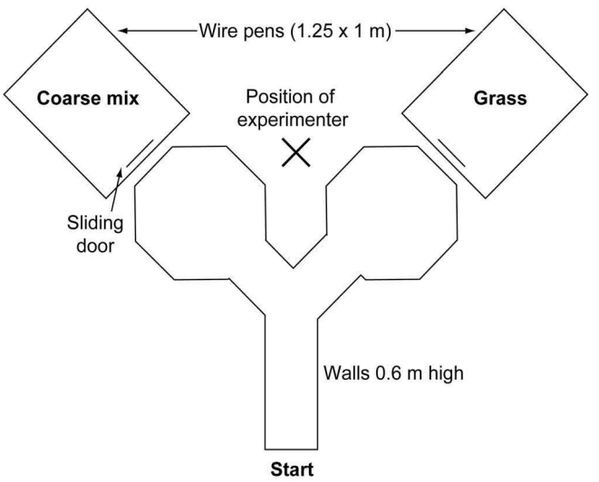
Keywords: *animal welfare, coarse mix, grazing, pasture, preference, rabbit*

Introduction

Pet rabbits (*Oryctolagus cuniculus*) tend to be kept either in outdoor runs or in hutches with limited or no opportunity to graze. Little research has been carried out on the importance of pasture to domestic rabbits, probably as it is not feasible to keep meat-producing and laboratory rabbits on grass because of difficulties in maintaining grassed areas and in cleaning the pens. However, rabbits are now the third most common pet in the UK (Meredith 1998), so it is important to provide informed advice about rabbit housing to owners. Other domesticated herbivores, such as ruminants, benefit from the provision of grazing for at least part of each year, so it is important that pet-rabbit owners are also advised to provide an area of grass if it is beneficial for the rabbits' welfare. There are many factors to be taken into account when designing an outdoor run, such as security from predators and prevention of escape from open-floored pens by digging. Contact with wild rabbits should be prevented, in order to minimise the risk of disease transmission by direct contact (eg viral haemorrhagic disease) or vectors such as the rabbit flea (eg myxomatosis) (Meredith 1998). There should also be a raised box in which rabbits can stay dry and sheltered from wind and heat. If the pen is not moved regularly, worm infestations may increase and, if overgrazed, the grass–soil interface may be disrupted with obvious health risks. However, if managed properly, an outdoor run can prevent hyperthermia, respiratory problems and flea infestation (Williams 1973; Cooke 1990). In addition, urine drains away under grass, whereas straw bedding can become soaked, and rabbits have shown a preference for drained floors (Morisse *et al* 1999). As wild rabbits spend much of their waking time grazing, provision of high-energy concentrated food that is rapidly consumed will result in rabbits spending more time performing alternative activities. As European rabbits have only been kept in cages since Victorian times and their behaviour is therefore very similar to that of wild rabbits (Stodart & Myers 1964), there is little reason to assume that they would benefit less from grazing than their wild relatives.

Many attempts have been made to enrich indoor rabbit cages, and these provide some useful insight into whether the provision of pasture would be beneficial. The most useful form of enrichment is something to chew upon (Brummer 1975; Huls *et al* 1992; Lidfors 1997; Berthelson

Figure 1



Design of apparatus for the preference test. The initial sections of the Y-maze were opaque and wood-floored, and the experimenter was only partially visible from within. The experimenter was always the same person, who was familiar to the rabbits. The two reward pens were wire-sided and contained either grass or, in the case of the coarse mix reward, carpet as floor. Passageways were 0.3 m wide, and 0.65 m wide at the ends. The entry race was 1.25 m long; the arms were 0.5 m long. Sliding doors were made of wire in a wooden frame, so that the rabbits could see and smell the reward.

& Hansen 1999, 2000), and high-fibre objects are preferred, with hay or straw remaining effective enrichment for the longest period (Lidfors 1997; Brummer 1975). They also cause less weight-gain than proprietary fibre sticks or compressed grass cubes (Lidfors 1997). Abnormal maternal behaviours and trichophagia or fur-chewing (Brummer 1975; Mulder *et al* 1992) are eliminated in caged rabbits when hay or straw is given. If the supplementary hay is ground up, it is ineffective at reducing problem behaviours, demonstrating the need for long fibre (Mulder *et al* 1992).

As well as providing cage enrichment, a high-fibre diet also improves rabbits' dental health and intestinal activity (Kamphues 2001), and increasing fibre intake above that available from commercial dried rabbit mixes can increase both appetite and growth rates (Tawfik *et al* 1997). There is, therefore, evidence that providing access to grass, either fresh or conserved, improves the health of rabbits. We carried out the following investigation to determine whether rabbits preferred a grass reward to a coarse mix reward. The effect of previous experience of grass on motivation to receive the grass reward was examined, and two tests were carried out: a simple Y-maze preference test, and a novel operant test to investigate which reward the rabbits would work hardest for. It has previously been shown that rabbits are able to learn to make choices in preference tests (Morisse *et al* 1999; Held *et al* 1995). The novel operant test required the rabbits to walk for increasing distances around an obstacle to gain access to a reward. Animals can associate walking with gaining access to food, and the motivation of sheep to gain access to better quality hay has been successfully investigated by making them walk various distances through a winding sheep race (Dumont *et al* 1998).

Materials and methods

Sixteen female rabbits (four Lionhead and twelve Dwarf Lop) were purchased at 8–13 weeks old, having been weaned at eight weeks and fed carrots, cauliflower, cabbage and a restricted ration of concentrate mix. Their desire for grass and coarse mix when fed a basic ration of carrots and hay was investigated using two tests, a preference test and a motivation test.

Preference test

Preparation for test

After acclimatisation to cages in the outdoor experimental site for one week with limited handling, the 16 rabbits were randomly allocated to housing either in runs enclosing an area of pasture or in outdoor raised hutches for 16 days, to determine whether previous experience of grass affected their preference for grass rewards. The first group of eight rabbits was housed in two 1 m × 1.25 m outdoor runs, each of which had an area for shelter and a box of dry straw. The runs were moved every day so that the rabbits had access to fresh grass. The second group of eight rabbits was housed outdoors in two 0.6 m × 1 m traditional wooden rabbit hutches, and the rabbits were allowed into a large pen for exercise for 2 h per day. These rabbits were not given access to grass, except for approximately 15 min each day when they were trained to operate the motivation test apparatus. All rabbits were fed 250 g coarse mix (Aristocrat, oil 2.2%, protein 11.36%, fibre 10.5%, ash 6.0%) and 100 g grass hay per cage before the start of the preference test.

Housing and feeding during test

From the first day of the preference test, the coarse mix in the rabbits' diet was replaced with carrots, and the outdoor runs were placed on green carpets to prevent access to grass. Therefore, during the preference test neither grass nor coarse mix was available to any of the rabbits unless they gained access to a reward in the test. At 1600h, rabbits were fed 125 g carrots per rabbit and unlimited hay, with refused food being removed daily at 0930h. This diet was chosen as it was nutritionally adequate and contained long fibre in the form of hay, so that any demonstrated preference for grass would indicate that it was preferred to the feed that is normally provided in cages.

Test procedure

An outdoor Y-maze was used for the test (Figure 1), with the reward pens being accessed through sliding doors; both reward pens contained drinking bowls. One reward pen was placed on a green carpet (to prevent colour preference influencing the selection) and a bowl containing 100 g of coarse mix (the same type as that used during the training period) was placed centrally in the pen. This quantity of reward was considerably more than a rabbit could consume in 3 min, the duration of each reward period. In the other reward pen was the same area of grass, with an average height of 12.5 cm.

https://doi.org/10.1017/S0962728600026671 Published online by Cambridge University Press

The Y-maze was moved to a new patch of grass when the average grass height had been reduced to 3.8 cm, and at this time the sides of the Y-maze that led to each reward were swapped. Following each change of side, which occurred three times during the test to remove any side preference bias, the rabbits were briefly retrained. This involved allowing the rabbits to operate both doors for about 5 min to familiarise them with which sides of the Y-maze led to the coarse mix and grass rewards. There were two test periods per day lasting 2 h each, one from 1000h to 1200h and the other from 1400h to 1600h, and the four rabbits housed in each cage were each tested for two morning and two afternoon periods. During a test period, one cage of four rabbits was tested. Each rabbit was tested six times during this test period with approximately 20 min between tests. Several of the rabbits were observed to sample the two rewards a few times before consistently choosing one side, which is why so many tests were carried out on the same rabbit each day.

In each test, the rabbit was placed at the beginning of the Y-maze, facing away from the arms of the maze so that it would not be encouraged to enter one arm in preference to the other. When the rabbit approached within 10 cm of a sliding door, a bell was rung (as a reinforcer) and the door was opened by the experimenter. If the rabbit walked into a reward pen, the door was shut behind it, and the rabbit would remain in the reward pen for 3 min, which was found in pilot tests to be approximately the maximum length of time for which the rabbits would show an interest in the coarse mix reward. If the rabbit moved away from the door, the door was closed and the rabbit given the opportunity to approach the other, or the same, door. Some rabbits approached doors several times before making a decision and there was no limit to the available time in the Y-maze.

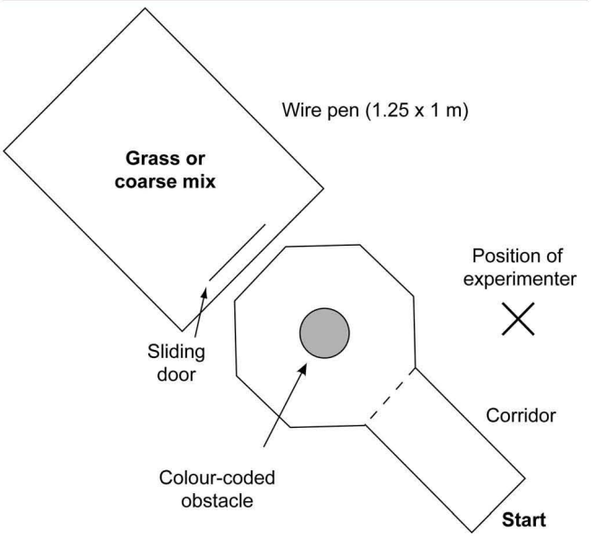
Behaviour observations

During the 3 min reward periods, the behaviour of the rabbit was recorded by scan-sampling every 15 s, with 12 observations being recorded per 3 min period. It was assumed that the time spent carrying out each behaviour was proportional to the number of observations of that behaviour in the 3 min. Twelve behaviours were recorded: eating (either coarse mix or grass); drinking; sniffing; grooming; lying (laterally or sternally recumbent); sitting (hind quarters and front feet in contact with ground); standing on all four legs; hopping (series of body movements in which two forepaws on ground are followed by springing off with both hindlimbs); jumping (single elevation of the body from the ground in which all four feet leave the ground simultaneously); standing up on back legs (rearing); scraping the ground; and chewing the wire of the pen.

Motivation test

This test was carried out a week after the end of the preference test using the eight hutch-kept rabbits and four of the grass-kept rabbits. All of these 12 rabbits were housed in three raised hutches with no access to grass from a week before the test. The rabbits were kept on the same diet as during the preference test, and the motivation for the two rewards, grass and coarse mix, was determined by measuring the number of times that each rabbit was prepared to circumnavigate an obstacle before receiving the reward. The obstacles were metal drums coloured white and blue, one signalling each reward. Visual conditioning to food has previously been successful in rabbits (Ruckebusch *et al* 1971), and it was assumed that the rabbits were able to learn to determine which reward was present in the reward pen by noting the colour of the obstacle that they were required to circumnavigate.

Figure 2



Design of the apparatus for the motivation test, consisting of one arm of the Y-maze. The obstacle was a metal drum 0.6 m high and 0.3 m in diameter, painted either white or blue depending on the reward.

During the test, each rabbit was placed in the passageway leading to the obstacle (Figure 2) and trained over a two-week period to circumnavigate the obstacle in order to receive a reward. Rabbits were trained on average for 15 min per day over a two-week period, and worked for both rewards approximately equally during the training. During the test, the number of circumnavigations required per reward was progressively increased by one each time a rabbit was tested, provided that it had succeeded in obtaining the reward at the lower level. Each rabbit was given two chances to obtain the reward at each level, with a 15 min rest in between. Both grass and coarse mix rewards were tested independently and in alternating order. The rabbit was allowed 3 min to complete the required number of circumnavigations, and if after this time the rabbit had not achieved the required number, the test was terminated. If the rabbit failed a test, it would be allowed into the reward chamber after the next completed circumnavigation when the 3 min had elapsed, even though the test would be counted as a failure. This was necessary to prevent the rabbits from giving up completely when they worked for the next reward. A circumnavigation did not count if, during it, the

https://doi.org/10.1017/S0962728600026671 Published online by Cambridge University Press

Table 1 The effect of reward type (grass or coarse mix) and previous experience of grass on the frequency of behaviours demonstrated by more than one half of the rabbits during the 3 min tests.

Behaviour (% of total observations)	Reward type		Grass experience		Probability	
	Grass	Coarse mix	Yes	No	Reward	Experience
Eating	86	56	73	67	<0.001	0.72
Sniffing	1.5	3.3	2.7	2.1	0.16	0.48
Sitting	2.8	16.0	10.9	8.3	<0.001	0.99
Hopping	6.9	18.0	12.6	12.9	0.001	0.99

Table 2 The effect of reward type (grass or coarse mix) on the frequency of behaviours demonstrated by less than one half of the rabbits during the 3 min tests.

Behaviour (% of total observations)	Reward type		1 – probability that median > 0	
	Grass	Coarse mix	Grass reward	Coarse mix reward
Grooming	0.7	2.1	0.02	<0.01
Lying down	0	0.1	1.00	0.50
Standing	0.7	1.1	0.06	<0.01
Jumping	0.3	0.6	0.13	0.13
Rearing	1.0	2.1	<0.01	<0.001
Scraping ground	0.2	0.2	0.25	0.25
Chewing cage	0	0.4	1.0	0.03

rabbit re-entered the corridor of the maze. During training, vocal encouragement was provided to the rabbits and proved necessary to the success of the experiment. Therefore, in the tests a stereotyped voice stimulus was given after every successful revolution, and the same conditioned stimulus as in the preference test, a bell, was rung just before opening the door.

Statistical analysis

The selection of grass or coarse mix during the preference test was analysed by χ^2 distribution. The behaviours performed during this test were not normally distributed, as demonstrated by the Anderson-Darling test (Minitab 1995). Differences were analysed using Mood's median test if the number of integers was more than 50% of the total sample; otherwise, the Sign test was used to determine whether the true median for each reward treatment was greater than zero.

The motivation test was analysed by a general linear model in Minitab, after the data were found to be normal using the Anderson-Darling test. The model included treatment (grass or no grass experience) and reward type (grass or coarse mix) as fixed factors and rabbit number as a random factor. There were no significant interactions between the two factors 'grass experience' and 'reward type', so results are shown for the main effects only.

Results

The mean daily intake per rabbit from the start of the preference test to the end of the experiment was 30 g hay and 125 g carrots.

Preference test

The rabbits made a greater number of choices of grass (223) than coarse mix (161) ($P < 0.05$). This difference in reward preference was seen only in the rabbits that had not been previously kept on grass, which selected grass 130 times and coarse mix 62 times ($P < 0.001$). The rabbits that had been previously kept on grass selected grass 93 times and coarse mix 99 times ($P < 0.25$).

The behaviour of the rabbits during the test was affected by reward type but not by whether they had previously had experience of grass (Table 1). In the grass reward pen, the rabbits spent more time eating and less time sitting and hopping than when in the coarse mix pen. The time spent eating was greater for grass than for coarse mix throughout the 3 min test period, and the difference tended to increase over the course of the 3 min period (Figure 3). In the grass reward pen, the time spent eating remained high throughout the period. Of the behaviours that were seen in less than 50% of the tests, there was no difference in frequencies for rabbits that did or did not have experience of grass, so results are tabulated for the effects of reward type only (Table 2). When in the coarse mix pen, the rabbits showed greater frequencies of grooming, standing, rearing and chewing the cage wire than when in the grass pen. There were significant differences in the occurrence of cage chewing and standing.

Motivation test

There was no effect of experience of grass on motivation to obtain a reward (Table 3). The rabbits offered a grass reward showed a slight tendency to perform more circumnavigations ($P = 0.12$), and they required a greater number of attempts (ie required number of circumnavigations completed within 3 min), both at each level and in total (Table 4). Two attempts to perform the required number of circumnavigations in 3 min were allowed per level.

Discussion

The preference test

The preference for grass compared with coarse mix probably reflects a desire to graze rather than a nutritional deficit, since the nutrient intake in 3 min from coarse mix would

https://doi.org/10.1017/S0962728600026671 Published online by Cambridge University Press

Table 3 The effect of experience of grass on the motivation of rabbits to obtain a reward.

	Grass	No grass	SED*	Probability
Maximum circumnavigations (no.)	10.4	10.3	0.63	0.91
Total attempts (no.)	11.1	11.0	0.85	0.91
Attempts/level (no.)	1.07	1.07	0.026	0.94

* Standard error of the difference between two means

Table 4 The effect of reward type (grass or coarse mix) on the motivational behaviour of rabbits.

	Grass	Coarse mix	SED*	Probability
Maximum circumnavigations (no.)	10.8	9.8	0.51	0.12
Total attempts (no.)	11.9	10.3	0.69	0.04
Attempts/level (no.)	1.10	1.04	0.021	0.02

* Standard error of the difference between two means

potentially be in excess of that from grass. The rate of dry matter intake from coarse mix is usually greater than grass in herbivores (Phillips 2002). The observation that more time was spent eating in the grass reward pen suggests that the intake of some nutrients, and particularly energy, could have been equated by the rabbits for the two rewards. It is possible that the balance of nutrients in the grass was perceived by the rabbits to be more appropriate to their requirements than that in the coarse mix. However, their basic ration of hay and carrots should not have been deficient in any nutrients (NRC 1966), and fibre requirements would have been provided by the hay (Lehmann 1990). Therefore, the preference may have been purely for the taste of grass or the experience of grazing.

The absence of any preference for reward type in those rabbits that were experienced in grazing suggests that the novelty of grass, or grazing, to rabbits without experience of this fulfilled a behavioural drive that may have been present following weaning. If such a drive existed, it may have been extinguished following exposure at an early age, or alternatively it may have derived from novelty alone. The former is the most likely explanation because both exposed and unexposed rabbits had received brief periods of exposure during the initial training sessions for the motivation test. It is also possible that the rabbits had learnt, through repeated exposure to grass and coarse mix during the tests, that it was easier to obtain their nutrients from coarse mix, even though they had an initial desire to graze. Future work needs to address the preference for grass at different ages and following different periods of exposure.

A mixed diet is a feature of herbivore selection in preference tests, attributable to their desire to sample different foods regularly in case of disappearance of one food-type (Parsons *et al* 1994). Thus the preference of inexperienced rabbits for grass was not complete, with approximately 70% of selections being for grass. A longer-term study may have shown a preference for coarse mix for short periods only, whereas grass might be preferred for longer periods of feeding. This is suggested by the short-term nature of eating of coarse mix; in contrast, the rabbits receiving the grass reward spent most of their time eating. The behavioural problems associated with coarse mix feeding became apparent even during the 3 min period of the test, with chewing of the cage wire being significant in these rabbits but not in those receiving a grass reward.

The motivation test

This test demonstrated only a weak tendency for a greater demand for grass ($P = 0.12$) than for coarse mix. Any strong preference for grass may have been extinguished by the rabbits' repeated exposure to grass during the preference test, which suggests a transient nature to the demand for grass or that it derived only from novelty. The increase in the number of attempts, both in total and at each level, probably derived from the rabbits tending to reach a greater number of circumnavigations for the grass reward. The number of attempts was seen to increase at the higher levels, which would have increased the total number of attempts for the rabbits rewarded by grass. The strength of the rabbits' preferences for the two rewards is likely to depend on the basal diet on which they were fed, and future work could address the motivation of rabbits to work for a fibre reward when they are kept on a diet deficient in fibre.

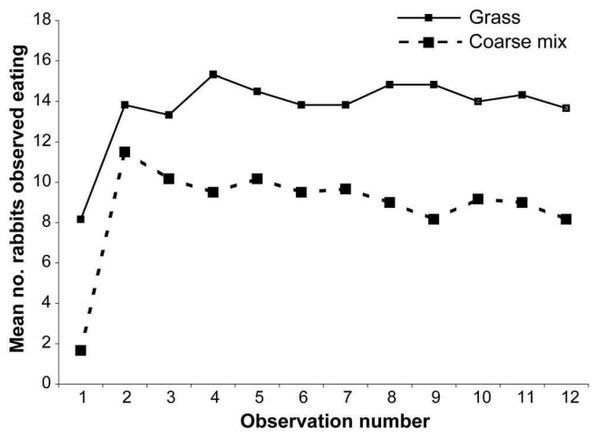
The motivation test apparatus was successfully operated by most rabbits, but whether it provides an accurate test of their motivation for the rewards has yet to be determined. It was chosen because the most practical alternative, a weighted door, was suspected of causing stress to some of the smaller rabbits.

Conclusions and animal welfare implications

Rabbits on a balanced diet demonstrated a preference for grass only if they had not been kept on grass before. Therefore it seems likely that grazing had a novelty value, or that sufficient reward could be obtained from access to grazing even if it was available only infrequently (provided that hay was always available). There was only limited evidence that rabbits were more strongly motivated to obtain a grass reward than a coarse mix reward. When rabbits did show a preference for grass, they did not chew the wire of their cage, whereas those receiving a coarse mix reward did, demonstrating the problem behaviours that can arise with a coarse-mix-based diet. The increased amount of time spent standing still or self-grooming in rabbits receiving the coarse mix reward could be interpreted as resulting from

https://doi.org/10.1017/S0962728600026671 Published online by Cambridge University Press

Figure 3



Change in the number of rabbits observed eating over the 12 observations during the 3 min periods for which they received the grass or coarse mix reward.

boredom, demonstrating the unsuitability of a coarse-mix-based diet. The novel test for measuring strength of motivation was successful, with rabbits circumnavigating an obstacle up to ten or eleven times before failing the test.

Acknowledgements

TK Leslie acknowledges the award of a Vacation Scholarship by the Universities Federation for Animal Welfare, and L Dalton acknowledges the help of the Nuffield Foundation in the provision of a summer scholarship.

References

Berthelson H and Hansen LT 1999 The effect of hay on the behaviour of caged rabbits. *Animal Welfare 8*: 149-157

Berthelson H and Hansen LT 2000 The effect of environmental enrichment on the behaviour of caged rabbits (*Oryctolagus cuniculus*). *Applied Animal Behaviour Science 68*: 163-178

Brummer H 1975 Trichophagia: a behavioural disorder in the domestic rabbit. *Deutsche Tierarztliche Wochenschrift 82*: 350-351

Cooke B 1990 Rabbit burrows as environments for European rabbit fleas, *Spilopsyllus cuniculi* (Dale), in arid South Australia. *Journal of Australian Zoology 38*: 317-325

Dumont B, Dutronc A and Petit M 1998 How readily will sheep walk for a preferred forage? *Journal of Animal Science 76*: 965-971

Held SDE, Turner RJ and Wootton RJ 1995 Choices of laboratory rabbits for individual or group-housing. *Applied Animal Behaviour Science 46*: 81-91

Huls WL, Brooks DL and Bean-Knudsen D 1992 Responses of adult New Zealand White rabbits to enrichment objects and paired housing. *Laboratory Animal Science 31*: 609-612

Kamphues J 2001 The species-specific feeding of rabbits in pet husbandry. *Deutsch Tierarztlich Wochenschrift 108*: 131-135

Lehmann M 1990 Activity requirement for young domestic rabbits: raw fibre consumption and animal welfare. *Schweiz Archiv Tierheilkeld 132*: 375-381

Lidfors L 1997 Behavioural effects of environmental enrichment for individually caged rabbits. *Applied Animal Behaviour Science 52*: 157-169

Meredith A 1998 *The Rabbit: Online Information for Veterinary Students at the Royal School of Veterinary Studies, University of Edinburgh, UK*. http://www.aquavet.i12.com/Rabbit.htm

Minitab 1995 *Minitab Reference Manual, Release 10Xtra for Windows and Macintosh*. Minitab Inc: Pennsylvania, USA

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

Mulder A, Nieuwenkamp AE, van der Palen JG, van Rooijen GH and Beynen AC 1992 Supplementary hay reduces fur-chewing in rabbits. *Tijdschrift fur Diergeneeskunde 117*: 655-658

National Research Council (NRC) 1966 *Nutrient Requirements of Rabbits*. National Academy of Sciences: Washington DC, USA

Parsons AJ, Newman JA, Penning PD, Harvey A and Orr R J 1994 Diet preference of sheep — effects of recent diet, physiological state and species abundance. *Journal of Animal Ecology 63*: 465-478

Phillips CJC 2002 *Cattle Behaviour and Welfare, Edn 2*. Blackwell Publishing: Oxford, UK

Ruckebusch Y, Grivel ML and Fargeas MJ 1971 Electrical activity of the intestine and feeding associated with a visual conditioning in the rabbit. *Physiology and Behavior 6*: 359-365

Stodart E and Myers K 1964 A comparison of behaviour, reproduction and mortality of wild and domestic rabbits in confined populations. *CSIRO Wildlife Research 9*: 144-159

Tawfik ES, Sherif SY, El-Hindawy M, Attia AI and Abou-Ela S 1997 The role of fibre in rabbit nutrition. *Der Tropenlan, Beitrage zur Tropischen Landwirtschaft und Veternarmedizin 98*: 73-81

Williams RT 1973 Establishment and seasonal variation in abundance of the European rabbit flea, *Spilopsyllus cuniculi* (Dale), on wild rabbits in Australia. *Journal of Entomology A 48*: 117-127